
# MANAGEMENT PLAN
# FINAL
# 2010-2015

The Puerto Rico Department of Natural and Environmental Resources, Jobos Bay National Estuarine Research Reserve is part of the National Estuarine Research Reserve System (NERRS), established by Section 315 of the Coastal Zone Management Act, as amended. Additional information about the System can be obtained from the Estuarine Reserves Division, Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, US Department of Commerce, 1305 East West Highway – N/ORM5, Silver Spring, MD 20910.

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This management plan has been developed in accordance with NOAA regulations, including all provisions for public involvement. It is consistent with the congressional intent of Section 315 of the Coastal Zone Management Act of 1972, as amended, and the provisions of the Puerto Rico Coastal Management Program (1978).

## Acknowledgements

In recognizing the hard work and dedication of an excellent group of people I can only think of how privileged I am to be a part of this extraordinary System that comprises the National Estuarine Research Reserves. Thanks to the support of NOAA's Estuarine Reserves Division and to the unconditional commitment of Ms. Nina Garfield, our Program Specialist, Jobos Bay National Estuarine Research Reserve presents this Management Plan for the period of 2010 to 2015. On behalf of the Jobos Bay Reserve Staff, we dedicate this accomplishment to her and, by doing so, express our greatest gratitude and admiration.

To the Reserve Staff, Mr. Luis Encarnación, Mr. Angel Dieppa, Mrs. Sandra Lebrón, Mrs. Lillian Ramirez and Mrs. Nilda Peña, I extend my gratitude and acknowledgement for their enthusiasm, wisdom and perseverance. Thanks to their vision, this plan contains remarkable ideas, suggestions and desires that will be of great importance as Jobos Bay NERR moves forward into the next five years.

Our special thanks to Dr. Alida Ortiz, Dr. Manuel Valdez Pizzini and Mrs. Judy Haner, who guided the process, evolution and edition of this document. I also want to express our gratitude to Mrs. Damaris Delgado, Director of the Bureau of Coasts, Reserves and Refuges, as well as the other Department of Natural and Environmental Resources personnel, who assisted in reviewing and commenting on various drafts of this document.

Many others have made possible the completion of this Plan; some have contributed formally and many others informally. While I would like to mention all of the names, I do not want to inadvertently miss any of the outstanding contributors. So, thank you to all who, at some stage of this process, helped us achieve our goal.

Last, but not least, I would like to express my gratitude to life, for allowing me the honor of guiding the ideas and projects contained in this Jobos Bay NERR Management Plan.

Carmen. M. González
Reserve Manager

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## ACRONYMS

| | |
|---|---|
| ARRA | American Recovery and Reinvestment Act |
| AES | Allied Energy Services |
| BMPs | Best Management Practices |
| CaRA | Caribbean Regional Association |
| CariCOOS | Caribbean Coastal Ocean Observing System |
| C-CAP | Coastal Change Analysis Program |
| CDMO | Centralized Data Management Office |
| CEAP | Conservation Effects Assessment Project |
| CFR | Code of Federal Regulations |
| CO-OPS | Center for Operational Oceanographic Products and Services |
| CTP | Coastal Training Program |
| CZMA | Coastal Zone Management Act |
| EQB | Environmental Quality Board |
| FGDC | Federal Geodetic Control Subcommittee |
| GIS | Geographic Information System |
| GRF | Graduate Research Fellowship |
| HADS | Hydrometeorological Automated Data System |
| ISAT | Impervious Surface Analysis Tool |
| JBNERR | Jobos Bay National Estuarine Research Reserve |
| LIDAR | Light Detecting and Ranging |
| MOU | Memorandum of Understanding |
| MPA | Marine Protected Area |
| NCERT | National Coastal and Estuarine Research and Technology |
| NCCOS | National Centers for Coastal Ocean Science |

| | |
|---|---|
| NEMO | Nonpoint Education for Municipal Officials |
| NERR | National Estuarine Research Reserve |
| NGO | Non-Governmental Organization |
| NGA | National Geodetic Survey |
| NOAA | National Oceanic and Atmospheric Administration |
| NRCS | Natural Resources Conservation Service |
| N-SPECT | Nonpoint Source Pollution and Erosion Comparison Tool |
| OCRM | Ocean and Coastal Resource Management |
| PRCZMP | Puerto Rico Coastal Zone Management Program |
| PRDNER | Puerto Rico Department of Natural and Environmental Resources |
| QA/QC | Quality Assured / Quality Controlled |
| SAV | Submerged Aquatic Vegetation |
| SWAT | Soil and Water Assessment Tool |
| SWMP | System-Wide Monitoring Program |
| UPR | University of Puerto Rico |
| US EPA | US Environmental Protection Agency |
| USVI | US Virgin Islands |
| VIMS | Virginia Institute of Marine Science |

# EXECUTIVE SUMMARY

## Background

The Jobos Bay National Estuarine Research Reserve (Jobos Bay NERR), located in Aguirre along the southeast coast of the island of Puerto Rico, is managed by the Puerto Rico Department of Natural and Environmental Resources. Encompassing vast mangrove forests, seagrass beds and coral reefs, the Reserve is home to 8 species of mammals, 106 species of birds, 12 species of reptiles, 4 species of amphibian, and numerous species of fish, marine invertebrates and plants. The Puerto Rico Department of Natural and Environmental Resources (PRDNER), in cooperation with the National Oceanic and Atmospheric Administration (NOAA), designated Jobos Bay in 1981 as one of 27 National Estuarine Research Reserves.

The mission of Jobos Bay NERR is to *practice and promote coastal and estuarine stewardship through innovative research, monitoring, education, training and community involvement at the Jobos Bay NERR.* With this revised plan, Jobos Bay NERR will coordinate research, education and training within the 3,299.90 acre Reserve and influences activities within its 34,000-acre (137-km$^2$) watershed.

Reserves are required to update their Management Plans every five years to reflect additions, deletions or changes in program direction. The Reserve has accomplished the majority of the Research and Education goals identified in the former Plan and has moved forward with additional programmatic growth. The time is ripe for this Management Plan revision which focuses reserve programs on emerging coastal management priorities.

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

- **Climate change**, in terms of the effects of sea level rise and temperature change on mangrove forests, seagrass beds, coral reefs and coastal population centers;
- **Watershed land use impacts** on coastal communities and reserve ecosystems from agricultural, residential and industrial development resulting in: 1) nutrient inputs to groundwater, which may contaminate the local drinking water supply and contribute to eutrophication in the bay and 2) flooding in low-lying communities bordering the bay, restricting access for emergency responders and transporting sediment, which causes increased turbidity and impacts to seagrass beds and coral reefs;
- **Ecological integrity**, especially how degraded ecosystems affect coastal communities through increased storm impacts and reduced habitat for commercial and subsistence fisheries; and,
- **Resilience of coastal population centers** to withstand storm events, flooding impacts, reduced fishing opportunities and climate change.

These issues affect not only the Reserve proper and its adjacent communities, but are also relevant to Puerto Rico and the broader Caribbean. Thus, Jobos Bay NERR will work to affect change through research, education, stewardship and coastal training within three 'spheres of influence' in Jobos Bay and its adjacent watershed, Puerto Rico and the Caribbean.

With four overarching goals, each program chapter identifies specific objectives, strategies and measures of success to address these issues in one or more 'spheres of influence'. The strategies have been nested into programmatic Action Plans and linked to coordinated timelines for implementation.

This plan also modifies the former Reserve boundary from 2,883 to 3,299.90 acres, incorporating 416.90 acres, resulting from the acquisition of four new areas known as: Cayos de Barca (4 islets), El Salitral Las Mareas, Secondary Forest Land Authority, and Hacienda El Batey de Aguirre. These newly incorporated units have adequate Commonwealth protection of natural resources to support the mission of the reserve.

By actively using this Plan to guide the Reserve, Jobos Bay NERR will become a more effective resource for NOAA, PRDNER, and scientific, education and management communities to address issues throughout the Caribbean region.

*For copies of the Jobos Bay NERR Management Plan, please call 787-853-4617 or visit our website at www.jbnerr.org.*

## 1.0 INTRODUCTION

In 1981, the National Oceanic and Atmospheric Administration (NOAA) designated Jobos Bay a National Estuarine Research Reserve (NERR). Jobos Bay NERR is the only Reserve in Puerto Rico and the greater Caribbean, and is one of two Reserves representing the West Indian Biogeographic Region. Located on the southeast coast of Puerto Rico, Jobos Bay NERR formerly comprised 2,883 acres of coastal ecosystems and with this revision will expand its boundaries to encompass 3,299.90 acres. The habitats within the reserve boundaries include mangrove forests, salt flats, coastal strand, beach dunes, seagrass beds, algae beds and coral reefs. These coastal resources are surrounded by the local communities of Las Mareas, Coqui and Aguirre in the municipality of Salinas and the communities of Puerto de Jobos, Pozuelo and Puente de Jobos in the municipality of Guayama.

The Jobos Bay NERR is administered through a partnership between NOAA's Estuarine Reserves Division and the Puerto Rico Department of Natural and Environmental Resources (PRDNER). Many other partner agencies and organizations that assist the Reserve's program implementation are identified throughout the plan. This revised Management Plan will diverge from the previous plan by (1) expanding Reserve boundaries to encompass new acquisitions (2) addressing climate and anthropogenic impacts on coastal ecosystems and coastal communities, (3) addressing the historic facilities that dot the Reserve landscape (many of which are in disrepair), and (4) planning for improved facilities to support Reserve programming. The Plan identifies measurable outcomes in three spheres of influence: 1) the Reserve and its local and adjacent watersheds; 2) the Commonwealth of Puerto Rico; and, 3) the broader Caribbean bioregion. The outcomes reflect four overarching goals mirroring the priorities of the NERR System and PRDNER, with the action plans identifying program specific strategies for achievement.

### 1.1 National System

The Jobos Bay NERR is part of the National Estuarine Research Reserve System (NERRS). The National Estuarine Reserve System was created by the Coastal Zone Management Act (CZMA) of 1972, to provide a network of protected areas established to promote informed management of the Nation's estuaries and coastal habitats. The Reserve System currently consists of twenty-seven (28) reserves in twenty-two (23) states and territories, protecting over one million acres of estuarine lands and waters. The Estuarine Reserves Division (ERD) of the Office of Ocean and Coastal Resource Management (OCRM) administers the Reserve System, working with state partners to establish shared priorities and system-wide programs. NOAA provides financial support for the day-to-day management of site resources, technical assistance and coordination of nationally significant and locally relevant programs for the individual reserves.

<u>Mission</u>
As stated in the NERRS regulations, 15 CFR Part 921.1(a) (Appendix 1), the National Estuarine Research Reserve System mission is:

> *To promote the establishment and management, through Federal-State cooperation, of a national system of Estuarine Research Reserves representative of the various regions*

*and estuarine types in the United States. Estuarine Research Reserves are established to provide opportunities for longterm research, education and interpretation.*

Goals

Federal regulations, 15 CFR Part 921.1(b), provide 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.

### 1.1.1 National Estuarine Research Reserve System Strategic Goals 2005 – 2010

The Reserve System began a strategic planning process in 1994 in an effort to help NOAA achieve its environmental stewardship mission to 'sustain healthy coasts'. In conjunction with the strategic planning process, ERD and reserve staff have conducted a multi-year action planning process annually since 1996. The resulting three-year action plan provides an overall direction for the Reserve System. As part of this process, the Reserve System developed a vision:

*Healthy estuaries and watersheds where coastal communities and ecosystems thrive*

and mission:

*To practice and promote coastal and estuarine stewardship through innovative research and education, using a system of protected areas*.

The following goals are outlined in the 2005-2010 Strategic Plan:

1) Strengthen the protection and management of representative estuarine ecosystems to advance estuarine conservation, research and education.

2) Increase the use of reserve science and sites to address priority coastal management issues.

3) Enhance peoples' ability and willingness to make informed decisions and take responsible actions that affect coastal communities and ecosystems.

### 1.1.2 Biogeographic Regions

Each reserve is established to represent a specific biogeographic region (Figure 1). NOAA defines a biogeographic region as a geographic area with similar dominant plants and animals, and a prevailing climate. There are eleven (11) distinct biogeographic regions nationally, with twenty-nine (29) sub-regions. Designed to include sites from all biogeographic sub-regions, the Reserve System currently represents eighteen (18) of those twenty-nine (29) sub-regions, with each site representing a different type of estuary. Research, education and stewardship programs are developed at each Reserve based on locally relevant issues of the bioregion and state.

