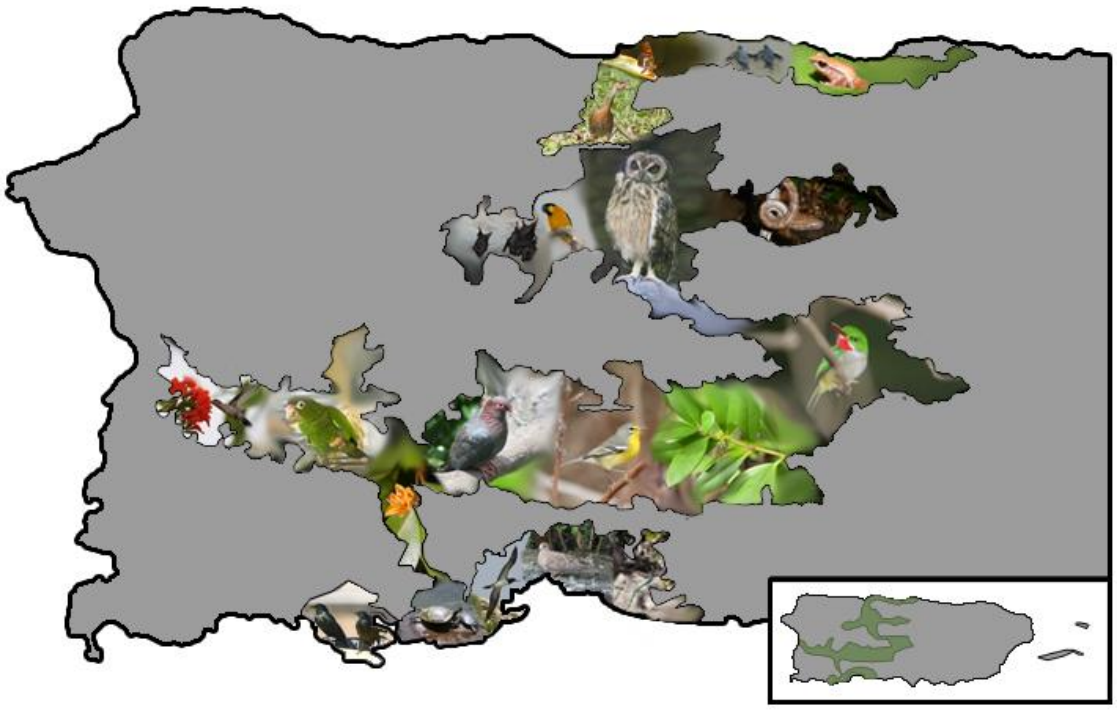
Puerto Rico State Wildlife Action Plan: Ten Year Review



Puerto Rico Department of Natural and Environmental Resources.
September 2015.

Page

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

ACKNOWLEDGMENTS

Financial support for the completion of this initiative was provided to the Puerto Rico Department of Natural and Environmental Resources (DNER) by U.S. Fish and Wildlife Service (USFWS) State Wildlife Grants Program.

Thanks to the colleagues that participated in the Puerto Rico State Wildlife Action Plan (PRSWAP) Steering Committee: Mr. Ramón Rivera, Dr. Nilda Jimenez, Ms. María de Lourdes Olmeda, Dr. Craig Lilyestrom and Dr. Miguel A. García for their collaboration in different aspects of this strategy.

A number of collaborator participated in current and earlier revisions of this Plan, including many collaborators within the DNER. These include: Julissa I. Irizarry, José A. Salguero-Faría, José Sustache, Coralys D. Ortíz, Rossanna Vidal, Dr. Ricardo López, Rosseane Medina, Katsí Ramos, María Camacho, Gustavo Olivieri, Grisel Rodríguez, Daniel Matos, Aida Rosario, Alberto Álvarez, Hana Y. López and Alexis Martínez and Félix Grana.

Staff from the USFWS Ecological Services Office in Cabo Rojo contributed valuable input and support in the creation of this document. Collaborators from Non-Governmental Organizations and Academia include: Dr. Alberto Puente (UIPR Arecibo), Dr. Armando Rodríguez (UIPR Bayamón), Dr. Neftalí Ríos López (UPR Humacao), Alcides Morales (SOPI), Dr. Jaime Collazo (NCSU), Sara Prado (NCSU), José L. Herrera (Island Conservation) and Wayne Arendt (IITF).

The cover image was designed by IDEAS, Inc. and includes images provided by Mr. Alcides Morales and IDEAS, Inc.

EXECUTIVE SUMMARY

Ten years ago, the first comprehensive strategy for the conservation of our wildlife resources — then known as the Comprehensive Wildlife Conservation Strategy (CWCS, 2005) began leading our local conservation initiatives. The strategy, which is now known as the Puerto Rico State Wildlife Action Plan (PRSWAP, 2015) was originally perceived as a requirement for receiving funds from the US Fish and Wildlife Service's State Wildlife Grants Program, but rapidly evolved into "a real" guide and a handbook for prioritizing and implementing projects, particularly those associated to the island's non-game species and their associated habitats.

Today, we can report that great progress has been made in the accomplishment of the following expected results and for the predicted benefits stated in the original Comprehensive Wildlife Conservation Strategy from 2005.

- Identifying and addressing the greatest conservation needs of Puerto Rico's fish and wildlife.
- Prioritizing efforts on species with greatest conservation needs.
- Allowing the Department of Natural and Environmental Resources (DNER) to work in partnerships to conserve, enhance and protect Puerto Rico's diverse, but not necessarily rare or at risk, fish and wildlife species.
- Improving the DNER's ability to address present and future challenges and opportunities for Puerto Rico's fish and wildlife populations.
- Integrating monitoring and management actions for game and non-game species.

Careful analysis is not required to realize that a decade has only served to identify and partially attend to the needs of Puerto Rico's fish and wildlife resources. This task is ongoing and never ending, due to the unstable nature of our environmental and socio-economic realms. Beside the intrinsic and monumental challenges of the aforementioned assignments, Puerto Rico receives limited federal funding allocations, further restricting the DNER's potential achievements. Notwithstanding, the following actions have been completed, reflecting the usefulness of having an up to date State Wildlife Action Plan:

- New species have been identified and included as *Species of Greatest Conservation Need*. In fact, plant species are a new and important component of this revised plan.

- Several species previously identified as *Data Deficient* were studied and their designations updated. Great progress was particularly made with the river native fish communities, an amphidromous group that was previously poorly studied on the island.

- Newly completed databases resulting from terrestrial and aquatic gap analysis projects.

- Coral reefs, as well as riparian and mangrove forest have been identified as *habitats of greatest conservation need.*

- Climate change has been recognized as a new stressor and threat for wildlife species and habitats.

- We have adopted the creation or enhancement of biological corridors linking public and private wildlife habitats and/or new riparian and marine corridors as a new conservation priority. These

actions are expected to benefit native, endemic and migratory species whose habitats and ranges are projected to shift as a direct result of climate change.

- The “Puerto Rico Model Forest” initiative has been created to protect and manage forested lands at a large scale by including the communities within them and the economic development of the area.

- Updating the strategic plan for fish and wildlife resources from 2014.

- Adopting the Puerto Rican Parrot as and emblematic and surrogate species for advance the conservation of other wildlife species, through on a landscape ecology approach.

- Implementing a more aggressive approach to the eradication of specific invasive species that were impacting negatively ecological, economic and cultural attributes

In conclusion, the milestones reached in the conservation of Puerto Rico’s wildlife resources during last decade generate mixed emotions; we are being challenged by the many tasks the island currently faces and dared by the ones to come. Climate change and sea level rise, combined with the island’s current economic situation have been exacerbating the already complex scenario we faced when work on the original action plan began back in 2005.

SUMMARY OF CHANGES

Chapter	Section	Summary	Page(s)
II – SGCN	Status and Protection of SGCN	New species were added, others were removed. Plants and pollinators were included for this review	20-32
III – Habitat Requirement	Forest Composition	Types and conditions of our forests	34-39
IV – Identifying Stressors/Threats	List of main stressor/threats	New stressor/threats were added	49-70
V – Conservation Strategies for PRSWAP	PR GAP	Update of the PR GAP data included	72
V – Conservation Strategies for PRSWAP	Marine Gap Analysis Project	To develop a comprehensive set of databases on Puerto Rico's freshwater and marine recreational fisheries resources.	73
V – Conservation Strategies for PRSWAP	Develop strong private lands programs	New available private lands programs were added.	75-78
V – Conservation Strategies for PRSWAP	Comprehensive Land Use Plan	A new Land Use Plan (2014) was added.	91-94
V – Conservation Strategies for PRSWAP	Identification of areas of hydrologic importance	Puerto Rico's most important hydrological regions were identified.	94
V – Conservation Strategies for PRSWAP	Conserving Working forest landscape	In order to promote the forest landscape, the outputs, priority landscape and the strategies are show.	97-100
V – Conservation Strategies for PRSWAP	Protecting forests and wildlife from harm	Methods to identify, manage and reduce threats to the forest and its wildlife are mentioned.	99-101
V – Conservation Strategies for PRSWAP	Enhance public benefits associated with forests and wildlife.	Strategies recognized for this goal are analyzed.	100-102
V – Conservation Strategies for PRSWAP	Marine Mammals Rescue Program	Description of the actions during a marine mammal situation, including stranding and necropsies.	102-103
VI – Habitats of Greatest Conservation Need	Terrestrial Habitats	Urban Forests were added in this review.	105
VI – Habitats of Greatest Conservation Need	Freshwater Habitats	Riparian Forests and Mangrove Forests were added	108 and 112
VI – Habitats of Greatest Conservation Need	Saltwater Habitats	Coral Reefs were added	112
VI – Habitats of Greatest Conservation Need	Marine Protected Areas	These protected areas were added.	132

VI – Habitats of Greatest Conservation Need	Puerto Rico Model Forest	This initiative, which started in 2014, was included.	134
VI – Habitats of Greatest Conservation Need	Caribbean Landscape Conservation Cooperative	To develop and provide the best available conservation science and strategies in order to conserve, restore and sustain natural and cultural resources in the US Caribbean.	134
VII – Monitoring and Adaptation of Conservation Action	Joint Priority Landscapes	This effort seeking public engagement began in 2011, and was included in this plan.	148-150

CHAPTER 1. INTRODUCTION

I. Background

The Caribbean is considered a global biodiversity hotspot (Cincotta and Engelman 2000; Helmer et al. 2002; Myers et al. 2000). The islands commonly known as the Greater Antilles occupy the larger area within the Caribbean Region, with Puerto Rico being the smallest (8,892 km^2 or 3,425 $miles^2$) and most eastward (18º 15'North/66º 30' West) (Cruz and Boswell 1997). Paradoxically, the majority (80%) of the documented species extinctions have occurred on islands (Island Conservation, 2014). The combination of a high extinction rate with high indices of biodiversity and endemism makes implementing conservation initiatives and allocating funding toward these ecosystems a necessary and important priority.

Unsustainable exploitation of resources (Myers 1989), habitat loss and invasive species (Walker and Steffen 1997) have been identified as the main culprits for species extinctions on islands. Moreover, insular species exhibit greater extinction rates, and are more susceptible to environmental stress than their mainland counterparts (Vitousek 1988, Vitousek et al. 1995). This increased vulnerability has been linked to low population numbers, reduced genetic diversity, constrained geographical range (Adsersen 1995, Vitousek, 1988), and limited migratory capabilities (Ives and Foufopoulus 2003).

Puerto Rico is an archipelago composed of several islands and cays where the majority are managed as protected areas under local and federal designations, and only a few are privately owned. A complex topography, soils and climate produce distinct life zones (Ewel and Whitmore 1973) and several vegetation associations, ranging from high elevation elfin forest to coastal alluvial swamps. Likewise, the marine environment is diverse, including some of the deepest dephs in the world (the Puerto Rican Trench), and shallow ecosystems dominated by coral reefs and sea grass prairies.

Habitats in Puerto Rico have been degraded over the past 3 to 4 centuries as the swelling human population had increased the use of its natural and environmental resources, significantly transforming the landscape. Population growth caused a dramatic change in the local economy, shifting from an agriculture-based economy (ca. 1930-1950) to an industrial one (López et al. 2001). These changes resulted in major deforestation during the first half of the past century. The abandonment of agricultural lands sparked a remarkable forest recovery process, where the forest cover on the island increased from approximately 6% to 34% (Birdsey and Weaver 1987). However, the island's growing population has affected forest recovery, as many abandoned agricultural lands have been replaced by rapid urbanization (López et al. 2001).

Puerto Rico's current economy is influenced by high debts to local and external investors, causing a stagnation that has halted the production of infrastructure and caused a massive emigration of human resources. The current mosaic of land uses and conditions found on the island represent a significant challenge for conservation, in which species and habitat conservation must be harmonized in managed and undisturbed ecosystems. Timely and proactive landscape conservation approaches, such as the creation and enhancement of biological corridors, have been identified as a priority for the island.

Puerto Rico has approximately 5,847 native wildlife species. Of these, 51 are reptiles (Rivero 1998), 18 are amphibians (Rivero 1998), 5,573 are insects (Torres and Medina-Gaud 1998), 190 are birds (Raffaele 1989) and 15 are mammals. Most of these are considered non-game, and are poorly known by the government and the general public. Unless recognized as threatened or endangered (T/E), non-game species lack the public constituency and awareness needed to support basic research and management. As a result, the population status and distribution of most non-game, non-listed species is unknown, limiting the implementation of actions and management strategies.

In Puerto Rico, management priorities for wildlife and fisheries resources have been sharply delineated by conditions established by the four primary sources of federal funds supporting the majority of our management efforts. These are the Sport Fish and Wildllife Restoration Programs, the Endangered Species Program and the State Wildlife Grants Program. User fees and taxes paid by hunters and anglers have financed management and restoration efforts during several decades, but these funds are mostly used for conservation of game species and are not sufficient for addressing the needs of the other species. In fact, the total allocated amount for endangered, threatened and species of greatest conservation needs identified as Data Deficient (García et al. 2005), has been around $750,000 per year. Consequently, conservation goals and initiatives can only be achieved by teaming other conservation entities, particularly the US Fish and Wildife Service, National Resources Conservation Serivices and NGO's such as The Nature Conservancy (International) and Para La Naturaleza (local). Such partnerships are instrumental for fulfilling the shared goal of conserving wildlife resources and their habitat.

II. Objective

The State Wildlife Action Plan (SWAP) represents a comprehensive, statewide approach for conserving Puerto Rico's wildlife and natural areas for future generations. The objectives of this document include: (1) Identify the current status of the species and their habitats, (2) Identify and update conservation priorities for these species and their habitats, and (3) establish a regular monitoring process aimed at updating the previous two objectives.

III. Expected Results and Benefits

The Puerto Rico State Wildlife Action Plan will:

- Identify and address the greatest conservation needs of Puerto Rico's fish and wildlife resources.
- Prioritize efforts on species with greatest conservation needs.
- Allow the DNER to work in partnership to conserve, enhance and protect Puerto Rico's diverse, but not necessarily rare or at risk, fish and wildlife species.
- Improve the DNER's ability to address present and future conservation challenges and opportunities.
- Integrate monitoring and management of game and non-game species.

IV. Approach

Staff from the Puerto Rico DNER revised the original Comprehensive Wildlife Conservation Strategy (CWCS) from 2005 using internal resources. However, stakeholders, the Academia, local and federal agencies, and the general public have been able to participate in the review process for the priority list of Species of the Greatest Conservation Need (SGCN). DNER staff referred to existing Wildlife Action Plans from other states and the Guiding Principles for States to Consider in Developing Comprehensive Wildlife Conservation Plans for the State Wildlife Grants, as well as the Sport Fish and Wildlife Restoration Programs. A draft version of the new PR SWAP was posted in the agency's website for a 30 day period in order to allow for a broad and general public review.

The Puerto Rico State Wildlife Action Plan addresses the following required elements:

Element 1: Inventory

Information on the distribution and abundance of wildlife species, including low and declining populations as the State Fish and Wildlife Agency deems appropriate, that are indicative of the diversity and health of the State's wildlife.

Element 2: Condition

Description of the locations and relative condition of key habitats and community types essentials to conservation of species identified in Element 1.

Element 3: Threats

Descriptions of problems which may adversely affect species identified in Element 1 or their habitats, and priority research and survey effort needed to identify factors which may assist in restoration and improved conservation of these species and habitats.

Element 4: Actions

Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions.

Element 5: Monitoring

Proposed plans for monitoring species identified in Element 1 and their habitats, for monitoring the effectiveness of the conservation actions proposed in Element 4 and for adapting these conservation actions to respond appropriately to new information or changing conditions.

Element 6: Review

Descriptions of procedures to review the PRWAP at intervals not exceeding ten years.

Element 7: Coordination

Plans for coordinating the development, implementation, review, and revision of the PRWAP with federal, state, and local agencies.

Element 8: Public Participation

Involvement of general public in the development of the conservation strategy and resulting actions.

The first version of PRSWAP, known as the CWCS (2005), the updated Fisheries and Wildlife Resources Strategic Plan (DNER 2004), the Puerto Rico Critical Wildlife Areas (Ventosa-Febles et al. 2005a), the Puerto Rico Waterfowl Focus Areas (Ventosa-Febles et al. 2005b), and the Puerto Rico Terrestrial Gap Analysis (2007) and Aquatic Gap Analysis (2011) were used to update and inform this plan. These documents provide detailed information about wildlife species and their habitat and are recommended references for obtaining more detailed information.

VI. CONCLUSION

The original Comprehensive Wildlife Conservation Strategy (2005) considered the broad range of Puerto Rico's wildlife with appropriate emphasis placed on the species and habitats with greatest conservation needs, particularly species considered Data Deficient (DD). Nevertheless, this revised document includes the development and improvement of biological corridors as a new national priority (e.g. Figure 25). These actions are of utmost importance in order to adapt to the changes and threats caused by climate change, which are expected to force changes in the current habitat use and distribution of Puerto Rico's Wildlife. By prioritizing the creation of habitat corridors and "softening" the mosaic of fragmented habitat found on the island, we expect to protect and adapt the landscape in order to facilitate the projected changes in species ranges caused by climate change.

CHAPTER 2. SPECIES OF GREATEST CONSERVATION NEED

The New Wildlife Law of Puerto Rico (Law No. 241 of August 15, 1999) and its Regulations (Regulation No. 6765, for the Conservation and Management of Wildlife, Exotic Species and Hunting in the Commonwealth of Puerto Rico, and Regulation No. 6766, to Govern the Threatened and Endangered Species of the Commonwealth of Puerto Rico), are the legal framework empowering DNER to protect Puerto Rico's wildlife resources (DRNA 2004). Other selected statutes related to wildlife and forest resources protection in Puerto Rico are listed in Table 1.

Table 1. List of selecte statutes.

Statutes	Name	Objectvie
Constitution of the Commonwealth of Puerto Rico adopted in 1952	Constitution	It establishes as a public policy "the most efficient conservation of natural resources, as well as the best development and use of these for the benefit of the community"
Commonwealth Law No. 23 of 1972, as amended	Organic Law of the Department of Natural Resources	It creates DNER and assigns to it, among several things, the responsibility of establishing programs for the conservation of the PR natural resources, including forests
Commonwealth Law No. 133 of 1975, as amended	Puerto Rico Forests Act	It establishes the public policy of the Commonwealth to protect, expand and conserve the forest resources of PR. It creates the Commonwealth Forest Service.
Planning Board Regulation No. 25	Planting, Cutting and Foresting Regulations for Puerto Rico	It requires a DNER permit for cutting and grooming trees on public or private land in Puerto Rico.
Commonwealth Law No. 144 of 1976, as amended	Law for the extraction and excavation of Earth's crust components	It prohibits the issuance of Earth's crust components extractions and excavations in natural resources "reserves" (includes Commonwealth Forests)
Commonwealth Law No. 136 of 1976 (also known as the "Water Act")	Act for the Conservation, Development and Use of the Water Resources of Puerto Rico	It assigns the faculty of planning and ruling the usage, conservation and development of water resources in the Commonwealth, to DNER, including those superficial as subterranean water.
Commonwealth Law No.29 of 1976	Department of Natural and Environmental Resources Rangers Corp Act	It creates DNER Rangers Corp to enforce all the Commonwealth statutes available for the protection of all natural resources (forests included)
Commonwealth Law No. 241 of 1999	New Wildlife Law of Puerto Rico	It authorizes the DNER Secretary to rule all activities related to the wildlife well-being, included its habitats (forests included)

Species of conservation priorities were originally listed in Regulation No. 6766 (Table 2). This regulation presented an updated species list with their respective level of endangerment. However, our PRSWAP includes an improved list of species of greatest conservation need (SGCN), using recently available source of information (e.g., Núñez-García and Hunter 2000, among others; Table 2). Some of this species will be recommended for listing under Regulation No. 6766.

Information about threats, population numbers, current distribution, and reason for categorization are included for each species. The DNER adapted the following five categories from the International Union for the Conservation of Nature (IUCN) Red List (1994) in order to classify priority species (Table 1). See appendix I for detailed category definitions.

1. Critically Endangered (CR): A critically endangered species faces an extremely high risk of extinction in the wild in the immediate future.
2. Endangered (EN): A species is considered endangered when it is not CR, but faces a very high risk of extinction in the wild in the near future.
3. Vulnerable (VU): A species is considered vulnerable when it is not CR or EN, but it faces a high risk of extinction in the wild in a foreseeable future.
4. Low Risk (LR): A species is considered low risk when, after an evaluation, it did not satisfy any of the previous categories (CR, EN, or VU) and it is not Data Deficient.
5. Data Deficient (DD): A species falls under this category when there is not enough information for a direct or indirect assessment of its risk of extinction based on distribution and/or population status. Some aspects of the ecology of a species in this category may be well studied and its biology

might be well known, but appropriate data about its abundance and distribution may be lacking. Therefore, Data Deficient is not a threat category.

Table 2. Number of species by taxon included in Regulation No. 6766 as SGCN.

Taxon	CR	EN	VU	DD	LR	Total
Amphibians	3	1	4	1	0	**9**
Birds	7	5	5	9	1	**27**
Reptiles	3	6	3	5	0	**17**
Marine Mammals	0	1	1	0	0	**2**
Terrestrial Mammals	0	0	3	2	1	**6**
Fresh Water Fish **Marine Fish**	2	1	1	0	0	**4**
Terrestrial Invertebrates **Fresh Water Invertebrates**	2	0	1	8	8	**19**
Marine Invertebrates **Plants**	30	15	3	0	0	**48**
Total	**47**	**29**	**21**	**25**	**10**	**132**

Species and Actions for Prioritization

Conservation actions and funding allocation are ranked according to the level of endangerment of the taxon. Critically endangered species receive the highest conservation priority, followed by endangered, vulnerable and low risk (Figure 1). Data deficient species are important because they may be included into any of the previous categories after proper evaluation. However, DNER is strongly concerned about Data Deficient (DD) species (Table 3), which comprise the majority of the SGCN list. Thus, we seek to encourage and facilitate research on this group. Interestingly, a large portion of the DD species is considered non-game. The lack of information about non-game species is related principally to the scarcity of funds to determine basic population parameters and threats, although the academia and some NGOs have worked to partially fill this knowledge gap.

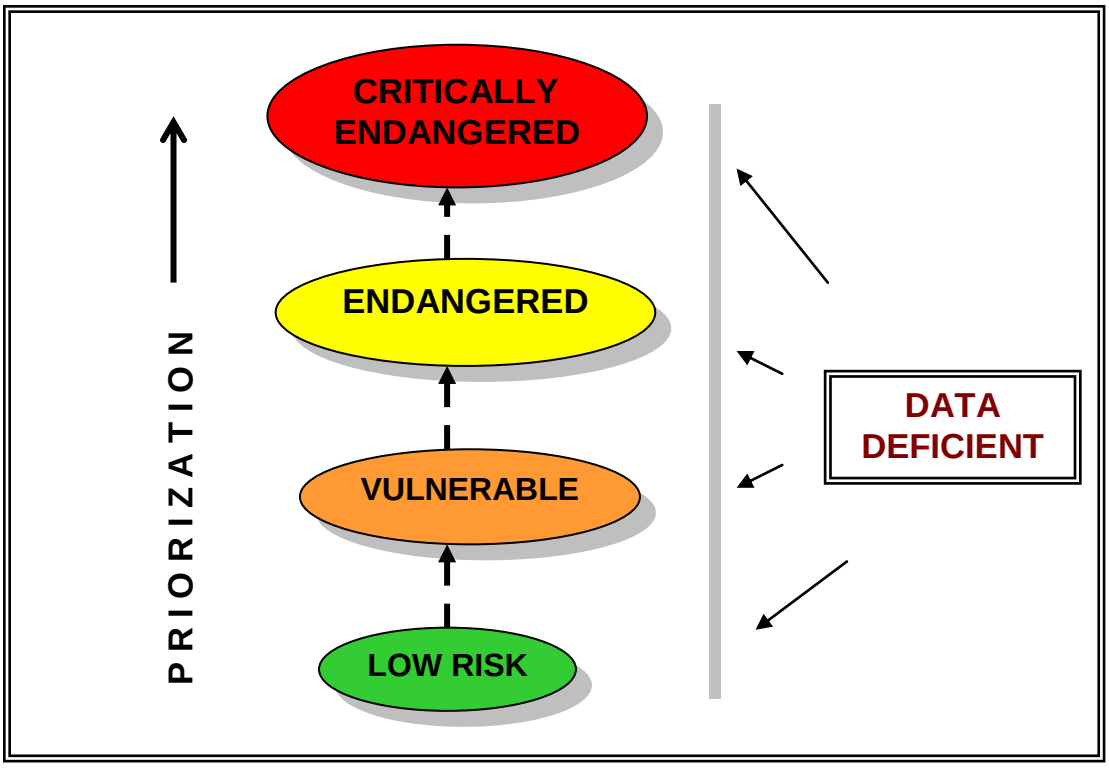


Figure 1. Scheme of species and actions of conservation priorization.

Table 3. Number of species per taxon included in the PRSWAP as SGCN.

Taxon	CR	EN	VU	DD	LR	Total
Amphibians	4	1	4	6	0	**15**
Birds	5	6	16	45	9	**81**
Reptiles	3	5	4	8	0	**20**
Marine Mammals	0	2	0	2	0	**4**
Terrestrial Mammals	0	0	2	10	1	**13**
Fresh Water Fishes	0	0	0	9	6	**16**
Salt Water Fishes	1	1	5	57	0	**64**
Invertebrates	3	0	13	19	8	**43**
Plants	32	26	3	0	0	**61**
Total	**48**	**41**	**47**	**156**	**24**	**317**

The following list details information related to species of greatest conservation need (SGCN) for Puerto Rico. Letters E, N, M, and I next to the scientific name indicate if the species is endemic, native, migratory, or introduced, respectively. Please refer to Appendix I for additional definitions.

Status and Protection of Species of Greatest Conservation Need

Common Name	Scientific Name	Category	
		2005	2015
Marine Mammals			
Humpback Whale	*Megaptera novaeangliae*	VU	EN
Atlantic Spotted Dolphin	*Stenella frontalis*	DD	DD
Bottlenose Dolphin	*Tursiops truncatus*	DD	DD
West Indian Manatee	*Trichechus manatus*	EN	EN
Terrestrial Mammals			
Brazilian Free Tailed Bat	*Tadarida brasiliensis*	LR	LR
Velvety Free-Tailed Bat	*Molossus molossus*	DD	DD
Antillean Ghost-faced Bat	*Mormoops blainvillii*	DD	DD
Parnell's Mustached Bat	*Pteronotus parnellii*	DD	DD
Sooty Mustached Bat	*Pteronotus quadridens*	DD	DD
Fishing Bat	*Noctilio leporinus*	DD	DD
Red Fruit Bat	*Stenoderma rufum*	VU	VU
Brown Flower Bat	*Erophylla bombifrons*	VU	VU
Jamaican Fruit Bat	*Artibeus jamaicensis*	DD	DD
Cave Bat	*Brachyphylla cavernarum*	DD	DD
Greater Antillean Long Tongued Bat	*Monophyllus redmani*	DD	DD
Big Brown Bat	*Eptesicus fuscus*	DD	DD
Red Bat	*Lasiurus minor*	DD	DD
Birds			
Sharp-shinned Hawk	*Accipiter striatus venator*	CR	CR
Broad-winged Hawk	*Buteo platypterus brunnescens*	CR	CR
West Indian Whistling Duck	*Dendrocygna arborea*	CR	CR
Masked Duck	*Nomonix dominicus*	EN	EN
Ruddy Duck	*Oxyura jamaicensis*	VU	VU
White-cheeked Pintail	*Anas bahamensis*	VU	VU
Black Swift	*Cypseloides niger*	DD	VU
Limpkin	*Aramus guarauna*	CR	DD
Least Bittern	*Ixobrychus exilis*	DD	DD
Puerto Rican Nightjar	*Antrostomus noctitherus*	EN	EN
Antillean Nighthawk	*Chordeiles gundlachii*	-	DD
Piping Plover	*Charadrius melodus*	CR	DD
Snowy Plover	*Charadrius nivosus*	CR	CR
Wilson's Plover	*Charadrius wilsonia*	CR	VU
Plain Pigeon	*Patagioenas inornata wetmorei*	EN	EN
White-crowned Pigeon	*Patagioenas leucocephala*	-	DD
Key West Quail-Dove	*Geotrygon chrysia*	DD	DD

Common Name	Scientific Name	Category	
		2005	2015
Ruddy Quail-Dove	*Geotrygon montana*	DD	DD
Bridled Quail-Dove	*Geotrygon mystacea*	DD	**DD**
Puerto Rican Lizard-Cuckoo	*Coccyzus vieilloti*	DD	LR
Yellow-billed Cuckoo	*Coccyzus americanus*	-	DD
Grasshopper Sparrow	*Ammodramus savannarum*	DD	DD
Antillean Euphonia	*Euphonia musica*	DD	DD
Magnificent Frigatebird	*Fregata magnificens*	DD	VU
American Oystercatcher	*Haematopus palliates*	LR	VU
Cave Swallow	*Pterochelidon fulva*	DD	DD
Yellow-shouldered Blackbird	*Agelaius xanthomus*	EN	EN
Roseate Tern	*Sterna dougalli*	VU	VU
Brown Noddy	*Anous stolidus*	DD	DD
Bridled Tern	*Onychoprion anaethetus*	DD	DD
Sooty Tern	*Onychoprion fuscata*	DD	DD
Least Tern	*Sterna antillarum*	DD	VU
Adelaide's Warbler	*Setophaga adelaidae*	DD	LR
American Redstart	*Setophaga ruticilla*	DD	DD
Black and White Warbler	*Mniotilta varia*	DD	LR
Black-throated Blue Warbler	*Dendroica caerulescens*	DD	DD
Cape May Warbler	*Setophaga tigrina*	-	DD
Elfin Woods Warbler	*Setophaga angelae*	VU	EN
Golden-winged Warbler	*Vermivora chrysoptera*	-	DD
Northern Parula	*Setophaga americana*	DD	DD
Louisiana Waterthrush	*Parkesia motacilla*	DD	DD
Northern Waterthrush	*Parkesia noveboracensis*	DD	DD
Ovenbird	*Seiurus aurocapilla*	DD	DD
Prairie Warbler	*Setophaga discolor*	DD	DD
Yellow Warbler	*Setophaga petechia*	VU	VU
Brown Pelican	*Pelecanus occidentalis*	EN	EN
Red-billed Tropicbird	*Phaethon aethereus*	DD	VU
White-tailed Tropicbird	*Phaethon lepturus*	DD	VU
Puerto Rican Woodpecker	*Melanerpes portoricensis*	DD	LR
Pied-billed Grebe	*Podilymbus podiceps*	DD	DD
Least Grebe	*Tachybaptus dominicus*	DD	DD
Audubon's Shearwater	*Puffinus lherminieri*	CR	VU
Puerto Rican Parrot	*Amazona vittata vittata*	CR	CR
Caribbean Coot	*Fulica caribaea*	VU	VU
Yellow-breasted Crake	*Porzana flaviventer*	DD	DD
Clapper Rail	*Rallus longirostris*	DD	DD
Purple Gallinule	*Porphyrio martinicus*	-	DD
Red Knot	*Calidris canutus*	DD	DD
Willet	*Tringa semipalmata*	-	DD

Common Name	Scientific Name	Category	
		2005	2015
Short-eared Owl	*Asio flammeus*	DD	DD
Puerto Rican Screech Owl	*Megascops nudipes*	DD	DD
Masked Bobby	*Sula dactylatra*	DD	VU
Brown Bobby	*Sula leucogaster*	DD	LR
Red-footed Bobby	*Sula sula*	DD	VU
Puerto Rican Bullfinch	*Loxigilla portoricensis*	DD	LR
Puerto Rican Spindalis	*Spindalis portoricensis*	DD	LR
Puerto Rican Tanager	*Nesospingus speculiferus*	DD	DD
Puerto Rican Tody	*Todus mexicanus*	DD	LR
Antillean Mango	*Anthracothorax dominicus*	DD	DD
Green Mango	*Anthracothorax viridis*	DD	DD
Puerto Rican Emerald	*Chlorostilbon maugaeus*	DD	DD
Green-throated Carib	*Eulampis holosericeus*	DD	DD
Antillean Crested Hummingbird	*Orthorynchus cristatus*	DD	DD
Bicknell's Thrush	*Catharus bicknelli*	-	DD
Caribbean Elaenia	*Elaenia martinica*	DD	LR
Lesser Antillean Pewee	*Contopus latirostris*	-	DD
Loggerhead Kingbird	*Tyrannus caudifasciatus*	DD	DD
Puerto Rican Flycatcher	*Myiarchus antillarum*	DD	DD
Black-whiskered Vireo	*Vireo altiloquus*	DD	DD
Puerto Rican Vireo	*Vireo latimeri*	VU	VU
Puerto Rican Oriole	*Icterus portoricensis*	DD	DD
Reptiles			
Puerto Rican Bank Boa/Virgin Island Boa	*Chilobotrus granti*	CR	CR
Mona Island Boa	*Chilobotrus monensis*	EN	VU
Puerto Rican Boa	*Chilobotrus inornatus*	VU	VU
Green Sea Turtle	*Chelonia mydas*	EN	EN
Hawksbill Sea Turtle	*Eretmochelys imbricata*	EN	EN
Leatherback Sea Turtle	*Dermochelys coriacea*	EN	EN
Puerto Rican Slider	*Trachemys stejnegeri*	DD	DD
Monito Island Gecko	*Sphaerodactylus micropithecus*	CR	CR
Desecheo Island Gecko	*Sphaerodactylus levinsi*	DD	DD
Pandura's Gecko	*Sphaerodactylus gaigae*	DD	DD
Mona Island Iguana	*Cyclura stejnegeri*	EN	**EN**
Culebra's Giant Lizard	*Anolis roosevelti*	CR	CR
Dry Forest Lizard	*Anolis cooki*	DD	EN
Puerto Rican Giant Lizard/Giant Anole	*Anolis cuvieri*	-	DD
Southern Garden Lizard	*Anolis poncensis*	VU	VU
Puerto Rican Galliwasp	*Diploglossus pleei*	-	DD
Puerto Rican Twig Anole, Pygmy Anole	*Anolis occultus*	DD	DD

Common Name	Scientific Name	Category	
		2005	2015
Southern Ground Lizard	*Ameiva wetmorei*	DD	**DD**
Slippery Back Skink	*Mabuya sloanii*	VU	VU
Blind Snakes	*Typhlops* spp.	DD	DD
Amphibians			
Puerto Rican Crested Toad	*Peltophryne lemur*	CR	CR + EN
Eneida Coqui/Mottled Coqui	*Eleutherodactylus eneidae*	CR	CR
Golden Coqui	*Eleutherodactylus jasperi*	CR	CR
Web Footed Coqui	*Eleutherodactylus karlschmidti*	CR	CR
Plain Coqui	*Eleutherodactylus juanriveroi*	CR	CR
Cave Coqui	*Eleutherodactylus cooki*	VU	VU
Warty Coqui	*Eleutherodactylus locustus*	VU	VU
Richmond's Coqui	*Eleutherodactylus richmondi*	VU	VU
Puerto Rican Mountain Coqui/Forest Coqui	*Eleutherodactylus portoricensis*	VU	**VU**
Grass Coqui	*Eleutherodactylus brittoni*	DD	DD
Cricket Coqui	*Eleutherodactylus gryllus*	DD	DD
Hedrick's Coqui	*Eleutherodactylus hedricki*	DD	DD
Mona Island Coqui	*Eleutherodactylus monensis*	DD	DD
Burrowing Coqui	*Eleutherodactylus unicolor*	DD	DD
Wrinkled Frog	*Eleutherodactylus wightmanae*	DD	DD
Freshwater Fishes			
American Eel	*Anguilla rostrata*	DD	LR
Large Scaled Spinnycheeck Sleeper	*Eleotris amblyopsis*	DD	LR
Bigmouth Sleeper	*Gobiomorus dormitor*	DD	LR
Sirajo Gobby	*Sicydium plumieri*	-	LR
Spotted Algae Eating Gobby	*Sicydium punctatum*	DD	LR
Burro	*Pomadasys crocro*	DD	DD
Short-tail River Pipefish	*Microphis brachyurus*	DD	DD
Flautín de Agua Dulce	*Pseudophalus mindii*	DD	DD
Pejerrey Lagunero	*Malanorhinus boeki*	DD	DD
Fat Sleeper	*Dormitator maculatus*	DD	DD
Spinycheek Sleeper	*Eleotris pisonis*	DD	DD
Emerald Sleeper	*Erotelis smaragdus*	DD	DD
Renacuajo de Río	*Gobiesox nudus*	DD	DD
River Goby	*Awaous banana*	DD	LR
Mountain Mullet	*Agonostomus monticola*	DD	LR
Tapaculo	*Citharichthys uhleri*	DD	DD

Common Name	Scientific Name	Category	
		2005	2015
Saltwater Fishes			
Tarpon Snook	*Centropomus pectinatus*	DD	DD
Mexican Snook	*Centropomus mexicanus*	DD	DD
Common Snook	*Centropomus undecimalis*	-	DD
Nurse Shark	*Ginglymostoma cirratum*	VU	VU
Tarpon	*Megalops atlanticus*	DD	DD
Spotted Goatfish	*Pseudupeneus maculatus*	DD	DD
Yellow Goatfish	*Mulloidichthys martinicus*	DD	DD
Goliath Grouper	*Epinephelus itajara*	CR	CR
Nassau Grouper	*Epinephelus striatus*	EN	EN
Red Grouper	*Epinephelus morio*	-	DD
Sea Horse	*Hippocampus* spp.	VU	VU
Bonefish	*Albula vulpes*	-	DD
Permit	*Trachinotus falcatus*	-	DD
Palometa	*Trachinotus goodei*	-	DD
Greater Amberjack	*Seriola dumerilli*	-	DD
Blue Runner	*Caranx crysos*	-	DD
Horse Eye Jack	*Caranx latus*	-	DD
Caribbean Reef Shark	*Carcharhinus perezi*	-	DD
Tiger Shark	*Galeocerdo cuvieri*	-	DD
Lemon Shark	*Negaprion brevirostris*	-	DD
Spotted eagle ray	*Aetobatus narinari*	-	DD
Atlantic Goliath Grouper	*Epinephelus itajara*	-	DD
Coney	*Cephalophilis fulvus*	-	DD
Black Grouper	*Mycteroperca bonaci*	-	DD
Rock Hind	*Epinephelus adscencionis*	-	DD
Hogfish	*Lachnolaimus maximus*	-	DD
Mangrove Snapper	*Lutjanus griseus*	-	DD
Lane Snapper	*Lutjanus synagris*	-	DD
Mutton snapper	*Lutjanus analis*	-	DD
Vermillion Snapper	*Rhomboplites aurorubens*	-	DD
Gray Snapper	*Lujatnus griseus*	-	DD
Silk Snapper	*Lujatnus vivanus*	-	DD
Dog Snapper	*Lujatnus jocu*	-	DD
Cubera Snapper	*Lujatnus analis*	-	DD
Crevalle Jack	*Caranx hippos*	-	DD
Jolthead Porgy	*Calamus bajonado*	-	DD
Rainbow Parrotfish	*Scarus guacamaia*	DD	VU
Blue Parrotfish	*Scarus coeruleus*	-	VU
Midnight Parrotfish	*Scarus coelestinus*	-	VU
Princess Parrotfish	*Scarus taeniopterus*	-	DD

Common Name	Scientific Name	Category	
		2005	2015
Queen Parrotfish	*Scarus vetula*	-	DD
Redtail Parrotfish	*Sparisoma chrysopterum*	-	DD
Stoplight Parrotfish	*Sparisoma viride*	-	DD
Reef Croaker	*Odontoscion dentex*	-	DD
Barred Grunt	*Conodon nobilis*	-	DD
White Grunt	*Haemulon plumieri*	-	DD
Black Grunt	*Haemulon bonariense*	-	DD
Smallmouth Grunt	*Haemulon chrysargyreum*	-	DD
French Grunt	*Haemulon flavolineatum*	-	DD
Bluestriped Grunt	*Haemulon sciurus*	-	DD
Porkfish	*Anisotremus virginicus*	-	DD
Ocean Surgeon	*Acanthurus bahianus*	-	DD
Trunkfish	*Lactophyrys trigonus*	-	DD
Gray Triggerfish	*Balistes carpiscus*	-	DD
Queen Triggerfish	*Balistes vetula*	-	DD
Tomtate	*Haemulon aurolineatum*	-	DD
Black Snapper	*Apislus dentatus*	-	DD
Cero	*Scomberomorus regalis*	-	DD
Doctorfish	*Acanthurus chirurgus*	-	DD
Bar Jack	*Caranx ruber*	-	DD
Great Barracuda	*Sphyraena barracuda*	-	DD
Schoolmaster	*Lujatnus apodus*	-	DD
Graysby	*Cephalopholis cruentata*	-	DD
Blackfin Snapper	*Lujatnus buccanella*	-	DD
Invertebrates			
Threerowed Sea Cucumber	*Isostichopus badionotus*	-	VU
Furry Sea Cucumber	*Astichopus multifidis*	-	VU
West Indian Sea Cucumber	*Actinopyga agassizi*	-	VU
Long Spined Sea Urchin	*Diadema antillarum*	-	DD
Puerto Rican Harlequin Butterfly	*Atlantea tulita*	CR	CR
Mona's Cave Shrimp	*Typhlatya monae*	CR	CR
Blind Amphipod/Fresh Water Cave Shrimp	*Alloweckellia gurnee*	CR	CR
Mona/Monito/Little-land Crab	*Gecarcinus lateralis*	DD	DD
Purple Land Crab	*Gecarcinus ruricola*	VU	VU
Common Land Crab	*Cardisoma guanhumi*	LR	LR
Mangrove Crab	*Aratus pisonii*	DD	DD
Mangrove Root Crab	*Goniopsis cruentata*	LR	LR
Fiddler Crab	*Uca leptodactyla*	DD	DD
Fiddler Crab	*Uca thayeri*	DD	DD

