

JOBOS BAY NATIONAL ESTUARINE RESEARCH RESERVE

Management Plan 2017-2022

Draft August, 2017



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Acronyms and abbreviations



ACS	American Community Survey
AMLC	Association of Marine Laboratories of the Caribbean
ANDA	Spanish acronym for National Environmental Law Association
AO	Administrative Order
As	Arsenic
ATV	All-terrain vehicle
BMPs	Best Management Practices
CariCOOS	Caribbean Coastal Ocean Observing System
C-CAP	Coastal Change Analysis Program
CDMO	Centralized Data Management Office
CEAP	Conservation Effects Assessment Project
CFMC	Caribbean Fishery Management Council
CICA	Spanish acronym for Auxiliary Corps of Scientific Interpreters
CIS	Center for Social Innovation
CLCC	Caribbean Landscape Conservation Cooperative
Cu	Copper
CTP	Coastal Training Program
CZMA	Coastal Zone Management Act
DECEP	Division of Continued Education and Professional Studies
EBA	Ecosystem- based adaptation
EQB	Environmental Quality Board
ERD	Estuarine Reserves Division (NOAA)
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FIRM	Flood Insurance Rate Maps
FMP	Facilities Master Plan
FURA	Joint Forces of Rapid Action
GIS	Geographic Information System
GRF	Graduate Research Fellowship
IDEBAJO	Iniciativa de Eco-Desarrollo de Bahía de Jobos
INCICO	Instituto de Ciencias para la Conservación de Puerto Rico
IOOS	Integrated Ocean Observing System

JBNERR	Jobos Bay National Estuarine Research Reserve
K	Kindergarten
Km ²	square kilometers
LIDAR	Light Detecting and Ranging
LNG	Liquefied Natural Gas
MA	Market Analysis
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPA	Marine Protected Area
NA	Needs Assessment
NAI	National Association for Interpretation
NCCOS	National Centers for Coastal Ocean Science
n.d.	no date
NERRSCS	National Estuarine Research Reserve System classification scheme
NERR	National Estuarine Research Reserve
NERRS	National Estuarine Research Reserve System
NGO	Non-Governmental Organization
NGSS	Next Generation Science Standards
NMFS	National Marine Fisheries Service (NOAA)
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OCAM	Office of the Commissioner of Municipal Affairs
OCM	Office for Coastal Management
OGPe	Spanish acronym for the Puerto Rico Permits Management Office
OPAS	Organización Pro Ambiente Sustentable
PAHs	Polycyclic Aromatic Hydrocarbons
PRCCC	Puerto Rico Climate Change Council
PRCMP	Puerto Rico Coastal Management Program
PRDNER	Puerto Rico Department of Natural and Environmental Resources
PREPA	Puerto Rico Energy Power Authority
PREQB	Puerto Rico Environmental Quality Board
PRLA	Puerto Rico Land Authority
PRPB	Puerto Rico Planning Board
PRPD	Puerto Rico Police Department

PRSGP	Puerto Rico Sea Grant Program
PRSHPO	Puerto Rico State Historic Preservation Office
QA/QC	Quality Assured / Quality Controlled
SAV	Submerged Aquatic Vegetation
SJBEP	San Juan Bay Estuary Program
SoCMon	Socioeconomic Monitoring
SOPI	Spanish acronym for the Puertorrican Ornithological Society
SPA	Special Planning Area
SWMP	System-Wide Monitoring Program
TOTE	Teachers on the Estuary
UPR	University of Puerto Rico
UPRM	University of Puerto Rico, Mayagüez Campus
USACE	US Army Corps of Engineers
USCG	US Coast Guard
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USFS	US Forest Service
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
Uv	Ultra violet
VIMS	Virginia Institute of Marine Science

1 EXECUTIVE SUMMARY



1.1 Plan Purpose and Scope

The Jobos Bay National Estuarine Research Reserve (hereinafter JBNERR or the Reserve) was designated in 1981 as part of the National Estuarine Research Reserve System (NERRS), established by Section 315 of the Coastal Zone Management Act, as amended.

JBNERR is the only Estuarine Research Reserve in Puerto Rico and the wider Caribbean, and is one of two Reserves representing the West Indian Biogeographic Region. The Reserve is administered through a Memorandum of Understanding (MOU) between the National Oceanic and Atmospheric Administration's (NOAA) Estuarine Reserves Division and the Puerto Rico Department of Natural and Environmental Resources (PRDNER).

Federal regulations require reserves to have a NOAA-approved management plan that is updated every five years. The Jobos Bay NERR management plan was last updated in 2000 and since then, substantial progress has been made. The time is ripe for this Management Plan to be revised in order to incorporate the results of recent research and monitoring, update information on the status of the Reserve and its watershed, as well as identify management and emerging issues that need to be addressed.

This renewed management plan will guide Reserve actions from 2017-2022. It was revised in accordance to NOAA regulations (15 C.F.R. Part 921.13), provisions for public involvement, and the Reserve System's Management Plan Guidelines and Resources. (A summary of comments on the Plan provided during the public review period will be included in Appendix 8).

Reserve context

JBNERR is located in the Southeast coast of the island of Puerto Rico, between the municipalities of Salinas and Guayama. The Reserve covers an area of 2,800 acres of diverse habitats including salt flats, mudflats, shallow lagoons, offshore cays, and mangrove forests. The mission of Jobos Bay NERR is to practice and promote coastal and estuarine stewardship through innovative research, monitoring, education, training, and community involvement.

The Reserve formal boundaries include Mar Negro, Cayos Caribe and the coastal waters of the Jobos Bay, excluding the navigation channel. Boundaries between JBNERR and the communities were clarified, a formal delineation of boundaries was conducted, and

boundary monuments and signs were installed in the western portion of Mar Negro, adjacent to Las Mareas and Camino del Indio.

This management plan also acknowledges acquisitions since the approval of the last management plan which have not been formally incorporated into the Reserve boundary. These acquisitions are planned to be formally incorporated into the Reserve's boundaries as per 15 CFR 921.33 as a separate action. These, include the Salitral (or saltflats) at Las Mareas, the Jagüeyes forest, the Aguirre component, and offshore cays known as Cayos Barca and Cayo Pájaros. The proposed boundary expansion will include the entire Jobos Bay, up to the higher high water line (excluding ports, harbors and developed areas) and coral habitats within one mile offshore of Cayos Caribe, Cayos La Barca and Cayo Pájaros. Once formally incorporated, these additional properties and the Jobos Bay will add approximately 8,233.9 acres to the formal boundary, creating a more continuous area for the Reserve to administer. All these lands and waters are administered by the PRDNER, and have adequate Commonwealth protection to support the mission of the Reserve.

The Reserve also has the authority to influence activities within its 34,000-acre watershed. By actively using this Plan to guide the Reserve, Jobos Bay NERR will become a more effective resource for NOAA, PRDNER, the scientific community, academic institutions, and management experts to address issues throughout the Caribbean region.

Coastal management issues and goals

The Management Plan is organized around the following priority issues affecting Jobos Bay, its watershed and its adjacent communities:

- **Climate change-** Climate change, especially sea level change, acidification, temperature increase and extreme weather events including extreme droughts and precipitation events, represents a challenge for the Reserve's ecosystems and the already vulnerable surrounding communities. More research is needed to assess impacts on the Reserve ecosystems.
- **Habitat loss and degradation-** Habitat loss and degradation, which occur in the Reserve and its watershed, result from nutrient inputs to surface and ground water, cutting and filling of mangroves, and land use impacts such as sedimentation from development and groundwater withdrawal to support agriculture and communities. By addressing these issues not only ecosystems, but communities will be more resilient.
- **Economic constraints-** This management plan is developed under a challenging economic scenario. As a result, many of the proposed activities depend on the collaboration and joint efforts of many other partner agencies and organizations

such as Commonwealth and federal agencies, municipalities, businesses, academia, communities, and Non-Governmental Organizations (NGO).

These local priorities align with the Reserve System overarching priority issues of environmental change, water quality and habitat protection. These issues affect not only the Reserve and its adjacent communities, but are also relevant to Puerto Rico and the broader Caribbean. Jobos Bay NERR will position itself as a living laboratory, classroom, and a reference site for understanding the dual stressors of climate and land use impacts on habitats and communities in Puerto Rico and the Caribbean.

The Goals of the Jobos Bay NERR are to:

- ✿ Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and, education;
- ✿ Increase the use of Reserve science to address priority coastal management issues;
- ✿ Enhance people's environmental literacy by increasing their ability and willingness to make informed decisions and take responsible actions when interacting with coral and coral-related ecosystems;
- ✿ Improve decision makers' and communities' understanding of the effects of climate change on ecosystems and provide them with the necessary knowledge and tools to make informed decisions to adapt ; and,
- ✿ Enhance the administrative capability and infrastructure of the Jobos Bay NERR to meet the stewardship, research, education and, training challenges of the future.

Reserve Programs Overview

This management plan focuses on increasing knowledge about the climate change effects on the Reserve's resources, reducing anthropogenic stressors on its ecosystems, educating students and the public to be stewards of coastal resources, and providing tools to communities and decision makers. This will foster more resilient communities and coastal resources. It is divided into the following nine programmatic areas.

Research and Monitoring Program: Research and monitoring projects are the basis for the development of management actions, education, and training strategies in the Jobos Bay NERR. A priority area of research will be to increase knowledge about the potential impacts of climate change on coastal ecosystems and vulnerable communities. To this end, research efforts will focus on developing collaborative relationships and networks, integrating research in the social sciences, and expanding knowledge about Reserve hydrology and hydrodynamics, blue carbon processes,

ocean acidification, and sea level change impacts on coastal habitats. In order to disseminate and increase access to information, the Reserve will maintain and active and updated website, coordinate a biennial research symposium, and develop a georeferenced research and monitoring database. To strengthen monitoring efforts, the Reserve will expand the System-Wide Monitoring Program (SWMP). At least one full sentinel site will be completed by 2018 (SSAM-1). The Reserve will also develop a Habitat Mapping and Change Plan, and monitor additional priorities identified by the Research Advisory Committee, such as ground water quality, water column, mudflats, and key species. Funding sources will be sought for a SWMP technician to support critical research and monitoring efforts, as mentioned in the Administrative Plan.

Education Program: This program will target three audiences: teachers and students, local communities, and visitors. These audiences' engagement will be increased through educational activities, increased stewardship, and by promoting involvement in addressing priority issues.

To increase the participation of students and teachers in using the Reserve and its resources, the Program will provide high quality, place-based educational activities. The Reserve will develop a Conservation Action Education Program in order to increase knowledge and engagement among community members and to increase its volunteer base. Finally, the Reserve will increase the numbers of visitors exposed to the JBNERR as an area of ecological and historical significance, as well as a learning tool for climate resilience.

Overall, the program seeks to promote active stewardship of the Reserve among future generations, locals, and broader public audiences, who will also be encouraged to view the Reserve as a training ground to learn about adaptation and resiliency. The program will assess the effectiveness and satisfaction of participants on each Educational Program activity by developing evaluation methods and modifying activities and content as needed in order to ensure that participants acquire the needed knowledge, skills, awareness, and attitudes to become effective stewards of not only the Estuary, but also the surrounding coastal and marine resources.

Coastal Training Program (CTP): This program focuses on improving the capacity and skills of decision makers to use and apply scientific information in determinations that affect estuaries and coastal watersheds. The Reserve CTP will focus on providing coastal decision makers with skills and knowledge to implement strategies and actions that will effectively protect and enhance Jobos Bay NERR marine and terrestrial ecosystems. These initiatives will also improve capacity to assess the vulnerability of coastal communities and select appropriate adaptation measures. To accomplish these objectives, the CTP will provide training and technical assistance to key decision makers. In addition, this program will work to expand its network and partnerships with

Commonwealth, federal, and community organizations so that they become engaged partners in addressing priority issues.

Administrative Plan: The administrative plan acknowledges that the Commonwealth's fiscal situation has resulted in various cost-reduction measures, which include a restriction in the recruitment of new personnel. Given this situation, the Jobos Bay NERR will strengthen internal capacity to meet management needs, while also developing partnerships and volunteer initiatives required to fill in gaps. At the same time, creative sources of funding and resources to recruit three staff that are essential to supporting the Reserve Programs will be sought, including an Administrative Assistant/Facilities Coordinator, SWMP Technician, and Volunteer Coordinator. It also identifies the need to acquire an additional vessel and vehicle to support the Reserve's programmatic areas.

Resource Protection Plan: Currently there are illegal activities taking place that threaten the health of the Reserve, including overfishing and the use of illegal fishing gears, human-induced fires, vandalism and destruction of property, and cutting and filling of mangroves. To address these illegal activities, enhanced enforcement is paramount. A surveillance plan has been developed by the Reserve and the PRDNER. It includes patrolling the area and process to improve surveillance. The Reserve will continue implementing this plan. The focus will be to reduce unauthorized activities and to eliminate threats to the Reserve and its surroundings through proper coordination with law enforcement officers and other PRDNER units. The Reserve will also work to enhance awareness to help protect specific sensitive areas and species.

Public access and visitor use plan: The Reserve will continue enriching the visitors' experience. This will involve enhancing trails and improving connectivity to areas of interest within the Reserve. The enhancement of trails will be designed to balance access, promote stewardship, and avoid negative impacts to the ecosystem. Promoting visitor access to Reserve property in Camino Del Indio will be pursued. Access will be informed by a carrying capacity study which will be implemented within the first year of this Plan's implementation.

Facilities plan: The priority projects for the next five years will be: 1) complete the renovation of the old Train Depot into the Climate Change Resiliency and Community Meeting Center, and 2) the renovation of the old plantation restaurant as an Education and Training Center. The Train Depot has already been renovated to large extent, but requires the installation of bathrooms, electricity, and exhibits to complete its transformation and obtain the use permit. Other priorities include renovation of the two casitas behind the Education Center to support extended stays by visitors, a kiosk at Camino Del Indio, updated exhibits and welcome center at the visitor center, and renovation of the planned maintenance building behind the visitor center.

Land acquisition and Boundary Expansion plan: The plan proposes acquisition of two properties: one adjacent to the Visitor Center and the eastern portion of Cayos de Barca. These will add approximately 76.2 acres to the Reserve. These acquisitions not only promote the Reserve's purpose to protect natural patrimony, but also develop migration corridors for vulnerable and endangered species. Funds have already been earmarked from the Settlement Offer resulting from the 2007 Oil Spill, for the acquisition of the Sucesión Vázquez-Bruno property adjacent to the Visitor Center, and the Reserve is investigating whether or not the settlement might also provide full or partial funding for the acquisition of the Cayos de Barca property. The Reserve will continue exploring additional potential funding sources and partners for future acquisitions. In addition the Reserve's boundaries will be modified to include past acquisitions, boundary clarifications and coastal waters. This will occur within the first year following this Plan's approval.

Restoration Plan: During the next management period a priority restoration project will be to carry out the Fish and Wildlife Habitat Enhancement project in the Mar Negro Unit. This project will benefit resident and migratory bird populations. The Reserve will continue to investigate further habitat enhancement and restoration projects including the hydrologic re-connection of Mar Negro to the Caribbean.

2 Introduction to the National Estuarine Research Reserve System

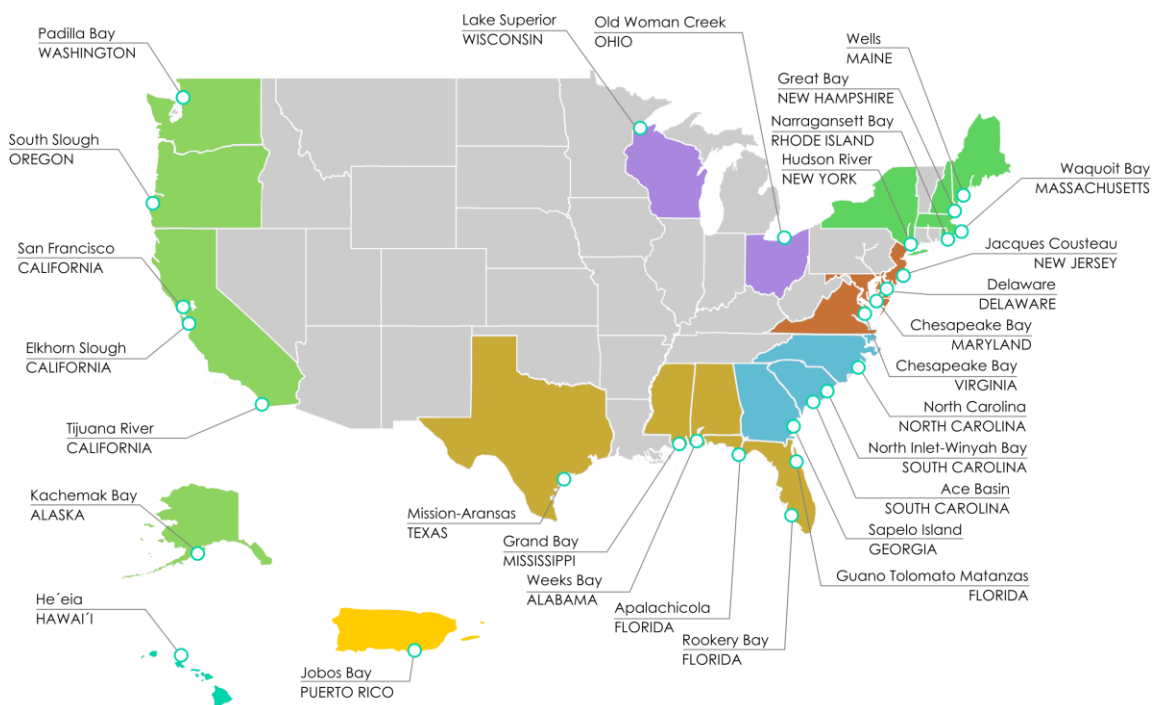


2.1 Introduction to the National Estuarine Research Reserve System

The National Estuarine Reserve System was created by the Coastal Zone Management Act of 1972, as amended, to augment the National Coastal Zone Management Program which is dedicated to comprehensive, sustainable management of the nation's coasts.

The Reserve System is a network of protected areas representative of the various biogeographic regions and estuarine types in the United States. Reserves are established for long-term research, education and interpretation to promote informed management of the Nation's estuaries and coastal habitats. (15 C.F.R. Part 921.1 (a)) The Reserve System currently consists of 29 reserves in 24 states and territories, protecting over one million acres of estuarine lands and waters (Figure 1).

Figure 1. National Estuarine Research Reserve System Map



The Reserve System is a partnership program between the National Oceanic and Atmospheric Administration (NOAA) and the coastal states. NOAA provides funding, national guidance and technical assistance. The state partner manages reserve resources on a daily basis working collaboratively with local and regional partners.

2.2 National Estuarine Research Reserve System Strategic Goals

Estuaries are biologically rich, economically valuable, and highly vulnerable ecosystems. The vision and mission of the Reserve System reflect the importance of these systems within our communities.

Vision: Resilient estuaries and coastal watersheds where human and natural communities thrive.

Mission: To practice and promote stewardship of coasts and estuaries through innovative research, education, and training using a place-based system of protected areas.

The program goals, per Federal regulations 15 C.F.R. Part 921.1(b), outline five specific goals for the Reserve System:

1. Ensure a stable environment for research through long-term protection of National Estuarine Research Reserve resources;
2. Address coastal management issues identified as significant through coordinated estuarine research within the system;
3. Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
4. Promote Federal, state, public and private use of one or more Reserves within the System when such entities conduct estuarine research; and
5. Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.

These foundational goals are complemented by those that are systematically set by the program every five years. Strategic planning has been an integral part of the National Estuarine Research Reserve System for nearly twenty years. The planning process is designed to bridge national program direction with local coastal management needs through a representative and participatory process that supports NOAA's mission of science, service, and stewardship. The 2017-2022 Reserve System Strategic Plan focuses

on protecting places, applying science and educating communities. The Reserve System Strategic Plan Goals are:

1. Protecting Places: Enhance and inspire stewardship, protection, and management of estuaries and their watersheds in coastal communities through place-based approaches
2. Applying science: Improve the scientific understanding of estuaries and their watersheds through the development and application of reserve research, data, and tools.
3. Educating communities: Advance environmental appreciation and scientific literacy, allowing for science-based decisions that positively affect estuaries, watersheds, and coastal communities.

2.3 Biogeographic Regions and Boundaries of the National Estuarine Research Reserve System

NOAA has identified eleven distinct biogeographic regions and 29 subregions in the United States, each of which contains several types of estuarine ecosystems (15 C.F.R. Part 921, Appendix 1 and 2). When complete, the Reserve System will contain examples of estuarine hydrologic and biological types, characteristic of each biogeographic region. As of 2017, the Reserve System includes 29 reserves.

Reserve boundary size will vary greatly depending on the nature of the ecosystem. Boundaries must include an adequate portion of the key land and water areas of the natural system to approximate an ecological unit and to ensure effective conservation. Reserve boundaries encompass areas for which adequate state control has or will be established by the managing entity over human activities occurring within the reserve. Reserve boundaries include a “core” area which is comprised of key land and water encompassing resources representative of the total ecosystem, which if compromised could endanger the research objectives of the reserve, as well as a “buffer” area designed to protect the core area and provide additional protection for estuarine-dependent species, including those that are rare or endangered. Buffer areas may also include areas necessary for facilities required for research and interpretation. Additionally, buffer areas are identified to accommodate a shift of the core area as a result of biological, ecological or geo-morphological change which reasonably could be expected to occur. (15 C.F.R. Part 921.11 (c)(3))

2.4 National Estuarine Research Reserve Administrative Framework

The process for federal designation of a National Estuarine Research Reserve has many steps and involves many individuals and organizations. While each reserve is a partnership program between NOAA and a coastal state, there are many entities that collaborate to support designation of a reserve. Other partners include federal and state agencies, non-profit groups, universities and members of the local community. For more information on the designation process see nerrs.noaa.gov/background.

Upon designation, the reserve implements the approved management plan and is eligible for NOAA financial assistance on a cost-share basis with the state. A reserve may apply to NOAA for funds to help support implementation of the management plan largely funding operations, research, monitoring, education/interpretation, training, stewardship, development projects, facility construction, and land acquisition. Management plans provide a vision and framework to guide reserve activities during a five year period and enable the reserves and NOAA to track progress and realize opportunities for growth. Each management plan contains the reserve goals, objectives, and strategies supported by programs focused on research and monitoring, education and outreach, training, and stewardship. They also outline administration, public access, land acquisition and facility plans and needs, as well as restoration and resource manipulation plans, if applicable. Reserves are increasingly confronted with complex questions regarding new uses in or near reserves that may or may not be compatible with the Reserve System's mission. A thoughtful and comprehensive management plan provides a foundation for addressing these challenges to protect and manage reserve resources wisely and ensure the public and coastal decision makers value and protect coastal resources.

NOAA administers the Reserve System and establishes standards for designating and operating reserves, provides support for reserve operations and system-wide programming, undertakes projects that benefit the Reserve System, and integrates information from individual reserves and programs to support decision-making at the national level. Additionally, NOAA periodically evaluates reserves for compliance with federal requirements and with the individual reserve's federally approved management plan, as mandated under Section 312 of the Coastal Zone Management Act (15 C.F.R. Part 921.40). NOAA currently provides leadership and support for three system-wide programs including the System-Wide Monitoring Program, the K-12 Estuarine Education Program, and the Coastal Training Program, as well as the NERRS Science Collaborative. They also provide support for initiatives focused on the Reserve System's priorities: climate change, water quality and habitat protection.



INTRODUCTION TO THE JOBOS BAY NERR



3 Introduction to the Reserve



3.1 History and Local Management of the Reserve

In 1981, NOAA designated Jobos Bay a National Estuarine Research Reserve (NERR). It is the only NERR in Puerto Rico and the wider Caribbean¹ and covers an area of approximately 2,800 acres of coastal ecosystems.

The Jobos Bay NERR is administered through a partnership between NOAA's Office for Coastal Management and the Puerto Rico Department of Natural and Environmental Resources (PRDNER). There are many other partner agencies and organizations that assist the Reserve's program implementation, which include the Natural Resources Conservation Service (NRCS), and the Puerto Rico Sea Grant Program (PRSGP).

Jobos Bay NERR is part of the NOAA's National System of Marine Protected Areas (MPA)², and was also designated as a part of a larger Special Planning Area (SPA) in 1978, with the approval of the Puerto Rico Coastal Management Program (PRCMP).³ The PRCMP also recommended the protection of Bahía de Jobos and Mar Negro as a Natural Reserve. At present, the PRDNER and the Puerto Rico Planning Board (PRPB) are working on the administrative procedures for its designation.

The following sections present a brief description of the Jobos Bay NERR ecological, social and cultural attributes as well as threats and stressors. Detailed and updated information can be found at: https://coast.noaa.gov/data/docs/nerrs/Reserves_JOB_SiteProfile.pdf, and in Appendix 7, respectively.

¹ Wider Caribbean as defined by the UN Environment Program.

² 2015 Framework for the National System of Marine Protected Areas of the United States of America :<http://marineprotectedareas.noaa.gov/nationalsystem/framework/final-mpa-framework-0315.pdf>

³ SPAs are defined as "important coastal resource areas subject to serious present or potential use conflicts, and, therefore, require detailed planning". This SPA has a management plan and a land use plan which are under the consideration for approval by the PRPB.

3.2 Ecological attributes

Geomorphology

Geography

Jobos Bay NERR is located in the South coastal plain of Puerto Rico, between the Municipalities of Guayama and Salinas (See Figure 2). The south coastal plain is narrower than the northern plain, with shorter and smaller rivers, and with an irregular insular shelf that extends two to five miles (3-8 km) seaward.

JBNERR is the second largest estuary in Puerto Rico, with three times as much shoreline as any other estuary on the Island. It is composed of mangrove forest and diverse habitats that vary from the coastal fan-delta and alluvial deposits of the landward transition zone, to offshore cays in the Caribbean Sea (Kuniansky, & Rodríguez, 2010). The North Equatorial Current, flowing in a west-northwesterly direction, dominates the entire south coast of Puerto Rico (Laboy, 2009).

The Jobos Bay watershed covers 137.3 km² (34,000-acre) of the South coastal plain (Whitall, Costa, Bauer, Dieppa & Hile, 2011). The watershed's northern boundary begins in the foothills of the Central Interior Mountain Range and extends about 6 km to 11 km seaward to the shoreline of Jobos Bay. It reaches elevations of greater than 700 m at its landward boundary (Whitall et al., 2011). The watershed is framed by two perennial stream networks; Río Nigua to the West and Río Guamaní to the East. Its altitude ranges from sea level, to approximately 130 ft. above sea level along the northern edge of the foothills (Kuniansky, E. & Rodríguez J, 2010).

Geology

Jobos Bay NERR watershed is mostly underlain by 10 to 200 ft. thin fan delta and alluvial deposits that are predominantly Quaternary in age. Deposits within Jobos Bay NERR consist predominantly of swamp, beach and alluvial deposits.

Swamp deposits cover most of the surface of the Reserve. These deposits, which consist of unconsolidated clay, silt and organic matter, are covered almost entirely by mangroves. Beaches along the coastal margin consist primarily of carbonate sand derived from nearby fringing reefs. Alluvial plain deposits (Alluvium) dominate the northern part of the Reserve and consist of unconsolidated sand, gravel and pebbles.

Figure 2. Geography



MAP KEY:

- Jobos Bay National Estuarine Boundary
- Future Incorporations Land Boundary
- Future Incorporations Marine Boundary
- Aguirre Navigational Channel*
*Not included within the boundary
- Main Roads
- Jobos Bay Watershed

Source: U.S. Geological Survey, 2005.



Along the coast, the surface of the fan-delta sequence is separated from the Caribbean Sea by a narrow land-marine transition zone of marsh and mangrove swamps, tidal and supratidal salt flats, and beach deposits. In the Jobos Bay area, mangroves, marshes, and tidal flats are mostly restricted to those areas protected by offshore, fringing reefs. Within the marsh and mangrove swamp area, the fan-delta deposits are mostly overlain by organically rich clay deposits.

The cays are composed of sand, gravel, volcanic rock cobble and shell fragments. Beaches along the coastal margin consist primarily of carbonate sand derived from nearby fringing reefs.

Climate and weather

Jobos Bay NERR is on the leeward side of the Island. It lies in the South coastal plain within the Subtropical Dry Forest Zone, characterized by a mean annual rainfall that ranges from a minimum of about 600mm to a maximum of 1,000-1100mm (Ewel and Whitmore, 1973).

Orographic factors give rise to a zone of low precipitation throughout the entire length of the South coast (Whitall et al., 2011). As a result, the South coastal plain is warmer and drier than the rest of the island. Temperature at Jobos Bay NERR shows little seasonal fluctuation. The mean annual temperature is 78.8° F (26° C), with a maximum of 81.6° F (27.5° C) in August and a minimum of 75.7° F (24.3° C) in January (NCDC, 2010, as cited in Whitall et al., 2011).

Data from NOAA's climatological stations indicate that the 30-year normal precipitation for the period 1991–2010 was about 37.74 inches in the South Coast and 61.61 inches in the Southern Slopes (Torres & Rodríguez, 2016). September and October have been recorded as the wettest months, with an average rainfall of 6.6 inches (167 mm), while January was the driest month, with an average rainfall of 0.8 inches (20 mm). (NCDC, 2010 as cited in Whitall et al., 2011).

In Puerto Rico rainfall declines significantly during the months of December to April. Drought periods typically begin to be observed during the months of April-May and may be extended until August, due to changes in the regional climate of the Caribbean (Quiñones, 2010). Below-average rainfall has been recorded in the South coast during 12 years period (1986-2004) (Kuniansky & Rodríguez, 2010). In the latter half of the month of July the southeastern portion of Puerto Rico, where the Reserve is located, was classified by the US Drought Monitoring Program as Extreme Drought (D3). This classification persisted throughout August 2015.

Trade winds in the Reserve blow regularly (46.8%) from an easterly direction, averaging six to seven knots (7-8 mph) (Laboy, 2009; Whitall et al., 2011). The strongest winds occur

in the winter with a slight decrease in strength during the summer (Federal Energy Regulatory Commission, 2015).

JBNERR is exposed to the effects caused by weather systems that have the potential to create higher than average rainfall and flooding in short periods of time, as well as strong winds and storm surges. The hurricane season in the Atlantic and the Caribbean is from June to November. Hurricane trajectories and the shallow coasts makes Puerto Rico's Southern and Eastern coasts the most vulnerable areas for storm surges. This vulnerability could increase due to climate change.

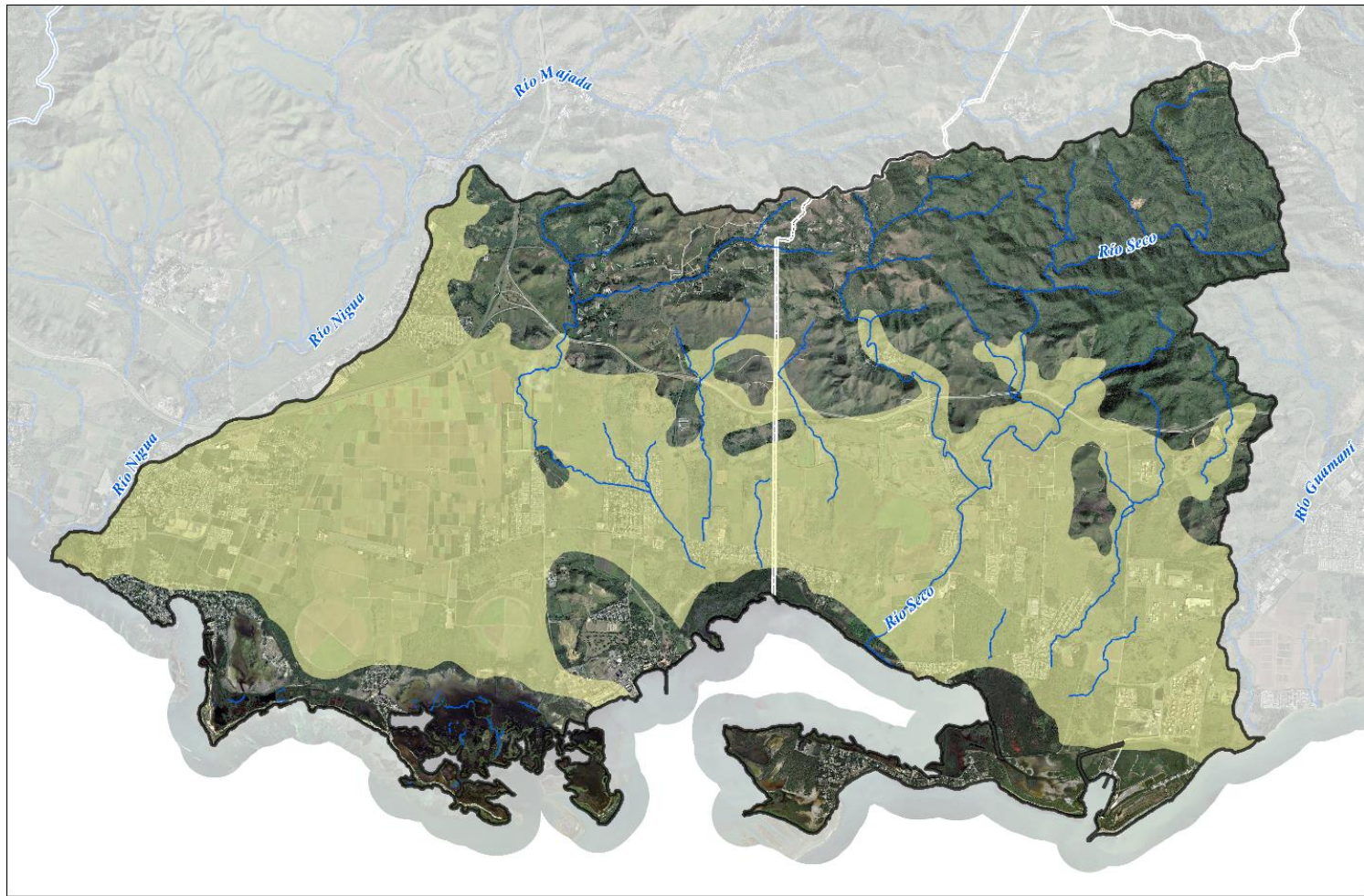
Hydrology

The hydrologic conditions of the area are typical of a semiarid region. The Jobos Bay watershed does not contain one single river network that accumulates surface water flow throughout the basin. This watershed contains a variety of distinct pathways by which surface waters are contributed to Jobos Bay. These include perennial stream discharges, intermittent stream discharges that join and flow directly into the Bay, and diffuse overland runoff (Whitall et al., 2011).

The Río Seco, in the east, is the only major river that discharges seasonally into Jobos Bay through the Reserve (Whitall et al., 2011). Many streams do not reach the coastal systems because they percolate into the aquifer in the upper valley, limiting freshwater inflows to the downstream estuaries.

Groundwater is the main source of freshwater for the Jobos Bay estuary. JBNERR is located along the South Coastal Plain aquifer, which extends from the municipalities of Ponce to Patillas. The source of fresh water to this aquifer resides further up, in the high-rainfall Cordillera Central mountain slopes where the aquifer is unconfined. Freshwater inflow to the mangrove wetlands occurs through groundwater seepage from the shallow aquifer and the adjacent watershed (Quiñones-Aponte and Gómez-Gómez, 1987).

Figure 3. Hydrology



MAP KEY:

- Jobos Bay Watershed
- Streams and Rivers
- South Coast Aquifer
- - - Municipal Boundaries

Miles 20

Source: U.S. Geological Survey, National Geospatial Program.

Groundwater from the South Coast aquifer is the principal source of potable water for towns along the southern coast of the Island, and also is a primary source of water for agricultural irrigation (Torres & Rodríguez, 2016).

A combination of reduced precipitation, changes in agriculture and irrigation practices, and increased withdrawals have significantly depleted freshwater in the aquifer, and limited its recharge. This may affect the availability of freshwater for agriculture and public water supply, as well as the quantity that reaches the estuary. In addition, there is evidence that water quality in the aquifer has deteriorated due to the lateral intrusion of saline water, as well as other contaminants (Torres & Rodríguez, 2016).

Biological Resources

Habitats

According to the *Detailed Land Use and Habitat Inventory, 2012 of the Jobos Bay National Estuarine Research Reserve Watershed*, most of the Reserve and the proposed boundary are estuarine habitat (subtidal and intertidal), marine habitat (39.1%), and palustrine wetlands, cultural land cover and uplands (12.94%).

Estuarine habitats in the Reserve include mangrove forests, salt flats, and mudflats.

- **Mangroves** are a dominant biological cover of the JBNERR ecosystem, although during the 1990's hydrological changes in the watershed affected the mangrove forest. Of the 8.3 km² area inside the JBNERR boundaries mapped in the Whitall *et al.*, 2011 study, approximately 41% is colonized by mangroves. Three of the six physiographic types of mangrove forests (Lugo and Snedaker, 1974), are found in Jobos Bay: basin, fringe and overwash forests (Laboy, 2009). Four species of mangroves are found within Jobos Bay NERR; red mangrove, black mangrove, white mangrove, and buttonwood mangrove. The majority of the shoreline in the Jobos Bay is dominated by the saltwater-tolerant red mangrove.

The rich protected substrate provides habitat for a large variety of organisms, which in turn serve as the food base for the marine environment. Mangroves provide important nursery habitat for commercially and recreationally important finfish and shellfish species and nesting sites for native and migratory birds, including the endangered yellow-shouldered black bird (*Agelaius xanthomus*).

- **Hyper saline lagoons and salt flats** occur inland from the mangrove forests, and border the Reserve's western proposed boundary north of Mar Negro (Field *et al.*, 2008). They are formed as a result of reduced inland runoff, limited tidal flushing, and high evaporation rates and reduced rainfall. The area experiences water exchange during spring tides. During this period, salt crystals accumulate and leave particular conditions including hypersaline regimes that reach over 100 PSU.

High organic matter transported to the area during this time also results in low oxygen in the sediments, and consequently inhibits most of the plant growth.

Vegetation is limited mostly to the black mangrove that in turn struggles with such high concentrations of salts. Where additional vegetation does exist, it is dominated by salt-tolerant species, such as saltwort (*Batis maritima*) and sea purslane (*Sesuvium portulacastrum*), which have thick fleshy leaves adapted for water storage. Both saltwort and sea-purslane are low shrubs that stabilize the soil, thereby preventing erosion. Among the faunal species, birds such as sandpipers, great egrets, blue herons among other duck migratory species can be observed during drought periods. Arthropods such as the land crab and the fiddler crab can be found in the area and at their larval stage, they provide a food source for birds.

- **Mudflats** are important soft-bottom littoral systems formed inland from the mangrove forest as a result of reduced water runoff, higher evaporation rates, and drought (Laboy, 2009). Mudflats are exposed at low tide and contain considerable quantities of detritus, a mixture of sand, mud, and plant and animal remains. The moist humid bottom supports bacteria, fungi, diatoms and a spectrum of marine animals, including clams, worms and nematodes, from ¼" (2-3 mm) below the surface of the mud flat, sometimes to more than 3 ft (1 m) down. These mud flats are especially important forage areas for wading birds and shorebirds. Mud flats are the least-studied community in Jobos Bay NERR. A detailed analysis of aerial photographs from 1937 and 2004, revealed that the surface area of mud flats is increasing behind the mangrove fringes of Jobos Bay, particularly in Mar Negro and Punta Pozuelo (Laboy, 2009).

In relation to marine habitats, a *Baseline Assessment of the Ecological Resources of Jobos Bay*, reported that the unconsolidated sediments⁴ are colonized most commonly by seagrass (31%), followed by no cover (28%), and algae (20%) (Whitall et al., 2011). Coral reef and hardbottom comprised around 7% of the area surveyed by Whitall et al., 2011.

- **Algae**-On hardbottom, turf algae accounted for the highest overall mean percent cover, followed by macroalgae, hard coral, sponges, and gorgonians and zoanthids. Other algae groups included crustose coralline algae, cyanobacteria and filamentous algae and rhodoliths (Whitall et al., 2011). Green algae (Chlorophyta) grow in stressful environments where nutrients are high and herbivory low. Red algae (Rhodophyta) are the largest and most diverse group.