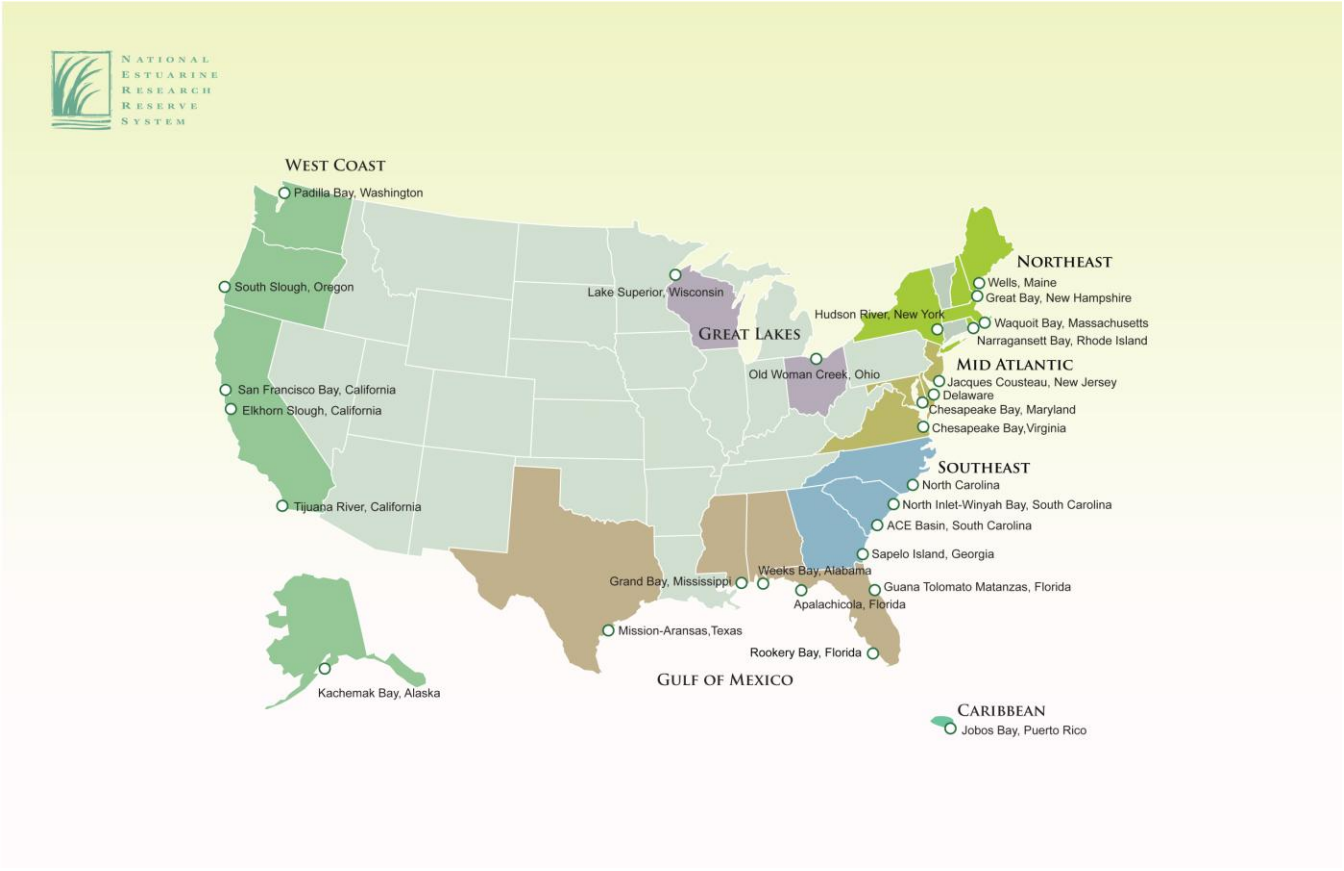


Figure 1. National Estuarine Research Reserve Bioregions

### 1.1.3 Reserve Designation and Operation

Under Federal law (16 USC Section 1461), a state can nominate an estuarine ecosystem for Research Reserve status so long as the site meets the following conditions:

1. The area is representative of its biogeographic region, is suitable for long-term research, and contributes to the biogeographical and typological balance of the System;

2. The law of the coastal State provides long-term protection for the proposed Reserve's resources to ensure a stable environment for research;

3. Designation of the site as a Reserve will serve to enhance public awareness and understanding of estuarine areas, and provide suitable opportunities for public education and interpretation; and,

4. The coastal State has complied with the requirements of any regulations issued by the Secretary [of Commerce].

Reserve 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.

If the proposed site is accepted into the Reserve System, it is eligible for NOAA financial assistance on a cost-share basis with the state. The state exercises administrative and management control, consistent with its obligations to NOAA, as outlined in a memorandum of understanding (Appendix 2). A reserve may apply to NOAA's ERD for funds to help support operations, research, monitoring, education/interpretation, stewardship, facilities construction and land acquisition.

### 1.1.4 National Estuarine Research Reserve System Administrative Framework

The Estuarine Reserves Division of the Office of Ocean and Coastal Resource Management (OCRM) administers the Reserve System (Figure 2). The Division 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 to support decision-making at the national level. As required by Federal regulation, 15 CFR Part 921.40, OCRM periodically evaluates reserves for compliance with Federal requirements and with the individual reserve's Federally-approved management plan (Appendix 3). This revised management plan addresses the Necessary Action identified in the reserve's evaluation conducted in 2006.

The Estuarine Reserves Division currently provides support for four system-wide programs: the System-Wide Monitoring Program, the Graduate Research Fellowship Program, the Coastal Training Program and the K-12 Estuarine Education Program. They also provide support for reserve initiatives on restoration science, invasive species and reserve specific research, monitoring, education and resource stewardship initiatives and programs.

## 1.2 Puerto Rico Department of Natural and Environmental Resources

The Puerto Rico Department of Natural and Environmental Resources (PRDNER) is an umbrella department in charge of the implementation and formulation of public policy with regards to environmental protection and natural resource conservation - environmental and energy. Created in 1972 and reorganized in 1993, the PRDNER is part of the Constitutional Office of the Governor.

The PRDNER has a wide range of public servants from various disciplines and skills committed to protecting and conserving the environment, including skilled workers, administrative staff,

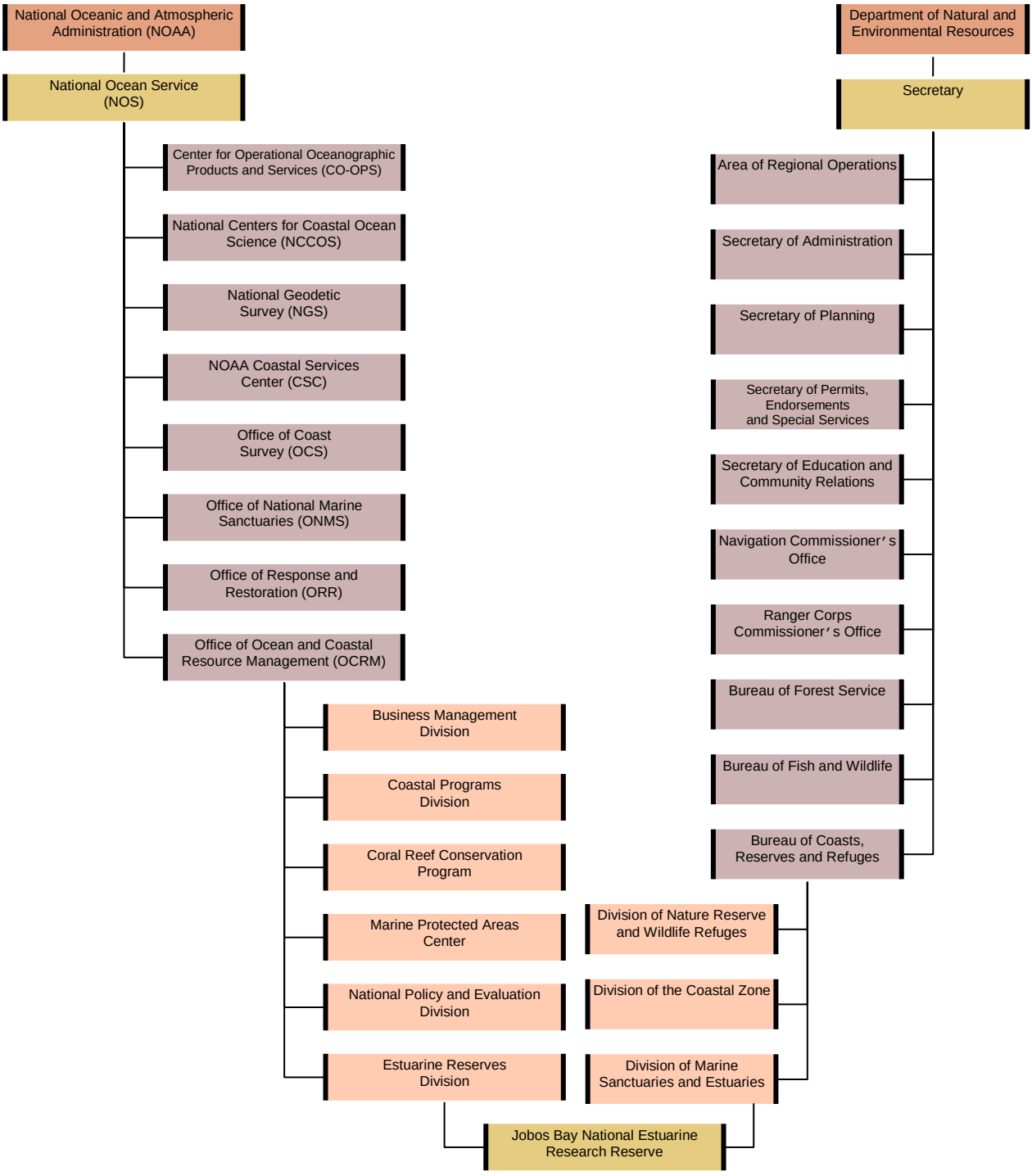


Figure 2. NOAA and PRDNER Management Framework

officers and managers, as well as experts in education, biology, geology, ecology, planning, information technology, architecture, translation, law, engineering, agronomy and surveying among others.

## Vision

The vision of the PRDNER is to:

> *Promote a healthy environment through the promotion of the sustainable use of natural resources, environmental management and transformation of the culture of Puerto Ricans to environmental conservation with the participation of all sectors of society to improve the quality of life.*

## Mission

The mission of the PRDNER is to:

> *Protect, conserve and manage natural resources and the environmental balance of the country to guarantee future generations enjoyment and encourage a better quality of life.*

The organizational structure of the PRDNER is designed to integrate management, education and outreach, research, law enforcement surveillance, legal actions, capacity building, community empowerment and other socioeconomic factors, permits, endorsements, navigational safety, and agency management for effective implementation of its ministerial duties. The responsibilities of the agency include implementing a significant number of laws and regulations.

The responsibilities of the Bureau of Coasts, Reserves and Refuges are covered by several state regulatory Acts. A summary of these regulations is provided in Appendix 4 and they are provided in their entirety on the Reserve's website (www.jbnerr.org) .

Management functions are performed by PRDNER's three management Bureaus: Forest Service, Fish and Wildlife, and Coasts, Reserves and Refuges. Jobos Bay NERR is nested in the Division of Marine Sanctuaries and Estuaries under the Bureau of Coasts, Reserves and Refuges (Figure 2). The Bureau of Coasts, Reserves and Refuges also oversees Puerto Rico's Coastal Zone Management Program, assuring integration and coordination between programs. This Bureau has certified that this revised management plan is consistent with the Puerto Rico Coastal Zone Management Program (Appendix 5).

The new PRDNER administration, which took office in January 2009, eliminated the departmental Areas that previously oversaw Reserve operations to reduce operational costs within the Department. Therefore, the Bureau of Coasts, Reserves and Refuges is now providing advice directly to the Secretary with regards to natural protected areas management under its purview and coastal zone issues, recommending the establishment and implementation of public policy associated with coastal affairs and the administration of Natural Reserves and Refuges.

## Special Planning Area (SPA) Designation

The Puerto Rico Coastal Zone Management Program (PRCZMP) designated Jobos Bay and its environs as a Special Planning Area (SPA), authorized under Resolution PU-002 of 1978 and certified by NOAA in CZM Guidance PRCZMP-EIS (Figure 3). SPAs are defined as 'important

coastal resource areas subject to serious present or potential use conflicts, and, therefore, require detailed planning'. The planning process emphasizes a consensus-based approach among all concerned Federal, Commonwealth and local entities on future development policy. The consensus derived planning agreements are legitimized through a legally binding MOU between the participants in the SPA process. Since the Jobos Bay SPA extends from Guamani River in Guayama to Playa de Salinas, and inland to Highway PR-53 – Puerto Rico's Coastal Zone - a considerable number of governmental agencies are participants in the SPA task force, including: the US Army Corps of Engineers, US Environmental Protection Agency, US Fish and Wildlife Service, Puerto Rico Environmental Quality Board, Puerto Rico Planning Board, Puerto Rico Land Authority and PRDNER, among others. PRDNER initiated this consensus planning process. These partners and the ensuing agreement will be integrated with and supportive of the Jobos Bay NERR.