Common Name	Scientific Name	Category	
		2005	2015
Fiddler Crab	*Uca vocator*	DD	DD
Fiddler Crab	*Uca major*	LR	LR
Swamp Ghost Crab	*Ucides cordatus*	LR	LR
River Shrimp	*Macrobrachium acanthurus*	DD	DD
River Shrimp	*Macrobrachium faustinum*	-	DD
River Shrimp	*Macrobrachium heterochirus*	DD	DD
River Shrimp	*Macrobrachium carcinus*	LR	LR
Shrimp	*Macrobrachium crenulatum*	LR	LR
Green Lobster	*Panulirus laevicauda*	VU	VU
Buruquena	*Epilobocera sinuatifrons*	LR	LR
Octopus	*Octopus spp*	DD	DD
Queen Conch	*Strombus gigas*	-	LR
West Indian Topshell	*Cittarium pica*	DD	VU
Magnificent Feather Duster	*Sabellastarte magnifica*	DD	DD
Social Feather Duster	*Bispirina brunnea*	DD	DD
Christmas Tree Worm	*Spirobranchius giganteus*	DD	DD
Lobed Star Coral	*Orbicella annularis*	-	VU
Mountainous Star Coral	*Orbicella faveolata*	-	VU
Boulder Star Coral	*Orbicella franksi*	-	VU
Pillar Coral	*Dendrogyra cylindrus*	-	VU
Rough Cactus Coral	*Mycetophyllia ferox*	-	VU
Staghorn Coral	*Acropora cervicornis*	-	VU
Elkhorn Coral	*Acropora Palmata*	-	VU
-	*Agapostemon viequensis*	-	DD
-	*Coelioxys spinosa*	-	DD
-	*Melissodes trifasciata*	-	DD
-	*Nomada krugii*	-	DD
-	*Xeromelecta tibialis*	-	DD
-	*Ceratina guamacciana*	-	DD
Plants			
-	*Marsdenia woodburyana*	-	EN
Cook's Holly	*Ilex cookii*	-	CR
-	*Ilex sintenisii*	-	EN
Palma Manaca	*Calyptronoma rivalis*	-	EN
-	*Pseudophoenix sargentii*	-	EN
Palma de Lluvia	*Gaussia attenuata*	-	EN
Palma de Sombrero	*Sabal causiarum*	-	EN
-	*Chromolaena borinquensis*	-	EN
-	*Vernonia proctorii*	-	CR
Higüero de Sierra	*Crescentia portoricensis*	-	CR

Common Name	Scientific Name	Category	
		2005	2015
Puerto Rico Manjack	*Varronia bellonis*	-	EN
-	*Varronia rupicola*	-	VU
Vahl's Boxwood	*Buxus vahlii*	-	EN
Higo Chumbo	*Harrisia portoricensis*	-	EN
-	*Leptocereus grantianus*	-	CR
Chupacallos	*Pleodendron macranthum*	-	CR
Helecho de Bosque Enano.	*Alsophyla amintae*	-	EN
-	*Gonocalyx concolor*	-	CR
-	*Lyonia truncata var. proctorii*	-	CR
Tamarindillo	*Chamaecrista glandulosa var.mirabilis*	-	CR
Cobana Negra.	*Stahlia monosperma*	-	CR
-	*Gesneria pauciflora*	-	VU
Palo de Rosa	*Ottoschulzia rhodoxylon*	-	CR
Nogal / West Indian Walnut	*Juglans jamaicensis*	-	CR
Capa Rosa, Palo de Rosa	*Callicarpa ampla*	-	CR
Nigua/ Palo de Nigua	*Cornutia obovata*	-	CR
Bariaco	*Trichilia triacantha*	-	CR
-	*Calytranthes acevedoi*	-	EN
-	*Calyptranthes estremerae*	-	EN
-	*Eugenia fajardensis*	-	CR
Uvillo	*Eugenia haematocarpa*	-	EN
-	*Eugenia woodburyana*	-	EN
Ausú	*Myrcia paganii*	-	CR
Araña	*Schoepfia arenaria*	-	EN
-	*Cranichis ricartii*	-	CR
-	*Lepanthes eltoroensis*	-	VU
-	*Peperomia wheeleri*	-	EN
-	*Aristida chaseae*	-	EN
Pelos del Diablo	*Aristida portoricensis*	-	EN
-	*Adiantum x vivesii*	-	CR
-	*Elaphoglossum serpens*	-	CR
-	*Polystichum calderonense*	-	CR
-	*Tectaria x estremerana*	-	CR
-	*Thelypteris inabonensis*	-	CR
-	*Thelypteris verecunda*	-	CR
-	*Thelypteris yaucoensis*	-	CR
-	*Aurodendron pauciflorum*	-	CR
-	*Catesbaea melanocarpa*	-	CR
-	*Mitracarpus maxwelliae*	-	EN

Common Name	Scientific Name	Category	
		2005	2015
-	*Mitracarpus polycladus*	-	EN
Quina	*Stenostomun sintenisii*	-	EN
St. Thomas prickly-ash	*Zanthoxylum thomasianum*	-	EN
Palo de Ramón	*Banara vanderbiltii*	-	CR
-	*Xylosma pachyphyllum*	-	CR
Mata Buey	*Goetzea elegans*	-	EN
Erubia	*Solanum ensifolium*	-	EN
Palo de Jazmín	*Styrax portoricensis*	-	CR
Palo Colorado	*Ternstroemia luquillensis*	-	CR
-	*Ternstroemia subsessilis*	-	CR
-	*Bonellia pauciflora*	-	CR
-	*Daphnopsis helleriana*	-	EN

- Species not included in this list do not fall under the jurisdiction and scope of this State Wildlife Action Plan.

CHAPTER 3. HABITAT REQUIREMENTS AND INFORMATION NEEDS FOR PRIORITY SPECIES.

Most of the information related to the species included on the Species of Greatest Conservation Need (SGCN) list was compiled as part of the revision conducted between 2002 and 2003 of Regulations No. 6765 and 6766. A first draft of this list was produced by the Bureau of Fisheries and Wildlife staff which was later revised by the scientific community, general public and interested non-governmental organizations. The final product was a comprehensive accomplishment, more broad and updated than the USFWS list of threatened and endangered (T/E) species for Puerto Rico.

Research to understand the natural history of priority species, habitat requirements, demographics, activity patterns, and home ranges is needed to develop conservation and management plans. DNER has been gathering biological/habitat information and monitoring game species that are currently hunted (e.g., Scaly-naped Pigeon *Patagioenas squamosa*) or have the potential to be hunted (e.g., White-crowned Pigeon *Patagioenas leucocephala*) or are listed as T/E species in Puerto Rico. However, the long-term conservation of biological diversity of Puerto Rico would benefit from a comprehensive, spatially based bank of information of its wildlife and associated habitats. Several approaches are currently ongoing or completed within DNER or through interagency collaboration.

Forest composition, structure and function (from DRNA 2010).

The Holdridge life zone model is used to facilitate comparisons of ecological information around the world (Holdridge, L.R.1967). Life zones are broad bioclimatic units of land that can be further subdivided into associations based on the combination of soils, vegetation, and microclimates within them. There are six Subtropical Holdridge Life Zones present in Puerto Rico (Figure 2) (Ewell and Whitmore 1973). At 62%, the Subtropical moist forest life zone contains the most

land in mainland Puerto Rico. (Brandeis et. al. 2007). The Lower montane wet forest and the Lower montane rain forest zones combined are only slightly over 1% of land cover. Land area in the dry forest zone is almost 14%, and the combined wet forest and rain forest zones account for about 23% of land cover.

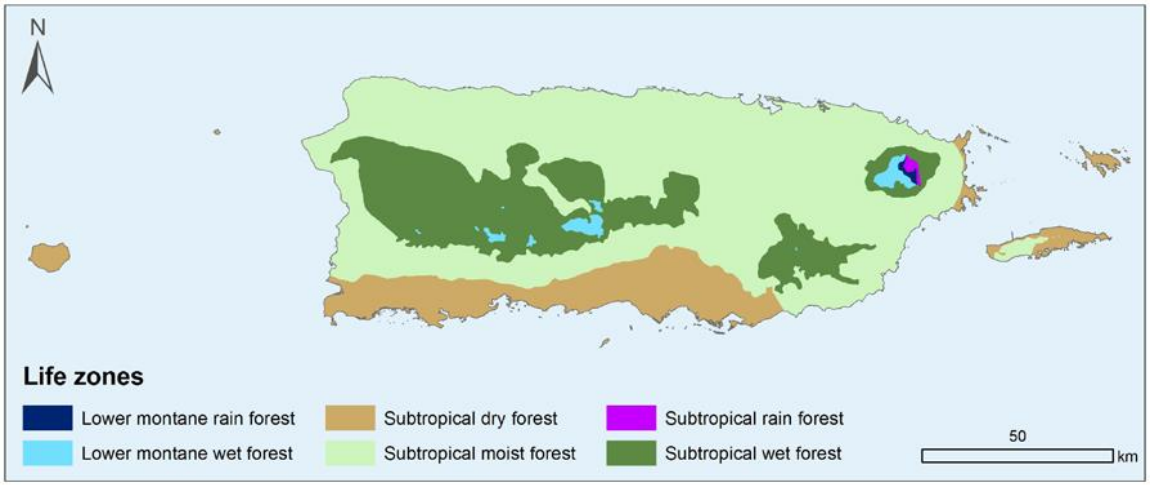


Figure 2. Land distribution among the Subtropical forest life zones of mainlad P.R. (Brandeis 2007).

Figure 3 depicts the proportion of each life zone in forest cover as of 2003 (Brandeis et. al. 2007). The Lower Montane Wet and Rain Forest group has the highest percentage of forest cover but, as indicated in figure 4 above, it has the smallest land area. The moist and dry forest zones together account for three quarters of the land area in Puerto Rico but each has less than 50% forest cover.

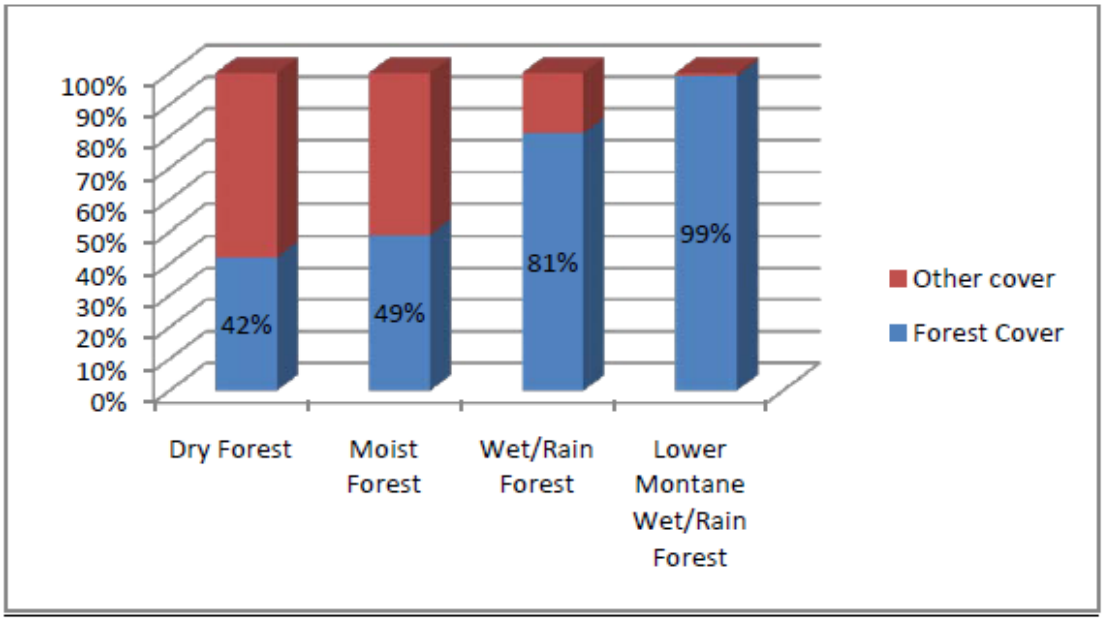


Figure 3. Percen forest cover within each subtropical life zones group in mainland P.R. in 2003 (Brandeis et al. 2007).

An estimated 68% of Puerto Rico is comprised of young secondary forest, 12% is mature forest; and land reverting to forest accounts for 18% of the total forest cover. Subtropical moist forest had the most land in the reversion category. The lower montane group had no reverting forest; the wet and rain forest had 30.4%; and dry forest had 12.5% reverting forest.

Size class information is collected on stands with at least 10% stocking by live trees. Figure 4 provides information for all islands. Trees in the seedling stage have a d.b.h. <5", small trees have a d.b.h. of 5-8", medium trees have a d.b. h. of 8 to 20" and large trees have a d.b.h. > 20". Slow growth is common in stressful environments so a given species growing at high elevations, on barren land, or in drought prone areas does not accumulate girth as rapidly as the same species in more hospitable environments.

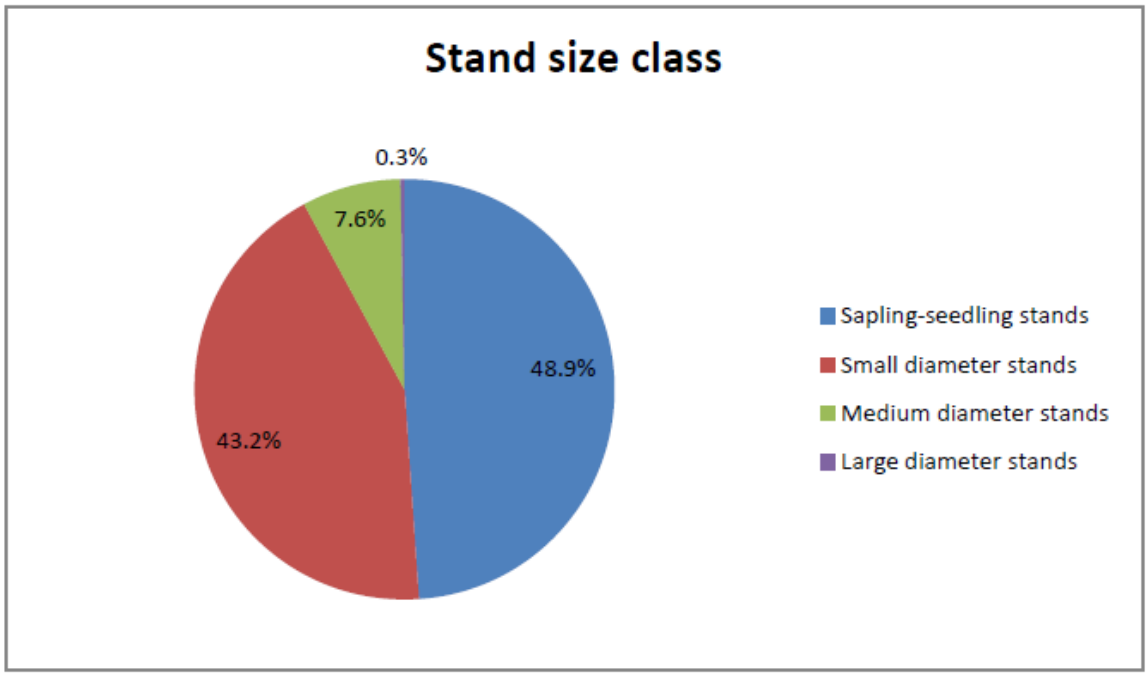


Figure 4. Percentage of forest in each class in P.R., Vieques, and Culebra in 2003 as measured by diameter at breast height (DBH) (Brandeis 2007).

Plant species composition, dominance and importance in today's regenerating forests are different from forests that were present before the island was deforested (Lugo and Helmer 2004). A total of 305 tree species were identified in the 2003 forest inventory (Brandeis et. al. 2007). Among trees with diameters at breast height (d.b.h.) of 12.4 cm, 210 species were identified. Evaluation of the latter group revealed that the exotic African tulip tree (*Spathodea campanulata*) was the single most abundant tree species on the island. The native's guaraguao (*Guarea guidonia*), moca (*Andira inermis*) and yagrumo (*Cecropia schreberiana*) follow in abundance. Thirty six (36) tree species were encountered in the dry forest, 130 in the moist forest, 112 in the wet and rain forest group and 25 in the lower montane wet and rain forest group. Common exotics were often fruit bearing trees. As an example, the only two exotic species encountered in the Lower montane life zones were the sweet orange (*Citrus sinensis*) and the Malabar plum (*Syzgium jambos*).

The mixes of native and non-native naturalized species are creating novel plant and animal communities. Many of today's forests are far from maturity, so definitive successional pathways, and the ultimate composition and structure of future forests is conjecture. We are gathering evidence that these novel forests provide public benefits. They support wildlife, mitigate species extinctions, and provide ecosystem services such as soil stabilization, temperature regulation, nutrient transformation, and water and carbon cycling (Lugo 2004). For example, the African tulip tree is a pioneer species that colonizes abandoned lands and facilitates the establishment of native trees species under its canopy (Lugo and Helmer 2004, Brandeis 2006).

There is no field inventory of forest vegetation communities in Puerto Rico, but some general taxonomic principles are informing remote sensing inventories such as the work produced by Kennaway and Helmer (2007), summarized in Table 4.

Table 4. Satellite image mapping zones in P.R. and associated vegetation formations (Kennaway and Helmer 2007).

Satellite image mapping zone [1, 2]	Woody vegetation formations[2]
Dry forest-Alluvial	Lowland dry semi-deciduous forest or woodland/shrubland Tidally and semi-permanently flooded evergreen sclerophyllous forest
Dry forest[3]-Volcanic, Sedimentary, Limestone	Lowland dry semi-deciduous forest or woodland/shrubland Lowland dry mixed evergreen drought-deciduous shrubland with succulents
Dry and moist forests –Serpentine	Lowland dry and moist , mixed seasonal evergreen sclerophyllous forest with succulents
Moist forest-Alluvial	Lowland moist evergreen hemi-sclerophyllous srubland Lowland moist seasonal evergreen forest or forest/shrub Lowland moist coconut palm forest Seasonally flooded evergreen forest Tidally and semi-permanently flooded evergreen sclerophyllous forest
Moist forest-Volcanic and Sedimentary	Lowland moist seasonal evergreen forest or forest shrub Lowland moist semi deciduous forest[4]
Moist forest with rainfall<1500 mm yr^{-1} Northern Limestone [5]	Lowland moist semi-deciduous forest or forest/shrub
Moist forest with rainfall>1500 mm yr^{-1}-Northern Limestone[5]	Lowland moist and wet, seasonal evergreen and semi-deciduous forest and forest/shrub
Wet and lower montane wet forest-Serpentine	Submontane and lower montane wet evergreen sclerophylous forest or forest/shrub[6]
Wet and rain forest, lower montane wet and rain forest-Volcanic, Sedimentary and Alluvial	Submontane wet evergreen forest Active sun/shade coffee, submontane/lower montane wet evergreen forest/shrub, other agriculture Submontane/lower montane wet evergreen forest/shrub, active/abandoned shade coffee Lower montane wet evergreen forest[7] -tall cloud forest Lower montane wet evergreen forest[7]-palm and elfin cloud forest Lower montane wet evergreen forest-elfin cloud forest

[1] Aggregated from Geoclimatic Zones in Figueroa Colón (1996), which overlay Holdridge life zone (Ewel and Whitmore, 1973) onto generalized geology (Krushensky, unpubl.). Volcanic refers to intrusive/plutonic and extrusive/volcanoclastic geology.

[2] Forest are subtropical sensu Holdridge (1967) and broadleaf unless otherwise indicated; lowland refers to forests from 0 to 400 m elevation. Both forest/shrub and woodland/shrubland refer to stands with a)25-60% covers of trees with distinct canopies and an under story of shrubs, seedlings, or saplings, or b) dense shrubs, seedlings or saplings, as indicated by a matrix of woody vegetation or a smooth canopy.

[3] The Dry Volcanic/Sedimentary/Limestone Zone included southern limestone areas in the drier part of the moist forest zone.

[4] Coastal areas in southeastern Puerto Rico

[5] Northern Limestone refers to limestone areas north of the Central Cordillera with well-developed karrst topography and areas at the Cordillera's southern edge.

[6] Includes forest in the rain forest zone sensu Holdridge (1967).

[7] Includes forest in the lower montane rain forest zone sensu Holdridge (1967).

Puerto Rico GAP Analysis

The Puerto Rico Gap Analysis (PR-GAP) is a spatially based project designed to provide comprehensive species/habitat information. Gap analysis was developed as a proactive coarse-filter approach to protect biodiversity (Scott et al. 1987 and 1993). The PR-GAP provides an overview of the island's biological diversity, serving as a benchmark for landscape conservation approaches and providing resource managers with a tool to establish conservation priorities (e.g., land acquisition). This project is a joint effort among the DNER, the U.S. Forest Service International Institute of Tropical Forestry (IITF), the North Carolina Cooperative Fish and Wildlife Research Unit (NCSU), and the U.S. Geological Survey Biological Resources Division.

The Gap Analysis seeks to identify "gaps" (i.e., vegetation types or species not adequately represented in areas managed for long term maintenance of natural systems) that may be filled through changes in land management practices. GAP researchers use terrestrial vertebrates and vegetation alliances as indicators of, or surrogates for, biodiversity (Austin and Margules 1986, Scott et al. 1993, National Gap Analysis Program 1994, Csuti and Kiester 1996, Noss and Cooperrider 1994, Jennings 1996). Digital maps containing these elements of diversity are overlaid in a GIS with maps of areas managed for biodiversity and land ownership to identify those that are underrepresented in the existing network of areas.

a. **Land Cover** – IITF, in coordination with DNER, developed a semi-automated process to create a Landsat-7 ETM+ image mosaic based on 2001-2003 satellite imagery that is 97.5% cloud and cloud-shadow free (Martinuzzi et al. 2003a). Initial classification includes mapping the extent of four classes of urban cover in Puerto Rico (Martinuzzi et al. 2003b). Urban cover comprises nearly 15% of the land surface of Puerto Rico, and the urban forest and low- and high- intensity urban land cover classes are important in both our habitat modeling, and in understanding the dynamics

of land cover changes and threats to habitat sustainability and biodiversity. Vegetation descriptions have been compiled from the plant community, and later organized into a hierarchical structure along gradients of climate, substrate, and topographic position (Gould et al. 2003a). The analysis includes an updated map of the physiography of Puerto Rico (Gould et al. 2003b), and an analysis and a map of the landforms (slope position) of Puerto Rico (Martinuzzi et al. 2003c) (Figure 5).

According to Gould et al., (2008) land cover in Puerto Rico today consists of 53% forest, woodland and shrub land vegetation; 32% dry and wet grasslands and pasture; 3% herbaceous agriculture, 4% saline and freshwater wetlands, 1% barren land, 1% fresh water, and 10% developed land. This history of land use is typical of most Caribbean islands.

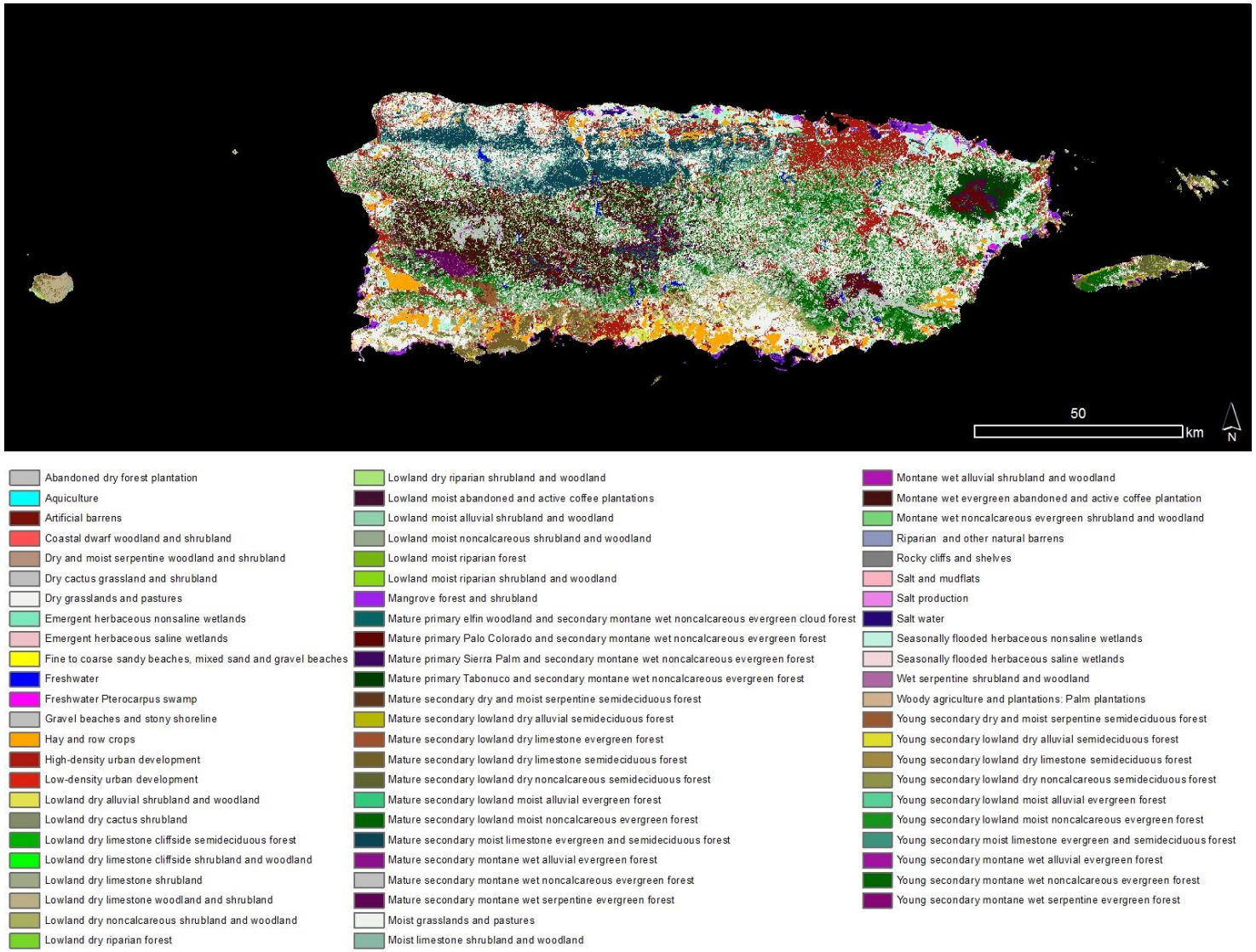


Figure 5. Puerto Rico Land Cover 2015. Data obtained from DNER.

b. Animal Modeling – The original list of 437 vertebrate species has gone through expert review and now the list consists of 426 vertebrate species known to occur across Puerto Rico or its offshore islands. A large proportion of Puerto Rico's vertebrate fauna is composed of species dependent upon aquatic and/or coastal-marine habitats. Therefore, DNER is developing the relational database model with the understanding that the aquatic and marine species are important components of the landscape and have good potential for gap analysis after the completion of the terrestrial and marine GAP Analyses. A subset of 168 species was for inclusion in the terrestrial component of the gap analysis. This list contains those species considered endemic, resident, breeding migrants, and species of conservation concern that have become established through human introductions (e.g., Small Indian Mongoose *Herpestes javanicus*) or range expansion (e.g., Hispaniolan Parrot *Amazona ventralis*). The PR-GAP adopted a modification of the U.S. Forest Service's Forest Inventory and the Analysis hexagon grid of the Caribbean as the minimum mapping unit for creating species' geographic range maps. The smaller hexagon size (24 km^2) was considered as a valid scale for representing species distribution while considering the challenge of representing Puerto Rico's diverse and heterogeneous landscape. The Puerto Rico Ornithological Society assisted in the development of field survey methods for a Breeding Bird Atlas for Puerto Rico and to incorporate PR-GAP data, maps, and analyses into the Atlas. Peer revisions of species geographic range maps are currently in progress (Figure 6).

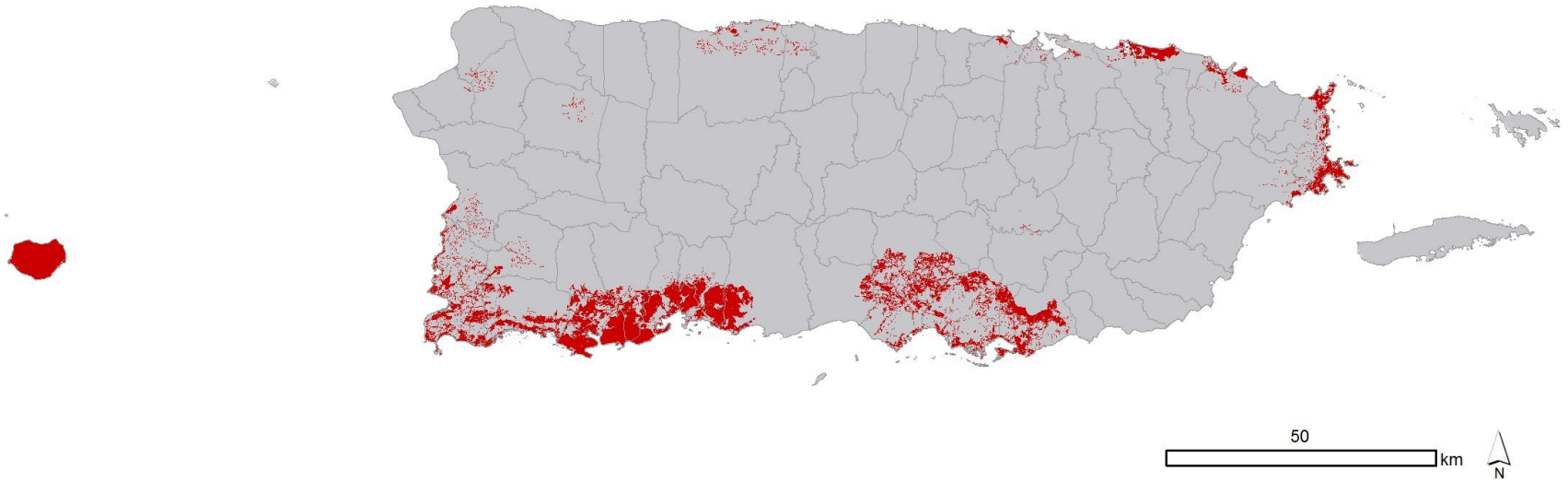


Figure 6. Example of a geographic range map for the endangered Yellow-shouldered Blackbird (Agelaius xanthomus). Data from DNER 2015.

c. Land Stewardship Mapping – DNER is currently establishing an interagency collaborative effort to update an existing, but incomplete, land stewardship layer of Puerto Rico. To date, we have identified a total of 21 public land managers (Figure 7). Land management areas will be identified by contacting land managers to determine management policies, classifying land parcels into the management strategies used in the GAP program, and developing a land management geospatial database in order to facilitate the final GAP analyses.

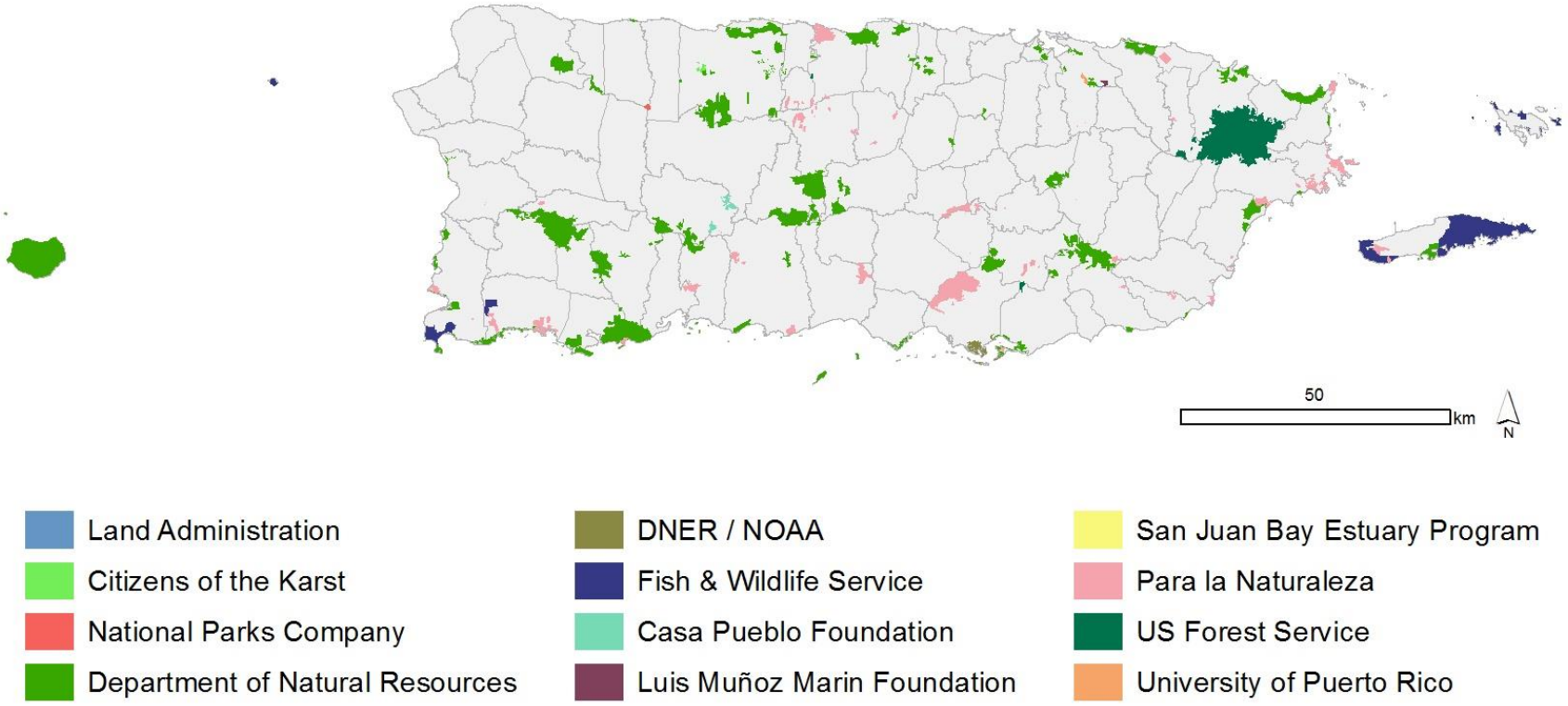


Figure 7. Puerto Rico Land Stewardship 2015. Data obtained from DNER.

Revision of the New Wildlife Law (Law 241 of 1999).

This law is under revision, which is expected to be completed by fall 2016. The revised law will include a revised list of Species of Greater Conservation Need (SGCN) with updated statuses, and in some cases, will include designations of Critical Natural Habitat (see Figure 8).

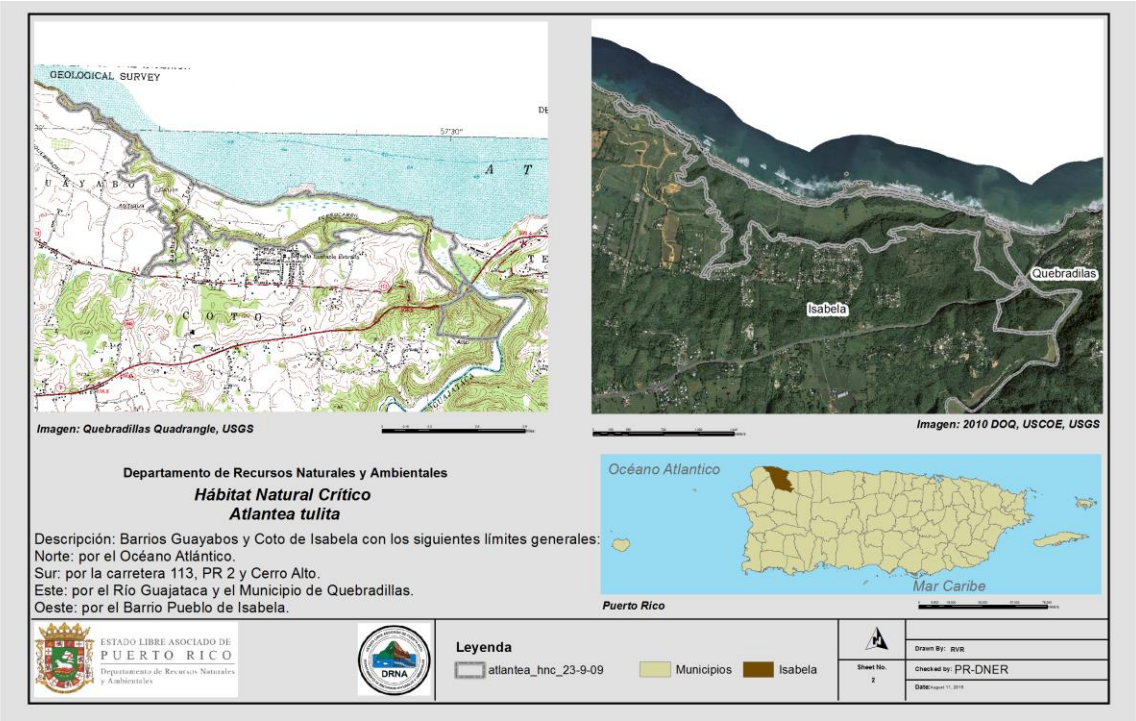


Figure 8. Critical Natural Habitat for the endangered Arlequin Butterfly (*Atlantea tulita*).

DNER Natural Heritage Program

DNER's Natural Heritage Program (NHP) maintains a conservation data center of species of concern or critical elements (Figure 9). This information is available to other DNER divisions, partners, and to the general public. The conservation data center employs a full time manager who maintains updated maps of species distribution, and provides technical assistance for using the data bank. Relevant data is primarily obtained from other DNER units, federal institutions, and academia.

Critical elements are not limited to federally or locally listed species, according to the NHP. Species important to Puerto Rican heritage and culture, such as the Common Coquí (*Eleutherodactylus coqui*), and other endemics (e.g., the Mona Island Gecko *Sphaerodactylus monensis*) although abundant, are considered critical elements for this unit.

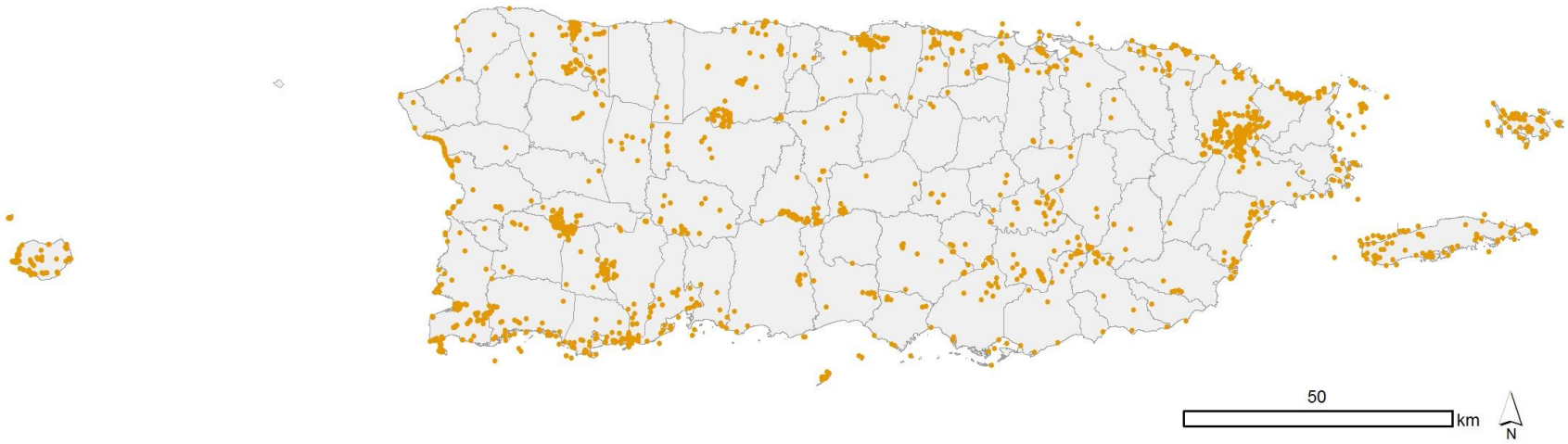


Figure 9. Distribution of Critical Elements in the Natural Heritage Program. Data from DNER 2015.