⁴ Unconsolidated sediments refers to an area on the seafloor consisting of small particles (<0.25 m) with less than 50% cover of large stable substrate.

Red algae are extremely important reef-building organisms, which may form reef crests (e.g. *Lithophyllum* spp.) and large calcareous plates (*Sporolithon* spp.).

- **Seagrass** - From the 8.3 km² area inside the JBNERR boundaries mapped approximately 18 % is colonized by seagrass, as a biological cover by Whitall et al., 2011. Seagrasses provide food and shelter to commercial and recreational fishery species as well as invertebrates, birds, and manatees. Seagrasses also reduce wave and current action and improve water clarity and quality.
- **Coral Reefs**- In the Jobos Bay percent live coral cover was <10% for 95% of the mapped area, while the remainder was mapped as 10% ≤ 50%. Most of Jobos Bay's coral reefs are linear in formation, running along cays encircling the central bay (García-Sais et al., 2003). Whitall et al., 2011, reported that Individual Patch Reefs, Aggregated Patch Reefs and Aggregate Reef comprised 3.1% of the total mapped area: sea floor and intertidal shoreline in and around JBNERR. Hard coral cover averaged 6.5%, with higher amounts occurring on aggregate reef on the fore reef adjacent to the cays. The most abundant coral was mustard hill coral (*Porites astreoides*) (Whitall et al., 2011). According to Laboy (2009), bladed fire coral (*Millepora complanata*) and the elkhorn coral (*Acropora palmata*) were the dominant coral species in this area. However, neither *Acropora palmata* (elkhorn coral) or *Acropora cervicornis* (staghorn coral), both of which are listed as threatened under the Endangered Species Act (ESA), were observed by Whitall et al., 2011.

Elkhorn coral and staghorn coral, were observed at two sites along the fore reef of Cayos Caribe (Whitall et al., 2011). The presence of *Acropora* rubble at several locations observed during a study by García-Sais et al., 2003 is additional evidence of their former abundance (Whitall et al. 2011).

Sedimentation, thermal and chemical pollution, and mechanical damage due to anchoring and overfishing are the main factors that have almost exterminated the coral reefs in the Mid Bay zone of the Jobos Bay (Laboy, 2009). Recent hurricanes have broken massive pieces of the typical surf zone corals. Extreme flooding discharges from Río Seco, Río Melanía and Río Guamaní, associated to abnormal rainfall, seems to have lowered the physiological limits for transparency and salinity that corals can tolerate, producing an extended mass mortality, similar to that reported by Laboy-Nieves and Conde, 2001 (Laboy, 2009).

In addition, JBNERR has been subject to region-wide stresses that have affected the wider Caribbean in the last few decades, including a widespread die-off of *D. antillarum* in the 1980s, mass *Acropora* species mortality due to white band disease, and coral bleaching (Whitall et al., 2011). All of these factors have led to a significant reduction in live coral cover.

Upland vegetation in the Reserve is characteristic of the Subtropical Dry Forest. Small variations in elevation, hydrology and climate, and pulses from catastrophic events, such as hurricanes, seem to be responsible for the physiographic diversity of the Jobos Bay upland (Laboy, 2009). Grasslands were described as the most representative community in the upland of Jobos Bay (Laboy, 2009). Littoral woodland on Jobos Bay is represented by more than 220 species of which 26% are trees and the majority are native. The littoral or coastal scrub (lacustrine habitat) is a dry, mainly evergreen community.

Globally, dry forests represent a threatened ecosystem and dry forests in the Caribbean have come under intense pressure from agricultural and urban development (Genet et al. 2001). With many protected and endemic species using this habitat, including neotropical migratory birds and several species of lizards, protection of dry forest communities is essential.

Fauna

Invertebrates

Jobos Bay is enriched by a wide variety of endemic, native, migrant and exotic species. Associated with the submerged prop roots of the red mangrove is a rich epibiota. Competition for space on these roots is high (Kolehmainen, 1972). Among the most abundant groups are oysters, tunicates, sponges, crustaceans, cnidarians, and algae (Laboy, 2009). In 2001, Laboy reported 16 species of holothurians. Crustaceans (brachyuran larvae, amphipods and copepods), tunicates and gastropod larvae compose most of the zooplankton in Jobos Bay (PRWRA, 1972).

Mangroves are commonly inhabited by snails (*Melampus coffeus*), termites (*Coptotermes brevis*) and bees (*Apis mellifera*). The littoral woodland shows more biodiversity with a variety of insects. The presence of dinoflagellates *Pyrodinium bahamensis* and *Ceratium furca* (Laboy, 2009) also has been documented in the Jobos Bay. Corals were discussed above.

Vertebrates

The Reserve is home to a variety of vertebrate communities including amphibians, reptiles, fish, mammals, and birds. Among the reptiles are the endemic garden snake (*Alsophis portoricensis*) and the snapping turtle (*Pseudemys terrapen*), that share the land habitat in Jobos Bay with 11 lizards.

Three federally listed species of reptiles have been documented in the Reserve and Jobos Bay: one threatened, green sea turtle (*Chelonia mydas*); and two endangered, leatherback sea turtle (*Dermochelys coriacea*) and hawksbill sea turtle (*Eretmochelys imbricata*).

The suite of aquatic habitats provides for a diversity of fish species. The fish community varies by habitat type and consist of 34 taxonomic families and 112 species (Whitall et al., 2011).

JBNERR is one of the few reproduction sites for the nurse shark (*Ginglymostoma cirratum*) in Puerto Rico. The arrival of nurse sharks during the summer, specifically June-July to a specific area in the Jobos Bay as well as their mating activity has been observed by the JBNERR staff for the past 10 years (2006-2016). Jobos Bay mating ground zones were previously identified during the early 1970's by the Nuclear Center while they were performing assessment studies for the Aguirre Power Plant.

Nurse sharks often congregate in shallow waters and are slow-moving bottom-dwellers. This species is a nocturnal predator, and feeds mainly on fish especially stingrays, molluscs (octopi, squids and clams) and crustaceans. This makes it susceptible to be caught as by-catch.

Only six species of mammals inhabit the Jobos Bay upland, including primarily bats and rodents. One federally endangered species of marine mammal, the Antillean manatee (*Trichechus manatus manatus*), frequently forages in the seagrass beds of Jobos Bay. Jobos Bay is one of four areas in Puerto Rico with relatively higher concentrations of manatees (US Fish and Wildlife Service, 2014). The reason for which manatees prefer this area is unknown and needs to be studied, but it is evident that the protection of this ecosystem is critical for the conservation and survival of the species. The bottlenose dolphin (*Tursiops truncatus*), is another marine mammal that has been documented in the area.



1. Antillean manatee in the Mar Negro Unit 2. Bottlenose dolphin 3. Nurse shark
Source: Jobos Bay NERR staff

Birds are the most prominent vertebrate fauna in Jobos Bay (Laboy, 2009). JBNERR is an

Important Bird Area (IBAPR-013), according to Bird Life International.⁵ The relatively undisturbed mangrove system of Jobos Bay NERR makes it an important area for pelicans, herons, shorebirds and waterfowl, with a total of 87 bird species identified in Jobos Bay. There are two federally endangered bird species found in JBNERR: the Puerto Rican plain pigeon (*Columba inornata wetmorei*) and the yellow-shouldered blackbird. Both are endemic.

The following table presents listed species present in Jobos Bay NERR that are protected under the Endangered Species Act and the New Wildlife Act of Puerto Rico, Law Num. 241 of 1999, as amended, and the PRDNER Regulation No. 6766. There is a total of ten federally listed species that has been identified in the Jobos Bay NERR.

Table 1. Federal and Commonwealth listed Species in the Jobos Bay NERR

	Common Name (English)	Common Name (Spanish)	Scientific Name	Federal Status	Local Status
1	Puerto Rican plain pigeon	paloma sabanera	<i>Columba inornata wetmorei</i>	E	E
2	Roseate tern	palometa	<i>Sterna dougallii</i>	T	V
3	Yellow-shouldered blackbird	mariquita	<i>Agelaius xanthomus</i>	E	E
4	Hawksbill sea turtle	carey	<i>Eretmochelys imbricata</i>	E	E
5	Green sea turtle	tortuga verde	<i>Chelonia mydas</i>	T	E
6	Leatherback sea turtle	tinglar	<i>Dermochelys coriacea</i>	E	E
7	Antillean manatee	manatí Antillano	<i>Trichechus manatus manatus</i>	E	E
8	Elkhorn coral	coral cuerno de alce	<i>Acropora palmata</i>	T	T, CH
9	Lobed star coral	coral estrella	<i>Orbicella annularis</i>	T	T
10	Staghorn coral	coral cuerno de ciervo	<i>Acropora cervicornis</i>	T, CH	T, CH

E=Endangered T=Threatened CH= Critical Habitat NL= Not Listed V =Vulnerable
Sources: PRDNER 2009, NOAA, 2011, and USFWS, 2014

⁵ See: <http://www.birdlife.org/datazone/sitefactsheet.php?id=19902>

Social attributes

Jobs Bay NERR is located in Aguirre and Jobs wards in Salinas and Guayama, respectively. Aguirre, with a population of 13,505 has 44.3% of the population of Salinas, which is of 30,506 inhabitants. While Jobs, with 7,510 inhabitants, has 17% of the population of Guayama, which is of 44,261 people, according to the 2014 American Community Survey (ACS).

It is estimated that the watershed has a population of 30,811⁶ which constitutes approximately 41% of the population of both municipalities. The population distribution by age in the watershed suggests a reduction in the number of children and a marked aging of the population. While the majority of the population (67%) in the watershed has a high-school degree or higher, 20% did not reach the 9th grade. According to the Socioeconomic Monitoring (SocMon) conducted for the Reserve in 2009, the school dropout rate is high in the watershed (CIEL, 2009). The estimated unemployment rate for the watershed is at 6%, and 54.1% of the families live under poverty level.



Typical house in Las Mareas community

Source: Ernesto M. Olivares and Victor Cuadrado

The majority of the employed population in the watershed works in the “educational services, and health care and social assistance” sector which accounts for 21% of employment, followed by public administration (14%), arts, entertainment recreation, accommodation and food services (13%), manufacturing (11%), and retail trade (11%).

The Reserve is of social, cultural, and economic significance for the livelihoods of residents of the 13 neighboring coastal communities (García et al., 2013).⁷ In Guayama, the

⁶ The population for the Jobs Bay watershed was estimated using GIS. The watershed does not cover the municipalities of Salinas and Guayama entirely. It covers only portions of both municipalities. Also their urban centers are outside the watershed. That explains why the population in the watershed is less than the population of both municipalities.

⁷ This information was obtained from a study conducted to explore the relationships between the use of coastal resources and the well-being and quality of life of people living along the coast of Southeastern Puerto Rico. It was based on an extensive, three year-long research project conducted by García et al., funded by the University of Puerto Rico Sea Grant Program. The study, published in 2013, includes communities located in the JBNERR region, specifically the communities of Pozuelo, Jobs, and surroundings in Guayama, and Playa, Playita, Aguirre and surroundings in Salinas. The study included extensive field research and analysis, including ethnographic field work, cultural mapping, interviews, workshops and meetings, among other methods.

community of Pozuelo has an active fishing industry. It is a center for seafood restaurant and eateries. The study found an “obvious link” between the fishing industry and the restaurant business, where fresh catch is sold. Pozuelo is home to both recreational and security-based boating in the area: there exist two fishing associations, with a total of at least 50 fishers, the Guayama Yatch Club, the maritime police, and Puerto Rico's elite anti-drug-smuggling unit (FURA). The Pozuelo community has been active in protecting the estuary in order to preserve ecosystem health, which they perceive as essential to their livelihood and well-being (García et al., 2013). The study also encountered areas in Guayama where “extensive use of mangrove and coastal forest products, especially land crabs and mangrove oysters and clams”. It was observed that many houses have land crab pens, and there were signs throughout the area indicating that land crabs are commonly sold in local stands (García et al., 2013).

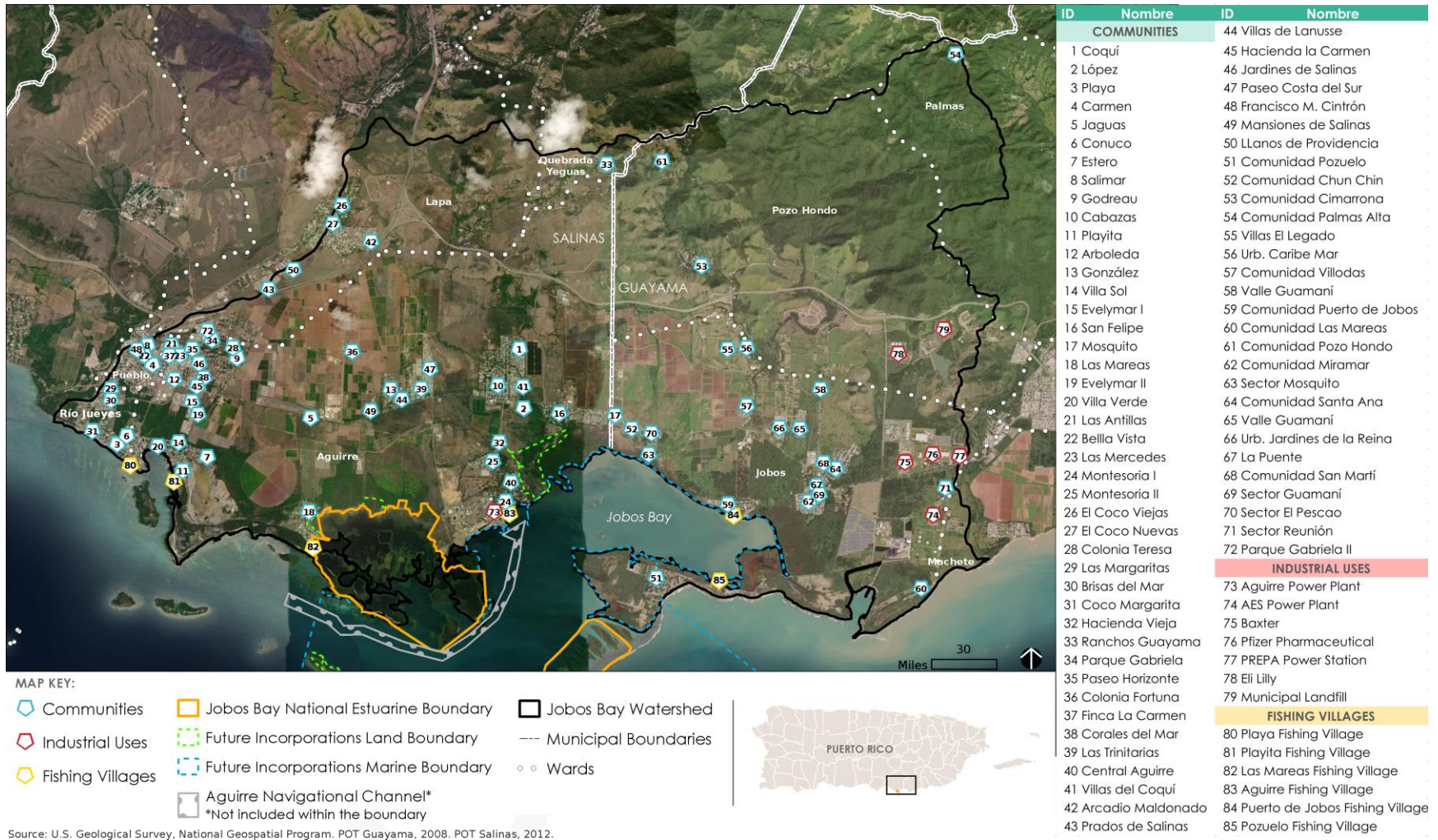
In Salinas, the community of Aguirre directly neighbors the Reserve. The study identifies the following principal human dwellings associated to Aguirre: El Coquí, houses that used to belong to the Aguirre Sugar Mill Complex, Montesoria I and II and Eugene Rice. Ten to twelve active fishers from Aguirre were identified, though the number is on the decline. Nevertheless, the study observed a lot of fishing activity in Aguirre and a sea-oriented community and lifestyle (García et al., 2013).

The communities of Playa and Playita also lay within the Jobos Bay watershed, though they are not direct neighbors of the Reserve. The seafood industry, land-crab hunting, boating, and recreational fishing are important industries in these communities, providing “an abundance of economic opportunities”. With regard to coastal forest resources, communities were observed using mangroves, tidal flats, channels, and lagoons to harvest land crabs, mangrove clams and oysters, coconuts, and mavi tree bark.

Las Mareas, which was not described in the study, is a small, economically depressed fishing community, adjacent to the west end of Jobos Bay. It also has an active fishing community. (Additional information on social attributes can be found in Appendix 7.)

Communities that surround the reserve, as well as industries and fishing villages are presented in the following figure.

Figure 4. Jobos Bay and Surrounding Communities and Industries



Archeological and Cultural Resources

The Reserve and adjacent areas contain important historical resources. The Central Aguirre Historic District was included in the National Register of Historic Places in October of 2002. The Aguirre Historic District is the only company town in Puerto Rico, legacy of the sugar mill companies. It is a corporate complex that included the sugar mill and refinery, as well as administrative, commercial, institutional, recreational (golf course, hotel, swimming pool and social club) and residential areas.

Some of the Central Aguirre sugar mill (Central sector) buildings, structures, and facilities have since been demolished after their peak period. Only a few have been remodeled after the closing of the mill, some of which are located within the Reserve premises, such as the Visitor Center, formerly the American Club House, and the train station.



Historic house in the Aguirre Historic District
Source: Ernesto M. Olivares and Victor Cuadrado

According to the Puerto Rico State Historic Preservation Office (PRSHPO) archeological records, there are seven archeological sites within the Reserve boundaries. Cayo Cofresí, which is located in Mar Negro, belongs to the archaic period with a date 300BC. It is considered important to understand ancient human occupation (SHPO, n.d.). The casual discovery of stone figurines, (known as 'Cemí'), in the Central Aguirre area is evidence of settlements of the Taíno Indians, the most important indigenous cultural group of the Island.

3.3 Summary of threats and stressors

The Reserve is subject to numerous natural and anthropogenic stressors that affect its ecosystems and surrounding human settlements. Some of these stressors occur inside the Reserve, others take place in the watershed and surrounding waters. Threats and stressors include competing water uses, which affect the availability of water in the South coast aquifer; contaminants and sediments from agricultural and land use practices, industries and households' sewage discharge; and illegal or conflictive recreational practices. These anthropogenic stressors are exacerbated by the effects of climate change. These are summarized and briefly described in the following section. A more detailed description is included in Appendix 7.

Competing for ground water uses

Competing commercial, recreational, industrial, agricultural, and residential land uses are putting increased stress on the Reserves ecosystems. Groundwater is the main source of freshwater for the Jobos Bay estuary. It is also the single source of water supply for the municipality of Salinas. Various factors like water extraction from the aquifer for industrial purposes, impermeabilization of the land surface due to urbanization and changes in agricultural practices, combined with a reduction in rainfall has significantly diminished aquifer recharge. This has caused the death of mature black mangrove forest in the Mar Negro Unit. According to the US Geological Survey (USGS), prolonged time-periods with reduced aquifer recharge may have substantial implications for groundwater levels and fresh groundwater availability (Torres & Rodríguez, 2016).

Degraded water quality

Besides water quantity, water quality is also affected. Agricultural practices, major industrial point sources, onsite wastewater systems, urban runoff/storm sewers, and upstream impoundment are the causes of impairment of the Jobos Bay waters (Environmental Quality Board, 2014).

Stressors related to agricultural practices include the use of pesticides in surrounding agricultural lands. Research conducted as part of the Conservation Effects Assessment Project (CEAP) with the collaboration of the NRCS, detected a pesticide spike in water samples after a storm event, confirming a direct link between nonpoint source runoff from

the watershed and water quality in the Reserve. The study reported a site in JBNERR with a high concentration of the pesticide atrazine after a rain event (Potter et al., 2013).⁸

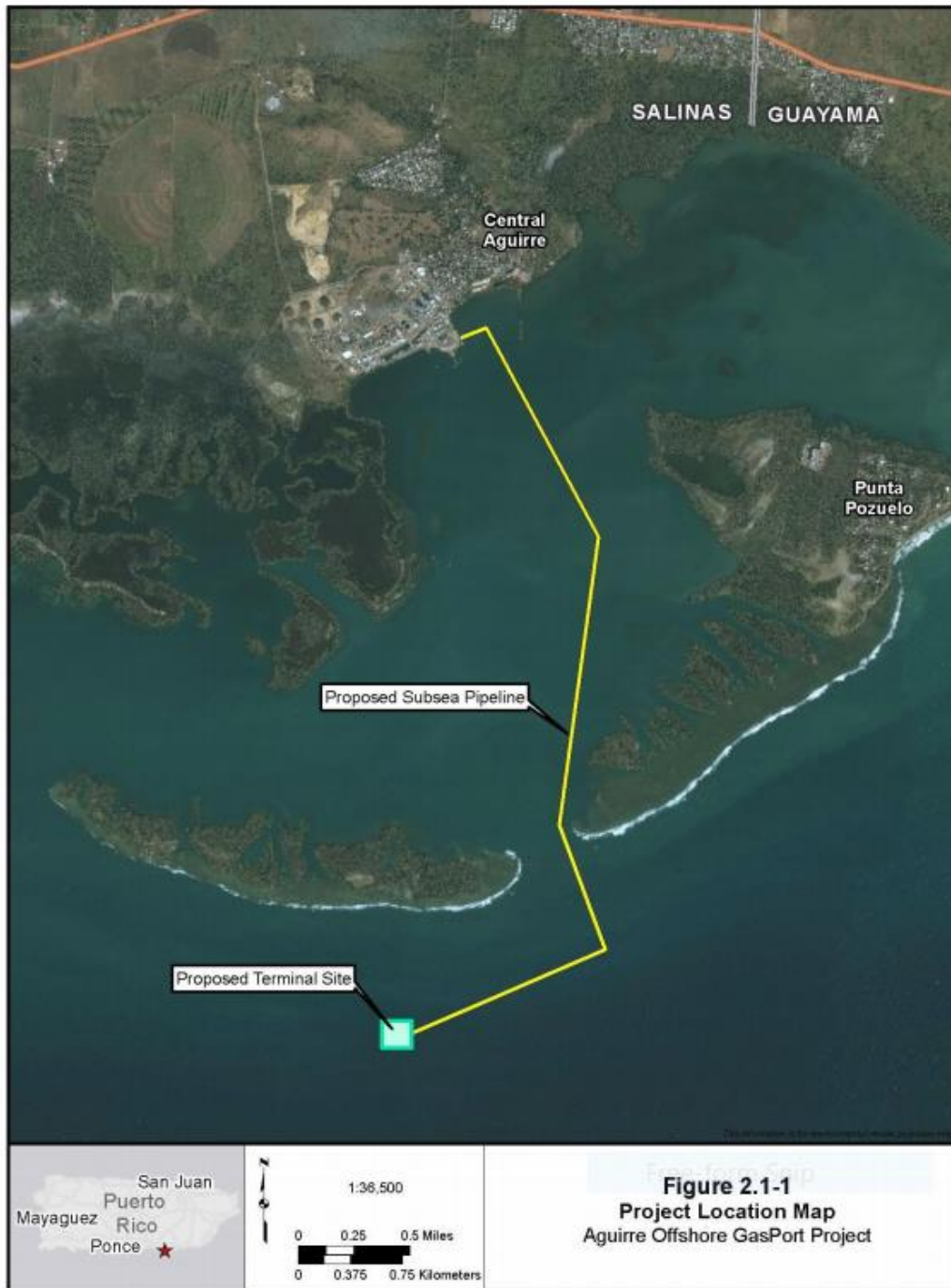
There are other industrial activities in the Jobos Bay NERR watershed that may impact the Jobos Bay waters. The North Equatorial Current, flowing west-northwest, influences the marine current coming from the eastern side of Jobos Bay that runs along the coast, coming into contact with potential pollution sources, such as agricultural fields, a coal power plant, a Phillips Core oil refinery (closed in 2005) and other industries (NERRS, 2011).

In addition, PREPA is proposing the development of the Aguirre Offshore Gasport for the purpose of receiving, storing, and re-gasifying Liquefied Natural Gas (LNG) that will be used in the Aguirre Power Plant (See the following figure). The proposed project includes the construction and operation of an offshore marine LNG receiving facility (Offshore GasPort) located in the south side of Cayo de Barca and Cayo Caribe and a 4.0-mile-long (6.4 km) subsea pipeline connecting the Offshore GasPort to the Aguirre Plant, through the Boca del Infierno pass. Concerns are mainly related to the potential impacts of the pipeline on marine ecosystems and livelihoods.

The Environmental Impact Statement prepared by the Federal Energy Regulatory Commission (2015), informed that the construction of the offshore facilities, including the Offshore GasPort, subsea interconnecting pipe, and lay barge construction areas, would directly impact approximately 129.9 acres of the seafloor. Operation of the offshore facilities would permanently impact approximately 22.9 acres of seafloor. This project involves the passage of vessels which may disrupt and divide the landscape, besides impacting the development of ecotourism in the area.

⁸ Atrazine is an herbicide use to stop pre- and post-emergence broadleaf and grassy weeds in crops.

Figure 5. Proposed Aguirre Offshore Gasport Project



Source: Federal Energy Regulatory Commission (2015). Aguirre Offshore GasPort Project Final Environmental Impact Statement.

The other existing power plant is located at the North-east side of Jobos Bay NERR and uses coal as fuel to produce electricity. There is lack of information about the effects of coal combustion residuals on the Jobos Bay NERR ecosystems. However, available data suggests potential effects on marine ecosystems that should be further studied.

Withall et al., 2011, reported arsenic (As) concentrations in coral tissues in the Jobos Bay that were higher than other studies in Puerto Rico. Arsenic concentrations in corals were higher in the offshore stratum than inshore. This pattern could be a result of atmospherically deposited as from fossil fuel combustion at the nearby power plants (coal and oil fired). Relative to other regions in Puerto Rico, concentrations of metal in airborne particles were higher in the Salinas watershed, which incorporates Jobos Bay (Jiménez-Vélez et al., 2003 cited in Withall et al., 2011).

Sedimentation from land-use practices also affect water quality. Recent observations from mapping efforts conducted by NOAA's National Center for Coastal and Ocean Science (NCCOS) revealed that the corals offshore of Jobos Bay are being impacted by severe sedimentation, which have led to decreased growth rates, and reduced recruitment, but the effects vary among coral species, sediment types, and environmental conditions (Whitall et al., 2011).

Lack of proper infrastructure to manage sewage discharges in surrounding communities is another stressor to the Reserve's ecosystems. Water quality in the Mar Negro Unit is characterized by high nutrients, resulting from lack of proper infrastructure to manage sewage in Las Mareas and Camino del Indio communities.

Illegal and conflictive uses and activities

The incidence of illegal practices in the Jobos Bay NERR, the lack of proper enforcement and processing of violators, are important issues that have affected the Reserve resources over the past years. Violations include illegal fishing practices; illegal captures of blue land crab; illegal construction of ramps, piers, filling of rubble in the maritime zone and JBNERR terrains; and vandalism of property. Additional unauthorized activities include the use of vehicles in the Reserve terrains, the presence of horses through the Reserve and the celebration of picnic activities in the Reserve lands mainly in the Salitral trail and in the dock and gazebo areas.

In addition, threats to marine species, such as the nurse shark in the Jobos Bay waters, are active fishery/capture, and harassment during mating and reproduction.

Another is threat is the celebration of massive festivals in private cays in the Jobos Bay waters. Although outside the Reserve, these activities affect this delicate ecosystem. These events put substantial pressure on marine resources within the Reserve and its periphery. Sometimes boats are anchored to mangroves in the cays. In addition, boat operators attempting to dislodge their vessels from groundings have caused prop scars and larger blowholes throughout the shallow seagrass beds. The Reserve conducted a seagrass restoration project in these areas, but the risk of damage continues. Some users also leave trash that can be seen throughout the marine environment and in some trails.

This is exacerbated by the fact that at present, there's only one Ranger assigned by the PRDNER to the Reserve, significantly hindering proper enforcement of environmental laws.

Climate change effects

Climate change impacts affecting JBNERR ecosystems and surrounding communities include: increases in surface and sea surface temperature, increases in the intensity of extreme weather events, sea level rise and ocean acidification. Although JBNERR lacks a vulnerability assessment, an existing assessment conducted for Puerto Rico⁹ provides an overview of the major challenges facing the Reserve.

- Increase in surface temperature: Extreme temperature events are likely to lead to an increase in the number of hotter days and a decrease in the number of cooler days (PRCCC, 2013). Wildlife, particularly ectothermic species, are more vulnerable to an increase in surface temperature. An increase in temperatures may alter adult nest attendance and prey fish behavior, and indirectly contribute to nest failure (PRCCC, 2013). Mean higher sand temperatures can lead to changes in sex ratios of marine turtles or prevent eggs from hatching.
- Increase in sea surface temperature: The PRCCC (2013) reported that higher incidents of this trend are being observed in the South coast of Puerto Rico. A common effect of warmer ocean temperatures is coral bleaching and disease.

A simulation model study showed that increased sea surface temperature causes shifts in faunal communities and heightens the possibility of invasive species among species of barnacles (Svenson et al., 2006, as cited in PRCCC, 2013). Mollusks, particularly in the earlier stages of life, are particularly vulnerable to changes in UV radiation, pH, and water temperature (Przeslawski et al., 2005, as cited in PRCCC, 2013).

Marine mammals are most vulnerable to the effects of climate change related to increasing temperatures and habitat degradation. Impacts may include: changes in abundance, distribution, timing and range of migration, community structure, the presence and species composition of competitors and predators, prey availability and distribution, timing of breeding, reproductive success and, ultimately, survival (Defra 2005, as cited in PRCCC, 2013). This report states that combined with toxicological stress, thermal stress may increase mortality. In addition, warmer temperatures may increase toxicity of pollutants that already exist in coastal waters. In the Reserve this is a matter of concern, given that current

⁹ "Puerto Rico's State of the Climate (2010-2013)", prepared by the Puerto Rico Climate Change Council (PRCCC).

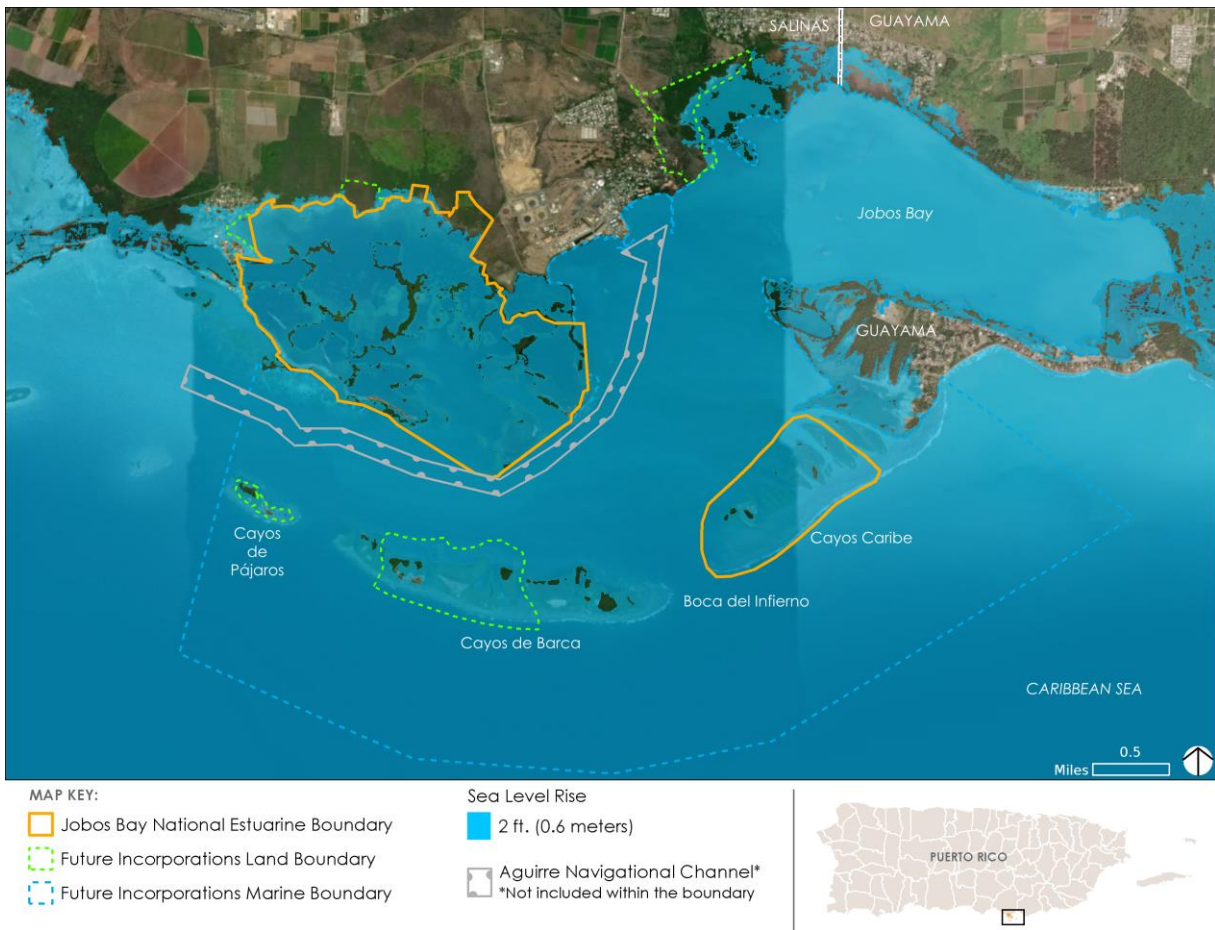
stressors, such as thermal discharge from the power plant may exacerbate the warm water conditions.

- Ocean acidification: Ocean acidification could interfere with critical processes such as reef building, carbon sequestration via phytoplankton sedimentation, and consumer-resource interactions, due to the increase in CO₂ concentrations and subsequent decreasing pH in seawater. In the Jobos Bay, the species most affected by this impact are coral reefs and other organisms such as the queen conch and many other mollusks, polychaetes, coralline algae, barnacles and a wide variety of species that produce calcium carbonate shells or skeletons.
- Decrease in precipitation: Current evidence suggests that drier conditions are more likely than wetter conditions in Puerto Rico (PRCCC, 2013). A reduction in precipitation, which has been documented in the watershed, will worsen recharge of the South coast aquifer. Droughts can affect aquifer water depletion by prompting excessive extraction, which can cause its subsidence, a situation that could be worsened by sea level rise. Saline intrusion could also occur, which could in turn impact the water balance needed by species such as mangroves. In addition, the amount of freshwater entering the Bay could be reduced, impacting the manatees. These are only two examples of the many potential impacts of decreased rainfall on the Reserve's flora and fauna.
- Increase in extreme weather events: Extreme weather events include an increase in the frequency and intensity of heavy downpours and an increase in the intensity of hurricanes and tropical storms. Natural disturbances, such as hurricanes, can alter both the physical and biological structure of coral reefs. Although the reef, in the absence of additional stressors, can recover through growth and recruitment, intense events can cause severe, long-lasting damage. Other effects include: coastal floods and potential damage to vegetation due to wind and surges, and an increase in coastal erosion, which can be severe in the Reserve's cays and cause a reduction of habitat for sea turtle nesting.
- Sea level rise: The Reserve is highly vulnerable to sea level change. Effects include saline intrusion in the South coast aquifer and the resulting impacts on ecosystems, agriculture and livelihoods. The rise in sea levels will cause changes in mangrove forest structure and migration. If the mangrove and the dry forest located north of the Reserve do not expand at the same rate, migratory songbirds that depend simultaneously on both habitats will be affected (Rodríguez, 2012).

Ecosystems loss and degradation will have adverse impacts on the economically disadvantaged communities surrounding the Reserve, which depend on the ecosystems for protection, fisheries, tourism, among other services. Economic activities that depend on the aquifer will also be adversely affected.

According to the NOAA sea level rise model¹⁰, an increase of two (2) feet would inundate 82% of the Reserve's lands, particularly the cays and the Mar Negro Unit, as presented in the following figure.

Figure 6. Effects of 2ft sea level rise in JBNERR



¹⁰ Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Coastal Services Center (CSC). NOAA Coastal Services Center Sea Level Rise Data: 2 ft Sea Level Rise Inundation Extent, 2012. Retrieved from: [https://coast.noaa.gov/]

3.4 Reserve Boundaries Description

The Jobos Bay NERR covers an area of approximately 2,800 acres and includes the main property of Mar Negro, also known as “Finca Lugo Viña” adjoining to the North with lands from the Puerto Rico Land Authority (PRLA); to the northeast with the Aguirre Power Plant and the Aguirre Sugar Mill; to the west with Las Mareas community and Camino del Indio; and to the South it extends to Jobos Bay coastal waters where there are no conflictive issues at the moment (PRPB, PRDNER & NOAA, 2000). To the south it also includes the Cayos Caribe. (See Figure 7).

Future incorporations to the Jobos Bay NERR boundaries

Since the adoption of the 2000 management plan. The PRDNER has acquired lands, clarified boundaries and identified important species in the Jobos Bay waters. As a result, a boundary amendment will be submitted as per 15 CFR 921.33 to expand the Reserve's boundaries. This management plan identifies these areas as “proposed boundaries”, since they have not been formally incorporated in the Reserve's boundaries. (See Figure 8).

These proposed boundaries include lands that were purchased and coastal waters of public domain that are under the PRDNER control. These areas, when incorporated, will provide the Reserve with better control over its resources and direct access to Jobos Bay's waterfront. Figure 8 depicts current boundaries and future incorporations to the Reserve's boundaries.

Figure 7. JBNERR Boundaries



MAP KEY:

 Jobs Bay National Estuarine Research Reserve Boundary

 Aguirre Navigational Channel*
Not included within the boundary



Source: Caribbean Landscape Conservation Cooperative. 2015. Puerto Rico Protected Areas Database [version of September, 2015]. GIS data. San Juan, PR. Coastal Zone Management Program, DRNA. JBNERR. NOAA. *Navigational Channel displayed for illustrative purposes only.



Figure 8. Current Reserve boundary and proposed future land and water incorporations



MAP KEY:

 Jobos Bay National Estuarine Research Reserve Boundary

Future Incorporations

 Land Boundary
 Marine Boundary

 Aguirre Navigational Channel*
 Not included within the boundary



Source: Caribbean Landscape Conservation Cooperative, 2015. Puerto Rico Protected Areas Database [version of September, 2015]. GIS data. San Juan, PR. Coastal Zone Management Program, DRNA. JBNERR. NOAA. *Navigational Channel displayed for illustrative purposes only.

Table 2. Future incorporations to the Jobos Bay NERR boundaries

# in the map	Area	Acres	Description
1	El Salitral	13.9	El Salitral (or Las Mareas salt flat) is the common name for salt marsh. It is very important as a buffer zone between the basin and fringe mangrove forests. It was property of the Puerto Rico Housing Department, and was acquired as a result of interagency transactions to provide better protection to the western boundary of the Reserve.
2	Jagüey Forest	26.4	Located north of Mar Negro and includes mangrove forest, salt flats, mud flats, and evergreen littoral woodland forest. Its name comes from the jagüey blanco or short-leaf fig (<i>Ficus laevigata</i>). The area was also affected by intense agricultural uses in the early century through the 1980's. The acquisition of this upland forest came as a result interagency transactions with the Puerto Rico Land Authority (PRLA) and the US Environmental Protection Agency (USEPA) Consent Order.
3	El Batey de Aguirre	103.00	Hacienda El Batey de Aguirre was purchased from the PRLA through an acquisition grant from NOAA/NERRS funds. These lands located behind the Visitor's Center enhance access to the bay and facilitate protection and restoration efforts of this critical ecological area, in addition to diversifying educational and recreational experiences of the Reserve's visitors. The area includes mangrove forests, salt flats, and evergreen littoral woodland forest. The area was affected by intense agricultural uses from the early century through the 1980's.
4	Cayos de Barca	73.80	Four of the seven cays have been purchased. Cayos Barca is a linear formation of 7 tear-shaped, reef fringed, mangrove islands, extending westward from Boca del Infierno passage and Cayos Caribe to the east. Cayos de Barca covers an area of approximately 275.1 acres. Formed by beach deposits, both reef island formations provide an excellent protection of the bay in terms of wind and wave action. The four cays of Cayos La Barca were acquired from the Federal Court with Commonwealth funds; these had been expropriated from their original owner.
5	Cayo Pájaros	16.27	Mangroves are the dominant forest cover. Approximately 1.5 acres are uplands. Purchased from a private owner in 2011.
6	Jobos Bay waters	5,217.96	It includes the entire Jobos Bay waters, except the Aguirre Power Plant navigation channel, which is 150 feet wide by 27 feet deep, approximately. This Unit is defined by the mean high tide line, and seaward from a line drawn 100 m from existing harbors and developed shorelines. It is important to clarify that the original boundaries covered the Jobos Bay, but not to the extent that is described here. These are coastal waters and submerged lands that are of public domain under Commonwealth laws, and administered by the PRDNER.
7	Coral reef Unit	4,233.70	Includes submerged lands and offshore waters extending one (1) mile seaward of Cayos Caribe, Cayos La Barca and Cayo Pájaros. Effectively unifies the entire coral-related ecosystem.