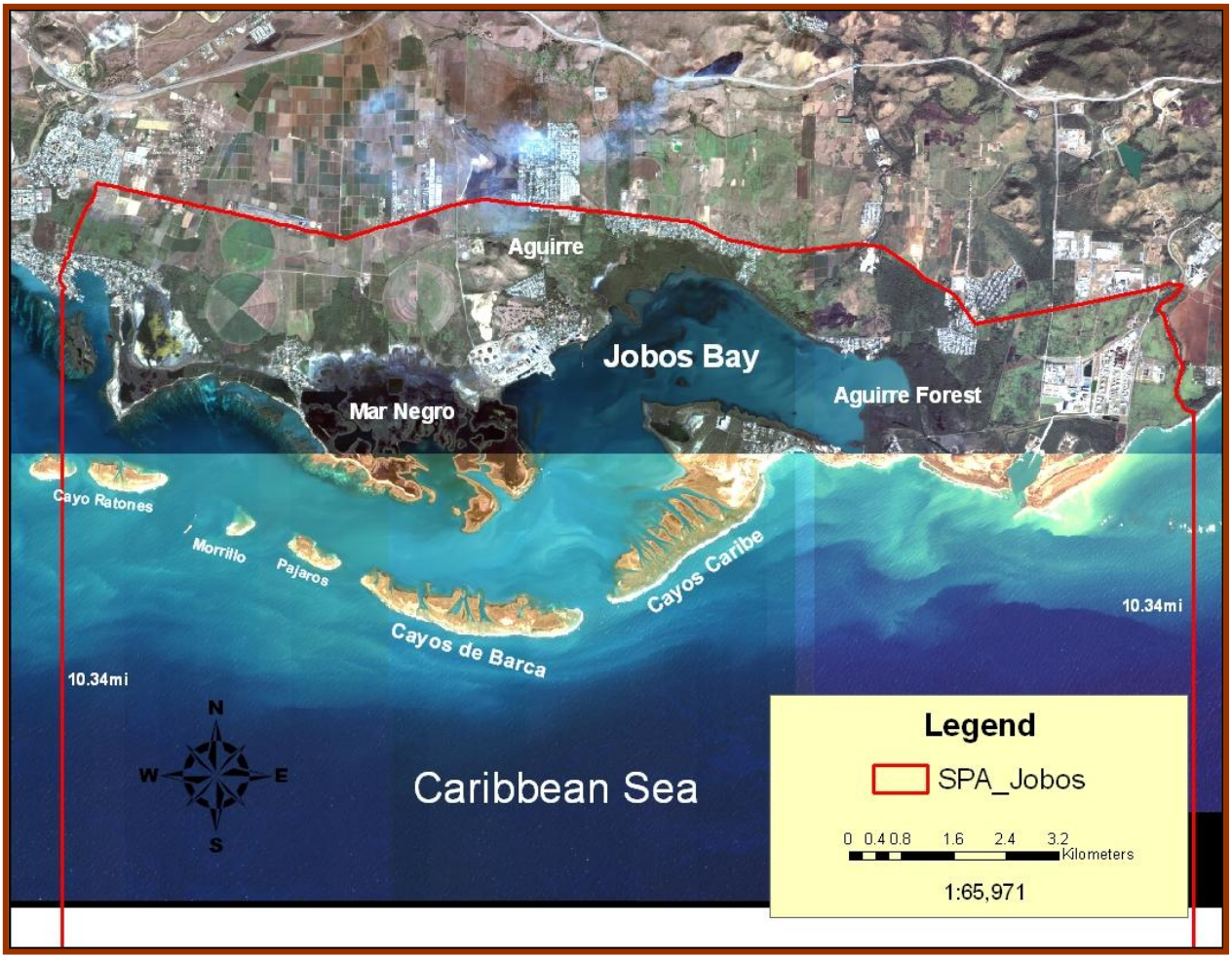


Figure 3. Jobos Bay Special Planning Area

## 1.3 Jobos Bay National Estuarine Research Reserve

### 1.3.1 Physical Setting

Puerto Rico is the eastern-most island of the Greater Antilles and is located between the US Virgin Islands and the Dominican Republic (Figure 4). Jobos Bay is the second largest estuary in Puerto Rico, with three times as much shoreline as any other estuary on the island. It is a shallow embayment with maximum depths of around 30 ft (10 m). Tides at Jobos are mixed, but primarily diurnal, with a mean of approximately 5.5 in (13.7 cm) and range from 6.7 in (17.0 cm) to 14.2 in (36.0 cm) (Lugo et al. 1987). Lowest tides occur early in the year, while the highest water levels occur around October, a period that coincides with higher rainfall water storage in the mangrove forest (Robles et al 2002).

Figure 4. Puerto Rico in the Caribbean

### Geography

Centered at about 18°15'N and 66°30'W, at the eastern end of the Greater Antilles, Puerto Rico is part of a volcanic island platform that includes the US and British Virgin Islands. The Virgin Islands and Puerto Rico comprise a segment of the Caribbean Island Arc which arose along the leading edge of the Caribbean Plate from the subsidence of the North American Plate. The Caribbean Plate is bounded by the Puerto Rico Trench to the north, Anegada Passage to the east, Muertos to the south, and an extensive fault system underlying the island of Hispaniola to the west (Dillon et al. 1998). An ancient inactive fault, known as the Esmeralda Fault, runs in a northwest-southeast direction, north of Jobos Bay. A projection of the fault suggests that it probably passes under Jobos Bay towards the Caribbean Sea.

Caribbean island formation occurred over the last 65 million years. The period of volcanism lasted from Cretaceous through Eocene time, but Puerto Rico's actual shape and size was essentially completed 40 million years ago (Morelock et al. 2000). The island has a total area of

approximately 2,224,000 acres (9,000 $km^2$), of which 75 percent is mountainous. A central mountain range, the Cordillera Central, largely of volcanic origin, divides the island along an east-west axis. A section of the range oriented to the southeast, is known as the Sierra de Cayey. The coast is characterized by an interrupted band of alluvial plains, with small limestone hill clusters on the north coast known as 'mogotes'. The south coastal plain is narrower than the northern plain, with shorter and smaller rivers, and an irregular insular shelf that extends two to five miles (3-8 km) seaward.

## Climate

Jobos Bay NERR lies in the south coastal plain within the Subtropical Dry Forest Zone (Ewel and Whitmore 1973). The mountains of the Cordillera Central serve as a barrier to the moisture-laden northeast trade winds. Orographic factors give rise to a zone of low precipitation throughout the entire length of the south coast. Mean annual rainfall is 44 ½ inches (1,129 mm). October is the wettest month with an average rainfall of 9 inches (228 mm), and March is the driest with an average precipitation of 0.2 inches (5 mm).

Temperature at Jobos Bay NERR shows little seasonal fluctuation. The mean annual temperature is 79.8ºF (26.5ºC), with a maximum of 81.3ºF (27.4ºC) during August and a minimum of 76.6ºF (24.8ºC) during February. Winds in the Reserve blow regularly from an easterly direction, averaging six to seven knots (7-8 mph).

## Geology

Berryhill (1960) mapped and described the geological formations and units in the Central Aguirre quadrangle, where most of Jobos Bay NERR is located. The superficial unconsolidated deposits within Jobos Bay NERR are mainly quaternary in age and consist of lagoon, swamp, beach and alluvial deposits.

Lagoon and swamp deposits cover most of the surface of the Reserve. They consist of unconsolidated clay, silt and organic matter. These deposits are covered almost entirely by mangroves. Beach deposits occur along the islands of Cayos Caribe. The islands 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. Alluvial plain deposits dominate the northern part of the Reserve and consist of unconsolidated sand, gravel and pebbles. The coastal portion of the aquifer is overlain by permeable, fine grained material (Renken et al. 2002).

There are no metal mineral deposits of commercial value in the general area of the Reserve. Small amounts of hematite have been found several kilometers northeast of Jobos Bay.

## Hydrology

The hydrologic conditions of the area are typical of a semiarid region. The Río Seco drains into Jobos Bay, near the Puente de Jobos community, to the east of the Reserve, with various small streams flowing into the Bay from the north (Figure 6). The Quebrada Aguas Verdes and Quebrada Coqui join and flow directly into the Bay. 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.

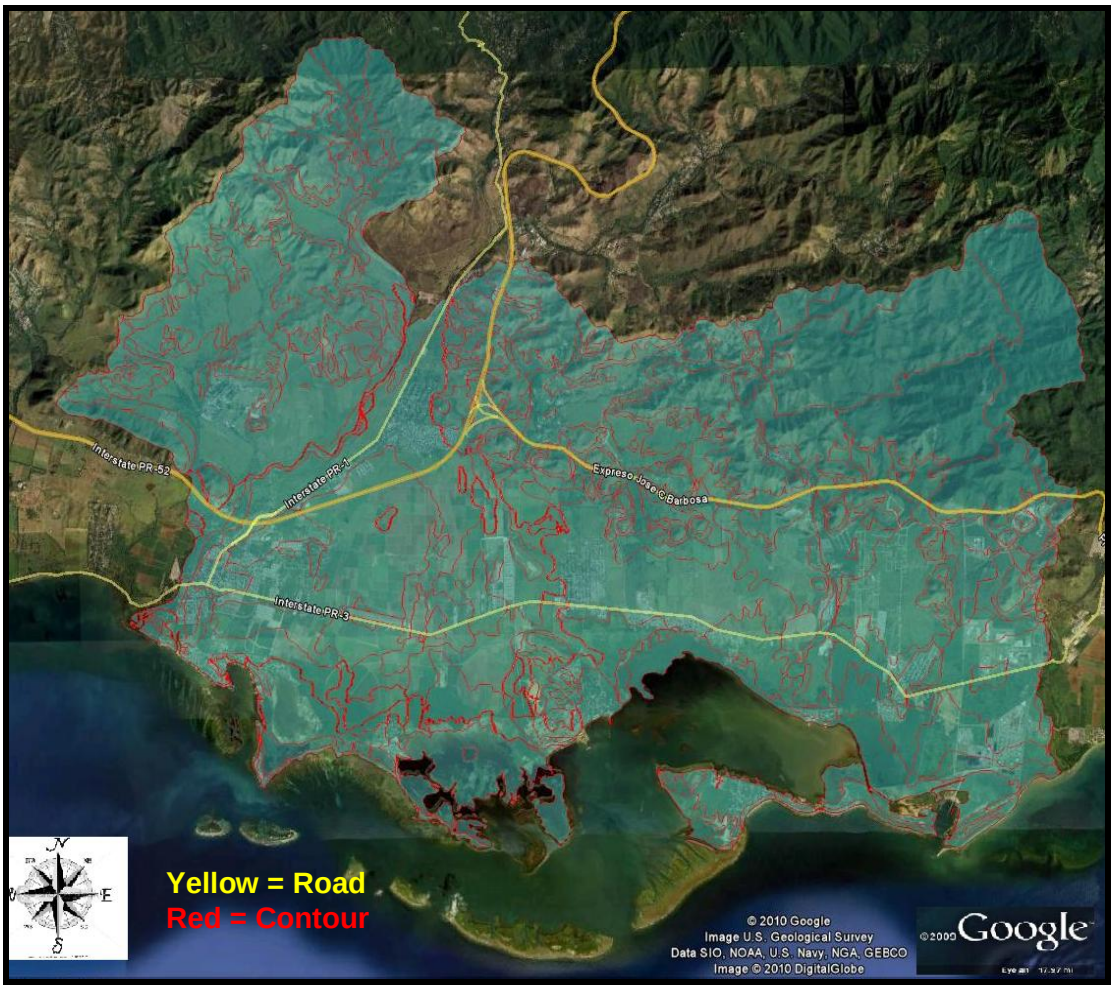

Figure 5. Jobos Bay Watershed

Groundwater is the main source of freshwater for the Jobos Bay estuary. Three main hydrogeologic units constitute the aquifers in the South Coastal Plain: 1) the shallow water table and confining clay unit; 2) the main groundwater flow zone; and, 3) the unconsolidated hydrogeologic unit (Quiñones-Aponte 1991). The confining formation, present primarily along the coastal area, is a fine grained, barely permeable clay or silt bed, averaging about 20 ft (6 m) in thickness, although in some areas it is less than 10 ft (3 m) thick. It extends from 1 mile (1.6 km) at Jobos Bay to 4 miles (6½ km) in the Salinas fan delta. Freshwater inflow to the mangrove wetlands occurs through groundwater seepage from the shallow aquifer and the adjacent watershed (Quiñones-Aponte and Gómez-Gómez 1987).

Prior to industrial, urban and residential development, the aquifer was recharged mainly by stream seepage and rainfall. Runoff from heavy rains in the mountains (annual avg. 77 in / 1,976 mm) recharged the aquifer by percolation through riverbeds. Irrigation practices, principally for sugar cane cultivation, have resulted in modifications to the natural hydrology. To meet the increasing water demand for agriculture, canals and reservoirs were constructed in the late 1800's to divert streams from populated areas and, by 1914, an extensive network of canals

and a diversion tunnel were used to carry water from Lago Carite and Lago Patillas to the coastal plain, from Patillas to Salinas (http://pubs.usgs.gov/ha/ha730/ch_n/N-PR_VItext3.html). Both are artificial lakes located in two different watersheds east of Jobos Bay. Lago Carite is a lake located north of the Guayama municipality in Sierra de Cayey and is the origin of the Guamani-West Irrigation Channel, while Patillas Lake is located southwest of the Patillas municipality and is the origin of the Patillas Irrigation Channel. The two channels provide water to populations covering 27,000 acres of the south littoral zone of Puerto Rico.

Historically, the south coast area is one of the most important agricultural areas on the island. As in other agricultural areas in Puerto Rico, sugarcane was the principal crop for many years, but is being replaced by vegetables. This eventual crop replacement and the associated changes from furrow to drip irrigation may increase the groundwater demand for agriculture. This change will also affect the recharge patterns to the alluvial aquifer (USGS 1996).

### 1.3.2 Biological Setting

Jobos Bay NERR encompasses several upland, wetland and submerged primary habitats:

- Upland Habitats
  (1) Scrub Shrub
  (2) Forested
- Wetland Habitats
  (1) Emergent Wetlands
  (2) Salt Flats
- Submerged Habitats
  (1) Mud Flats
  (2) Algae Beds
  (3) Seagrass Beds
  (4) Coral Reefs

The habitats of the Reserve support a wide range of highly valued flora and fauna requiring careful management and protection from anthropogenic influences.

Vegetation and Habitats

Since the arrival of European colonists in the 19th century, 90% of the island of Puerto Rico has been deforested and almost all remaining forests have been significantly disturbed (Ewel and Whitmore 1973). Much of the present tree cover is secondary forest and has increased to about 40% cover with the decline of the sugar industry (Brash 1987, Ewel and Whitmore 1973).

Uplands

*Scrub-Shrub - Subtropical Dry Forests*

Gleason and Cook (1927) described the original vegetation types of the area surrounding Jobos Bay NERR as a semi-evergreen seasonal forest type, consistent with tropical hardwood hammocks and covering the great majority of the area from the coast to medium elevations in the hills. Located landward of the mangrove and salt flat communities, the dominant species were black olive *(Bucida buceras)* and West Indian elm *(Guazuma ulmifolia)*. Anthropogenic and natural phenomena have continuously disturbed this habitat. Within the entire Reserve, only a single individual of the native milktree *(Plumeria alba)* has

been found and Royen's tree cactus *(Pilosocereus royenii)* is rarely found either on Cayo Caribe or Camino del Indio.