CHAPTER 4. IDENTIFYING STRESSOR/THREATS TO PUERTO RICO'S WILDLIFE

The Caribbean region is one of the world's biodiversity hotspots (Myers et al. 2000). Historically, Puerto Rico's landscape has undergone widespread deforestation. In fact, by the 1930's only 6-15% of the surface area of the island was covered by forest. Forest conversion had profound effects on the resident avifauna, our largest group of terrestrial vertebrates. It is believed that forest destruction precipitated the extinction of the Culebra Island race of the Puerto Rican Parrot (*Amazona vittata gracilipes*), and the extirpation of the White-necked Crow (*Corvus leucognaphalus*) (Raffaele 1983, Snyder et al. 1987). The distribution of presently endangered species such as the Broad-winged Hawk (*Buteo platypterus brunnescens*), Sharp-shinned Hawk (*Accipiter striatus venator*), and the Puerto Rican Nightjar (*Caprimulgus noctitherus*) has been restricted by to habitat destruction (Raffaele 1983). The distribution of other more common forest dependent species such as the Puerto Rican Tanager (*Nesospingus speculiferus*) has also been limited by accelerated forest conversion. Nevertheless, the species-habitat relationships for many species are not as straightforward; hence, more integrated approaches to conservation are necessary.

Many members of island bird communities tend to be ecological generalists and opportunistic species (Ricklefs and Cox 1978, Abbot 1980, Terborgh 1980, Blondel 1985). These attributes can lead to unsuspected ecological resiliency in many instances (Lugo 1988). Indeed, it has been postulated that these traits may have ameliorated extinction rates of resident avifauna in Puerto Rico during the 20th century (e.g., Brash 1987). In addition, some agricultural activities such as the cultivation of shade coffee in the mountains may have served as surrogate refugia for some of the more plastic flora and fauna.

Towards the latter part of the 20th century, forested acreage increased in Puerto Rico to about 35% (Birdsey and Weaver 1982). This encouraging trend was driven primarily by a socio-economic transition from an agrarian to an

industrialized society. Although gains in forested habitats must have been beneficial to many elements of the island's biodiversity, the reality is that Puerto Rico's increasing human population is reversing this trend through urbanization (López et al. 2001). The human population of Puerto Rico increased almost 3.7 times from 1899 to 1992, causing an increment in the number of settlements (Cruz-Báez and Boswell 1997). In 2010, the island's population was estimated at 3.7 million people with a density of 1,112 persons per square mile (U.S. Census Bureau 2010). A significant part of urban expansion on the island has been the product of a suburbanization process, or the outward physical expansion of urban areas toward rural areas (Cruz-Báez and Boswell 1997).

The following is a list of the main stressors and threats to the Puerto Rico's wildlife:

Development and forest fragmentation

Humans depend on natural systems for survival. The primary impact of development is that built up areas displace forests and other vegetation with inert materials that do not provide the environmental, economic, and social benefits discussed in the sections above (Martinuzzi, et. al 2007). Eleven percent (95,342 ha) of Puerto Rico is composed of urban/built-up surface that is distributed throughout the island but tends to concentrate in coastal plains and valleys and follows transportation routes to the very interior of the island. In Puerto Rico, one-quarter of the rich soils that are suitable for agriculture have been developed.

Forest cover remained relatively constant between the 1980 and 1990 inventories and then increased dramatically between the 1990 and 2003 inventories from 32 to 57% (Birdsey and Weaver 1982, Franco et. al. 1997, Brandeis et. al. 2009). A 25% increase is substantial even after a portion of this increase is attributed to changes in inventory methods and definitions. Forest is defined in the 2003 inventory as any area with mature trees providing ten percent canopy cover or, having ten percent coverage in tree seedlings, (the equivalent of 1,500 seedlings per hectare). This is, intentionally, a more encompassing

definition of forest than used previously. It is intended to capture forests developing on old farm fields and pastures. Forest covered 85 percent of Vieques, and 88 percent of Culebra. The spatial distribution of forest cover is shown in Figure 10.

Forest fragmentation can involve a simultaneous decrease in the average size of habitat patches, an increase in the average distance between patches, and an increase in edge effects and habitat degradation. As a general rule, large fragments have more wildlife species and can sustain larger wildlife populations than small fragments. As the amount of fragmentation increases, species populations may become isolated, and the migration of individuals and populations between areas of suitable habitat becomes more difficult.
This intense growth pattern in land use has impacted a significant amount of geographic zones associated to the recharge areas of the main aquifers in Puerto Rico and has the direct consequences of soil erosion and sedimentation of water bodies and reservoirs (DRNA 2008-a). Likewise, it affects the quality of the resource and contributes to the deterioration of the environmental conditions necessary to sustain the aquatic biodiversity.

Site location consultations filed at the Puerto Rico Planning Board show the trend for *urban sprawl*, with urban activities dominating the territory and threatening watershed functions that support mainly the Río Grande de Loíza, Río La Plata, Río Piedras-Río Puerto Nuevo, Río Guaynabo-Río Bayamón, Río Cibuco, Río Grande de Manatí, Río Grande de Arecibo, and Río Guanajibo basins.

The increase of population densities in rural land puts pressure on the young forests and open space on the urban fringe (Martinuzzi et al 2007). A majority of new development inquiries in the non-zoned areas of Puerto Rico are occurring in the land use designation “Common Rustic Land”. This land use zoning designation is the most permissive classification of the Municipal Territorial Plans. An additional overlay of this zoning with the wildland urban interface areas shows that a large portion of the open space on the island is facing development

pressure or that the concerned land has not been yet designated under specific land use zoning. These areas shall be considered priorities, particularly those portions overlapping Forest priorities (high, medium or low) areas according to Southern Forest Land Assessment.

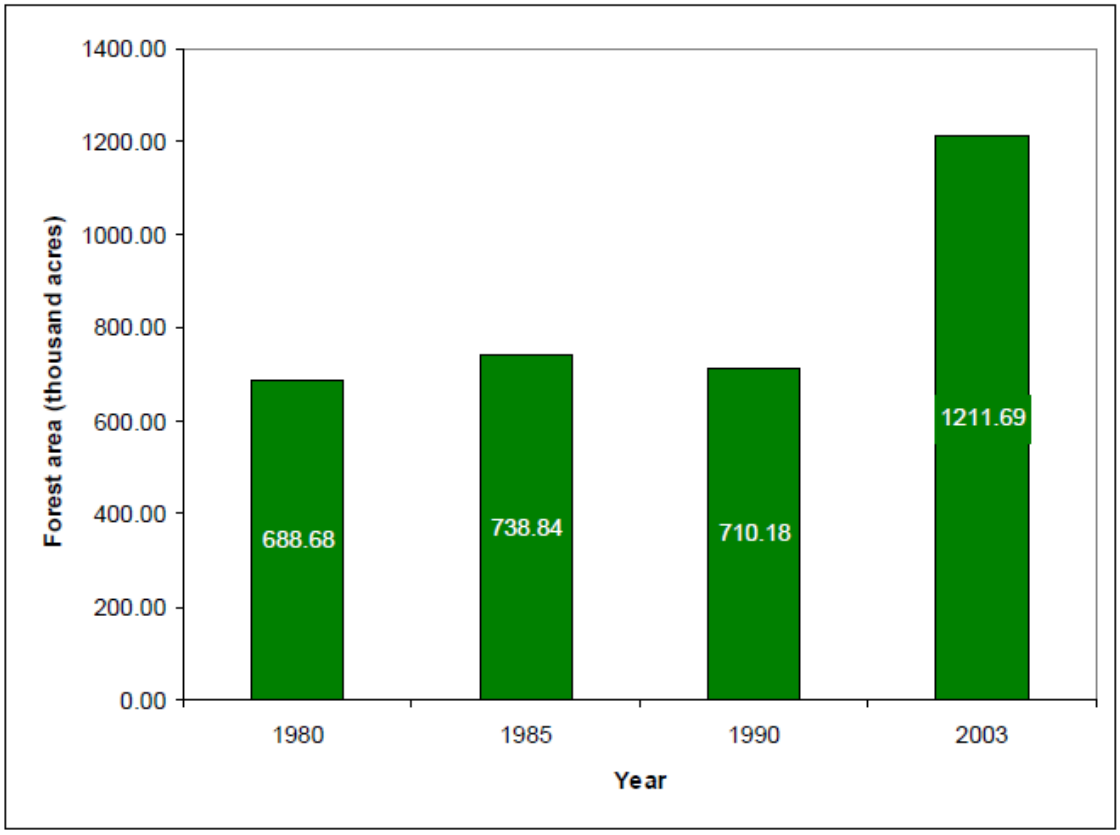


Figure 10. Forest area on the main island of P.R. as measured by forest inventories in 1980, 1985, 1990, and 2003. (Birdsey and Weaver 1987, Franco et al. 1997, Brandeis 2007).

Wildfires

Managing wildfires is an important global and local issue given interactions among people, fire and wild lands. While studies have shown fire has effects on ecosystem structure and functioning, uncertainties prevail on the particular effects to ecosystem services due to feedback loops involving multiple factors such as land cover, invasive species and climate change (Gould et al., 2008).

Understanding the ecological and social consequences of wildfires in Puerto Rican natural ecosystems is fundamental and key for important conservation and

management actions to be planned. Fire prevention efforts need to reach private forest owners and others as the majority of fires in Puerto Rico are set by people (Gould et al., 2008). Research and monitoring of fires in our region has not been a high priority. Most fires and the highest potential for fire occur in the dry forest zones. Climate change, extended drought and human-induced landscape fragmentation have the potential to greatly expand fire-prone areas to moist and wet tropical forests and even non forested landscapes traditionally fire-free (Gould 2008). The Caribbean Fire Ecology and Management Symposium held in San Juan, Puerto Rico in 2007 sent a clear message that in the New World Tropics, human activities and fire are intricately linked; and at the same time, forest fragmentation will increase the likelihood of fire.

Hurricanes

Tropical forests are shaped by natural disturbances of varying forces and frequency (Hartshorn 1978; Lugo 2000). Flooding and landslides are secondary disturbances associated with hurricanes. Hurricanes are one of several natural disturbances that contribute to the dynamics, structure, and function of forest ecosystems (Borman & Likens 1979; Pickett and White 1985).

Known effects of hurricanes on Caribbean forests include: defoliation, tree mortality, felling of trees by uprooting and snapping, variation of food supplies for animal populations and direct damage to a proportion of their individuals, modifying microclimate, modifying seeds and seedling bank dynamics (Tanner et al. 1991; varies based on environmental gradients, topographic location, stand characteristics, tree size, and species characteristics such as wood density (Tanner et al 1991; Basnet et al 1992). Hurricanes are an important factor controlling species composition and important aspects of ecosystem dynamics in our region (Tanner et al; 1991; Lugo 2000; Flynn et al 2010). Their effects have been theorized as a major determinant of distribution patterns of tree species in tropical forests affected along their pathways (Basnet et al., 1992). A strategy in urban areas is to establish green infrastructure with the goal mitigating the

potential for wind damage, flooding, and mass wasting (Lugo 2000). Decades are required for both urban and natural systems to recover from the passage of a single category 4 or 5 hurricane. Hurricane Hugo in 1989 and Georges in 1998 passed through the natural forested regions of Puerto Rico with various effects.

They removed foliage or caused tree mortality over hundreds of acres of forested land on subtropical wet or moist, lower montane wet, and rain forest life zones. Urban forest resources were not exempt as trees fell onto power lines, houses, vehicles, and roads. Habitat loss and fragmentation has increased the threat that stochastic events like hurricanes and tropical storms pose to plants and animals on the island (e.g., Wiley and Wunderle 1993). For example, half the population of the Puerto Rican Parrot (*Amazona vittata*) (ca. 35 individuals) disappeared when Hurricane Hugo (ca. 35 individuals) struck the island in 1989 (Wiley and Vilella 1998). In fact, about half of the wild parrot population disappeared when hurricane Hugo struck the Luquillo forest in 1989 (Vilella and García 1995).

Climate change

Climate change refers to any significant change in the measures of climate lasting for an extended period of time, and includes major changes in temperature, precipitation, or wind patterns, among others that occur over several decades or longer (EPA 2015). The recent and ongoing rise in average global surface temperatures, known as global warming, is causing changes in climate patterns. Global warming, primarily caused by increasing concentrations of greenhouse gases in the atmosphere, is only one aspect of climate change (EPA, 2015). However, the effects of human induced climate change have the potential of devastating many areas of the world, including islands with substantial portions of its coastal plain composed of lowlands close to current sea level. The predicted intensity of change and the time frame over which change will occur depends on the model; however, most of these agree that climate will result affect forests along the coastlines. The expected changes, presented so far by the United Nations Environmental Program (UNEP 2008) include:

- deteriorating coastal conditions as, for example, beach erosion and coral bleaching, affecting fisheries and touristic coastal scenarios;
- floods, storm surge, erosion and other coastal hazards, exacerbated by sea-level rise, threatening fundamental infrastructure, settlements and facilities that support the livelihood of island communities;
- reduction in freshwater resources to the point where they cannot meet demand during drought periods;
- increased invasion by non-native species as result of higher temperatures, particularly on middle and high latitude islands;
- economic losses from reduced agricultural yields (shortening of the growing seasons and droughts)
- loss of mangrove forests and coral reefs as a consequence of sea level rise;
- coral bleaching and acidification of the ocean;
- damage to terrestrial forests caused by extreme events;
- reduction of the size of freshwater aquifers or lenses and of general water resource availability due to decreased rainfall and salt water intrusion;
- inundation on coastal settlements and arable land on the coast;
- reduction in tourism due to increased frequency and extreme severe weather.
- hurricanes and tropical storm winds could reach more than 170 miles per hour, with the ability to devastate entire landscapes (Reilly 1991).

Human induced climate change is one of the most critical issues facing biodiversity and natural resource management in the world today. Land and ocean surface temperatures have warmed, the spatial and temporal patterns of precipitation have changed, sea level has risen, and we are experiencing more intense storms. These changes, particularly warmer regional temperatures, have affected the timing of reproduction in animals and plants and/or migration of animals, the length of the growing seasons, species distributions and population

sizes, and the frequency of pest and disease outbreaks. Climate change is projected to affect all aspects of biodiversity; however, the projected changes have to take into account the impacts from other past, present, and future human activities. The effects of climate change, in terms of rising sea levels, increasing mean atmospheric and sea surface temperatures and changes in rainfall and weather patterns, are likely to be particularly severe for the ecological systems of the Caribbean islands and small island states (Puerto Rico Climate Change Council 2013).

Climate change is already affecting some aspects of society, the economy and natural ecosystems of Puerto Rico, withthese effects are expected to increase. Not all of these changes will be gradual. When certain tipping points are crossed, impacts can increase dramatically. Past climate is no longer a reliable guide to the future. This affects planning for public and private infrastructure, tourism and industry, water resources, energy and all other social and economic systems.

Observed trends in precipitation for the Caribbean as a whole are unclear from available literature. An analysis for the PRCCC shows that since 1948 the Caribbean Basin has seen decreasing precipitation (-0.01 to -0.05 mm/day/year), with a greater drying trend for the Eastern Caribbean. Specifically for Puerto Rico, one analysis of weather station data from the period of 1948 to 2007 found no clear trends in total annual rainfall for the island as a whole, while another analysis showed decreases in rainfall for the island as a whole, while another analysis showed decreases in rainfall from -0.01 to -0.1 mm/day/year. Regionally within the island, there are indications that the southern region of Puerto Rico has experienced positive trends in annual rainfall while the western and a portion of the northern region showed decreases. Additionally, seasonal trends with observations show negative trends in summer and positive trends in winter (Puerto Rico Climate Change Council 2013).

The expected sea level rise is another issue that will significantly affect certain forests in Puerto Rico, mainly within the coastal zone. A rise in sea level of just

one foot could have a detrimental effect on coastal forests areas, including mangrove systems and other coastal swamps characteristic of lower saline intrusion such as bloodwood swamps (*Pterocarpus officinalis*) and pond apple swamps (*Annona glabra*). All these coastal forests act as nurseries for fish, habitat for other wildlife, and sediment filters for runoff. Data available suggests that under current conditions sea level could rise from 48 cm (1.3') (Pfeffer and O'Neel, 2008) to as much as 880 cm (27.7') (Carlson et al. 2008) over the next hundred years. The more conservative numbers from IPCC estimate 40-102 cm over next 100 years. Sea level rise could have a domino effect if FEMA flood zones, push development back into the central volcanic parts or karstic zones of Puerto Rico.

Climate change is likely to exacerbate many of the existing threats to forest ecosystems. Climatic warming and drying and the increase in invasive species will make forests more vulnerable to wildfires. Evidence of this is already being seen in the Island where wildfires are increasing in frequency and occurring in areas where such fires have never been recorded before (Robbins et al. 2009).

The main effect of climate change on Puerto Rico's ecosystems and species will be synergistic in that already stressed systems will be exposed to additional stressors that push them over their limit of existence, resulting in widespread loss of habitat, unfavorable changes to structure and function, or diminished services to Puerto Rico's society. Some ecosystems and species will acclimate to changing environmental conditions better than others (Puerto Rico Climate Change Council 2013).

While some species may potentially migrate to more favorable conditions in Puerto Rico (e.g., Colorado trees, swamp cyrilla) species already reaching the upper limits of their range may not be so fortunate, and could be diminished or lost from Puerto Rico altogether due to the lack of suitable environmental conditions (e.g., dolphinfish, yellowfin tuna). Others may not have the ability to relocate and may become globally extinct, like the Coquí Duende, the Cricket

Coqui, and the forest-dwelling Puerto Rican Upland Sphaero. On the other hand, new species or community assemblages could occur in Puerto Rico that may benefit society as they might provide new ecosystem services (Puerto Rico Climate Change Council 2013).

Puerto Rico has been identified by World Bank among nations with higher carbon dioxide emissions per person in Latin America and the Caribbean compared to world average emission. Climatic warming is mainly caused by increasing CO2 emissions in our atmosphere. Forests store carbon dioxide therefore decreases in forest cover increase the amount of carbon dioxide in other parts of the cycle.

Climate change requires a monitoring mechanism or protocol to categorize management applications and setting priorities can focus on adapting to the climate change process. Given the importance role forests play in sequestering carbon, expanding forest cover is a logical response to climate change. Carbon credit trading is one way that private landowners may participate and prosper while contributing to mitigation efforts. At present there is no active market for carbon on the island.

The Department of Natural and Environmental Resources (DNER) through the Puerto Rico Coastal Zone Management Program (PRCZMP) serves as coordinator of the Puerto Rico Climate Change Council (PRCCC). The PRCCC was created in 2010 to conduct the assessments and develop adaptation strategies to current and potential impacts of climate change and sea level rise on coastal communities, infrastructure, ecosystems, habitats, and populations of coastal and marine species. Over 180 PRCCC members from partner organizations, as well as researchers from Federal and Commonwealth agencies, universities, independent researchers and investigators, non-governmental and community-based organizations contributed and continue investigating, evaluating, assessing, and contributing to develop and catalog the best scientific, technical, and communities' knowledge to support decision making at the public and private sectors and each individual member of our

population. PRCCC First comprehensive assessment were completed through four working groups: Geophysics and Chemistry, Scientific Knowledge, Ecology and Biodiversity, Economy and Society and Communicating Climate Change and Coastal Hazards. The report Puerto Rico's State of the Climate Report 2010-2013 – Assessing Puerto Rico's Social-Ecological Vulnerabilities in a Changing Climate integrates assessments for different climate and ocean conditions and delineates a course of action to address the effects and impacts as well as to develop adaptation strategies and build resilience for coastal communities, critical infrastructure, and biodiversity.

Prior to 2010 and immediately after the Intergovernmental Panel on Climate Change (IPCC) issued its 4th Assessment Report in 2007, the Government of Puerto Rico established a high level Commission to address climate change mitigation and adaptation in Puerto Rico (Executive Order 2008-09). Although the Commission discussed and recommended public policies no specific vulnerability-impact assessments nor adaptation strategies were devised or implemented in Puerto Rico. Before 2008 most climate variability and change impacts on biodiversity and society were assessed and adaptation strategies recommended by scientists and resource managers from the Academia, Federal and Commonwealth agencies. Notable work had been conducted by researchers of the fields of amphibian's ecology, marine science, and coastal hazards.

In 2010, the PRCCC met for the first time and committed to develop a comprehensive report on the potential effects and impacts of climate change based on publications and direct participation of the most knowledgeable researchers and practitioners in the field, collecting the best available science and scientific knowledge, coming to agreement on key drivers of ecosystem changes and ways Puerto Rico's ecology and biodiversity may be affected and impacted, as well as identifying research gaps, information needs, and adaptation strategies.

The adaptive capacity of Puerto Rico's flora and fauna, and therefore the current status and threats to each of the systems is intrinsically related to each ecological system's vulnerabilities.The following climate conditions were assessed: Air and Sea Surface Temperatures, Precipitation, Extreme Events (e.g., downpours, droughts), Sea Level Rise, Tropical Storms and Hurricanes, and Ocean Acidification. PRCCC report presents the results of the vulnerability assessments conducted on sub-tropical forests, coral reefs, seagrasses, beaches, amphibians and reptiles, fishes, marine mammals, among other.

The PRCCC Ecology and Biodiversity working group conducted the assessment of the impacts of changing climate conditions on Puerto Rico's biodiversity. The United Nations Convention on Biological Diversity defines Biodiversity as defined as the means the variability among living organisms from all sources including, among others, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biodiversity is highly stressed World-wide. Human activities globally and in Puerto Rico have caused and are likely to continue causing losses in ecosystems and habitats, potentially inducing species losses. The introduction of non-native species, disease and pests, and speciation by hybridization may be a signature of the Anthropocene. Claims that Conservation is losing the battle to protect biodiversity in the Era of Man also known as the Anthropocene have been highly controversial, and so is the position that changes induced by humans may bring increased animals and plant diversity and distribution as they respond to warming temperatures, are signs of the recognition of climate change impacts on global biodiversity.

The losses of biodiversity directly impact society as we also lose ecosystem services, such as clean water, air pollution abatement, CO2 sequestration, natural protection against storm surges, floods, and hurricanes, prevention of

landslides, erosion and sedimentation control, as well as recreation and tourism opportunities, among others.

The PRCCC report on Ecology and Biodiversity examined the effects and impacts of changing climate and ocean conditions on beach ecosystems, wetlands, coastal lagoons, sea birds, shore birds, forests, woodlands, amphibians, reptiles, coral reefs, submerged aquatic vegetation and seagrasses, coastal and pelagic fishes, bioluminescent bays, marine mammals, as well as intersecting issues. Vulnerability assessments were conducted through literature review, expert meetings, PRCCC summits and Working Group's workshops.

The PRCCC members continue collaborating and exchanging information through the pr-cc-listserv@googlegroups.com, workshops, and annual summit meetings. The PRCZMP as Executive Secretariat of the PRCCC has initiated the update of The State Puerto Rico's Climate aiming to publish it in 2018. The PRCZMP has also completed the Puerto Rico Guide to Climate

Change Adaptation (in print) and is currently conducting pilot Ecosystem-based adaptation plans at 5 of the 44 coastal municipalities of Puerto Rico. These plans are envisioned to build resiliency in those communities using a triple bottom line approach: economics, social, and environmental. Focused on stakeholders, the process will be conducted in four steps in each community: (1) Community Resiliency Report Cards, (2) Engage with stakeholders to develop master plan scenarios for the community, (3) Scenario Stress Testing, and (4) Reach consensus on master plan.

The Convention on Biological Diversity calls for action to combat climate change and its impacts, recognizing that Climate change is a threat to human well-being and development in all countries, and the Millennium Ecosystem Assessment identifies it as one of five global drivers of biodiversity loss. Climate change is already forcing biodiversity to adapt either through shifting habitat, changing life cycles, or the development of new physical traits in species. Climate change is

also projected to reduce economic growth and reduce the livelihood assets of vulnerable people, especially those dependent on biodiversity and ecosystem services for access to food, water and shelter. It will have impacts on these basic needs to all people. Further, climate change will increase the vulnerability of populations to perturbations such as drought, flood and disease. While biodiversity plays a major role in mitigating and adapting to climate change by contributing to long-term sequestration of carbon, and reducing the impacts of extreme events such as droughts and floods, it is also highly vulnerable to the effects of climate change.

The DNER continues leading biodiversity conservation efforts through its Fisheries and Wildlife Bureau and promoting adaptation and building resilience through its Coastal Management Division. Current Island-wide collaboration takes place through the Caribbean Landscape Conservation Cooperative and the PRCCC, among others.

Invasive species

Biological invasions are considered one of the major threats to the conservation of biodiversity (Mack et al. 2000; Levine et al. 2003; D'Antonio et al. 2004). At a global scale, plants are among the most widespread invasive organisms as they are frequently introduced for agriculture, agroforestry and ornamental purposes (Daehler 2003; D'Antonio et al. 2004; Pysˇek et al. 2012).

In 1999, Executive Order Num. 13112 was signed by President Bill Clinton, with the purpose of preventing the introduction of invasive plant and animal species, providing resources for their control, and diminishing their main economic and ecological impact. Under this Executive Order, federal agencies could not authorize, nor provide funding or accomplish any action considered capable of causing or promoting the introduction or dispersion of invasive species to the United States of America (USA), unless all reasonable measures that diminish risks are considered first. This Order is applicable to Puerto Rico and requires action by several federal or Commonwealth agencies.

These following terms are commonly used when discussing exotic organisms and invasive species:

- Native – Organisms found within what is considered their natural range.
- Endemic – Similar to native but usually refers to a more specific geographic range.
- Exotic – Exotic species are any organism taken from their natural range and transported to a new area. This only pertains to organisms moved by humans, such as in cargo ships or planes. It does not include natural migrations like birds or fish that travel great distances.
- Naturalized – An organism that is able to reproduce itself unassisted in their new habitat is considered naturalized.
- Invasive – An organism that grows or spreads aggressively in its new environment and causes environmental and/or economic harm.

Islands have long been considered to be particularly vulnerable to biotic invasions. Usual predictions concerning the number of invasive plant species per island group are based on factors such as: area and isolation, habitat diversity and human development. Comprehensive data set to date on the global distribution of invasive plant species in natural areas of oceanic islands have shown that island area, latitude, isolation from continents, number of present non native species with known invasion history, and native species richness do not seem to be retained as significant factors in the multivariate models (Kueffer et al 2009).

The 1,032 species of alien plants reported for Puerto Rico and Virgin Islands (PRVI) represent about a third of total plant diversity on these islands. This proportion is relatively high when compared to other islands of the Greater Antilles (Rojas-Sandoval and Acevedo-Rodríguez 2014). For instance, alien plant species represent about 12 % of the total plant diversity in Cuba, 18.4 % in

Hispaniola and 21.4 % in Jamaica (Acevedo-Rodríguez and Strong 2012; González et al. 2012). These differences are even more noteworthy in PRVI as they are the smallest land mass within the Greater Antilles. In general, the origin and quantity of alien plants in PRVI may be explained by historical and ecological (but not exclusively) factors. First, the historic role of Puerto Rico as a port of call for Europe-American trading routes during the colonization expansion (between 1500's and 1890's; Dietz 1986) facilitated the introduction of numerous alien species, mostly from continental America but also from Africa, Asia, and Europe. Second, the extensive rates of human mediated disturbance to which natural ecosystems in PRVI have been subjected (Rojas-Sandoval and Acevedo-Rodríguez 2014).

The alien flora in PRVI is very diverse and includes a wide range of taxonomic groups. Poaceae and Fabaceae are the families with the highest numbers of naturalized and invasive species, a fact that is not surprising since these two families are among the more diverse plant families of the world as well as among other Caribbean floras (Acevedo-Rodríguez and Strong 2012).

Other examples of invasive species are introductions of domestic cats (*Felis catus*). This has resulted in detrimental effects, including extinctions, on native prey populations (Ebenhard 1988). In Puerto Rico, there are already established a number of exotic species whose negative effects on native fauna have been documented (Camacho-Rodríguez et al. 1999, García et al. 2001 and 2002).

Nonetheless, there are many other introduced species (e.g., Lionfish [*Pterois* spp.] [Green iguana [*Iguana iguana*], Australian Red Claw crawfish [*Cherax quadricarinatus*], Yellow-crowned parrot [*Amazona amazonica*], feral pigs [*Sus scrofa*] and goats [*Capra hircus*] on Mona Island, White-tailed deer [*Odocoileus virginianus*] on Culebra Island, and Bottlebrush trees [*Melaleuca quinquenervia*]) that potentially affect the native flora and fauna of Puerto Rico. Exotic bird species may also be vectors of diseases that could negatively affect native fauna, especially those classified as vulnerable or endangered (Camacho-

Rodríguez et al. 1999). However, the impact of these species has not been comprehensively quantified. Due to the potential establishment of exotic animals imported as pets, DNER regulates through Regulation No. 6765, all wildlife species introductions and breeding. This document presents several lists that establish the following criteria:

1. Low Risk Species that can be imported without a permit.
2. Established Exotic Species that can be captured for exportation.
3. Exotic species that can be bred with or without authorization.

Predatory and competitive impacts of biological invasions are well documented, same as success of invading exotics due to having escaped their natural enemies and not because of novel interactions with their new neighbors (Callaway and Aschehoug 2000; Jenkings and Pimm 2003). Plant diversity patterns, plant community structure and forest regeneration patterns have been interpreted as strongly affected in the Luquillo Mountains of Puerto Rico due an invasive tropical tree species introduced over 180 years ago into the Island (Brown et al 2006). In contrast, perspectives and paradigms based on such data seem to be threatened by new concepts and observations. Searches through recent ecological literature found that facilitative interactions between invasive and native species occur in a wide range of habitats, and can have cascading effects across trophic levels, for example, restructuring communities and leading to evolutionary changes; recent evidence suggests that several mechanisms that exemplify how exotic species can facilitate native species (Rodriguez 2006), having important implications for management, eradication and restoration. The change in species composition taking place due to invasiveness might not be seen as a chaotic process, instead a directed process responding to fundamental changes the conditions of the planet (Lugo 2004).

Pests and diseases

The Agricultural Extension Service of the University of Puerto Rico in Mayagüez has been able compile a list of native and non native insect species that at

certain life-cycle stages, adversely affect particular organs of native or naturalized tree or shrub species occurring on forested ecosystems or urban forest systems (Martorell 1945; Almodovar 2008). Table 5 shows a list of the species considered pests in Puerto Rico forests and their host woody plants.

Table 5. Native and non-native insect's species in P.R., considered harmfull to local tree or shrub species.

Insect scientific name	Insect common name	Tree or shrub species affected, present in Puerto Rico
Apate monacha	The apate borer	*Bixa orellana; Bucida buceras; Casuarina equisitefolia; Delonix regia; Inga vera; Eugenia jambos; Linociera domingensis; Melia azedarach; Persea americana; Picramnia pentandra; Salix chilensis*
Aspidotus destructor	The coconut scale	*Cocos nucifera; Annona glabra/ Barringtonia speciosa; Grevillea robusta; Mammea americana; Persea americana; Phoenix dactylifera; Psidium guajava; Terminalia catappa*
Chlorida festiva	The mango borer	*Albizzia lebbeck; Casuarina equisetifolia;Mangifera indica; Stahlia monosperma*
Chrysomphalus aonidum	The Florida red scale	No information available
Diapprepes abbreviatus	Sugarcane weewil	*Albizzia lebbeck; Andira jamaicensis; Byrsonima spicata; Cedrela mejicana; Cedrela odorata; Ceiba pentandra; Chrysophyllum cainito; Coccoloba uvifera; Cordia alliodora; Delonix regia; Ficus stahlii; Guaicaum officinale; Inga vera; Lagerstromia speciosa; Melicocca bijugata; Thespessia grandiflora; Persea americana; Psidium guajava; Swietenia macrophylla; Swietenia mahogani; Tamarindusindica; Terminalia catappa*
Eulepte concordalis	The oak leaf-weeber	*Tabebuia argentea; Tabebuia heterophylla; Tabebuia lucida; Tabebuia rigida; Tabebuia schumaniana; Crescentia cujete;*

		Spathodea campanulata
Exophthalmus roseipes	The green bug	*Andira inermis; Chrysobalanus icaco; Coccoloba uvifera; Conocarpus erectus; Dalbergia ecastophyllum; Elaodendrum xylocarpum; Hymanea courbaril; Inga vera; Inga laurina; Terminalia catappa*
Homaledra sabalella	The palm leaf-webber	*Cocos nucifera; Prestoea montana*
Iceria motserratensis	No official common name	*Byrsonima spicata; Callophyllum calaba; Casearia sylvestris; Casuarina equisitefolia; Chrysophyllum argenteum; Cocos nucifera; Ficus nítida; Inga vera; Inga laurina; Mammea americana; Psidium guajava; Samanea saman*
Megalopyge krugii	Flannel moth	*Andira inermis; Byrsonima spicata; Cocos nucifera; Delonix regia; Erythrina glauca; Ficus laevigata; Guaiacum officinale; Guarea trichiloides; Guazuma ulmifolia; Inga vera; Inga laurina; Nectandra sintenisii; Ormosia krugii; Psidium guajaba; Rhizophora mangle; Sciacassia siamea; Spondias purpurea; Terminalia catappa; Triplaris caracasana*
Nasutitermes costalis	Common termite	*Albizzia lebbeck; Albizzia procera; Andira inermis; Artocarpus communis; Bucida buceras; Bursera simarouba; Callophyllum calaba; Canagium odorata; Capparis portoricensis; Casuarina equisetifolia; Cecropia peltata; Cedrelaodorata; Ceiba pentandra; Coccoloba uvifera; Cocos nucifera; Colubrina arborescens; Crescentia cujete; Delonix regia; Eucalyptus robusta; Ficus*

		elástica; Inga vera; Petitia domingensis; *Prestoea montana; Roystonea borinquena; Swietenia mahogani; Terminalia catappa*
Oiketicus kirbyi	Bagworm	*Casuarina equisetifolia; Casearia sylvestris; Ceiba pentandra; Chrysophyllum cainito; Cordia alliodora; Cupania americana; Guazuma ulmifolia; Thespesia populnea; Ochroma pyramidale; Petitia domingensis;* *Persea americana; Pisonea aculeata; Randia portoricensis; Terminallia catappa; Thuja orientalis; Tabebuia* spp.
Pachylia ficus	The ficus sphinx	*Ficus nitida; Castilla elastica*
Pectynophora gossypiella	The pink bollworm	*Thespesia grandiflora; Thespesia populnea*
Phyllophaga portoricensis	May beetle	*Coccoloba uvifeera; Schefflera morototoni; Lagerstromia speciosa; Bucida buceras; Cordia alliodora; Cordia sebestena; Grevillea robusta; Sterculia apétala; Sterculia foetida; Swietenia mahogani; Swietenia macrophylla;* *Terminalia catappa*
Pseudalcapasis pentagona	West indian peach scale	*Calatropis procera; Clibadium erosum;* *Erythrina poeppigiana; Fraxinus sp.; Gleditsia triacanthos; Mammea americana; Mangifera indica; Thespessia grandiflora; Hibiscus tiliaceum; Salix chilensis; Trema lamarkiana; Trema micrantha*
Pseudococcus adonidum	Mealybug	*Barringtonia speciosa; Callophyllum calaba; Erythrina glauca; Hibiscus tiliaceus*
Psychonoctua personalys	Mangrove stem-borer	*Eugenia jambos; Laguncularia racemosa;* *Rhizophora mangle*
		Andira inermis; Annona muricata; Cedrela mejicana; Cordia alliadora; Cordia sulfata; Crescentia cujete; Erythrina berteroana; Erythrina glauca; Erythrina poeppigiana;Ficus

Saissetia oleae	Black scale	*laevigata; Ficus nitida; Gleditsia triacanthos; Guarea trichiloides; Guazuma ulmifolia; Isandrina emarginata; Eugenia jambos; Lagerstromia speciosa; Manilkara bidentata; Thespesia grandiflora; Ocotea portoricensis; Petitia domingensis; Psidium guajava; Sciacia siamea; Sideroxylon foetidissimum;Spathodea campanulata; Spondias dulcis; Sterculia apétala; Swietenia mahogani; Tamarindus indicus; Tectona grandis; Terminalia catappa; Trema lamarckiana; Trema micrantha; Zanthoxylum flavum*
Selenothrips rubrocinctus	Cacao thrips	*Anacardium ; occidentale; Bixa Orellana; Chrysobalanus icaco; Coccoloba laurifolia; Mangifera indica; Psidium guajava; Spondias bombim; Terminalia catappa; Zanthoxylum monophyllum*
Sericocerina krugii	Sea grape wasp	*Coccoloba uvifera*; other *Coccolobba* spp; *Triplaris surinamensis*
Xyloborus affinis	Ambrosia beetle	*Albizzia lebeck; Cocos nucifera; Inga vera; Inga laurina*

There are major threats and stressors that currently affect Puerto Rico's wildlife (Table 6). Most of them are well known, such as urban development, but others are more subtle, like the installation of power lines.

Table 6. Other threat categories and classes used for PRSWAP.

Threat Category	Threat Class
Habitat Conversion: Intentional conversion of natural habitat that is detrimental to wildlife use and survival by causing loss or degradation of wildlife habitat and available forage.	Housing and urban development
	Agricultural practices
	Recreational areas
	Intentional fires

	Illegal dumping areas
	Wetland filling
Invasive Species: Introduction and/or spread of unwanted exotic and native organisms into ecosystems that increases wildlife predation, competition, and reduced fitness or causes loss of wildlife habitat.	Invasive Plants Invasive animals and plants Pathogens
Transportation and Infrastructure: Development of corridors/passages that increase wildlife mortality and fragmentation of wildlife habitat.	Roads
	Pier and harbor
	Power lines, aqueducts, gas ducts
	Wind power plants
Abiotic Resources Use: Extraction or use of rocks, minerals, and water that causes direct or indirect negative impacts to wildlife habitats.	Land cover removal for construction material (e.g., sand, limestone, other rocks)
	Water use
	Drilling (wells)
Consumptive Use of Biological Resources: Harvest or use of plant and animal populations in a manner that negatively impacts wildlife distributions and fitness, or the ecosystem.	Forest and woodland management
	Grazing
	Collection
	Illegal hunting and fishing practices
Non-consumptive Resources Use: Activities that have an incidental, but negative impact on wildlife and their habitats.	Motor-powered recreation
	Non-motorized recreation
Pollution: Introduction and spread of unwanted matter and energy into ecosystems from point and non-point sources that cause increased mortality of wildlife and degradation of their habitats and available foraging opportunities.	Solid waste
	Waste or residual materials
	Chemicals and toxins
	Eutrophicants substances
	Noise pollution

CHAPTER 5. CONSERVATION STRATEGIES FOR PRSWAP

Puerto Rico GAP Analysis

Land protection is an important conservation tool today. The Puerto Rico Gap Analysis Project conducted an inventory of protected areas and an evaluation of the degree of their management for conservation purposes using information from federal and state agencies, the Conservation Trust of Puerto Rico and the Puerto Rico Planning Board. (Gould et. al, 2008). The project identified 90 stewardship areas, 77 of which have some type of management for conservation. Among areas, 59% of the stewardship areas are managed by commonwealth agencies, 30% by federal agencies, and 11 % by non-government agencies (Figure 11). Another key finding was that management plans for many areas either do not exist or have not been updated to provide direction for today's conditions (e.g. reduced timber production, focus on forest restoration, and increased development pressures).

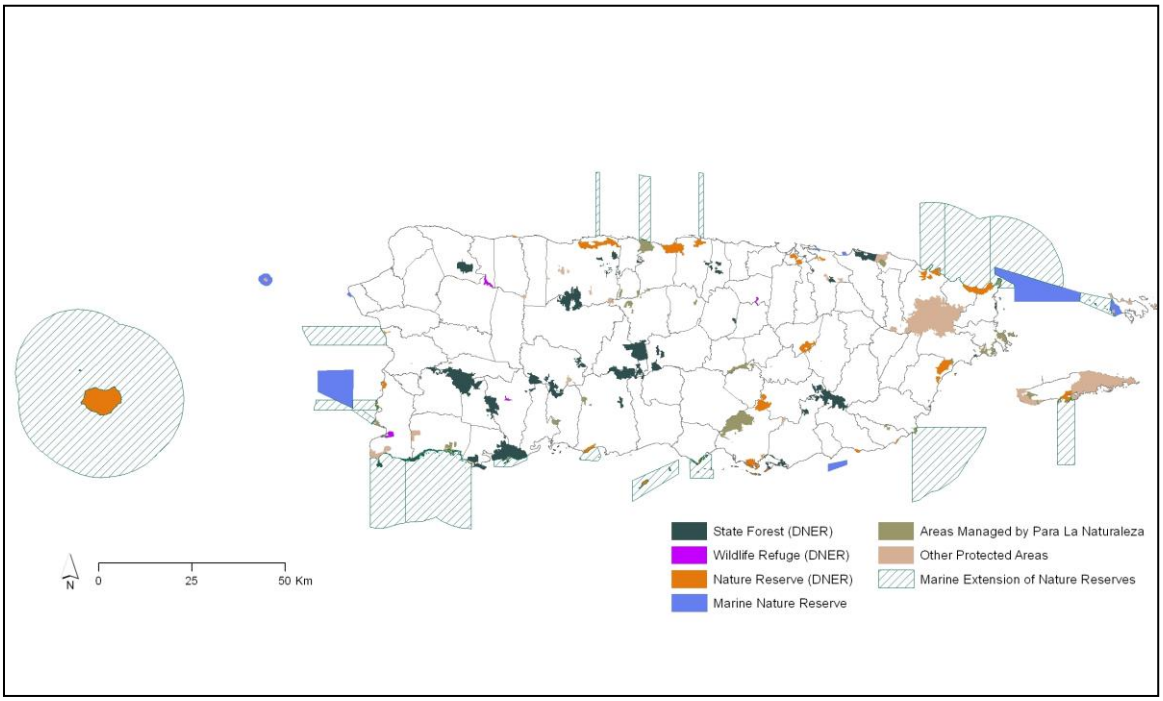


Figure 11. Location of land currently (2014) protected by Federal or Commonwealth designation, or proclamation or as private reserves of non-government organizations.

The Sportfish Gap Analysis Project

The Sportfish Gap Analysis Project aimed to develop a comprehensive set of databases on Puerto Rico's freshwater and marine recreational fisheries resources in order to assess the conservation status of species and habitats. The Sportfish Gap Project included four components: habitat description and mapping; protected areas and conservation priorities; species distributions and conservation status; and analyses of gaps in species conservation protection. The Project provided information on marine and terrestrial protected areas stewardship, species natural history accounts and bibliographic information, species occurrences and habitat characterization. The species included in the report are those identified by DNER staff as priority for recreational fisheries.