With these proposed incorporations the Reserve would have two main components: a proposed terrestrial component of approximately 1598.47 acres, and a proposed marine component of 9,451.66 acres of water, for an approximate total of 11,050.13 acres.

Table 3. Area of the JBNERR boundaries and future incorporations

Unit	Area (acres)
Aguirre	139.17
Cayos Caribe	155.38
Cayos de Barca	73.80
Cayos de Pájaros	16.27
Mar Negro	1,213.85
Proposed total Land Component	1598.47
Jobos Bay	5,217.96
Coral Habitat	4,233.70
Proposed Total Marine component	9,451.66
Proposed total area	11,050.13

Source: The areas of Cayos Caribe, Cayos de Barca and Pájaros were provided by the PRDNER Real Estate Division. The rest of the areas were estimated by Estudios Técnicos, Inc. using ArcGIS and shapefiles provided by the PRDNER in 2016.

The proposed boundary of the JBNERR would cover mangrove forest and diverse habitats from the landward transition zone of coastal fan-delta and alluvial deposits to offshore cays in the Caribbean Sea. The habitats represented at the JBNERR would include salt flats and mudflats, shallow lagoons, fringing reefs, several offshore cays, and a diverse mangrove forest.

Management Units

For management purposes, JBNERR current and proposed boundaries are subdivided into five management units. The terrestrial units are: 1) Mar Negro Unit; 2) Aguirre Unit 3) Cays Unit (includes Cayos de Barca (4 of 7 islands), Cayos Caribe (15 of 17 islands); and Cayo Pájaros. The marine component includes: 4) Coral reef unit and 5) Jobos Bay Unit. (See Figure 9).

Management of uses within each unit is based on whether the unit, or portions thereof, are designated as core or buffer areas. Core areas at JBNERR are those that include habitats essential to the functioning of the estuarine ecosystem. They preserve a full range of significant physical, chemical, biological and ecological attributes that support the diversity of fauna, flora and natural processes occurring within Jobos Bay. Public access is limited to low impact activities such as observation of nature, guided tours by the Reserve staff, research and education.

Figure 9. Jobos Bay NERR Units: Core and Buffer Areas



MAP KEY:

Core

Buffer

Aguirre Navigational Channel*
*Not included within the boundary

Units

- 1. Aguirre
- 2. Mar Negro
- 3. Cays Unit
- 4. Coral Habitat Unit
- 5. Jobos Bay Unit



Source: Jobos Bay National Estuarine Research Reserve. DNER Coastal Zone Management Program. National Oceanic and Atmospheric Administration (NOAA).

The core areas of the Reserve include: the Mar Negro and the Cays Units. Buffer zones within the Reserve protect the core areas and provide additional protection for estuarine-dependent species, including endangered listed species. Buffer areas also include facilities for public access. The Aguirre Unit, where the Visitor Center Complex is located, the Jobos Bay Unit as well as the Coral habitat Unit, serve as buffer areas.

Following is a description of the management areas within the newly proposed Reserve management zones, reflecting the distinct ecological regions of the Reserve and their designation as core or buffer areas.

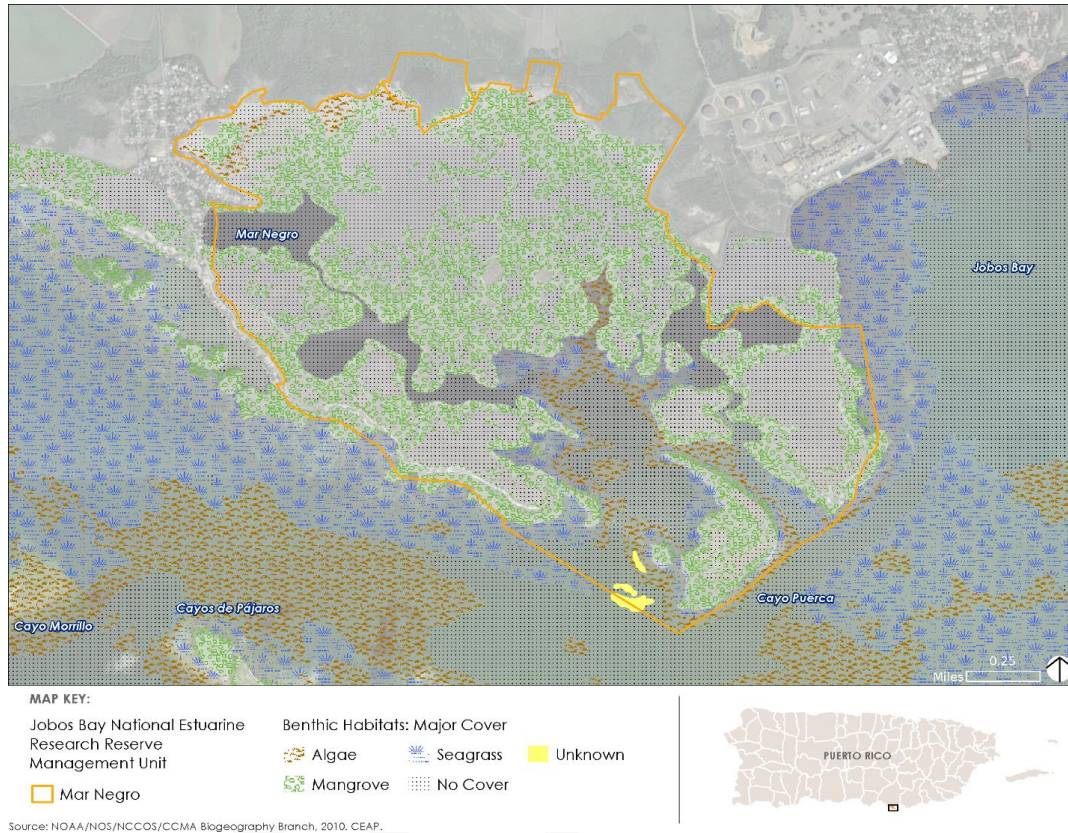
Mar Negro Unit

The Mar Negro Unit covers 1,213.85 acres, and includes red and black mangrove habitats, as well as mud and salt flats used extensively as forage and nesting areas by wading and shorebirds (See Figure 10). The shallow waters of Mar Negro provide shelter for the endangered Antillean manatee; while the mangrove forests provide essential nursery habitat for more than 80% of coral, recreational and commercial finfish and shellfish species.

This unit is the primary focus of the Reserve's Kayak Trail, Jagüeyes Trail and Wildlife Pond Trail. It is bordered by the communities of Las Mareas and Camino del Indio, and managed for guided public access and research. There is a boardwalk maintained by the Reserve staff used by researchers and Reserve's employees in Camino del Indio. Along the northern boundary of this unit are extensive salt flats that are important breeding areas for migratory shorebirds. The Jagüeyes Trail traverses these habitats and connects to the community of Las Mareas. Portions of this unit also include excavated ponds that have become valuable wading and shorebird habitat.

The Mar Negro Unit has also been impacted by agricultural uses adjacent to the northern boundary (buffer). Encroachment by the PRLA, in an effort to drain agricultural fields, decimated mangroves in this area. As part of a USEPA Consent Order, the PRLA restored the ditches that were created to drain the area and worked with NRCS to complete construction of an agricultural buffer strip to further protect Reserve habitats.

Figure 10. Mar Negro Unit

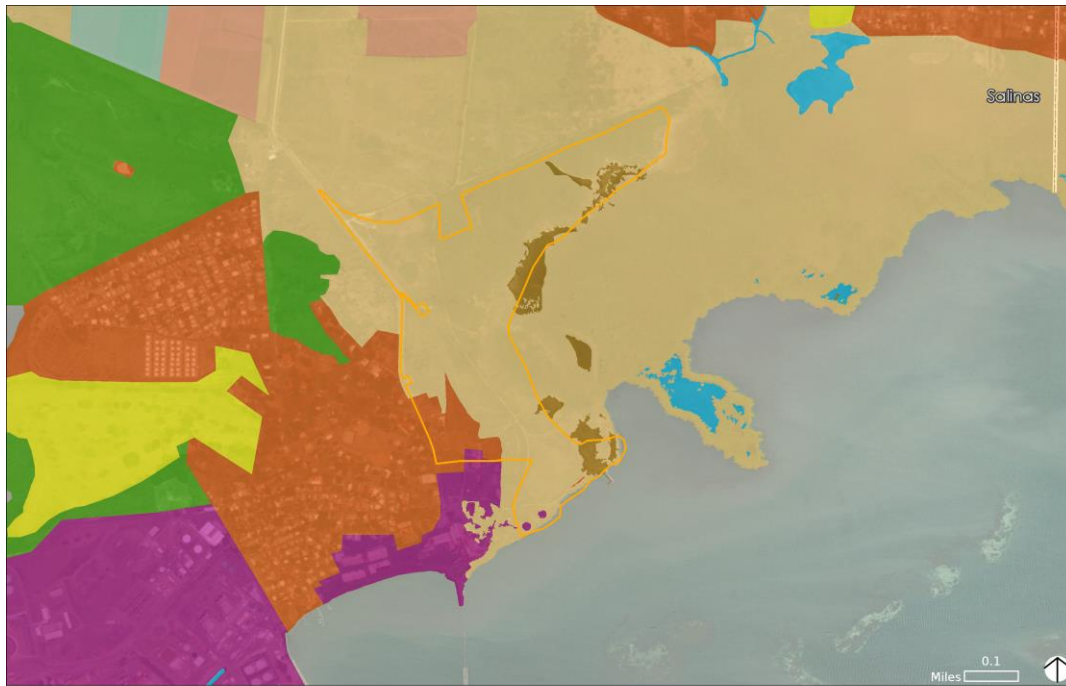


Aguirre Unit - Headquarters facilities and associated lands

The Aguirre Unit covers approximately 139.17 acres and is classified as a buffer area. It supports the Reserve Visitor Center complex and the Sugar Mill Trail. The boundaries of this area extend from the PR-3 to the town of Aguirre. Habitats in the northern portion of the Aguirre Unit include upland dry forest heavily impacted by the sugar cane industry. These previously disturbed uplands provide an ample footprint for future facility expansion needs (See Figure 11). The Sugar Mill Trail extends from the Reserve's Visitor Center to the new dock and boat ramp, which is the primary Reserve access point to Jobos Bay.

All birds typical of coastal zones within the Reserve can be observed here, such as sandpipers, great egrets, blue herons, and pelicans among several other migratory species.

Figure 11. Aguirre Unit



MAP KEY:

Jobs Bay National Estuarine Research Reserve Management Unit	General Land Use	Scrub-Shrub Upland	Urban	Urban - Recreational
	Agriculture	Forested Wetland	Urban - Industrial	Water
	Barren Land	Forested Land	Urban - Landfill	
Aguirre	Scrub-Shrub Wetland			

Source: JBNERR, Puerto Rico Water Resources and Environmental Research Institute (PRWREI) of the University of Puerto Rico at Mayaguez (UPRM), 2012.

Cays Unit

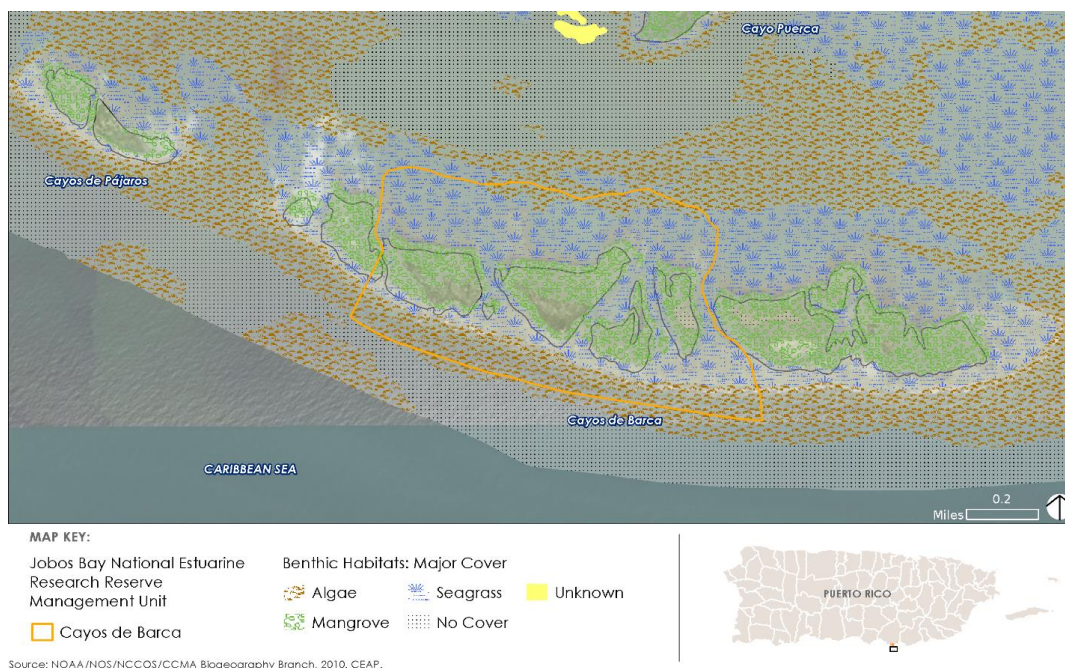
This unit consist of cayos de Barca, Cayos Caribe and Cayo Pájaros.

Cayos de Barca is a network of seven islands that covers approximately 73.8 acres. Four of the seven Cays have been purchased by the PRDNER (See Figure 12). The remaining three islands are held in private ownership and are acquisition priorities for the Reserve. These islands support mangroves and are fringed by coral habitat.

The submerged part of the cays is surrounded by coral reef formation to the south, east, and west, and seagrass beds to the north. Some of the islands have internal lagoons with hypersaline conditions while others have low land supporting dry forest vegetation. These cays have an over wash mangrove forest dominated by red and black mangrove, but white and buttonwood are present as well. The beach wort or saltwort and the sea-purslane grow in non-submerged beach deposit areas. Few trees grow in the upland area which is very limited in size.

No public access is supported, in Cayo Barcas, with the exception of Dos Palmas where a limited use area has been established.

Figure 12. Cayos de Barca



Cayos Caribe covers 155.38 acres and is a network of seventeen (17) islands that extend from the Pozuelo Peninsula on the southeastern boundary of the Reserve westward to Cayos de Barca. Fifteen (15) of the seventeen (17) cays are part of the Reserve boundaries. The remaining two are part of the Aguirre Forest. Therefore, all are effectively in PRDNER ownership. Of the fifteen (15) Reserve-managed islands, one island, la Cabeza de Cayos Caribe, supports public access and includes a trail, observation tower and small pier. It is used for education, outreach and recreational use.

Cayo Pájaros covers approximately 16.27 acres. It consists mainly of red and white mangrove fringe, with limited coastal strand communities in the interior. Research, education and interpretation are supported in this cay.

Figure 13. Cayos Caribe

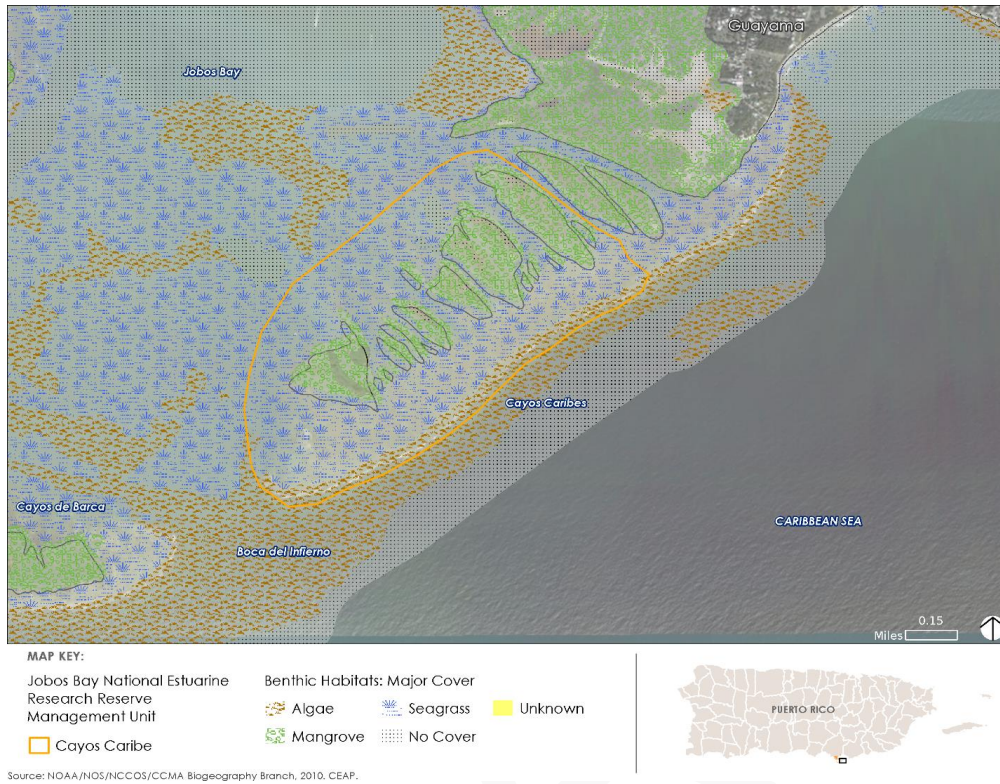
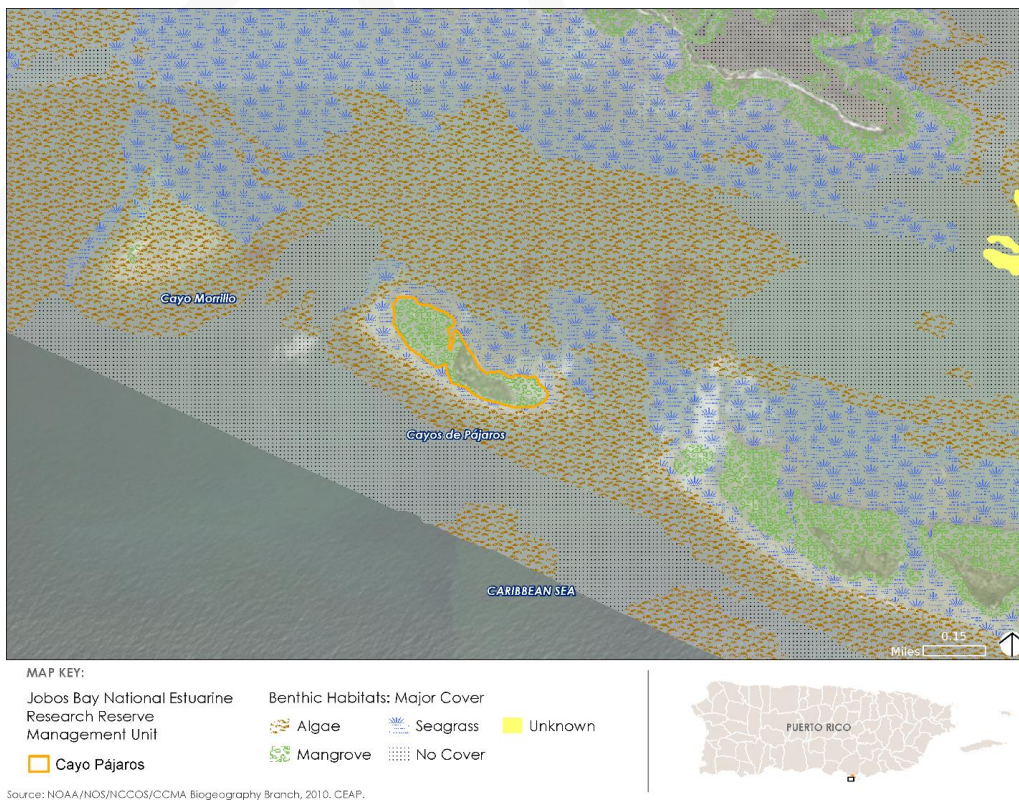


Figure 14. Cayo Pájaros



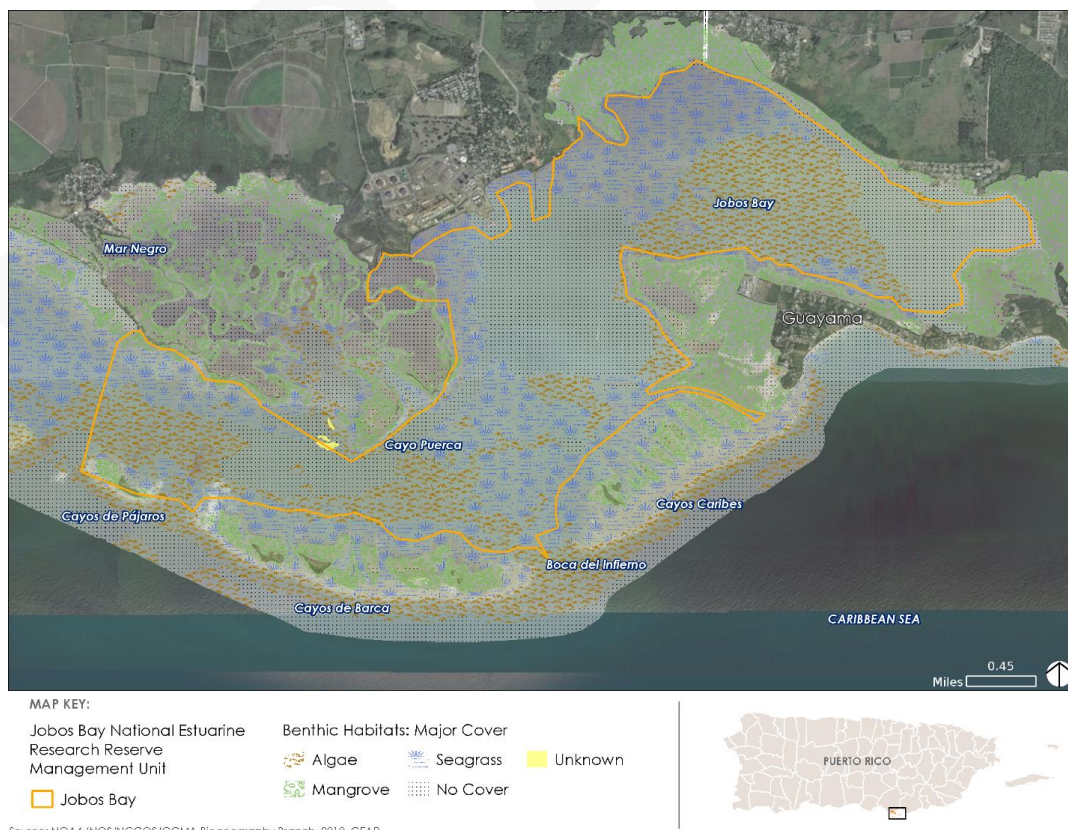
Jobs Bay Unit

The entire Jobs Bay Unit, an estimated 5,217.96 acres is defined by the mean high tide line, and seaward from a line drawn 100 m from existing harbors and developed shorelines. It is classified as a buffer area. Uses in Jobs Bay include maintenance of shipping channels to support harbors, commercial and recreational fishing, and recreational boating. The main navigation channel is 150 feet wide by 27 feet deep and is maintained only when required.

The Jobs Bay ecosystem is characterized by the interaction between mangroves and submerged aquatic vegetation (SAV). Seagrass beds and algae are the two types of SAV found in Jobs Bay. Together these cover nearly 66% of the Bay (Whitall et al. 2011).

The presence of these benthic cover types supports a rich and complex assortment of marine fauna. Many organisms are not associated with a single habitat, but instead move freely between several habitats for daily forage and shelter needs, like the manatee. Furthermore, a single individual may use a number of habitats during different stages in its life cycle. For example, many fish species use the fringing mangrove roots as nursery areas early in their lifecycle, migrating seaward as they mature to reside on the coral reef.

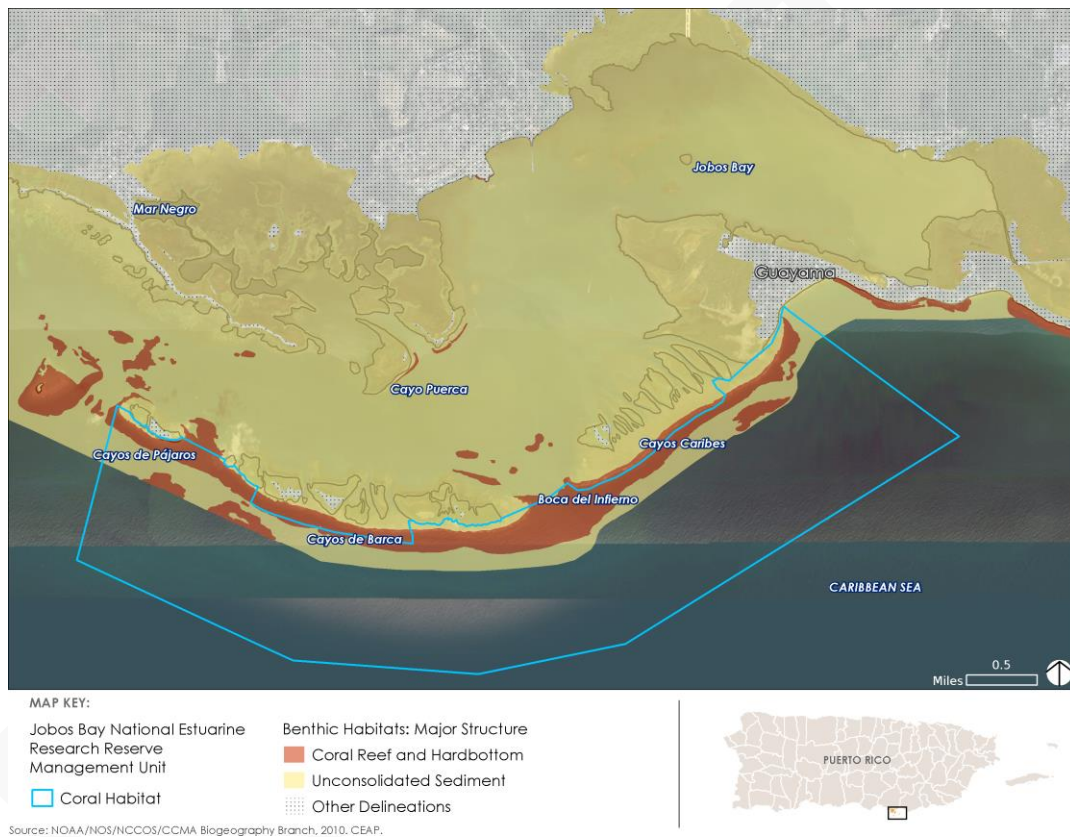
Figure 15. Jobs Bay Unit



Coral Habitat Unit

Offshore waters extending one (1) mile seaward of the Cays Unit comprise the Coral Habitat Unit. This unit covers approximately 4,233.7 acres. Higher amounts of hard coral cover were observed on the fore reef adjacent the cays (Whitall et al, 2011). *A. palmata* y *A. cervicornis* were observed at two sites along the fore reef of Cayos Caribe. This area does not have infrastructure to support public uses. However, research, education and interpretation are supported.

Figure 16. Coral Habitat Unit



Land ownership and type

All lands and waters that comprise JBNERR are either public lands or public domain lands. Reserve lands are under the PRDNER ownership. While the marine component (waters and submerged lands) are of public domain, which according to the Commonwealth legal framework (Civil Code, Subtitle 2, part I, Chapter 127), does not belong to anyone in particular. However, these are administered by the PRDNER. The PRDNER Organic Act provides that the agency has the duty to exercise surveillance and see to the conservation of territorial waters, submerged lands thereunder and the maritime terrestrial zone.

To the west, JBNERR is surrounded by two natural protected areas: Aguirre State Forest and Punta Pozuelo Natural Protected Area. The Aguirre State Forest, which covers 1,054.19 acres, was proclaimed in 1908 and is property of the PRDNER. Punta Pozuelo, covers 124.57 acres and since 2015, is property of the local NGO, Puerto Rico Conservation Trust and its unit Para La Naturaleza. Both protected areas represent an opportunity for a comprehensive management of these coastal resources.

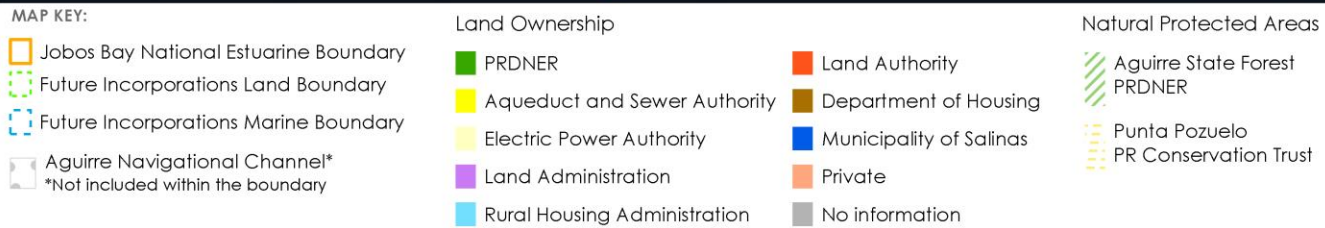
To the north, the Reserve is surrounded by agricultural lands, property of the PRLA that are leased to private parties for agricultural activities, specifically crop cultivation. These areas must be properly managed to avoid impacts to the coastal waters resources and surrounding wildlife.

Between Mar Negro and Aguirre Units is the Aguirre Power Plant, property of the Puerto Rico Power Authority and the old Aguirre Sugar Mill, which is no longer in operation. Some of these lands and properties were transferred to the Municipality of Salinas in 2010¹¹, in order to preserve six of the historic structures and promote tourism. Other lands remain under the PR Land Authority ownership.

The Reserve is also surrounded by private lands where various communities have been established. Bordering the western limits of the Reserve is Las Mareas community and other residential construction along El Camino del Indio.

¹¹ Transferred by the Senate Joint Resolution No. 169 of 2010.

Figure 17. Land Ownership



Source: Catastro Digital, CRIM. Vía <https://www.satagis.crimpr.net/catastrodigital>. Accessed February 2016. PRDNER.

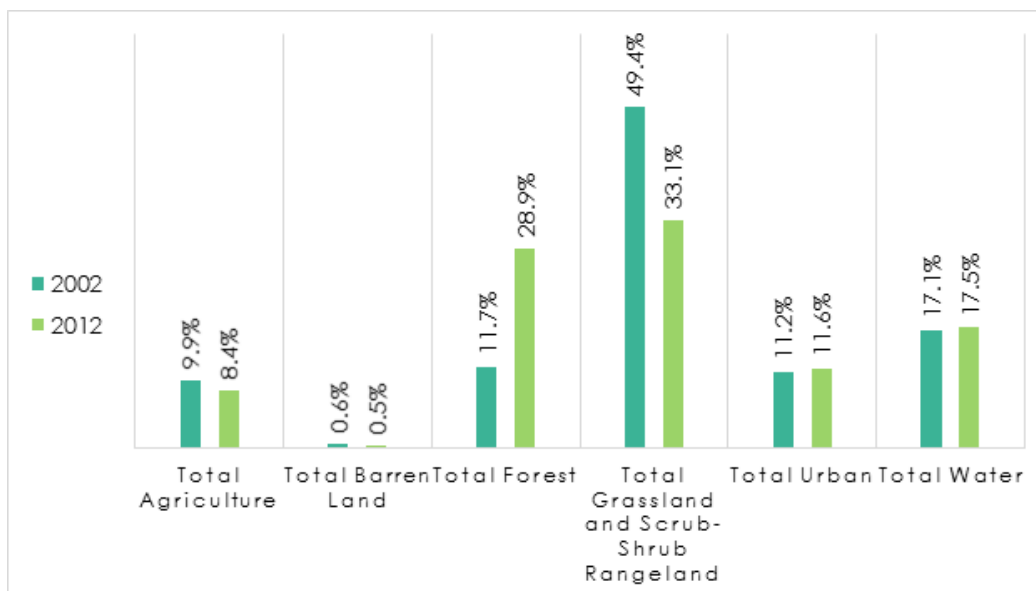
Targeted watershed's habitat types and land uses

According to the “Detailed Land Use and Habitat Inventory, 2012 of the Jobos Bay National Estuarine Research Reserve Watershed” land use at the watershed has gone through changes that can potentially affect the ecosystems. Some of these include growth in urban development and corresponding conversion of agricultural lands to commercial or residential areas, changes in irrigation methods and the establishment of new industries (PRWRERI, 2013).

Grassland and Scrub-Shrub Rangeland had the largest acreage 12,063.7 acres (33.1%). However, the largest increase was observed in the Forested Land (144.4%). In 2012, Forested Lands covered 9,366.8 acres of the Jobos Bay watershed.

Shrub and Scrub Rangeland, which was the main land use in the watershed in 2002, decreased -33.6% in 2012. The difference can be explained by changes in the ecosystem over time. During the 2002 land use classification, Shrub and Scrub Rangeland predominated due to the fact that when the sugar cane industry disappeared from the area, the plantations were abandoned and grass, and scrub and shrub started growing. As the land matured, small trees emerged that caused a change in classification in 2012 due to their new height: from the 2002 Scrub-Shrub Upland classification, in 2012 the trees were now tall enough to fall under the definition of Forested Land (PRWRERI, 2013). Scrub-Shrub Upland decreased by -86.4%. Most of this change was observed in the northeastern area of the watershed.

Figure 18. Jobos Bay watershed and general land cover classification



Source: Puerto Rico Water Resources Environmental Research Institute. (2013). Detailed Land Use and Habitat Inventory, 2012 of the Jobos Bay National Estuarine Research Reserve Watershed.

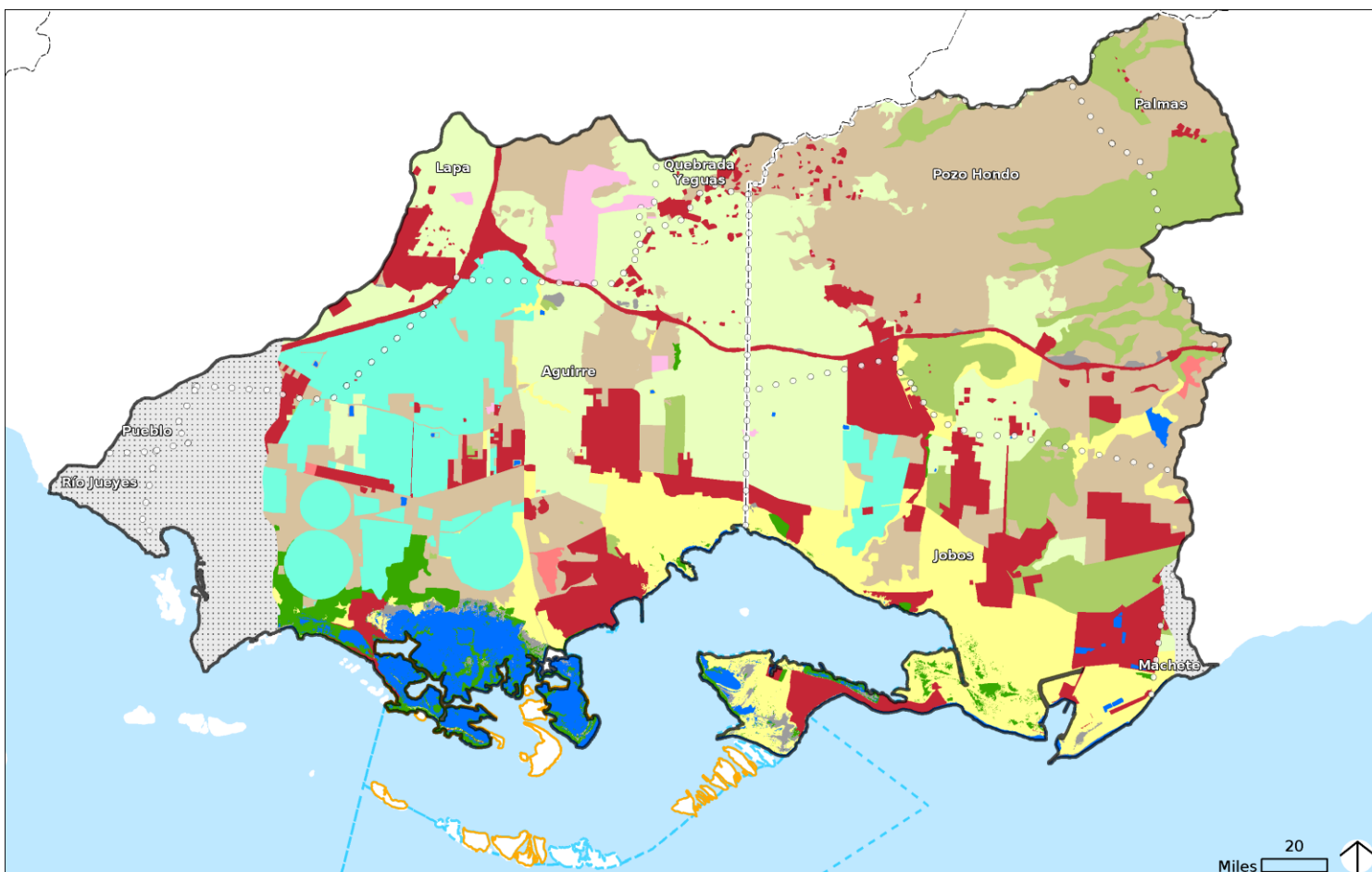
Urban residential (10.65%) also increased during that period, as well as other urban uses such as recreational (108.4%), educational (77.7%), industrial complex (13.3%), and landfill operation (34.2%). In the meantime, agricultural uses decreased by -15.6%.

Land use planning in the JBNERR watershed

The Puerto Rico Land Use Plan (PRLUP) was approved in 2015 with the purpose of harmonizing sustainable growth, social activity and the protection of natural resources (PRPB, 2015). The PRLUP classifies present and future land uses into different categories. Specially, protected rustic land—the more restrictive classification in terms of urban developments—is sub-classified into agricultural, scenery, ecological and a combination of various criteria.

In the Reserve's watershed, "Specially Protected Rustic Land-Agricultural" comprises approximately 35% (11,678 acres) of all land uses. It is followed by "Common Rustic Land" with 27% (9,287.7 acres). Common Rustic Land is used for those lands that at present are not needed to accommodate urban uses. Especially Protected Rustic Land- Ecological comprises 17% (5,601.5 acres) of the watershed; while Urban Lands constitute 13% (4,361.6 acres). Urban Land is characterized by road access, water supply, power supply and other infrastructure necessary to the development of administrative activities, and economic and social changes that are made in these lands (PRPB, 2015).