Caribbean subtropical dry forests commonly consist of white cedar (*Tabebuia pallida*), Mountain manna *(Begonia retusa)*, red rodwood *(Myrcia citrifolia var imrayana)* and grass *(Aristida suringari)*, with large numbers of *Acacia* and orchids found in specific locations (http://www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0220_full.html). 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, including neotropical migratory birds and several species of lizards, using this habitat, protection and restoration of dry forest communities is essential (http://www.fws.gov/southeast/partners/StateFactSheets/Caribbean_longv.pdf). Due to the extreme environmental conditions, natural dry forest regeneration is very slow, and disturbed habitats remain degraded with little wildlife value for very long recovery periods, making protection and restoration that much more critical (http://www.fws.gov/southeast/partners/StateFactSheets/Caribbean_longv.pdf).
Characterization of this secondary forest will be pursued to evaluate its composition and identify possible impacts by invasive, exotic species within the forest.

The littoral or coastal scrub (lacustrine habitat) is a dry, mainly evergreen community that sustains trees like sea grape *(Coccoloba uvifera)*, white cedar *(Tabebuia spp.)*, manchineel *(Hippomane mancinella)*, gumbo limbo *(Bursera simaruba)* and bearded fig *(Ficus citrifolia)*. It resembles the hedge of coastal scrub that develops behind the mangrove edge, pruned by the wind and salt environment. It may include clumps of pipe organ cactus *(Pilosocereus royenii)*. The Caribbean has over 20 endemic species of *Coccothrinax*, the thatch palm, which are common in the littoral forests of various islands. This community can be found on mangrove islands of Cayos Caribe and Cayos La Barca.

Wetlands

*Emergent Wetlands - Mangrove Forests*
Mangroves are a dominant feature of the Jobos Bay marine ecosystem and cover almost 3,000 acres (12 km²), an estimated 25% of the entire bay (Zitello et al. 2008). An inventory of Puerto Rico's mangrove resources indicated that Jobos Bay contained nearly 50% of this habitat on the southern coast of Puerto Rico (Martínez et al. 1979). For that reason, Jobos Bay is considered a site of unique ecological value and fundamental in maintaining biodiversity in Puerto Rico. This emergent vegetation borders all of Jobos Bay's undisturbed shoreline and represents the transition between the bay and the upland (Zitello et al. 2008).

One of the most productive coastal systems worldwide, mangroves act as sediment traps that retard water movement and trap suspended materials, gradually raising the land level and producing organic soil. The rich protected substrate provides habitat for a large variety of organisms, which in turn serve as the base of the food chain for the marine environment. Many commercially and recreationally important finfish and shellfish spend a portion of their life cycles in this nursery habitat. Mangroves also provide nesting sites for both resident and migratory birds.

Four species of mangroves are found within the Reserve: red mangrove *(Rhizophora mangle)*; white mangrove *(Laguncularia racemosa)*; black mangrove *(Avicennia germinans)*;

and buttonwood *(Conocarpus erectus)*. Three of the five mangrove forest types (Lugo and Snedaker 1974) occur within the Reserve: fringe forests, basin forests and overwash forests. Riverine and dwarf forests are not found in Jobos Bay NERR. These systems are described in greater detail in the Reserve's Site Profile.

*Salt Flats*

Hypersaline lagoons and salt flats occur inland from the mangrove forests. They are formed as a result of reduced inland runoff, limited tidal flushing, high evaporation rates and reduced rainfall. Dead black mangroves are often seen in these lagoons. Where vegetation does exist, it is dominated by salt-tolerant species, such as saltwort *(Batis maritima)* and sea purselane *(Sesuvium portulacastrum)*, which have thick, fleshy leaves adapted for water storage. Generally, these species are not intermixed. Sea purselane prefers drier soils and typically grows on higher ground, while saltwort is often found in wetter substrates, like those associated with the mangrove fringe forests.

<u>Submerged Habitats</u>

The entire Jobos Bay, an estimated 2,718 acres (11 km2), is defined by the higher high water line and seaward from a line drawn ~300 feet (100 m) from existing harbors and developed shorelines (Figure 19). Uses in Jobos Bay include maintenance of shipping channels to support harbors, commercial and recreational fishing, and recreational boating. The main navigation channel is 150 feet (46 m) wide by 27 feet (8 m) deep and is maintained only as required, with the last maintenance occurring more than ten years ago.

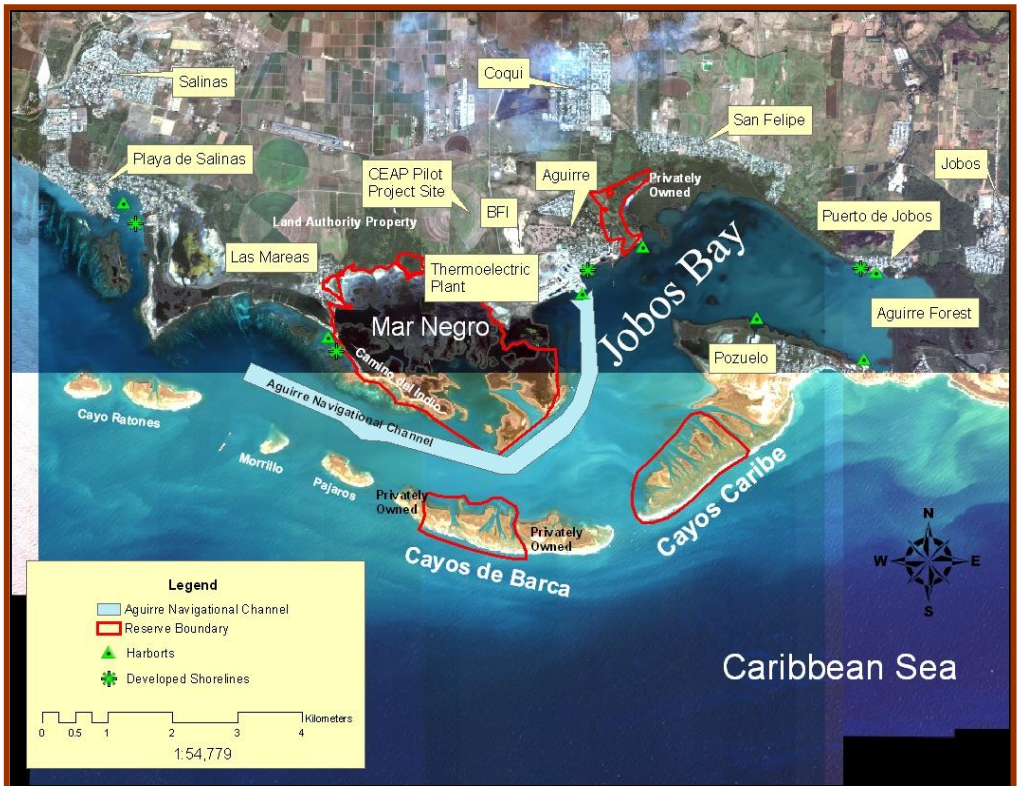

Figure 6. Jobos Bay

The Jobos Bay ecosystem is characterized by the interaction between four primary habitat types: mangroves, submerged aquatic vegetation (SAV), coral reefs and unconsolidated sediments. The presence of different 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. 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.

The Jobos Bay includes almost 12,000 acres (48 km²) of seagrass, coral reef and other habitat types that span both intertidal and subtidal areas (Figure 20) (Zitello et al. 2008, Kendall et al. 2001). Of the known benthic habitats, SAVs are the most common, covering slightly less than 30% of the bay (Zitello et al. 2008) (Figure 20). Seagrass beds totaling 3,200 acres (13 km²), and macroalgae to a much lesser degree (173 acres, 0.7 km²), are the two types of SAV found in Jobos Bay (Zitello et al. 2008). Seagrass beds cover approximately 70% of Jobos Bay's shallows up to 10 feet (3 m) in depth (Robles et al. 2002). Both linear and patch reefs are some of the most productive habitats found in Jobos Bay. The less than 500 acres (2 km²) of coral reefs comprise only 4% of the total benthic habitat, but provide important habitat and nursery grounds for fish and invertebrates of commercial and recreational value (Zitello et al. 2008). Most of Jobos Bay's corals are in linear reef formations that are oriented parallel to the shore of the mainland (Zitello et al. 2008).

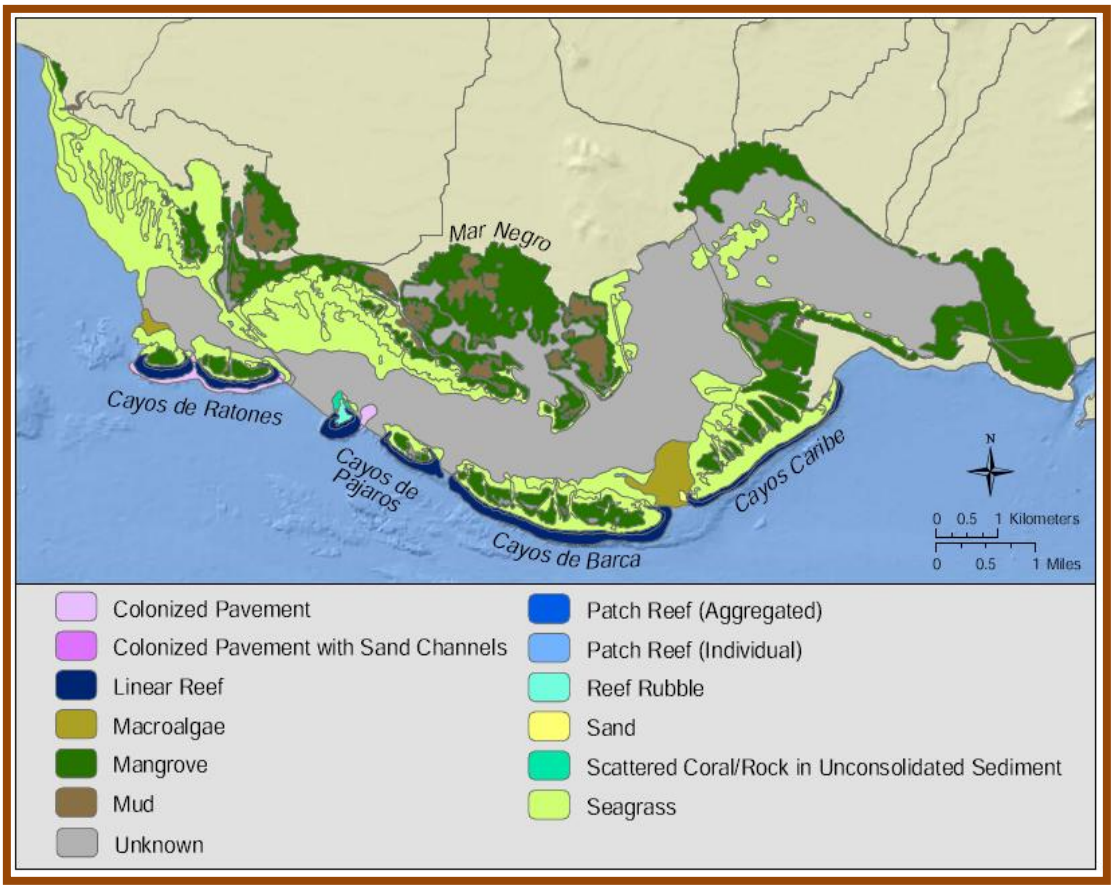


Figure 7. Distribution of Benthic Habitats in Jobos Bay

The Jobos Bay area supports use by high concentrations of manatees, as evidenced from aerial surveys conducted by US Fish and Wildlife Service. The manatee population in Puerto Rico is considered endangered due to the low estimated population numbers, prevailing threats, lack of information about their life history and loss of critical habitat. This management plan incorporates conservation practices directed to positively influence this protected species, which can be considered an indicator species for ecosystem and watershed health. Across Puerto Rico, manatees are found in greatest numbers in Jobos Bay, likely due to specific characteristics of the area and watershed. Preservation and conservation management issues include buffer zones and a navigation channel established for boats coming in and out of the eastern side of Jobos Bay.

With the development of the habitat, bathymetry and contaminants maps, as well as existing data on the estuarine environment, the Reserve will use this opportunity to engage its partners within the Stewardship Agreement (Appendix 8) to develop a marine spatial plan for Jobos Bay and the offshore waters included in the new Commonwealth Natural Reserve designation. This additional area adds 2,718 acres (11 km2) of estuarine habitat to the Reserve.

*Mud Flats*

Mud flats are important soft-bottom littoral systems exposed at low tide and containing considerable quantities of detritus, a mixture of sand, mud, and plant and animals remains. From ¼" (2-3 mm) below the surface of the mud flat, sometimes down to more than 3 ft (1 m) in depth, the moist humic bottom supports bacteria, fungi, diatoms and a spectrum of marine animals, including clams, worms and nematodes. These mud flats are especially important forage areas for wading birds and shorebirds. List it as Marine

*Algae Beds*

Macroalgae species are represented among the three large groups (green, brown and red algae). Macroalgae are present throughout the Jobos Bay marine ecosystem. Green algae *(Chlorophyta)* contain chlorophyll and are well represented in the tropics (Littler et al. 1989) (e.g. *Enteromorpha* spp.), preferring stressful environments where nutrients are high and herbivory low. Others are calcified (e.g. *Halimeda* spp.) and contribute heavily to the sandy sediments of reef areas.