For the habitat mapping component an extensive geospatial database was compiled of all available habitat related information and modified or developed new data in order to integrate geospatial information to develop predicted habitat models for the species. For the marine component, in addition to the existing layers of information, new layers, such as slope and rugosity, were developed using bathymetry. Eleven (11) new layers were developed for the freshwater component of the project, integrating hydrographic and landscape features for species distribution modeling purposes.

For protected areas and conservation priorities, a comprehensive database documenting terrestrial and marine protected areas for Puerto Rico was developed. This geospatial layer was used for analyzing conservation "gaps".

A total of 29,571 records for 66 marine species were obtained during the species distribution and conservation status component. Ocurrence maps were completed for each species and, a complete report was created for ten species. For the freshwater/brackish/marine species a total of 582 occurrence records were obtained and eight occurrences maps were completed.

Development of a Strong Private Lands Program

During the last ten years, it has become increasingly evident that private landowners play a critical role in the conservation of fish and wildlife resources, particularly listed species. The US Forest Service has a number of programs that provide technical and financial assistance to non-industrial private landowners and communities (Table 7). The Department of Natural and Environmental Resources' Forestry Bureau is the primary state administrator for most USFS Cooperative programs, with one exception; the Puerto Rico Fire Service is designated as the primary agency responsible for implementation of the State Fire Assistance and Volunteer Fire Assistance Program.

Table 7. USDA Forest Service Cooperative Programs available in P.R.

Program	Purpose
Forest Stewardship	-Provides technical assistance, through State forestry agency partners, to nonindustrial private forest owners to encourage and enable active long-term forest management. A primary focus of the Program is the development of comprehensive, multi-resource management plans that provide landowners with the information they need to manage their forests for a variety of products and services. -Promotes the conservation of soil, water, flora and fauna through the protection and effective management of private forest land. -Promotes greater participation of owners in the programs. -Develops projects that are aimed at improving water quality through the protection and conservation of watersheds and forest areas.
Urban and Community Forestry	-Provides technical and financial assistance to communities, public and private entities and municipalities on the management of urban forest resources to promote a sustainable ecosystem. -The program has an Advisory Council composed of representatives of various sectors of society, whose primary function is to advise the director of the DNERFSB in the process of implementing the program. -Provide technical and financial assistance to communities, public and private entities and municipalities on the management of urban forest resources to promote a sustainable ecosystem.
	-Promotes the protection of forest areas through the purchase of private

Forest Legacy	land forest value that are under threat to be converted to non-forest uses and have features that warrant preservation and enrich our natural areas. This goal can be achieved through the purchase of land or purchase conservation easements Puerto Rico competes with other states for funding of this program which should provide a matching 25% of the state.
Community Forest Open Space Conservation	-The purpose of the CFP is to competitively award grants to enable local governments, Indian Tribes, and nonprofit organizations to establish community forests by acquiring and protecting private forest lands that will provide continuing and accessible community benefits. Community benefits provided by community forests established through this program include, but are not limited to: economic benefits through sustainable forest management; environmental benefits such as clean water and wildlife habitat; benefits from forest-based educational program, including vocational education program in forestry and serving as models to guide stewardship on private forest lands; and recreational benefits, including hunting and fishing. Public access to the community forests is required and intended to enhance public health and well-being.
Forest Health Management	-Works in partnerships to prevent, suppress and slow-the-spread of native and nonnative forest insects, pathogens, and invasive plants affecting urban, rural, and wildland forests.
Forest Health Monitoring	-Monitors the forests of the United States to determine detrimental changes or improvements to forest health that occur over time.
State Fire Assistance	-Provides financial and technical support directly to the states, to enhance firefighting capacity, support community-based hazard mitigation, and expand outreach and education to homeowners and communities concerning fire prevention. The program requires a 50-50 match by the state. The delivery system is through the State Forester.
Vounteer Fire Assistance	Provides financial, technical and other assistance to rural communities with a population of less than 10,000, matched on a 50-50 basis either by the state or community. The State Foresters and their staff deliver this program. Some benefits include: • Available funding to renovate equipment obtained through the Federal Excess Personal Property Program • Improved fire protection capabilities and capacity in rural areas to protect lives and other rural investments • Improved effectiveness of fire protection in wildland urban interface areas

	• Complements state and federal firefighting forces to optimize fire protection across ownerships • Complements the Rural Fire Assistance Program provided by the Bureau of Land Management

The US Department of Agriculture and the US Department of Interior have technical and financial assistance programs that are complementary to the Cooperative Programs described above. The cost incentive programs are the one most commonly used to establish, restore and manage forested lands (Table 8).

Table 8. USDA, NRCS, and the USFWS incentive programs available to non-industrial private landowners in P.R.

Environmental Quality Incentive Program, EQUIP	-Provides a voluntary conservation program for farmers, ranchers and owners of private, non-industrial forest land that promotes agricultural production, forest management and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible producers install or implement conservation practices on eligible agricultural land.
Wildlife Habitat Incentive Program, WHIP	-Is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Indian land.
Partners for Fish and Wildlife, PFW	-Partners with landowners, municipalities, schools, and other organizations to restore habitats on private lands. The program provides technical assistance and matching federal funds to more than 90 projects to restore stream banks, uplands, wetlands, and other habitats used by wildlife in Puerto Rico and the Virgin Islands. Projects are designed to benefit fish and wildlife while meeting the needs and desires of private landowners.
Conservation Reserve Program, CRP	The Conservation Reserve Program (CRP) is a voluntary program for agricultural landowners. Through CRP, you can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland.
Conservation Stewardship Program, CSP	A voluntary conservation program that encourages producers to address resource concerns in a comprehensive manner by: • Undertaking additional conservation activities; and

	• Improving, maintaining, and managing existing conservation activities,
Healthy Forests Reserve Program, HFRP	Assists landowners, on a voluntary basis, in restoring, enhancing and protecting forestland resources on private lands through easements, 30-year contracts and 10-year cost-share agreements.

Offering tax incentives is one of the strategies used for land conservation. The Auxiliary Forest Program is authorized by Article 10 of Law 133, Forest Law of Puerto Rico, and enables the Secretary of the DNER to designate private forest land as State Auxiliary Forests Figure 12. Private forest landowners with five or more acres of continuous forest dedicated to conservation or to the production of forest products. In return, landowners are exempt from taxes on the land and any income from forest products produced and sold in the market. As part of the program, each landowner must have a Forest Service Bureau approved forest management plan. The tax exemption is assigned by the Treasury Department. This designation has to be revised and renewed every year. In 2007, 2,938 hectares and 67 landowners were enrolled in the program, but 110 landowners with 2,300 hectares, previously enrolled in the program, had not reenrolled.

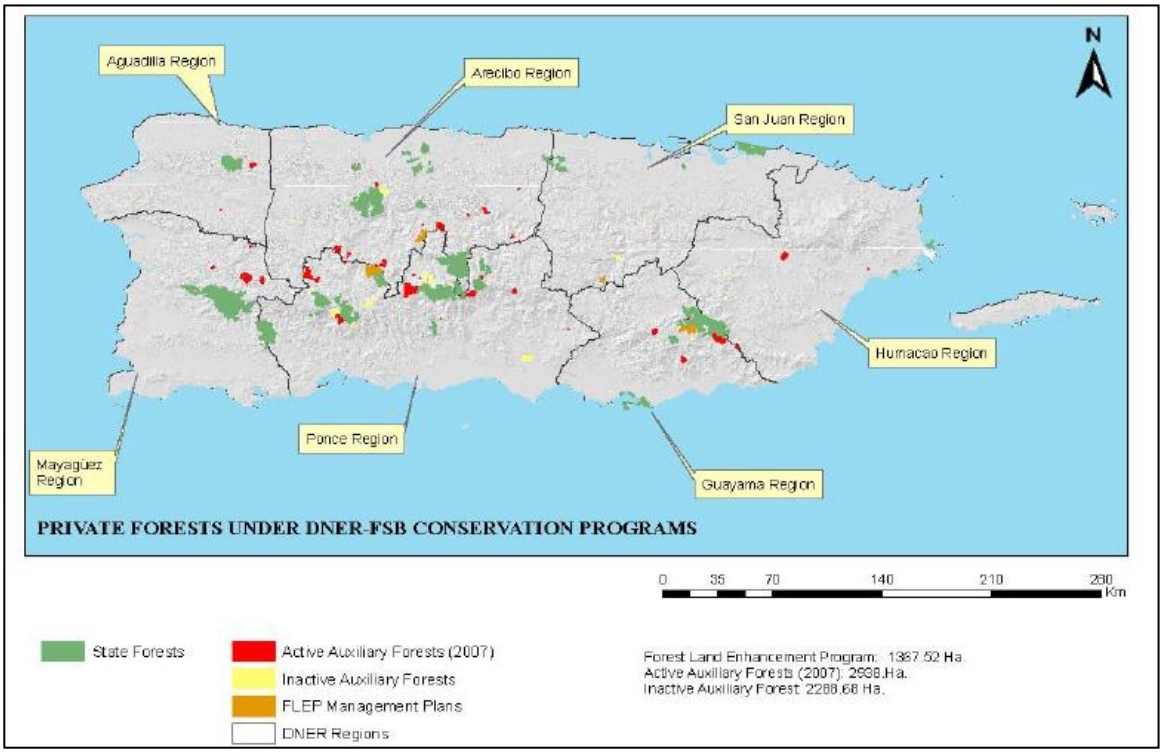


Figure 12. Location of private forests enrolled in DNER state auxiliary forest programs.

Private conservation and management are necessary for preserving the ecological benefits of forests, since it has been documented that as much as 82% percent of forested lands in Puerto Rico are held in private ownership (DNER 2000). An analysis conducted by the Forest Stewardship Program (FSP) documents 104 private landowners with management plans covering four thousand eight hundred thirty-three (4,833) acres distributed among five major river basins: the Rio La Plata, the Rio Grande de Arecibo, Río Grande de Manatí, Rio and Rio Grande de Patillas Guamaní. Of this acreage nearly 61% is forested, 3.7% is in agroforestry use, and 0.01% is in riparian ecosystems (Figure 13).

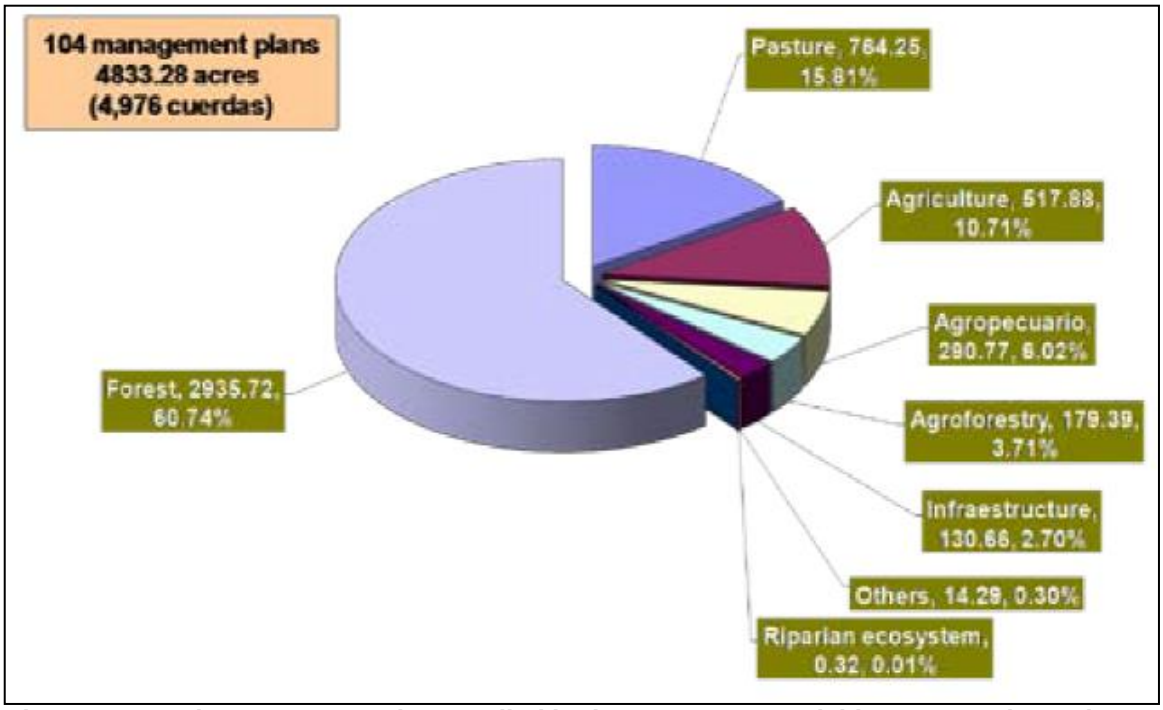


Figure 13. Land use on properties enrolled in the Forest Stewardship Program (DNER).

Strengthening of the Existing Natural Heritage Program

Law 150 of 1988 formally vested authority for habitat acquisition in the National Heritage Division. The National Heritage Division was authorized to administer the NHP, which was funded with an initial appropriation of $2,000,000 under the 1988 enabling legislation, and given the mandate for:

- Establishing criteria for state government acquisition of natural habitats within Puerto Rico;
- Developing a priority list of critical habitats for acquisition, according to these criteria;
- Acquisition, transfer and classification (e.g., Natural Reserve, Sanctuary, etc.) to state control of lands containing priority habitats;
- Developing and coordinating supplementary support, such as NGOs funding, for habitat acquisition and management.

The NHP workplan includes land acquisition projects and other technical studies as priority activities. The latter includes development of an ecological land-use

management plan, development of a natural areas databank, assessing the feasibility of sourcing outside funding, identification of natural areas within state-owned properties and land-titling analyses. The NHP also establishes actual boundaries within formally designated state protected areas.

Identification of Waterfowl Focus Areas

Another conservation strategy is the identification of Puerto Rico's Waterfowl Focus Areas (PRWFA), as part of the Atlantic Coast Joint Venture (ACJV). The ACJV is a partnership focused on the conservation of habitat for native birds in the Atlantic Flyway of the United States from Maine south to Puerto Rico and the Virgin Islands. The joint venture is a partnership of 17 states and 1 commonwealth: Maine, New Hampshire, Vermont, New York, Massachusetts, Rhode Island, Connecticut, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida and Puerto Rico. With the addition of Puerto Rico in 2001, the joint venture boundary evolved to match the entire U.S. Atlantic Flyway boundary.

The main purpose of the ACJV is to develop and maintain a strong scientific foundation for planning, implementing and evaluating conservation actions and to work together to identify and conserve the key breeding, migration and wintering habitats for priority bird species in the Atlantic Flyway. The joint venture was originally formed as a regional partnership focused on the conservation of waterfowl and wetlands under the North American Waterfowl Management Plan of 1986. The ACJV has since broadened its focus to the conservation of habitats for all birds consistent with major national and continental bird conservation plans and the North American Bird Conservation Initiative (ACJV 2004).

Wetlands in Puerto Rico are threatened. As mentioned before, the economy of the island has evolved from one based on agriculture to an economy sustained on urban development (i.e., construction) and industry. Nonetheless, human-made ponds initially constructed for irrigation purposes were left abandoned and

became a new habitat for water birds. These artificial ponds were deep enough to benefit waterfowl species such as Ruddy Ducks, and other diving species. Today, some of these ponds, mainly those in the south of the island, are critical habitat for the Ruddy duck, a vulnerable species in Puerto Rico, as well as for many other migrant species. Protection of these ponds is imperative in order to save this species from local extinction.

The PRWFA were selected based on the presence of wetlands and lagoons optimal for the occurrence of migratory waterfowl, and for the intense use of these habitats by birds. This includes optimum habitat for these species to feed and roost. Twenty primary areas were selected, including lagoons in Vieques and Culebra Islands. The areas were also selected according to their importance as habitat that supported migratory, rare, and endangered waterfowl such as Black Ducks (*Anas rubripes*), Blue-winged Teals (*Anas discors*), Masked Ducks (*Nomonyx dominicus*), West Indian Whistling Ducks (*Dendrocygna arborea*), and White-cheeked Pintails (*Anas bahamensis*), among others. The study also included a list of other migratory, native, endemic, and exotic bird species reported in selected areas. Some of the references used were documents available at DNER, such as literature about important lagoons on the island (Negrón-González 1986, Scott and Carbonell 1986, Ortiz-Rosas and Quevedo-Bonilla 1987), the status of the waterfowl (Chabert et al. 1984, Bonilla et al. 1992, NOAA et al. 2000), and the Critical Wildlife Areas documents (Raffaele and Duffield 1979, Cardona and Rivera 1988, Ventosa-Febles et al. 2005a).

The PRWFA document identifies and describes what DNER classifies as main waterfowl areas in Puerto Rico (Figure 14 and Table 9, Ventosa-Febles et al. 2005b). DNER and other agencies that through their ministerial duties approve endorsements or permits need to be aware that their action does not jeopardize those sites recognized as Waterfowl Focus Areas.

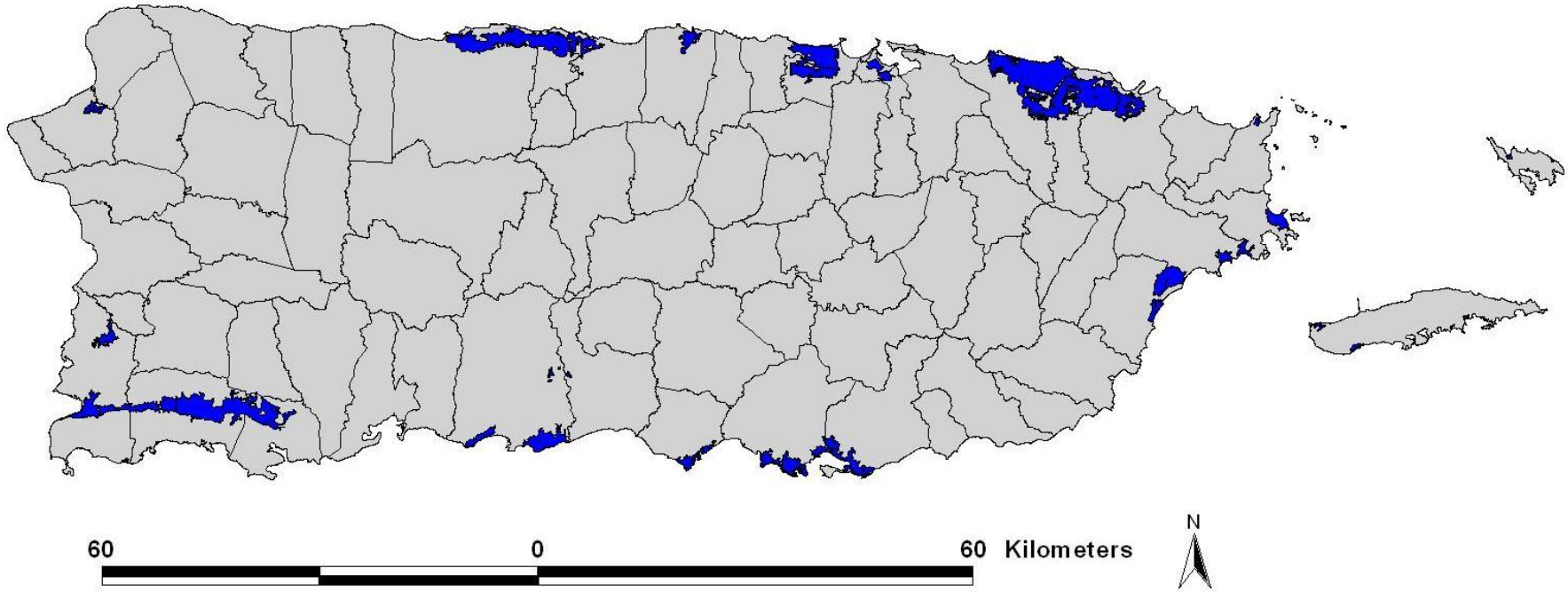


Figure 14. Puerto Rico Waterfowl Focus Areas (Ventosa-Febles et al. 2005b).

Table 9. Puerto Rico Waterfowl Focus Areas, Sub-Fucas Areas and Municipalities.

Focus Area	Sub-Focus Area	Municipality
Caño Tiburones	None	Arecibo and Barceloneta
Hacienda La Esperanza	None	Manatí
Cibuco Swamp	None	Vega Baja
El Mameyal	None	Dorado
Las Cucharillas Marsh	None	Cataño, Guaynabo and Bayamón
Torrecillas Lagoon	Piñones and Torrecilla Alta	Loíza
Aguas Prietas	None	Fajardo
Ceiba Mangrove Forest and Lagoons	None	Ceiba
Culebra Island Lagoons	Flamenco Lagoon, Zoni Lagoon and Cornelio Lagoon	Culebra Island
Vieques Island Lagoons	Kiani Lagoon Complex, Playa Grande Lagoon, Chiva Swamp and Yanuel Lagoon	Vieques Island
Humacao Natural Reserve	None	Naguabo and Humacao
Punta Arenas, Mar Negro, Bahía de Jobos and Punta Pozuelo	None	Salinas and Guayama
Punta Petrona	None	Santa Isabel
El Tuque/Punta Cucharas/ Salinas Lagoon	None	Ponce
La Esperanza/ Cabuyón Mangrove	None	Ponce
Serrallés Lagoons Complex	None	Ponce
Cartagena Lagoon	None	Lajas
Boquerón Wildlife Refuge	None	Cabo Rojo
Cuevas Lagoon	None	Cabo Rojo
Cayures	None	Añasco

Identification of Critical Wildlife Areas

Another conservation strategy is the identification and description of Puerto Rico's Critical Wildlife Areas (CWA). The CWA fulfills one of the most fundamental responsibilities of DNER: to provide comprehensive information on important wildlife and habitat resources in Puerto Rico and its offshore islands. This wildlife and habitat information is used by local governments, state and federal agencies, private landowners and consultants for land use planning purposes. This document seeks to protect critical wildlife habitat from degradation due to incompatible land uses. Wildlife species have differential capabilities to cope with human encroachment, thus, careful planning is needed to ensure that important wildlife habitats are not destroyed and that wildlife/human conflicts are minimized or eliminated.

The first version of the CWA was published twenty six years ago, in 1989. To date, some or the original CWA are degraded, therefore they were lowered in rank or removed from the list. Others, which maintain their wildlife value, were recommended to be maintained or upgraded and sought their conservation. Most Commonwealth forests, refuges, and reserves, as well as other areas, were included in the 2005 CWA document (Table 10; Figure 15). Each CWA was evaluated in relation to its faunal composition following the criteria used by Raffaele and Duffield (1979):

1) Is there one or more species unique to the locality and found nowhere else?
2) Is the site of particular importance for breeding, roosting, feeding, or some other behavior, even though the organism ranges elsewhere?
3) Is the site a center of abundance for game or endangered species?
4) Does the site have outstanding potential to be developed as (2) or (3) above?

Other categories for evaluating each CWA were the presence of species of limited distribution and/or game species. These categories are similar to those from Cardona and Rivera (1988):

1) Species considered endangered or threatened under the Federal Endangered Species Act of 1973, as amended.
2) Species considered endangered or threatened under the Regulation to Govern the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico (DRNA 2004).
3) Species of importance for hunting, even though their hunting is prohibited, and do not belong to the above categories.
4) Aquatic, wading and shorebirds, migratory or resident, which largely depend on coastal habitats up to about one kilometer inland.

The latest version of the Puerto Rico CWA (2005) has significantly improved its format. For each area, the following information is provided: Area Description, Ownership/Protection, Special Recognition, Wildlife (Birds, Reptiles, Amphibians, Mammals, Fishes, and Invertebrates), Critical Plants, Threats, Conservation Recommendations, References, and Maps.

The municipality, boundaries, geographic location, and land cover (hectares) of each CWA were identified for each area description. Also, a description of the topography, life zone and plant associations are given for each area. The owner and/or administrator, and any actual or potential protection were identified in the Ownership/Protection section. In the Special Recognition segment it was mentioned if the area was previously classified as a CWA or if it had any other recognition (e.g., Forest, Reserve, Important Bird Area, National Estuary, etc.). The area's present classification in terms of wildlife importance was included. The 1979 and 1988 documents were followed for classifying areas as of primary or secondary importance to wildlife.

Inventories available in the literature, forest or land manager's wildlife checklist, and censuses conducted by project personnel or other DNER researcher or by the Puerto Rico Ornithological Society Inc. were documented for the wildlife segment. Agricultural or domesticated species were not considered as wildlife. Scientific and common names were obtained from the Integrated Taxonomic Information System (ITIS 2005), from PR-GAP Terrestrial Vertebrates Species List (USFS 2004), and from NatureServe (2005). Wildlife considered in this document includes birds, reptiles, amphibians, mammals, fish, and invertebrates. Exotic species were also mentioned. Inventories of plants of special concern (rare, threatened or endangered) were included.

Past and current threats of each CWA, along with recommendations, are included in the Threats and Conservation Recommendations sections. These sections seek to identify main threats to the integrity of the CWAs, and recommend actions to protect and conserve wildlife habitat. The following methodology was used to accomplish this task: field observation, photo interpretation (IKONOS satellite images 2002), land manager interviews, and literature review. In the Reference section, a list of literature cited (published and unpublished) used for the documentation of each CWA is presented. Unpublished literature includes reports, memos, and checklist, among others.

For each area, two types of maps were included. The first map uses the USFWS National Wetland Inventories, the Puerto Rico Roads, and the Puerto Rico Forest and Reserve layers (Figure 16). The second map is the corresponding IKONOS satellite image (using the same projection) of the CWA (Figure 17). Municipality boundaries, Priority Areas for Conservation, and other reference data are also shown.

Table 10. Puerto Rico Critical Wildlife Areas (2005) and their respective locality (Municipalities).

AREA	LOCALITY
1- Cucharilla's Marsh	Cataño
2- Buchanan Haystack Hills and Fort Buchanan Pond	Bayamón
3- Torrecillas Swamp System-Piñones-Vacía Talega	Carolina-Loíza-Canóvanas
4- Barrio Borinquen, Trujillo Alto Lake, Bairoa Lake La 25, and Gurabo River Mouth	Trujillo Alto-Caguas-Gurabo
5- Baja Swamp and Herrera River Mouth	Río Grande
6- Ensenada Comezón	Río Grande
7- Río Mar, North of Road # 968	Río Grande
8- Luquillo Mountains	Luquillo
9- San Miguel, La Paulina and El Convento Natural Area	Luquillo-Fajardo
10- Laguna Grande, Laguna Aguas Prietas and adjacent areas	Fajardo
11- Fajardo Coast Line	Fajardo
12- La Cordillera Natural Reserve	Fajardo
13- Flamenco Peninsula	Culebra
14- Flamenco Lagoon	Culebra
15- Cornelius Lagoon	Culebra
16- Resaca Mountain	Culebra
17- Resaca Beach	Culebra
18- Brava Beach	Culebra
19- Larga Beach and Zoní Lagoon	Culebra
20- Maillux Lagoon	Culebra
21- Puerto del Manglar	Culebra
22- Los Caños	Culebra
23- Cementerio Bay	Culebra
24- Culebra's Surrounding Islets	Culebra
25- Vieques west coast	Vieques
26- Ensenada Honda Mangrove	Vieques
27- Yanuel Lagoon	Vieques
28- Chiva Swamp	Vieques
29- Tapón Bay	Vieques

Table 10 (Continued). Puerto Rico Critical Wildlife Areas (2005) and their respective locality (Municipalities).

AREA	LOCALITY
30- Ferro Bay, Mosquito Bay, and Sombe Bay	Vieques
31- East tip of Vieques and Conejo Cay	Vieques
32- Roosevelt Roads Naval Base	Ceiba
33- Ceiba State Forest	Fajardo, Ceiba and Naguabo
34- Humacao Natural Reserve	Humacao
35- Pandura Mountain Range	Yabucoa-Maunabo
36- Palmas Pond	Arroyo
37- Carite State Forest	Cayey
38- Cerro El Gato and Associated Areas	Cayey
39- Cidra Lake	Cidra
40- Aguirre State Forest, Punta Pozuelo, Cayos Caribe and Mar Negro	Guayama-Salinas-Santa Isabel
41- Punta Arenas	Salinas
42- Salinas Training Area	Salinas
43- Punta Petrona Mangroves and Caracoles	Santa Isabel
44- Cabuyón Mangrove and Fríos Cays	Ponce
45- Caja de Muertos Complex	Ponce-Juana Díaz-Santa Isabel
46- Serrallés Lakes	Juana Díaz-Ponce
47- Toro Negro State Forest	Ciales-Jayuya-Orocovis
48- Las Salinas Lagoon, El Tuque	Ponce
49- Monte Guilarte State Forest	Adjuntas-Guayanilla-Peñuelas-Yauco
50- Punta Verraco, Cerro Toro and Punta Ventana	Guayanilla
51- Guayanilla Hills	Guayanilla
52- Guánica Lagoon	Guánica
53- Guánica State Forest	Guánica
54- San Jacinto Salt Flats and Tamarind Lagoon	Guánica
55- Susúa State Forest and Adjacent Lands	Yauco-Sabana Grande
56- La Parguera Natural Reserve	Lajas
57- Cartagena Lagoon	Lajas
58- Boquerón State Forest	Cabo Rojo

Table 10 (Continued). Puerto Rico Critical Wildlife Areas (2005) and their respective locality (Municipalities).

AREA	LOCALITY
59- Boquerón Wildlife Refuge	Cabo Rojo
60- Cabo Rojo Salt Flats and Adjacent Areas	Cabo Rojo
61- Punta Guaniquilla Natural Reserve	Cabo Rojo
62- Joyuda Lagoon Natural Reserve	Cabo Rojo
63- Cuevas Lagoon	Cabo Rojo
64- Sabanetas Swamp-Boquilla Channel	Mayagüez
65- Maricao State Forest	Maricao
66- Mona Island	Mona
67- Monito Island	Monito
68- Pozo Hondo Swamp	Añasco
69- Cayures Swamp	Aguada
70- Desecheo Island	Desecheo
71- Barrio Coto	Isabela
72- Guajataca Cliffs	Isabela-Quebradillas-Camuy
73- Guajataca State Forest	Isabela
74- Guajataca Lake	Quebradillas
75- Barrio Cocos and Bellaca Creek	Quebradillas
76- Carrizales Mangroves	Hatillo
77- Tiburones Swamp and La Tembladera Pond	Arecibo
78- Cambalache State Forest	Arecibo
79- Río Abajo State Forest	Arecibo and Utuado
80- Hacienda La Esperanza Natural Reserve	Manatí
81- Tortuguero Lagoon, Cabo Caribe Swamp and Rica Lake	Vega Baja
82- Cibuco Swamp	Vega Baja
83- Vega State Forest	Vega Alta
84- Lakes and Forests of Dorado	Dorado
85- Mogotes Río Lajas y Nevárez	Dorado-Toa Baja
86- El Mameyal	Dorado
87- San Pedro Swamp	Toa Baja

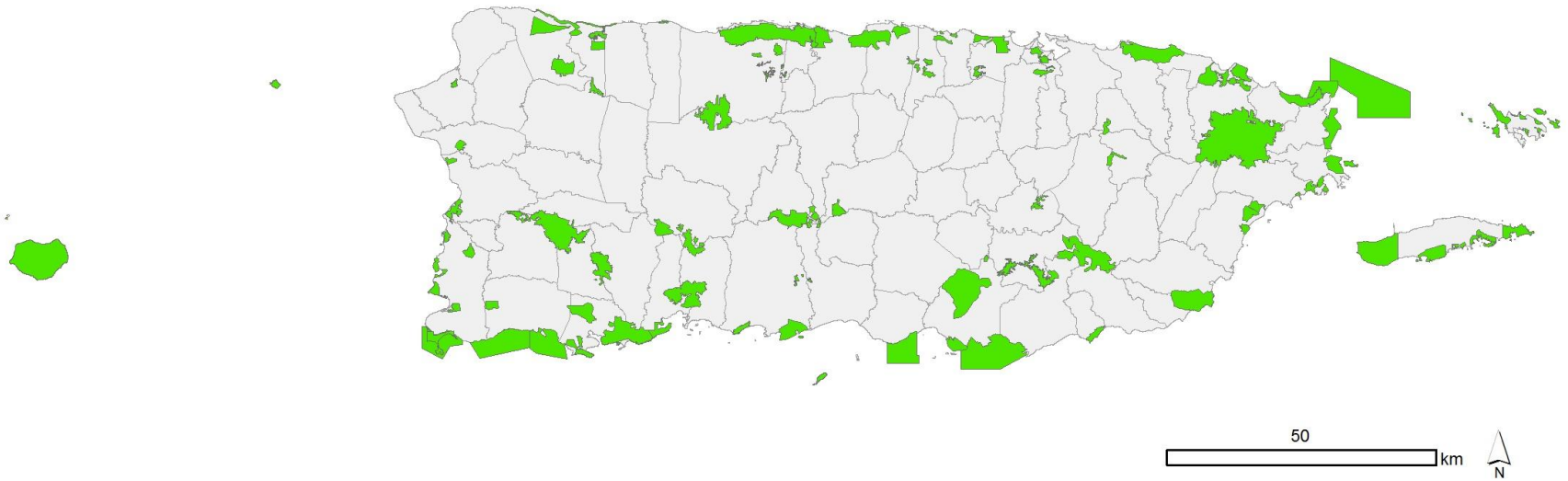


Figure 15. Puerto Rico Critical Wildlife Areas. From DNER 2015.

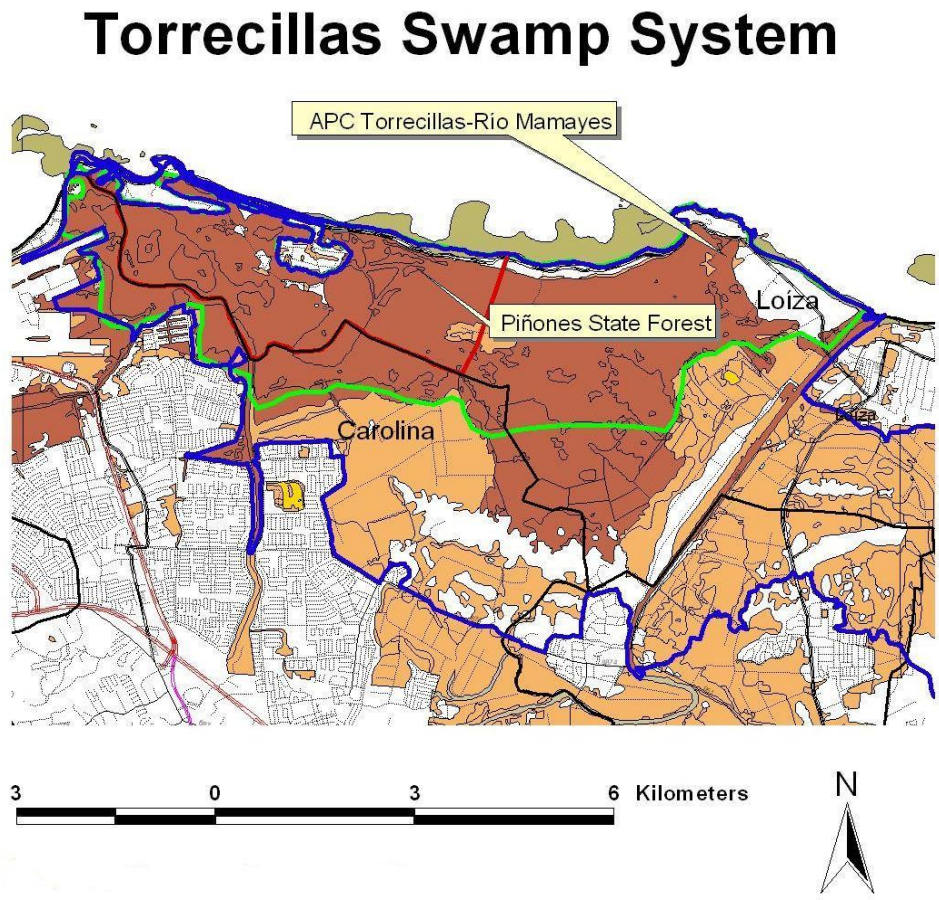


Figure 16. An example of a map included in the 2005 Critical Wildlife Areas document.

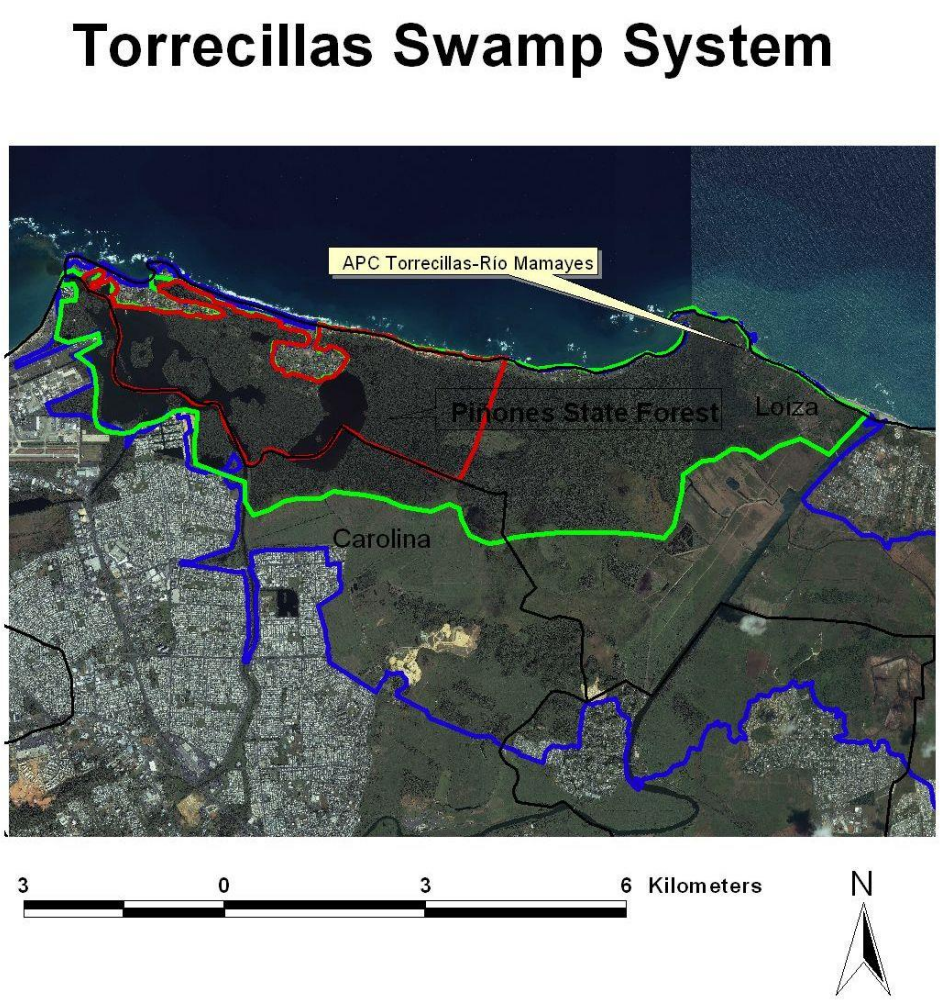


Figure 17. An example of a map included in the 2005 Critical Wildlife Areas document.

Comprehensive Land Use Plan

Puerto Rico faces a considerable number of challenges for sustainable land use planning. As a small island in the Caribbean, land is a scarce and highly valuable resource. Measuring 8,870 square kilometers with a population density of almost 450 inhabitants per square kilometer (in 2010, the U.S. Census estimated the island's population at approximately 3.7 million), one of the highest population densities in the world and the fourth highest in America, Puerto Rico is running out space and out of time (Center for Sustainable Development Studies 2009).

According to the classifications of the U.S. Census in 2000, 50% of the island is urban and 50% is rural. The majority of this population (94%) lives in urban areas. This is a significant change from 1900-1930, when almost 80% of the island's population was rural (U.S. Census Bureau, 1900-1930, 2000). Industrialization in Puerto Rico followed the United States model of suburban growth in the 1940's and 50's, and this paved the way for an accelerated urbanization of Puerto Rican society. Urban sprawl became one of its more evident consequences and one of the greatest threats to sustainability on the island (Center for Sustainable Development Studies 2009).

The Puerto Rico Land Use Plan, a long-delayed master blueprint designed to guide all future development, zoning and land conservation efforts on the island for the foreseeable future, was finished in January 2014.

The vision as to what the plan should represent has changed over time as well. At one point, the plan was intended to classify every piece of land in Puerto Rico as an area suitable for conservation or development into residential, commercial or industrial zones, and whether the jurisdiction of such-and-such area fell to the state government or municipalities. The latter issue has previously been a main point of contention, as previous drafts of the plan frequently contradicted municipal land use plans, also known as "planes de ordenamiento territorial", regarding the classification of certain lands. In many cases, decisions as to the intended use of certain areas were also based on outdated information regarding flooding and ecological sensitivity, among other issues.

The Land Use Planning Law (Law No. 550 of October 3, 2004) mandated the creation of this office, the development of the PRLUP, the creation of an Advisory Committee, and the creation of an Interagency Committee to develop the plan. In January 30th, 2014, the Puerto Rico Planning Board began the process and submitted the first draft of this Plan for public discussion, in a participatory process unprecedented on the island.

The goal of the 2014 PRLUP is to identify, evaluate and classify land uses for Puerto Rico in order to:

1. Give valuation to Puerto Rico, identifying the land according to their ecological, agricultural, equity landscapes, rural or urban.
2. Improve coordination of planning and development efforts by state agencies, public corporations and municipalities.
3. Encourage economic development and revitalization in municipalities, both urban and developable land as well as in rural settlements with the necessary infrastructure.
4. To preserve and promote at least 600,000 agricultural acres.
5. Prioritize planning the population increase for older adults and their needs, as well as the downward trend in the population.
6. Provide alternatives to accommodate housing needs and new developments, and engage without impacting agricultural soils, natural systems, watersheds, aquifers, heritage values and landscapes.
7. Encourage citizens to dwell in secure areas and that the necessary infrastructures are out of primary risk areas.
8. Establish guidelines and principles to be considered in local planning
9. To promote the equitable and sustainable development of Puerto Rico.
10. Take measures to adapt and mitigate climate change.