Figure 19. Habitat classification 2002

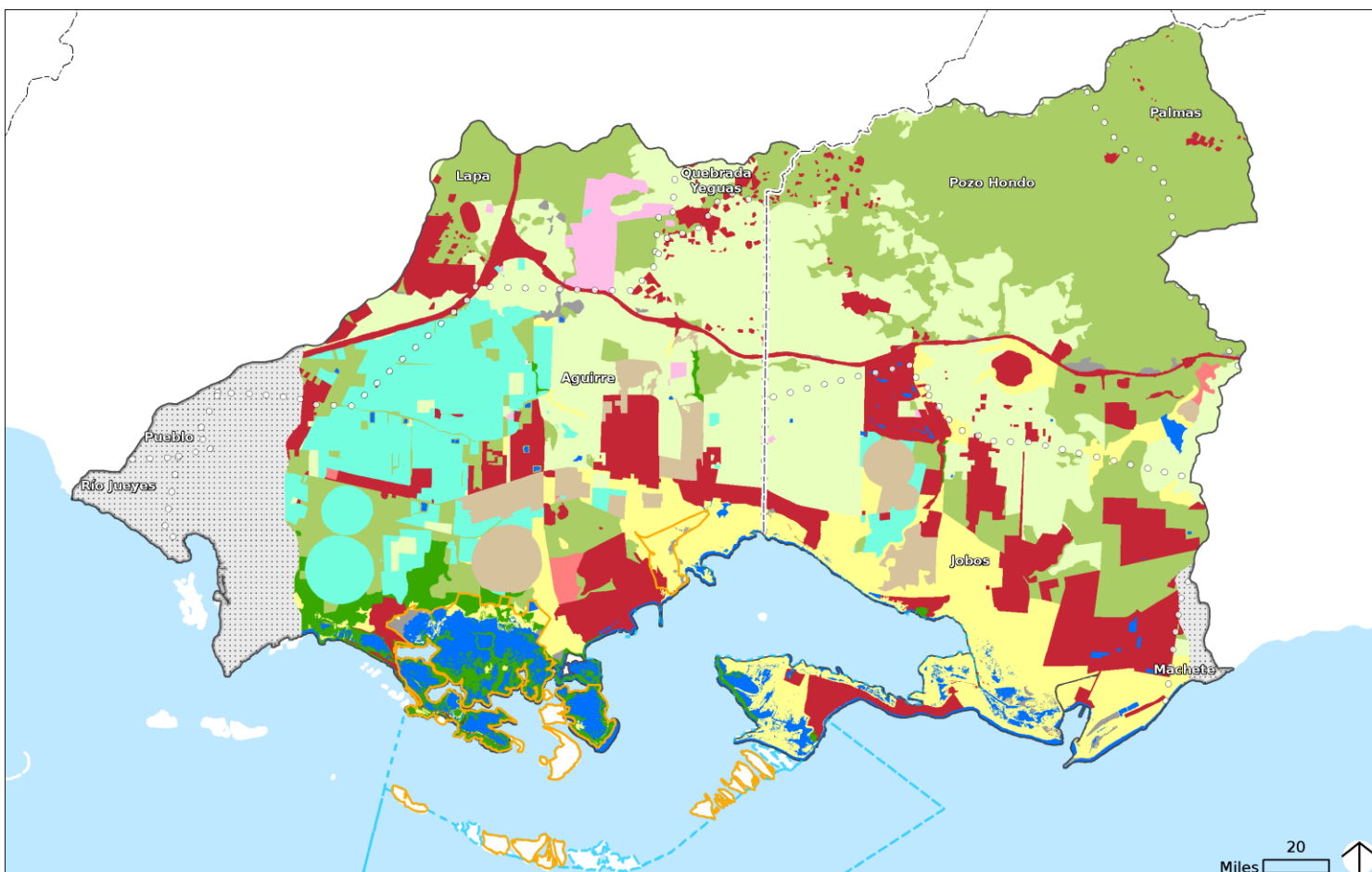


MAP KEY:

Jobos Bay National Estuarine Research Reserve	Habitat Classification		Barren Land
Proposed Land Boundary	Agriculture	Scrub-Shrub Wetland	Urban - Landfill Operation
Proposed Marine Boundary	Confined Feeding Operations	Grassland/Herbaceous	Urban and Build Up
	Forested Wetland	Scrub-Shrub Upland	N/A
		Forested Land	

Source: JBNERR. Puerto Rico Water Resources and Environmental Research Institute (PRWRERI) of the University of Puerto Rico at Mayaguez (UPRM), 2012.

Figure 20. Habitat classification 2012

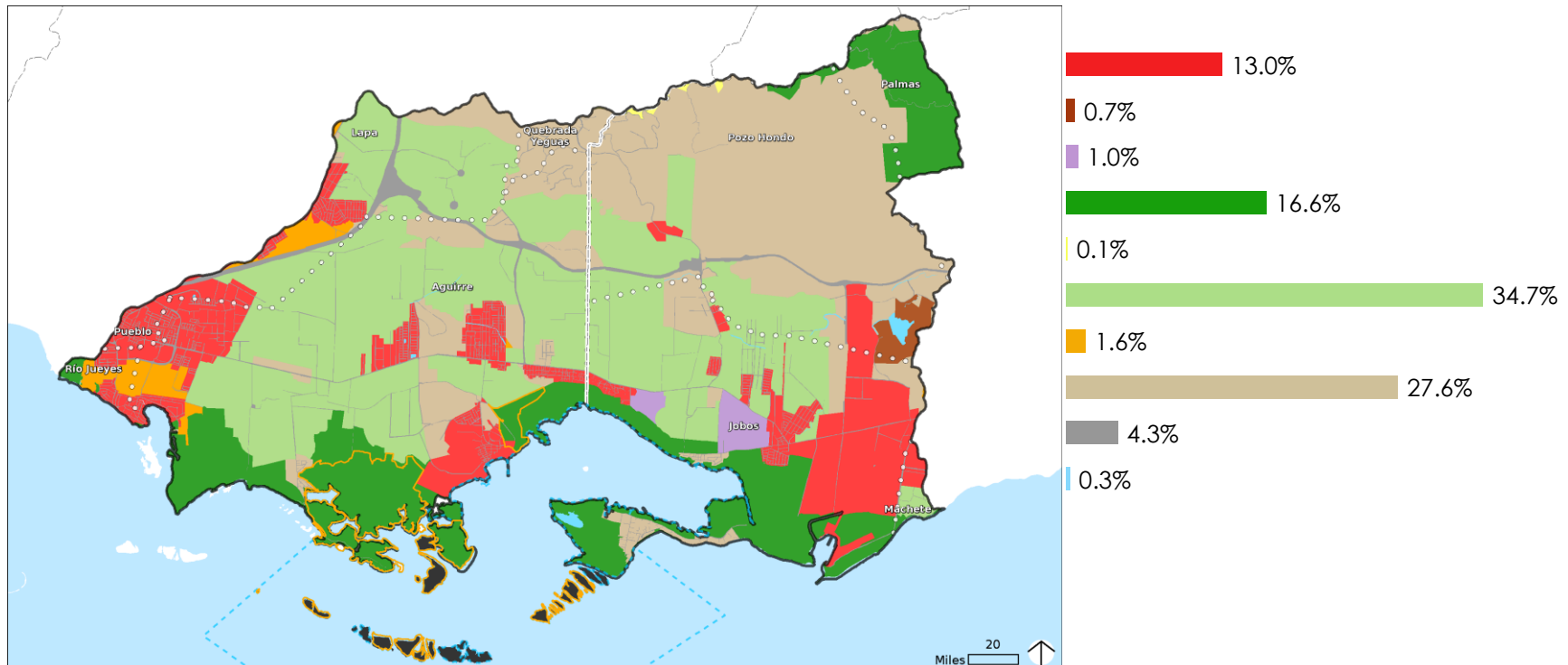


MAP KEY:

Jobos Bay National Estuarine Research Reserve	Habitat Classification		Barren Land
Proposed Land Boundary	Agriculture	Scrub-Shrub Wetland	Water
Proposed Marine Boundary	Confined Feeding Operations	Grassland/Herbaceous	Urban - Landfill Operation
	Forested Wetland	Scrub-Shrub Upland	Urban and Build Up
			N/A

Source: JBNERR. Puerto Rico Water Resources and Environmental Research Institute (PRWRERI) of the University of Puerto Rico at Mayaguez (UPRM), 2012.

Figure 21. Jobos Bay watershed and land use classification (PRPB, 2015)



MAP KEY:

Jobos Bay National Estuarine Research Reserve

- Land Boundary
- Marine Boundary

Land Use

- | | | | |
|---------------------------------|---------------------------------------------------------------|------------------------------------------------|----------------|
| Urban Land | Specially Protected Rustic Land - Ecological | Specially Protected Rustic Land - Hidrological | Roads |
| Common Rustic Land | Specially Protected Rustic Land - Agricultural | Specially Protected Rustic Land -Scenery | Not Classified |
| Specially Protected Rustic Land | Specially Protected Rustic Land - Ecological and Agricultural | Water | |

Source: Puerto Rico Planning Board.

STRATEGIC PLAN



4 Reserve Strategic Plan



4.1 Jobos Bay NERR Vision and Mission

Vision

The vision at the Jobos Bay NERR is as follows:

Puerto Rico will have healthy and resilient estuaries and watersheds, where coastal ecosystems and communities thrive.

Mission

To practice and promote coastal and estuarine stewardship through innovative research, monitoring, education, training and community involvement at the Jobos Bay NERR.



4.2 Guiding Principles

The guiding principles that will be reflected within each program are:

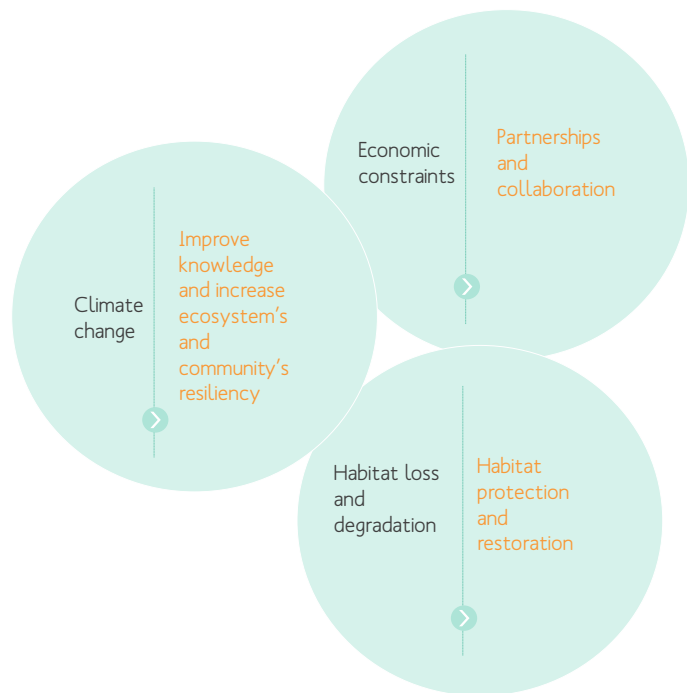
- | **Partnerships:** Implementation of Jobos Bay NERR programs will rely on strong partnerships and program alliances within the PRDNER, among Commonwealth and federal agencies, municipalities, universities, non-governmental organizations (NGOs) and other collaborators. Engagement of local communities and citizens will be fundamental to improve stewardship of coastal areas.

- | **Integration:** Integration of science, education, training and stewardship to serve as a catalyst and a model for demonstrating and facilitating objective problem-solving and best management practices to conserve and restore estuarine habitats and their watersheds.
- | **Evaluation:** Evaluation of the effectiveness of Reserve programs will be an integral component of program's implementation.
- | **Ecosystem based approach:** Implementation of an ecosystem-based management approach within all Reserve programs, recognizing the interdependence between humans, habitats and species.

4.3 Jobos Bay NERR Priority Issues

This Management Plan will guide the activities of the Reserve for the next five years (2017-2022). The NERRS defines national priorities that guide the focus, development, and implementation of the Reserve System management plans. These national priority issues are: environmental change, water quality and habitat protection, and provide the framework for the JBNERR management plan.

For the next management period, Jobos Bay NERR will focus on addressing the following priority issues: climate change, habitat loss and degradation and economic constraints.



Climate change

Climate change, specially sea level change, acidification, temperature increase and extreme weather events, represents a challenge for the Reserve's ecosystems and the already vulnerable surrounding communities. Although specific impacts on the Reserve's habitats and species are not well known.

Communities bordering the Reserve are predominantly low-income populations located in low lying coastal areas. According to the Intergovernmental Panel on Climate Change, small islands have characteristics which make them especially vulnerable to the effects of climate change, sea-level rise, and extreme events (Mimura et al., 2007;

Nurse et al., 2013). Consequently, JBNERR and its surrounding communities would experience more intense impacts, relative to the continentally-based reserves. This amplifies the importance of the programs conducted at JBNERR.

Given the breadth of potential impact of climate change on JBNERR and its surrounding communities, it is imperative to reduce stressors on its ecosystems, work with the communities to increase their resiliency, and improve knowledge on the potential effects on the Reserve and its watershed. Thus, information generated through research in these topics will be the baseline for the development of management measures, as well as education and training activities in the Reserve and its watershed, to reduce stressors, increase resiliency, and develop adaptive capacity.

Habitat loss and degradation

Habitat loss and degradation increases ecosystem's vulnerability. By addressing this issue not only ecosystems, but communities will be more resilient. Coastal and marine habitats in the Jobos Bay, as well as in other parts of Puerto Rico show signs of degradation through illegal clear cutting and development, watershed impacts and climate impacts. The Reserve is also affected by the watershed's habitat loss and degradation. Combined, these effects will compromise species' ability to adapt their habitat ranges to new climate realities (Taïssir-Bencharif, 2010). Cumulative and sequential impacts may limit the ability of coastal and marine ecosystems to recover, resulting in long-term consequences on their community structure and function. In addition, coastal communities are becoming increasingly vulnerable to the effects of climate change, as they depend on coastal ecosystem protection.

Reducing threats and stressors is critical to increasing the resiliency of ecosystems and coastal communities. The watershed's non-point sources of pollution and their effects on marine and terrestrial ecosystems should be targeted through effective management, education, training and collaboration. Proactive surveillance by the PRDNER Ranger Corps, and proper coordination and partnerships with decision makers in the watershed is essential to address this issue.

Inter-habitat connectivity is also essential for species protection. Increasing connectivity has emerged as the most favored option for conservation in the face of climate change (Hodgson, Thomas, Wintle and Moilanen, 2009). Ecosystem connectivity is fundamental to mitigate the effects of climate change on habitats and biodiversity. It allows for species migration, and sustaining biodiversity. It can be achieved through proper management of the watershed's public and private lands and the cays. This is an important step for sustaining healthy and resilient coastal ecosystems.

Economic constraints

This management plan is developed under a challenging economic context. The Commonwealth government is experiencing unprecedented economic challenges

leading to a reduction in budgets, including staff and programs. Legislation has been approved to address these issues that include restrictions in the recruitment of new personnel.¹²

In times of economic difficulty, partnerships will be critical. The Reserve will foster collaboration and partnerships to help meet Reserve needs and to ensure the proper management and the implementation of programmatic areas. As a result, many of the proposed activities will depend on the collaboration and joint efforts of many other partner agencies and organizations, such as Commonwealth and federal agencies, municipalities, businesses, academia, communities, and NGO.

Given the economic constraints within the Commonwealth, The Reserve will maximize its geographic and institutional reach, by providing education, training and management support for other PRDNER coastal protected areas.

4.4 Goals and objectives

The following table presents the management goals for the Jobos Bay NERR and its relation with the objectives of each programmatic area.

Table 4. Jobos Bay NERR Management Goals, Objectives, and Actions

GOALS	
Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and, education	1
Increase the use of Reserve science to address priority coastal management issues	2
Enhance people's environmental literacy by increasing their ability and willingness to make informed decisions and take responsible actions when interacting with estuarine and coastal ecosystems	3
Improve decision makers' and communities' understanding of the effects of climate change on ecosystems and provide them with the necessary knowledge and tools to make informed decisions to adapt	4
Enhance the administrative capability and infrastructure of the Jobos Bay NERR to meet the stewardship, research, education and, training challenges of the future	5

¹² "Government of the Commonwealth of Puerto Rico Special Fiscal and Operational Sustainability Act," Law No. 66 of 2014, and the Circular Letter No. 111-14, which restricts the recruitment of new personnel, during its term, except in certain circumstances such as that 50% or more of the salary is defrayed by Federal funds or the agency's own income.

OBJECTIVES					
Research and Monitoring Program					
1. Conduct research to better understand the Reserve's hydrological changes and estuarine dynamics, climate change effects and social dynamics	1	2	3	4	
2. Increase availability and accessibility of scientific data, research findings and the Reserve's capabilities to researchers, resources managers and other audiences	1	2	3	4	
3. Expand the SWMP and Non-SWMP monitoring initiatives to enhance understanding of the key habitats in the Reserve and their stressors	1	2	3	4	
Education Program					
1. Increase the participation of students and teachers in the Reserve by providing high-quality, place-based educational activities	1	2	3		
2. Develop a Conservation Action Education Program to increase knowledge and engagement among community members as well as to increase the volunteer base	1		3	4	
3. Increase the number of visitors exposed to the Jobos Bay NERR as an area of ecological and historical significance as well as a learning tool for community resilience	1	2	3	4	
4. Assess the effectiveness and satisfaction of participants on each Educational Program activity	1	2	3	4	
Coastal Training Program					
1. Provide annual trainings and technical assistance to decision makers to increase their capacity to protect and enhance coastal resources and assess community vulnerability	1	2	3	4	
2. Provide two annual trainings and technical assistance to decision makers to increase their capacity to assess the vulnerability of coastal communities and develop adaptation measures	1	2	3	4	
3. Increase collaboration with coastal decision-makers representing the Commonwealth, federal and community organizations	1	2	3	4	
4. Determine the needs of target audiences for the CTP program in order to continue providing relevant services	1	2	3	4	
Administrative Plan					
1. Recruit three additional JBNERR staff to support administrative and monitoring efforts	1				5
2. Strengthen JBNERR staff capabilities by providing trainings and developing annual work plans	1				5
3. Acquire one vessel to meet the needs of the Reserve's expanding programs	1				5
Resources Protection Plan					
1. Improve law enforcement in the Reserve and its watershed	1				5
2. Protect sensitive areas from human induced perturbations	1				5
Public Access and Visitor Use Plan					
1. Establish a baseline to develop the necessary visitor control measures	1				5
2. Enhance and improve trails connecting areas of interest in the Reserve	1				5
Facilities Development and Improvement Plan					
1. Renovate and enhance existing structures and provide tools to meet the education and training needs of the Reserve	1	2	3	4	5
2. Renovate and enhance existing structures to provide facilities to meet the needs of the Administrative and Research programmatic areas	1				5
Acquisitions Plan					

OBJECTIVES				
1. Acquire two properties to support programmatic areas and to expand wildlife corridors	1			
2. Diversify funding sources and partners for future acquisitions	1			
3. Modify Reserve boundaries to include previously acquired parcels and the Jobos Bay proper	1			
Restoration Plan				
1. Carry out habitat enhancement projects to benefit resident and migratory bird populations.	1			

RESEARCH PROGRAM



5 Research and Monitoring Program



5.1 NEERS Research and Monitoring Program

The National Estuarine Research Reserve System's mission provides that reserves are protected and managed to afford opportunities for long-term research. Research at each reserve is designed to fulfill the Reserve System goals as defined in the regulations (15 C.F.R Part 921 (b)):

- | Address coastal management issues identified as significant through coordinated estuarine research within the system;
- | Promote federal, state, public and private use of one or more reserves within the system when such entities conduct estuarine research;
- | Conduct and coordinate estuarine research within the system, gather and make available information necessary for improved understanding and management of estuarine areas.

To sustain these system goals, the 2017-2022 Reserve System Strategic Plan outlines the following research objectives:

- | The reserve system will maintain and expand monitoring of relevant and emerging biophysical and socioeconomic parameters, increasing their capacity to track the effects of changes in land use, coastal development, and climate.
- | Reserves and coastal researchers will increase their collaborative research to address the needs of decision-makers and stakeholders.
- | Scientific, management, and educational audiences will know about and effectively use reserve research, data, and products to understand the effects of climate and land-use change on estuaries, ecosystem services, and human well-being.

The Reserve System's research and monitoring programs provide the scientific basis for addressing coastal management challenges. The associated activities provide valuable information about estuarine resources to increase understanding and awareness of their importance to a variety of audiences including scientists, resource managers, educators, and the general public.

Reserve System Research Programs

Currently, there is one focused effort to fund estuarine research in the Reserve System. The National Estuarine Research Reserve System Science Collaborative, a partnership between NOAA and the University of Michigan (at the time of drafting this plan), is a program that focuses on integrating science into the management of coastal natural resources. Currently administered through the University of Michigan, the program integrates and applies the principles of collaborative research, information and technology transfer, graduate education, and adaptive management with the goal of developing and applying science-based tools to detect, prevent, and reverse the impacts of coastal pollution and habitat degradation in a time of climate change. The program is designed to enhance the Reserve System's ability to support decisions related to coastal resources through collaborative approaches that engage the people who produce science and technology with those who need it. In so doing, the Science Collaborative seeks to make the process of linking science to coastal management decisions, practices, and policies more efficient, timely, and effective and share best practices and examples for how this can be done.

Reserve System Monitoring Program

The System-Wide Monitoring Program provides standardized data on national estuarine environmental trends while allowing the flexibility to assess coastal management issues of regional or local concern and is guided by the Reserve System-Wide Monitoring Program Plan. The principal mission of the monitoring program is to develop quantitative measurements of short-term variability and long-term changes in water quality, biological systems, and land use/ land cover characteristics of estuaries and estuarine ecosystems for the purposes of informing effective coastal zone management. The program is designed to enhance the value and vision of the reserves as a system of national references sites and focuses on three ecosystem characteristics:

1. **Abiotic Characteristics:** Abiotic measurements are supported by standard protocols, parameters, and approaches that describe the physical environment including weather, water quality, hydrological, and sediment related parameters. The monitoring program currently provides data on water temperature, specific conductivity, percent saturation of dissolved oxygen, pressure, pH, turbidity, salinity, concentration of dissolved oxygen, and pressure corrected water depth. Meteorological data include air temperature, relative humidity, barometric pressure, wind speed, wind direction, rainfall, and photosynthetically active radiation (PAR). In addition, the program collects monthly nutrient and chlorophyll a samples and monthly diel samples at one SWMP data logger station. Data is Federal Geographical Data Committee compliant and available via the *Reserve System Centralized Data Management Office*.
2. **Biotic Characteristics:** As funds are available, reserves are focusing on monitoring habitats and biodiversity.

3. Watershed and Land Use Classifications: The Reserve System is examining the link between watershed land use and coastal habitat quality by tracking and evaluating changes in coastal habitats and watershed land use/cover. This element is guided by the Reserve System Habitat Mapping and Change Plan.

Building on these foundational elements, the Reserve System is implementing a network of sentinel sites to address specific hypothesis-driven questions concerning drivers of habitat change. A SWMP Module refers to the package of SWMP protocols required to address specific questions. The first sentinel site module implemented by most reserves impacted by sea level rise is referred to as the Sentinel Site Application Module - 1, also known as SSAM-1. Pursuant to the NERRS Sentinel Site Guidance Document, revised in 2016, SSAM-1 assesses the impacts of changes in local sea level and inundation on vegetative communities (marsh, mangrove, and submerged, aquatic vegetation). The SSAM-1 module includes surface elevation tables and monitoring of pore water chemistry along vegetation monitoring transects and links their SWMP infrastructure to a network of specialized spatial infrastructure to allow precise measurement of local sea level changes and vegetative responses. The Reserve System is working in partnership with NOAA's National Geodetic Survey and the Center for Operational Oceanographic Products and Services to support the development of this sentinel site module.

5.2 Program context, capacities and delivery

The JBNERR Research and Monitoring Program is focused on providing a data-rich environment to support and attract research that explores the interactions of watershed, oceanic and climatic forces on coral and coral-related environments. The Program supports science by implementing long-term water quality and biological monitoring programs, supporting visiting investigators, mentoring graduate researchers and Hollings Scholars, and partnering with other university and governmental programs.

The Program, focused on addressing the priority issues of the Reserve and through integration with other programs, incorporates the watershed, the Jobos Bay and nearshore environments in a 'Summit to Sea' approach. Target audiences include graduate and undergraduate students and academics from Puerto Rico, universities in the U.S. and the Caribbean, as well as independent researchers.

Accomplishments

Several milestones have been accomplished since the last management planning period related to research and monitoring in the Reserve and its watershed. In addition to increasing knowledge about the Reserve and its watershed's ecosystems and their status, advances include the installation of the necessary equipment to strengthen the Program, and the integration of students in research, as described below.

Advances in Research in the Reserve and its watershed

- | The Conservation Effects Assessment Program (CEAP) 2007-2009 - The purpose of the project was to determine environmental effects that agricultural conservation practices may have on coastal waters and associated habitats in a tropical ecosystem, and ultimately, on coral reefs. Products developed as part of the project include elevation from high resolution imagery, comprising LIDAR imagery of the Reserve's watershed and bathymetry. The project was developed through a partnership between federal and Commonwealth entities: USDA, NOAA and JBNERR-PRDNER. Collaborators included the USFWS, USGS, Puerto Rico Agricultural Extension Service, Puerto Rico Environmental Quality Board (PREQB), Puerto Rico Land Authority, University of Puerto Rico Mayagüez (UPRM) and the PRSGP at UPRM. Results are available at:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/ws/?cid=nrcs143_014129#jobs/

- | Baseline Assessment of Contaminants and Ecological Resources in Jobos Bay, Puerto Rico, 2011. A baseline environmental assessment of Jobos Bay and adjacent marine ecosystems was developed, as part of the CEAP. It included the distribution and condition of habitats, nutrients, contaminants, fish, and benthic communities. The aim of the project was to establish a collaborative long-term research and monitoring program for the bay in order to develop collective watershed and coral reef management and conservation options. It was developed through a partnership between NOAA-National Centers for Coastal Ocean Science (NCCOS) and the USDA. Results are available at:
<https://coastalscience.noaa.gov/projects/detail?key=99>.

- | Assessments of the condition of the aquifer. The USGS published two important reports: "Effects of Changes in Irrigation Practices and Aquifer Development on Groundwater Discharge to the Jobos Bay National Estuarine Research Reserve near Salinas, Puerto Rico", published in 2010, and the "Hydrologic Conditions in the South Coast Aquifer, Puerto Rico, 2010–15", published in 2016.

- | Detailed Land Use and Habitat Inventory, 2012 of the JBNERR Watershed. The project had two objectives: to develop a detailed habitat classification for JBNERR using the NOAA Coastal Change Assessment Program (C_CAP) Classification Scheme, and (2) to reclassify the detailed land use of the JBNERR watershed conducted in 2002, using the categories developed by the National Estuarine Research Reserve System classification scheme (NERRSCS). General land use/land cover and impervious surfaces for 2002-2012 were developed for JBNERR and the watershed. This inventory was developed in coordination with the Puerto Rico Water Resources Environmental Research Institute. Products included a report and ArcGIS data. Results are available at:
http://geodec.com/jbnerr2012/JBNERR_Final_Report2012.html

- | Exploratory JBNERR System Wide Monitoring Program (SWMP) Time Series Data Analysis Report by the Caribbean Coastal Ocean Observing System (CariCOOS), 2015. The report includes statistical analysis of water quality and meteorological time series. This will allow researchers to visualize and compare actual measurements with range and median values. The next step is to verify Centralized Data Management Office's (CDMO) datasets in order to deplete previous quality assurance/quality control (QA/QC's).

Advances also include the installation of the following instruments to strengthen research and monitoring:

- | NOAA-National Geodetic Survey (NGS) - In 2007, NGS started planning a project to establish a new V-Datum for Puerto Rico, tying local benchmarks to tidal datum's and Continually Operating Reference Stations (CORS). The purpose was to increase the vertical accuracy of all benchmarks from 3 meter vertical resolution to 2-5 centimeter vertical accuracy. A local vertical control network was implemented enabling millimetric level of accuracy within the network. The Reserve is planning to establish a tidal datum at the Reserve using the SWMP data loggers. This will allow the Reserve to further monitor sea level changes at SWMP stations and mangrove forest uplands as part of the Sentinel Site Project.
- | Wireless network: In 2009, the NERRS provided funding to develop a wireless network within the Reserve to deliver data in real and near-real time via the internet, supplemental to the SWMP telemetry system. Wireless antennas have been installed at strategic areas- close to the visitor's center, the old train depot, and the dock-trail area, in order to be used for the research, education and coastal training programs.

Graduate student research

The Graduate Research Fellowship (GRF) Program was in place from year 2000 through 2011. During that period, the Reserve hosted 11 GRFs and received 19 proposals from nine universities in Puerto Rico and U.S. Appendix 6 provides GRF projects at Jobos Bay NERR organized by the five priority research areas.

Since the termination of the GRF, the Reserve has had students working on masters and doctorate degrees. Two undergraduate students were accepted to support with the SWMP and wells' piezometers monitoring. Students develop their own research projects as well. Interns have represented NOAA's Hollings Scholarship Program, and also come from local and U.S. universities.

To promote graduate student research, the Research and Stewardship coordinators work together to promote the Reserve as a research site. This effort is known as the "Road Trip initiative" and was conceptualized with the Research Advisory Committee. One of the purposes is to engage new students to work on their Masters of Science (MS) or PhD thesis

at JBNERR. Both coordinators visited local post-secondary institutions and gave presentations about the research and volunteer opportunities under both Programs. At present, professors and students have expressed interest in collaborating.



Research and Stewardship coordinators presenting research and collaboration opportunities at the Reserve to graduate and undergraduate students

Continued monitoring projects

System-Wide Monitoring Program (SWMP)

Since 1995, JBNERR has implemented the SWMP according to the NERR-SWMP protocols, and will continue to doing so as a core element of Reserve's implementation. Through SWMP, Reserves provide long-term environmental monitoring data on abiotic, biotic, and habitat elements, which can be used to address management issues. At present, the Reserve monitors weather parameters; and abiotic parameters, nutrients and chlorophyll for water quality, through the SWMP.

- | **Water quality-** The Reserve collects temperature, conductivity, salinity, turbidity, dissolved oxygen, pH, depth and chlorophyll at four locations within the Reserve. These are: Mar Negro – Inner Coast (Station #9); Mar Negro – Outer Coast (Station #10); Inner Jobos Bay (Station #19); and Cayos Caribe (Station #20) (See Figure 22).

The station 20 data logger transmits data in near-real-time every hour through the NOAA Geostationary Operational Environmental Satellite (GOES) as part of the Integrated Ocean Observing System (IOOS). The Reserve collects monthly samples at all four SWMP data loggers and diel nutrient samples at the Mar Negro Inner Coast data logger. The locations of the data loggers were selected to monitor coastal activities, including adjacent agriculture, thermoelectric plant and watershed influences. The same data logger sites are used for nutrient sampling to complement the abiotic data. Analysis of nutrients is conducted by the Virginia Institute of Marine Science (VIMS) via a contract with the PRDNER. All data is QA/QC processed before being delivered to CDMO.

In addition, the Jobos Bay NERR installed CariCOOS telemetry equipment on one of the SWMP stations for transmission of water quality parameters in near real time.

Figure 22. Monitoring stations at Jobos Bay NERR



MAP KEY:

Jobos Bay National Estuarine Research Reserve

- Proposed Land Boundary
- Proposed Marine Boundary

- Monitoring Sites
- Sentinel Site
 - SWMP Sites
 - Weather Station

Source: Jobos Bay National Estuarine Research Reserve.



- | **Weather Variables-** In 2001 the JBNERR established a long-term monitoring weather station located at the visitors center, as part of the SWMP. The principal objective is to record long-term meteorological data to track changes in conditions that can be associated with changes in estuarine habitats.

This meteorological weather station is located at 0.40 Km off the Jobos Bay coast, and records data and information of the conditions affecting the estuary. The station is designed to evaluate the relative changes of climate on coastal dynamics. In addition, the station captures information on watershed inputs affecting hydrodynamics, nutrient dynamics, and other ecological processes within the estuary. Data is used as a reference for atmospheric conditions for ongoing research projects at the Reserve and for other short and long-term environmental monitoring projects within the Reserve. The station collects data that is integrated into 15 minute intervals. Data is transmitted in near-real-time every hour through the NOAA GOES satellite as part of the IOOS.

Sentinel Site

JBNERR has taken steps to set up a sentinel site monitoring program (also known as SSAM-1), which provides the necessary information to understand sea level change impacts on the Reserve's ecosystems and coastal communities. JBNERR will be the only NERR Sentinel Site representative of the West Indian biogeographic region.

The Reserve prepared and submitted to NOAA the final Sentinel Site Plan in the spring of 2016, and is working on the final version. To begin implementing the Plan, the Reserve has acquired the necessary instruments, and a surveyor was contracted to install and to survey three Surface Elevation Table (SET's). The continuous implementation of this site will be a priority for the next five years.

According to the Plan, expected outputs, in the long term, are: (1) understanding the inter-relationship of changes in water budget and sea level rise and its impacts on mangroves; (2) monitoring of water quality changes that will result from sea level rise and climate change with respect to water level and its impacts on coastal vegetation and fresh water resources; and (3) water level changes in relation to episodic storm events and flood and inundation predictions.

The Research and Monitoring Sentinel Site Program proposes monitoring the composition, structure and condition of the following key habitats:

- | **Mangroves:** Mangroves are of critical importance as a nursery area for commercially and recreationally important finfish and shellfish. The coastal type of mangrove forest found in the Reserve is heavily influenced by freshwater inflows. This system will be used as an indicator to track alteration of freshwater

inflows from the watershed, as well as effects from sea level rise, by monitoring parameters such as diameter at breast height (DBH), canopy cover, leaf litter and growth rate.

- | Dry Forests: Dry forests in the Reserve support a high diversity of insects and birds. Given the limited footprint of this important community, the Reserve plans to monitor the health of these forests, using parameters such as DBH, canopy cover, leaf litter and growth rate.
- | Submerged Aquatic Vegetation (SAV): The presence and health of SAV in the form of seagrass and algae beds are strongly influenced by water quality. Suspended sediments block light for photosynthesis and can easily stress these vital habitats. These systems will be used as indicators of water quality degradation and sea level rise, by monitoring parameters such as diversity, density, biomass, and growth rate. Protocols adopted for SAV monitoring will be consistent with those developed by Moore et al. (2009). The first SAV monitoring program began in January of 2017 with students from UPR Rio Piedras Campus.

Non-SWMP monitoring

Other monitoring efforts conducted in the Reserve are:

- | Monitoring of interstitial pore water in Mar Negro: Interstitial pore water is monitored for fluctuations in salinity concentrations in a coastal secondary forest and in a mangrove area affected by a mass mortality. Abiotic parameters, such nutrients and conductivity, are collected.
- | Monitoring of *Placeres Majaguas* inland lagoon. This place is visited every other week in an effort to monitor surface water runoff from coastal lagoons into Mar Negro area. This lagoon is a candidate for a future hydrological restoration project. During previous years, salinity values in this station showed freshwater influence. In recent years, the salinity regime has been stronger due to less precipitation in the watershed. This may be an indication of lower influence of the effects from runoff and low aquifer recharge. The Research Coordinator plans to continue monitoring this station.
- | The Reserve started a plankton monitoring pilot study in 2013. The Research Coordinator led plankton collection in the Reserve and the analysis was performed, under a contract, by the UPRM-Marine Sciences Laboratory. The monitoring program was suspended in 2014 due to lack of funding. This pilot study characterized primary components within the Bay, established baseline data and was used to develop a long-term monitoring strategy for implementation during this management period.

Research Program Capacity

Staff

The Program is managed by a Research Coordinator with the support of a Lab Technician (a chemist), who is responsible for data acquisition and processing. The Coordinator develops the long-term vision for the program and oversees all aspects of research and monitoring, including the coordination with the researchers doing work at the Reserve. The Coordinator also supports other Reserve's programmatic areas by providing talks and trainings as well as other management assistance needed.

The Lab Technician collects, maintains and submits the abiotic data associated with the SWMP Program, including data logger maintenance and database management. In addition, the Technician manages lab space and equipment used by staff, graduate students and visiting researchers, and also analyzes samples collected for the interstitial pore water and watershed monitoring programs.

Facilities and equipment

The Reserve has a research laboratory for staff, dormitory facilities that have been expanded to provide more rooms, a lab for students and visiting researchers and a living room, and office space to support reserve staff. The research program includes a 22' Boston Whaler boat for research use, one (1) drone, one (1) meteorological station, and eight (8) YSI EXO's multiparametric water quality instruments.

In addition, the Reserve has improved its internet capabilities, which will have significant benefits for the Program, particularly data dissemination and exchange of information with researchers. A server was acquired and installed in order to increase the internet speed and to ensure that the wireless network that was installed in the Reserve is working properly. The wireless network is an essential tool to deliver data to researchers at any location worldwide, and will be valuable in facilitating future partnerships with researchers and universities.

The Visitors Center's Library provides access to research conducted in the Reserve as well as monitoring data. It includes all research publications, peer reviewed, technical reports, theses, and dissertations.

Partners

The Program works closely with its Research Advisory Committee which provides guidance on research, monitoring, restoration, and science initiatives within the Reserve and its watershed. This Committee has been actively involved in the revision of this management plan and members provided their input on research needs and priorities. The Committee meets at least twice a year or as needed. It is comprised of representatives from the following entities:

Table 5. Research Advisory Committee

Federal agencies	<ul style="list-style-type: none"> • USDA-International Institute of Tropical Forestry • USFWS-Coastal Program • USGS- Water Resources Division
Commonwealth agencies	<ul style="list-style-type: none"> • PRDNER- Office of Coastal Management Program and Climate Change • Bureau for the Management of Natural Protected Areas and Forestry Services- Dr. Ricardo Colón, Manager of three natural reserves in the Northeast of Puerto Rico and collaborator in the Sentinel Site Project)
Universities	<ul style="list-style-type: none"> • University of Puerto Rico, Río Piedras Campus (Center for Applied Tropical Ecology and Conservation) • University of Puerto Rico (UPR) Medical Science Campus, School of Public Health • UPR Computing Engineering Department, (Marine Sciences Department) • Universidad del Turabo
Associations	<ul style="list-style-type: none"> • CariCOOS, Inc.
Individuals	<ul style="list-style-type: none"> • Jesús Rodríguez (USGS-Retired)

A Memorandum of Agreement (MOA) signed in April 2016 by the PRDNER and CariCOOS strengthens collaboration between the latter and the Research Program. The purpose of this MOA is to establish procedures for planning and conducting cooperative efforts, including support with the provision of data, data analysis and instrumentation. This will enable users to discover and use the vast and growing quantities of data in JBNERR's database.

The Reserve also collaborates with universities and nationwide programs to develop research and student internship opportunities. The Coordinator continually carries out efforts to recruit graduate students from local universities to support the Reserve's water quality and biological monitoring initiatives.

Research Program Delivery

Reserve research and monitoring activities are guided by the “National Estuarine Research Reserve System Research and Monitoring Plan 2012-2017”, which identifies goals, priorities and implementation strategies. In turn, the Reserve has developed complimentary objectives and actions which aim to expand knowledge, disseminate and increase access to information, and strengthen monitoring initiatives.

The Research Program will help ensure the availability of scientific information that has long-term, system-wide consistency and utility for managers and members of the public involved in protecting or improving coastal ecosystems. The Program's results will support PRDNER coastal natural protected areas' managers and decision makers in addressing complex coastal management issues. In the Reserve, research and monitoring are the baseline for the development of management measures, and provide the basis for the Education and CTP programmatic efforts.

A priority area of investigation during the next management period is to better understand the potential impacts of climate change on coastal ecosystems. Through research and monitoring initiatives, target audiences will increase their understanding of how climate and other natural and anthropogenic stressors affect coastal ecosystems in the Reserve and the wider Caribbean. To this end and in compliance with the 312 performance measures, at least one full sentinel site (SSAM-1) will be completed by 2017. The Reserve also plans to continue and expand the SWMP to include the monitoring of additional biotic and abiotic parameters. The Reserve will carry out complimentary research and monitoring initiatives in order to investigate the nature of hydrology and water quality in the Reserve, and to fill knowledge gaps about important but understudied species and habitats.

The Reserve recognizes the importance of having system-wide monitoring protocols, as well as ensuring the monitoring of its ecosystems which are unique within the NERR system. Implementation of this monitoring program will utilize standard protocols adopted by the SWMP, NOAA's Coral Program and other regionally, nationally and internationally agreed upon sampling protocols to ensure that Reserve efforts integrate with broader monitoring initiatives. All non-core protocols used will be submitted to the NERRS- SWMP guidance committee for approval and inclusion in the SWMP protocol "toolbox". Strong QA/QC and statistical power will be the cornerstone of all biological monitoring. In addition, given the limited human and financial resources, the Reserve staff will explore the best possible use of available technology and partnerships to carry out the monitoring effectively.