Brown algae *(Phaeophyta)* may range in color from beige to almost black, however, their abundance and diversity in tropical seas is reduced. Some of the most common tropical genera include *Sargassum* and *Turbinaria* which are often associated with reef flats, and *Lobophora* which is fairly ubiquitous.

The red algae *(Rhodophyta)* are the largest and most diverse group. Red algae are extremely important reef-building organisms, which may form reef crests (e.g. *Lithophyllum* spp.) and large calcareous plates (*Sporolithon* spp.).

*Seagrass Beds*

Seagrass beds have long been recognized as one of the most productive biological communities in the world (Zieman1982). Providing nursing grounds, food and shelter for most fish and invertebrate species in Jobos Bay, four types of seagrasses have been observed in Jobos Bay: turtle grass (*Thalassia testudinum*) (Figure 7), manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and paddle grass (*Halophila*

*decipiens*). Generally, shoal grass inhabits only the shallowest areas; turtle and manatee grasses intermix on the shallower portions of the seagrass bed; turtle grass is the sole occupant of the deeper bed; and, paddle grass grows in the much deeper areas (PRNC 1975). The presence of seagrass is limited to locations where there is an adequate amount of sunlight to support photosynthesis (Zitello et al 2008).

Figure 8. *Thalassia* Beds *(NOAA Biogeography Branch)*

The seagrass beds cover approximately 70 percent of the shallow (9 ft, < 3 m) substrata in Jobos Bay, and about 30 percent in deeper areas down to 30 ft (10 meters) (PWRA 1972). Seagrass beds develop mainly in low energy zones protected by fringing reefs. Light penetration and turbidity of the water column are the major limiting factors in their distribution. *Thalassia* beds are present from the intertidal zone to depths of up to thirty feet (10 m). Large, well-developed meadows occur at depths of six feet (2 m) or less. These meadows occupy most of the shallow bottoms just offshore from the mangrove fringe. Dense beds of *Thalassia* are also present in the semi-enclosed areas of Jobos Bay with good circulation and clear water.

Seagrass beds serve as habitat, feeding and nursery grounds for a wide variety of marine organisms, including conch, octopus, squid, shrimp and juvenile lobster. Some of these organisms, especially lobster, octopus and conch, are of considerable commercial value. The endangered hawksbill sea turtle *(Erectmochelys imbricata)*, the green sea turtle *(Chelonia mydas)*, and the West Indian manatee *(Trichechus manatus manatus)* frequent the seagrass beds of the Reserve.

*Coral Reefs*

Coral reefs, in conjunction with mangroves and seagrass beds, form one of the most complex, diverse and productive marine associations in the world. The islands of Cayos Caribe are fronted by a reef-flat terrace containing patches of green sea mat or button polyp *(Zoanthus sociatus)*, seaward of which the coral reef begins to appear.

The coral reefs at Jobos Bay follow the typical zonation of Caribbean reefs (Figure 8). The reefs are primarily composed of thin finger coral *(Porites porites)*, mustard hill coral *(P. asteroids)*, golf ball coral *(Favia fragum)*, lettuce coral *(Agaricia agaricites)*, lesser starlet coral *(Siderastrea radians),* elkhorn coral *(Acropora palmata)*, bladed fire coral *(Millepora complanata)*, sea anemones *(Palythoa caribaea),* gorgonians *(Erythropodium caribaeum),* encrusting zoanthids, sea urchins and calcareous algae (Figure 9) (García and Castro 1997). The reef system is described in greater detail in the Reserve's Site Profile (Robles et al. 2002).

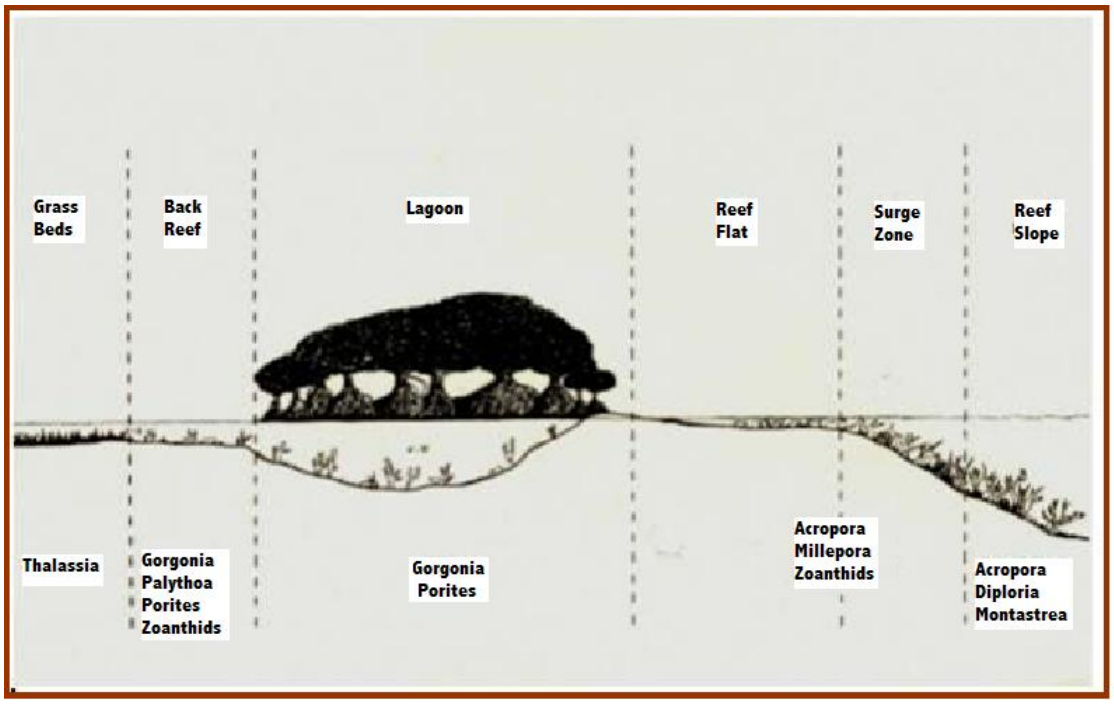

Figure 9. Cross-section of Coral Zonation at Jobos Bay *(PRWRA 1972)*

Evolution of coral reef communities has occurred during relatively stable climatologic and environmental conditions. Natural disturbances, such as hurricanes, can alter both the physical and biological structure of coral reefs. However, since these episodic events are sporadic and transitory, the reef can recover through growth and recruitment.


Figure 9. Coral Reef *(NOAA Biogeography Branch)*

Unfortunately, corals are vulnerable to many anthropogenic effects, such as eutrophication, sedimentation, thermal pollution and mechanical damage due to anchoring and overfishing. Cumulative and sequential impacts may limit recovery from anthropogenic impacts and may have long-term consequences on the community structure of coral reefs. These critical issues will need immediate attention if the Jobos Bay reef system is to recover.

Offshore waters extending one (1) mile seaward of Cayos Caribe and Cayos de Barca comprise the Coral Habitat (Figure 21).

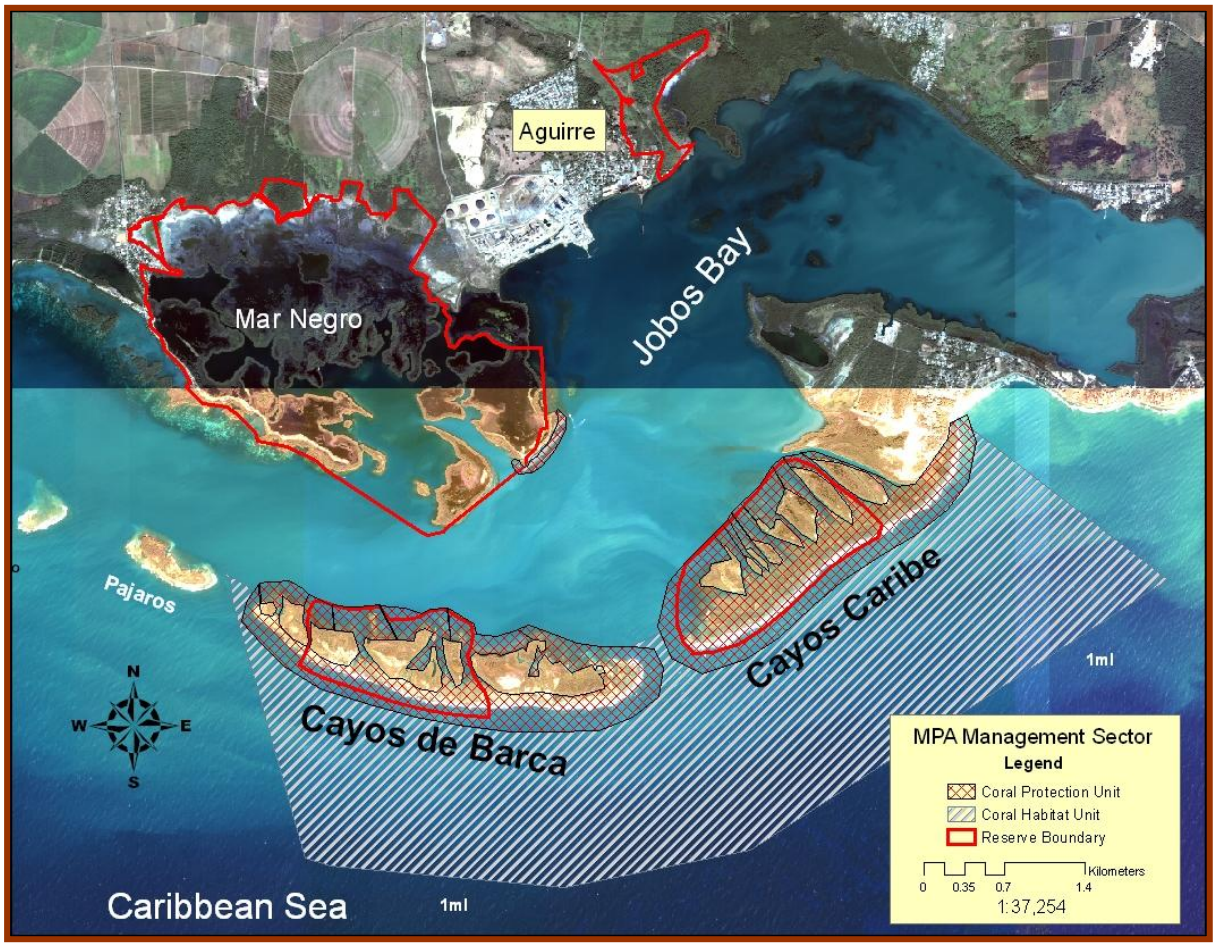


Figure 10. Coral Habitat

There are two areas of coral in the reserve - a small set of coral rubble within the Jobos Bay just outside of Mar Negro and linear reefs seaward of the Cayos. A marine community assessment conducted by García-Sais et al. (2003) on the reef offshore of Cayos Caribe and Cayos de Barca resulted in an inventory of percent cover of sessile benthic biota. At both sites, algal turf was the predominant cover at 61-62%, but significant amounts of stony corals were also found at both sites, accounting for 20-21% cover. Stony corals included great star coral (Montastrea cavernosa), boulder star coral (Montastrea annularis), mustard hill coral (Porites astreoides), massive starlet coral (Sidastrea siderea) and several others of lesser cover. Two small linear reefs exist to the west of Cayo Puerca and Punta Colchones within Jobos Bay. These two reefs represent almost all of the corals located inside of Jobos Bay at 5¼ acres (21,298 m²). García-Sais et al. (2003) surveyed several sites along these two reefs and found almost no live cover of stony corals. They observed that the reef formations are relict staghorn coral (Acropora palmata) communities that are now mostly rubble overgrown with calcareous and turf algae. Throughout both reefs, a green calcareous alga, known as watercress alga (Halimeda opuntia), was the main component colonizing available hard substrate. These internal reefs were likely impacted by the

thermal discharges associated with the hydroelectric plant and sedimentation impacts from dredging of the ship channel.

To further protect the current and additional resources over the next five years, management priorities for the Reserve include:

- Strengthening the relationship and involvement with the partners in the Stewardship Agreement, which was developed to address issues of encroachment and provide a more coordinated management approach for the Reserve (Appendix 8). Management and regulatory agencies adjacent to and with oversight of Reserve resources will coordinate large-scale planning efforts, including public access, as well as jointly addressing impacts to the Reserve's natural resources. The Reserve will work with partners in the Agreement, as well as any additional partners identified as a result of the new Commonwealth designation, to define priorities over the next five years, including: (1) coordinated marine and estuarine spatial planning within the Commonwealth Natural Reserve; (2) joint facility, stewardship and habitat management planning and strategy development; and, (3) training and capacity building among the partners.

- Developing a management MOU to manage the natural areas within and outside of Jobos Bay as a unified system with: the Puerto Rico Department of Natural and Environmental Resources' Forest Service Bureau; Bureau of Coasts, Reserves and Refuges, Division of Marine Sanctuaries and Estuaries; Puerto Rico Land Authority; and, Puerto Rico Department of Agriculture. The Agreement will include the Puerto Rico Land Authority parcels along the northern boundary of the Mar Negro Area, the Aguirre Forest (managed by the Puerto Rico Department of Agriculture and Puerto Rico Forest Service Bureau), and the two islands of Cayo Caribe managed by the Puerto Rico Department of Agriculture and Puerto Rico Forest Service Bureau in the Cayos Caribe.

Fauna

The most common sport and commercial fishes are whalebone anchovies, herring, jacks and parrotfish. The complex of aquatic habitats provides for a diverse array of fish species. Jobos Bay NERR's upland and wetland habitats support four species of lizards and two amphibians. The relatively undisturbed mangrove system of Jobos Bay NERR makes the area a haven for pelicans, herons, shorebirds and waterfowl, with a total of 87 bird species identified in Jobos Bay (Appendix 6).