Land Classification and Categories for the PRLUP:

Categories:

1. Urban Land: Land consolidated by buildings and other structures, roads, water supply, electricity, and other infrastructure that serve it

up. Most of the social, administrative, and economic activities take place in these lands.

2. Urban Fringe Land: Land suitable for urbanization and development according to the expected population growth in a period of time:
    a. Programmed: Land served by infrastructure. This land will be developed first.
    b. Not Programmed: Land not served by infrastructure.

3. Rustic Land (Rural): Land that should be protected from urbanization:
    a. Common: Land that may accommodate growth in the long run.
    b. Specially Protected: Land for conservation, agricultural use, etc.

Identifying areas of hydrological importance

The primary objective in this landscape is to maintain and/or restore sufficient forest cover to extend the lifespan of existing water supply reservoirs. The target zones are areas upstream of existing reservoirs (Figure 18) as well as Hydrological Reserves (Table 11). Management activity will focus on lands where reforestation or other forest management will improve sediment and erosion control. The analysis was conducted by the DNER and the Office of the Land Use Plan of the Puerto Rico Planning Board. It considered precipitation intensity, slope, soil types, aquifer recharge zones, and land use in the preparation of the base map. Alternative and much more expensive responses to loss of reservoir capacity include new construction, hydraulic engineering, and continuation of existing dredging operations (DNER 2008-a).

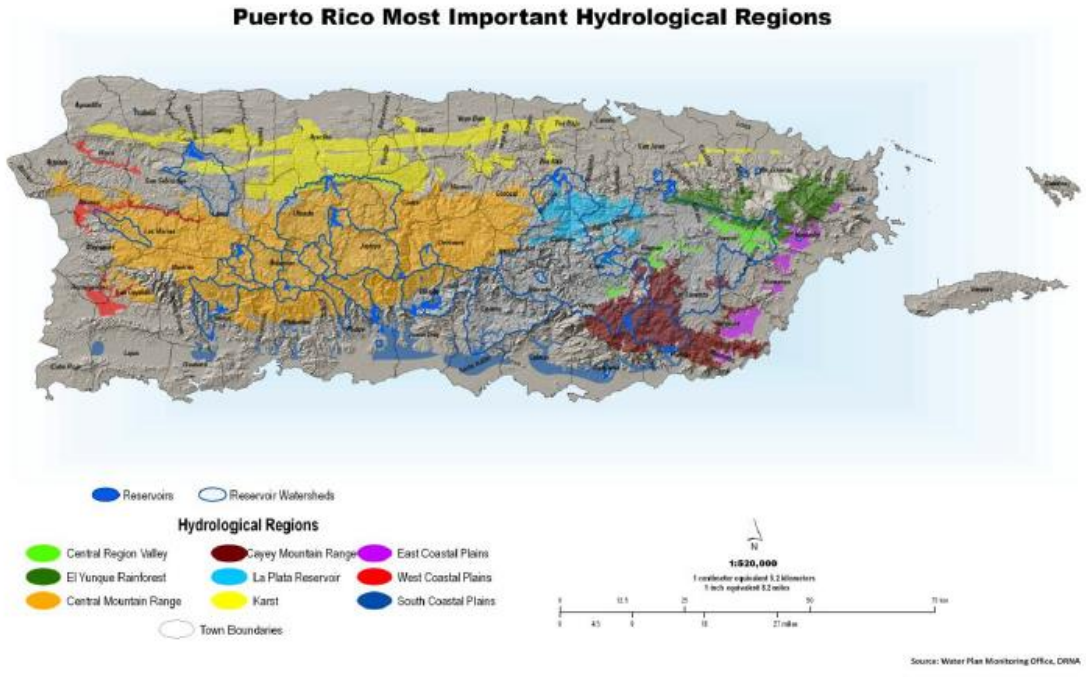


Figure 18. Hydrological regions in P.R. recommende for water quality protection by DNER and P.R. Planning Board (DNER 2008a).

Table 11. Hydrological Reserves in P.R.

I-Surface Hydrological Protection Areas	II-Groundwater Hydrological Protection Areas	III-Combined Hydrological Protection Areas (surface and groundwater
Cordillera Central Hydrological Reserve	Southern Coastal Plains Hydrological Reserve	Karst Hydrological Reserve
Sierra de Luquillo Hydrological Reserve	Eastern Coastal Plains Hydrological Reserve	Karst Hydrological Reserve
Sierra de Cayey Hydrological Reserve	Western Coastal Plains Hydrological Reserve	Karst Hydrological Reserve
La Plata Hydrological Reserve	Interior Plains Hydrological Reserve	Karst Hydrological Reserve

Conserving working forest landscapes

This goal encompasses the need to perpetuate the multiple values, uses and services provided by the Puerto Rico forest cover. These benefits may be protected or increased by implementing better conservation practices. The main objectives under this goal are:

• Identifying and conserving high priority forest ecosystems and landscapes in Puerto Rico currently under private control;
• Actively and sustainably managing private forested lands.

Table 12 shows the outputs, priority landscape, and the strategies in order to promote the forest landscape.

Table 12. Conserving Working Forest Landscapes (DNER 2010).

Outputs	Priority landscape	Strategies	Resources	Performance Measures
Recreation and Tourism	Public lands and surrounding private lands	-Continue land acquisition of key forested land by available mechanisms (USFS Forest Legacy Program) -Promote Conservation Easements on private forest land -Provide adequate conservation management to private forests through Forest Stewardship plans -Develop Forest and wildlife interpretation trainings	-USFS Forest Legacy Program -DNER PR Natural Heritage Program -DNER PR High Ecological Value Land Acquisition and Conservation Fund -USFS Forest Stewardship Program -NRCS Healthy Forest Reserve Program -USFWS State Wildlife Grant -PR Conservation Trust Land Acquisition Initiative	-High priority forest ecosystems and landscapes are protected from conversion (acres-annual and cumulative). -Number of acres in forest areas being managed sustainably as defined by current Forest Stewardship Management Plan -Number of interpretation trainings offered to private landowners and community members.
Wood products	Area around Toro Negro State Forest due to high risk of development.	--Continue land acquisition of key forested land by available mechanisms (USFS Forest Legacy Program) -Promote Conservation Easements on private forest land -Provide adequate conservation management to private forests through Forest Stewardship plans	-USFS Forest Legacy Program -DNER PR Natural Heritage Program -DNER PR High Ecological Value Land Acquisition and Conservation Fund -USFS Forest Stewardship Program -NRCS Healthy Forest Reserve Program -USFWS State Wildlife Grants Program -PR Conservation Trust Land Acquisition Initiative -PRIDCO PR Arts and Crafts Development Program	-High priority forest ecosystems and landscapes are protected from conversion (acres-annual and cumulative). -Number of acres in forest areas being managed sustainably as defined by current Forest Stewardship Management Plan (cumulative1) – through a Nationally consistent monitoring program.
Agroforestry products, Wood, fruit, medicinal products, craft products, shade grown coffee	Rio Loco Watershed/Guanica Bay Watershed	-Develop management information on agroforestry practices suitable to the Río Loco Watershed at Guánica Bay Watershed -Develop nursery quality standards (Work with nursery growers to provide quality nursery stock)	-USFS Forest Stewardship Program -NRCS Healthy Forest Reserve Program -USFWS State Wildlife Grant	-Number of educational fact sheets, talks, and training sessions offered to landowners and community members. -Number of nursery growers participating. -Number of nurseries producing high quality nursery stock.

Control, forest health, wood products, mulch, wildlife, green infrastructure, Recreation, safety, energy conservation, air quality improvement	Urban Areas and wildland urban interface.	-Increase capacity of communities to manage trees (i.e. promote municipal tree boards) -Increase tree canopy cover and condition. -Acquire community open space to protect key forested areas -Hazard tree mitigation. -Increase use of native plant material (native tree propagation and use) -Develop educational programs, activities (i.e. demonstration forests projects) -Develop nursery quality standards -Introduce agroforestry concepts -Promote arboriculture in University curricula	-USFS U&CF Community Cost-share Grants -NGOs Education Programs -Tree City USA -PR Via Verde Program -DNER Reforestation Programs -USFS Community Forest and Open Space Conservation Program -International Society of Arboriculture -Municipalities -Universities -DNER -PR U&CF council -UPR Extension Service -PR Association of Professional Arborists -College of Architects and Landscape Architects. -PR Correctional and Rehabilitation Department	-Number of cities protecting urban forests after working with U&CF to develop management plans and ordinances. -Number of cities and communities managing their urban forest. -Number of Municipal Tree Boards. -Number of cities participating of the Tree City USA Program. -Number of ISA Certified Arborists (private and public sector). -Number of communities participating of the Open Space Community Forest Program. -Number of nursery growers improving nursery protocols. -Number of nurseries producing high quality nursery stock. -Number of demonstration projects using high quality plant material and native species. -Number of arboriculture courses offered at the University of Puerto Rico in Mayaguez, College of Agriculture

Protecting forests and wildlife

This goal pursues the recognition of real threats affectingforested lands and its wildlife, and to identify ways to control or substantially reduce any harmful effects. Main threats with strong capacity of affecting present forest resources and wildlife in the island have been identified by the Puerto Rico Statewide Assessment of Forest Resources (DNER 2011) and are hereby presented in Table 13, followed by the strategies recognized as of great value under the objectives of this goal.

Table 13. Threats and management strategies for P.R. forests and wildlife.

Threats/(risk map)	Resources affected/resource effects	Strategies	Resources	Performance Measures
Fire fire map showing fire occurrence	Biodiversity, wildlife habitat and populations, water	-Create a database to collect information on fire occurrences recording: (1)	-PR Fire Department Fire Prevention	-Number of acres treated to restore fire-adapted ecosystems that are (1)

information)	quality, Air quality esp. in Urban environment, recreation experiences, coastal resources.	location, (2) type of vegetation, (3) number of acres affected, (4) resources used, and (5) resources needed -Develop and implement a Fire Danger Rating System for the areas with high wildland fires occurrences - Offer Fire prevention education to the communities within the areas with high wildland fire occurrences. Increase efforts on the forest-urban interface -Develop Community Wildfire Protection Plans and educational programs -Wildland Fire suppression -Use Prescribed Burning as a resource to control fire occurrences in areas with high fire incidence -Tree planting and resource restoration in areas affected by fires -Acquire, maintain, and preposition essential equipment and supplies for wildand fire suppression. -Develop an effective communication tool between partners involved in the suppression of wildand fires	Program -DNER Forest Service Bureau -USFWS -USFS -USFS Cooperative Fire Program -USFS Volunteer Fire Program	moved toward desired conditions and (2) maintained in desired conditions. -Total # of acres treated to reduce hazardous fuels on state and private lands through State Fire Assistance -Percentage of at risk communities reporting increased local suppression capacity as evidenced by: (1) The increasing number of trained and/or certified fire fighters and crews or (2) Upgraded or new fire suppression equipment obtained or (3) Formation of a new fire department or expansion of an existing department involved in wildland fire fighting.
Insect pests and disease	Loss and displacement of wildlife, decreased reproduction, stained wood, poor tree form, aesthetics, hazard trees, increased fire risk, fragmentation	-Establish a forest health monitoring program at the DNER Forest Service Bureau -Encourage early detection and rapid response from forest managers -Provide professional training to forest managers -Promote public education about possible detrimental effects on forest floristic components -Maintain adequate urban tree inventories and management practices -Promote Integrated Pest Management	-USFS Forest Health Monitoring Program -UPR Extension Service Forest Health Clinic and Diagnostics Lab -DNER Forest Health Program -UPRP -USFS	-Number and percentage of forest acres restored and/or protected from (1) invasive and (2) native insects, diseases and plants. -Percent of population living in communities developing or managing programs to plant, protect and maintain their urban and community trees and forests.
Development, Urban Sprawl, Fragmentation (consultation map, urban sprawl map).	Decreased and fragmented forest cover decreases the quantity and quality of all forest dependant values	-Protect large contiguous forest areas and corridors to ensure connectivity by: Land acquisition -Conservation easements -Adequate land use zoning -Voluntary protection -Encourage planting trees to increase canopy cover and create green corridors -Promote proper land use planning and accurate zoning on forested areas -Promote professional training about assessing forest cover and its benefits on agencies involved in determining present and future land use	-USFS Forest Legacy program -USFS Forest Stewardship Program Professionals who evaluate zoning, planning and permits -Municipalities -USFS Community Forest and Open Space Conservation Program -USFS U&CF Program -PR U&CF	-Number of communities and percent of population served under an active urban forest management plan. -Percent of population living in communities developing or managing programs to plant, protect and maintain their urban and community trees and forests. -Number of acquisitions completed that are instrumental for corridor protection. -Number of communities participating of the Community Forest Open

		-Increase program availabilities for the Eastern side of the Island by: (1) Increasing outreach, (2) Increasing Water Conservation (3) Enhancing Forest Diversity, (4) Enhancing all restored riparian habitats.	Council -International Society of Arboriculture -PR Association of Professional Arborists	Space Program.
Hurricanes/storms (Island-wide)	Biodiversity, wildlife, urban forest, forest products, recreation experiences, coastal resources	-Urban forest inventory -Tree Management Plan development -Hazard tree mitigation -Tree selection	-USFS U&CF Program -PR U&CF Council -International Society of Arboriculture -PR Association of Professional Arborists -Tree City USA -ITree (adapted to tropics) -FEMA Programs -PR Conservation Trust	-Number of communities and percent of population served under an active urban forest management plan. -Percent of population living in communities developing or managing programs to plant, protect and maintain their urban and community trees and forests.
Climate change (sea level rise map)	Coastal forests and wildlife, salinization of fresh water swamps, increase in fires, more intense storms, salt water intrusion, biodiversity, forest products, decreased recreational experiences	-Corridors for tree migration -Increase carbon storage through increases in tree cover - Urban forest inventory -Tree Management plan development -Hazard tree mitigation -Tree selection	-USFS U&CF Program -USFS Forest Stewardship Program -USFS Forest Legacy Program -USFS Community Forest and Open Space Conservation Program -International Society of Arboriculture -PR Association of Professional Arborists -Tree City USA -ITree (adapted to tropics) -PR Conservation Trust –UPR Marine Science Department	-Population of communities benefiting from S&PF activities designed to contribute to an improvement in air quality. -Population of communities benefiting from S&PF activities that result in energy conservation.
Flooding	Water quality, tree health, human safety, stream and bank erosion, erosion and sedimentation	-Forested wetland protection -Riparian buffer installations -Maintain and increase forest cover in catchment and groundwater recharge areas -Urban tree inventory and hazard mitigation	- USFS U&CF Program -USFS Forest Stewardship Program -International Society of Arboriculture -PR Association of Professional Arborists -PR Conservation Trust	-Percent of population living in communities developing or managing programs to plant, protect and maintain their urban and community trees and forests to mitigate the effects of flooding events.

Drought (See fire, see climate change)				
Invasive plants	Biodiversity, wildlife, displacement of native species	-Professional and public education -Promote native and other suitable species -Early eradication -Law enforcement -Early detection.	-Nursery growers and buyers, -DNER -Puerto Rico Forest Health Advisory Committee -USFS Forest Health Program -San Juan Bay Estuary Program -Puerto Rico Conservation Trust -PR Department of Agriculture	-Number and percent of forest acres restored and/or protected from (1) invasive and (2) native insects, diseases and plants (annual).
Invasive animals	WL habitat, egg predation, rare pant seedling recruitment	-Law enforcement -Public education	-DNER -San Juan Bay Estuary Program -Puerto Rico Conservation Trust -Lion Fish Control Program	-Number and percent of forest acres restored and/or protected from (1) invasive and (2) native insects, diseases and plants (annual

Enhancing benefits to the public associated with forests and wildlife.

There are several objectives under this goal, which focuses on maximizing the profitable social, environmental and economic services trees and forests provide to the community. Objectives include:

- protecting and enhancing water quality and quantity;
- improving air quality and conserving energy;
- assiststing communities in planning for and reducing forest health risks;
- maintaining and enhancing the economic value and benefits of trees;
- protecting, conserving and enhancing wildlife and fish habitat;
- connecting people to trees and forests, and engaging in environmental stewardship activities
- managing trees and forests to mitigate and adapt to global climate change.

Strategies of great value for these goals are summarized in Table 14.

Table 14. Enhance public benefits associated with forests and wildlife (DNER 2010).

Benefits	Priority area	Strategy	Resources	Performance measures
Water Quality Benefits	-Riparian areas around rivers and reservoirs. -Aquifer Recharge areas -Upland Catchments	-Continue encouraging reforestation -Maintain and manage existing forest	-DNER reforestation program -USFS Forest Stewardship Program -NRCS Healthy Forest Reserve Program -USFWS State Wildlife Grant -NRCS Wildlife Habitat Incentive Program	-Acres and percent of priority watershed areas where S&PF activities are enhancing or protecting water quality and quantity.
Coastal Resources	-Through all PR Coastal Zone (1 km from the sea) -Existing forested wetlands (i.e.mangrove and or swamps, etc.), -Coastal upland remnants	-Continue encouraging reforestation -Maintain and manage existing forest	-COE Wetland Banking -USFS Forest Stewardship Program -NRCS Healthy Forest Reserve Program -USFWS State Wildlife Grant -NRCS Healthy Forest Reserve Program	-High priority forest ecosystems and landscapes are protected from conversion (acres-annual and cumulative). -Number of acres in forested areas being managed sustainably as defined by current Forest Stewardship Management Plan
Wildlife habitat	-Coastal upland forest remnants -Mature forest habitats -Corridors that link mature forest areas (i.e. riparian areas along streams, -Corridors required under CommonwealthLaw Number 14 of 1999 -Threatened and Endangered Species habitat.	-Private forested land acquisition by several means including Forest Legacy Program -Encourage Conservation Easements -Promote voluntary private land conservation management. -Provision of proper management on public forested lands -Continue land acquisition programs to conserve mature forest -Promote and Encourage agroforestry practices(Sun coffee plantations to shade grown coffee) -Establish Maricao Commonwealth Forest and a 5 mile buffer (including Susúa Commonwealth Forest)	-Forest Legacy Program -DNER PR Natural Heritage Program -DNER PR High Ecological Value Land Acquisition and Conservation Fund -USFS Stewardship Program -NRCS WHIP, EQUIP -US F&WS Partners for WL -Federal and State agencies management -NRCS Healthy Forest Reserve Program -NRCS Wildlife Habitat Incentive Program	-High priority forest ecosystems and landscapes are protected from conversion (acres-annual and cumulative). -Number of acres in forest areas being managed sustainably as defined by current Forest Stewardship Management Plan -Detectable increases in frequency numbers of priority critical species for WHIP. -Establishment of wild reproductive couples of Puertorrican Parrot in Maricao Commonwealth Forest. -Increase of riparian forests under conservation practices. -Reduction of predator numbers on Maricao Commonwealth Forests and its 5 mile buffer zone. -Increase the number of ecological corridors created

				between public and private forested land.
Plant biodiversity	Public forested lands	-Private forested land acquisition by several means including Forest Legacy Program -Promote voluntary private land conservation management.	-USFS Forest Legacy Program -USFS Community Forest and Open Space Conservation Program -Conservation Easement Commonwealth Law -DNER Puerto Rico Natural Heritage Program -DNER High Ecological Value Land Acquisition and Conservation Fund -NRCS Wildlife Habitat Incentive Program -NRCS Healthy Forest Reserve Program -USFS Forest Stewardship Program -USFWS State Wildlife Grant -NRCS Wildlife Habitat Incentive Program	-High priority forest ecosystems and landscapes protected from conversion (acres- annual and cumulative). -Number of acres in forest areas being managed sustainably as defined by current Forest Stewardship Management Plan
Carbon Sequestration	Private forested land	-Retain forest cover -Manage for forest health and growth -Forest products benefits to incentivize protecting and enhancing cover	-USFS Stewardship Program -USFS Forest Legacy Program -USFS Community Forest and Open Space Conservation Program -Conservation Easement Commonwealth Law -Forest Legacy Program -NRCS Healthy Forest Reserve Program	-Population of communities benefiting from S&PF activities designed to contribute to an improvement in air quality. -Population of communities benefiting from S&PF activities that result in energy conservation

Marine Mammals Rescue Program

The DNER established the Marine Mammal Rescue Program in 2007. The program leads and coordinates the actions from the different governmental and non-governmental entities during emergency situations involving marine mammas, including stranding events and necropsies. The program is also in charge of establishing agreements with stakeholders interested in marine mammal conservation, maintaining a mortality database, implementing management actions to protect the marine mammals and their habitat. These

include the deployment of buoys to regulate vessel speeds, the design and implementation of an outreach program, addressing emerging threats, oversee compliance agreements between participating entities, evaluate and analyze causes of death and maintain a sighting and population survey database.

CHAPTER 6. HABITATS OF GREATEST CONSERVATION NEED

Terrestrial Habitats

General

Habitat loss is the major threat to wildlife in terrestrial ecosystems. The most important habitats for conservation have been identified by the Nature Conservancy'sEcoregional Plan for Puerto Rico, and the DNER through the Natural Heritage Program and the Critical Wildlife Areas Initiative. The DNER completed an island-wide comprehensive habitat analysis for the PRSWAP. This task was the final result of the Puerto Rico GAP Analysis Program (PRGAP). This project developed a landcover/landuse map representing the Puerto Rico landscape, and modeling animal species distribution. PRGAP uses remote sensing and GIS technology, satellite imagery, aerial photography, and geoclimatic and topographic data to map the land cover units for the Island. Each land cover unit description includes information and references on the composition, structure, and ecology of the dominant plant communities of that unit. Table 6 presents the hierarchical vegetation classification for the PRGAP.

Helmers et al. (2002) found that only 1.2% of lowland moist seasonal evergreen forest or forest/shrub is protected. Some forest types are better protected, including 45 to 68% of cloud forests and 43 to 80% of the sclerophyllous forests that develop on serpentine substrates. Excluding riparian wetlands, about 20% to 63% of remaining forested or non-forested wetlands receive protection.

Caves

Puerto Rico has approximately 2,000 caves, which harbor a great array of species that are totally dependent or are associated to the biotic and abiotic conditions found in the habitat they provide. The formation of caves and caverns

in Puerto Rico occurs mainly due to the weathering of the limestone rock by the underground water or water that filters through rocky ceiling.

Urban Forest

Urban forests are forested ecosystems characterized by a high concentration of human influences (Dwyer et. al. 2000). They capture significant levels of carbon and represent important economic benefits including tourism, nursery production, food production, pharmaceuticals for research as well as some wood and non-wood products (National Urban and Community Forestry Advisory Council 2008).

The types of trees and plant associations in urban forests vary with regional and local environmental conditions and human activities. Native, exotic and naturalized plants and animals, ground cover, buildings, and human activities affect the character and values associated with an urban forest. Vegetation within urban environments is important in providing wildlife habitat, environmental services related to water, heat control, air quality, temperature regulation, and carbon storage. They provide oxygen, shade, food, and attributes important to human well-being. Recent studies reveal the psychological benefits of trees helping people adjust to their societies. (Kuo and Sullivan 2001). In addition properties and neighborhoods with well developed tree cover are appraised higher.

Martinuzzi et al. (2007) estimated developed land, land use, and urban sprawl across the Puerto Rico landscape and explained important distinctions among urban land classification schemes (Table 15). Depending on the classification, between 11 and 50% of Puerto Rico could be called “urban”. They found that most urban areas exist on the coastal plains, lower hills and valleys, and that urban sprawl is occurring at low elevations, over flat topography and close to roads and existing urbanized areas.

Table 15. Definitions of urban and related classifications and the percentage of land in each class in P.R. (Martinuzzi et al. 2007).

Classification	% in class	Definition
Urban/built-up cover or developed land	11%	Developed and non-vegetated surface that results from human activity (built structures, concrete, asphalt, buildings, barrens, roads, some of which occur in rural areas.)
Urban use setting	16%	Includes development and undeveloped lands that are part of the urban landscape and excludes development that is part of a non-urban setting. (urban centers, exurban agglomerations, industrial areas, large isolated residential complexes, port, airports, parklands and urban forests)
Census Bureau Urban Area	50%	Census block with a population density of at least 1000 people/ mi^2 (390 people/ km^2) plus surrounding census blocks with at least 500 people/mi^2 (195 people/km2)
Urban sprawl	40%	Low density construction and areas with significant land consumption

Source: US Census Bureau (2000). Urban and rural classification. http://www.census.gov/geo/ohim/hs01/mv1.htm.

Freshwater Habitats

General

There are numerous rivers and streams on Puerto Rico's main island. There are reservoirs but no freshwater inland lakes. Seventy eight percent of water in Puerto Rico comes from surface sources and 22% comes from groundwater sources. Fifty five rivers discharge directly into the sea. Problems with freshwater ecosystems are a major environmental issue in Puerto Rico. Water pollution, siltation of reservoirs, and excessive withdrawals of fresh water from rivers are associated with the growing human populations of the Island. Unauthorized wetland filling is alsoa substantial and continuing problem (U.S.

Department of the Interior 1994). Detailed descriptions of the freshwater communities in Puerto Rico are available (U.S. Army Corps of Engineers 1978).

According to the Puerto Rico Gap Analysis Project, Puerto Rico has 34,000 ha (4%) of coastal wetlands, of which 42% are saline wetlands and 58% are freshwater wetlands. Among the freshwater wetlands, 74% (25,100 ha) are dominated by herbaceous vegetation and 92% (23,000 ha) are seasonally flooded. Of the herbaceous wetlands, 77% (19,300 ha) are not saline and 23% (58,000 ha) are salty. Forested coastal wetlands cover approximately 1% of the Commonwealth's territory, of which 6,700 ha are mangroves and 300 ha are bloodwood swamps also known as *Pterocarpus* forests (Gould, et al. 2008).

Rivers and Streams

Puerto Rico has about 1,200 rivers, streams, and creeks. None of the rivers are navigable by large vessels (Wiley and Vilella 1998). Only twenty of these rivers have a permanent minimum water flow of at least 0.28 cubic meters per second and are relatively important to the island's fishery. Major river systems are the Río Grande de Loíza (64 km), Bayamón (41 km), La Plata (73 km), Arecibo (64 km), Culebrinas (40 km), and Añasco (65 km). The profile of the streams changes radically from rapidly flowing in the steep mountains to slower and more winding courses across the narrow coastal plain, creating habitats for fish and other aquatic wildlife. Many fishes migrate up or downstream to or from saltwater habitats (Wiley and Vilella 1998). Some rivers are dammed principally for water uptakes and thus have small lakes along their courses. The majority of the main rivers are either channelized or in process of canalization, mostly for flood control. These constructions obstruct the natural movement of native fishes along the rivers, and are together with pollution, the major threats to these aquatic systems.

Riparian forest

Riparian areas are the lands adjacent to a body of water, stream, river, marsh, or shoreline. These areas form the transition between the aquatic and the terrestrial environment. A riparian area may include several riparian ecosystems. Riparian ecosystems include the soil, surface structure (woody debris, rocks, depressions), and the plant and animal communities. Because of their position in the landscape, riparian areas interact with the flow of surface and groundwater from upland areas, and play an important role in filtering runoff, reducing excess nutrients and other pollutants, and providing critical ecological values such as shade, food, and structural habitat. Species abundance and richness tends to be greater in riparian ecosystems than in adjacent uplands (Odum 1979). Although healthy riparian vegetation of any kind is desirable, forests provide the greatest number of benefits and highest potential for reaching both water quality and living resource goals. As functional ecosystems, they have large energy, nutrient, and biotic interchanges with aquatic systems on one side and with upland terrestrial ecosystems on the other. Their linear nature and high edge-to-area ratios contribute to this functionality, which is why riparian areas are best evaluated and managed as parts of larger landscapes.

Streamside forests are important riparian areas. Under natural conditions, these forests would protect most of the rivers and streams in our land, but deforestation associated with agricultural and urban expansion has drastically reduced their extent. In agricultural areas, many floodplain forests have been reduced to isolated fragments no longer capable of supplying the river with essential woody debris or an adequate organic food supply for healthy fisheries. The linkage between streamside forests and the health of fish stocks may stretch to ocean fisheries where the natural process of delivering large quantities of wood from the watershed to the sea has essentially been severed (Maser and Sedell 1994).
Riparian forests can help remove or ameliorate the effects of pollutants in runoff, and increase the biological diversity and productivity of aquatic communities by

improving habitat and adding to the organic food base. Riparian forests can also play a large role in buffering urban and agricultural development. When conserved and managed as buffers, riparian forests can dramatically reduce the impacts of land use activities (Welsch 1991). In fact, studies show dramatic reductions from 30 to 98 percent in nutrients, sediments, pesticides, and other pollutants in surface and groundwater after passing through a riparian forest buffer (Lowrance et al. 1984).

Reservoirs

Puerto Rico has no natural inland bodies of fresh water (lakes), but 20 reservoirs, varying from 6 to 390 surface hectares, have been constructed as a source of potable water, irrigation, electrical power, and flood control (Figure 19). The associated reservoirs are the main surface water source in Puerto Rico (DNER 2008-a). During 2004, reservoirs provided 370 mgd of waters for domestic use and over 32 mgd for agricultural purposes. Jointly, reservoirs account for 55 per cent of fresh water extraction on the island. Thus preservation of reservoir capacity is an important management objective.

Figure 19. Distribution of reservoirs in P.R. From DNER 2015.

The larger native shrimps, gobies, and Mountain Mullet may come into some of the reservoirs from the rivers. Several game fish, including Peacock Bass, Largemouth Bass, and Channel Catfish, have been introduced into Puerto Rican reservoirs (Wiley and Vilella 1998), representing the only important freshwater sportfish.

Artificial Freshwater Bodies

Ponds are important habitats in Puerto Rico, almost all are artificial and mostly intended for irrigation, livestock, or aesthetic reasons. Most go dry at some point during the year. Fish are stocked in some of these ponds for sport fishing and for mosquito and weed control. Channels irrigating sugarcane fields also are important habitats for fishes and aquatic invertebrates.

Lagoons

All of Puerto Rico's lagoons have shallow water, usually with mud bottoms, are weedy over large stretches, and if brackish or salty, are surrounded by mangrove forests (Figure 20). Cartagena Lagoon, one of the most important wetland habitats in in Puerto Rico (Danforth 1926), has been greatly degraded by nearby agricultural practices. This lagoon has recently been acquired by the USFWS and its restoration is proposed. Other important lagoons include Joyuda, San José, Torrecillas, Tortuguero, and Piñones.

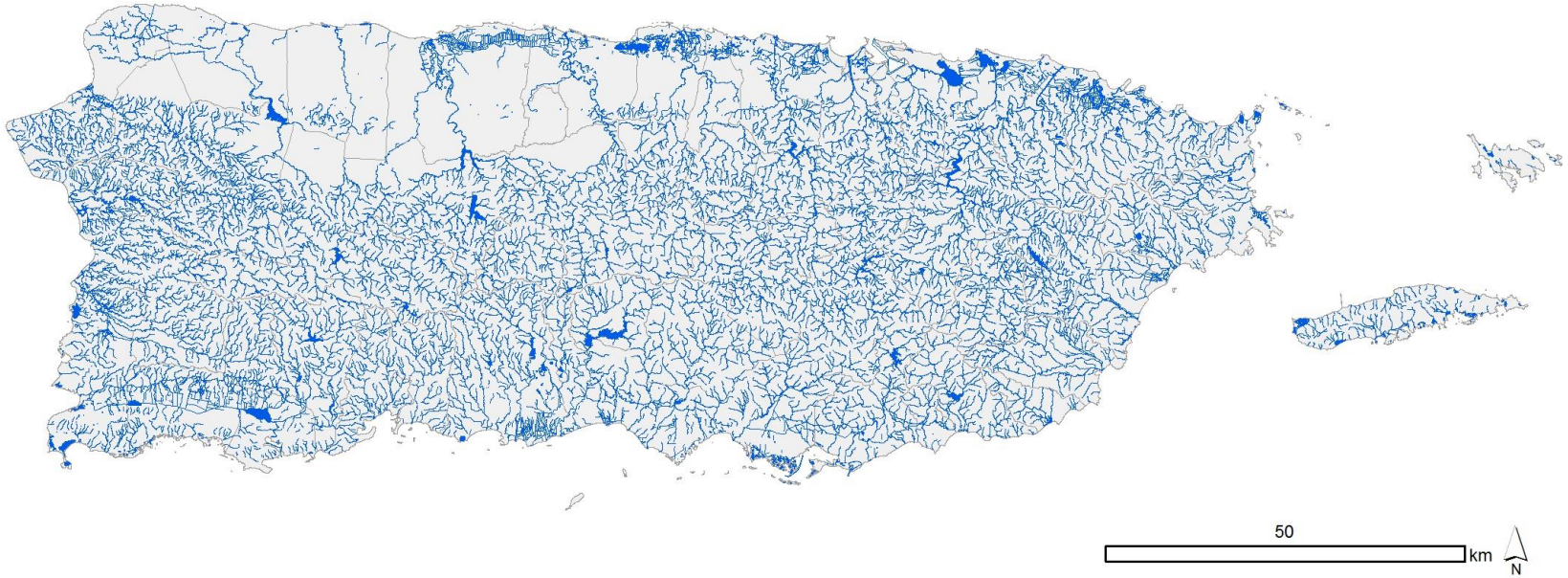


Figure 20. Puerto Rico freshwater habitats. From DNER 2015.

Mangrove forests

Mangroves are particularly important coastal forests due to their variety of functions and services they provide (Puerto Rico Coastal Zone Management Program 2009). Mangroves are found along the coast of Puerto Rico in wetlands subject to salt water intrusion and provide many ecosystem services. They buffer coastlines against the onslaught of wind caused by weather events. They serve as wildlife refuges, fisheries, and nurseries for marine life and they serve as sources and natural filters to purify water. These characteristics distinguish mangroves as coastal systems of high ecologic and economic value. Between 70% and 90% of marine life with commercial or recreational value uses mangroves for at least part of their respective life cycles (DNER, 2003). Mangroves are also part of the habitat for native and migratory birds, including birds which are on the federal list of endangered species.

Mangroves can be degraded or destroyed by activities such as drainage, dredging, filling, sedimentation, and oil spills. Land filling, which affects hydrology, is most serious threat mangroves and adjacent lands currently face.. Despite the massive destruction of these systems in the first decades of the 20th century, mangrove coverage is increasing due to new legal protections.

Saltwater Habitats

Coral Reefs

Coral reefs and rock reef communities are productive marine ecosystems, and are well represented in Puerto Rico (Table 16). They provide habitat for a large number and variety of fish and invertebrates. Coral reefs protect coastlines from wave action. They are a primary source of carbonate sand. They promote the deposition of sand on beaches as well as the formation of seagrass beds and mangroves. They serve as buffers against coastal erosion.

Puerto Rico is surrounded by approximately 500,000 ha of easy access coral reefs (reefs less than 20 meters deep) (CSOR, 2005). Some 228 species of corals have been identified in the territorial waters, including: 117 *scleractinian* corals (rocky), 99 *antipatharia* corals (black or spiny), 13 *corallimorpharia* (fungi type coral), three fire corals and five hydrocorals (DNER, 2000). These coral reefs are formed mainly by three types of structures: fringing or marginal reefs (which are the most common), bank reefs and barrier reefs.

Living coral reefs are present around Puerto Rico, but a large number are degraded, largely because of increased sediment and nutrient discharge resulting from anthropogenic modifications of the densely populated island. These modifications are associated with intensive land clearing, agricultural and industrial development that accompany a steady increase in the standard of living (Goenaga and Cintrón, 1979; Morelock et al. 1980, 1983, 1985; Rogers, 1990; Acevedo and Morelock, 1988; Clark and Wilcock, 2000; Larsen, 2000; Larsen and Santiago-Román, 2001; Torres and Morelock, 2002; Weil, 2004, Warne et al. 2005).

Table 16. Area of coastal wetland types (López 2007).

System	Definition	Hectares
Marine	Area exposed to sea waves and sea currents with a water salinity greater than 30-35 parts per thousand (e.g. coral reefs seagrass beds).	23,642
Estuarine	Area affected by the tide with low energy waves, where the water salinity is greater than 0.5 parts per million (e.g. saltpeter beds, mangroves and coastal rivers).	31,947
Palustrine	Areas in freshwater that may be subject to the ebb and flow of tides. Persistent trees, shrubs, and herbaceous plants. Upright and entrenched, submerged and/or floating plants predominate in them. (e.g. swamps, marshes, wet meadows, shallow ponds).	31,555
Total		87,144

Initiatives to Identify Areas of Greatest Conservation Need

Natural Heritage Program

Fifty conservation priority areas (covering about 319,631 acres) have been identified by the NHP of the DNER (e.g., the northern karst region; Figure 21). The mechanisms used by the NHP to obtain their objectives are the following:

- Land acquisition by way of purchase, donation, lease, or public land title or management transfer.
- Agreements and Contracts.
- Funding, both recurring and non-recurring.
- Joint projects between the Puerto Rico Natural Heritage Program and NGOs.

Areas of greatest importance for protection of ecosystems and viable populations of native species are shown in Figure 22.

Figure 21. The norther karst region, an area of conservation priority identified by the DNER.

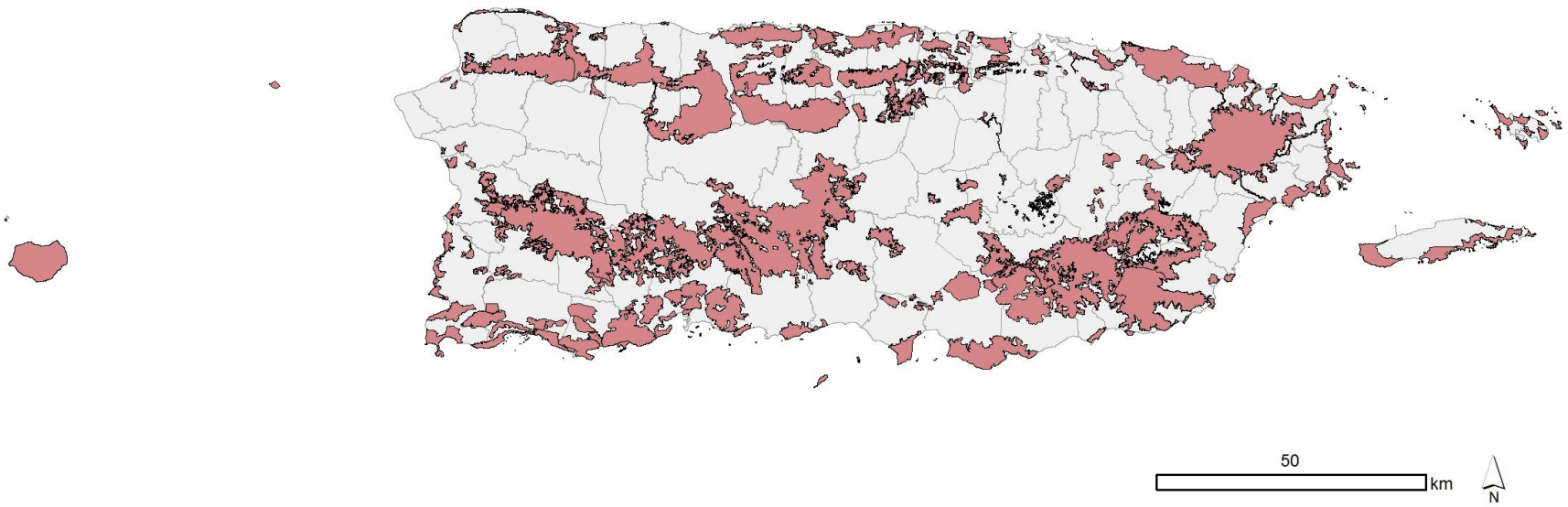


Figure 22. Areas of Conservation Priority identified by the Natural Heritage Program. DRNA 2015.

Critical Wildlife Areas

The third source of information used in lieu of a comprehensive statewide landscape analysis is the target species found in those zones classified as a CWA. The CWA effort identifies areas within Puerto Rico that are necessary to perpetuate the existence of species of special interest for DNER. The CWA identifies public lands as priorities for conservation, lands which DNER considers important wildlife habitat. Table 17 shows target species found in each CWA. Below (Figure 23) is the Plain Coqui (*Eleutherodactylus juanriveroi*), which was discovered in 2005 (northern Puerto Rico). Although DNER is currently working on designating critical habitat for this species, the USFWS has already completed this process.

Figure 23. Plain Coqui (*Eleutherodactylus juanriveroi*).

Table 17. Data Deficient, Vulnerable, Endangered or Critically Endangered species found in each CWA of P.R.