The Reserve will also apply to the NERRS Science Collaborative, which is a program that links decision-makers with research and applies science and technology to the coastal zone. The Research Program will integrate and apply the principles of collaborative research, engagement, post-secondary education, and adaptive management with the goal of developing and applying science-based tools to detect, prevent, and reverse the impacts of anthropogenic stressors in the context of climate change. Partnerships established through Research Advisory Committee, and the expertise of the Committee members will be important factors in helping to develop a comprehensive research and monitoring program. In order to expand its collaborative network, the Reserve plans to partner with universities and seek members with important research organizations and associations.

5.3 Research Future Needs and Opportunities

Research needs and opportunities were identified in coordination with the Research Advisory Committee, and include:

Needs

- | **Staffing needs.** Having a Coordinator with only one technician (Chemist) limits the ability to accomplish other research projects to fulfill the Reserve's research and monitoring needs. There's a need for, at least, one additional full time SWMP tech to support and lead implementation of monitoring efforts. Currently, the groundwater quality monitoring program is constrained by lack of support staff and resources. The Reserve also lacks staff to follow up and formalize collaborations with professors and students who have expressed interest in conducting research and monitoring after the "Road Trip Initiative" conferences. The Reserve will need additional staff, partnerships, and continuous support from the PRDNER's administrative units, which represents a challenge given the Commonwealth's current fiscal situation.
- | **Improve knowledge on the Reserve's hydrological condition and estuarine dynamics:** Another priority is to improve the understanding of water resources that sustain the Reserve ecosystems. The USGS has documented the hydrologic conditions in the South Coast aquifer since 1958, including groundwater levels and withdrawals, and water quality. However, there is uncertainty regarding major water-budget components, where better understanding is much needed in order to develop groundwater management alternatives.

At present, neither the net freshwater contribution to the estuary, nor the surface/groundwater balance are well known. Due to changes in irrigation methods and reduced precipitation over time, it is known that there has been a reduction of freshwater contributed to the Jobos Bay since 1981, when the Reserve was originally designated as a NERR. Other factors are the conversion of agricultural lands to urban development, which has changed the amount of infiltration occurring in the watershed, as well as the delivery of freshwater to the Reserve.

The Research Advisory Committee also identified the need to know the location of the aquifer points of discharge. Knowing the amount of groundwater entering the system, and the discharge points is important in order to develop management measures, especially for species of interest, such as the Antillean manatee.

The Committee also identified the need to understand the hydrodynamics of the Jobos Bay waters in order to link the path of contaminants affecting the marine habitats to their potential sources.

- | **Assess the climate change impacts most likely to affect the Reserve.** This revised management plan includes a general description of climate change effects on the Reserve's ecosystems. However, it is important to deepen the analysis to assess the potential effects of climate change on the Reserve's habitats, species, infrastructure, uses and users, as well as the interrelation with other natural and anthropogenic stressors.
- | **Diversify research topics to include other disciplines such as the social sciences.** The Advisory Committee identified the need to understand the relationship between coastal communities and their surrounding ecosystems in order to develop management, education and training efforts. There is a need to promote research in various disciplines, such as the social sciences, and to integrate social and environmental research and monitoring programs in order to address coastal management issues.
- | **Disseminate scientific information generated by the Jobos Bay NERR.** Three main drivers require that improved data dissemination be a high priority for the Reserve: 1) the expansion of data generated at the Jobos Bay NERR since the last management plan; 2) the interest among universities, management staff and educators in working at the Reserve and using data to enhance their work; and, 3) the wireless network developed within the Jobos Bay NERR to deliver data in real and near-real time via the internet. Currently, updated research bibliography and documents are available to users upon request. Most of the users contact the Reserve's staff to get access to this list and the publications that are available at the library. Having this information available through the Reserve web site is essential to promoting future research. There is also the need to disseminate information through regular research symposiums.
- | **Develop a long-term monitoring strategy.** The Reserve's ecosystems are unique within the NERRS. There is a need to carry out monitoring on vegetated communities, water column, mudflats, fish and invertebrate communities, plankton, and key species.

Opportunities

- | **Existing baseline information:** During the past years, significant progress has been made with respect to baseline information on the Reserve's current condition. Products from the recent independent efforts of NCCOS and CEAP provide a data-rich baseline from which multiple research, monitoring, and modeling projects can be initiated.

- | **Partnerships and volunteer work:** In recent years, the interest in conducting research in the Reserve has substantially increased among universities from Puerto Rico and the mainland U.S. The Reserve offers one of the most data rich, stable, and equipped protected areas for conducting research in the Caribbean.

The Research Advisory Committee, is interested in exploring opportunities for collaboration with existing research stations and laboratories in Puerto Rico and the Caribbean. Although fiscal challenges makes it extremely difficult to recruit staff using Commonwealth funds, the wide range of potential research topics opens up an opportunity to develop a broad network of partnerships. Academic institutions and the Research Advisory Committee participating agencies have demonstrated their interest in collaborating with the Research Program. The Research Program is also well positioned to benefit from a volunteer program if funds can be identified to hire a volunteer coordinator, as outlined in the Administrative Plan.

5.4 Research related objectives and actions

The objectives of the Research and Monitoring Program will be focused on: collaborating with the Research Advisory Committee and other partners in Puerto Rico and the Caribbean to generate expanded knowledge, making the information and services of the Reserve available to researchers, and strengthening and expanding monitoring efforts.

Many of the actions were identified in coordination with the Advisory Committee. Although the implementation of some of the actions will take more than five years, the Reserve plans to initiate the required coordination, including the search for funds and collaboration for implementation.

Objective 1. Conduct research to better understand the Reserve's hydrological changes and estuarine dynamics, climate change effects and social dynamics

1. Establish collaborative networks with existing research stations in Puerto Rico and the Caribbean

Collaboration is essential to position the Reserve and to generate the necessary knowledge about the estuarine ecosystems in Puerto Rico and the Caribbean. In Puerto Rico, the Isla Maguëyes Field Station, administered by the Marine Sciences Department at the UPRM, provides an opportunity for collaboration. Another opportunity for regional engagement is the Association of Marine Laboratories of the Caribbean (AMLC). It focuses on research in marine science of the tropical Atlantic and the Caribbean. Its purpose is aligned with the Reserve's, which includes: fostering cooperative research projects, encouraging the exchange of research results, and exposing students to established scientific methods.

The Research Coordinator will inquire into the offerings and membership requirements of the AMLC, as this could help project the Reserve as an important research partner in the Caribbean. The Reserve will also seek to participate in its workshops and trainings.

2. Convene social science researchers to discuss research needs and opportunities

The Reserve will convene social scientists that have conducted research in the Reserve to identify: future research needs and topics, infrastructure, equipment and materials as well as the potential for collaboration.

3. Carry out a climate change vulnerability assessment for the Reserve

This assessment will determine the scope and scale of future research, education and stewardship activities in the Reserve. Coordination with the Puerto Rico Coastal Management Program (PRCMP) is important, given that they are conducting a Community-based Climate Change Adaptation Plan for the municipality of Salinas. This plan can provide valuable information on the vulnerability of the communities surrounding the Reserve and their relation with coastal ecosystems.

4. Develop field maps to locate aquifer points of discharge in collaboration with the Research Advisory Committee

The Research Advisory Committee recommended initiating this effort by identifying the points where changes in salinity have been observed, and analyzing historical events that may explain those changes. To date, a reduction in salinity has been observed at stations 19 and 20. This could indicate seepage, and should be further monitored.

5. Develop a hydrodynamic model for the Jobos Bay in collaboration with CariCOOS

This model will: 1) aid in defining the long-shore transport component that delivers sediments and contaminants to coral reefs; 2) link the path of contaminants present in Jobos Bay and offshore corals to their likely origins within nearby watersheds; 3) serve as an instrumental application in response to potential hazardous material spills from shipping activities and the adjacent industrial facilities; and, 4) aid in identifying habitats impacted by the thermoelectric plant's thermal discharge delivered by an outfall pipe into the center of Jobos Bay.

The CTP will apply this model to determine where to target training efforts to reduce the impacts of contaminants and sediments from the adjacent watershed. The Education Program will also use the model to produce targeted outreach efforts. CariCOOS may collaborate to develop this model.

6. Develop a hydrologic model in the Jobos Bay NERR watershed to better define the contribution of surface and groundwater to the estuary in collaboration with the Research Advisory Committee

The groundwater flow model developed by the USGS provides the baseline for the development of this hydrologic model, as discussed with the Research Advisory Committee. The USGS also collects the surface data needed to develop this numeric model, with the support of the Reserve. The USGS will be an important collaborator in the development of this model.

Objective 2. Increase availability and accessibility of scientific data, research findings and the Reserve's capabilities to researchers, resources managers and other audiences

1. Keep the Reserve website updated and active to engage researchers, graduate students, and the public and to make known the availability of the Reserve's resources and research facilities

The Reserve has a wealth of historical and current data characterizing its ecosystems. The integration of this data will have powerful analytic implications. By making this data and/or metadata accessible via the Reserve's website, researchers and students can apply this information towards further research at the Reserve.

The Reserve Webpage will list research capabilities, including: available infrastructure; equipment; staff; past, ongoing and future research opportunities, and available data and models. This is essential for credibility and positioning.

2. Update the Reserve Site Profile

The Reserve Site Profile will be updated to include detailed descriptions and analyses of the history, ecology, climatology, research and monitoring activities. This includes the ecological characterization that resulted from the CEAP, GRF and academic research, USGS recent reports, among other relevant documents. This is an additional tool that allows documenting and disseminating Reserve research.

3. Coordinate a biennial Research Symposium

The Research Program will also facilitate information exchange by coordinating a research symposium. The symposium will be hosted every two years. The Advisory Committee recommended to start with a small symposium focused on research generated in the Reserve which will then be expanded by inviting investigators conducting research in other estuaries in Puerto Rico and the Caribbean. The symposium will help with the interchange of information generated within and outside of the Reserve, as well as the identification of research topics and collaborative research opportunities.

4. Develop a georeferenced research and monitoring database

Given the high level of research activity at the Reserve, it is extremely important to understand who is conducting research, and the themes and location of the research. A database will be developed to provide this information to interested researchers.

A GIS-based map of research sites will be developed and populated with attributes such as: contact information, research topic, year and estimated duration and other project-relevant information and location. It can also include monitoring stations and the USGS monitoring wells and CariCOOS stations.

Objective 3. Expand the SWMP and Non-SWMP monitoring initiatives to enhance understanding of the key habitats in the Reserve and their stressors

1. Keep updating and refining the SWMP time series data analysis to have a robust long-term basis to support management decisions

The Research Coordinator will continue working with CariCOOS in order to have robust SWMP data to support management decisions. The report prepared by CariCOOS in 2015 (Exploratory JBNERR System Wide Monitoring Program (SWMP) Time Series Data Analysis) recommends that the exploratory data analysis process be updated and refined periodically, on a long-term basis, in order to provide a useful management tool for the Reserve. Other programs and institutions will be invited to participate in this initiative.

The report also included the following specific recommendations that will be initiated during the next management period: (1) select data trends and correlations that may be of interest to explore further; (2) update time series to 2015 due to drought events; (3) add USGS hydrological time series to the analysis, as well as other suitable data sets to be determined; (4) increase the density of nutrient sampling to obtain a more robust nutrient dataset; (5) explore the suitability of the JBNERR data set for ecological modeling and forecasting; (6) consider alternate "general direction of change" scenarios for JBNERR that may be investigated through ecological modeling and forecasting; and (7) include SWMP data trends in the updated JBNERR Estuarine Profile.

2. Complete one full Sentinel Site module, specifically the SSAM-1

During the next management period, establishing SSAM-1 will be a priority for the Research and Monitoring Program, which will make efforts to acquire the necessary equipment and personnel to successfully implement the module according to the NOAA guidelines. The PRCMP will support this monitoring program by expanding and installing eight (8) SET's platforms across the Island.

3. Seek resources and collaboration to establish a ground-water quality monitoring program

The Reserve continued monitoring aquifer water level at selected wells and runoff events at SWMP Station 9. During this next planning period, the Program will also explore

establishing aquifer water quality monitoring at two sites within Mar Negro with two instrumented piezometers to track groundwater levels and water quality.

Eventually, and according to the availability of resources, the Reserve will continue the long-term monitoring plan that was developed for CEAP. The Reserve will explore options for the support for long-term data analysis.

4. Develop a Habitat Mapping and Change Plan (HMC Plan)

The Reserve will develop a HMC Plan, using the Standard Operating Procedures Mapping Land Use and Habitat Change in the NERRS. This will allow for the assessment of long-term changes of habitats in the Reserve related to local sea level change and human-caused stress from the Reserve watershed.

The Reserve will use the characterization of land-use/land cover and benthic habitat as a baseline. In addition to the established NERR protocols, the HMC Plan will also identify monitoring protocols and requirements for mapping change, including the geographic extent of change and its relation to elevation and land cover/land use change. Habitat and mapping experts will be convened in the early phases of this Plan's implementation to assist in its development, which will link closely with developing abiotic, biotic and restoration monitoring plans to form an integrated monitoring strategy.

The HMC will enable the Research Program to carry out habitat monitoring in a coordinated and standardized way within the system. The following actions identify specific habitats and parameters that should be monitored that were also recommended in various studies as well as discussions with the Advisory Committee.

5. Conduct a biennial water column monitoring in the Jobos Bay to assess conditions of the estuarine waters

The Reserve will continue the plankton long-term monitoring program, with the support of external sources. Zooplankton and phytoplankton form the foundation of the ecosystem upon which coral and coral-related species depend. The health of these species assemblages are impacted by both anthropogenic and climate change.

An option is to request that PREPA conduct plankton monitoring as part of the Aguirre offshore gas proposed project. The DRNA and NOAA requested this in their comments as part of the environmental document review process. This will provide JBNERR with additional information about plankton communities in the Bay.

6. Monitor mudflats to assess for environmental changes

Mudflats are the least-studied community in Jobos Bay NERR. Laboy (2009), reported that the surface area of mudflats is increasing behind the mangrove fringes of Jobos Bay, particularly in Mar Negro and Punta Pozuelo. This observation resulted from an analysis of

aerial photographs from 1937 and 2004. The Reserve plans to conduct a more detailed assessment of the physical and biological attributes.

7. Select key species to be monitored to know the status of their populations and distribution in the Reserve

A monitoring network will be established to study the use of the Reserve's habitats by key species, particularly those that are endangered and threatened and which have been documented, but whose populations' status and habits are not well known. Partners like USFWS and NMFS would be engage.

Additional important species such as migratory birds or marine fauna will be monitored. Experts will be consulted for the selection and development of efficient and cost-effective monitoring protocols. The Reserve will also play an important role in closing the knowledge gaps and research needs related to the effects of climate change in marine mammals.

EDUCATION PROGRAM



6 Education Program



6.1 NERRS Education Program

The National Estuarine Research Reserve System's mission includes an emphasis on education, interpretation, and outreach. Education at each reserve is designed to fulfill the Reserve System goals as defined in the regulations (15 C.F.R Part 921 (b)):

- | Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
- | Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.

To sustain these system goals, the 2017-2022 Reserve System Strategic Plan outlines the following education objectives:

- | Coastal residents and visitors will increase their awareness and ability to improve stewardship of estuaries, coastal watersheds, and their communities.
- | Educators and students will better understand and use reserve system and NOAA resources for place-based and inquiry-based learning.

The Reserve System provides a vehicle to increase understanding and awareness of estuarine systems and improve decision-making among key audiences to promote stewardship of the nation's coastal resources. Education and interpretation incorporate science-based content into a range of programs and methodologies that are systematically tailored to key audiences around priority coastal resource issues.

Reserves conduct formal and informal education activities, as well as outreach activities that target culturally diverse audiences of educators and students, environmental professionals, resource users and the general public. Education and public programs, interpretive exhibits and community outreach programs integrate elements of Reserve System science, research and monitoring activities and ensure a systematic, multi-faceted, and locally focused approach to fostering stewardship.

The reserves system is committed to preparing tomorrow's future leaders with the knowledge and understanding of our nation's oceans and coasts to be responsible stewards. To fulfill this commitment, the Reserve System has created the K-12 Estuarine

Education Program (KEEP) to increase the estuarine literacy of students, teachers and the general public. The KEEP Program helps students and teachers learn about essential coastal and estuarine concepts, develop data literacy skills and strengthen their critical thinking, team building, and problem-solving skills. K-12 and professional development programs for teachers include the use of established coastal and estuarine science curricula aligned with state and national science education standards and frequently involves both on-site and in-school follow-up activities.

Community education is another priority for the Reserve System. Community education programs foster behavioral change to promote resource conservation. These programs work with audiences whose choices directly impact the integrity of our estuaries and their associated watersheds.

6.2 Program context, capacities and delivery

The Education Program seeks to promote the understanding of the Reserve resources, focusing on the interdependence of the watershed's activities and ecosystems and their impact on the Reserve. The geographic scope of the Jobos Bay NERR Education Program prioritizes the Reserve's watershed followed by the rest of Puerto Rico.

Accomplishments

Since the last management plan, additional information has been gained by the program via the *JBNERR Educational Program Needs Assessment and Market Analysis (NA/MA)* study completed in 2016. Teachers from 31 schools were consulted for the NA. These schools belong to the Department of Education Caguas Region where the Reserve is located, which is comprised of 11 municipalities, including Salinas and Guayama. In addition, 18 educators from NGOs that collaborate with the JBNERR were consulted for the MA as well as community members. The results and recommendations provided in the NA/MA helped inform the target audiences, needs, objectives, and actions for the Education Program over the next five years. By developing Jobos Bay NERRS MA/NA, educational gaps and opportunities have been identified to enhance the estuary literacy in Puerto Rico for K-12 academic achievement and community outreach. Consistent with the audiences identified in the NA/MA, the Education Program target audiences are: students and teachers from private and public schools, communities and visitors to the Reserve (including local and international tourists).

In addition to the NA/MA, the Education Program has developed the following trainings tools and activities aimed for schools, communities and the general population as described below:

Schools

- The Jobos Bay Education Guide was completed in March 2017. The Guide was developed as an interdisciplinary educational tool where teachers of diverse disciplines (science, mathematics, Spanish, social studies, arts and technology), and grade levels are encouraged to incorporate estuarine literacy in their classrooms. The guide contains eight lessons, each with more than 10 activities. It was developed based on the needs identified in the NA / MA. Lessons are aligned with the PR Department of Education Standards and the Next Generation Science Standards, and it includes KEEP lessons.
- The Education Program implemented a summer camp program at the Reserve called “Guardians of the Estuary” as a strategy to engage students from the local schools in estuarine science. Participants are students from elementary school grades 4-6 and middle school. It was developed in response to a community need for a locally-based school summer program. Through this program, students spend a week exploring the Jobos Bay estuary, hearing from local and regional experts on issues affecting natural resources and using student booklets and presentations to showcase their newly acquired knowledge. This summer camp program functions in collaboration with local schools. Teachers are notified of the summer camp and provided with eligibility criteria. With these criteria, the teachers make a preliminary selection of students that are eligible to attend the camp.
- The Educational Program provided workshops on topics such as solid waste management and sustainable energy to three schools in the watershed that were engaged in the international School Green Flag Program. This was coordinated with Organización Pro Ambiente Sostenible (OPAS), which is the local entity that administers the Program.
- Annual Teacher Training Workshops have attracted local and regional elementary, middle and high school teachers. As parts of these workshops The Education Program is starting a new program, the “Jobos Bay Certification” for neighboring schools to improve skills and provide hands on experience to teachers and students. Workshops will be provided to teachers implementing tools from the Estuarine 101 Curriculum and TOTE program.
- The Education Program has provided educational talks to schools, universities and various activities in the Jobos Bay watershed and throughout Puerto Rico. The program also receives hundreds of students and teachers in the Reserve each month.

Community and visitors

- In 2015 the Education Program worked with the CTP in the Jobos Bay Community Interpretative Guide Program, aimed at community members as well as interested ecotourism volunteer guides. Through this program, participants obtained the National Association for Interpretation (NAI) certification and completed 20 contact hours in topics related to the Reserve's ecosystems and key issues. Partner entities included: other PRDNER units, the community-based group known as *Iniciativa de Eco Desarrollo de Bahía de Jobos (IDEBAJO)*, the National Environmental Law Association (ANDA, by its Spanish acronym), and the PRSGP).
- Additional community workshops have been provided on topics such as climate change adaptation, in coordination with the CTP.
- Several environmental festivals have been celebrated, with the support of partner entities, to raise awareness about specific ecosystems and species: the Migratory Bird Festival, the Festival on Endemic Birds of Puerto Rico and the Caribbean, the Worlds Wetland Day, the National Manatee Day, the Jobos Awareness Month, the World Water Monitoring Day, the Jobos Bay NERR Open House, the Earth Day, the Coral Reef week, and the Mangrove Festival (led by IDEBAJO). These special activities have strengthened the relations between the Reserve and its surrounding communities.



During the last planning period, the Reserve significantly increased its outreach efforts and its presence in the community.

Source: D'Jesus Asencio Photography (C)2013 and JBNERR Staff

Education Program Capacity

Staff

The Program has an Education Coordinator and an Education Assistant. The Coordinator develops the long-range vision for the program and oversees all aspects of its development and delivery, interpretive exhibits and coordination with Commonwealth partners, the Education Advisory Committee, local schools and surrounding communities and other Reserve programs. The Education Assistant develops and delivers presentations for schools, organizations and community groups, and also leads field-based education activities. Both, the Education Coordinator and the Educational Assistant are Certified Interpretative Guides by the NAI.

The Education Coordinator and other Reserve staff provide assistance to students visiting the Reserve library with how to use the local resources, and guidance for school work and science fairs.

Partners

The Education Program works closely with its Education Advisory Committee. It advises the program coordinator and the Reserve Manager on education, outreach and interpretation projects and materials in the Reserve and its watershed. This Committee meets at least once a year or as needed, to assist the Education Coordinator with special topics and activities. It was convened to assess the goals, objectives and actions for this Plan, and their input has guided the revision of this document. It is comprised of representatives from the following entities:

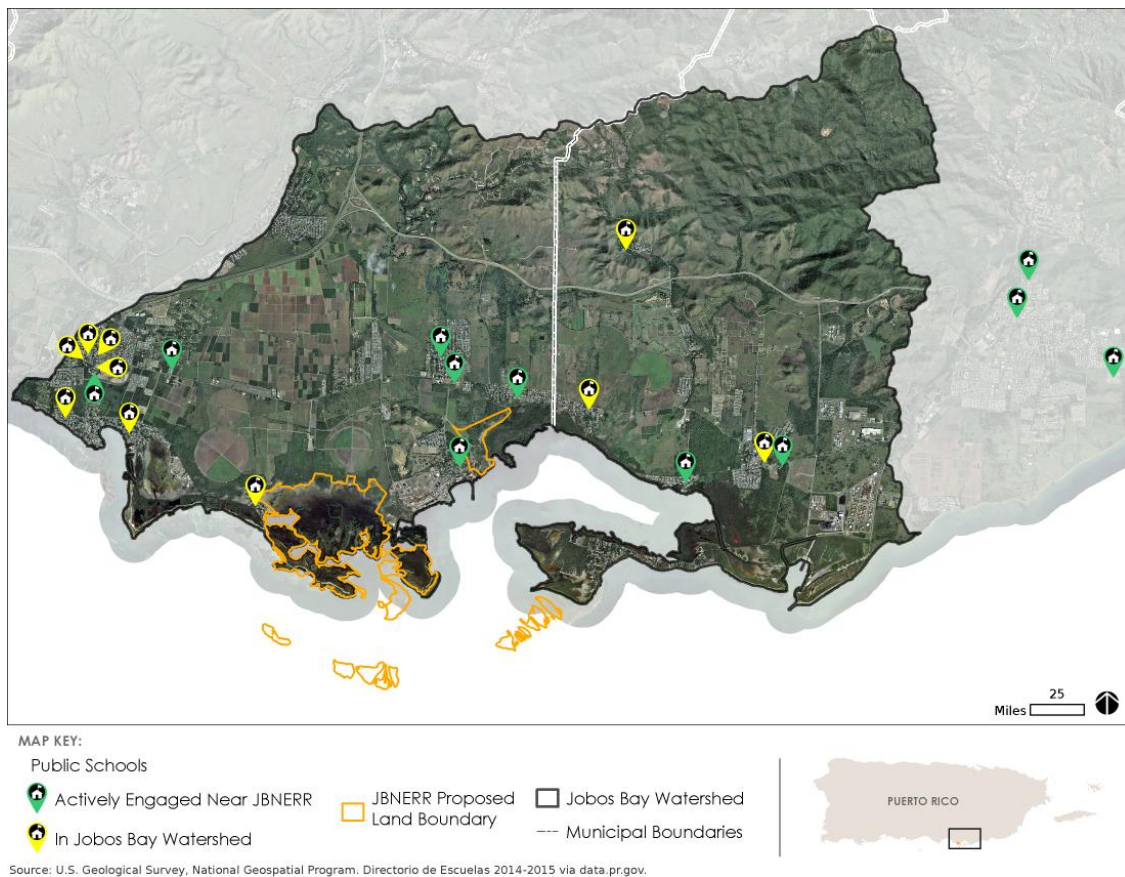
Table 6. Education Advisory Committee

Commonwealth agencies	<ul style="list-style-type: none"> • PRDNER, Office of Education and Community Relations
Universities	<ul style="list-style-type: none"> • UPRM, Sea Grant Program • Metropolitan University • Turabo University
Schools	<ul style="list-style-type: none"> • Salinas: Woodrow Wilson Elementary School (Aguirre), Urbana Nueva High School, Sabana Llana Middle School • Guayama: Adela Brenes Texidor High School, Simón Madera Middle School • Arroyo: José de Choudens Middle School • Ponce: Colegio San Conrado
Community/ NGO	<ul style="list-style-type: none"> • Miriam Gallardo, retired teacher and community leader representative from Pozuelo, Guayama • Consultores Educativos Ambientales

In addition, the Education Program networks with many partners from other public and private educational programs in Puerto Rico. Some of the current education partnerships include local schools, universities and NGO.

- | Schools- The Education Coordinator works closely and continuously with local schools from the watershed, such as: Woodrow Wilson Elementary School (Aguirre), Pedro Soto Elementary School, Las Mareas Bilingual Elementary School, Ana Hernández Elementary School, the Coquí Middle School, Urbana Nueva High School, Sabana Llana Middle School, all four schools in Salinas; the Bartolo Caussade, Adela Brenes Texidor High School, Simón Madera Middle School, all in Guayama; the José de Choudens Middle School in Arroyo; and Colegio San Conrado (private school) in Ponce.

Figure 23. Public Schools in the Jobos Bay Watershed



- | Universities- PRSGP, ascribed to the UPRM and UPR Humacao works with the Coordinator to provide locally relevant information to teachers, students and the public. Interamerican, Turabo and Universidad Metropolitana (UMET) universities are partners in a wide range of educational activities, among other universities from Puerto Rico and US.

- | NGO- IDEBAJO, who has a collaborative agreement with the PRDNER, works with the Reserve staff in multiple educational activities focused on Jobos Bay NERR surrounding communities. Other NGOs collaborate with the Program including, the Puertorican Ornithological Society (SOPI by its Spanish acronym), the Santa Ana Environmental Center, Puerto Rico al Sur, Sor Isolina Ferrer Centers, and the San Juan Bay Estuary Program.

Education Program Delivery

The Education Program will strengthen its place-based approach, by applying science and SWMP data to education in the Jobos Bay NERR to enhance the capacity and skills of teachers and students and to promote stewardship practices. The Education Program will involve cross-sector support from the Research, Stewardship and CTP Programs.

In the next planning period, the Program will continue to work to implement NERRS *Teachers on the Estuary* (TOTEs) workshops. TOTE is a NERRS initiative where teachers learn at a NOAA National Estuarine Research Reserve, work with local scientists and experienced estuary and coastal educators, explore coastal habitats, practice field based studies, learn how to use estuary data and guide student investigations, and learn how to implement in their classrooms Estuaries 101 Curriculum activities.

The recently developed Jobos Bay Education Guide will be a valuable tool for these workshops. The guide establishes meaningful, local connections between teachers, students, the community and JBNERR. The guide provides modules (or lessons) that feature hands-on activities and experiments. They use and adapt activities or resources of other existing curriculums such as Estuaries 101, Latino Earth Partner and Aquatic Wild.

Research conducted at the Reserve and SWMP data will be used in the development of activities and materials that will also provide meaningful, hands-on scientific activities for teachers, students, and the community as well, in accordance with the needs and priorities identified in the NA/MA. In addition, the Education Program will take advantage of the technology to access NOAA based educational products and promote the Reserve initiatives through a social media strategy.

With strong education initiatives already in place, the Education Program will explore new outreach venues locally and across the island, while updating and expanding existing programs. To implement the objectives and actions identified in this plan and those of the NA/MA, the Education Program will partner with teachers, non-formal environmental education groups and local communities to raise awareness of environmental related issues affecting communities in the Reserve's watershed and Puerto Rico.

6.3 Education Needs and Opportunities

The education needs and opportunities for this next planning period were identified in the NA/MA and also in coordination with the Education Advisory Committee.

Needs

- | **Audiences:** Expand the education efforts to broader audiences in the watershed, whose actions benefit and/or may impact the resources. There's a need to educate businesses on the legal framework that protects endangered species, emphasizing on the Antillean manatee. Educate the organizers and participants of the numerous activities that are carried out in private cays located in the Jobos Bay on the legal framework protecting these areas.
- | **Teacher trainings:** Additional training to teachers is needed in the areas of estuarine science, building skills in conducting hands-on activities, incorporating new lab activities, and facilitating field work/data collection, as well as unstructured outdoor experimental activities.
- | **Accessibility of information:** In the NA teachers expressed the need for synthesized learning material in different subject areas that is available and accessible online in downloadable formats. The Advisory Committee recommended maximizing the use of the web and social media to make information accessible.
- | **Increase presence in the community:** The NA makes clear that there is a need to increase knowledge about the Reserve's programmatic areas and activities, and increase connections between the JBNERR and the community. In the NA the community expressed the need for events in public spaces that help raise awareness about environmental issues, developing youth-oriented activities, continuing the summer camp program, providing outdoor activities, and training volunteers. The NA indicates that JBNERR facilities are important to community members, but that the community must be further educated to change their perception of the JBNERR and its staff, and better understand the services provided.
- | **Performance measures:** The Education Advisory Committee stressed the importance of measuring the true impact of the Program on participants' attitudes towards the protection and stewardship of estuarine resources (e.g. on the increase of knowledge, changes in behavior, and the promotion of specific actions). It was recommended to strengthen the metrics by designing a pre and post evaluation method.
- | **Facilities and vehicle:** Additional facilities are needed to further support the Education Program that include a laboratory and a meeting space that can be

used by teachers and students. Indoor exhibits have been recently updated but need to provide a more interactive experience among visitors. There is also a need for a vessel that can transport students and teachers into the cays.

Opportunities

- | **Location and historic context:** The Reserve's history as well as the existing natural resources are important to promote knowledge and understanding of the estuarine and coastal resources, and ecosystems changes. Through this approach, the Reserve promotes a sense of belonging and empowers the audiences, especially local communities.
- | **Education and volunteering:** The Green Contact Program Act (Law No. 36 of March 2015) provides the opportunity to use the Reserve as an outdoor classroom and living laboratory and to promote volunteering. This Program is administered by Puerto Rico's Department of Education in coordination with the PRDNER. The purpose of this program is to ensure the participation of students in workshops and visits to areas of ecological value in order promote contact with nature. Students must have, at least ten contact- hours of nature-related activities per semester, which are part of the 40 contact-hours students already have to offer in volunteer and community hours. In addition, the Program requires that the teachers will help guide the students through the visits and implement environmental interpretation techniques based on internationally recognized standards. JBNERR is part of the Green Contact Network, which is composed of federal and Commonwealth agencies, NGO's and private entities.
- | **The role of the Reserve in the Community:** The Reserve can be an asset to the local community by providing the education and facilities to increase their capacity for stewardship of the estuary and coastal resources. The Education Coordinator could work with the CTP, Stewardship and Research programs to provide trainings that could include the restoration of wetlands, monitoring, resources interpretation, guided tours, among other strategies aimed at improving resiliency and adaptive capacity of communities and ecosystems in the face of climate change.
- | **Partnerships:** Continue to strengthen partnerships with the communities, teachers, and members of the Education Advisory Committee that are committed to supporting the Education Program in aspects such as, for example, the provision of workshops and volunteers and the development of assessment tools.

6.4 Education related objectives and actions

The Jobos Bay NERR's Education Program's objectives and actions will increase the use of updated educational materials and augment the participation of teachers, students and the communities in Program's activities. Visitors will be exposed to the ecological, historical, and educational significance of the JBNERR.

In addition, during the next planning period the Program will develop tools to measure the number of users, their satisfaction with the Program contents and approach, and also the impact of the program on users' knowledge and behavior, to ensure that it continuously responds to the needs of its audiences.

Objective 1. Increase the participation of students and teachers in the Reserve by providing high-quality, place-based educational activities

1. Continue performing Teachers on the Estuary (TOTE) workshops with the aim to offer hands on, field based, professional teacher development opportunities by the Reserve

The Education Program is working on an innovative approach to increase the participation and commitment of teachers in the TOTE's workshops, called the "Jobos Bay NERR Certification". This certification will be provided to schools whose teachers continuously participate in workshops provided at the Reserve, and who commit to implementing the activities and skills learned in their classroom. The Reserve will provide (loan) the teachers a box filled with scientific instruments that can be used for data collection for one week per month. Workshops are anticipated to begin in the fall of 2017. The JBNERR plans to certify five schools in the Jobos Bay watershed and around the island.

The TOTE workshops will cover a total of 20 hours of professional development for teachers in schools surrounding the JBNERR. Hours of professional development will first cover a 15 hour TOTE workshop followed by a 5 hour workshop. Workshops will be oriented mainly towards 20 teachers. By the end of this management term (2021), the Education Program plans to be serving a total of 25 teachers in two TOTE workshops and follow-up workshops throughout the year.

2. Facilitate workshops to teachers in collaboration with partners to increase their knowledge in various emerging topics such as climate change adaptation and resiliency

The Education Program will continue to offer teacher training workshops in various topics, paying attention to the issues identified in this Management Plan, such as climate change adaptation and resiliency.

The Reserve will coordinate with the PRDNER's Office of Coastal Management Program and Climate Change, and the PRSGP (which also provides teacher trainings), as well as

universities and other collaborators in the design and implementation of community education workshops which will cover various topics not included in the Jobos Bay Education Guide.

3. Develop a “School Interactive Estuarine Literacy Pilot project”

The Reserve plans to conceptualize an initiative named the “School Interactive Estuarine Literacy Pilot project”. The Education Program will support local schools in the development of a newsletter written by students.

One newsletter will be published digitally at the end of the school year, describing the educational initiatives implemented, and experiences of teachers and students in JBNERR. This will give students an opportunity to publish their school work, describe science fair projects developed in the Reserve, and publish reflections about their experiences visiting the Reserve as well as during summer camps. The content could also result from the knowledge obtained through the implementation of educational guides.

The Education Program will continue using social media as an outreach tool, and plans to increase the use of digital platforms as part of this project. In addition, it will coordinate to create a “Student's Corner” in the Reserve's Web page, to publish the students' works and to provide additional information to these audiences.

4. Continue the summer camps

During the next management term, the Program will continue to collaborate with teachers to strengthen participation of students in the summer camp program. The camp will incorporate new information and modify content to include emerging issues such as climate change and community resiliency. Our aim is to develop at least one new summer camp targeting rising juniors and seniors focusing on estuarine science and conservation to promote the field of estuarine and marine biology in the university.

Objective 2. Develop a Conservation Action Education Program to increase knowledge and engagement among community members as well as to increase the volunteer base

This program is expected to increase community awareness and stewardship while reducing anthropogenic stressors that impact Reserve ecosystems.

1. Provide conferences to community members on the importance of coastal ecosystems to reduce vulnerability

Topics will include the role of estuaries and mangroves in coastal protection, and the importance of reducing anthropogenic stressors (such as cutting and filling of mangrove). The conference will be implemented in a two day format, focusing on fieldwork and theoretical learning.

2. Work with partners to develop educational materials to target businesses, tour providers, boat and other users of marine resources

This will be coordinated with partner entities such as the PRSGP, the PRCMP, the NOAA Coral Reef Program and the USFWS to develop and implement educational and outreach strategies to reduce threats and stressors in the Reserve's ecosystems that can be addressed through proper education.

Many of the participants depart from nearby docks and marinas. As a result, these audiences can be targeted with information on permissible and prohibited uses, lawful interaction with species, and penalties for violations of state and federal environmental laws. Materials could include posters, brochures and short educational videos to be distributed through social media, thereby impacting a larger audience. This action will be developed in collaboration with the Stewardship coordinator.

3. Provide a workshop to enhance the community's adaptive capacity through the protection of coastal resources

The purpose is to provide the communities and people interested in becoming volunteers at the Reserve with the necessary skills to support the Reserve staff to meet management needs. Skills to implement ecosystem-based adaptation (EBA) measures will be one of the topics discussed (e.g. mangrove planting). Possible presentations will include community-based wildfire management, restoration of coastal ecosystems, and development of green infrastructure projects and other emerging issues. The workshop will target community members to serve as volunteer trainers and leaders to implement these initiatives within their communities and the Reserve. By increasing volunteer capacity, the Reserve can improve its ability to meet program goals despite fiscal constraints.

This action will be implemented in collaboration with the CTP and Stewardship coordinators.

4. Implement a program of activities within the Reserve and its surrounding communities to promote its presence within the community.

In the NA/MA, participants provided a menu of activities that the JBNERR could do to improve its visibility and presence in the community such as: talks, excursions, outdoor activities, youth-oriented activities, and open houses.

Based on the recommendations, the Coordinator will develop a program of activities through the year. By developing a predictable program, the public will come to anticipate and expect activities, thereby facilitating their participation.

Objective 3. Increase the number of visitors exposed to the Jobos Bay NERR as an area of ecological and historical significance as well as a learning tool for community resilience

1. Enhance and update indoor and outdoor educational exhibits and signage

Within the next five years, the Education Program plans to create one interactive display as part of the visitor's center exhibits, with access to the internet so visitors can learn about diverse NERRS and NOAA products available online. Information on habitats, species of interest such as the manatees, and programmatic efforts such as the Sentinel Site will be available.

Outdoor signage will be updated to reflect the key priorities of the Reserve. Three types of signage will be developed as needed: interpretative, directional, and regulatory. There are currently plans to update the Trail and Kayak trail signs. Signage will use Quick Response Codes so that visitors will have access to in-depth information about the topics presented.

Objective 4. Assess the effectiveness and satisfaction of participants on each Educational Program activity

1. Evaluate knowledge acquisition during the workshops and talks performed for teachers

Design and implement pre-and post-tests to measure gains in knowledge of teachers that participated in workshops. The Coordinator will convene the Education Advisory Committee to develop both instruments. Results of the evaluation will be used to refine and improve future workshops.

2. Design a user satisfaction survey to evaluate the program of activities

A user satisfaction survey will be developed to evaluate the perception of the participants of the activities to be programmed as recommended in Action 4 under Objective 2.

Aspects to be evaluated will include the educational contents of the activities as well as the satisfaction with the resources and methods used in order to refine and improve future activities.

3. Evaluate the fulfillment of the exhibitions and guided tours that are provided to visitors and tourists

The Education Coordinator will develop a simple user-satisfaction survey in English and Spanish that can be filled out by visitors who are exposed to the indoor and outdoor exhibits. Results of the evaluation will be used to refine and improve exhibits.

COASTAL TRAINING PROGRAM



7 Coastal Training Program



7.1 NEERS Coastal Training Program

The National Estuarine Research Reserve System's mission includes an emphasis on education and interpretation. The Reserve System recognizes it has a responsibility to educate coastal decision makers and supports the Reserve System goals, as defined in the regulations (15 C.F.R Part 921 (b)), through the Coastal Training Program:

- | Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation;
- | Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.