Invasive Species

Biological invasions pose considerable threat to the ecological integrity of Jobos Bay NERR. Non-native marine, estuarine and terrestrial plant and animal species have become established in Reserve habitats. In many cases species are so well established or so likely to re-invade, the most realistic policy is simply to control their growth and prohibit introductions of new species where possible.

Invasive plant and animal species will be controlled to the extent practicable in core tidal wetland areas. Measures will be taken to minimize the spread of these species through reduction of existing populations and reproductive? control. The creation of habitat conditions, such as altered hydrology, that contribute to the spread of invasive species will be avoided. Where possible, altered conditions will be restored to minimize further degradation to the ecological integrity of the system.

Invasive Flora

The invasive aloe plant *(Aloe vera)* and wild tamarind *(Leucaena leucocephala)* (Figure 10) are taking hold on Cayo Caribe. They already dominate areas around the headquarters and boat ramp. Wild tamarind, in conjunction with velvet mesquite *(Prosopis juliflora)* and several *Acacia spp.,* also dominate much of the dry forest habitats.

Figure 11. Invasive Wild Tamarind

Invasive Fauna

The small Indian mongoose (*Herpestes auropunctatus*) was first brought to Puerto Rico from the Malay Peninsula in 1877 to control the black rat (*Rattus rattus*) infestation on sugar cane plantations (http://www.fs.fed.us/r8/el_yunque/wildlife-facts/2002/wildlife-facts-august-2002.shtml). Feeding on insects, frogs, snakes, birds, other small animals and fruit, mongooses are reported to live up to 20 years (http://www.fs.fed.us/r8/el_yunque/wildlife-facts/2002/wildlife-facts-august-2002.shtml) and have had a substantial impact on native species.

Listed Species

Several threatened and endangered species live within or periodically make use of the Jobos Bay estuary and watershed (Table 1). Protected species include the brown pelican *(Pelecanus occidentalis)*, the peregrine falcon *(Falco peregrinus)*, the Puerto Rican plain pigeon *(Patagioenas inornata)*, the yellow-shouldered blackbird *(Agelaius xanthomus)*, hawksbill sea turtle *(Eretmochelys imbricata)*, elkhorn coral *(Acropora palmata)* and the West Indian manatee *(Trichechus manatus manatus)*.

The hawksbill sea turtle forages in shallow waters, feeds on the bottom of reef areas and *Thalassia* beds, and has a preference for invertebrates, algae and submerged roots.

Table 1. Jobos Bay NERR Protected Species

| Common Name (English) | Common Name (Spanish) | Scientific Name | Federal Status |
|---|---|---|---|
| Brown Pelican | pelicano pardo | *Pelecanus occidentalis* | E |
| Peregrine Falcon | falcon peregrine | *Falco peregrinus* | E |
| Puerto Rican Plain Pigeon | paloma sabanera | *Columba inornata* | E |
| Roseate Tern | | *Sterna dougallii* | T |
| Yellow-shouldered Blackbird | mariquita | *Agelaius xanthomus* | E |
| | | | |
| Hawksbill Sea Turtle | carey | *Eretmochelys imbricata* | E |
| Green Sea Turtle | tortuga verde | *Chelonia mydas* | T |
| Leatherback Sea Turtle | tinglar | *Dermochelys coriacea* | E |
| | | | |
| West Indian Manatee | manati Antillano | *Trichechus manatus manatus* | E |
| | | | |
| Elkhorn Coral | coral cuerno de alce | *Acropora palmata* | T |

E=Endangered T=Threatened

Historically, the manatee was found in shallow coastal waters and lagoons throughout much of the tropical and subtropical regions of the Atlantic and Caribbean. However, manatees are now rare or extinct in many parts of their former range (Brownell 1980). Recent surveys indicate that the total Puerto Rican manatee population might be less than 100 animals (USFWS unpublished data). The data from aerial surveys for manatees conducted by state and federal agencies around the island identifies Jobos Bay and Mar Negro as areas of high concentrations for this population.

While the specific factors influencing manatee preference for this area are unknown, it is evident that conservation of this ecosystem is critical for the longterm conservation and survival of the species.

### 1.3.3 Cultural Setting

The Reserve and adjacent areas contain several important cultural sites.

*Archaeology*
A large Indian settlement was located at the Carmen site adjoining the Reserve. The casual discovery of stone figurines, ('Cemi'), in the Central Aguirre area reflects settlements of the Taino Indians, the most important indigenous cultural group of the Island.

*Historic*
The Aguirre Sugar Mill is an important historic asset. In 1898, an American company bought the Aguirre properties. They modernized sugar technology and developed a corporate complex on Jobos Bay 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. The State Office of Historic Conservation of Puerto Rico identified the importance of the Aguirre settlement as a significant thematic target as a company town, a legacy of the sugar mill companies. Aguirre, in conjunction with the Sugar Mill Company, is the only 'company town' in Puerto Rico, meaning it is the only town built by a company to provide lodging and amenities for its employees.

In October of 2002, with support from the former State Office of Historic Preservation (today the State Office of Historic Conservation), the National Register of Historic Places listed Aguirre as a Historic District. In 2006, the American Institute of Architecture, in cooperation with the State Office of Historic Preservation, the Mayor of Salinas and students from the Polytechnic University of Puerto Rico, developed an initiative for renovation, preservation and sustainable use of this important historic community (http://www.aia150.org/bl_150_aia_puerto_rico.php). These plans will serve as reference and help inform facilities planning at Jobos Bay NERR.

*Future Research*
The Reserve and adjacent areas contain several important archaeological and historic sites. However, the area has never been systematically surveyed by an archaeological team (Fewkes 1907, Anon. 1975), and it is possible that the area contains other important cultural sites. While a desirable future activity, funding sources need to be identified for this endeavor.

### 1.3.4 Reserve Boundaries

The current Reserve boundary of 2,883 acres is solely comprised of the Mar Negro (2,087.13 acres) and Cayos Caribe (795.87 acres) components. The northern limit of the Reserve abuts properties owned by the Puerto Rico Land Authority leased for agricultural use to multiple farmers. On the Reserve's northeast boundary are the Aguirre Power Plant (AEE) and the remnants' of the Old Central Aguirre sugar mill. Bordering the western limits of the Reserve is the Las Mareas community and the residential construction along El Camino del Indio. Its southern boundary extends seaward into Jobos Bay. The Aguirre State Forest is situated along the northern and eastern shores of the Bay. The legal boundaries of the Reserve are described on property maps and deeds. (Figure 13)

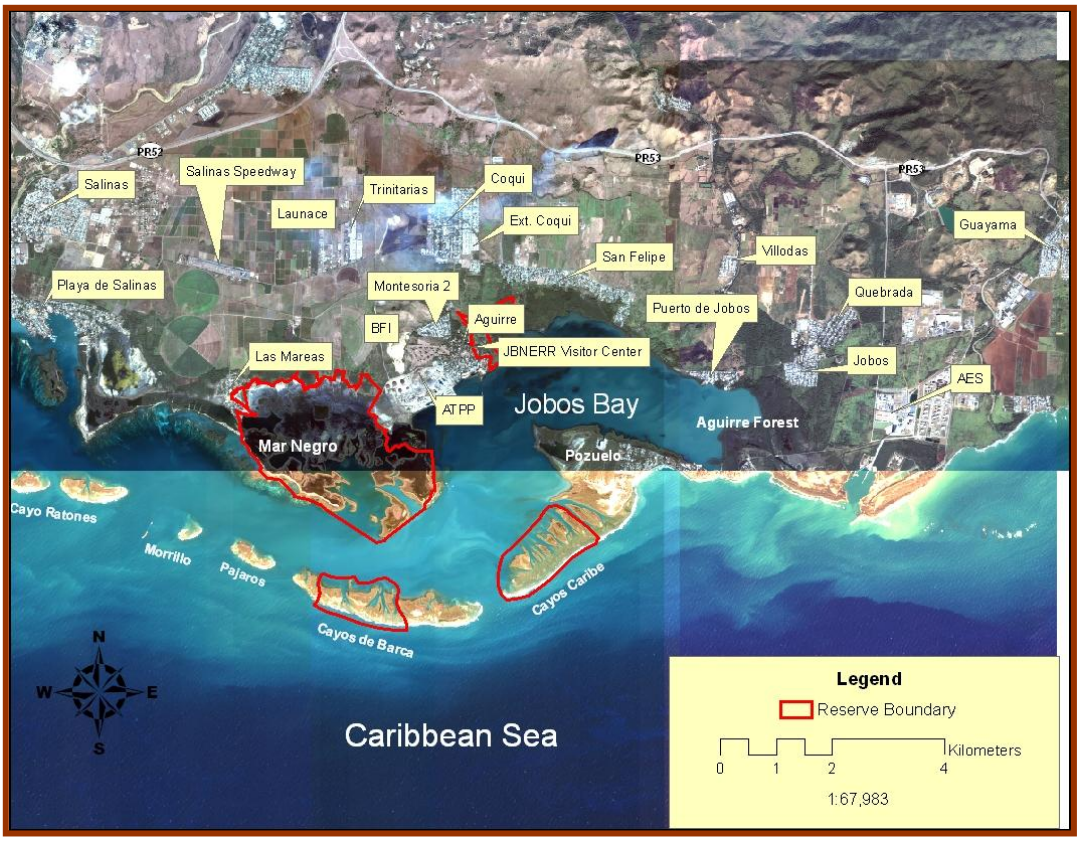


Figure 12. Jobos Bay and Surrounding Communities

This revised plan adds 416.90 acres of habitat to this former boundary expanding the Reserve boundary to 3,299.90 acres. These parcels provide critical upland, wetland and fringe habitats for several protected species, including a diversity of native and migratory birds, and threatened and endangered species. Coastal wetlands including salt flats, mangroves, lagoons, and associated habitats benefit from this expansion of the Reserve boundary. The new acquisitions are:

*El Batey de Aguirre* (101.7 acres)
El Batey de Aguirre is the most Eastern part of the Reserve and includes mangrove forest, salt flats, and evergreen littoral woodland forest. The area was affected by the intense agricultural

uses in the early century through the 1980's. Although the native flora diversity is limited especially due to the extreme physical conditions such low rain, high temperatures, salinity regime, and anthropogenic alterations, it is significantly important for the fauna especially insects and birds. The presence of the Royal Palm (*Roystonea sp*.) and the Mangrove Fern (*Acrostichum danaeifolium*) indicates fresh water availability for those two salinity sensitive species. Royal Palms fruit is important as a food source for many birds' species. Among the most dominant flora are the Emajaguilla (*Thespesia populnea*), aka. Portia-tree, cork tree or seaside mahoe which is a native to coastal tropical areas around the world. It grows naturally in thickets, coastal forests, and on the edges of mangroves. The Zarzilla (*Leucaena sp*.) or Leadtrees, a legume, is among most dominant specie in this area due to anthropogenic disturbances. It is native to Central and the southern part of North America. In the most seaward area halophytes dominate the zone which is subject to high salt concentrations ranging from average seawater salinity (~35 PSU) to hypersaline conditions (>70 PSU). The mangrove fringe forest has all four mangrove species in JBNERR, *Rhizophora mangle*, *Avicenia germinans*, *Laguncularia racemosa*, and *Conocarpus erectus*. The Beachwort or Saltwort (*Batis maritima*) and the Sea-purslane (*Sesuvium sp*.) are low shrubs that stabilize the soil preventing erosion. Among the faunal species, all birds typical of coastal zones within the Reserve can be observed here such sandpipers, great egrets, blue herons, pelicans among several other migratory species. It is important to mention the Mariquita or Yellow Shouldered Black bird *(Agelaius xanthomus)* which is and endemic and endangered species in Puerto Rico. Some other non native species are the Dominican Parrot (*Amazona sp*.), and the Monk Parakeet, also known as the Quaker Parrot (*Myiopsitta monachus*). The soil conditions near the coast are optimal for the Juey Común or land crab (*Cardisoma quanhumi*), Juey pelú or the swamp ghost crab (*Ucides cordatus*), and the Fiddler crab or Cangrejo Violinista (*Uca spp.*). They recycle organic matter and have an important role in the mangrove and salt flats areas allowing air exchange in the soil preventing anoxic conditions. Hacienda El Batey de Aguirre was purchased from the Puerto Rico Land Authority through an acquisition grant from NOAA/NERRS funds. These lands behind the Visitor's Center, enhance access to the bay and catalyzes protection and restoration efforts of this critical ecological area, in addition to diversifying educational and recreational experiences of the Reserve's visitors.

*Jagüey Forest (26.25 acres)*

The Jagüey Forest is 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 (Ficus laevigata). As most of the boundaries within the Reserve, the area was affected by the intense agricultural uses in the early century through the 1980's. During the 1990's hydrological changes in the watershed affected the mangrove forest. The mangrove zone is typical of a basin mangrove forest that is characterized by a slow sheet flow of water that washes their roots and receives fresh water input. Toward the mangrove ecotone, the area is dominated by evergreen flora such Zarzilla (Leucaena sp.) or Leadtrees, Mesquita or Mesquite (Prosopis sp.) although they are not native species, both flowering shrubs-trees provide shelter and food for many birds species. The Guácima or Bay cedar (Guazuma ulmifolia) is found toward the upland area of the forest, also Emajagüilla (Thespesia populnea) and Roble or Trumpet tree (Tabebuia spp.). This forest support a wide variety of birds, among migratory and local ones, also reptiles are represented. Among them are the Sigüana (Ameiva exsul), Lagartijo común or Tree anole (Anolis cristatelus), the Gecko or Salamanca (Hemidactylus brooki), and Santalucía (Sphaerodactylus macrolepis, Sphaerodactylus nicholsi). This upland forest came as a result interagency transactions with Land Authority and the EPA Consent Order.