AREA	ENDANGERED AND VULNERABLE SPECIES
Cucharilla's Marsh, Cataño	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
	Caribbean Coot-*Fulica caribaea*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Masked Duck-*Nomonyx dominicus*
	Brown Pelican-*Pelecanus occidentalis*
	Fishing Bat-*Noctilio leporinus*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican vireo-*Vireo latimeri*
	Piping Plover-*Charadrius melodus*
Buchanan Haystack Hills and Fort Buchanan Pond, Bayamón ,	Ruddy Duck-*Oxyura jamaicensis*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto RicanOriole-*Icterus portoricensis*
	Adelaide's Warbler-*Setophaga adelaidae*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Puerto Rican Boa-*Chilobotrus inornatus*
	Puerto Rican Slider-*Trachemys stejnegeri*
Torrecillas Swamp System Piñones-Vacía Talega, Carolina-Loíza-Canóvanas - ,	Brown Pelican-*Pelecanus occidentalis*
	Least Tern-*Sterna antillarum*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Masked Duck-*Nomonyx dominicus*
	Caribbean Coot-*Fulica caribaea*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Yellow Warble-*Setophaga petechia*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican Boa-Chilobotrus inornatus
	Leatherback Sea Turtle-*Dermochelys coriacea*
	Hawksbill Turtle-*Eretmochelys imbricata*
	West Indian Manatee-*Trichechus manatus*
	Juey Palancú-*Cardisoma guanhumi*
	Camarón Palaí-*Macrobrachium carcinus*
	Mangrove Crab-*Aratus pisoni*
	Cangrejo de Mangle-*Goniopsis cruentata*
Bo. Borinquen, Trujillo Alto Lake, Bairoa Lake La 25 and Gurabo River Mouth, Trujillo Alto-Caguas-Gurabo	Caribbean Coot-*Fulica caribaea*
	Least Grebe-*Tachybaptus dominicus*
	Puerto Rican Plain Pigeon-*Patagioenas inornata*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieillot*
Baja Swamp and Herrera River Mouth, Río Grande ,	White-cheeked Pintail-*Anas bahamensis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Ruddy Duck-*Oxyura jamaicensis*
	Masked Duck-*Nomonyx dominicus*
	Juey Palancú-*Cardisoma guanhumi*

AREA	ENDANGERED AND VULNERABLE SPECIES
Ensenada Comezón, Río Grande	Brown Pelican-*Pelecanus occidentalis*
	Caribbean Coot-*Fulica caribaea*
	Piping Plover-*Charadrius melodus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Nassau Grouper-*Epinephelus striatus*
	Juey Palancú-*Cardisoma guanhumi*
	Mangrove Root Crab-*Goniopsis cruentata*
	Zambuco-*Ucides cordatus*
	Mangrove Crab-*Aratus pisoni*
Street # 968, Río Mar, Rio Grande	Puerto Rican Boa-*Chilobotrus inornatus*
	Virgin Island Tree Boa-*Chilobotrus granti*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
Luquillo Mountains, Luquillo	Sharp shinned Hawk-*Accipiter striatus*
	Broad-winged Hawk-*Buteo platypterus*
	Puerto Rican Parrot-*Amazona vittata*
	Puerto Rican vireo-*Vireo latimeri*
	Puerto Rican Oriole *Icterus portoricensis*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Elfin Woods Warbler *Setophaga angelae*
	Adelaide's Warbler-*Setophaga adelaidae*
	Puerto Rican Boa-*Chilobotrus inornatus*
	Puerto Rican Coqui-*Eleutherodactylus portoricensis*
	Ground Coqui-*Eleutherodactylus richmondi*
	Tree hole Coqui-*Eleutherodactylus hedricki*
	Mottled Coqui-*Eleutherodactylus eneidae*
	Web footed Coqui-*Eleutherodactylus karlschmidti*
	Free tailed Bat-*Tadarida brasiliensis*
	Cave Bat-*Brachyphylla cavernarum*
	Greater Antillean Long-tongued Bat-*Monophyllus redmani*
	Red fruit Bat-*Stenoderma rufum*
San Miguel, La Paulina and El Convento Natural Area, Luquillo-Fajardo	West Indian Whistling Duck-*Dendrocygna arborea*
	Masked Duck-*Nomonyx dominicus*
	Ruddy Duck-*Oxyura jamaicensis*
	Puerto Rican Plain Pigeon-*Patagioenas inornata*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Brown Pelican-*Pelecanus occidentalis*
	Least Grebe-*Tachybaptus dominicus*
	Adelaide's Warbler-*Setophaga adelaidae*
	Yellow Warble-*Setophaga petechia*
	Caribbean Coot-*Fulica caribaea*
	White-cheeked Pintail-*Anas bahamensis*
	Least Tern-*Sternulla antillarum*
	Snowy Plover-*Charadrius alexandrinus*
	Piping Plover-*Charadrius melodus*
	Roseate Tern-*Sterna dougalli*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican Boa-Chilobotrus inornatus
	Virgin Island Tree Boa-*Chilobotrus granti*
	Leatherback Sea Turtle-*Dermochelys coriacea*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Hawksbill Turtle-*Eretmochelys imbricata*
	Puerto Rican Slider-*Trachemys stejnegeri*
	West Indian Manatee-*Trichechus manatus*
	Schoepfia arenaria
	Cobana Negra *Stahlia-monosperma*
	Beautiful Goetzea-*Goetzea elegans*
	Bloodwoodtree-*Pterocarpus officinalis*
Laguna Grande, Laguna Aguas Prietas and adjacent areas, Fajardo	West Indian Whistling Duck-*Dendrocygna arborea*
	Brown Pelican-*Pelecanus occidentalis*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Caribbean Coot-*Fulica caribaea*
	Adelaide's Warbler-*Setophaga adelaidae*
	Yellow Warble-*Setophaga petechia*
	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
Fajardo Coast Line, Fajardo	Green Sea Turtle-*Chelonia mydas*
	Leatherback Sea Turtle-*Dermochelys coriacea*
	Hawksbill Turtle-*Eretmochelys imbricata*
	White-cheeked Pintail-*Anas bahamensis*
	Brown Pelican-*Pelecanus occidentalis*
	Roseate Tern-*Sterna dougalli*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Yellow Warble-*Setophaga petechia*
	West Indian Manatee-*Trichechus manatus*
La Cordillera Natural Reserve, Fajardo	Roseate Tern-*Sterna dougalli*
	Brown Pelican-*Pelecanus occidentalis*
	White-cheeked Pintail-*Anas bahamensis*
	Roseate Tern-*Sterna dougalli*
	Virgin Island Tree Boa-*Chilobotrus granti*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Green Sea Turtle-*Chelonia mydas*
	Slippery-backed Mabuya-*Mabuya mabouya*
Flamenco Peninsula, Culebra Island	Slippery-backed Mabuya-*Mabuya mabouya*
	Roseate Tern-*Sterna dougalli*
Flamenco Lagoon, Culebra Island	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
	Caribbean Coot-*Fulica caribaea*
	Least Grebe-*Tachybaptus dominicus*
	White-crowned Pigeon-*Patagioenas leucocephala*
Cornelius Lagoon, Culebra Island	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
	Masked Duck-*Nomonyx dominicus*
	Brown Pelican-*Pelecanus occidentalis*
Resaca Mountain, Culebra Island	Culebra Iisland GiantAnole-*Anolis roosevelti*
Resaca Beach, Culebra Island	Leatherback Sea Turtle-*Dermochelys coriacea*
	Hawksbill Turtle-*Eretmochelys imbricata*
Brava Beach, Culebra Island	Leatherback Sea Turtle-*Dermochelys coriacea*
	Hawksbill Turtle-*Eretmochelys imbricata*

AREA	ENDANGERED AND VULNERABLE SPECIES
Larga Beach and Zoní Lagoon, Culebra Island	Leatherback Sea Turtle-*Dermochelys coriacea*
	Hawksbill Turtle-*Eretmochelys imbricate*
	Brown Pelican-*Pelecanus occidentalis*
	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
	Caribbean Coot-*Fulica caribaea*
Mailux Lagoon, Culebra Island	White-cheeked Pintail-*Anas bahamensis*
Puerto del Manglar, Culebra Island	Brown Pelican-*Pelecanus occidentalis*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Roseate Tern-*Sterna dougalli*
Los Caños, Culebra Island	White-crowned Pigeon-*Patagioenas leucocephala*
	White-cheeked Pintail-*Anas bahamensis*
Cementerio Bay, Culebra Island	White-crowned Pigeon-*Patagioenas leucocephala*
Culebra's Surrounding Cays, Culebra Island	Roseate Tern-*Sterna dougalli*
	Slippery-backed Mabuya-*Mabuya mabouya*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Green Sea Turtle-*Chelonia mydas*
Vieques west coast, Vieques Island	White-crowned Pigeon-*Patagioenas leucocephala*
	White-cheeked Pintail-*Anas bahamensis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Leatherback Sea Turtle-*Dermochelys coriaceae*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Adelaide's Warbler-*Setophaga adelaidae*
	Yellow Warble-*Setophaga petechia*
	Green Sea Turtle-*Chelonia mydas*
	Loggerhead Turtle-*Caretta caretta*
	West Indian Manatee-*Trichechus manatus*
	Cobana Negra-*Stahlia monosperma*
	Thoma's lidflower-*Calyptranthes thomasiana*
Kiani Lagoon, Vieques Island	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Adelaide's Warbler-Setophaga adelaidae
	Yellow Warble-*Setophaga petechia*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Brown Pelican-*Pelecanus occidentalis*
Playa Grande Lagoon, Vieques Island	White-crowned Pigeon-*Patagioenas leucocephala*
	White-cheeked Pintail-*Anas bahamensis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Ruddy Duck-*Oxyura jamaicensis*
	Cobana Negra-*Stahlia monosperma*
	Beautiful Goetzea-*Goetzea elegans*
Ensenada Honda Mangrove, Vieques Island	West Indian Manatee-*Trichechus manatus*
	Cobana Negra-*Stahlia monosperma*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
Yanuel Lagoon, Vieques Island	Yellow Warble-*Setophaga petechia*
	White-crowned Pigeon-*Patagioenas leucocephala*
	White-cheeked Pintail-*Anas bahamensis*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Cobana Negra-*Stahlia monosperma*
Chiva Swamp, Vieques Island	White-cheeked Pintail-*Anas bahamensis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Least Tern-*Sternulla antillarum*
Tapón Bay, Vieques Island	White-crowned Pigeon-*Patagioenas leucocephala*
	White-cheeked Pintail-*Anas bahamensis*
Ferro Bay, Mosquito Bay and Sombe Bay, Vieques Island	Key West Quail-Dove-*Geotrygon chrysie*
	Brown Pelican-*Pelecanus occidentalis*
	White-cheeked Pintail-*Anas bahamensis*
	West Indian Manatee-*Trichechus manatus*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
East tip of Vieques and Conejo Cay, Vieques Island	White-cheeked Pintail-*Anas bahamensis*
	Roseate Tern-*Sterna dougalli*
	Brown Pelican-*Pelecanus occidentalis*
	Adelaide's Warbler-*Setophaga adelaidae*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Leatherback Sea Turtle-*Dermochelys coriacea*
	Green Sea Turtle-*Chelonia mydas*
Roosevelt Roads Naval Base, Ceiba	West Indian Whistling Duck-*Dendrocygna arborea*
	Least Grebe-*Tachybaptus dominicus*
	White-cheeked Pintail-*Anas bahamensis*
	Brown Pelican-*Pelecanus occidentalis*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Ruddy Duck-*Oxyura jamaicensis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Key West Quail-Dove-*Geotrygon chrysia*
	West Indian Manatee-*Trichechus manatus*
	Green Sea Turtle-*Chelonia mydas*
	Hawksbill Turtle-*Eretmochelys imbricata*
Ceiba State Forest, Fajardo, Ceiba and Naguabo	Brown Pelican-*Pelecanus occidentalis*
	Key West Quail-Dove-*Geotrygon chrysia*
	Bridled Quail-Dove-*Geotrygon mystacea*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
Humacao Natural Reserve, Humacao	Caribbean Coot-*Fulica caribaea*
	Least Tern-*Sternulla antillarum*
	Least Grebe-*Tachybaptus dominicus*
	Brown Pelican-*Pelecanus occidentalis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Masked Duck-*Nomonyx dominicus*
	Adelaide's Warbler-*Setophaga adelaidae*
	Ruddy Duck-*Oxyura jamaicensis*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Leatherback Sea Turtle-*Dermochelys coriacea*
	Hawksbill Turtle-*Eretmochelys imbricate*
	Yellow-breasted crake-*Porzana flaviventer*
	Loggerhead Turtle-*Caretta caretta*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Puerto Rican Slider-T*rachemys stejnegeri*
	Juey Palancú-*Cardisoma guanhumi*
	Mangrove root Crab-*Goniopsis cruentata*
	Cangrejo violinista-*Uca thayeri*
Pandura Mountain Range, Yabucoa-Maunabo	Brown Pelican-*Pelecanus occidentalis*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Adelaide's Warbler-Setophaga adelaidae
	Puerto Rican plain Pigeon-*Patagioenas inornata*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto RicanOriole-*Icterus portoricensis*
	Puerto Rican demon-*Eleutherodactylus cooki*
Palmas Pond, Arroyo	Brown Pelican-*Pelecanus occidentalis*
	Ruddy Duck-*Oxyura jamaicensis*
	Masked Duck-*Nomonyx dominicus*
	Caribbean Coot-*Fulica caribaea*
	Least Tern-*Sternulla antillarum*
Carite State Forest, Cayey	Elfin woods Warbler-*Setophaga angelae*
	Sharp shinned Hawk-*Accipiter striatus*
	Broad-winged Hawk-*Buteo platypterus*
	Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto RicanOriole-*Icterus portoricensis*
	Puerto Rican Boa-Chilobotrus inornatus
	Golden Coqui-*Eleutherodactylus jasperi*
	Puerto Rican Coqui-*Eleutherodactylus portoricensis*
	Ground Coqui-*Eleutherodactylus richmondi*
	Eneida's Coqui-*Eleutherodactylus eneidae*
	Warty Coqui-*Eleutherodactylus locustus*
	Tree hole Coqui-*Eleutherodactylus hedricki*
	Web footed Coqui-*Eleutherodactylus karlschmidti*
Cerro El Gato and Associated Areas, Cayey	Golden Coqui-*Eleutherodactylus jasperi*
39- Cidra Lake, Cidra	Puerto Rican plain Pigeon-*Patagioenas inornata*
Aguirre State Forest, Punta Pozuelo, Cayos Caribe & Mar Negro, Guayama-Salinas-Santa	Brown Pelican-*Pelecanus occidentalis*
	White-cheeked Pintail-*Anas bahamensis*
	Least Tern-*Sternulla antillarum*
	Roseate Tern-*Sterna dougalli*
	Least Grebe-*Tachybaptus dominicus*
	Puerto Rican-Oriole-*Icterus portoricensis*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto Rican plain Pigeon-*Patagioenas inornata*
	Puerto Rican Vireo-*Vireo latimeri*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-Setophaga adelaidae
	Leatherback Sea Turtle-*Dermochelys coriacea*
	Green Sea Turtle-*Chelonia mydas*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Dryland grass Anole-*Anolis poncensis*
	West Indian Manatee-*Trichechus manatus*
	Fishing Bat-*Noctilio leporinus*
	Nassau grouper-*Epinephelus striatus*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Jewfish-*Epinephelus itajitara*
Punta Arenas, Salinas	Brown Pelican-*Pelecanus occidentalis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	White-cheeked Pintail-*Anas bahamensis*
Salinas Training Area, Salinas	Dryland Grass Anole-*Anolis poncensis*
	Adelaide's Warbler-Setophaga adelaidae
	Key west Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Oriole-*Icterus portoricensis*
	Erubia-*Solanum ensipholium*
Punta Petrona Mangroves and Caracoles Cay, Santa Isabel	Brown Pelican-*Pelecanus occidentalis*
	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
	Yellow Warble-*Setophaga petechia*
	Green Sea Turtle-*Chelonia mydas*
	West Indian Manatee-*Trichechus manatus*
Cabuyón Mangrove and Fríos Cays, Ponce	Brown Pelican-*Pelecanus occidentalis*
	Caribbean Coot-*Fulica caribaea*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	White-cheeked Pintail-*Anas bahamensis*
	Brown Pelican-*Pelecanus occidentalis*
	Snowy Plover-*Charadrius nivosus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Grasshopper Sparrow-*Ammondramus savannarum*
Caja de Muertos Complex, Ponce-Juana Díaz-Santa Isabel	Brown Pelican-*Pelecanus occidentalis*
	Least Tern-*Sternulla antillarum*
	White-tailed Tropicbird-*Phaeton aethereus* (nesting)
	Roseate Tern *Sterna dougalli*
	Yellow Warble-*Setophaga petechia*
	Green Sea Turtle-*Chelonia mydas*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Grant's Blind Snake-*Typhlops granti*
	Cook's Anole-*Anolis cooki*
	Jueyita de Tierra-*Gecarcinus lateralis*
	Juey Morado-*Gecarcinus ruricola*
	Juey de Mangle-*Aratus pisonii*
Serrallés Lakes, Juana Díaz-Ponce	Ruddy Duck-*Oxyura jamaicensis*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Adelaide's Warbler-*Setophaga adelaidae*
	Caribbean Coot-*Fulica caribaea*
	Least Grebe-*Tachybaptus dominicus*
	Puerto Rican Oriole-*Icterus portoricensis*
	Brown Pelican-*Pelecanus occidentalis*
Toro Negro and Tres Picachos State Forest, Ciales-Jayuya-Orocovis	Sharp-shinned Hawk-*Accipiter striatus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto Rican Oriole-*Icterus portoricensis*
	Cave Bat-*Brachyphylla cavernarum*
	Long-tongued Bat-*Monophyllus redmani*
	Red Fruit Bat-*Stenoderma rufum*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Brown Flower Bat-*Erophylla sezekorni*
	Slippery-backed Mabuya-*Mabuya mabouya*
	Treehole Coqui-*Eleutherodactylus hedricki*
	Ground Coqui-*Eleutherodactylus richmondi*
	Eneida's Coqui-*Eleutherodactylus eneidae*
	Camarón Palaí-*Macrobrachium carcinus*
	Camarón-*Macrobrachium crenulatum*
	Camarón-*Macrobrachium faustinum*
	Camarón-*Macrobrachium heterochirus*
	Buruquena-*Epilobocera suinuatifrons*
Las Salinas Lagoon, El Tuque, Ponce	White-cheeked Pintail-*Anas bahamensis*
	Brown Pelican-*Pelecanus occidentalis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Least Tern *STernulla antillarum*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto RicanOriole-*Icterus portoricensis*
	Dryland Grass Anole-*Anolis poncensis*
Monte Guilarte State Forest, Adjuntas-Guayanilla, Peñuelas-Yauco -	Sharp-shinned Hawk-*Accipiter striatus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Puerto Rican Vireo-*Vireo latimeri*
	Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Oriole-*Icterus dominicensis*
	Red fruit Bat-*Stenoderma rufum*
	Cave Bat-*Brachyphylla cavernarum*
	Eneida's Coqui-*Eleutherodactylus eneidae*
	Puerto Rican Coqui-*Eleutherodactylus portoricensis*
	Puerto Rican Boa-*Chilobotrus inornatus*
	West Indian Walnut-*Juglans jamaicensis*
	Puerto Rican manac-*Calyptronoma rivalis*
Punta Verraco, Cerro Toro and Punta Ventana, Guayanilla	Puerto Rican CrestedToad-*Peltophryne lemur*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-Setophaga adelaidae
	Brown Pelican-*Pelecanus occidentalis*
	Puerto Rican Nightjar-*Caprimulgus noctitherus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Key West Quail-Dove-*Geotrygon chrysia*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
Guayanilla Hills, Guayanilla	Puerto Rican Nightjar-*Caprimulgus noctitherus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Bariaco-*Trichilia triacantha*
Guánica Lagoon, Guánica	Puerto Rican Nightjar-*Caprimulgus noctitherus*
	Yellow-breasted Crake-*Porzana flaviventer*
	West Indian Whistling Duck-*Dendrocygna arborea*
	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
Guánica State Forest, Guánica	Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Nightjar-*Caprimulgus noctitherus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Puerto Rican Oriole-*Icterus dominicensis*
	Puerto Rican Vireo-*Vireo latimeri*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Bridled Quail-Dove-*Geotrygon mystacea*
	Puerto Rican CrestedToad- *Peltophryne lemur*
	Slippery-backed Mabuya-*Mabuya mabouya*
	Grant's Blind Snake-*Typhlops granti*
	Juey Morado-*Gecarcinus ruricola*
	Camarón Troglobita de *Mona-Typhlatya monae*
	Bariaco-*Trichilia triacantha*
San Jacinto Salt Flats and Tamarindo Lagoon, Guánica	Puerto Rican Nightjar-*Caprimulgus noctitherus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Brown Pelican-*Pelecanus occidentalis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	White-cheeked Pintail-*Anas bahamensis*
	Roseate Tern-*Sterna dougallii*
Susúa State Forest and Adjacent Lands,	Yauco-Sabana Grande Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Nightjar-*Caprimulgus noctitherus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Puerto Rican Vireo-*Vireo latimeri*
	Adelaide's Warbler-*Setophaga adelaidae*
	Puerto Rican Oriole-*Icterus dominicensis*
	Cobana Negra-*Stahlia monosperma*
	Pelos del Diablo-*Aristida portoricensis*
La Parguera Natural Reserve, Lajas	White-cheeked Pintail-*Anas bahamensis*
	Puerto Rican Nightjar-*Caprimulgus noctitherus*
	Yellow Warble-*Setophaga petechia*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Brown Pelican-*Pelecanus occidentalis*
	Adelaide's Warbler-*Setophaga adelaidae*
	Least Tern-*Sternulla antillarum*
	Puerto Rican Vireo-*Vireo latimeri*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Green Sea Turtle-*Chelonia mydas*
	Leatherback Sea Turtle-*Dermochelys coriacea*
	West Indian Manatee-*Trichechus manatus*
Cartagena Lagoon, Lajas	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Caribbean Coot-*Fulica caribaea*
	Least Grebe-*Tachybaptus dominicus*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Ruddy Duck-*Oxyura jamaicensis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	White-cheeked Pintail-*Anas bahamensis*
	Masked Duck-*Nomonyx dominicus*
	Broad-winged Hawk-*Buteo platypterus*
	Least Tern-*Sternulla antillarum*
	White-crowned Pigeon-*Patagioenas leucocephala*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Oriole-*Icterus dominicensis*
	Puerto Rican Vireo-*Vireo latimeri*
	Yellow-breasted Crake-*Porzana flaviventer*
	Grasshopper Sparrow-*Ammondramus savannarum*
Boquerón State Fores, Cabo Rojo	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Brown Pelican-*Pelecanus occidentalis*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	West Indian Whistling Duck-*Dendrocygna arborea*
	White-cheeked Pintail-*Anas bahamensis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Ruddy Duck-*Oxyura jamaicensis*
	Caribbean Coot-*Fulica caribaea*
	Least Tern-*Sternulla antillarum*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto Rican Oriole-*Icterus dominicensis*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Yellow-breasted Crake-*Porzana flaviventer*
	Piping Plover-*Charadrius melodus*
	West Indian Manatee-*Trichechus manatus*
	Cook's Anole-*Anolis cooki*
	Free tailed Bat-*Tadarida brasiliensis*
	Bariaco-*Trichilia triacantha*
Boquerón Wildlife Refuge, Cabo Rojo	Least Grebe-*Tachybaptus dominicus*
	Brown Pelican-*Pelecanus occidentalis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	White-cheeked Pintail-*Anas bahamensis*
	Masked Duck-*Nomonyx dominicus*
	Ruddy Duck-*Oxyura jamaicensis*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-Setophaga adelaidae
	Caribbean Coot-*Fulica caribaea*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto Rican Oriole-*Icterus dominicensis*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Fishing Bat-*Noctilio leporinus*
	West Indian Manatee-*Trichechus manatus*
	Swamp Ghost Crab-*Ucides cordatus*
	Juey Palancú-*Cardisoma guanhumi*
	Mangrove Root Crab-*Goniopsis cruentata*
Cabo Rojo Salt Flats and Adjacent Areas, Cabo Rojo	Snowy Plover-*Charadrius alexandrinus*
	Piping Plover-*Charadrius melodus*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	Least Tern-*Sternulla antillarum*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	White-cheeked Pintail-*Anas bahamensis*
	Roseate Tern-*Sterna dougalli*
	Green Sea Turtle-*Chelonia mydas*
	Hawksbill Turtle-*Eretmochelys imbricata*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Leatherback Sea Turtle-*Dermochelys coriacea*
	Woodbury's stopper-*Eugenia woodburyana*
	Chase's threeawn-*Aristida chaseae*
	Cobana Negra-*Stahlia monosperma*
Punta Guaniquilla Natural Reserve, Cabo Rojo	Least Grebe-*Tachybaptus dominicus*
	Brown Pelican-*Pelecanus occidentalis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Ruddy Duck-*Oxyura jamaicensis*
	White-cheeked Pintail-*Anas bahamensis*
	Least Tern-*Sternulla antillarum*
	Cobana Negra-*Stahlia monosperma*
	Bariaco-*Trichilia triacantha*
Joyuda Lagoon Natural Reserve, Cabo Rojo	Ruddy Duck-*Oxyura jamaicensis*
	Yellow Warble-*Setophaga petechia*
	Puerto Rican Oriole-*Icterus dominicensis*
	Brown Pelican-*Pelecanus occidentalis*
Cuevas Lagoon, Cabo Rojo	White-cheeked Pintail-*Anas bahamensis*
	Ruddy Duck-*Oxyura jamaicensis*
	Masked Duck-*Nomonyx dominicus*
Sabanetas Swamp-Boquilla Channel, Mayagüez	Leatherback Sea Turtle-*Dermochelys coriacea*
	Hawksbill Turtle-*Eretmochelys imbricata*
	West Indian Manatee-*Trichechus manatus*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Caribbean Coot-*Fulica caribaea*
	Brown Pelican-*Pelecanus occidentalis*
	Least Tern-*Sternulla antillarum*
	Roseate Tern-*Sterna dougalli*
	Puerto Rican Oriole-*Icterus portoricensis*
	Swamp Ghost Crab-*Ucides cordatus*
	Mangrove root Crab-*Goniopsis cruentata*
	Juey de mangle-*Aratus pisonii*
Maricao State Forest, Maricao	Sharp-shinned Hawk-*Accipiter striatus*
	Broad-winged Hawk-*Buteo platypterus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican Vireo-*Vireo latimeri*
	Adelaide's Warbler-*Setophaga adelaidae*
	Elfin Woods Warbler *Aetophaga angelae*
	Puerto Rican Manac-*Calyptronoma rivalis*
	Higüero de Sierra-*Crescentia portoricensis*
	Orquid-*Cranichis ricartii*
	Gesneria pauciflora
	Palo de Rosa-*Ottoschulzia rhodoxylon*
Mona Island	White tailed Tropicbird-*Phaeton aethereus* (nesting)
	Yellow shouldered Blackbird-*Agelaius xanthomus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Sharp shinned Hawk-*Accipiter striatus*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Key west Quail-Dove-*Geotrygon chrysia*
	Higo Chumbo-*Harrisia portoricensis*
	Slippery-backed Mabuya-*Mabuya mabouya*
	Mona Island Ground Iguana-*Cyclura cornuta stejnegeri*
	Mona Blind Snake-*Typhlops monensis*
	Mona Boa-Chilobotrus monensis monensis
	Hawksbill Turtle-*Eretmochelys imbricata*
	Green Sea Turtle-*Chelonia mydas*
	Fishing Bat-*Noctilio leporinus*
	Humpback Whale-*Megaptera novaeangliae*
	Camarón Troglobita de Mona-*Typhlatya monae*
	Juey Morado-*Gecarcinus ruricola*
	Jueyita de Tierra-*Gecarcinus lateralis*
Monito Island	Yellow-shouldered Blackbird-*Agelaius xanthomus*
	Brown Pelican-*Pelecanus occidentalis*
	Slippery-backed Mabuya-*Mabuya mabouya*
	Monito's Gecko-*Sphaerodactylus micropithecus*
	Higo Chumbo-Harrisia portoricensis
Pozo Hondo Swamp, Añasco,	West Indian Whistling Duck-*Dendrocygna arborea*
Cayures Swamp, Aguada	Masked Duck-*Nomonyx dominicus*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Brown Pelican-*Pelecanus occidentalis*
	Caribbean Coot-*Fulica caribaea*
Desecheo Island	Brown Pelican-*Pelecanus occidentalis*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Slippery-backed Mabuya-*Mabuya mabouya*
	Desecheo's Gecko-*Sphaerodactylus levinsi*
	Higo Chumbo-*Harrisia portoricensis*
Barrio Coto, Isabela	Puerto Rican Boa-*Chilobotrus inornatus*
	Beautiful Goetzea-*Goetzea elegans*
	Adelaide's Warbler-*Setophaga adelaidae*
	Puerto Rican CrestedToad-*Peltophryne lemur*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Auerodendron pauciflorum
Guajataca Cliffs, Isabela-Quebradillas-Camuy	White-tailed Tropicbird-*Phaeton aethereus* (nesting)
	Bridled Tern-*Onychoprion anaethetus* (nesting)
Guajataca State Forest, Isabela	Key West Quail-Dove-*Geotrygon chrysia*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Bridled Quail-Dove-*Geotrygon mystacea*
	Sharp shinned Hawk-*Accipiter striatus*
	Adelaide's Warbler-*Setophaga adelaidae*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto Rican Boa-*Chilobotrus inornatus*
	Slippery-backed Mabuya *Mabuya mabouya*
	Grant's Blind snake-*Typhlops granti*
	Puerto Rican Crested Toad-*Peltophryne lemur*
	Long-tongued Bat-*Monophyllus redmani*
	Vahl's Boxwood-*Buxus vahlii*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Palo de Rosa-*Ottoschulzia rhodoxylon*
	Ausú-*Myrcia paganii*
	Uvillo-*Eugenia haematocarpa*
	Spider-*Schoepfia arenaria*
	St. Thomas prickly-ash-*Zanthoxylum thomasianum*
	Beautiful Goetzea-*Goetzea elegans*
	Erubia-*Solanum drymophilum*
	Daphnopsis helleriana
	Palo de Nigua-*Cornutia obovata*
Guajataca Lake, Quebradillas	Key West Quail-Dove-*Geotrygon chrysia*
	Brown Pelican-*Pelecanus occidentalis*
	Broad-winged Hawk-*Buteo platypterus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Ruddy Duck-*Oxyura jamaicensis*
	Adelaide's Warbler-Setophaga adelaidae
	Caribbean Coot-*Fulica caribaea*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican Boa-Chilobotrus inornatus
	Puerto Rican Slider-*Trachemys stejnegeri*
	Fishing Bat-*Noctilio leporinus*
Barrio Cocos and Bellaca Creek, Quebradillas	Puerto Rican CrestedToad-*Peltophryne lemur*
	Adelaide's Warbler-Setophaga adelaidae
	Beautiful Goetzea-*Goetzea elegans*
	Puerto Rican Boa-*Chilobotrus inornatus*
Carrizales Mangroves, Hatillo	Least Grebe-*Tachybaptus dominicus*
	Brown Pelican-*Pelecanus occidentalis*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Grasshopper Sparrow-*Ammondramus savannarum*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Puerto Rican Slider-*Trachemys stejnegeri*
Tiburones Swamp and La Tembladera Pond, Arecibo	Least Grebe-*Tachybaptus dominicus*
	Yellow-breasted Crake *Porzana flaviventer*
	Brown Pelican-*Pelecanus occidentalis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	White-cheeked Pintail-*Anas bahamensis*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Masked Duck-*Nomonyx dominicus*
	Ruddy Duck-*Oxyura jamaicensis*
	Caribbean Coot-*Fulica caribaea*
	Roseate Tern-*Sterna dougalli*
	Least Tern-*Sterna antillarum*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Oriole-*Icterus portoricensis*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Yellow shouldered Blackbird-*Agelaius xanthomus*
Cambalache Forest, Arecibo	Puerto Rican Boa-*Chilobotrus inornatus*
	Red fruit Bat-*Stenoderma rufum*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Cave Bat-*Brachyphylla cavernarum*
	Beautiful Goetzea-*Goetzea elegans*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Adelaide's Warbler-*Setophaga adelaidae*
	Palo de Ramón-*Banara vanderbiltii*
	Palo de Rosa-*Ottoschulzia rhodoxylon*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican Vireo-*Vireo latimeri*
Río Abajo State Forest, Arecibo	Broad-winged Hawk-*Buteo platypterus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Adelaide's Warbler-*Setophaga adelaidae*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Puerto Rican Parrot *Amazona vitatta*
	Puerto Rican Vireo-*Vireo latimeri*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican Boa-*Chilobotrus inornatus*
La Esperanza Natural Reserve, Manatí	Ruddy Duck-*Oxyura jamaicensis*
	White-cheeked Pintail-*Anas bahamensis*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Brown Pelican-*Pelecanus occidentalis*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Roseate Tern-*Sterna dougalli*
	Bridled Tern-*Sterna anaethetus* (nesting)
	Grasshopper Sparrow-*Ammondramus savannarum*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Masked Duck-*Nomonyx dominicus*
	Caribbean Coot-*Fulica caribaea*
	Puerto Rican Oriole-*Icterus portoricensis*
	Puerto Rican vireo-*Vireo latimeri*
	Puerto Rican Slider-*Trachemys stejnegeri*
	Puerto Rican Boa-*Chilobotrus inornatus*
Tortuguero Lagoon, Cabo Caribe Swamp and Rica Lake, Vega Baja	Least Grebe-*Tachybaptus dominicus*
	Caribbean Coot-*Fulica caribaea*
	Brown Pelican-*Pelecanus occidentalis*
	Ruddy Duck-*Oxyura jamaicensis*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Yellow Warble-*Setophaga petechia*
	Adelaide's Warbler-*Setophaga adelaidae*
	Key West Quail-Dove-*Geotrygon chrysia*
	White-crowned Pigeon-*Patagioenas leucocephala*
	West Indian Whistling Duck-*Dendrocygna arborea*
	Bridled Quail-Dove-*Geotrygon mystacea*
	Yellow-breasted Crake-*Porzana flaviventer*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Puerto Rican Boa-*Chilobotrus inornatus*
	Puerto Rican Senna-*Chamaecrista glandulosa var. mirabilis*
Cibuco Swamp, Vega Baja	Brown Pelican-*Pelecanus occidentalis*
	Least Grebe-*Tachybaptus dominicus*
	White-crowned Pigeon-*Patagioenas leucocephala*
	West Indian Whistling Duck-*Dendrocygna arborea*

AREA	ENDANGERED AND VULNERABLE SPECIES
	Ruddy Duck-*Oxyura jamaicensis*
	White-cheeked Pintail-*Anas bahamensis*
	Roseate Tern-*Sterna dougalli*
	Yellow Warble-*Setophaga petechia*
	Puerto Rican Vireo-*Vireo latimeri*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Long-tongued Bat-*Monophyllus redmani*
	Juey Palancú-*Cardisoma guanhumi*
	Mangrove Root Crab-*Goniopsis cruentata*
	Juey de Mangle-*Aratus pisonii*
	Swamp Ghost Crab-*Ucides cordatus*
	Juey Morado-*Gecarcinus ruricola*
Vega State Forest, Vega Alta	Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Adelaide's Warbler-*Setophaga adelaidae*
	Puerto Rican Vireo-*Vireo latimeri*
	Cobana Negra-*Stahlia monosperma*
Lakes and Forests of Dorado	White-crowned Pigeon-*Patagioenas leucocephala*
	Brown Pelican-*Pelecanus occidentalis*
	Caribbean Coot-*Fulica caribaea*
	Hawksbill Turtle-*Eretmochelys imbricata*
	Juey Palancú-*Cardisoma guanhumi*
	Bloodwood tree-*Pterocarpus officinalis*
Mogotes Río Lajas y Nevárez, Toa Baja	Key West Quail-Dove-*Geotrygon chrysia*
	Puerto Rican Lizard-Cuckoo-*Cocccyzus vieilloti*
	Puerto Rican Boa-*Chilobotrus inornatus*
	Slippery-backed Mabuya-*Mabuya mabouya*
	Palo de Ramón-*Banara vanderbiltii*
	Daphnopsis helleriana
El Mameyal, Toa Baja	West Indian Whistling Duck-*Dendrocygna arborea*
San Pedro Swamp, Toa Baja	West Indian Whistling Duck-*Dendrocygna arborea*
	White-crowned Pigeon-*Patagioenas leucocephala*
	Yellow Warble-*Setophaga petechia*
	Grasshopper Sparrow-*Ammondramus savannarum*
	Puerto Rican Boa-*Chilobotrus inornatus*
	Juey Palancú-*Cardisoma guanhumi*
	Green Sea Turtle-*Chelonia mydas*
	Loggerhead Turtle-*Caretta caretta*

Marine Protected Areas

Wetlands are natural areas defined by their hydrology, soil and vegetation (Cowardin et al., 1979). Wetlands have important functions and economic, social and scientific value. They help control floods, provide water and recharge areas for aquifers, feed springs, modify climate, improve water quality, maintain the salt balance needed for estuarine life, and stabilize and protect coasts. Economically, wetlands are a highly productive resource by being a source of food, wood, energy, and recreational opportunities. They influence the quality and ecological status of associated water bodies and moderate peak stream flows during storm events. They are important nurseries for aquatic life.

Inventories of wetlands in Puerto Rico mainly cover the coastal zone (Figure 24). Through an NOAA initiative, in 2004 approximately 160,000 ha of benthic niches in the territorial waters of Puerto Rico were mapped. Approximately 87,578 ha of wetlands were inventoried (Table 17). It is estimated that 25% of them are found within marine protected areas (Lopez, 2007). Marine protected areas can be natural reserves, marine reserves, coastal state forests, national estuarine research reserves or seasonal fishing closures.

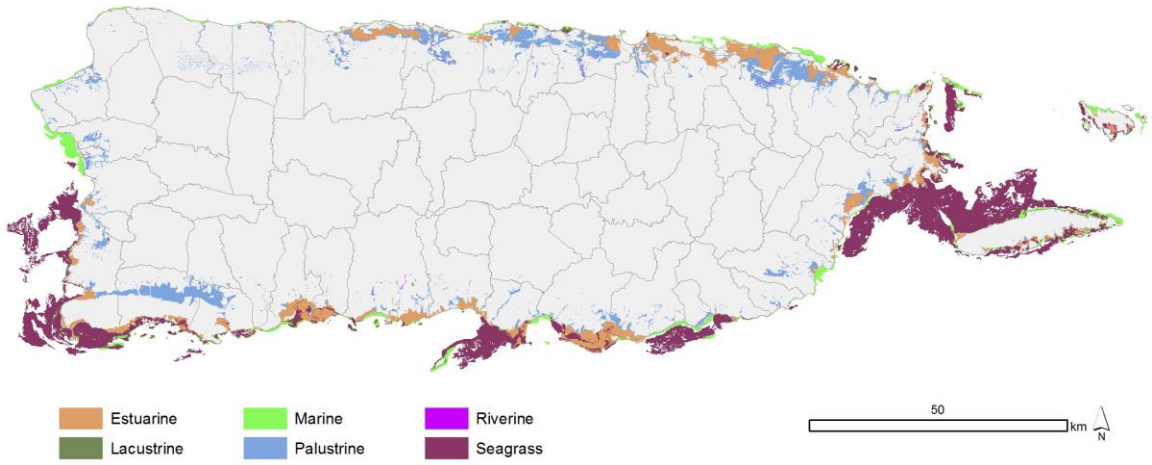


Figure 24. Inventory of Puerto Rico's Wetlands. From DNER 2015.

Puerto Rico Model Forest ("Bosque Modelo")

On November 3rd, 2014, Governor Alejandro García Padilla approved the Puerto Rico Model Forest Law. With this law, Puerto Rico becomes the first country in the world to appoint a Model Forest through legislation. The Puerto Rico Model Forest, or "bosque modelo"in Spanish, covers about 390,000 acres of land in 31 municipalities (over 17% of the island). The Model Forest connects 26 natural areas (state forests, nature reserves and refuges), which make up approximately 66,000 acres (17%) of the total area of the Model Forest (Figure 25). The Model Forest area is an ecological corridor in west-central Puerto Rico. The most comprehensive, collaborative management initiative in the history of Puerto Rico is being implemented in the remaining 83% of land in the Model Forest. This comprises integrated management, land uses of high ecological value, agriculture and tourism initiatives.

Given the fiscal and economic situation in Puerto Rico, the Model Forest initiative needs to identify the most effective and efficient ways of using public resources for promoting conservation, sustainable development and collaborative management. The future of Puerto Rico's natural resources lies in collaboration. Therefore, the Model Forest will encourage collaboration with

volunteers and other entities in order to promote sustainable practices with landowners, farmers, retailers and municipalities within the agro-forestry zone in west-central Puerto Rico. .

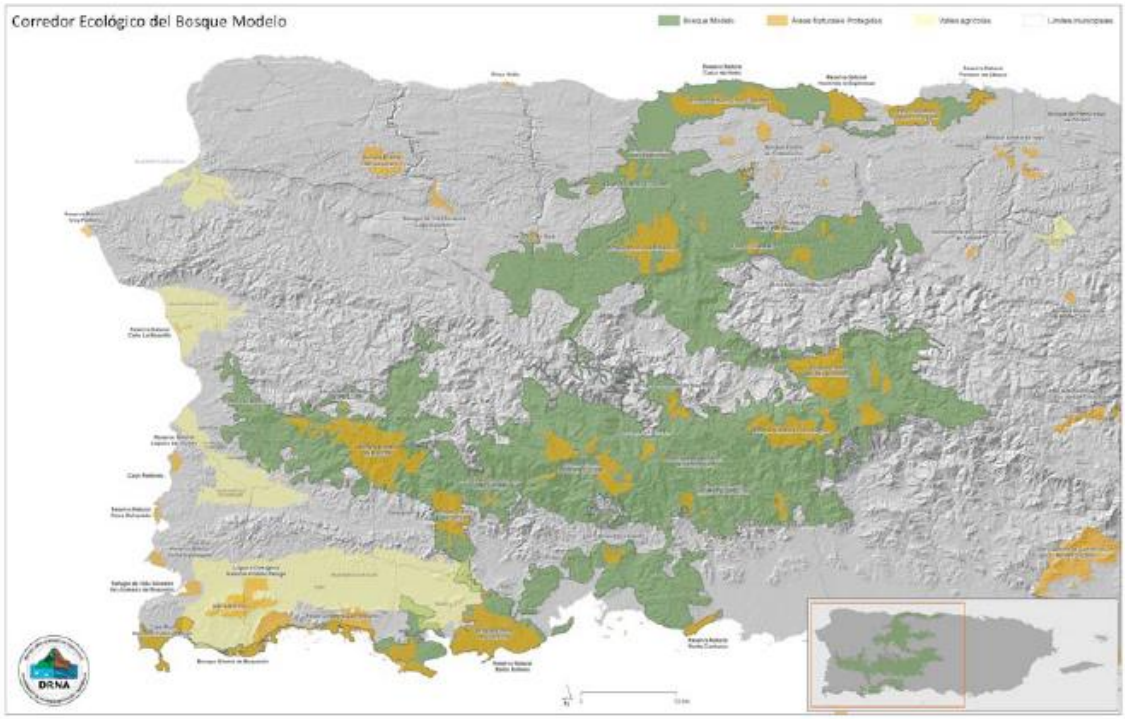


Figure 25. The Model Forest in west-central P.R.