To sustain these system goals, the 2017-2022 Reserve System Strategic Plan outlines coastal training objectives that support the focus areas of climate change, habitat protection and water quality:

- | Coastal decision-makers and environmental professionals will understand and effectively apply science-based tools, information, and planning approaches that support resilient estuaries and coastal communities.
- | The next generation of coastal professionals and environmental stewards will expand and be motivated through access to programs and facilities that facilitate research, resource management, and educational opportunities.

The Coastal Training Program provides up-to-date scientific information and skill-building opportunities to decision makers responsible for making decisions affecting coastal resources. Through this program, reserves ensure that coastal decision makers have the knowledge and tools they need to address local critical resource management issues.

Coastal decision makers are defined as individuals whose duties include making decisions that affect the coast and its resources. The target decision-maker groups vary according to reserve priorities, but generally include groups such as locally elected or appointed officials, managers of both public and private lands, natural resource managers, coastal and community planners, and coastal business owners and operators. They may also include groups such as farmers, watershed councils, professional associations, recreation enthusiasts, researchers, and more.

Reserves are uniquely positioned to deliver pertinent information to local and regional decision makers given their place-based nature. Coastal Training Program coordinators know the local people, places, and science and are able to skillfully convene training participants and experts to address coastal management issues. Coastal training programs are built upon solid and strategic program documents, including an analysis of the training market and assessment of audience needs. Coordinators then work with the results to identify how their program can best address local and Reserve System priority issues.

Partnerships are integral to the success of the program. Reserves work closely with several other NOAA programs, as well as a host of local partners in determining key coastal resource issues, target audiences, and expertise to deliver relevant and accessible programs.

7.2 Program context, capacities and delivery

The JBNERR CTP implements actions to improve coastal resources management at local and regional levels in the Commonwealth of Puerto Rico, through the use of education, capacity building and technical assistance.

The JBNERR CTP is focused on providing knowledge and skills to decision makers and community leaders in the municipalities located in the Jobos Bay NERR watershed and the rest of Puerto Rico. For the next management period, target audiences will be:

| Coastal decision makers:

- Municipalities: local elected officials (Mayors and Municipal Legislators); staff from the Municipal Emergency Management Offices, Municipal Permits Offices and Territorial Ordinance Offices (according to Law 81-1991), Federal Affairs offices, Public Works, among other municipal units.
- Commonwealth agencies: PRDNER (e.g. natural resource managers, field technicians, biologists, law enforcement officials); Puerto Rico Planning Board, the Puerto Rico Permits Management Office (OGPe by its Spanish acronym), PREQB, Department of Agriculture, and Commonwealth Emergency Management and Disaster Administration Agency.
- Federal Agencies

| Public audiences:

- Professional associations related to land use planning, water quality, and ecosystem management such as planners, architects, engineers, biologists, marine scientists, social science specialists, and private consultants.

- Businesses: small businesses, industries, farmers, land developers, commercial fishers, tour operators, and owners or operators of nautical facilities.
- Community organizations: community based organizations, non-profits, applied sciences groups.

Accomplishments

Thousands of training hours have been conducted since the program's inception in 2003. The CTP has delivered education and training activities to elected officials, natural resources managers, decision makers, farmers, and law enforcement officials on topics such as resource protection, conservation, restoration and stewardship. During the last management period, new management of the CTP has permitted improved integration with other program areas, resulting in a more robust program with greater reach.

CTP continues to offer workshops and training programs on emerging issues and topics of interest, such as: solar powered rain barrel pumps, sand-filters to purify water, permeable pavement techniques, erosion control in construction sites, environmental interpretation certifications, rainwater harvesting, climate change adaptation and resiliency, invasive species and safe diving practices.

The following are additional accomplishments of the CTP in the last management period:

- | The CTP has worked extensively with USEPA to train local municipalities in developing municipal storm water management plans and obtaining the required permits to support these plans. USEPA provided collaboration and technical information for the coordination and implementation of the storm water management training series.
- | The CTP was instrumental in the partnership-based CEAP project. The Program worked closely with the Research coordinator and the USDA-NRCS in providing capacity building and training to farmers and agencies participating in the CEAP project.
- | The CTP has updated its marketing and promotional materials over the last planning period. Social media (Facebook and Twitter) are an integral part of the marketing strategy used to keep participants informed.
- | The CTP has been working with key decision makers in community resilience and adaption planning. The CTP carried out participatory mapping workshops with local coastal communities in order to assess their vulnerability. Final maps are being prepared, so the product is not yet available. Some of the training offered, such as rainwater harvesting, are targeted towards enabling local homeowners to implement sustainability principles and empower them to adapt and become more resilient in the face of climate change.

- | The environmental interpretation certification was a joint effort with the Education Program, known as the Certified Interpretive Guide program. Certifications were available for community members as well as ecotourism guides as part of a community empowerment initiative, in collaboration with the NAI. CTP managed logistics and resources, while the Education Program identified the type of information to be included in the workshops as well as potential participants.
- | The CTP provided technical assistance and training to decision makers in coastal communities and municipalities on lionfish capture techniques, handling and preparation. In collaboration with the Sea Grant Program and the Hyperbaric Chamber, CTP provided technical assistance to agencies that deal with scuba diving safety among fishermen.
- | The CTP has focused on strengthening partnerships with municipalities. The Municipality of Salinas collaborates with the Program in advertising the information about CTP workshops, specifically those geared towards sustainability and community empowerment.

CTP Program Capacity

Staffing

The CTP is managed by a full-time Coordinator who works collaboratively with the Research, Stewardship and Education programs in order to make the most of the Reserve's limited staffing resources.

Collaborative efforts are continuously emerging, including a joint effort with the Education Program to monitor seagrass beds. The Reserve's CTP Coordinator also works closely with a host of partners in determining key coastal resource issues to be addressed through training and technical assistance. These are external partnerships as described below:

Partners

The CTP works across sectors, organizations and government levels to provide training programs and workshops, and disseminate information about programs offered at the Reserve. This broad-based networking results in a myriad of partnerships, many grounded in the targeted training topic.

The CTP Advisory Committee provides guidance to the Coordinator in identifying emerging issues affecting the Reserve and its watershed that can be addressed through the Program, as well as the programs' priorities, contents, strategies, and partnerships. This Committee meets at least twice a year or as needed to assist with special topics. It has been actively involved in the revision of this management plan. The Committee is comprised of representatives from the following entities:

Table 7. CTP Advisory Committee

Federal agencies	<ul style="list-style-type: none"> • USDA-NRCS • USEPA • US Coast Guard (USCG)
Commonwealth agencies, public corporations and municipalities	<ul style="list-style-type: none"> • PRDNER, Office of Coastal Management Program and Climate Change • Municipality of Salinas • Municipality of Guayama • OGPe • PREQB • PREPA
Universities	<ul style="list-style-type: none"> • UPRM, Sea Grant Program • UPRM-Agricultural Extension Service, Guayama
Professional Associations	<ul style="list-style-type: none"> • Puerto Rico Architects and Landscape Architects Association

Additional partners include federal, Commonwealth and local governments, as well as universities and businesses organizations:

- | Federal agencies: In addition to the USEPA and NRCS collaboration previously described, the Program works with the US Coast Guard who recently joined the CTP Advisory Committee. NOAA-OCM has been an essential provider and collaborator in training programs related to natural resource management.
- | Commonwealth agencies: The PRCMP provides assistance in workshops on non-point sources of pollution. Close collaboration with the PRCMP also ensures a significant impact in initiatives and training programs regarding community adaptation and climate change mitigation efforts in coastal communities. The CTP supports the CZMP in its Community based Climate Change Adaptation Plan for Salinas, by providing contacts with resources and experts on different subjects. Other partner agencies are the PRPB, the Puerto Rico Department of Agriculture, and the Puerto Rico Tourism Company.
- | Municipalities: Apart from Salinas and Guayama who are represented in the Advisory Committee, the CTP also has partnerships with other southern coastal municipalities, including Arroyo and Yauco.
- | Academia: The CTP has partnerships with UPRM's Division of Continued Education and Professional Studies (DECEP) and the Department of Civil Engineering at the UPRM.

- | Businesses organizations: Puerto Rico Manufacturers Association and the Puerto Rico Chamber of Commerce.

With the recent recruitment of a full time CTP Coordinator, the reinstatement of partnerships with other entities has been a priority. As a result, the previous list will continue to evolve during the next management period.

Coastal Training Program Delivery

The Jobos Bay NERR CTP started in 2003, after the successful completion of a Needs Assessment and Market Analysis (NA/MA), which was revised in 2013. The CTP implements a systematic program development process, involving periodic review of the Reserve's niche in the training provider market and audience assessments, with the guidance of its Advisory Committee.

The CTP complements the National System's CTP priorities and uses the nationally implemented structure to frame project progression from needs assessment through evaluation. The Program implements strategies to improve coastal resource management at local and regional levels in the Commonwealth of Puerto Rico through the use of education and capacity building. The Program is an essential provider of appropriate training in conservation and stewardship.

It is continuously identifying emerging issues and fostering collaborations to maximize the Program's delivery and capacity. Following the NERRS Climate Change Initiative, the CTP will foster adaptation planning in coastal communities, increase the understanding of vulnerability and climate effects on the Reserve and its watershed, and take steps to ensure ecological resilience and long term ecosystems functions. Information and data produced through the Research and Monitoring Program at the Reserve and will be used for the development of workshops and training needs that may arise. The CTP will coordinate with the Education Program to enhance the organizational capacity of NGOs to more effectively accomplish community-based initiatives and adaptation. In addition to internal collaboration, the CTP will implement actions through partnerships with Commonwealth and Federal agencies, municipalities, businesses and professional associations.

The CTP intends to implement additional strategies to disseminate information, promote the program, and increase capacity of stewardship of coastal and marine resources. Priority will be given to implementing training programs that support municipalities, government agencies, professionals, and industries to address coastal management issues identified in this Plan.

To assess its efforts, the CTP administers post-event evaluations to participants. The CTP Coordinator reports data in progress reports of operational grants, according to a suite of performance indicators related to increases in participants' understanding, application of learning, and enhanced networking with peers and experts to inform

programs. In addition, the CTP assesses its performance through continuous communication and feedback from its Advisory Committee.

7.3 Needs and opportunities

CTP's needs and opportunities for the next management period were identified in coordination with its Advisory Committee.

Needs

Coastal decision makers need to strengthen their skills and knowledge to better manage coastal resources, assess the vulnerability of coastal communities, and develop and implement adaptation measures.

- | **Enable coastal decision-makers to make informed decisions to protect coastal resources:** Technical training and support to municipalities and other decision makers is needed to develop plans and make informed decisions to protect the coastal zone. Municipalities are required or authorized to prepare plans to address issues affecting the Reserve and its watershed, such as land use plans, recycling plans and storm-water management plans, which could help reduce stressors on the Reserve's ecosystems and protect the coastal zone. However, many do not have professionals with the knowledge and skills to include appropriate conservation measures. As such, there is a need and an opportunity to provide technical assistance to municipalities and land use professionals to ensure that coastal issues are addressed.
- | **Support the managers and supporting staff of the coastal protected areas:** PRDNER's managers of coastal natural protected areas have multiple responsibilities that transcend the management of habitats and species. Under the Commonwealth's fiscal situation, it is very difficult for the PRDNER to recruit staff for the management of coastal resources. Many managers are responsible for more than one area. While in many of these areas the PRDNER has signed collaborative agreements with community organizations to help with management duties, emerging issues such as climate change and increasing pressure on marine resources require that managers be trained with the proper skills to reduce and ultimately avoid stressors on resources.

In this regard, it is also necessary to provide information and skills to NGOs and community organizations that have collaboration or management agreements with the PRDNER so that they can effectively provide support in the management of coastal and marine resources.

There's also a need to strengthen the capabilities of the Ranger Corps officials and the Commonwealth and municipal police departments that will be supporting in the implementation of the "Surveillance and Prevention Enforcement Strategic

Plan of the PRDNER at JBNERR" that was prepared by the PRDNER and submitted to the NOAA. (For more information refer to Section 9, Resources Protection Plan).

- | **Technical assistance and capacity building to businesses and communities in the watershed:** There is a need to provide technical assistance to communities, businesses and farmers adjacent to sensitive habitats in order to avoid negative pressures on the ecosystems and watersheds. It is also necessary to strengthen and expand education and training on sustainable practices for water management in the watershed.
- | **Continue strengthening the program and its partnerships:** The CTP needs to strengthen its presence and partnerships among coastal decision makers, communities, businesses and professional groups. The CTP has been meeting with different organizations to publicize its work and the opportunities it provides. However, since the CTP Coordinator has been in the position for almost a year, additional efforts are needed. Fragmentation of farms and sprawl of communities poses an additional challenge. Outreach to a sprawling community is more complex, while the impacts are more widespread and diffuse.

Opportunities

- | **CTP as a facilitator:** In the current socioeconomically stressed times, CTP serves as a resource by providing cost-effective training for audiences including Commonwealth agencies and municipalities, professional associations, PRDNER managers and coastal stakeholders.
- | **Increase partnerships:** There has been an increased interest to collaborate with the Program. CTP Advisory Committee already identified areas of potential collaboration for each of its members.
- | **Existing baseline information:** Significant progress has been made with respect to research and baseline information on the Reserve's current condition, which can be used for training and capacity building purposes. In addition, partner entities have the tools and expertise to assist in trainings and workshops to target audiences.

7.4 Coastal Training Program Related Objectives and Actions

Objective 1. Enhance the capacity of decision makers to effectively protect and enhance coastal resources

1. Provide workshops and technical assistance to municipalities, professionals and other decision makers to strengthen their skills to develop mandatory plans

The CTP will provide education and technical assistance to municipalities, land use planners and related professionals to increase their knowledge on best practices related to land use and management. Land use plans can be used to reduce hazard exposure, mitigate the effects of climate change, and to enhance the ecosystem's structure and function. Training programs can be developed in areas such as: available mechanisms for the development of green infrastructure networks and projects (e.g. green corridors) and its benefits as a landscape conservation strategy; the use of green infrastructure in storm water design (e.g. materials to reduce runoff), and several other topics.

Storm water management plans can be used to address groundwater recharge, storm water quantity, and storm water quality impacts. On this topic, the CTP will continue working with the USEPA in providing assistance to municipalities in developing municipal storm water management plans.

2. Provide trainings and workshops to businesses, NGO and communities to reduce nonpoint sources of pollution that affect coastal and marine ecosystems

Jobs Bay NERR CTP will conduct workshops and training activities to address issues such as: construction and maintenance of septic tanks; management and impacts of chemicals such as fertilizers; erosion control; proper management and handling of chemicals in businesses such as oils and greases, among other topics.

The CTP Coordinator plans to assess industry leaders and regulators to determine the need for capacity building. The Reserve's database on contaminants, compiled by a GRF and as part of the habitat characterization conducted by NOAA's NCCOS, provides an excellent resource to target the appropriate businesses and industry-specific audiences for training activities.

3. Provide education and technical assistance to PRDNER's coastal managers and supporting staff to address issues affecting coastal resources

The CTP will provide assistance to coastal managers and other PRDNER supporting staff in strengthening their skills and understanding of the collaborative dimensions of ecosystem management.



During recent years the PRDNER has signed more than 15 agreements with NGOs for the management of the Commonwealth's protected coastal areas. The CTP will partner with experts from different entities and the PRDNER to provide technical assistance on relevant resource-based topics.



Using the concept of "train the trainers" the managers will be in a good position to collaborate with volunteers and coastal communities in the protection of coastal resources (i.e. transferring information and knowledge, and implementing the necessary tasks).

4. Provide knowledge and technical assistance to community organizations that have cooperative agreements with the PRDNER for the management of coastal resources

The CTP will partner with organizations and agencies with expertise in ecosystem restoration and monitoring, among other disciplines. The purpose is to train community representatives, giving priority to those with collaborative agreements with the PRDNER, in order to support management efforts in coastal areas.

The CTP Coordinator will conduct a needs assessment with these groups and their liaisons within the PRDNER to determine the education, training, and capacity building needs. Topics could include the ecosystem's ecology and anthropogenic impacts; restoration techniques, such as mangrove planting, and seagrass restoration; identification and monitoring of key species such as shorebirds and manatees, water quality monitoring, among other relevant resource-based topics.

5. Provide technical assistance and workshops to the Ranger Corps and other officials collaborating in the Reserve's patrol and surveillance team, as proposed in the "Surveillance and Prevention Enforcement Strategic Plan of the PRDNER at JBNERR"

The plan proposed the coordination of trainings and workshops to strengthen the Rangers Corps capabilities to address the surveillance needs in the Reserve. The CTP and the Stewardship coordinators will organize trainings and workshops in the following topics identified in the plan which include: Reserve's biodiversity, values, boundaries, major problems and primary management needs as well as laws and regulations that apply to JBNERR.

Objective 2. Provide trainings and technical assistance to decision makers to increase their capacity to assess the vulnerability of coastal communities and develop adaptation measures

1. Continue providing workshops related to sustainable use of water

Recent drought and climate projections make it necessary to strengthen and expand education and training on sustainable practices for water management in the watershed, including rainwater harvesting and water recycling and reuse.

Specific trainings will be organized to meet the needs of diverse audiences in the watershed: farmers, businesses, residences, and other institutions, such as schools.

2. Provide trainings and technical assistance on ecosystem-based management in coastal communities

During the past years, a number of events have occurred that required immediate response, but that the coastal decision makers were unprepared to handle due to their lack of proper management skills. Examples of these events are the massive arrival of *Sargassum* to the coasts of Puerto Rico and other Caribbean countries, coastal erosion and flooding, and wildfires.

The CTP Advisory Committee identified the need to train coastal municipalities and other coastal decision makers in the best management practices to address these issues. Through this support, the CTP seeks to improve knowledge among coastal decision makers so that decisions do not negatively impact coral reefs and related ecosystems. This can also support the limited staff of the PRDNER in addressing coastal management needs.

3. Enhance the capacity of natural resource managers to understand the vulnerability of coastal habitats to climate change impacts and adaptation strategies using the Climate Change Vulnerability Assessment Tool for Coastal Habitats (CCVATCH) developed by the NERR System

The CCVATCH is a spreadsheet-based decision support tool that integrates local data and knowledge and current research with climate change predictions to provide an assessment of potential habitat vulnerabilities¹³. During the next management period, the CTP plans to host a training workshop on how to use this tool with decision-makers from the PRDNER, particularly managers in charge of coastal protected areas and other protected area managers. Decision-makers in other agencies as well as municipal governments will also be targeted. These trainings will complement the CTPs ongoing efforts to evaluate the vulnerability of coastal ecosystems. The initiative will aim to create collaborative networks between different groups and individuals involved in the management of coastal resources, using a technology that is commonly applied in other NERRS.

4. Provide capacity building and technical assistance in climate change adaptation, disaster risk reduction and emergency response

The need to provide trainings on climate change adaptation, disaster risk reduction and emergency response was identified together with the CTP Advisory Committee. The Committee also acknowledged the availability of information from various agencies and

¹³ <http://www.ccvatch.com/about.html>

organizations that could be used to enhance local municipality and community understanding of these topics.

The CTP will provide information and training on tools developed through reports and models produced by organizations such as the Puerto Rico Climate Change Council (PRCCC), the PRCMP, and the NERRS network. The NOAA sea level rise viewer and the Puerto Rico Coastal Vulnerability viewer are two inundation tools that can be used to provide technical training to municipal staff, planners, local leaders, and emergency responders. These models are central to the development of emergency response plans, land use plans, and climate change adaptation plans. In the long run, with the Sentinel Site project, the Reserve will have additional information that can be used in the Program's trainings.

Complementary trainings in social science research methods, such as participatory mapping workshops, will be useful for these audiences. In combination, these methods can assist local governments, for example, with planning and zoning efforts to address these challenges.

The CTP will provide technical training to encourage local leaders to proactively plan to adapt to changes in climate and the potential long-term effect on local communities, including the NERR's 'Planning for Climate Change' workshop.

Objective 3. Increase collaboration with coastal decision-makers representing the Commonwealth, federal and community organizations

1. Continue raising awareness of the CTP and the opportunities it provides

The CTP will continue participating in meetings with professional organizations, agencies, and other entities to foster additional partnerships and increase its audiences. The PRCCC's annual meetings offer a platform to introduce the CTP at the Commonwealth level. The PRCCC is made up of representatives of federal and Commonwealth agencies, academia, private sector representatives and NGOs. The PRCCC is divided into four working groups. One of them, known as "Communicating Climate Change and Coastal Hazards," offers a good opportunity for collaboration and outreach to different organizations and entities.

2. Continue using digital media to promote the CTP and reach larger audiences

The CTP will explore new partnerships to expand its programs. The CTP Coordinator will explore opportunities for collaboration with entities such as the Office of the Commissioner of Municipal Affairs, a Commonwealth agency (OCAM, by its Spanish acronym). In 2016, the OCAM launched the Center for Social Innovation (CIS, for its

Spanish acronym)¹⁴ to provide distance learning to Commonwealth decision-makers, municipalities, and NGOs in order to stimulate local development through capacity building in the areas of grant and program management, and the use of best practices. This is the first government initiative of its kind in Puerto Rico using a distance learning approach. Activities and materials that are available through the CIS are: Webinars, instructional videos and documentaries on best practices and successful stories, instructional materials in Spanish and English and, periodic programs – including interviews to experts and in-classroom training. The CIS provides a good tool to provide training and educational materials and reach wider audiences in Puerto Rico and the Caribbean.

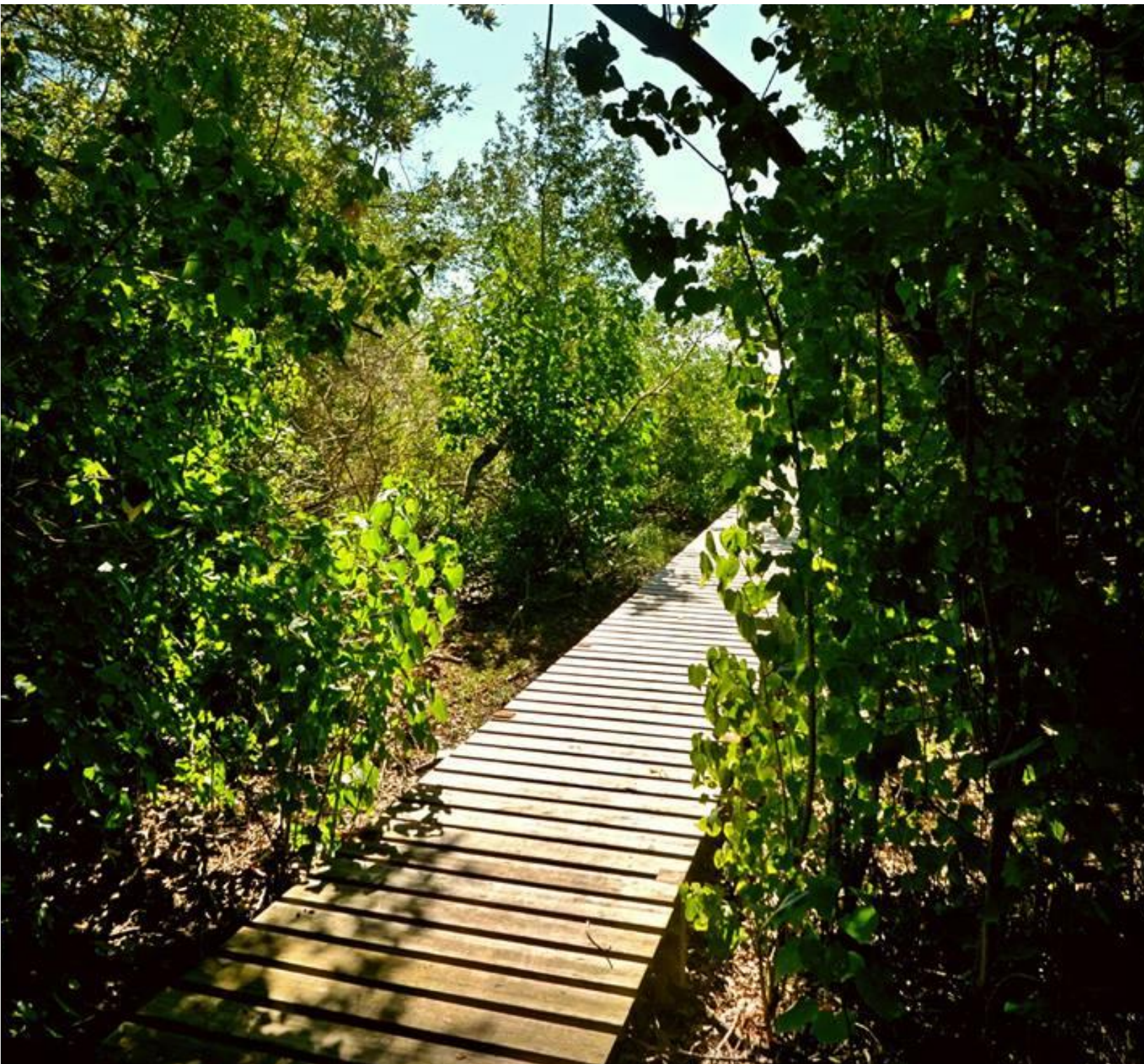
Objective 4. Determine the needs of target audiences for the CTP program in order to continue providing relevant services

1. Revise and update the NA/MA for 2018-2022

The last NA was conducted in 2013 and provides guidance for the CTP program direction through 2018. After 2018, it will be necessary to revise and update the NA in order to determine priority issues and services required by coastal decision makers. The NA will ensure that the CTP program continues to provide relevant services to its audiences.

¹⁴ <http://www.innovacionpr.com/>

ADMINISTRATIVE PLAN



8 Administrative Plan



8.1 Organizational framework and management authorities

The Puerto Rico Department of Natural and Environmental Resources (PRDNER) derives its powers and authorities from its Organic Act, Law No. 23 of 1972, and the Reorganization Plan No. 1 of 1993. Law No. 23 imposes on the PRDNER the responsibility of implementing the operational phase of the public policy contained in the Commonwealth's Constitution for the use and conservation of natural resources.

The PRDNER administers multiple laws and regulations for the protection and use of natural resources. A summary of these regulations is provided in Appendix 5, and can be retrieved in their entirety on the PRDNER's website: [<http://drna.pr.gov/cat/ley/>].

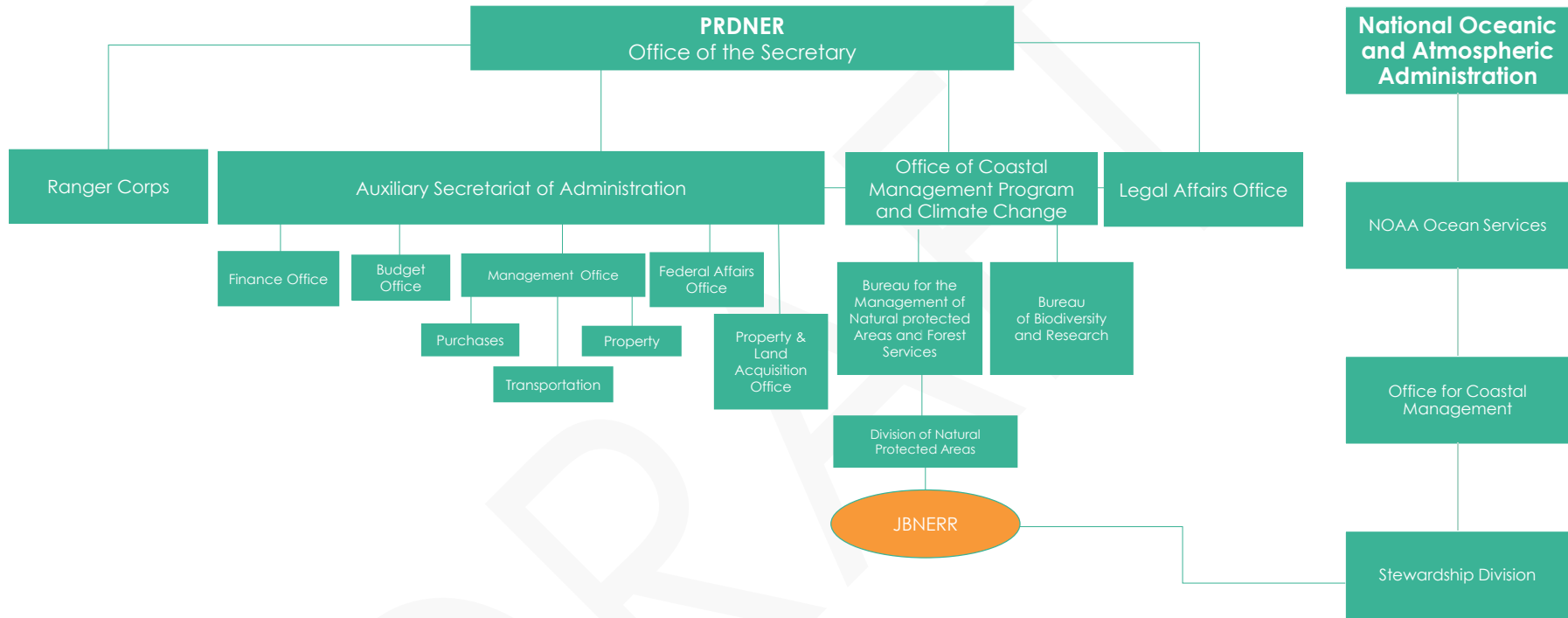
During the past years, the Commonwealth's government has taken several measures to reduce expenses given its difficult fiscal situation. This resulted in a reduction of human resources in several divisions of the PRDNER. To optimize the use of resources in the Agency, on January 2016 the Administrative Order (AO) No. 2016-01 was approved to reorganize units under the PRDNER's Natural Resources Administration. This AO creates the Auxiliary Secretary for the Management and Conservation of Natural Areas and Biodiversity, which substitutes the former Living Resources Administration. The former Bureau of Coasts, Natural Reserves and Sanctuaries and the Bureau of Forest Resources were merged into the Bureau for the Management of Natural Protected Areas and Forestry Services. This new Bureau is ascribed to the Auxiliary Secretary, and is responsible for implementing the Commonwealth's public policy for the conservation, management and study of natural protected areas. This Bureau has two divisions: the Division of Natural Protected Areas and the Division of Ecological and Forestry Services. This Division is responsible for management, conservation, and administration of the State Forests, Natural Reserves, Marine Reserves, Wildlife Refuges, and the Jobos Bay NERR.



As the State sponsor, DNER provides administrative support. JBNERR is administratively located in the Division of Natural Protected Areas.

The following organizational chart outlines the current location of JBNERR within the PRDNER and its alignment with NOAA's management structure.

Figure 24. Organizational Framework for the administration of JBNERR under the PRDNER and NOAA management structure



Other administrative and operational components of the PRDNER play an important role in the coordinated implementation of public policy to protect and conserve natural resources. Two key components in the implementation of public policy are the Ranger Corps and the Legal Affairs Office, both ascribed to the Office of the Secretary. Other PRDNER administrative personnel support all purchasing, contracting services, and administrative processes required to effectively manage and comply with the programs' requirements.

8.2 Jobos Bay NERR Administrative Structure

This Program is focused on enhancing the administrative capability and infrastructure of the Jobos Bay NERR to meet the research, education, and training challenges for program implementation. Components of the Reserve's Administration Program include developing and maintaining budgets for Reserve programs; assisting with procurement of necessary supplies, equipment, and contracts; handling of human resource issues; and, managing the overall office.

The Reserve has successfully filled key staff positions with highly qualified individuals, including the Director, Research Coordinator, Education Coordinator, CTP Coordinator, and Stewardship Coordinator positions. The fresh perspectives provided by these staff are reflected in the ambitious goals and direction of this Management Plan. In addition, the four Advisory Committees have been effective in supporting development and implementation of programs.

The Reserve Manager has direct supervision over program coordinators. Coordinators organize their respective program staff and are accountable for work plans developed to implement the strategies identified in this Plan.

Current staff

The total number of Reserve employees include permanent, full-time staff for all core positions, as well as support positions for programs, administration, and facilities. At present, the Reserve's staff is composed of eight people. It is important to note that most of the staff has been working in the Reserve for almost two years. The EC, CTP and Stewardship positions are not currently full time permanent positions and it is a high priority for the reserve to convert these position to stable full time positions.

Their primary office is located at the Reserve's Visitor Center Complex. The following table presents the staff position and responsibilities.

Table 8. Staff Positions and Responsibilities

```

graph TD
    DNER((Ranger Corps DNER)) <--> RD[Jobs Bay NERR Reserve Director]
    RD --- RC[Research Coordinator]
    RD --- EC[Education Coordinator]
    RD --- CTP[CTP Coordinator]
    RD --- SC[Stewardship Coordinator]
    RD --- GK[Ground Keeper]
    RC --- LT[Laboratory Technician]
    EC --- EE[Environmental Educator]
    
```

Position	Responsibilities
Reserve Director 100% PR funding	Responsible for overall program development and management, monitoring day-to-day operations of the Reserve, and progress of programs and projects. Prepares annual budget requests for state and federal funds. Oversees expenditures of funds. Prepares required quarterly and annual reports for NOAA. Supervises Program Coordinators, and administrative and facilities staff. Represents Jobs Bay NERR at the national level.
Stewardship Coordinator 100% NOAA funding	Manages all stewardship activities associated with trail, access, and maintenance, enforcement, boundary demarcation, mapping, contingency planning, and restoration, supported by the Reserve Director and other staff, as needed. Works with local governments and other stakeholders to promote resources protection and respond to environmental problems that require enforcement action and/or communication with appropriate agency personnel. Researches suitable lands for acquisition in the Jobs Bay watershed.
Research Coordinator 100% NOAA funding	Responsible for implementing and coordinating the Reserve's research and monitoring program. Designs and directs the research and monitoring program and carries out research projects and monitoring activities where appropriate. Ensures that the results of research projects are compiled and translated into usable information that is available for diffusion to the general public. Serves as a liaison with the scientific community, promotes data utilization, and serves as the primary contact for scientists conducting research in the Reserve. Coordinates implementation of the SWMP.
Laboratory Technician 100% NOAA funding	Assists Research Coordinator with Reserve-sponsored research and monitoring activities, maintaining computer software, hardware, and databases, as well as maintaining scientific collections and analytical equipment. Assists in field research, collecting and analyzing data, and preparing technical reports from biological, oceanographic, and geographical data and information. Conducts literature review and data-base searches and synthesizes the findings. Assists visiting investigators in the calibration and maintenance of the Reserve's

	laboratory and field equipment. Oversees the operation of the Reserve's laboratory facilities.
Education Coordinator 100% NOAA funding	Directs the Reserve's education program, designing and carrying out educational and outreach projects. Coordinates NOAA/Reserve-funded education grants, monitors progress of funded education, interpretation and visitor-use activities, evaluates progress toward achieving specified goals and objectives, and conducts peer review of education and interpretive products and media. Coordinates approved education, interpretation and visitor-use activities within the Reserve, and communicates with other Reserve management areas. Provides outreach to schools, colleges, universities, and other environmental education organizations. Conducts educational/research oriented field trips; makes educational and interpretive presentations to visitors and students in the visitor's center, and at local schools. Oversees maintenance and upgrades to reserve exhibits.
Environmental Educator 100% NOAA funding	Responds to the information requests of visitors. Assists in the maintenance of educational materials, development of presentations and group activities within the Visitor Center and local schools. Provides field support in educational activities and volunteer programs at Reserve sites. Maintains a record of visitors, information requests, educational materials, publications, and audiovisual materials. Maintains and organizes library holdings, maps, and photographs.
CTP Coordinator 100% NOAA funding	Coordinates and implements the Reserve's CTP. Identifies and develops partnerships. Markets and promotes professional training programs and services to target audiences, including coastal managers and decision-makers. Provides instructional design, program development, and facilitation services. Develops and distributes training materials. Evaluates programs. Maintains and submits performance measures to NOAA's Office for Coastal Management.
Grounds Keeper 90% PR funding 10% NOAA funding	One position responsible for maintaining facility grounds and ensuring that signs and boundary markers are in place. Periodically inspects areas frequented by visitors. Responsible for general maintenance and management of outdoor facilities.
Law Enforcement Officers 100% PR funding	One law enforcement officer is assigned to Jobos Bay NERR. He conducts routine patrols and responds to resource violations affecting Reserve's resources.
Boat Operator 100% PR funding	The position will support research, education and stewardship programs by providing reserve access for reserve staff, visiting researchers, and program participants.

Strategic Partnerships

The PRDNER has implemented a flagship initiative to develop partnerships with NGOs to support in the management of natural protected areas. The Jobos Bay NERR does not have the legal capacity to sign agreements with other entities; therefore these are carried out by the PRDNER Secretary. At present, there are two agreements related to Jobos Bay NERR. These are with IDEBAJO and CariCOOS, Inc. (Refer to Appendices 3 for copies of these agreements).

- | **IDEBAJO**- A collaborative agreement was signed in January 2015, to promote the development of ecotourism microenterprises in the Reserve. According to the agreement, JBNERR staff will provide support to this community-based NGO through its programs, and IDEBAJO will provide support in maintenance activities, research, and monitoring.
- | **CariCOOS, Inc.**- A MOA was signed in 2016 to foster collaboration and cooperation between both entities. Activities envisioned under this MOA include: providing JBNERR with specialized data products and expert advice as requested, collaborate in the development of research and monitoring activities in JBNERR, collaborate in the development of outreach and education materials, and participate in JBNERR's Advisory Committees.



The DNER-IDEBAJO collaborative agreement seeks to promote the development of ecotourism activities in JBNERR.

Source: DNER



The main objective for the MOA between DNER-CariCOOS is the exchanging of research data and information dissemination.

Source: CariCOOS

Stewardship Advisory Committee

The Stewardship Advisory Committee provides input, guidance, and support for programmatic direction and management of the Reserve to the Stewardship coordinator and the Reserve's Director. It gives advice on topics such as management priorities, uses, acquisitions, restoration priorities, and enforcement. This committee meets at least twice a year or as needs dictate. It has been actively involved in the revision of this management plan. This Committee is structured to assure that public concerns are considered. Its members include a variety of stakeholders, assigned by their respective organizations. It is comprised of representatives from the following entities:

Table 9. Entities represented in the Stewardship Advisory Committee

Federal agencies and other entities	<ul style="list-style-type: none"> • NOAA - NMFS - Habitat Conservation Division • USDA-Natural Resource Conservation Service • USDA- International Institute of tropical Forestry, Director • USDA-Caribbean Climate Hub, Director • USFWS, Habitat Conservation Program • USFS-Endangered Species
Commonwealth agencies, public corporations and municipalities	<ul style="list-style-type: none"> • PRDNER Special Assistant of the Secretary • PRDNER- Legal Affairs Office • PRDNER-Office of Coastal Management Program and Climate Change
Community representatives/ NGO	<ul style="list-style-type: none"> • IDEBAJO (3 representatives) • Carlos R. Vega Santos, Surveyor • Tour Operator - Bahía de Jobos • Southern Hunters Sport Association, Inc (3 representatives)

The Reserve is also continuously seeking partnerships, alliances, and community-volunteer support for other needed efforts. The Universidad del Turabo is a strong partner that uses the Reserve as a laboratory for its recently established academic program in ornithology and avian conservation (the only such effort in Puerto Rico). In addition, the university established a long-term monitoring program for migratory and year-round resident species of terrestrial birds that utilize secondary coastal dry forest and mangroves in and around Jobos Bay NERR. Students also volunteer to provide talks and workshops in the Reserve.

Federal partners include the Caribbean Fishery Management Council (CFMC), who has contributed with staff to provide workshops to PRDNER's Rangers Corps.

Other NGO and community-based organizations collaborate with the Reserve's programs. The San Juan Bay Estuary Program has been a close partner in coordinating the National Water Quality Monitoring Day, and providing technical assistance. Other NGO partners are: CIVITAS PLUS (currently working in Las Mareas community to address sanitary water discharges); Boys Scouts of America- Puerto Rico Council (trails and facilities maintenance and enhancement); Grupo Apícola Guaní (to explore the dynamics of the bees in the pollination of different plant species found in the Reserve), the Ornithological Society and the Santa Ana Environmental Center, both collaborate in providing talks and workshops.