*El Salitral* (13.85 acres)
El Salitral is the common name for salt marsh. The area has a water exchange during spring tides accumulating salt crystals that leaves singular conditions such hypersaline regimes ranging over 100 PSU and low oxygen in the sediments as well due to high organic matter transported to the area inhibiting most of the plants to growth. In terms of vegetation, it is very limited to Black mangrove (*Avicenia germinans*) that struggle with such high concentrations of salts. The Beachwort or Saltwort (*Batis maritima*) and the Sea-purslane (*Sesuvium sp*.) can growth in some areas of the salt flat. Among the faunal species, birds such sandpipers, great egrets, blue herons among other duck migratory species can be seen during drought periods. Arthropods such the land crab *Cardisoma quanhumi*), and the Fiddler crab or Cangrejo Violinista (*Uca spp.*) can be found in the area and their larval stages provide a food source for birds. Depicted the low diversity the salt flat is very important as a buffer zone between the basin and fringe mangrove forests. Las Mareas salt flat, property of the Puerto Rico Housing Department, was acquired as a result of interagency transactions to provide better protection to the western boundary of the Reserve.

*Cayos de Barca* (275.1 acres)
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. Formed by beach deposits, both reef island formations provide an excellent protection of the bay in terms of wind and wave action. The submerged part of the islands 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 other has low land supporting dry forest vegetation. It has an overwash mangrove forest dominated by *Rhizophora mangle* and *Avicenia germinans* but *Laguncularia racemosa* and *Conocarpus erectus* are present as well. The *Rhizophora* roots provide shelter to fishes and invertebrates in the water and birds in the upper part. The Beachwort or Saltwort (*Batis maritima*) and the Sea-purslane (*Sesuvium sp*.) growth in non submerged beach deposit areas. Few trees growth in the upland area which is very limited in size, as an example the Almacigo, Turpentine tree or Gumbo-limbo (*Bursera simar*) and the Emajagüilla (*Thespesia populnea*), and Roble or Trumpet tree (*Tabebuia spp*.).Cayos La Barca was acquired with State funds from the federal court; these had been confiscated from its original owner through a legal process.

These purchases provide the Reserve with better control over its resources and direct access to Jobos Bay's waterfront. These newly incorporated regions have adequate Commonwealth protection for the natural resources with the existing regulatory framework, including ten (10) law enforcement staff assigned specifically to the area. (Figure 14)

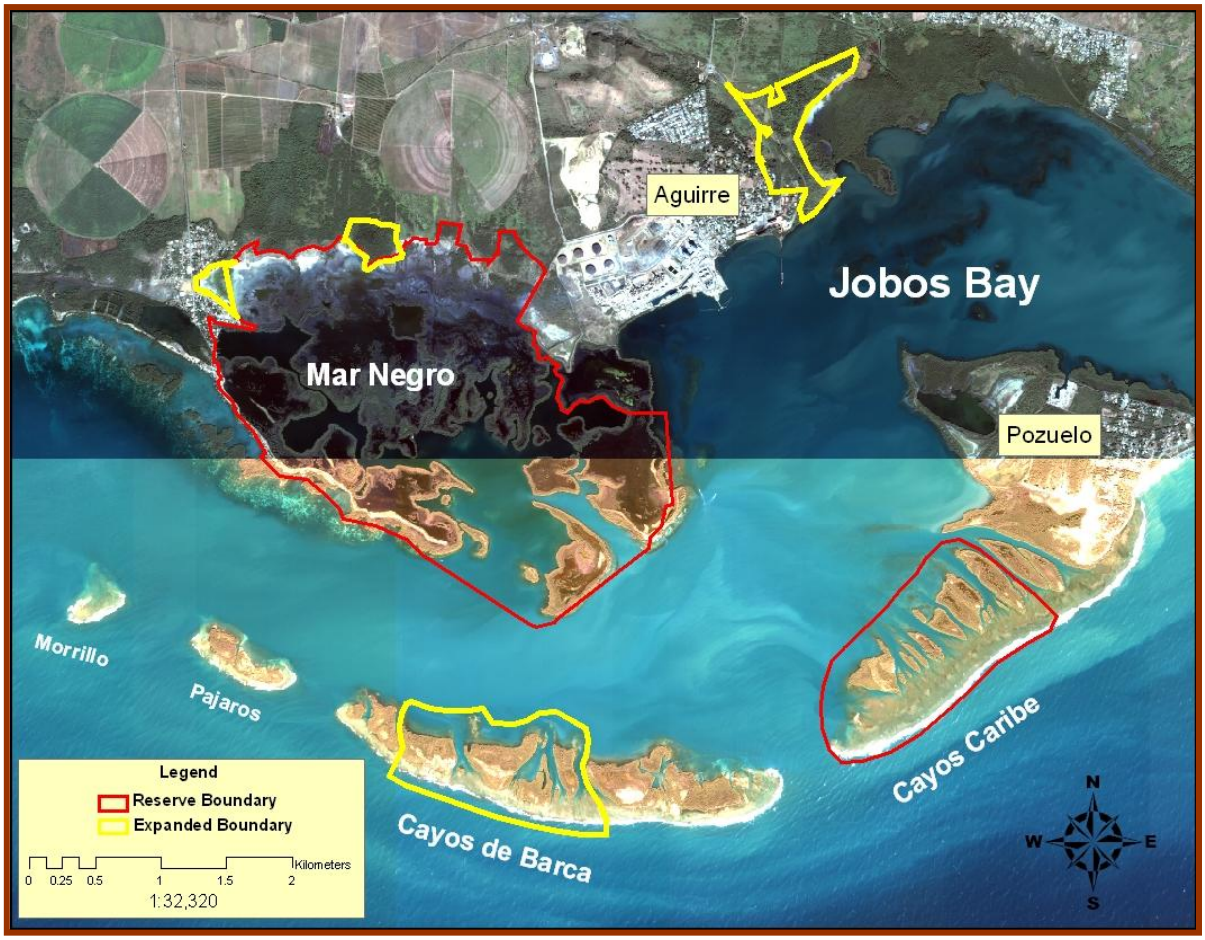


Figure 13. Jobos Bay NERR Expanded Boundary

Jobos Bay Reserve boundary can be sub-divided into the following units: 1) Aguirre Unit (the headquarters and associated lands); 2) Mar Negro Unit (the northern portion of the Reserve); 3) Cayos de Barca Unit (4 of 7 islands); and, 4) Cayos Caribe Unit (15 of 17 islands) (Figure 15). Together, these units encompass 3,299.90 acres of mangrove, estuarine and dry forest habitat (Appendix 7).

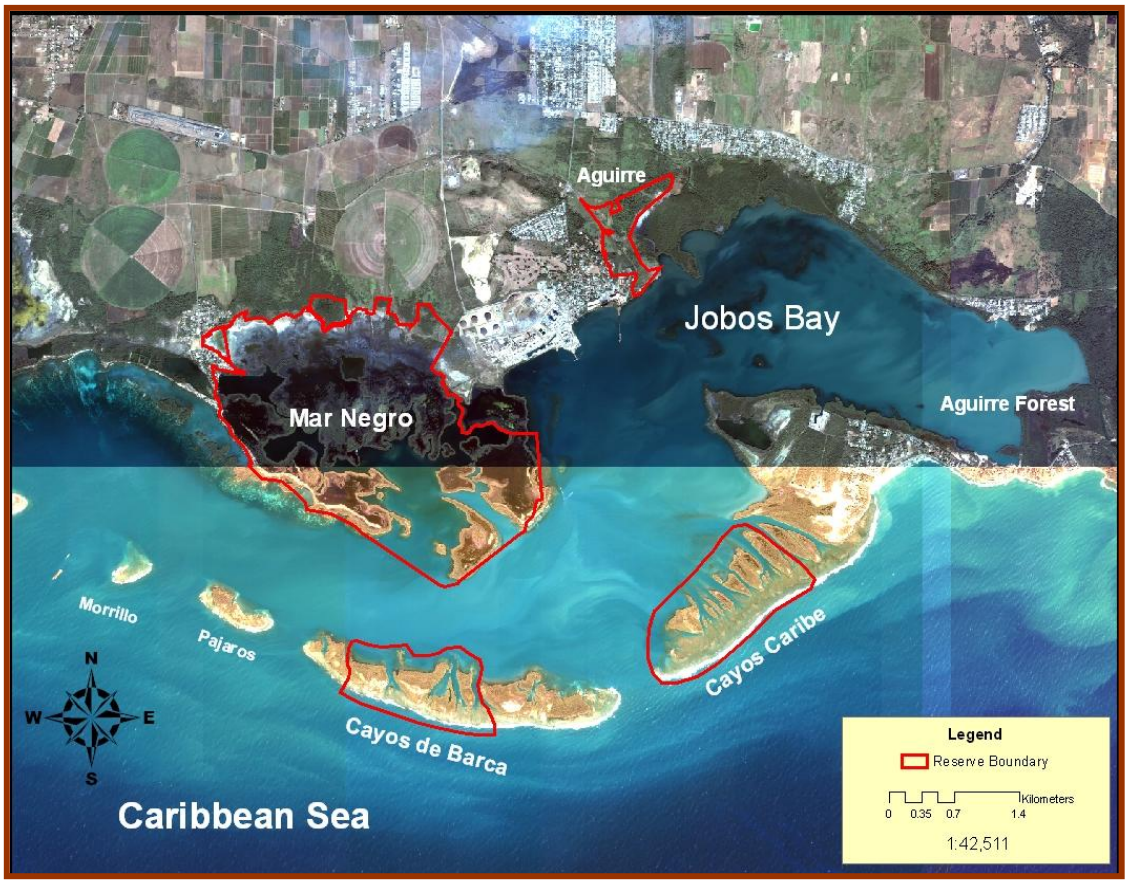


Figure 14. Jobos Bay Reserve Boundary Units

Management of uses within each unit is based on whether the units, or portions thereof, are designated as core or buffer areas (Figure 16). Core areas at Jobos Bay NERR are those areas that include habitats vital 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 in these areas is limited to researchers and Reserve staff for management purposes. Buffer areas within Jobos Bay NERR protect the core areas and provide additional protection for estuarine-dependent species, including listed species. Buffer areas include facilities and public access components.

These areas had been delineated within the boundaries of the reserve and extend to the line where there is presence of vegetation typical of secondary succession characteristic of anthropogenic influence.

Following is a description of the management units within the Reserve boundary, reflecting the distinct ecological regions of the Reserve and their designation as core or buffer areas. The core of the Reserve is located primarily in the Mar Negro, Cayos de Barca and Cayos Caribe Units, and the eastern half of the Aguirre Unit, with the western section of the Aguirre Unit, as well as the northern boundary of the Mar Negro Unit, and limited use areas in Cayos de Barca and Cayos Caribe serving as buffer areas. This buffer zone line is influenced by the highest tides, salinity content of the soil, and borders the mangrove ecotone. Public access is

encouraged based upon the Commonwealth's classifications of Conservation, Preservation or Limited Use Sectors, as described in Chapter 3 – Stewardship and Public Access.

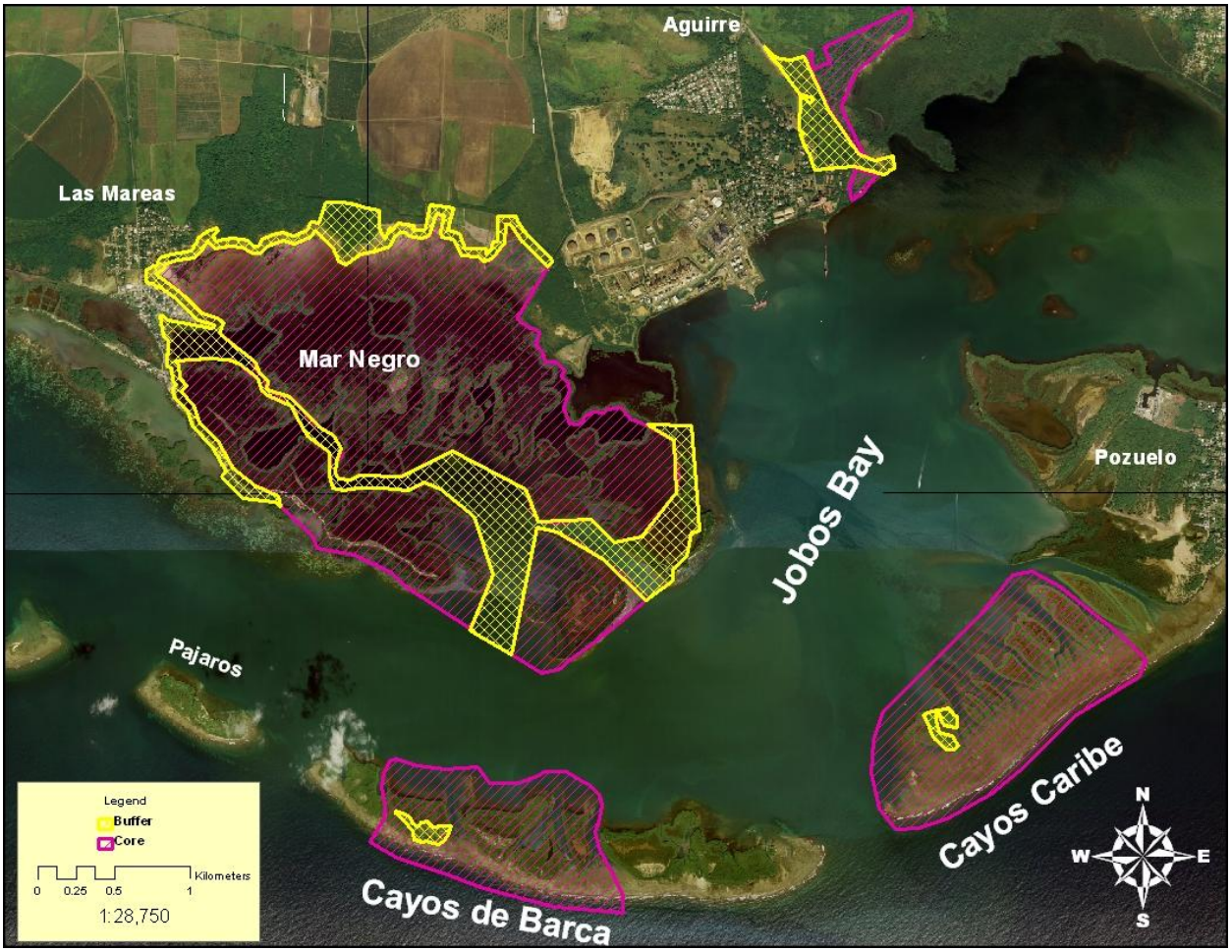


Figure 15. Jobos Bay NERR Core and Buffer Areas

Conservation classifications correspond to core areas and the Limited Use classification crosswalks with buffer areas. Therefore, the Mar Negro and Aguirre Units correspond to Limited Use. The Cayos Caribe, Cayos de Barca, Coral and coral-related habitats correspond mainly to Preservation and Conservation Sectors. These Management Sector classifications align with Commonwealth regulations and are upheld by the law enforcement officers. Regulations associated with Reserve resources and management is discussed in Chapter 3 – Stewardship and Public Access.