Caribbean Landscape Conservation Cooperative

The Caribbean Landscape Conservation Cooperative (CLCC) serves as a catalyst for interagency collaborations and a primary source for science-based information to sustain natural and cultural resources in Caribbean landscapes and seascapes. The DNER is a current partner of the CLCC. The CLCC provides a regional context for conservation planning and management at several scales, from making decisions on site management, understanding the implications of management actions at the regional, national and global levels. It offers a platform for partners working to integrate information, perform regional assessments of conservation status, assess future scenarios, and collaborate in applied conservation science. The CLCC supports site level conservation initiatives and complements other landscape conservation strategies to restore,

manage, and conserve natural resources in the region in the face of climate change and development pressure.

The CLCC's mission is to develop and provide the best available conservation science and strategies to agencies, decision-makers, organizations, researchers, and the general public, in order to conserve, restore and sustain natural and cultural resources in the US Caribbean. The CLCC is part of a national network of 22 Landscape Conservation Cooperatives (LCCs). An LCC is an applied conservation science partnership among state and federal agencies, regional organizations, tribes, NGOs, universities and other entities within a geographic area (http://caribbeanlcc.org/).

Other sources of information

Wildlife Conservation Areas, forest types, land cover, geographic shape, locations and descriptions

Several studies were conducted in order to select and describe wildlife conservation areas and their habitats. These studies provided geographic information about priority conservation areas (Figure 26), critical wildlife areas (Figure 27), wildlife-protected areas (Figure 28), forest type and land cover. Some priority conservation areas and critical wildlife areas are within the wildlife-protected areas managed and protected by DNER.

A map layer with wildlife conservation areas (Figure 29) was obtained by merging the geographic location of the priority conservation areas, critical wildlife areas and wildlife protected areas (Figure 30). Then, the Puerto Rico mainland forest types and land cover layers were clipped from this map (Helmer et al. 2002). Figures 31 to 36 present the geographic shape and locations of each of the different forest types and land cover as described by Helmer et al. (2002) within the wildlife conservation areas. With the information and analysis of our natural protected

areas, DNER can then focus conservation actions and efforts according to the habitat types of interest.

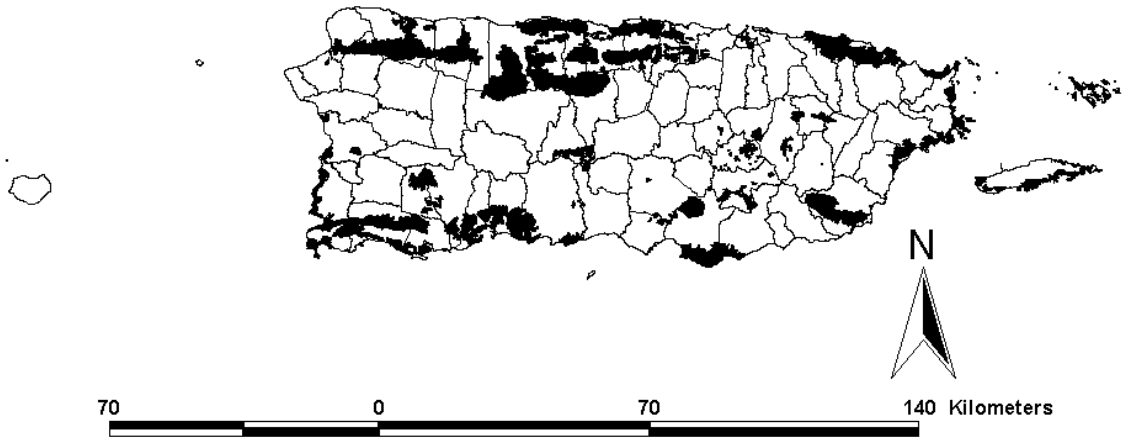


Figure 26. Marine and Terrestrial priority conservation areas.

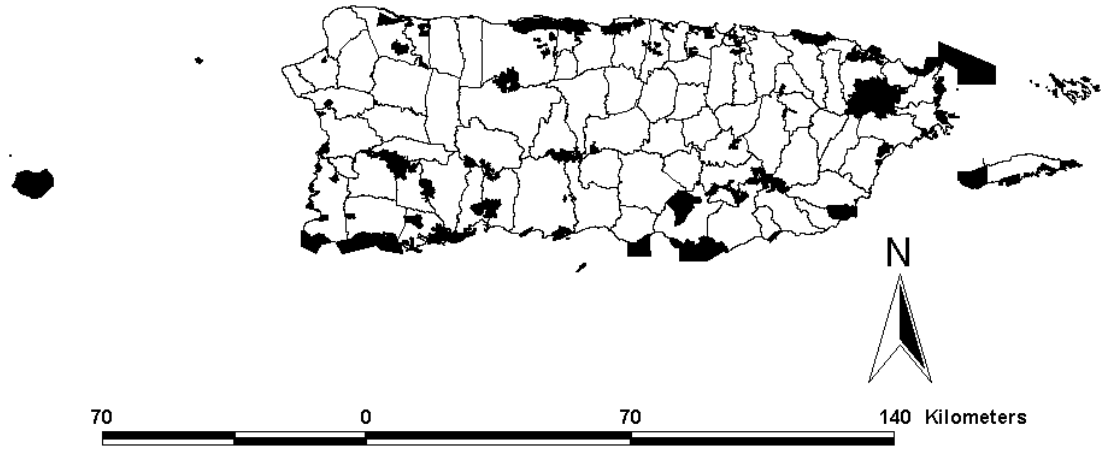


Figure 27. Critical Wildlife Areas and Waterfowl Focus Areas (marine and terrestrial).

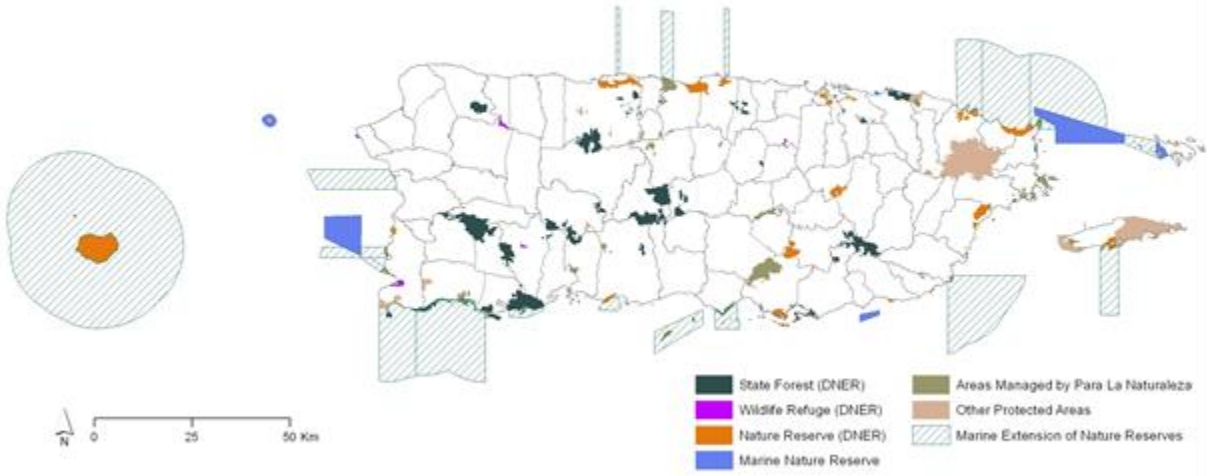


Figure 28. Marine and terrestrial wildlife protected areas.

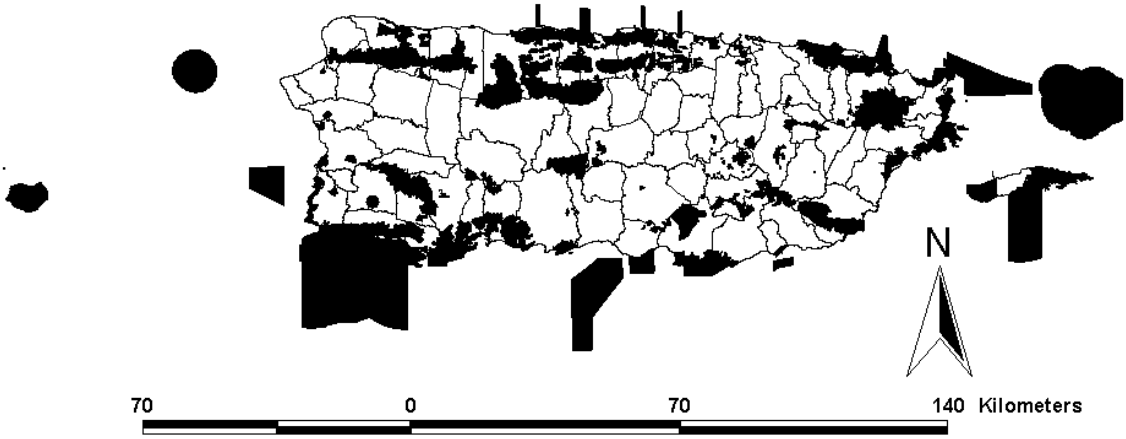


Figure 29. Marine and terrestrial wildlife conservation areas.

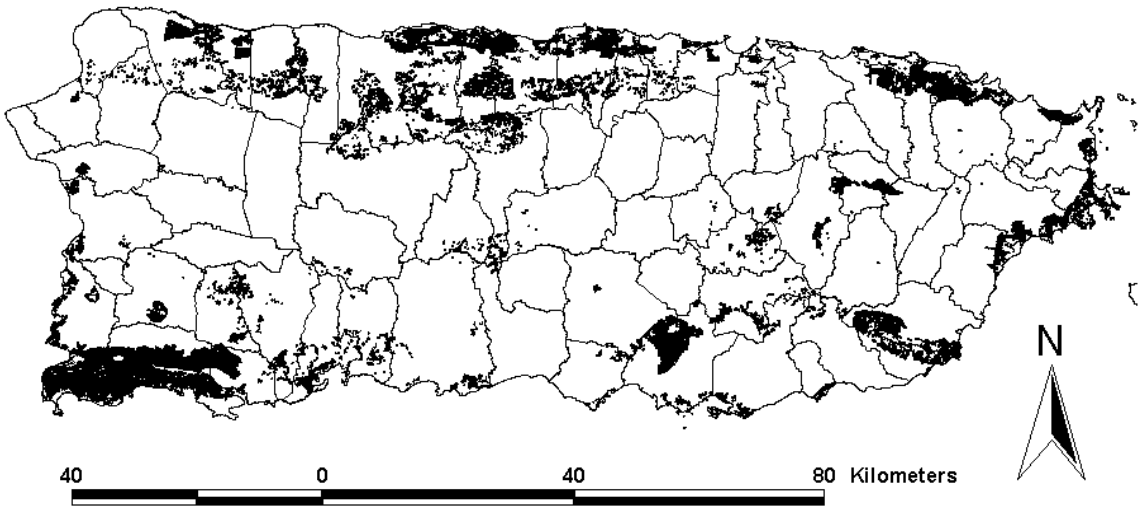


Figure 30. Agricultural land for conservation.

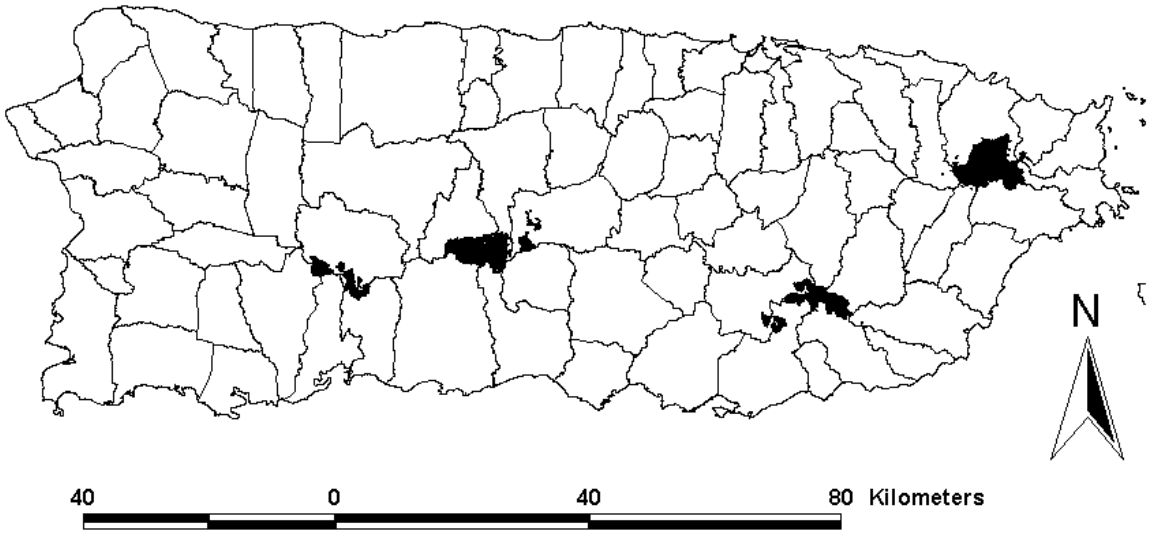


Figure 31. Lower montane wet evergreens forest for conservation.

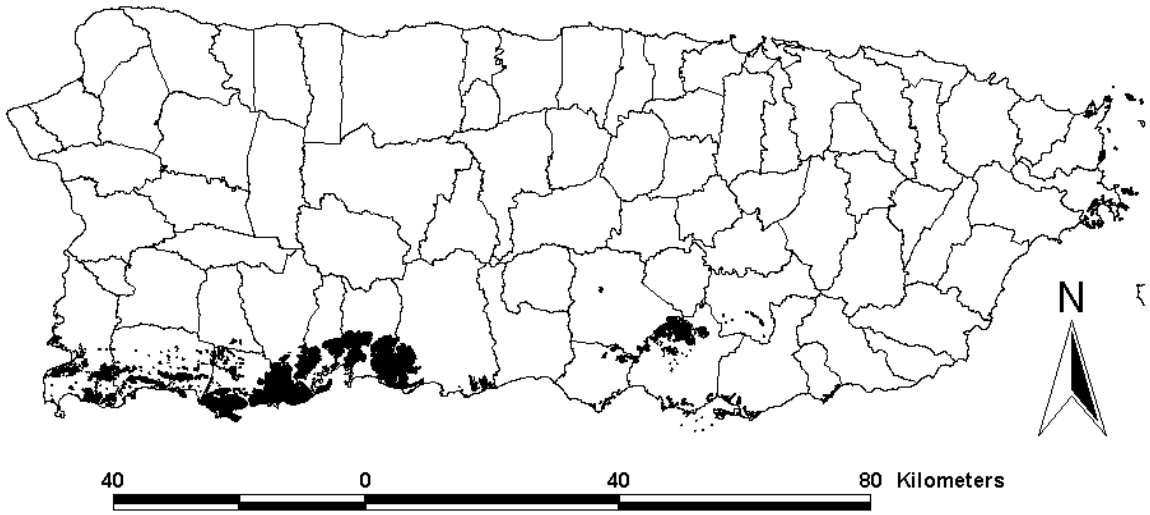


Figure 32. Lowland dry areas for conservation.

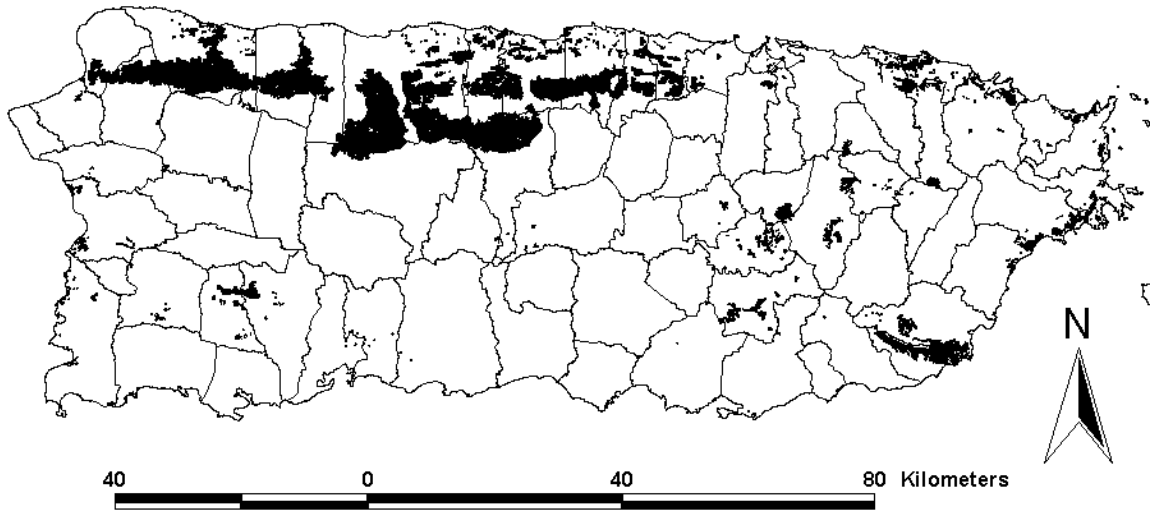


Figure 33. Lowland moist areas for conservation.

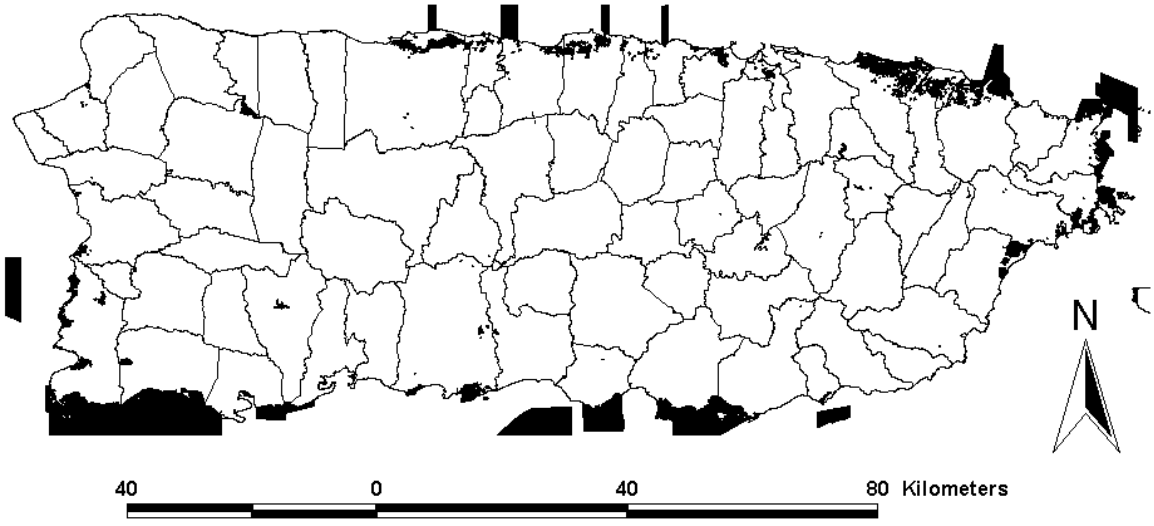


Figure 34. Wetlands, marine and terrestrial, for conservation.

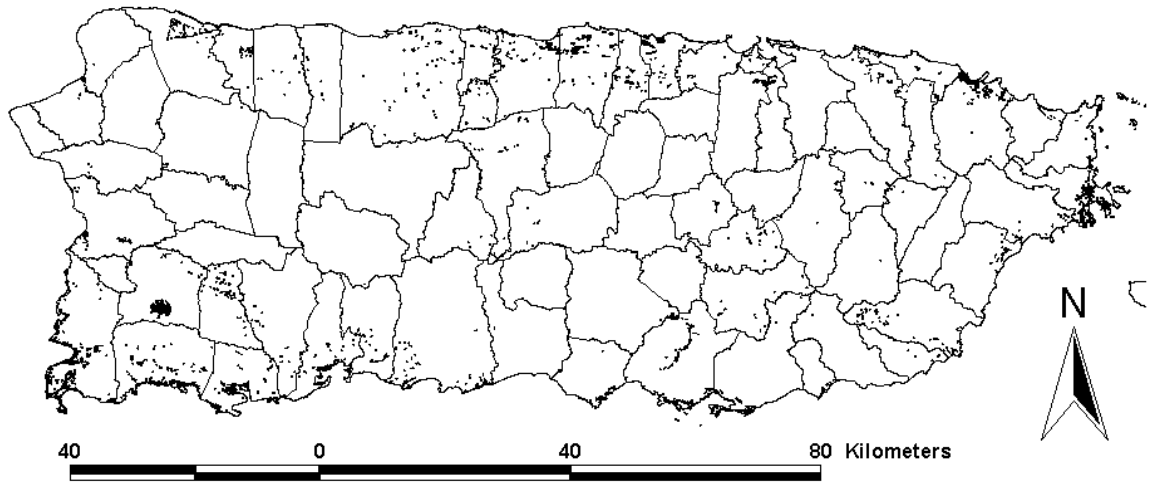


Figure 35. Deforested areas for conservation.

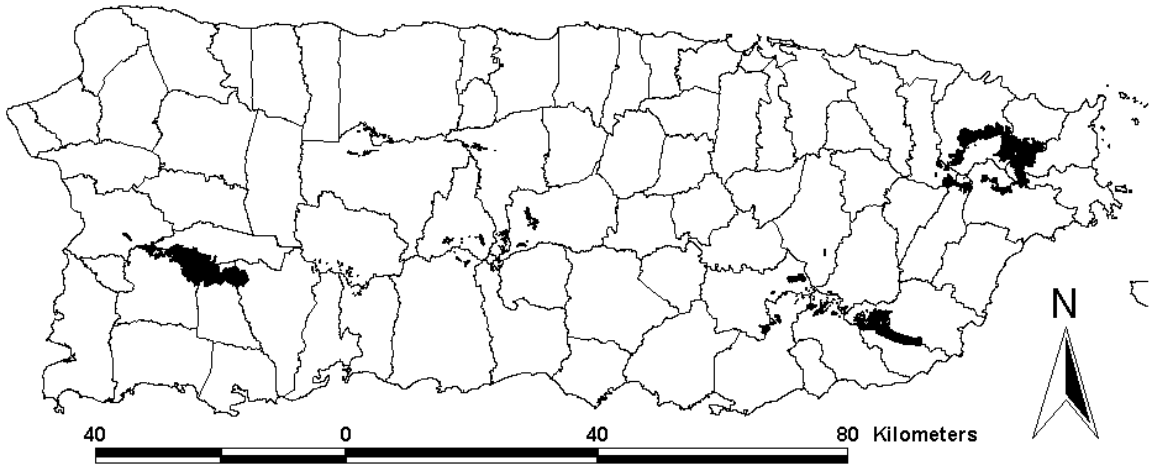


Figure 36. Submontane areas for conservation.

CHAPTER 7. MONITORING AND ADAPTATION OF CONSERVATION ACTIONS

Monitoring is an essential element for the success of the Puerto Rico State Wildlife Action Plan. Understanding ongoing activities, their effectiveness will allow DNER and its conservation partners to adapt to changing conditions and new knowledge. Our monitoring strategy is built upon existing efforts conducted by DNER and other entities to monitor individual wildlife populations, as well as to identify, protect, and manage important habitats on the Island.

Monitoring the success of conservation actions, changes in land use and habitat conditions will provide information for managers to design conservation actions and implement cost effective methods. Results from monitoring and evaluation efforts may also be used to effectively communicate conservation achievements to obtain support for programs with decision-makers such as legislators, funding organizations, non-profit organizations, and the general public.

Wildlife Permits

The New Wildlife Law of Puerto Rico stipulates that all related wildlife activities will be regulated by DNER. The Terrestrial Resources Division (TRD) of DNER is the office in charge of granting permits for scientific investigations, collections, importation, and exportation of wildlife, and education. One of the conditions of each permit is a report of authorized activities. These reports provide updated information on the status of studied species, and also inform DNER about programs being conducted by non-governmental organizations or individuals to educate the public about the conservation of wildlife resources.

Regulation No. 6766 specifically mandates a five year revision of the priority species list. It also dictates the preparation of recovery plans within a year for species listed as critically endangered, two years for endangered species, and three years for threatened species.

Game Species

The TRD has monitored game species populations for over 25 years through ground and aerial counts, and harvest data. Game species in Puerto Rico include migratory waterfowl, columbids, feral goats and pigs. However, non-game species such as native and resident waterfowl (e.g., White-cheeked pintail, West Indian whistling duck), and columbids (i.e., Puerto Rican Plain Pigeon) are also surveyed. These surveys are an important tool for continued monitoring of these priority species.

Threatened and Endangered Species

Commonwealth and federal legislations mandate the monitoring of Threatened and Endangered species. The DNER allocates monitoring priorities according to the level of endangerment of the species. Nevertheless, limited funding and resources restrict the number of species that may be effectively monitored. To cope with the lack of adequate resources, the DNER has established cooperative agreements with universities, federal agencies, non-governmental agencies, and more recently, with private landowners.

Habitat Conservation and Protection

Wildlife habitat is evaluated and characterized according to the categories established in Regulations No. 6765 and 6766. The DNER Secretary designates

habitat for endangered and threatened species as Critical Habitat (CH) or Critical Essential Habitat (CEH). The CEH can not be modified unless a change in designation is supported by scientific data. For instance, a CH may be modified only if the proposed action has a vital public interest and there is no other option. Any alteration to a CH will require a mitigation of at least a 3:1 proportion with habitat of same or higher ecological value.

The DNER-Terrestrial Resources Division evaluates the potential impact that development will have on our wildlife species and their habitats. Personnel from this Division provide technical guidance about proposed actions in accordance with regulations. The action to be implemented will depend upon the habitat designation (Table 18).

Table 18. Wildlife habitat categories and actions proposed to deter habitat loss.

Habitat Category	Protection	Action
Critical Essential	Endangered/Threatened Species (only known locality)	No Modification
Critical	Endangered/Threatened Species (Natural or Historical distribution) (Reintroduction Potential)	Restricted Modification Requires a 3:1 or higher habitats compensation (mitigation)
Irreplaceable	All Wildlife	No Net Loss
Essential	All Wildlife	No Net Loss or in situ or adjacent 1:1 compensation
High Ecological Value	All Wildlife	No Net Loss or in situ or adjacent 1:1 compensation
Ecological Value	All Wildlife	No Impact or in situ, adjacent or off-site 1:1 compensation
High Potential	All Wildlife	Mitigation through habitat enhancemen or land acquisition

Low Potential	All Wildlife	Mitigation through habitat enhancemen and other actions that improve habitat conditions

Technical Assistance for Wildlife Conservation in Puerto Rico

The Terrestrial Resources Division is currently conducting a technical assistance project that provides landowners with up-to-date management information and techniques to sustain and enhance wildlife habitats on their properties. This project is also responsible for reviewing projects proposed by government and private entities that could impact wildlife resources and provide guidance on how to minimize the negative impacts of such projects. The TRD and staff from other DNER units created a matrix to categorize habitats proposed for modification to facilitate the decision making process.. Habitat categories range from irreplaceable to habitats with low potential of being transformed into a higher category (see Table 8). Management and restoration of target habitats such as wetlands, shade coffee plantations,tropical hardwood forestsand riparian habitats are the focus of this project. Monitoring is accomplished by recording the number of private landowners consulted, the number of actual restoration and/or management projects developed, and the number of acres and/or kilometers enhanced, restored or protected.

Safe Harbor Agreements

The Safe Harbor Program is a conservation strategy that will be implemented by the DNER in order to monitor and manage species of concern on private lands. This programs will support recovery efforts of many federal and commonwealth trust species. With the development of multiple recovery projects for endangered

species in Puerto Rico (e.g., the establishment of a second wild population of the Puerto Rican parrot in northern Puerto Rico), a strong private lands program is critical for the success of these initiatives. Monitoring will be achieved through regular visits to enrolled properties to ensure compliance with the agreement. The DNER, possibly with the assistance of the USFWS, will monitor the protected species to ascertain the number of individuals occurring on enrolled lands.

Natural Heritage Program

The DNER's Natural Heritage Program is in charge of identifying lands for conservation throughout the Island. Once identified, the properties are prioritized for acquisition. This approach is another tool for conserving land to benefit wildlife species. This program also keeps a list of critical species, which includes both plants and animals. This list is regularly updated.

Para la Naturaleza ("For Nature" - part of the Puerto Rico Conservation Trust)

The Puerto Rico Conservation Trust is a private non-profit organization that currently manages 14 reserves (~13,000 acres) throughout the island. This entity monitors habitat as it relates to native habitat preservation and restoration. This organization also works to educate the public on the conservation of natural resources.

Ciudadanos del Carso (“Citizens of the Karst”)

Ciudadanos del Carso is a private non-profit organization whose mission is the acquisition of land, particularly in the karst region of Puerto Rico, for protection and conservation. This organization monitors habitat as it relates to native habitat preservation and restoration. Ciudadanos del Carso also educates the public on the conservation of natural resources, and collaborates with other environmental organizations and government agencies in projects and studies related to the conservation of the karst region.

Joint Priority Landscapes

Joint Priority Landscapes are created when Federal and State agencies and non-governmental organizations independently establish complimentary conservation priorities. It often makes sense to leverage these resources against each other. Joint Priority Landscapes have the potential to take many forms, due to the variety of approaches (e.g. watersheds, ecological units, issue centered) that are available. These efforts explicitly seek public engagement in a unified manner respects the time and talent of community members.

Work on two (2) joint priority priority landscapes will be in progress during this action plan’s implementation period: • The Guánica/Maricao joint priority landscape (Figure 36): This project is located in the southwestern corner of Puerto Rico. The Guanica/Maricao joint priority landscape will leverage most federal, state and independent conservation and management efforts. The NOAA Coastal Zone Management Program is working to protect the coral reef system, The Natural Resource Conservation Service is working with local famers to

improve water quality in the Rio Loco watershed and reduce soil erosion that affects streams and the reefs. Multiple wildlife and forestry agencies are collaborating with coffee growers to convert their plantations from sun coffee to shade coffee in order to benefit migratory birds and native wildlife. The EPA is considering a major estuary restoration effort. The US Forest Service and the DNER Forestry Bureau are working to promote the establishment of riparian buffer zones and agroforestry pilot programs in the area. The Fire Department and Guánica State Forest are working on strategies for managing wildlife fires. This landscape includes several important regional offices, including the Guánica State Forest (DNER), the Cabo Rojo Wildlife Refuge (USFWS) and the Maricao Critical Wildlife Area.

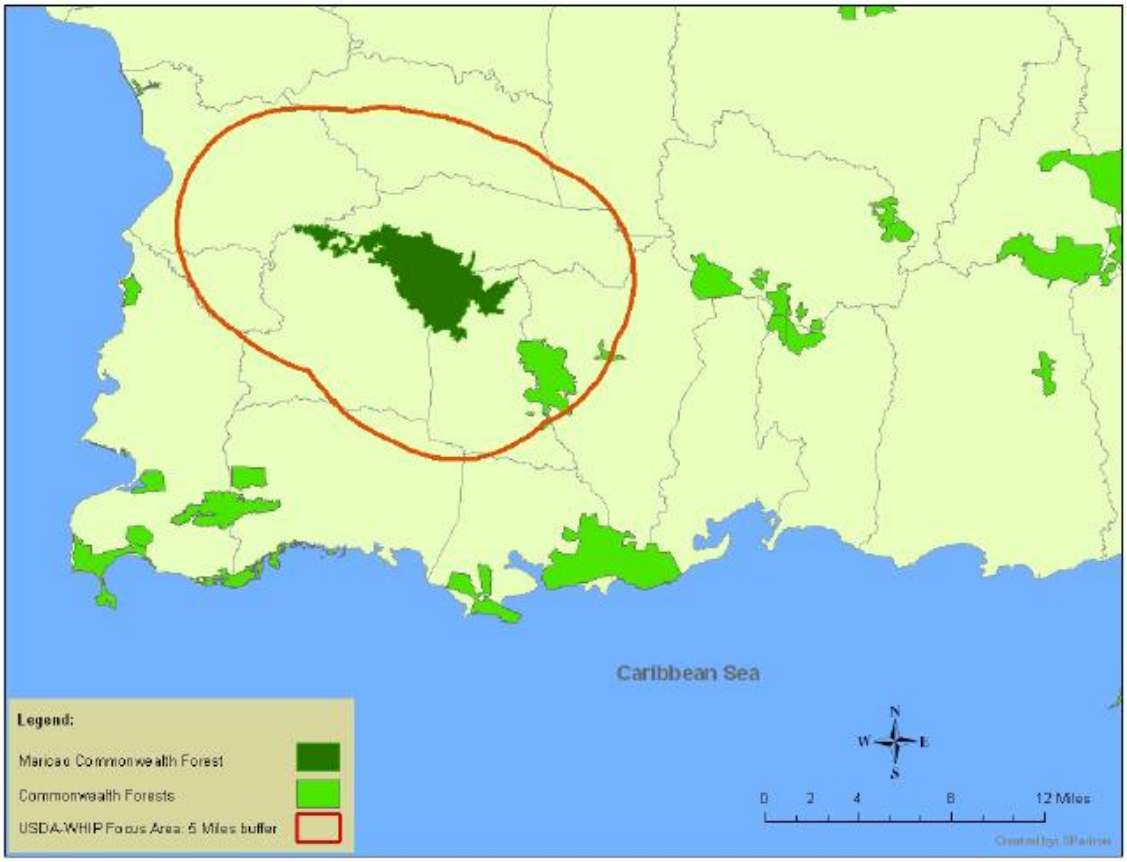


Figure 37. Overview of USDA-WHIP Focus Area, 5 miles around Maricao State Forest (From DNER 2011).

The Humacao joint priority landscape: This area is located in the southeastern corner of Puerto Rico, in an area of urban sprawl. All the federal and state partners in the NRCS State Technical committee have endorsed a collaborative effort in this area. The project would encourage the collaboration of several local communities in theconservation efforts. Efforts in the Humacao landscape will involve financial and technical assistance from federal agencies, as well as cost incentive programs. The DNER and the US Forest Service will be engaged through urban and community outreach programs, a forest stewardship program, a forest legacy program, and eventually a program creating new public spaces for Humacao communities. Federal and state fish and wildlife agencies will continue their conservation efforts focused species and habitats that are considered endangered and threatened. .

Adaptive Management

The Puerto Rico State Wildlife Action Plan does not pretend to be a fixed set of conservation strategies and goals. The main objective of the plan is to establish DNER's priorities for the conservation of wildlife species and their habitat in Puerto Rico. Once conservation actions are implemented, it is important to evaluate their progress and measure their effectiveness. Maintaining a loop between monitoring and management actions will help correct for the uncertainty resulting from management and adapt to new conditions and developments. Continued feedback among collaborators (e.g., DNER staff, stakeholders, academia, and the general public) is essential in order to fill information gaps related to particular conservation actions, as well aspropose alternatives for

improving project organization and fiscal responsibility. Conservation priorities and actions should be flexible in order to adapt to all possible situations.

Monitoring and conservation measures have been identified for many wildlife species in recovery or management plans. As previously mentioned, regular systematic surveys are conducted by DNER for some avian taxa. The Puerto Rican Ornithological Society conducts annual Audubon Christmas Bird Counts in southwestern and eastern Puerto Rico. However, most species require additional surveys, analysis, and conservation measures. For example, terrestrial invertebrates have not been adequately monitored, except for studies on specific species.

It is recognized that the monitoring phase will be time consuming and resource intensive. Thus, there will be a need to set limits on the number of species and habitats monitored. However, through this program, the DNER will encourage the participation of other parties (e.g., Universities, Conservation Organizations) by funding research projects that will provide information on the status of SGCN, particularly on data deficient species and habitats.

The specific long-term success of the PRSWAP conservation actions will be evaluated through different approaches: new scientific knowledge about SGCN and their habitats, number of funded and completed projects of conservation priority, net increase in the acreage of key habitats conserved through acquisition, restoration, or mitigation as mandated by Law No. 241, an increase of partnerships and public involvement resulting in the protection of wildlife resources, a reduction or elimination of threats to SGCN and priority habitats, and a long-term reduction in the number of SGCN and threats.

Portals of Information on the DNER Web Page

The development of a web site within the official DNER web page is recommended to facilitate the sharing up-to-date information related to current research findings, and monitoring data on species and habitats of concern.
http://www.drna.gobierno.pr/

CHAPTER 8. REVISIONS TO THE PRSWAP – 10 YEARS

The DNER will conduct internal evaluations and revisions of the PRSWAP every 2.5 years in order to adaptively address conservation priorities within the 10-year timeframe (Table 19). Changes in priorities will be based on changes in landscape and environmental conditions, and on wildlife and habitat responses to such changes and to implemented conservation actions. Performance reports for federally assisted projects and State Wildlife Grant projects, reports from wildlife permits granted by the agency, and in-house updates to the species priority list (mandated under Regulation No. 6766) will be used to document progress on activities related to the PRSWAP.

A detailed evaluation of the PRSWAP will be performed every 5 years in order to assess the status of conservation strategies and initiatives, SGCNs, and the stressors that significantly affect the island's wildlife and habitats. Input from partners and the general public will be requested during these evaluations. Previously identified partners and stakeholders will be asked to collaborate in the 5-year review with DNER staff. This mid-term evaluation will allow corrections to the strategy within the anticipated 10-year timeframe.

Table 19. Planned Wildlife Action Plan 2015-2025 timeline.

FY 01	FY 02	FY 03-04	FY 05	FY 06-09	FY 10
July 1st, 2014 – June 30, 2015	July 1st, 2015 – June 30, 2016	July 1st, 2016 – June 30, 2018	July 1st, 2018 – June 30, 2019	July 1st, 2019 – June 30, 2024	July 1st, 2024 – June 30, 2025
↓	↓	↓	↓	↓	↓
PRSWAP Preparation	PRSWAP Completion and Implementation	PRSWAP Implementation	PRSWAP Mid-Term Evaluation	PRSWAP Implementation	PRSWAP Revision

CHAPTER 9. COORDINATION OF DEVELOPMENT, IMPLEMENTATION, REVIEW OF THE PLAN-STRATEGY WITH FEDERAL, STATE, AND LOCAL AGENCIES AND INVOLVEMENT OF GENERAL PUBLIC IN THE PRSWAP

History

The DNER officially began the PRSWAP revision in September 2014, assembling an expert committee comprised of DNER staff within the Fisheries and Wildlife Bureau and collaborating with external resources to revise and develop the new action plan. External resources included technical assistance from Effective Environmental Restoration Inc., meetings with USFWS staff in Puerto Rico and information and feedback provided by researchers and members of the academia.

Coordination

The Puerto Rico State Wildlife Action Plan, was supported by a number of initiatives conducted before and after the development of the strategy that provided valuable information through data collection, final reports, and other scientific publications. Regulation No. 6766 was of particular importance to this endeavor. This regulation includes the original SGCN list, along with each species' status and threats. For the current revision, an expert committee assembled in 2011 worked to develop recommendations for the updated list of SGCN presented in this document.

Other key initiatives included in this revision include publications such as the Puerto Rico Critical Wildlife Areas (2005), the Puerto Rico Waterfowl Focus Areas (2005), and the Strategic Plan for Fisheries and Wildlife (PRDNER 1996). These documents have been subject to peer reviews by both private and public

(State and Federal) agencies and organizations, providing and exchanging valuable information and input. Thus, these entities provided indirect input in the development and revision of the PRSWAP.

In 2010, the DNER created the "Puerto Rico Statewide Assessment and Strategies for Forest Resources". This publication describes forest conditions on all ownerships in Puerto Rico; identifies forests related benefits and services; identifies threats to forest resources; highlights issues and trends of concern related to Puerto Rico's forests and delineates high priority forest landscapes. It serves its three main goals: 1) Conserve forest landscapes; 2) Protect forest from harm; 3) Enhance benefits from trees and forests. This publication was an important resource in the revision of the PRSWAP.

Agencies and Organizations that Provided Input:

State Agencies:
P.R. Department of Natural and Environmental Resources (several units)

Federal Agencies:
U.S. Fish and Wildlife Service, Caribbean Field Office and Caribbean Landscape Conservation Cooperative (www.caribbeanlcc.org).

Non-profit Organizations:
Effective Environmental Restoration, Inc.

Private Conservation Organizations:
Puerto Rican Ornithological Society

Academia:

University of Puerto Rico

Neftalí Rios, UPR Humacao

Interamerican University of Puerto Rico

Armando Rodriguez Duran

North Carolina State University

Jaime Collazo and Sara Prado

The draft of the Puerto Rico PRSWAP is currently posted on the DNER web page for revision. State and federal agencies, as well as other partners were asked to review the document and submit their comments in order to incorporate these inputs into the final document. Partners are encouraged to integrate SGCN, habitat, and conservation actions identified in the PRSWAP into their future plans and programs, and are invited to collaborate with DNER on the implementation of these actions.

Literature Cited:

Abbot, I. 1980. Theories dealing with the ecology of land birds on Islands. Ad. Ecol. Res. 11: 329-371.

Acevedo, R. and J. Morelock. 1988. Effects of terrigenous sediments influx on coral reef zonation in southwestern Puerto Rico: Proceedings of the Sixth International Coral Reefs Symposium, Townsville, Australia; 8th to 12th of August 1988, v.2, contributed papers, p. 189-194

Acevedo-Rodríguez P, and M.T. 2012. Catalogue of seed plants of the West Indies. Smithsonian Contributions to Botany, No. 98. Smithsonian Institution Scholarly Press, Washington DC.