In addition, the Reserve has partnered with the Hunters Association of the South to organize and supervise hunting activities during the waterfowl hunting season, while protecting Reserve's resources. Many hunters and their families volunteer to maintain the Reserve's trails.

8.3 Vessels and vehicles

Currently, to support the fleet needs of all programmatic areas, the Reserve has:

- | One (1) sport utility vehicle
- | One (1) extended cab pick-up truck
- | A flex fuel vehicle for longer trips
- | A 15 passenger van – for education activities and group visits
- | A 4X4 mule - for field access
- | A 4X4 extended cab truck - for field activities and boat launching
- | A large tractor, with mower deck and other attachments – for site and trail maintenance. The Reserve has acquired new heavy duty gas trimmers, a gas chain saw, for such purposes.
- | A medium chipper – for site and trail maintenance.

The Reserve has the following vessels to support water access and activities:

- | A 22' boat for field research use, 2 kayaks for remote site access, and a 17' boat.

6.2 Needs and opportunities

Needs

Staffing needs

The following are the positions that are needed for the Reserve.

- | **SWMP Technician**- This position will assist the Research Coordinator in monitoring duties of the SWMP and facilitate research projects at the Reserve. Duties will include: maintenance of the weather, nutrient, and water quality instrumentation; data uploading from field instruments and files using appropriate computer software; conducting all appropriate QA/QC on data; preparation of data to send to CDMO in South Carolina, and attending annual SWMP tech training offered by the NERRS.
- | **Administrative Assistant/Facilities Manager**- This position would provide the necessary administrative support in matters that should be coordinated with

PRDNER headquarters. Consequently, he/she would free the Director to address other matters and focus on strengthening the Reserve's programmatic areas. In addition, the person in this position would support the Reserve's staff in grant management duties and manage all uses of reserve facilities and oversee facility maintenance needs. This position is critical as reserve investments by NOAA and DNER are increasing dramatically leading to an increase in interest by students and researchers in using Reserve facilities.

- | **Volunteer Coordinator-** The Stewardship and Education Coordinators currently share the responsibility for developing task descriptions for volunteers, keeping a detailed count of volunteer and student contact hours for performance measuring purposes, in addition to managing a host of other responsibilities. They should be relieved of the task of organizing volunteers so that they can focus on program duties. Moreover, through the Road Trip Initiative, volunteer opportunities in the Reserve have been promoted and have received very positive responses. However, this staff lacks the time to properly organize a group of volunteers for the Reserve, and follow-up with those who have expressed interest. A Volunteer Coordinator position is needed to maximize a robust Volunteer Program. The Volunteer Coordinator will be responsible for the recruitment of volunteers and the coordination and logistics.

Vessel and vehicle needs

- | **A vessel-** A vessel is needed to support various programmatic areas, especially the Education Program. At present, there's only one 22' boat at the Reserve, which is used by the Research Program for the SWMP. An additional boat is needed to support education programs by transporting students participating in camps, teachers participating in TOTE workshops, and visitors to the reserve needing to tour the reserve for various purposes.

Opportunities

- | **Commonwealth law for the transfer of personnel-**The Reserve Director will continue seeking funds for the recruitment of personnel required for the effective management of the Jobos Bay NERR and the implementation of its programs. Federal and Commonwealth funding and available legal mechanisms will be explored in order to be able to recruit the necessary human resources to strengthen the Reserve's programs.

Although the current legal framework does not allow the hiring of additional staff with Commonwealth funds, Law Num. 8 was passed on February 4, 2017 in order to address the issue of the need for personnel in Commonwealth agencies. This law, known as the "Government of Puerto Rico Human Resources Administration & Transformation Act", allows for personnel to be transferred between agencies in order to carry out diverse functions. This represents an opportunity to acquire personnel from other agencies to support in the Reserve's administrative duties.

- | **Opportunities for a Volunteer Program** - Law Num. 261 of 2005, as amended in 2010, known as the Volunteer Law of Puerto Rico, authorizes the Commonwealth agencies to establish volunteer programs. It enables the DRNA to establish volunteer agreements regarding research, monitoring, conservation, adoption of beaches and trails, and education efforts.

The Reserve must seek opportunities to create formal agreements to delegate duties and attend areas of need, including efforts to recruit and coordinate with volunteers in order to better meet its programs' goals and objectives. Over the past five years, the JBNERR has been able to successfully incorporate volunteers into some of its programs, and has increased the number of hours of volunteer work done in different areas. Among the accomplishments, in 2014, the JBNERR Volunteer Program Manual was approved by the PRDNER. Additionally, the Jobos Bay NERR prepared the necessary forms to formalize student internship opportunities through PRDNER, focused on the Reserve. As demonstrated, the JBNERR has reached a point where staff functions are sufficiently organized to be able to effectively incorporate volunteer efforts to support programs. Nevertheless, the staff are too saturated managing their different roles to be able to also coordinate larger volunteer programs.

Through a robust volunteer program, the Reserve will:

- Further strengthen the local outreach "Road Trip Initiative": A Volunteer Coordinator would greatly help support this initiative by becoming the contact person for interested volunteers, following up with contacts, and coordinating activities.
- Have the necessary human resources to develop and maintain facilities: In both the Facilities and Public Access Plans, there is discussion of how volunteer groups can help to develop, maintain, and monitor aspects of each plan. Specifically, community groups, environmental groups, Boy and Girl Scouts, and academic groups have already participated in or demonstrated interest in initiatives varying from trail blazing and boardwalk construction to facilities rehabilitation. A Volunteer Coordinator is needed in order to handle logistics and truly harness the vast potential of these groups to supply voluntary labor for the improvement of conditions in the Reserve.
- Expand the offerings of the Education Program in the community: An expanded volunteer network will support the Education Program's initiatives such as the summer camp, as well as attending to visitors. More guided tours would be provided by trained volunteers, which will help the Reserve meet its goals of enhancing and managing public access, and education.
- Furthermore, the monitoring and surveillance challenges that the Reserve faces require the involvement of the public. The Reserve will be more successful in protecting its natural resources if the local community is educated, begins to

develop a sense of ownership, and becomes actively engaged in enforcement. To achieve this, many program coordinators must be involved, but ultimately a Volunteer Coordinator is needed to organize logistics.

8.4 Objectives and Actions

The Reserve will enhance its administrative efficiency and its ability to secure outside funding and positions. Objectives and actions for the next management period will focus on enhancing integration across programs, streamlining on-site reporting, project management and budget accountability, and enhancing capacity to seek outside funding.

Objective 1. Recruit three additional JBNERR staff to support administrative and monitoring efforts

1. Recruit an additional SWMP Technician

This position is urgently needed. The SWMP technician will be recruited during the first year of the implementation of this management plan.

2. Recruit an Administrative Assistant/Facilities Manager

This position will be established to manage grants and contracts, as well as to coordinate financial matters with PRDNER headquarters and NOAA, and manage facility use and maintenance. The Director will continue working with the PRDNER to identify available sources, such as the Law Num. 8 of 2017, to recruit the Administrative Assistant/facilities coordinator no later than December, 2018.

3. Recruit a Volunteer Coordinator

The Volunteer Coordinator will be responsible for developing, implementing and evaluating a Volunteer Program for the Reserve. Duties of this position would include: liaising between volunteers/compensated docents and each of the program coordinators, developing and maintaining mailing lists and databases to match volunteers with the Reserve's needs, tracking volunteer contributions, recruiting and training additional volunteers, and supporting various volunteer activities. The position should support volunteers and community NGO's in a number of projects and initiatives pertinent to Reserve themes and needs, in order to truly maximize the potential of a solid Volunteer Program.

Puerto Rico's Commission on Voluntarism and Community Service¹⁵, a Commonwealth entity, provides assistance to entities that receive funds from AmeriCorps program. The Reserve Director will explore the possibility of participating in this program to address the need of a volunteer coordinator. Other options will also be explored. The Reserve should be ready to hire a Volunteer Coordinator by the end of 2018.

Objective 2. Strengthen JBNERR staff capabilities by providing trainings and developing annual work plans

1. Each Reserve staff will be engaged in one professional development training per year

The Reserve is currently in an excellent position and has highly qualified individuals. The Reserve will continue strengthening staff skills and capabilities to address education, training, research, monitoring, administrative, and maintenance needs.

Creative avenues will be explored to provide both in-person and remote trainings. The Reserve will work closely with academia and other collaborators to provide opportunities for the provision of trainings and continued education to its staff in topics such as project management, grant writing, maintenance, marine mechanic training, and GIS.

2. Develop work plans to support the management plan implementation

The Reserve staff will prepare annual work plans to develop specific activities under each objective and action presented in this management plan. These annual work plans, or operational plans, will align with the goals and objectives of this management plan.

Any emerging issues that need to be addressed will be discussed with the Advisory Committees, as needed, and the OCM's Program Specialist before being considered in the annual work plans.

Objective 3. Acquire one vessel to meet the needs of the Reserve's expanding programs

1. Acquire a vessel to support the Reserve's programmatic areas

This vessel will support the Stewardship, CTP and Education programs by transporting Coordinators and visitors into the Bay. In this way, the existing 22' boat will be used exclusively for field research.

¹⁵ <http://comisionvoluntariado.pr.gov/>

RESOURCES PROTECTION PLAN



9 Resource Protection Plan



9.1 Commonwealth's Management and Statutory Authorities

This section describes all federal and Commonwealth authorities related to the protection and use of Reserve resources. In Puerto Rico, the Constitution and other overarching statutes establish the environmental public policy. The PRDNER has a comprehensive legal framework for the protection and use of natural resources, which are applicable to the management of the Reserve's resources. These can be broadly categorized as: wildlife resources; fisheries, including coral reefs; habitat protection; enforcement; navigation and safety, and include the following:

- | Department of Natural and Environmental Resources of Puerto Rico Organic Act, Law Num. 23 of 1972 as amended.
- | New Wildlife Act of Puerto Rico, Law Num. 241 of August 15, 1999, as amended and its regulations:
 - Regulation to govern the conservation and management of wildlife, exotic species, and hunting in the Commonwealth of Puerto Rico, Regulation Num. 6765 of February 11th, 2004
 - Regulation to govern vulnerable species and species in danger of extinction in the Commonwealth of Puerto Rico, Regulation Num. 6766 of February 11th, 2004.
- | Puerto Rico. Fisheries Act, Law Num. 278 of November 29, 1998, as amended
- | Law for the protection, conservation, and management of coral reefs in Puerto Rico, Law Num. 147 of July 15th, 1999.
 - Puerto Rico Fishing Regulation Num. 7949 of 2010
 - Administrative Order Num. 2016-08 To Establish Measures to Protect and Prohibit the capture of sea cucumbers (*Holothuria Spp.*) and sea urchins (*Class Echinoidea*)
- | Puerto Rico Forest Act, Law Num. 133 of July 1st, 1975, as amended.
- | Law for the Public Policy on Wetlands in Puerto Rico, Law Num. 314 of 1998, as amended.
- | Puerto Rico Navigation and Aquatic Safety Act, Law Num. 430 of 2000 as amended

- Regulation for the registration of navigation and Aquatic Safety, Num. 6979 as amended.
- | Department of Natural and Environmental Resources Rangers Act, Law Num. 1 of June 27th of 1977 and its regulations.
- | Regulation for the administration of uses through authorizations and concessions in Natural Protected Areas, Reg. 8013.

Another Commonwealth entity responsible for the protection of the environment in the Reserve is the Puerto Rico Environmental Quality Board (water, air, soil, noise and light control, and environmental emergency response). The PRPB is responsible for land use and must ensure federal consistency with the PRCMP.

Federal agencies responsible for the protection of natural resources in the Reserve include: the USFWS, NOAA-NMFS, US Army Corps of Engineers (USACE), USEPA and USCG. Appendix 5 summarizes the primary laws and regulations used by the PRDNER and other entities to exercise authority for the protection of natural resources.

9.2 Allowable and Unallowable Uses

Permitted and prohibited uses in the Jobos Bay NERR are conditioned by the current legal framework, the fragility of resources, the availability of infrastructure to provide access, as well as human resources to actively manage and patrol the various areas.

All activities must be registered at the Reserve. The use of motor vehicles inside the Reserve premises is not allowed, except for those authorized by the Director. Allowed and unallowable uses and restrictions in the Jobos Bay NERR are discussed below:

Research and monitoring: The use of all units for research and monitoring purposes is allowed, in coordination with the Reserve staff. All research and monitoring activities must be approved and registered at the Reserve Visitor Center.

Passive recreation/education/training: Guided tours for educational and training purposes are allowed within identified areas. Access off the trails must be authorized by the Reserve or otherwise, visitors must be accompanied by the Reserve's staff. Passive recreation activities, such as bird watching and hiking, are permitted where trails and infrastructure allow. The areas dedicated to public access include the trails, the observation towers, docks, and boardwalks as discussed in Section 10. Water activities such as snorkeling, kayaking and diving are also allowed in the Jobos Bay. Snorkeling around the cays is permitted.

The Mar Negro unit has physical and biological characteristics that require careful protection like coves, shallow semi-enclosed areas, seagrass beds, offshore cays, and fringing mangroves within the lagoon system. These are spawning areas and nursery

grounds for valuable commercial fish species. The protection of these resource areas is vital to maintain the equilibrium and population dynamics of the estuary.

Navigation: The use of kayaks and boats is allowed in the Reserve, according to the provisions of Law 430-2000 as amended, and its Regulation Num. 6979, as amended. The use of jet skis is prohibited in all waters of the Reserve.

To provide access to the Las Mareas Community, a right-of-way for boat traffic has been established through the central corridor of Mar Negro. Main users of this waterway are local fishermen. Boat size is limited to a maximum of 22 feet. Speed is limited to five knots (5.7 mph) for all motor boats using the area.

Anchoring in designated areas is limited to a maximum of three hours. Anchoring facilities have been installed by the PRDNER and appropriate signage posted. These measures will allow proper management of public use in a manner that will not threaten or significantly disturb the natural ecosystems.

Although excluded from the Reserve's boundaries, the Jobos Bay has a navigation channel established for boats coming out of the eastern side of the bay to provide services to the Aguirre Power Plant.

Fishing: Fishing is regulated by Commonwealth and federal regulations, as described before. All persons who fish for commercial purposes must have a license issued by the PRDNER, according to Law Num 278-1998 and Reg. 7949. Recreational fishers should also obtain a license as established by the aforementioned law and regulation and the AO 2016-012 that establishes the process for selling recreational fishing licenses.

Capture of invasive species in these protected waters also requires a permit issued by the PRDNER. Capture or possession of blue land crab is prohibited by Regulation No. 7949 as well as harvesting the nurse shark in territorial waters. Capture and possession of sea cucumbers (*Holothuria Spp.*) and sea urchins (*Class Echinoidea*) is also prohibited by AO 2016-08.

Hook and line fishing is allowed, but small or immature specimens must be released to ensure sustainability. Pot and net fishing is not allowed inside the Mar Negro area.

Traditional shellfish harvesting from mangrove roots is allowed. Shellfish fishermen will be encouraged to provide harvesting reports to the Reserve.

This Management Plan defines uses in the proposed Coral Reef Unit according to Law 147-1999 and Law 278-1998, and its regulations.

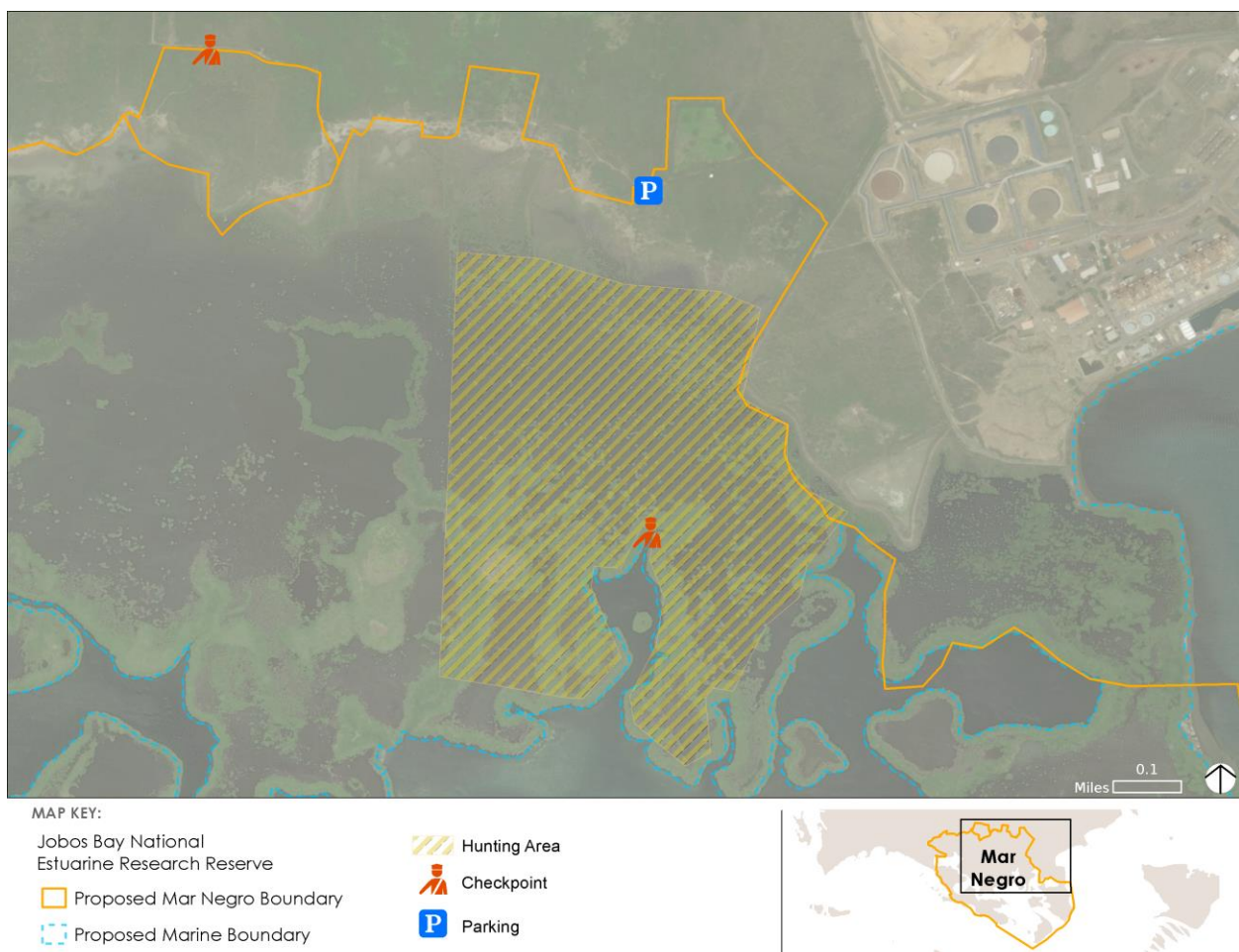
Hunting: Hunting is also prohibited, except for aquatic birds in a designated area in the Mar Negro Unit, to the east of the Jagüeyes trail and north of Mar Negro. Hunters need a license issued by the PRDNER and must follow the provisions established in Regulation

Num. 6765. This area is open for hunting between the 15th of December and the 15th of January, only on weekends.

Hunters must first pass by the administrative offices in Aguirre to receive educational materials, rules, and an authorization pass in order to enter the hunting area. Hunters must sign an order to state their agreement and compliance with the rules. All hunters must pass through either the checkpoint accessible by land, via the Jagüeyes trail or the checkpoint available via Mar Negro.

Hunting is only allowed between the half hour before sunrise and noon, on Saturday, Sunday, and Monday, as well as holidays (except Thanksgiving). If dogs are to be involved, they must be on a leash outside of the hunting zone. Hunting is not permitted in the pond, the Jagüeyes trail, nor any of the lookouts, boardwalks, or observation towers.

Figure 25. Hunting area in the Jobos Bay NERR

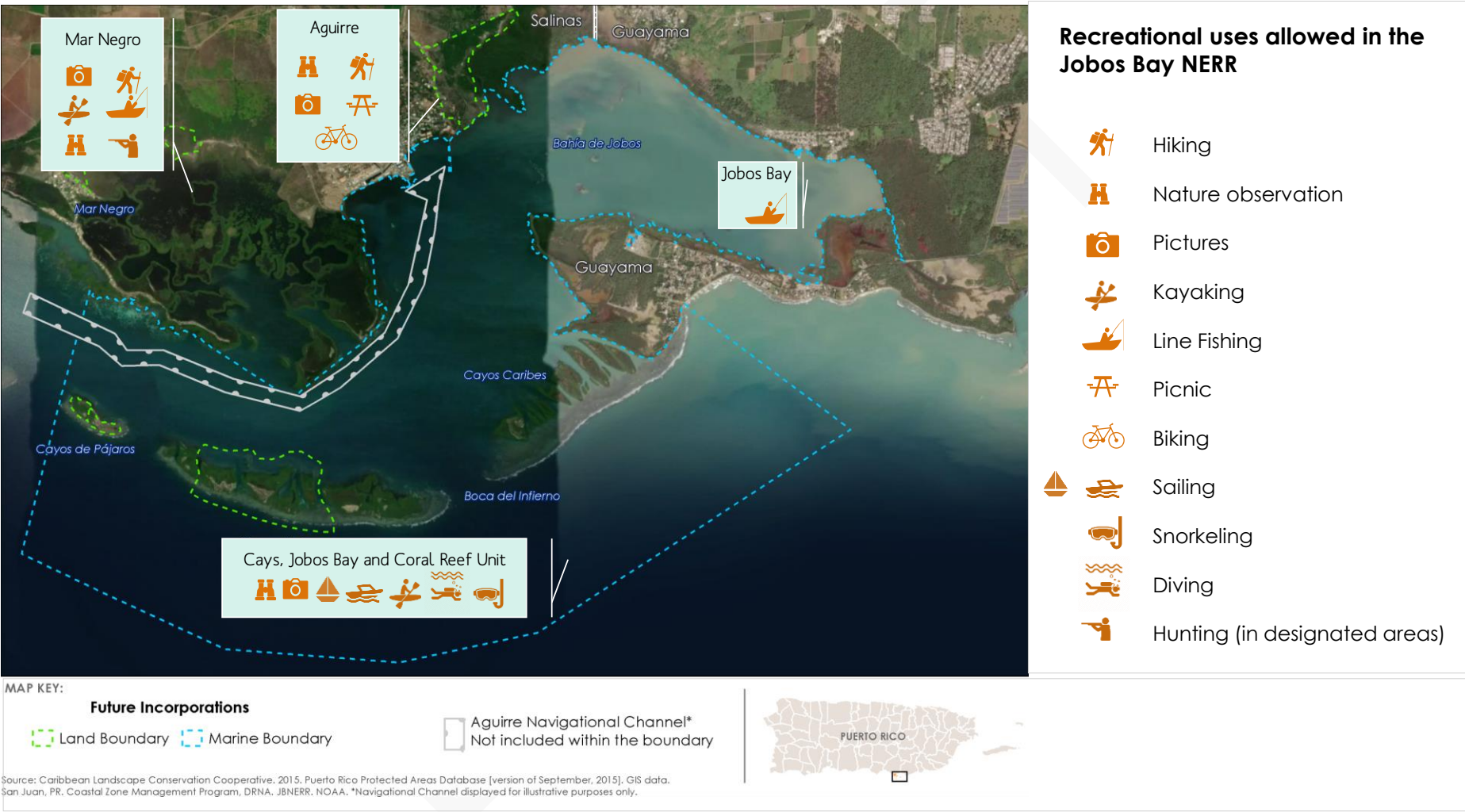


The following table summarizes the permitted and prohibited uses. It is important to note that this list is not exhaustive, and that JBNERR is under the purview of all Commonwealth and federal laws and regulations for the protection of natural resources in Puerto Rico and its coastal waters.

Table 10. Permitted and prohibited uses in the Jobos Bay NERR

Uses allowed	Uses not allowed
<ul style="list-style-type: none"> • Research and monitoring • Education and training • Hunting: In designated areas • Fishing: Hook and line fishing • Recreational uses: birdwatching, hiking, biking (in designated areas), kayaking, snorkeling, diving, swimming, photography • Anchoring on mooring buoys • Guided tours for educational and research purposes within identified areas • Collection of coral and other related species for scientific purposes (if granted prior authorization as established by Law) • Removal or protection of any sick or contaminated marine species provided that all required permits are in order and that guidance is given by JBNERR authorized personnel • Use of dead coral for artisanal purposes. Artisans should be registered in the Artisan Register of the Puerto Rico Economic Development Company and comply with the required permitting process • Collection of dead materials of the shore, provided that guidance is given by JBNERR authorized personnel 	<ul style="list-style-type: none"> • Pot, net fishing, harpoon fishing in Mar Negro Unit and Coral Habitat Unit • The use of motor vehicles outside designated areas • Hunting: outside designated areas • Jet skis or other similar motorized water bikes. • Capture or possession of blue land crab • Capture, possession or transport of sea urchins and sea cucumbers • Capture or collection of species of flora and fauna without required permits • Use of any kind of chemical and explosive fishing practices • Collection or extraction of corals and related species, including aquarium fishes • Walking on or touching of corals • Anchoring without using mooring buoys • Waste discharge • Cutting, pruning or any other practice that may in any way damage the mangroves or other trees

Figure 26. Allowable uses in the Jobos Bay NERR



9.3 Surveillance and Enforcement Capacities

Primary responsibility for enforcement of Commonwealth laws for the protection of the Reserve's resources rests on the PRDNER's Ranger Corps and Legal Division. Jobos Bay NERR is an area administered by the PRDNER and has the same level of protection against violations as other designated protected areas. The Stewardship Coordinator works closely with the Rangers to improve enforcement by providing technical assistance and presenting detailed reports on ecosystems impacts resulting from violations within the Reserve's boundaries and its surroundings.

The Puerto Rico Police Department (PRPD) is also empowered to enforce the PRDNER laws for the protection of natural resources. Through its Maritime Surveillance Unit of the Joint Forces of Rapid Action (FURA, by its Spanish acronym), it is responsible for ensuring the safety in territorial waters.

The Reserve Director, together with the Stewardship Coordinator and the PRDNER Legal Office, developed a "Legal Strategic Plan for the Removal of Illegal Structures in *Las Mareas* and *Camino del Indio*", according to the JBNERR §312 Final Evaluation Recommendations. This strategic plan consists of several tasks, including: formal delineation of boundaries and installation of boundary monuments; development of a surveillance and enforcement plan; prioritization of cases related to the Reserve that have been filed in the PRDNER Legal Office; and the establishment of partnerships with all the Commonwealth and Federal agencies with jurisdiction in the area to discuss and take the available legal measures to address violations and avoid future infringements.

The PRDNER contracted a surveyor to clarify the original cadastral survey of the Reserve. Boundaries between JBNERR and the communities were clarified, a formal delineation of boundaries was conducted, and boundary monuments and signs were installed in the western portion of Mar Negro, adjacent to *Las Mareas* and *Camino del Indio*. These clarifications will be part of the boundary amendments to be submitted to NOAA, as indicated in Section 3.4.

The PRDNER has also developed and submitted to the NOAA a "Surveillance and Prevention Enforcement Strategic Plan of the PRDNER at JBNERR". The purpose of this plan is to: (1) eliminate illegal fishing activities such as the capture of the blue land crab and of protected species during their closing seasons, as well as the use of prohibited fishing gear; (2) prevent illegal construction of ramps, piers, filling of rubble in the maritime zone and within the JBNERR boundaries; and (3) eliminate unauthorized use of vehicles in the Reserve terrains, the presence of horses and the picnic activities in the Reserve. The proposed work plan includes: (1) the design of biweekly work plans coordinated between the Reserve's Director, the Stewardship Coordinator and the Rangers Corps-Maritime Unit Supervisor to address identified surveillance needs; (2) the identification of the resources required by the PRDNER and the Reserve for the appropriate

implementation of the plan; (3) the identification of marine and terrestrial areas that require patrol and its frequency; and (4) the coordination with the municipalities and the PRPD to assist in the implementation of the biweekly work plans. The Surveillance and Prevention Enforcement Strategic Plan also proposes the coordination of trainings and workshops to strengthen the Rangers Corps capabilities to address the surveillance needs in the Reserve, as described in the CTP section.

The Director and the Stewardship Coordinator have been working with the PRDNER in the implementation of both plans. The Reserve has made additional efforts to improve security, such as installing cameras for remote surveillance of both high traffic and remote areas.

At the federal level, the USCG has responsibilities associated with marine environmental protection, surveillance and port security, navigation safety of recreational crafts and the defense of maritime areas. Other federal agencies, such as the USFWS, NOAA and the USACE have enforcement officers who have the responsibility of implementing the laws administered by each of the agencies.

NOAA, NMFS and the PRDNER, signed a collaboration agreement that empowers the Rangers Corps to implement the following federal laws: Magnuson-Stevens Fishery Conservation and Management Act, the Endangered Species Act, the Marine Mammal Protection Act and amendments to the Lacey Act.

Additional surveillance has been accomplished through concerned citizens and community members, who contact the Reserve or Rangers if they observe or encounter a violation.

9.4 Resource Protection Challenges

Challenges facing the Reserve regarding resource protection are related to lack of enforcement capabilities, and threats to sensitive areas and species. Regarding law enforcement, the Reserve staff is constantly documenting violations, but is not empowered to prosecute offenders. Some of the more continuous violations affecting the Reserve include encroachment in the Mar Negro Unit¹⁶, illegal cutting of mangroves, illegal fishing, and vandalism. Most of these violations occur in the Mar Negro area. Illegal fishing activities also occur in the Jobos Bay and near the cays. These areas require regular patrols to raise the visibility needed for effective enforcement of environmental protection regulations in the Reserve.

¹⁶ For further information on encroachment and legal actions taken, please refer to Chapter 13: Restoration Plan, section 11.1: Description of Restoration Areas.

Currently, there is only one Ranger assigned to the Reserve. He reports directly to the Reserve Director through his supervisor, responding to complaints and observations, as well as conducting routine patrols of areas with a history of violations. This represents a major challenge for the Reserve, as the area requires additional resources for enforcement and surveillance.

Other challenges relate to threats to specific sensitive areas and species, such as boating and fishing activities that disrupt sensitive habitats, including the nurse sharks' reproduction area, as previously described. Beyond illegal violations, there's a need for more education and awareness among the general public about the sensitive nature of these habitats and the impacts of their actions. To address these challenges, during the next management period efforts will be focus on improving enforcement and protecting sensitive areas.

9.5 Objectives and Actions

Objective 1. Improve law enforcement in the Reserve and its watershed

1. Continue implementing the Surveillance and Prevention Enforcement Strategic Plan of the PRDNER at JBNERR

This is an ongoing task that requires close coordination and follow up from the Reserve's Director, with the support of the Stewardship Coordinator. During the next management period, the Reserve's staff will continue coordinating the biweekly work plans to address illegal and unauthorized activities, ensure proper surveillance, equipment and staff.

2. Request at least two additional Rangers for the Reserve

Continued efforts are being made to improve communication and cooperation between JBNERR staff and the PRDNER Ranger Corps. However, the area is too large and complex to be patrolled by only one Ranger. Surveillance and enforcement needs to improve through the assignment of additional Rangers to the Reserve and more patrols of the area by boat and land vehicle.

3. Continue coordinating efforts to implement the legal strategic plan for the removal of illegal structures.

The Reserve Manager, the Stewardship Coordinator, and the PRDNER Legal Office developed a strategic plan for the removal of illegal structures inside the Reserve terrains at Las Mareas and Camino del Indio. During the next management period the Reserve Staff and the Stewardship Coordinator will continue with the proper coordination to implement this plan.

4. Provide technical and scientific opinion on authorizations or permits that have the potential to impact the Reserve and its watershed.

Although outside the Reserve's boundaries, the mass activities and festivals that are occurring in private cays are affecting the marine habitats and species. The Reserve will work with the PRDNER Legal Office to establish protocols to ensure that the expertise of the staff and the advisory committees are considered when issuing permits for activities of this nature.

Objective 2. Protect sensitive areas from human induced perturbations

1. Designate the nurse sharks (*Ginglymostoma cirratum*) mating grounds as a “No Take Zone” for the period of reproduction (June-July).

To protect this species during their mating activity and to conduct further research and monitoring to better inform management of future actions, this management plan proposes to set up an area east of Mar Negro, in the Jobos Bay for protection of mating nurse sharks, as presented in the following figure. The Reserve will work with the PRDNER to establish the required administrative procedures to designate the nurse shark reproduction area as a no take zone. This area will be temporary closed for navigation during the June/July mating season. The use of motorboats will be prohibited, except for official and PRDNER vessels to conduct research and monitoring, provide surveillance and assist in emergencies. Kayaks will be allowed, but speed will be limited to 5 mph. Signs will be installed to advice users and educational materials will be prepared.

Figure 27. Nurse shark reproduction area



2. Install signage indicating prohibited and/or allowed activities.

More signs will be placed or replaced to discourage both inadvertent and intentional violations. Signs with information about regulations will be posted at the boat ramps and other strategic points to educate the public and discourage unlawful behavior. The signs will identify restricted areas, prohibited activities, sensitive habitats, or areas where certain activities can occur (e.g. uses allowed, areas where boats are allowed to anchor, speed limits, areas where certain types of fishing practices are prohibited or allowed). These signs will be replaced periodically according to the weather conditions and possible vandalism.

PUBLIC ACCESS & VISITOR USE PLAN



10 Public Access and Visitor Use Plan



10.1 Current Public Access

JBNERR received more than 4,000 visitors in 2016 and expects an increase in the number of visits for the coming years as a result of the efforts by its various programmatic areas. The Visitor Center is open from Monday through Saturday from 7:30 am to 3:00 pm. However, most of the Reserve's premises and cays can be accessed by visitors at any time. There is no entrance fee.

Currently there are several points of land and water access to the Reserve, as well as a network of trails and facilities that permit access within the Reserve, as described below.

Access to the Reserve

Land Access

The major access road to the Reserve is State Highway PR-3, which can be reached from San Juan via the Luis A. Ferré Expressway (PR-52) or from the Guayama Expressway extension (PR-53) via State Highway 706. Highway 3 leads to the three main access roads: Highway 703 to Las Mareas, Highway 705 to Aguirre (Reserve facilities and Visitor Center); and, Highway 7710 to Punta Pozuelo.

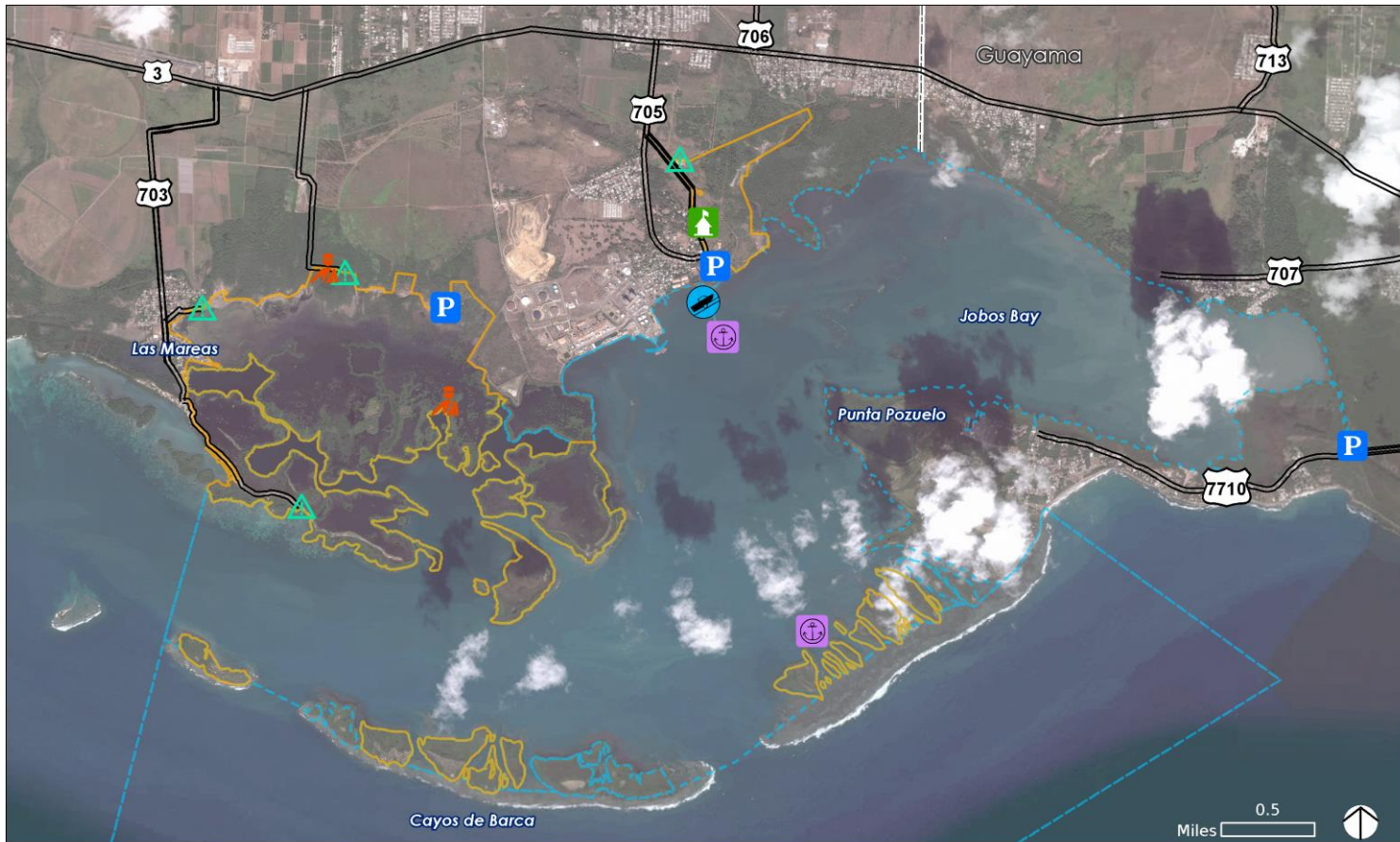
Access to hunting grounds is permitted at certain points via land and sea: the Jagüeyes trail and Mar Negro, respectively.

Water Access

Water access to the Reserve occurs through the various ports or docking facilities within the Bay: one at Puente de Jobos; two in Las Mareas; one at Pozuelo Marina; and, two in Aguirre. Boaters have access to Mar Negro, Cayos Caribe, Cayos La Barca, and Pájaros from these facilities. The Aguirre Thermoelectric Power Plant also has a pier that serves the industrial facilities.

There are a boat ramp and a dock in the Aguirre Unit that are frequently used by Reserve staff. There is also a dock in Cabezas de Cayos Caribe that belongs to the PRDNER and the Reserve. These facilities can also be used by visitors under certain restrictions.

Figure 28. Land and water access to the Jobs Bay NERR



MAP KEY:

Jobs Bay National Estuarine Research Reserve

Proposed Land Boundary

Proposed Marine Boundary



Jobs Bay Visitors Center



Dock



Parking



No vehicles beyond this point



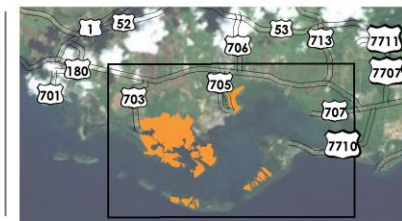
Boat ramp



Access road by car



Checkpoints



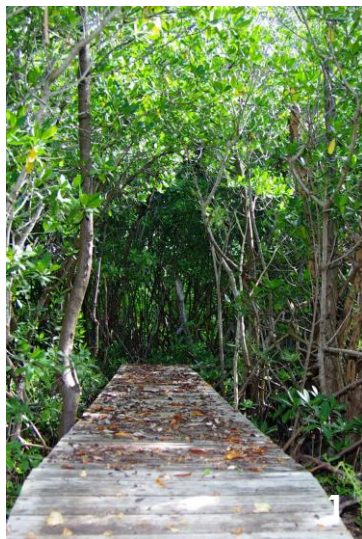
Source: JBNERR, Puerto Rico Planning Board.

JBNERR Trails

Within the Reserve's grounds, there are numerous trails that allow visitors to explore the terrain. The trails are marked with maps and signs. These trails are designed for diverse uses such as hiking, biking and kayaking.

During 2014, trail maps were prepared using Google Earth™. This allows users to access maps of the Reserve during non-working days and hours, and provide the option to download maps as pictures of kmz files. All of the Reserve trails were photographed by 360° street view and are available for viewing on the Google Earth platform and Google Street maps. Below is a description of the key elements of the Reserve's trail network:

Camino del Indio Trail and Boardwalk – Located in the Mar Negro Unit. This trail extends approximately for 4.7 km along the coastline on the western boarder of the Reserve, after which point it becomes a boardwalk extending for an additional 1.0 km. There is a small spur off the boardwalk in the south leading to an entry point for the kayak trail. The Camino del Indio trail and boardwalk provide access to diverse ecosystems such as coastline and mangrove. The trail head is located in the Las Mareas Fisherman Village, and is accessed via a dirt road extending from PR-3, west of the entrance to the Visitor Center. Upon reaching the village, but before the start of the trail-head, a small spur branching east off of the dirt road leads to an observation tower.



1. Entrance to the boardwalk in the Paseo del Indio trail

2. Observation tower located in Las Mareas Community

Source: Ernesto M. Olivares and Víctor Cuadrado

Jagüeyes Trail – The 0.75-mile (1.2-km) Jagüeyes Loop Trail borders farmlands on the north boundary of Mar Negro Unit and includes an observation platform. Named for the white jagüey tree, this trail passes through a secondary dry forest, mangroves, salt flats, and a seasonal lagoon. The seasonally dry lagoon provides a highly diverse and critical nesting habitat for an array of protected migratory shorebirds in the region. The trail is accessed by a dirt road extending from PR-3, west of the entrance towards the Jobos Bay Visitor Center.

Two boardwalks along the Jagüeyes Trail have been recently repaired between the Aguirre Power Plant in the East and Las Mareas neighborhood in the west, for a total of 95 m² (1024 feet²) of new boardwalk. The boardwalk was finished with the help of volunteers including the Education and Stewardship coordinators, as well as students of Mars Hill University in North Carolina, and the Metropolitan University in San Juan.



Jagüeyes trail

Source: Ernesto M. Olivares and Víctor Cuadrado

Wildlife Enhancement Ponds Trail (Artificial Pond)- Located in the Mar Negro Unit. Connecting from the Jagüeyes trail, this spur trail extends east and ends at the artificial pond where an observation tower has been constructed. Trail signage, observation tower, and access strategies (gates/balusters) will be included in the planning for this public access site.

Dock-Salt Flats Trail (El Salitral trail) – Located in the Aguirre Unit. This trail, or series of trails, extends from the parking lot just south of the Visitor Center. It begins as a small boardwalk that was installed next to the Visitor Center. The trail heads eastward toward the bay, crosses a dirt road, and continues through the brush and over the salt flats. Upon reaching the bay there is a small loop that passes by a wooden pier, a small shelter, and two spurs that connect to points of ecological interest.

The trail provides access to salt flats, mangrove ecosystems, lagoons, and the waterfront with views across the bay. Visitors can walk out over the water on the pier, which extends about 50 feet into the bay and serves as a docking point for boats. The ruins of the sugar mill are visible from this area, as well as the Aguirre power plant, providing important points of discussion in educational activities. There is signage along this section with maps. Another section of the trail extends northward as a bike/pedestrian path along the dirt road towards the old Train Depot.



1. El Salitral trail

2. Pier at the Jobos Bay (known as the research pier)

Source: 1. JBNERR 2. Ernesto M. Olivares and Victor Cuadrado

Sugar Mill Trail - Located in the Aguirre Unit, near the Reserve's research pier, this trail is frequently accessed by groups on educational field trips. There is an opportunity to connect the reserve with the Aguirre State Forest by extending this trail to the east along the footprint of the old railroad corridor.

Cayo Caribe Trail - Located on la Cabeza de Cayos Caribe, the 0.68-mile (1.1-km) trail is only accessible by water. Traversing mangrove forests, seagrass beds and coral reefs, the trail also highlights the barrier island coastal strand community. There is an observation tower that provides a vista of the local communities and the bay. This area is accessed by eco-tour operators, which assist with trail maintenance and site stewardship activities. No extensions of this existing trail are planned.



Sugar Mill trail

Source: JBNERR



Cayo Caribe trail

Source: JBNERR

Kayak Trail –The protected waters of Mar Negro provide opportunities for calm exploration. The Reserve's kayak trail begins in Las Mareas, and explores the many inlets and coves among the mangrove system. There are several possible routes based on the paddler's level of expertise that has not been assessed nor signalized.

Outside the Reserve's boundaries but inside the bay, more adventurous paddlers can explore a second route that extends from a parking lot in Aguirre, and parallels the northern coastline of Punta Pozuelo. This route, identified in the map as Aguirre kayak trail,

though protected somewhat by the land mass, is still in a zone of open water where there is more wind and current, making it a more challenging route. From this route kayakers can access and traverse the Cayo Caribe Trail.

Figure 29. Trails System in the Jobs Bay NERR



MAP KEY:

Jobs Bay National Estuarine Research Reserve

Proposed Land Boundary

Proposed Marine Boundary

Camino del Indio Trail and Boardwalk

Jagüeyes Trail

Jobs Bay Visitor Center Road

Old Train Depot Trail

Salt Flats Trail

Cayo Caribe Trail

Pond Trail

Salmarsh Trail

Aguirre Kayak Trail

Mar Negro Kayak Trail

Source: JBNERR.

10.2 Public Access Challenges and Opportunities

Challenges

There have been significant advances in access to and within the Reserve. These include access to new infrastructure, enhancement of the existing buildings, and promoting access among different users and the general public. Road access to the Reserve is good, but the lack of directional signage has been a problem. This is being addressed by the Director and Stewardship Coordinator, along the PRDNER and the Puerto Rico Department of Transportation and Public Works. A total of six signs will be installed in major roads to direct visitors to the Reserve.

Although the increase in visitors is positive, one of the major challenges facing the Reserve is the limited staff to receive and manage visitors. In addition, as previously indicated, the staff lacks enforcement capabilities, which is needed particularly in the Jobos Bay waters and cays.

Other potential challenge are the demographic changes. As previously discussed, the proportion of older people has been increasing in Puerto Rico and in the municipalities of Salinas and Guayama, where the Reserve is located. Changes in the demographic structure may also be considered when planning for access and visitor's experience.

The Reserve must also plan for new challenges posed by climate change. In the future, rising sea levels, storm surges, and a possibly increased frequency and intensity of storms and hurricanes may pose a threat to existing and planned public access points and infrastructure. For example, boardwalks and trails may be flooded by sea level rise. On the other hand, perception is a challenge that should not be ignored. Increases in mosquito-borne diseases may discourage visitor use.

Public Access Opportunities and the Visitor Experience

Over the next years, it is expected that there will be an increase in Reserve's visits resulting from outreach efforts conducted by all programmatic areas, and the improved exposure via the Web and social networks. The surrounding communities are seeing the Reserve as a resource to develop ecotourism businesses, and an agreement was signed with the PRDNER for such purposes as described in the Administrative Plan.

The Reserve will continue working with local communities and partners to accommodate and steer this growth in general attendance, while balancing the need for resource protection. The Reserve will focus on enhancing visitors' experiences and on expanding and improving existing access infrastructure. In some places, increasing visitors' numbers leads to decreasing satisfaction (Leung et al, 2015). This understanding must guide future plans for the Reserve that simultaneously take into account the expansion of attendance and the importance of maintaining a high level of visitor's satisfaction.

If visitors' experiences are well-managed, their visit can generate social, cultural, and economic benefits as well as an increase in the interest of protecting the area. However, without the proper control, the activities of visitors can cause a wide range of negative impacts including increased costs and lost opportunities.

10.3 Objectives and Actions

Objective 1. Establish a baseline to develop the necessary visitor control measures

1. Develop a carrying capacity study.

PRDNER Regulation No. 8013 requires a carrying capacity study prior to warrant a concession in natural protected areas. A carrying capacity study is needed to better monitor uses, permitted users, and resources and will help to mitigate the negative impacts of overuse by large groups arriving at the Reserve.

The study will serve to identify the maximum population size of visitors the Reserve can sustain on a given basis without negatively impacting its ecosystem, while maintaining a positive visitor experience. Such a study, if firmly grounded in accepted methodologies, will allow the Reserve to better justify increased monitoring of areas that are traditionally overused, such as the cays. In addition, as has been the case in other protected areas, this type of study will help determine if there needs to be a limit to the number of visitors accessing certain parts of the Reserve, especially in sensitive areas during fragile time-periods such as nesting, for example.

Objective 2. Enhance and improve trails connecting areas of interest in the Reserve

1. Re-route the south portion of the Jagüeyes trail.

The re-route of the south portion of the trail will be in about 470 meters (1540 feet). The actual path that borders the salt flats is demonstrating a good recovery of black mangrove trees that are currently closing up the existing trails. The new route is planned to run 20 meters inland to guarantee that it can remain open even during the rainy season.

2. Assess the difficulty levels of the Mar Negro kayaking trails.

The protected waters of Mar Negro provide opportunities for calm exploration. The kayak trails will be assessed based on their level of difficulty and whether they are appropriate for beginner, intermediate, or advanced kayakers. Materials illustrating the trails and their difficulty levels will be produced, as well as information on wind and current patterns, and ecosystems. In this way, visiting kayakers may choose routes most suitable to their experience level and interests.

3. Assess the feasibility of connecting the Jobos Bay NERR with the Aguirre State Forest

Currently there is a small trail in JBNERR that has the potential to connect with the Aguirre State forest along the footprint of the old railroad corridor. The area will be assessed to determine the feasibility of developing this trail, in order to connect the JBNERR trail network to the Aguirre Forest. The community is interested in restoring this trail. Support for this project may be sought through the *Rails to Trails Conservancy*.

4. Expand the Camino del Indio Trail and establish a kiosk and signage marking the trail

Currently at the end of Camino del Indio peninsula, a trail connects to Mar Negro on one side (eastern) and Mar Blanco the other side (western). The trail does not have a sign. The area is heavily impacted, and the mangrove forest has been partially cut. A welcoming kiosk will promote the adequate use of the area and will provide information to visitors.

FACILITIES DEVELOPMENT & IMPROVEMENT PLAN



11 Facilities Development and Improvement Plan



11.1 Purpose of Facilities

Since the publication of the last Management Plan, the Reserve has taken strides towards improving its facilities, an essential step towards providing the necessary infrastructure to support its programmatic goals and operational functions. The Reserve has developed a Facilities Master Plan to guide future developments. This Master Plan has drawn from prior plans that address facilities uses, including cost-benefit analysis relating to repurposing existing structures, versus constructing new ones. This document, essential in coordinating and executing facility improvements, includes an analysis of the historical background of the existing structures.

The Facilities Master Plan seeks to expand upon these current facilities by re-purposing several decaying historic structures that are remnants of the Aguirre Sugar Mill. This area has been zoned by the PRPB as a Historic District. This zoning code earmarks the Aguirre Sugar Mill properties for conservation and preservation due to the property's historic, architectural and cultural value. This classification guarantees its conservation as an important part of our cultural, urban and architectural heritage. Currently in a state of disrepair, many of these structures have the potential to complement the Reserve's existing facilities, while fulfilling the immediate and long-term needs of the Reserve's programs.

Given the history of the Aguirre area and the impact of the Sugar Mill on the local community, the Reserve has incorporated salvageable structures into its FMP, re-purposing structures to meet program needs, while retaining the historic essence. Creating a 'campus-like' atmosphere, the Reserve will connect the new or repurposed facilities with walking paths for non-motorized access throughout. For this management period, a high priority is to renovate the old plantation restaurant as an Education and Training Center. Developing this infrastructure will establish the Reserve as the Caribbean 'hub' for coastal research, education, stewardship, training and management information transfer, and dissemination.

Other opportunities include restoring the *cabañitas* behind the education center to support students and other users of the reserve who plan to stay for extended periods of time, renovating the building behind the visitor center for use for boat storage and maintenance area, a kiosk and signage marking the Camino del Indio Trail system and

providing a safe and inviting experiences for visitors, and expansion of trails and possible modifications to support elderly and disabled visitors.

The FMP was developed in collaboration with several academic institutions, whereby students have been incorporated in the design process. In this way, the Reserve seeks to take advantage of existing resources in order to explore the latest sustainable design technologies and principles. In addition, the collaborative design process engages academic institutions and future generations in caring for the future of the Reserve, thereby fostering citizens' interest from an early age and ensuring that the facilities reflect the needs of the communities who will be using them.

11.2 Description of Current Facilities

The existing facilities within JBNERR include the Visitor Center, offices, dormitories, a trail system, boardwalks, two docks, and a boat ramp. This section also describes existing vehicles and equipment available at the Reserve.

Facilities

Visitor Center Complex

The current facilities include a Visitor Center with exhibits, staff offices, a research laboratory, a small meeting room, kitchen, and dormitory facilities. It is a restored Club House of the Aguirre Sugar Plantation, which retains its historic architecture.

The dormitory facilities support 26 individuals (4 rooms @4 beds/room, 4 rooms @ 2 beds/room and one room with a full bed), and have been renovated to include a second story expansion of the original basic dormitory. The renovations were completed in December 2016 and the new facilities provide a more comfortable long-term place for researchers and students to stay overnight. The renovated dorms also include a living room, student lab, laundry facilities, and a kitchen.

The Visitor Center has also been renovated to increase the number of office spaces and to provide a small conference room to handle meetings. The current library has been divided in order to make room for offices. It was relocated in the reception of the Visitor Center. The size of the conference room is too small for meetings of greater than 8 people.

The Visitors' Center includes numerous stationary exhibits. Interpretive exhibits in the 2,800 square-foot space were refurbished, including interactive displays, photos, a watershed model, coral reef dioramas, and pictorial exhibits of key ecosystems, resources and the cultural history of Aguirre. School groups have contributed to the creation of some exhibits. There are opportunities to further enhance the exhibits and create a reception area.

Adjacent to the Visitor Center, there is a small parking lot that supports staff and visitor vehicles, Reserve's vehicles, boats, and trailers. In addition, there is a boat ramp, a dock and a gazebo in close proximity to the Visitor Center that are used by the Reserve's staff and visitors. The parking lot is often over capacity and is not large enough to handle the number of cars during reserve events.



1. Visitors' Center
2. The gazebo, which is located near the Jobos bay, is used as a meeting space
3. Students preparing materials for the exhibits during the Migratory Birds Festival in 2015

Source: (1)Ernesto M. Olivares and Víctor Cuadrado (2,3) JBNERR

Old Train Depot

The Aguirre Train Station Building was rehabilitated. The historic Train Depot terminal is located at what will become the new entrance to the Reserve Campus as indicated in the Facilities Master Plan. The purpose of the building is to serve as a Center for Resilience Education.

However, this building is not currently used because it lacks electric and water utilities, as well as a bathroom. The facility use permit is conditional upon the installation of electricity and the bathroom.



Old Train Depot

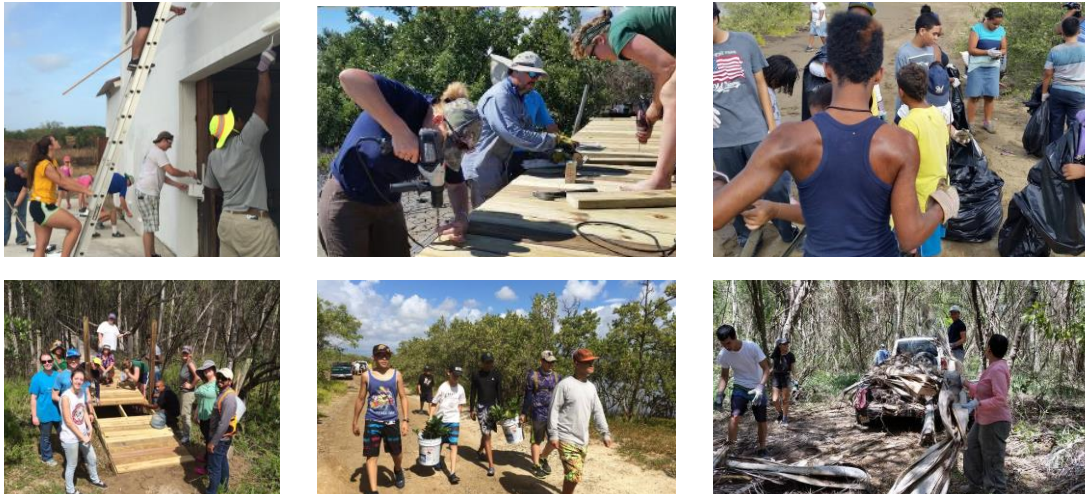
Source: Jobos Bay NERR Staff

Maintenance

Facilities are developed and maintained as deemed necessary for to the operations of the Reserve and based on the needs of visitors and staff. The Reserve has one groundskeeper to maintain the existing facilities. He maintains the landscapes around the Reserve's facilities.

The PRDNER administration has incorporated JBNERR facilities in a cleaning services global contract. The private company hires a maintenance technician that provides twenty hours of weekly janitorial work at the visitors' center and dormitories

In addition, the Reserve staff has been very successful in recruiting volunteers and boy and girl scouts for maintenance and repair of boardwalks, trails, facilities, gardens, and exhibits.



The number of volunteers who offer support for maintenance of the Reserve's facilities has increased substantially during the past management period

Source: JBNERR Staff

Figure 30. Map of Facilities Locations



MAP KEY:

Jobos Bay National Estuarine Research Reserve

Proposed Land Boundary

Proposed Marine Boundary

Jobs Bay Visitors Center Complex

Dock

Parking

Boat ramp

Gazebo

Old Train Depot

Observation Tower

Las Mareas Fishermen Village

Artificial Pond

Source: JBNERR, Puerto Rico Planning Board.

11.3 Facility Challenges and Gaps

The facilities within the Reserve will continue to experience stressors not only from the changing environment, but also from human populations as well. While the Reserve is already experiencing many environmental and anthropogenic stressors, it is taking steps to enhance its infrastructure to be more resilient, as described in upcoming sections.

Long-term environmental stressors include events such as flooding due to rising sea levels, increased temperatures, increased frequency of storms and extreme climate events. As previously described, sea level change would impact many areas of the Reserve, except the Visitor Center Complex at the Aguirre Unit.

Anthropogenic stressors include vandalism and destruction and/or theft of property and equipment, and human-induced fires. Exposed equipment and surveillance equipment is particularly vulnerable to vandalism and theft, and has been targeted in the past. Finally, as many of the buildings in the Reserve are or will be repurposed structures from the Aguirre Sugar Plantation, the age of the infrastructure must be considered.

Current facilities have also been found inadequate to accommodate all of the Reserve's programmatic, operational, and functional needs. Problems include the lack of operational and support space. These problems are exacerbated by the fact that an increasing number of institutions are interested in the Reserve as a research station. In the past few years, the number of visitors and researchers coming to the Reserve has increased. The new dormitories have generated expectations for the future of the Reserve. With better lodging capabilities, the Reserve will enjoy a higher participation of professors and students from different universities using the facilities for academic purpose. Additionally, the Reserve has been successful at recruiting volunteers in the past few years, and there has been an increase in the number of workshop and conference attendees. While improvements provide increased access to visitors, and the new dormitories have greatly improved the ability of the Reserve to host researchers, additional improvements are required to numerous facilities.

11.4 Planned Facilities

As mentioned in the Education Plan (specifically Objective 4, Action1), indoor and outdoor educational exhibits and signage will be updated and enhanced. This includes integrating interactive indoor exhibits in the Visitor's Center, and modernization of outdoor signage.

Planned long-term improvements include many additional expansions that are described in the Facilities Master Plan. A feasibility component within the Facilities Master Plan evaluates the potential uses for existing structures, and provides a cost-benefit analysis comparing the use of existing infrastructure versus constructing new facilities. The

Plan identifies priority needs, opportunities, limitations and timing of construction, as well as cost estimates.

Climate and Non-Climate Stressors

The Facilities Master Plan considers the impacts of climate change, and the development of resilient structures that are efficient and sustainable. The plan is based in background studies, including an energy and water audit of current and anticipated facility use, sustainable energy and design options, and a model for carbon footprint determination to guide sustainable engineering designs. New or restored facilities at JBNERR will be based on the following guiding principles:

- All facilities and infrastructure will be designed or enhanced with green building design concepts, to the extent possible.
- Buildings and the surrounding landscape will be constructed to be as close to carbon neutral or carbon negative as possible.
- The historic character of the structures will be maintained to the greatest extent possible in consultation with the PR State Historic Preservation Officer

As mentioned previously, an energy and water audit was completed on existing facilities. The audit lists recommendations to optimize the use of space and resources such as water and energy. In the past year, all lightbulbs were changed for more efficient LED bulbs. The renovated dormitories are equipped with solar panels, and air conditioning units have been replaced by inverters to save energy and costs. In addition, water-saving taps have been installed on all faucets and showers. These upgrades are consistent with the Reserve's policies to implement sustainable designs in all of its existing and future facilities. In addition, the fact that the buildings are all made of reinforced concrete makes them resilient against impacts such as hurricanes winds.

The Reserve has established several partners that are essential to executing the facility plans, maintaining upgrades, and ensuring systems and improvements remain efficient and relevant. Inclusive planning can result in partnerships for funding opportunities, as well as sustained use of the facilities for the long-term.

11.5 Objectives and Actions

The Reserve Director will seek to improve and expand existing facilities and continue reorganizing space in order to streamline operations and increase efficiency. The two priority projects for the next five year period are the following:

Objective 1. Renovate and enhance existing structures and provide tools to meet the education and training needs of the Reserve

1. Rehabilitation of the former hotel's restaurant into the Education and Training Center

The remains of this historic structure will be transformed into the Reserve's Education and Training Center. The Center will contain classroom and lab space, and will host workshops. The space will be used for training and education. The total programmed area is 2,875 sf. The architectural plans for the Center are currently being developed.

2. Complete the transformation of the old plantation Train Depot into the Climate Change Resiliency and Community Meeting Center

The transformation will be completed by installing bathrooms, electricity, and exhibits. The focus of the Center will be on climate change adaptation and resiliency strategies, geared towards local schools and communities. The building will be used as a center for meetings and workshops, and will be instrumental to achieving the Reserve's goal of becoming a hub for resilience education. Service-learning teams will help refurbish the facilities in and around the center, including the rain gardens, rain barrels, and water harvesting elements.

In addition, there will be spaces available for community use (e.g. for renting kayaks and bicycles). The building is connected to the Visitors' Center and the Reserve trails via a bike path. As mentioned, the building requires some upgrades to become fully functional, including the installation of electricity and a bathroom.

3. Acquire an additional vessel

A vessel is needed to support various programmatic areas, especially the Education Program. It will be used as part of the educational activities such as transporting students participating in camps, teachers participating in TOTE workshops, and visitors to the Reserve needing to tour the area for educational purposes.

4. Build a kiosk and enhance the Camino del Indio trail

A welcome kiosk and an enhancement of the Camino del Indio trail will increase visitors interest in doing hiking, kayaking and enjoying the waters of Mar Blanco. The community will take advantage of the site to promote the adequate use of the area, and also is expected that illegal activities will be reduced by this action.

5. Updated exhibits and welcoming area in the Visitor Center

Currently, there is a small conference room area imbedded with the footprint of the Visitor Center exhibits. A new welcoming area will be developed and exhibits will be updated and re-organized. The new exhibits will focus on the Reserve's priority issues, providing information based on the coastal resources within the Reserve and the NERRS programs. Some of the exhibits will be animated to show habitat changes over time and predicted watershed/land use changes.

Objective 2. Renovate and enhance existing structures to provide facilities to meet the needs of the Administrative and Research programmatic areas.

1. Restore two cabins (cabañitas) for long-term housing or faculty housing

Two cabins are localized north of the dormitories. The distances between buildings brings the opportunity to restore the spaces for a long-term housing or a faculty housing. Each one has sufficient area to have two living space with a living/dining room, kitchenette, bedroom, a bathroom and closet.

2. Renovate one of the buildings for enforcement staff

One of the building within the Reserve's premises is owned by the Puerto Rico Land Authority. The Reserve will coordinate with this agency to request the ownership's transference to the PRDNER. The structure will be assessed, and if it is in good condition, it will be re-purposed to provide an office for the Rangers, in order to increase surveillance at the Reserve.

3. Renovate the long house for boat storage and maintenance shop

This refers to a structure, behind the Visitor Center area, that requires renovation. An office space for maintenance staff and workshop will be incorporated. The structure will shelter the fleet under a roof, and will provide a safe facility for equipment and operations.



LAND ACQUISITION & BOUNDARY EXPANSION PLAN



12 Land acquisition and Boundary Expansion Plan



12.1 Acquisition Values

The Reserve must continue to acquire lands to further protect and enhance the natural and cultural heritage of the estuary, by creating habitat and migration corridors for species. Acquisitions are important for monitoring and research as it will allow for more expansive investigation of the Reserve's ecosystems and hydrological attributes, in a summit to sea environment. While surrounding developments may prohibit this broad acquisition, small expansions over time greatly contribute to the research potential in the Reserve, making it more attractive for interested institutions. Furthermore, acquisitions allow the Research Program to further study restoration and adaptation in the face of climate change.

Increased public access through acquisitions will also aid education, training and stewardship programmatic areas. As climate change increases pressures on natural resources, new land acquisitions become essential to the long-term protection of the estuarine and coastal resources, the development of migration corridors for vulnerable and endangered species, and the promotion of the Reserve's values.

Over the past years the Reserve has acquired five properties. These purchases provide the Reserve with greater control over its resources and much-needed direct access to the Jobos Bay waterfront. These properties are targeted for inclusion in the boundary as part of a boundary expansion action that will occur within a year of approval of this plan.



In Puerto Rico, forested coastal wetlands occur in small patches. According to Christopher et al., (2015) many of the guilds of birds that occupy coastal wetlands also utilize upland coastal hills as well. Therefore, when thinking about conservation of wetland species is important to consider the value of a landscape-scale strategy that links together the matrix of coastal and inland habitats.

Christopher et al., 2015

Figure 31. Acquired lands 2000-2016



MAP KEY:

Land Acquired During Last Management Plan

	Name	Acreage	Name	Acreage
1	El Batey de Aguirre	103	3	El Salitral
2	Jaguey Forest	26.4	4	Cayos de Barca
			5	Cayo de Pájaros



Source: Jobos Bay National Estuarine Research Reserve.

12.2 Boundary Expansion Areas

Descriptions of Properties that will be included in the boundary expansion

Several areas have been identified for future acquisition and ultimate inclusion in the Jobos Bay NERR proposed boundary. These cays and coastal habitats provide critical upland, wetland, and fringe habitats for several protected species, including a variety of wading and shorebirds, as well as the Antillean manatee. In addition, the acquisition of cays will complete comprehensive Commonwealth ownership of the cays' chains, ensuring the holistic management and enforcement of long-term resource protection plans.

The mainland components are either in-holdings or located along the Reserve's current boundary. There are many areas that have been identified for future acquisition. A number of the suggested sites will offer greater protection to sensitive habitats, while others will become invaluable in providing access and support for Reserve activities and program development. Examples of these include the remaining parcels of Cayos de Barca, a mangrove forest by Mar Negro, and a parcel behind the Visitor Center, known as Sucesión Vázquez. These are described as follows:

Cays' Components

The cays identified below consist mainly of red and white mangrove fringe, with limited coastal strand communities in the interior.

- Cayos Caribe, east end of island chain.
- Cayos de Barca parcels, east and west end.

Once acquired, all, except one of Cayos de Barca, will become core areas. As a management approach, one of the islands of Cayos de Barca will serve for passive recreation, while the others will become reference sites for research and education. Interpretative field trips will be facilitated within the Cayos de Barca and long-term monitoring programs will be encouraged within these islets to monitor use impacts.

Mainland Components

The mainland components identified below consist of red, black, white and buttonwood mangrove forest, subtropical dry forest, and coastal bluff habitats. At this time, the parcels remain undeveloped or unoccupied. As discussed in the Land Use section, these areas have been classified by the PRPB as "specially protected rustic lands", which means that these are not available for present or future urban developments.

These lands, described as follows, will be classified as buffer areas:

- Forested in-holding on the north and east proposed boundary, behind Visitors' Center- Sucesión Vázquez
- Forested in-holding on north proposed boundary of Aguirre Unit – Land Authority (buffer)

Coastal forest parcels, north and east of the Mar Negro Unit – PREPA, will be classified as core area as the rest of the Mar Negro Unit.

Several parcels along the north boundary of Mar Negro, predominantly secondary dry forest, are currently property of the PRLA and present an opportunity for inclusion in the Reserve's boundaries as core areas. Research by Rodríguez (2012) reported that several species of migratory birds, predominantly warblers, move between mangrove night-roosts and daytime foraging habitat in dry secondary forest. These results underscore the importance of secondary dry forest to this avian guild, despite the preference by most species for mangroves as nighttime roosts.

Figure 32. Proposed acquisitions



MAP KEY:

Jobos Bay National Estuarine Research Reserve

- Proposed Reserve Boundary
- Proposed Marine Boundary

Acquisition Opportunities

ID Name	ID Name
1 Cayo Barca A-B	4 PREPA Buffer
2 Cayo Barca G	5 Sucesión Vázquez-Bruno
3 Land Authority Buffer	



Source: Jobos Bay National Estuarine Research Reserve.

Prioritization Process and Criteria for New Aquisitions

The Reserve will prioritize acquisition of the Sucesión Vázquez parcel to facilitate public access, facility construction, and coordination between the JBNERR and the Aguirre Forest. The mainland Sucesión Vázquez parcel, located behind the Visitor Center, will provide numerous benefits for the Reserve as it develops into an integrated management component with the Aguirre State Forest. This parcel, dominated by Scrub-Scrub wetland, will serve as an ecological corridor, by connecting the JBNERR to the Aguirre State Forest. This will facilitate the coordination of education and public access strategies between the two natural areas. This acquisition will augment the Reserve's habitats with their diversity of flora and fauna and serve as buffer areas to Jobos Bay. This parcel, besides being a valuable addition to JBNERR, would contribute to preserving the unique habitats of the South coast of Puerto Rico.

The document "Avian Conservation Planning Priorities for Puerto Rico and the US Virgin Islands" identifies as a habitat conservation opportunity, expanding conservation protection around existing natural areas and establishing corridors among them and between adjacent habitat types. In the South coast of Puerto Rico, this plan identifies that there are habitat opportunities around the Jobos Bay NERR and Aguirre State Forest (Christopher et al., 2015).

Priorities will also be given to the remaining Cayos de Barca. In addition to their ecological value, the cays remain high priority for acquisition due to recreational impact, as there is no management of these habitats. There are pressures on the mangroves, coral reefs, and sea grass habitats, which are additional issues of great concern.

However, is important to note that the opportunities for land acquisition do not always align with the Reserve's highest priorities. Therefore, Jobos Bay will act to purchase any parcel identified in this plan, either through a fee simple acquisition process or through a conservation easement as they become available.

Acquisition Strategy

The following table provides information related to these properties and an estimated cost, using as comparable the transaction through which Cayos La Barca were acquired.

Table 11. Priority Acquisition Areas

Property Name	Title Owner	Total Area (acres)	Upland Area (acres)	Estimated Cost	Status	
					PRDNER priority	Willingness
Priorities during the next management period						
Sucesión Vázquez-Bruno	Private	72	0	\$1,207,440.00	high	No sell Yes- Conservation Easement
Cayo Barca A-B	Private	57	4.2	\$955,890.00 ¹⁷	medium	Yes
Acquisition areas for future management periods						
Cayo Barca G	Private	8	1.7	\$134,160.00	medium	Unknown
Land Authority Buffer	Commonwealth	78	78	Settlement	medium	Unknown
PREPA Buffer	Commonwealth	75	75	Settlement	high	Unknown

12.3 Objectives and actions

Objective 1. Acquire two properties to support programmatic areas and to expand wildlife corridors

1. Acquire property in the eastern portion of Cayo de Barca (A-B).

In March 2014 the PRDNER and the USFWS published a document describing the Settlement Offer for Compensating for Natural Resource Losses Resulting from the 2007 Guánica Oil Spill. Funds from the *Settlement* have been earmarked for the acquisition of Cayos de Barca, Cayos A&B.

¹⁷ The acquisition cost for this property was indicated in the Settlement Offer for Compensating for Natural Resource Losses Resulting from the August 2007 Guánica Oil Spill, March, 2014.

2. Acquire Sucesión Vázquez-Bruno property adjacent to the Visitor Center.

The PRDNER is working to determine if additional funds from the settlement offer could be used to acquire Sucesión Vazquez lands that will connect the Aguirre forest to the JBNERR.

Objective 2. Diversify funding sources and partners for future acquisitions

1. Continue exploring potential funding sources and partners for future acquisitions

The PRDNER has identified future acquisitions and will take advantage of opportunities as they become available. The identification of different funding sources and partnerships for future acquisitions will be a continuous tasks during the next management period, given the current fiscal constraints. The following laws and mechanisms will be considered:

- The Puerto Rico Land Acquisition and Conservation Fund Act, Law Num. 268 of 2003 establishes a permanent, dedicated funding source for land conservation and, specifically, the acquisition and conservation of lands with ecological value in Puerto Rico. Funds are administered by the PRDNER and lands are acquired on the basis of recommendations from an advisory group.
- Another option that will be explored is the protection of lands as part of compensatory mitigations required under the New Wildlife Act of Puerto Rico Law Num. 241 of 1999, as amended and its Regulation Num. 6765. This law and regulation are administered by the PRDNER.
- Other programs such as the Forest Legacy (USFS) and the National Coastal Wetlands Conservation Grant Program (USFWS), represent potential sources of matching funds for conservation parcels.
- Fee simple acquisition – using a combination of Commonwealth funds, NOAA acquisition funds, and competitive grant sources – will result in system-wide management and additional buffer areas to protect the core resources of the Reserve.

Objective 3. Modify Reserve's boundaries to include previously acquired parcels and the Jobos Bay proper

1. Submit the boundary amendment as per 15 CFR 921.33

During the next management period, the Reserve's staff will work with NOAA to amend boundaries following requirements set forth in 15 CFR 921.33. Boundary modifications will include: land that have been acquired by the PRDNER, boundaries that have been clarified and coastal waters.

RESTORATION PLAN



13 Restoration Plan



13.1 Description of Restoration Areas and Accomplishments

During the last management period, several habitat enhancement projects have been completed. Seagrass beds in Cayos Caribe have been restored. This project was one of the JBNERR Coastal Zone Management Act (CZMA) §312 Final Evaluation Recommendations, which addressed the degradation of submerged resources in Cayos Caribe. A pilot study for the restoration of seagrass in selected prop scar damaged areas was implemented in 2006, conducting a workshop as a training opportunity for natural resource managers throughout Puerto Rico. Buoys were also installed to delineate a navigation channel. Moreover, a seagrass restoration in two sites at Cayos de Barca has been initiated.

The Reserve also addressed the CZMA §312 Final Evaluation Recommendation which involved encroachment by the PRLA on the north boundary of Mar Negro. This north boundary was severely impacted in 1993 when lands managed by the Puerto Rico Land Authority (PRLA), including mangroves in the Reserve, were illegally bulldozed to drain leased agricultural fields to the north. The USEPA issued a Consent Order in 1997 that required the PRLA to restore the mangrove habitat and create an agricultural buffer strip with plants that will effectively uptake nutrients that would otherwise flow into Reserve's waters. In 2008, the wetland remediation and restoration were completed on the aforementioned parcels. The mangrove buffer has been restored and the Reserve collaborated with NRCS to determine suitable plant material and design for the buffer zone. The Consent Order was completed in 2011.

The Reserve has engaged communities and NGOs in habitat enhancement projects. For example, Boy Scouts have been engaged in helping to recover mangrove seedlings in Las Mareas community near a boat ramp, that were in danger of being affected by boaters. Over 300 red mangrove seedlings were planted and a cleanup of the area was performed.



Volunteers have been key in recent restoration projects in Mar Negro and Aguirre Units



Other volunteers helped restoring the areas in the Aguirre Unit affected by the human induced fires.

13.2 Objectives and actions

Objective 1. Carry out habitat enhancement projects to benefit resident and migratory bird populations.

1. Carry out the Fish and Wildlife Habitat Enhancement project in the Mar Negro Unit.

The Mar Negro Unit will be the priority for habitat enhancement during the next planning period. This project will be located in an existing artificial pond and an adjacent disturbed area, originally constructed to filter water discharged from the Aguirre power plant.

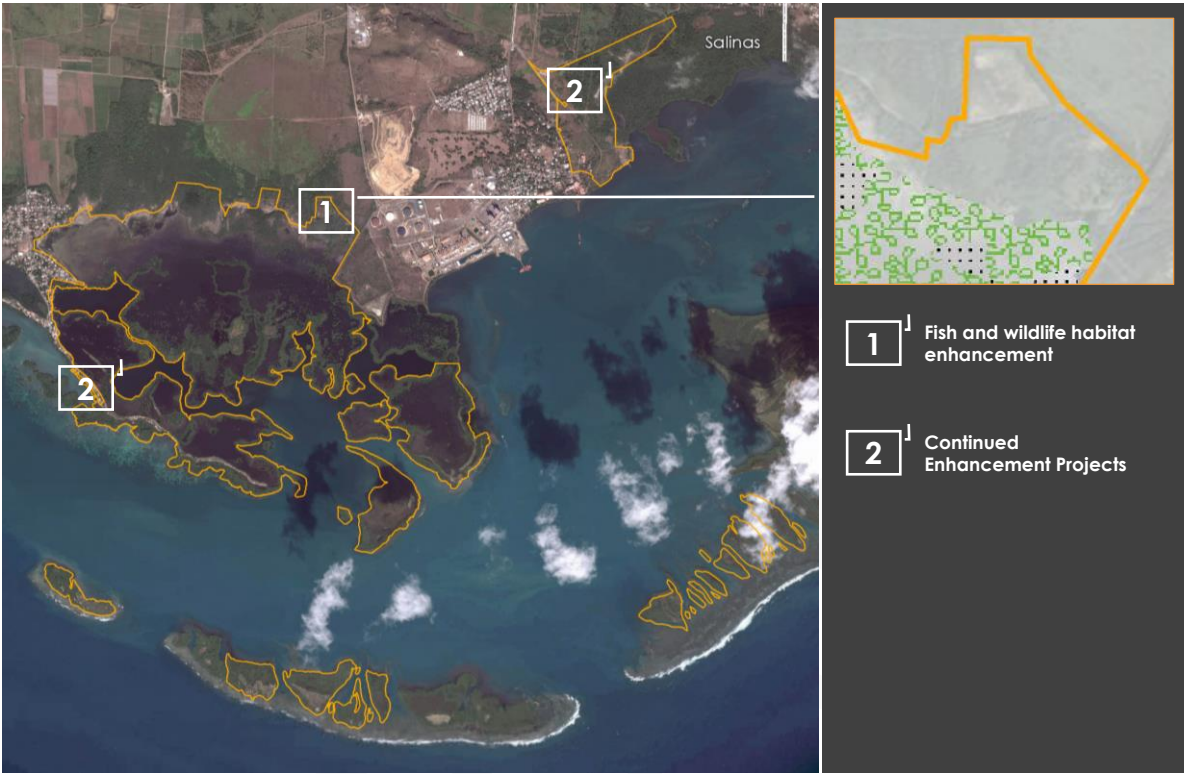
The pond is to be filled with excess water from the PREPA irrigation canals, considered non-contaminated water. With the shallow depth providing excellent avian forage habitat, observations at the constructed pond have shown the highest wading and coastal bird diversity in the area.

Given that this pond-type habitat is limited, the Reserve will evaluate further habitat enhancement for these resident and migratory bird populations.

2. Continued habitat enhancement projects in the Aguirre and Mar Negro Units

Enrichment planting will be a continued project in the disturbed lands in the Aguirre Units. This will be conducted with native species appropriate to its habitats. In addition, restoration of mangroves will be a continued task during the next management period. The Reserve staff will continue seeking volunteer collaboration to carry out this task.

Figure 33. Habitat enhancement projects in the Jobs Bay NERR



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