Almodovar, W.I. 2008A. Forest Health Management. http://seam.uprm.edu/forest/pagina_ insectos

Atlantic Coast Joint Venture. 2009. Atlantic Coast Joint Venture Strategic Plan. http://acjv.org/documents/ACJV_StrategicPlan_2009update_final.pdf

Austin, M. P., and C. R. Margules. 1986. Assessing representativeness. *In*: Wildlife conservation evaluation, M.B. Usher, ed. Chapman and Hall, Ltd., London. 394 p.

Basnet, K., G. E. Likens, F.N. Scatena, and A.E. Lugo. 1992. Hurricane Hugo: Damage to a Tropical Rain Forest in Puerto Rico. Journal of Tropical Ecology 8(1): 47-55.

Birdsey, R. A. and P. L. Weaver. 1982. The forest resources of Puerto Rico. USDA Resources bulletin SO-85, October 1982. South. For. Exp. Station, New Orleans, LA. 59 pp.

Birdsey, R. A. and P. L. Weaver. 1987. Forest area trends in Puerto Rico. Resource Bulletin SO-85. U. S. Department of Agriculture Forest Service, Southern Forest Experiment Station, New Orleans, LA.

Blondel, J. 1985. Habitat selection in island versus mainland birds. Pp. 477-517. *In:* M. L. Cody (ed.). Habitat selection in birds. Academic Press, Inc. San Diego, CA.

Bonilla, G., M. Vázquez, y E. Berríos. 1992. Status, estimado poblacional y distribución de cuatro aves acuáticas nativas en Puerto Rico. Departamento de Recursos Naturales de Puerto Rico. Simposio XVIII de los Recursos Naturales de Puerto Rico. Vol. XVIII.

Borman, F.H. and G.E. Likens. 1979. Pattern and process in a forested ecosystem. Springer-Verlag, New York, 253 pp.

Brandeis, T.J. 2006. Assessing tree species assemblages in highly disturbed Puerto Rican karst landscapes using forest inventory data. Plant Ecology (186): 189-202

Brandeis, J. T., E. Helmer, S.N. Oswalt. 2007. The Status of Puerto Rico's Forests, 2003.Resource Bulletin SRS-119. Knoxville, TN, United States Department of Agriculture, Forest Service: 75.

Brandeis, J. T., E. Helmer, H. Marcano Vega, and A.E. Lugo. 2009. Climate shapes the novel plant communities that form after deforestation in Puerto Rico and the U.S. Virgin Islands. Forest Ecology and Management258: 1704-1718.

Brash, A. R. 1987. The history of avian extinction and forest conservation on Puerto Rico. Biol. Cons. 39: 97-111.

Brown, K., F. N. Scatena, J. Gurevitch. 2006. Effects of an invasive tree on community structure and diversity in a tropcial forest in Puerto Rico. Forest Ecology and Management 226: 145-152.

Callaway, R. and E. T. Aschehoug. 2000. Invasive plants versus their new and old neighbors: A mechanism for exotic invasion. Science 290(20).

Camacho-Rodríguez, María, J. Chabert-Llompart and M. López-Flores. 1999. Guía para la identificación de las aves exóticas establecidas en Puerto Rico. Departamento de Recursos Naturales y Ambientales, División de Recursos Terrestres. 52 pp.

Cardona, J. E. and M. Rivera. 1988. Critical Coastal Wildlife Areas of Puerto Rico. Commonwealth of Puerto Rico. Department of Natural Resources. Puerto Rico Coastal Zone Management Program. Scientific Research Area. San Juan, Puerto Rico. 173 pp.

Carlson A.E., A.N. LeGrande, D.W. Oppo, R.E. Came, G.A. Schmidt, F.S. Anslow, J.M. Licciardi and E.A. Obbink. 2008. Rapid Early Holocene deglaciation of the Laurentide ice sheet. Nature Geoscience 1: 620-624

Center for Sustainable Development Studies. 2009. Sustainability of Land Use in Puerto Rico. Report for presentation at The Angora Convention Center, Caguas, Puerto Rico. March 30, 2009. Universidad Metropolitana, School of Environmental Affairs. www.proyectosambientales.info.

Chabert, J. L., M. Corbet, A. Molinaris y E. Nieves. 1984. Informe de status de las aves acuáticas de caza y sus hábitats. Departamento de Recursos Naturales, Área de Investigaciones Científicas. 46 pp.

Clark, J.J. and P.R. Wilcock (2000). Effects of land use change on channel morphology in northeastern Puerto Rico: Geological Society of American Bulletin. (112): 1763-1777.

Cowardin, L.M., V. Carter, F.C. Golet, E.T. La Roe. (1979). Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. Office of Biological Services, Fish and Wildlife Service, U.S. Departmente of the Interior, Washington, D.C. 103 pp.

Cruz-Báez, A. D., and T. D. Boswell. 1997. Atlas de Puerto Rico. The Cuban American Council, Inc., Miami, FL. 202 pp.

Csuti, B. and A. R. Kiester. 1996. Hierarchical gap analysis for identifying priority areas for biodiversity. *In*: Gap analysis: A landscape approach to biodiversity planning, J.M. Scott et al. eds. American Society for Photogrammetry and Remote Sensing, Bethesda, Maryland. 320 p.

D'Antonio C.M., N.E. Jackson, C.C.Horvitz, R. Hedberg. 2004. Invasive plants in wildland ecosystems: merging the study of invasion processes with management needs. Front Ecol Env 2:513–521.

Daehler, C.C. 2003. Performance comparisons of co-occurring native and alien invasive plants: implications for conservation and restoration. Annu Rev Ecol Evol Syst 1:183–211.

Departamento de Recursos Naturales y Ambientales (2000). Nuevo reglamento para regir la extracción, excavación, remoción y dragado de los componentes de la corteza terrestre en Puerto Rico.

Departamento de Recursos Naturales y Ambientales (2000). Programa de Legado Forestal para Puerto Rico. Reporte. 71 pp.

Departamento de Recursos Naturales y Ambientales. 2004. Reglamento para regir las especies vulnerables y en peligro de extinción en el Estado Libre Asociado de Puerto Rico. Departamento de Estado Número Reglamento 6766. ELA, DRNA, San Juan, P.R. 60 pp.

Departamento de Recursos Naturales y Ambientales. (2003). Plan de Manejo para el Área de Planificación Especial de los manglares de Puerto Rico. Documento Final. DRNA. Programa de Manejo de la Zona Costanera.

Department of Natural and Environmental Resources (2010) Puerto Rico Coastal and Estuarine Land Conservation Plan. Coastal Zone Management Program. 30 pp.

Department of Natural and Environmental Resources (2008-a). Comprehensive Plan of Water Resources of Puerto Rico. Eight chapters.

Department of Natural and Environmental Resources. 2010. Puerto Rico Statewide Assessment and Strategies for Forest Resources. http://www.drna.gobierno.pr/oficinas/arn/recursosvivientes/nsf/publicaciones/PRSWASFS_STRAT_APP_22%20OCT2010%20gul%20-%20FINAL.pdf

Dietz, J.L. 1986. Economic history of Puerto Rico: institutional change and capitalist development. Princeton University Press, USA.

Dwyer, John F., Nowak, David J.; Noble, Mary Heather; Sisinni, Susan M. 2000. Connecting people with ecosystems in the 21st century: an assessment of our Nation's urban forests. Gen.Tech. Rep. PNW–490. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 483 p.

Ebenhard, T. 1988. Introduced birds and mammals and their ecological effects. Sweden Wildlife Research 13: 1-107.

EPA. 2015. Climate Change: Basic Information. Official Website of the United States Environmental Protection Agency. http://www.epa.gov/climatechange/basics/. Retrieved August 31 2015.

Ewel, J. J. and J. L. Whitmore. 1973. The ecological life zones of Puerto Rico and the U.S. Virgin Islands. Forest Service Research paper ITF-18. U.S. Department of Agriculture, Forest Service, Institute of Tropical Forestry. Rio Piedras, Puerto Rico.

Flynn, D. F. B., M. Uriarte, T. Crk, J.B Pascarella, J.K. Zimmerman, T.M. Aide, and M. Caraballo. 2010. Hurricane disturbance alters secondary forest recovery in Puerto Rico. Biotropica 42(1): 149-157

Franco, P.A., P.L. Weaver and S. Eggen-McIntosh. 1997. Forest Resources of Puerto Rico. Ashville NC: USDA Forest Service, Southern Research Station, Resource Bulletin SRS-22

García, M. A., C. E. Diez, and A. O. Alvarez. 2001. The impact of feral cats on Mona island wildlife. Caribbean Journal of Science 37: 1-2.

García, M. A., C. E. Diez, and A. O. Alvarez. 2002. Eradication of *Rattus rattus* from Monito Island. Pages 116-119. *In* D. Veitch, and M. Clout, eds. Turning the tide: The eradication of invasive species. IUCN SSC Invasive Species Specialist Group/Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, United Kingdom.

Goenaga, C, & Cintron, G. (1979). Inventory of the Puerto Rican coral reefs. Department of Natural Resources, Office of Coastal Zone Management

González LR, R. Rankin and A. Palmarola. 2012. Plantas invasoras en Cuba. Bissea 6:1–140.

Gould, W., S. Martinuzzi, and O. Ramos. 2003a. Image analysis and land cover mapping for Puerto Rico Poster presented at the National GAP Annual Meeting, October 6-9, 2003 Fort Collins Colorado.

Gould, W., B. Fevold, G. González, and S. Martinuzzi. 2003b. Hierarchical vegetation classification for the Puerto Rico Gap Analysis Project: Integrating climate, substrate, topography, and species composition in a land cover map legend. Poster presented at the National GAP Annual Meeting, October 6-9, 2003. Fort Collins Colorado.

Gould, W., C. Alarcón, B. Fevold, M.E. Jiménez, S. Martinuzzi, G. Potts, M. Solórzano, & E. Ventosa. 2008. Puerto Rico Gap Analysis Project. USGS Moscow, ID y el USDA Forest Service Internaciotional Institute of Tropical Forestry. Río Piedras, PR. 159 pp. abd 8 appendices.

Hartshorn, G.S. (1978) Tree fall and forest dynamics. Pp. 617-638 in Tomlinson, P and M. Zimmerman (eds.) Tropical tress as living systems. Cambridge University Press, Cambridge.

Helmer, E. H., Ramos, O., T. del Mar López, M. Quiñones, and W. Diaz. 2002. Mapping the Forest Type and Land Cover of Puerto Rico, a Component of the Caribbean Biodiversity Hotspot. Caribbean Journal of Science. 38: 3-4.

Holdridge, Lee R. 1967. Determination of World Plant Formations from Simple Climatic Data. Science, volumen 105, páginas 367—368.

Island Conservation. 2014. Preventing Extinction: Why islands? http://www.islandconservation.org/why-islands/

ITIS. 2005. Integrated Taxonomic Information System. Smithsonian Institution/NMNH MRC – 0180. Washington, DC 20560-0180. URL: http://www.itis.usda.gov/

IUCN. 1994. IUCN Red List Categories, IUCN, Gland, Switzerland. http://www.iucn.org/

Jennings, M. D. 1996. Nomenclature and mapping units for gap analysis land cover data. *In*: Gap Analysis: A landscape approach to biodiversity planning. J.M. Scott et al. eds. American Society of Photogrammetry and Remote Sensing, Bethesda, Maryland. 320 p.

Kennaway, T. and E. H. Helmer. 2007. The Forest types and ages cleared for land development in Puerto Rico. GIScience & Remote Sensing. 44(4): 356-382.

Kueffer, C., C.C. Daheler, C.W. Torres-Santana, C. Lavergne, J.Y Meyer, R. Otto and L. Silva. 2009. A global comparisons of plant invasions on oceanic

islands. Perspectives in Plant Ecology, Evolution and Systematics. doi:10.1016/j.ppees.2009.06.002.

Kuo, F.E. & W.C. Sullivan. 2001. Environment and Crime in the inner city. Does vegetation reduce crime? Environment and Behaviour 33: 23

Little, E. L., R. O. Woodbury and F. H. Wadsworth. 1974. Trees of Puerto Rico and the Virgin Islands. Second Vol. U. S. Dept of Agric. Handbook no. 449. 1024 pp.

Larsen, M.C. (2000). Analysis of twentieth century rainfall and stream flow to characterize drought and water resources in Puerto Rico: Physical Geography 21(6): 494-521

Larsen, M.C.and A. Santiago-Román (2001). Mass wasting and sediment storage in a small montane watershed: an extreme case of antropogenic disturbance in the humidtropics, in Dorava, J.M., F. Fitzpatrick, B.B. Palcsak and D.R Montgomery, eds, Geomorphic processes and riverine habitat: American Geophysical Union Monograph, p. 142-170

Levine J.M., M. Vila, C.M. D'Antonio, J.S. Dukes, K. Grigulis, S. Lovorel, 2003. Mechanisms underlying the impacts of exotic plant invasions. Proc R Soc London B 270:775–781.

López, M. 2007. Áreas Marinas Protegidas en Puerto Rico. Programa de Manejo de la Zona Costanera: Los primeros 25 años. http://www.drna.gobierno.pr/oficinas/arn/recursosvivientes/costasreservasrefugios/pmzc/publicaciones/publicaciones/

López, T. del Mar, T.M. Aide, and J.R. Thomlinson. 2001. Urban expansion and the loss of prime agricultural lands in Puerto Rico. Ambio 30: 49-54.

Lowrance, R.L. R.L. Todd, L.E. Asmussen. 1984. Nutrient cycling in an agricultural watershed. I. Phreatic movement. Journal of Environmental Quality. 13: 22–27.

Lugo, A. E. 1988. Estimating reductions in the diversity of tropical forest species. Pp. 58-70. *In* E. O. Wilson (ed.), Biodiversity National Academy Press, Washington, D.C. 521 pp.

Lugo, A. E. (2000). "Effects and outcomes of caribbean hurricanes in a climate change scenario". Science of the Total Environment 262(3): 243-251.

Lugo, A. E. 2004. "The outcome of alien tree invasions in Puerto Rico". Frontiers in Ecology and the Environment 5(2): 265-273.

Lugo, A. and E. Helmer. 2004. "Emerging forests on abandoned land: Puerto Rico's new forests". Forest Ecology and Management190: 145-161.

Lugo, A. E., T.del M. López, O. Ramos y L. Vélez. 2004. Urbanización de los terrenos en la periferia de El Yunque. U.S.D.A., Forest Service. Gen. Tech. Report WO-66

Mack R.N., D. Simberloff, W.M. Lonsdale, H. Evans, M. Clout, F.A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecol Appl 10:689–710.

Martinuzzi, S., W. Gould, and O. Ramos. 2003a. Cloud and cloud shadow removal in the creation of a cloud-free composite Landsat ETM scene in tropical landscapes. Poster presented at the National GAP Annual Meeting, October 6-9, 2003, Fort Collins, Colorado.

Martinuzzi, S., W. Gould, and O. Ramos. 2003b. Urban cover estimates from image analysis and land cover mapping of Puerto Rico. Presented at the 2nd Congreso de Ecourbanismo, Centro de Bellas Artes, November 18-19, 2003 Caguas, Puerto Rico.

Martinuzzi, S., W. Gould, and O. Ramos. Integrating remote sensing and GIS for land cover mapping and analysis in the Karst area. Presented at the Second Symposium of Karst Research, September 27, 2003 University in Bayamón Puerto Rico.

Martinuzzi, S., W. Gould and O.M. Ramos. 2007. Land development, land use and urban sprawl in Puerto Rico integrating remote sensing and population census data. Landscape and Urban Planning 79: 288-297.

Martorell, L.F. 1945. A survey of the forest insects of Puerto Rico. Part II. The Journal of Agriculture of the University of Puerto Rico. Agricultural Experiment Station, Río Piedras, P.R. p. 355-608.

Maser, C, and J. R Sedell. 1994. From the forest to the sea: the ecology of wood in streams, rivers, estuaries and oceans The University of Chicago PressDelray Beach, Florida.

Morelock J, K.A Grove,and J.V.A. Trumbell. 1980. Sediments and recents geological history of the Guayanilla submarine canyon system, Puerto Rico: Novena Conferencia Geológica del Caribe, Santo Domingo, Dominican Republic.

Morelock J, K.A Grove, and M.L. Schwartz. 1983. Oceanography and patterns of shelf sediments Mayaguez, Puerto Rico. Journal of Sedimentary Petrology, 53:2:371-381.

Morelock, J. K.A., M. Hernández Ávila, M.L. Schwartz and D.M. Hatfield. 1985. Net shore-drift on the north coast of Puerto Rico: Shore and Beach, 53: 16-21.

Myers, N. R. A. Mittermeir, C. G. Mittermeier, G. A. B. da Fonseca, and J. Ke. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

National Gap Analysis Program. 1994. A handbook for gap analysis. Moscow, Idaho, USA.

National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, U.S. Coast Guard, Departamento de Recursos Naturales y Ambientales, and U.S. Department of the Interior. 2000. Sensitivity of Coastal and Inland Resources to Spilled Oil; Puerto Rico Atlas. Published in Seattle, Washington. Hazardous Materials Response Division of NOAA.

National Urban and Community Forestry Advisory Council. 2008. A Comprehensive look at tropical urban Foestry. Executive summary to the Secretary of Agriculture. Report.

NatureServe Organization. 2005. 1101 Wilson Boulevard 15th Floor, Arlington, VA 22209.http://www.natureserve.org/

Negrón-González, L. 1986. Lagunas de Puerto Rico. *En*: Compendio Enciclopédico de los Recursos Naturales de Puerto Rico. Volumen 3. Por

José L. Vivaldi (Editor). Estado Libre Asociado de Puerto Rico. Departamento de Recursos Naturales. San Juan, Puerto Rico. 248 pp.

Noss, R.F, and A.Y. Cooperrider. 1994. Saving nature's legacy. Island Press, Washington, D.C. 420 p.

Núñez-García, F. and W.C. Hunter. 2000. Puerto Rico and the U.S. Virgin Islands Bird Conservation Plan. Version 1.0. USFWS, 1875 Century Boulevard, Atlanta, Georgia. 76 pp.

Odum, Eugene P. 1979. Ecological importance of the riparian zone. In: Strategies for protection and management of floodplain wetlands and other riparian ecosystems: proceedings of the symposium. Gen. Tech. Rep. WO–12. Washington, DC: U.S. Department of Agriculture, Forest Service: 2–4.

Ortiz-Rosas, P. and V. Quevedo-Bonilla. 1987. Áreas con prioridad para la conservación en Puerto Rico. Programa Pro-Patrimonio Natural. Estado Libre Asociado de Puerto Rico, Departamento Recursos Naturales. 217 pp.

Pérez-Buitrago N, M.A. Garcia, A. Sabat, J. Delgado, A. Álvarez, O. McMillan, S.M. Funk. 2008. Do headstart programs work? Survival and body condition in headstarted Mona Island iguanas *Cyclura cornuta stejnegeri*. Endang. Species Res., 6: 55-65

Pfeffer, W. and J. O'Neel. 2008. Kinematic constrains on glacier contributions to 21st-century sea-level rise. Science 321: 1340-1343

Pickett, S.T.A. and P.S. White. 1985. The ecology of natural disturbance and patch dynamics. Academic Press Inc. Orlando, Florida. 472 pp.

Puerto Rico Climate Change Council (PRCCC). 2013. State of Puerto Rico's Climate 2010-2013 Executive Summary. Assessing Puerto Rico's Social-Ecological Vulnerabilities in a Changing Climate. ELECTRONIC VERSION. Puerto Rico Coastal Zone Management Program, Departament of Natural and Environmental Resources, Office of Ocean and Coastal Resource Management (NOAA-OCRM). San Juan, PR: pp. 27.

Puerto Rico Department of Natural and Environmental Resources. 1996. Strategic plan of the fish and wildlife natural resources. Government of Puerto Rico, San Juan, P.R.

Puerto Rico Planning Board. 2014. Puerto Rico Land Use Plan. www.oput.gobierno.pr

Pysˇek P, Jarosˇı´k V, Hulme PE, Pergl J, Hejda M, Schaffner U, Vila` M (2012) A global assessment of invasive plant impacts on resident species, communities and ecosystems: the interaction of impact measures, invading species traits and environment. Glob Change Biol 18:1725–1737

Raffaele, H. and J. M. Duffield. 1979. Critical wildlife areas of Puerto Rico. Division of Fish and Wildlife Planning, Dept. of Natural Resources, Puerto Rico. 165 pp.

Raffaele, H. 1983. A guide to the birds of Puerto Rico and the Virgin Islands. Fondo Educativo Interamericano, San Juan, Puerto Rico. 225 pp.

Raffaele, H. A. 1989. A guide to the Birds of Puerto Rico and the Virgin Islands. Princeton University Press. New Jersey.

Ricklefs, R. E. and G. W. Cox. 1978. Stage and taxon cycle, habitat distribution and population density in the avifauna of the West Indies. Amer. Nat. 112: 875-895.

Rivero, J.A. 1998. Los anfibios y reptiles de Puerto Rico. Segunda Edición Revisada. Editorial de la Universidad de Puerto Rico. 510 pp.

Robbins, A.M, C. Eckelmann and M. Quiñones. 2009. Forest Fires in the Insular Caribbean. Ambio: A Journal of the Human Enviroment 37: 528-534.

Rogers, C.S. 1990. Responses of coral reefs and reefs organisms to sedimentation. Marine Ecology Progress Series. Vol. 62. 185-202.

Rodriguez, L. F. 2006. "Can invasive species facilitate native species? Evidence of how, when, and why these impacts can occur.". Biological Invaisons 8: 927-939.

Rojas-Sandoval, L., and P. Acevedo-Rodríguez. 2014. Naturalization and invasión of alien plants in Puerto Rico and the Virgin Islands. Biol Invasions DOI 10.1007/s10530-014-0712-3.

Scott, D. A., and M. Carbonell. 1986. Inventario de Humedales de la Región Neotropical. IWRB Slimbridge and UICN Cambridge

Scott, J. M., B. Csuti, J.D. Jacobi, and J.E. Estes. 1987. Species richness. BioScience 37(11): 782-787.

Scott, J. M.,F. Davis, B. Csuti, R. Noss. B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'erchia, T. C. Edwards, Jr., J. Ulliman, and R. G. Wright. 1993. Gap Analysis: A geographic approach to protection of biological diversity. Wildl. Monogr. 123 pp.

Snyder, N. F. R., J. W. Wiley and C. B. Kepler. 1987. The parrots of Luquillo: natural history and conservation of the Puerto Rican Parrot. Western Foundation of Vertebrate Zoology. Los Angeles, California.

Tanner, J. V. E., V. Kapos, and J.R. Healy. 1991. Hurricane effects on forest ecosystems in ths Caribbean. Biotropica 23(4a): 513-521.

Terborgh, J. W. 1980. The conservation status of Neotropical migrants: present and future: Pp. 21-30. *In* A. Keast and E. S. Morton. Migrant birds in the Neotropics: ecology, behavior, distribution and conservation. Smithsonian Institution press. Washington, D.C.

Torres, J.A., S. Medina. 1998. Los insectos de Puerto Rico. Acta Científica 12(1-3): 3-41.

Torres J.L. and J. Morelock. 2002. Effects of terriginous sediment influx on coral cover and linear extension rates of three Caribbean masive coral species: Caribbean Journal of Science 38(3-4): 222-229.

United States Fish & Wildlife Service. 2009. Virgin Islands Tree Boa (Epicrates monensis granti) 5 Year Review: Summary and Evaluation. Southeast Region, Ecological Services, Boquerón, Puerto Rico. http://ecos.fws.gov/docs/five_year_review/doc2508.pdf

U. S. Census Bureau. 2000. Census Data for Puerto Rico. http://www.census.gov/census2000/states/pr.html.

U.S. Fish & Wildlife Service. 1987. Recovery plan for the Puerto Rican parrot, *Amazona vittata*. U. S. Fish and Wildlife Service, Atlanta, Ga. http://www.fws.gov/ecos/ajax/docs/recovery_plan/090617.pdf

Ventosa-Febles, E., M. Camacho-Rodríguez, J. L. Chabert-Llompart, J. Sustache-Sustache, D. Dávila-Casanova. 2005a. Puerto Rico Critical Wildlife Areas. P.R. Department of Natural and Environmental Resources, Terrestrial Resources Division, San Juan, P.R. 383 pp.

Ventosa-Febles, E., M. Camacho-Rodríguez, J. L. Chabert-Llompart, J. Sustache-Sustache, D. Dávila-Casanova. 2005b. Puerto Rico Waterfowl Focus Areas. Puerto Rico Department of Natural and Environmental Resources; North American Waterfowl Management Plan and Atlantic Coast Joint Venture. 95 pp.

Vilella, F. J., and E. R. García. 1995. Post-hurricane management of the Puerto Rican parrot. Pages 618-621. *In* J. A. Bissonette and P. R. Krausman, editors. Integrating people and wildlife for a sustainable future. Proceedings of the first international wildlife management congress. The Wildlife Society, Bethesda, Md.

Warne, A.G., R.M.T. Webb, and M.C. Larsen, (2005). Water, Sediment, and Nutrient Discharge Characteristics of Rivers in Puerto Rico, and their Potential Influence on Coral Reefs: U.S. Geological Survey Scientific Investigations Report 2005-5206, 58 p.

Weil, E. 2004. Coral Reef Disease in the wider Caribbean: in Rosemberg, E. and Y. Loya, eds. Coral Health and Disease, Springer-Verlag., p. 35-68.

Welsch, David J. 1991. Riparian forest buffers: function and design for protection and enhancement of water resources. NA–PR–07–91. Radnor [Newtown Square], PA: U.S. Department of Agriculture, Forest Service, State and Private Forestry, Northeastern Area. 20 p.

Wiley, J. W., and J. M. Wunderle. 1993. The effects of hurricanes on birds, with special reference to Caribbean islands. Bird Conservation 3: 319-349.

Wiley, J. W., and F. J. Vilella. 1998. Caribbean Islands. Pages 315-349. *In* M. J. Mac, P. A. Opler, C. E. Puckett Haecker, and P. D. Doran, editors. Status and trends of the nation's biological resources. 2 vols. U. S. Department of the Interior, U. S. Geological Survey, Reston, Va.

APPENDIX I - CATEGORIES AND DEFINITIONS

Critically Endangered (CR): A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing an extremely high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥90% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
    (a) direct observation
    (b) an index of abundance appropriate to the taxon
    (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
    (d) actual or potential levels of exploitation
    (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
2. An observed, estimated, inferred or suspected population size reduction of ≥80% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
3. A population size reduction of ≥80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
4. An observed, estimated, inferred, projected or suspected population size reduction of ≥80% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 100 km², and estimates indicating at least two of a-c:
    a. Severely fragmented or known to exist at only a single location.
    b. Continuing decline, observed, inferred or projected, in any of the following:
        (i) extent of occurrence
        (ii) area of occupancy
        (iii) area, extent and/or quality of habitat
        (iv) number of locations or subpopulations
        (v) number of mature individuals.
    c. Extreme fluctuations in any of the following:
        (i) extent of occurrence
        (ii) area of occupancy
        (iii) number of locations or subpopulations
        (iv) number of mature individuals.
2. Area of occupancy estimated to be less than 10 km², and estimates indicating at least two of a-c:
    a. Severely fragmented or known to exist at only a single location.
    b. Continuing decline, observed, inferred or projected, in any of the following:
        (i) extent of occurrence
        (ii) area of occupancy
        (iii) area, extent and/or quality of habitat
        (iv) number of locations or subpopulations
        (v) number of mature individuals.
    c. Extreme fluctuations in any of the following:
        (i) extent of occurrence
        (ii) area of occupancy
        (iii) number of locations or subpopulations
        (iv) number of mature individuals.

C. Population size estimated to number fewer than 250 mature individuals and either:

1. An estimated continuing decline of at least 25% within three years or one generation, whichever is longer, (up to a maximum of 100 years in the future) OR
2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):
    (a) Population structure in the form of one of the following:
        (i) no subpopulation estimated to contain more than 50 mature individuals, OR
        (ii) at least 90% of mature individuals in one subpopulation.
    (b) Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 50 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 100 years).

ENDANGERED (EN): A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥70% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
    (a) direct observation
    (b) an index of abundance appropriate to the taxon
    (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
    (d) actual or potential levels of exploitation
    (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
2. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not

have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.
3. A population size reduction of ≥50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
4. An observed, estimated, inferred, projected or suspected population size reduction of ≥50% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 5,000 km², and estimates indicating at least two of a-c:
    a. Severely fragmented or known to exist at no more than five locations.
    b. Continuing decline, observed, inferred or projected, in any of the following:
        (i) extent of occurrence
        (ii) area of occupancy
        (iii) area, extent and/or quality of habitat
        (iv) number of locations or subpopulations
        (v) number of mature individuals.
    c. Extreme fluctuations in any of the following:
        (i) extent of occurrence
        (ii) area of occupancy
        (iii) number of locations or subpopulations
        (iv) number of mature individuals.
2. Area of occupancy estimated to be less than 500 km², and estimates indicating at least two of a-c:
    a. Severely fragmented or known to exist at no more than five locations.
    b. Continuing decline, observed, inferred or projected, in any of the following:
        (i) extent of occurrence
        (ii) area of occupancy

(iii) area, extent and/or quality of habitat
(iv) number of locations or subpopulations
(v) number of mature individuals.

c. Extreme fluctuations in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

C. Population size estimated to number fewer than 2,500 mature individuals and either:

1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) OR
2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):

(a) Population structure in the form of one of the following:
(i) no subpopulation estimated to contain more than 250 mature individuals, OR
(ii) at least 95% of mature individuals in one subpopulation.

(b) Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 250 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

VULNERABLE (VU): A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are

clearly reversible AND understood AND ceased, based on (and specifying) any of the following:

(a) direct observation
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation
(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥30% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥30%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥30% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 20,000 km², and estimates indicating at least two of a-c:

a. Severely fragmented or known to exist at no more than 10 locations.
b. Continuing decline, observed, inferred or projected, in any of the following:
(i) extent of occurrence
(ii) area of occupancy
(iii) area, extent and/or quality of habitat
(iv) number of locations or subpopulations
(v) number of mature individuals.
c. Extreme fluctuations in any of the following:

(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

2. Area of occupancy estimated to be less than 2,000 km², and estimates indicating at least two of a-c:

a. Severely fragmented or known to exist at no more than 10 locations.

b. Continuing decline, observed, inferred or projected, in any of the following:

(i) extent of occurrence
(ii) area of occupancy
(iii) area, extent and/or quality of habitat
(iv) number of locations or subpopulations
(v) number of mature individuals.

c. Extreme fluctuations in any of the following:

(i) extent of occurrence
(ii) area of occupancy
(iii) number of locations or subpopulations
(iv) number of mature individuals.

C. Population size estimated to number fewer than 10,000 mature individuals and either:

1. An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b):

(a) Population structure in the form of one of the following:

(i) no subpopulation estimated to contain more than 1000 mature individuals, OR

(ii) all mature individuals are in one subpopulation.

b) Extreme fluctuations in number of mature individuals.

D. Population very small or restricted in the form of either of the following:

1. Population size estimated to number fewer than 1,000 mature individuals.

2. Population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations typically five or fewer such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.

E. Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years

Lower Risk (LR) - A species is at lower risk when, after an evaluation, it did not satisfy any of the categories of Critically Endangered, Endangered or Vulnerable, and it is not Data Deficient. Species included in the category of lower risk can be divided in three sub-categories:

1. Conservation Dependant (dc) - Species that are the center of a continuous conservation program of taxonomic or habitat specificity, focused on a particular species, which would be classified into one of the previous categories if the program ends within a period of five year.
2. Almost Threatened (ca) - Species that can not be classified as Conservation Depended, but are close to be classified as Vulnerable.
3. Lower Concern (lc) - Species that can not be classified as Conservation Depended or Almost Threatened.

Data Deficient (DD) - A species belongs to the category of Data Deficient when the information is not adequate for a direct or indirect evaluation of risk of extinction, over the base of distribution and/or condition of the population. A species in this category could be well studied, and its biology might be well known, but appropriate data about its abundance and distribution may be lacking. Therefore, data Deficient is not a threat or risk category. Including a species in this category indicates that more information is required, and it is recognized that future investigations could determine that a threatened classification can be appropriate. It is important to make a conscious use of all data available. In many cases caution is advised when selecting between Data Deficient and a threatened condition. If it is suspected that the distribution of a species is relatively restricted, and a considerable period of time has passed since the last time the species was registered, then the threatened condition could be well justified.

APPENDIX II - LIST OF ACRONYMS

ACJV – Atlantic Coast Joint Venture

CH – Critical Habitat

CR – Critically Endangered

CWA – Critical Wildlife Areas

PRSWAP – Comprehensive Wildlife Conservation Strategy

DD – Data Deficient

DNER – Department of Natural and Environmental Resources

DNR – Department of Natural Resources

E – Endemic

CEH – Critical Essential Habitat

EN - Endangered

FY – Fiscal Year

I - Introduced

IITF – International Institute of Tropical Forestry

ITIS - Integrated Taxonomic Information System

LR – Low Risk

M - Migratory

N - Native

NCSU – North Carolina State University

NGO – Non-governmental Organization

NHP – Natural Heritage Program

PFW – Partners for Fish and Wildlife

PRCT – Puerto Rico Conservation Trust

PR-GAP – Puerto Rico Gap Analysis Project

PRLUP – Puerto Rico Land Use Plan

PRPP – Puerto Rican Plain Pigeon

PRSWAP – Puerto Rico State Wildlife Action Plan

PRWFA – Puerto Rico Waterfowl Focus Area

SGCN – Species of Greatest Conservation Need

SWG – State Wildlife Grants

T/E – Threatened and Endangered Species

TRD – Terrestrial Resources Division

USFWS – United States of America Fish and Wildlife Service

VU – Vulnerable

WCRP – Wildlife Conservation and Restoration Program

APPENDIX III - ROAD MAP

This roadmap is provided for those who are evaluating the Action Plan for the purpose of determining how well it meets the eight elements required by congress.

Element 1:

Information on the distribution and abundance of species of wildlife, including low and declining populations as the state deems appropriate, that are indicative of the diversity and health of the state's wildlife.

Sub-elements:

A. The Action Plan indicates sources of information (e.g., literature, data bases, agencies, individuals) on wildlife abundance and distribution consulted during the planning process.
B. The Action Plan includes information about both abundance and distribution for species in all major groups to the extent that data are available. There are plans for acquiring information about species for which adequate abundance and/or distribution information is unavailable.
C. The Action Plan identifies low and declining populations to the extent data are available.
D. All major groups of wildlife have been considered or an explanation is provided as to why they were not. The State may indicate whether these groups are to be included in a future Action Plan revision.
E. The Action Plan describes the process used to select the species in greatest need of conservation. The quantity of information in the Action Plan is determined by the State with input from its partners, based on what is available to the State.

Chapter	Sub-element addressed	Page(s)
Executive Summary	D	9-13
Introduction - Background	A, E	14-16
Introduction - Approach	B,D	17
Species of Greatest Conservation Need	A, B, C, D, E	20-32
Habitats of Greatest Conservation Need	B	104-142

Acknowledgments	A	8
Literature Cited	A	156-169

Element 2:

Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in Element 1.

Sub-elements:

A. The Action Plan provides a reasonable explanation for the level of detail provided; if insufficient, the Action Plan identifies the types of future actions that will be taken to obtain the information.
B. Key habitats and their relative conditions are described in enough detail such that the State can determine where (i.e., in which regions, watersheds, or landscapes within the State) and what conservation actions need to take place.

Chapter	Sub-element addressed	Page(s)
Executive Summary	A	9-13
Introduction	A, B	15-20
Habitat Requirements and Information Needs for Priority Species	A, B	34-49
Habitats of Greatest Conservation Need	A, B	106-144

Element 3:

Descriptions of problems which may adversely affect species identified in Element1 or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats:

Sub-elements:

A. The Action Plan indicates sources of information (e.g., literature, databases, agencies, or individuals) used to determine the problems or threats.

B. The threats/problems are described in sufficient detail to develop focused conservation actions.

C. The Action Plan considers threats/problems, regardless of their origins (local, State, regional, national and international), where relevant to the State's species and habitats.

D. If available information is insufficient to describe threats/problems, research and survey efforts are identified to obtain needed information.

E. The priority research and survey needs, and resulting products, are described sufficiently to allow for the development of research and survey projects after the Action Plan is approved.

Chapter	Sub-element addressed	Page(s)
Introduction	A, C	15-20
Habitat Requirements and Information Needs for Priority Species	C, D	34-49
Identifying Stressor/Threats to Puerto Rico Wildlife	A, B, C, D, E	50-71
Acknowledgments	A	8
Literature Cited	A	156-169

Element 4:

Descriptions of conservation actions determined to be necessary to conserve the identified species and habitats and priorities for implementing such actions:

Sub-elements:

A. The Action Plan identifies how conservation actions address identified threats to species of greatest conservation need and their habitats.

B. The Action Plan describes conservation actions sufficiently to guide implementation of those actions through the development and execution of specific projects and programs.

C. The Action Plan links conservation actions to objectives and indicators that will facilitate monitoring and performance measurement of those conservation actions.

D. The Action Plan describes conservation actions (where relevant to the State's species and habitats) that could be addressed by Federal agencies or regional, national or international partners and shared with other States.

E. If available information is insufficient to describe needed conservation actions, the Action Plan identifies research or survey needs for obtaining information to develop specific conservation actions.

F. The Action Plan identifies the relative priority of conservation actions.

Chapter	Sub-element addressed	Page(s)
Executive Summary	C, D	9-13
Introduction	C, D	15-20
Habitat Requirements and Information Needs for Priority Species	A, B, C, D, E, F	34-49
Identifying Stressor/Threats to Puerto Rico Wildlife	A, B, C, D, E, F	50-71
Conservation Strategies for Puerto Rico Wildlife Action Plan	A, B, C, D, E, F	71-104

Element 5:

Proposed plans for monitoring species identified in Element 1 and their habitats, for monitoring the effectiveness of the conservation actions proposed in Element

4, and for adapting these conservation actions to respond appropriately to new information or changing conditions:

Sub-elements:

A. The Action Plan describes plans for monitoring species identified in Element 1, and their habitats.
B. The Action Plan describes how the outcomes of the conservation actions will be monitored.
C. If monitoring is not identified for a species or species group, the Action Plan explains why it is not appropriate, necessary or possible.
D. Monitoring is to be accomplished at one of several levels including individual species, guilds, or natural communities.
E. The monitoring utilizes or builds on existing monitoring and survey systems or explains how information will be obtained to determine the effectiveness of conservation actions.
F. The monitoring considers the appropriate geographic scale to evaluate the status of species or species groups and the effectiveness of conservation actions.
G. The Action Plan is adaptive in that it allows for evaluating conservation actions and implementing new actions accordingly.

Chapter	Sub-element addressed	Page(s)
Introduction	A, B, C, D, E, F, G	15-20
Executive Summary	A, B, C, D, E, F, G	9-13
Habitat Requirements and Information Needs for Priority Species	A, B	34-49
Monitoring and Adaptation of Conservation Actions	A, B, C, D, E, F, G	143-152

Element 6:

Descriptions of procedures to review the Action Plan at intervals not to exceed 10 years:

Sub-elements:

A. The State describes the process that will be used to review the Action Plan within the next ten years.

Chapter	Sub-element addressed	Page(s)
Executive Summary	A	9-13
Introduction	A	15-20
Revisions to the PRSWAP	A	153

Element 7:

Plans for coordinating, to the extent feasible, the development, implementation, review, and revision of the Action Plan with Federal, State, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats:

Sub-elements:

A. The State describes the extent of its coordination with and efforts to involve Federal, State and local agencies, and Indian Tribes in the development of its Action Plan.
B. The State describes its continued coordination with these agencies and tribes in the implementation, review and revision of its Action Plan.

Chapter	Sub-element addressed	Page(s)
Introduction	A, B	15-20
Revision to the PRSWAP	A, B	153
Coordination of Development, Implementation, Review, and Revision	A, B	154-156

Element 8:

Provisions to ensure public participation in the development, revision, and implementation of projects and programs. Congress has affirmed that broad public participation is an essential element of this process:

Sub-elements:

A. The State describes the extent of its efforts to involve the public in the development of its Action Plan.

B. The State describes its continued public involvement in the implementation and revision of its Action Plan.

Chapter	Sub-element addressed	Page(s)
Introduction	A, B	15-20
Coordination of Development, Implementation, Review, and Revision	A, B	154-156

APPENDIX V – SGCN REMOVED FOR THIS REVISION

Common Name	**Scientific Name**	**Category 2005**
Marine Mammals		
Minke Whale	*Balaenoptera acutorostrata*	DD
Sei Whale	*Balaenoptera borealis*	EN
Fin Whale	*Balaenoptera physalus*	EN
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	DD
Risso's Dolphin	*Grampus griseus*	DD
Killer Whale	*Orcinus orca*	DD
False Killer Whale	*Pseudorca crassidens*	DD
Striped Dolphin	*Stenella coeruleoalba*	DD
Spinner Dolphin	*Stenella longirostris*	DD
Birds		
Peregrine Falcon	*Falco peregrinus tundrius*	CR
Reddish Egret	*Egretta rufescens*	DD
Mangrove Cuckoo	*Coccyzus minor*	DD

Common Name	Scientific Name	Category 2005
Bobolink	*Dolichonyx oryzivorus*	DD
Common Yellowthroat	*Geothlypis trichas*	DD
Red Siskin	*Carduelis cucullata*	DD
Black Rail	*Laterallus jamaicensis*	DD
Stilt Sandpiper	*Calidris himantopus*	DD
Whimbrel	*Numenius phaeopus*	LR
Freshwater Fishes		
Hognose mullet	Joturus pichardi	CR
Puerto Rican Galliwasp	Diploglossus pleei	-
Saltwater Fishes		
Sword-spine Snook	Centropomus ensiferus	DD
Fat Snook	Centropomus parallelus	DD
Fairy Basslet	Gramma loreto	DD
Jackknife	Equetus lanceolatus	DD