1) Aguirre Unit - headquarters facilities and associated lands

The Aguirre Unit is divided into core( eastern) and buffer (western) areas. Core habitats include habitats vital to the functioning of the estuarine ecosystem, while buffer areas support the Reserve Visitor Center complex and the Sugar Mill Trail (Figure 17). The boundaries of this area extend from Route 3 to the Town of Aguirre. Habitats in the northern portion of the Aguirre Unit include upland dry forest heavily impacted by invasive species. Closer to Jobos Bay, the

forest is dominated by red and black mangrove forests. The boundary of the Reserve in this area encompasses the Reserve's offices, Visitor Center and boat ramp. Containing areas of previously disturbed uplands impacted by the historic sugar industry, this area provides an ample footprint for future facility expansion needs. 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. Along the northern edge of this boundary, adjacent lands are currently managed by the Puerto Rico Land Authority. There is also an in-holding along the western edge of this boundary that includes a residence on Land Authority managed property. Priorities in the Aguirre Unit will focus on acquisition of the adjacent Sucesión Vázquez and Finca Salitral parcels, aiming to enhance and expand facility infrastructure and provide additional access trails. Opportunities for a coordinated trail system linking the Jobos Bay NERR and Aguirre Forest habitats will be assessed.


Figure 16. Aguirre Unit

2) Mar Negro Unit

The Mar Negro Unit includes critical mangrove habitat, as well as mud and salt flats used extensively as forage and nesting areas by wading and shorebirds (Figure 18). Core areas include the vast majority of mangrove, lagoons, salt flats and associated habitats. Buffer areas include a northern and western corridor, the navigation channel, and external lagoons. The

shallow waters of Mar Negro provide shelter for the endangered West Indian manatee; while the mangrove roots provide essential nursery habitat for more than 80% of coral, recreational and commercial finfish and shellfish species. The Reserve's Kayak Trail, Jagüeyes Trail, and Wildlife Pond Trail are found in this unit. It is bordered by the communities of Las Mareas and Camino del Indio and managed for public access and research. There is a boardwalk maintained by the Reserve and used by researchers and Reserve staff in Camino del Indio.

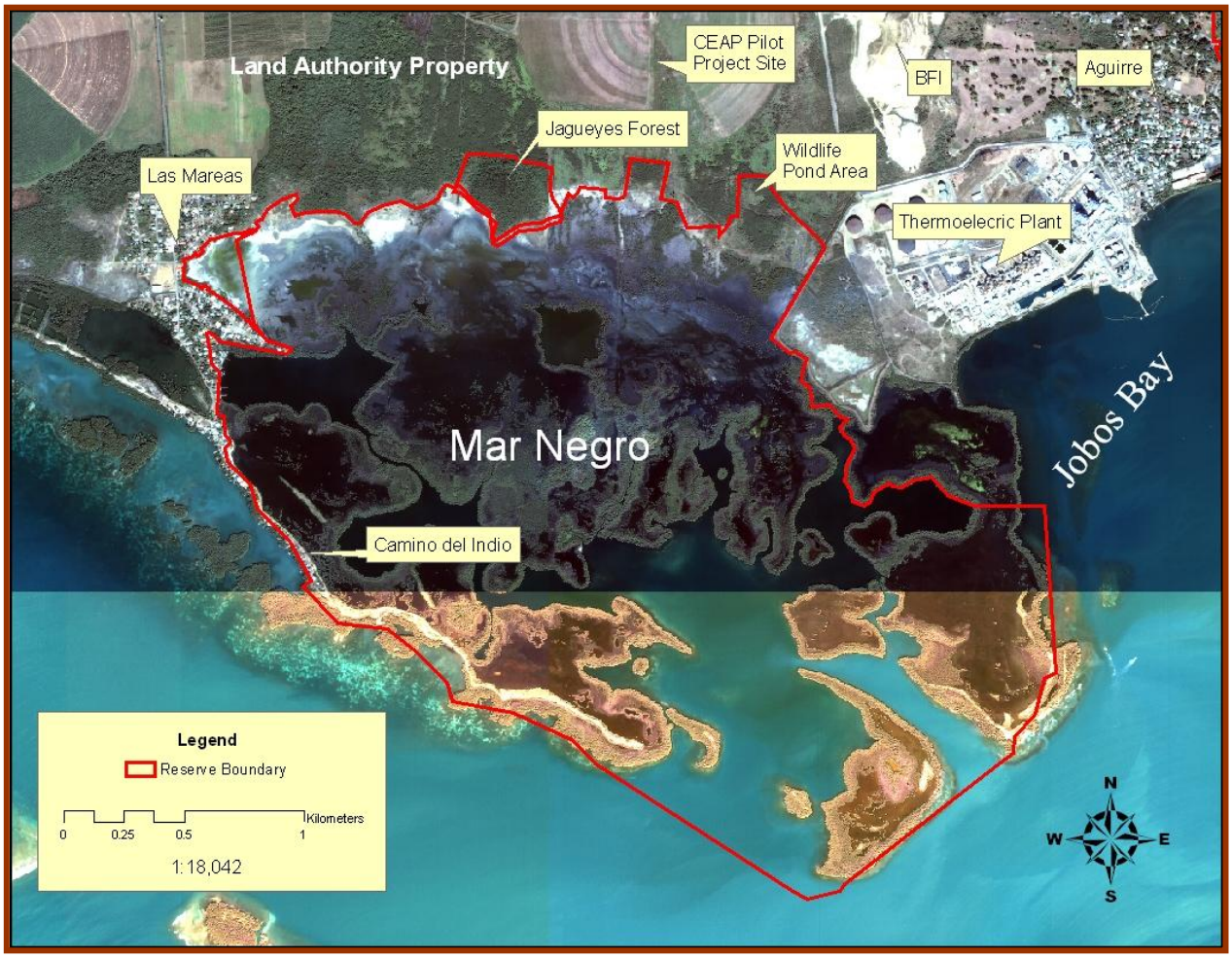


Figure 17. Mar Negro Unit

Fishing is a common activity in this area and illegal fishing practices - harvesting land crabs and using nets across the Mar Negro tributaries - are frequently encountered. Water quality is characterized by high nutrients, resulting from human activities in the Las Mareas and Camino del Indio communities. This is further exacerbated by restricted tidal exchange due to the construction of an access road to Camino del Indio which filled low areas and passes between Mar Negro and Jobos Bay. The Mar Negro Unit activities will focus on restoration, specifically restoring hydrologic connectivity with Jobos Bay to enhance flushing. Boundary maps of this area exclude private in-holdings along Camino del Indio, but identify a conflict area that needs resolution (Figure 19). As part of the resolution, the Reserve will conduct a boundary survey during the time frame of this Management Plan that will be used to address the conflict area and management actions.

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. As such, illegal use of the trails by off-road vehicle operators is evident. This trail, therefore, will be targeted for enhancements that will prevent all terrain vehicle (ATV) access. Portions of this unit also include excavated ponds that have become valuable wading and shorebird habitat. A public access point has been partially developed near the ponds, but is not yet complete. The upland portion of this unit is targeted for additional public access trails, habitat enhancement and increased law enforcement strategies.

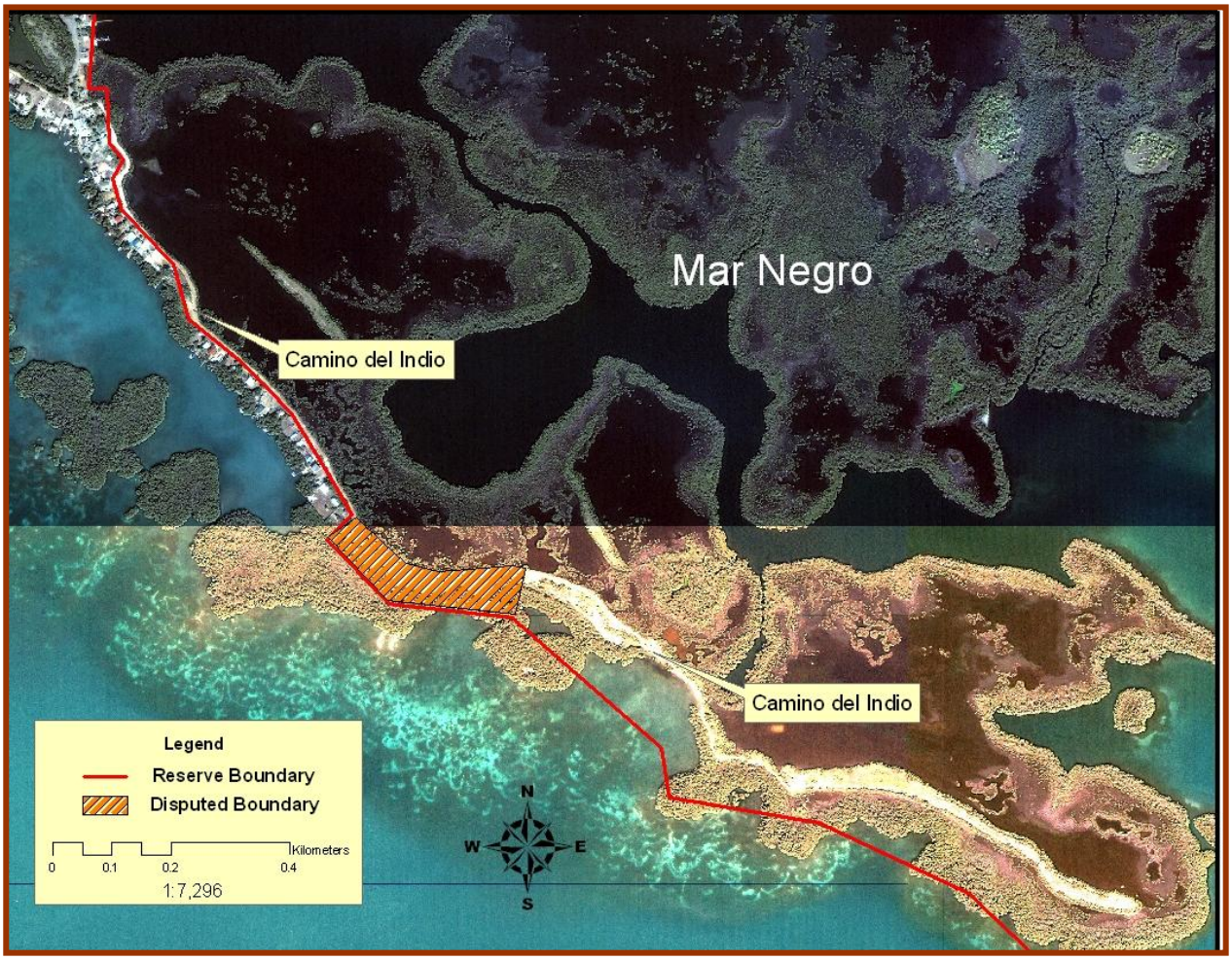


Figure 18. Camino del Indio Boundary

The Mar Negro Unit has also been impacted by agricultural uses adjacent to the boundary. Encroachment by the Puerto Rico Land Authority, in an effort to drain agricultural fields, decimated mangroves in this area. As part of a USEPA Consent Order (Appendix 7), the Land Authority restored the ditches that were created to drain the area and is working with NRCS to complete construction of an agricultural buffer strip to further protect Reserve habitats.

Thus, completion of the buffer strip, enhanced trails and access infrastructure near the upland ponds, modifications to the Jagüeyes Trail to restrict ATV access, and improved enforcement of illegal fishing activities are the key management priorities for land currently owned by the Reserve in this unit.

3) Cayos de Barca Unit

The Cayos de Barca Unit is a network of seven islands within the municipality of Salinas, situated on the western border of the Reserve (Figure 20). Four (4) of the seven (7) Cayos are within the Reserve's boundaries. 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 Cayos de Barca Unit is mainly designated as core habitat and no public access is supported. Only *Dos Palmas* cay includes a limited use area that has been zoned as a buffer.

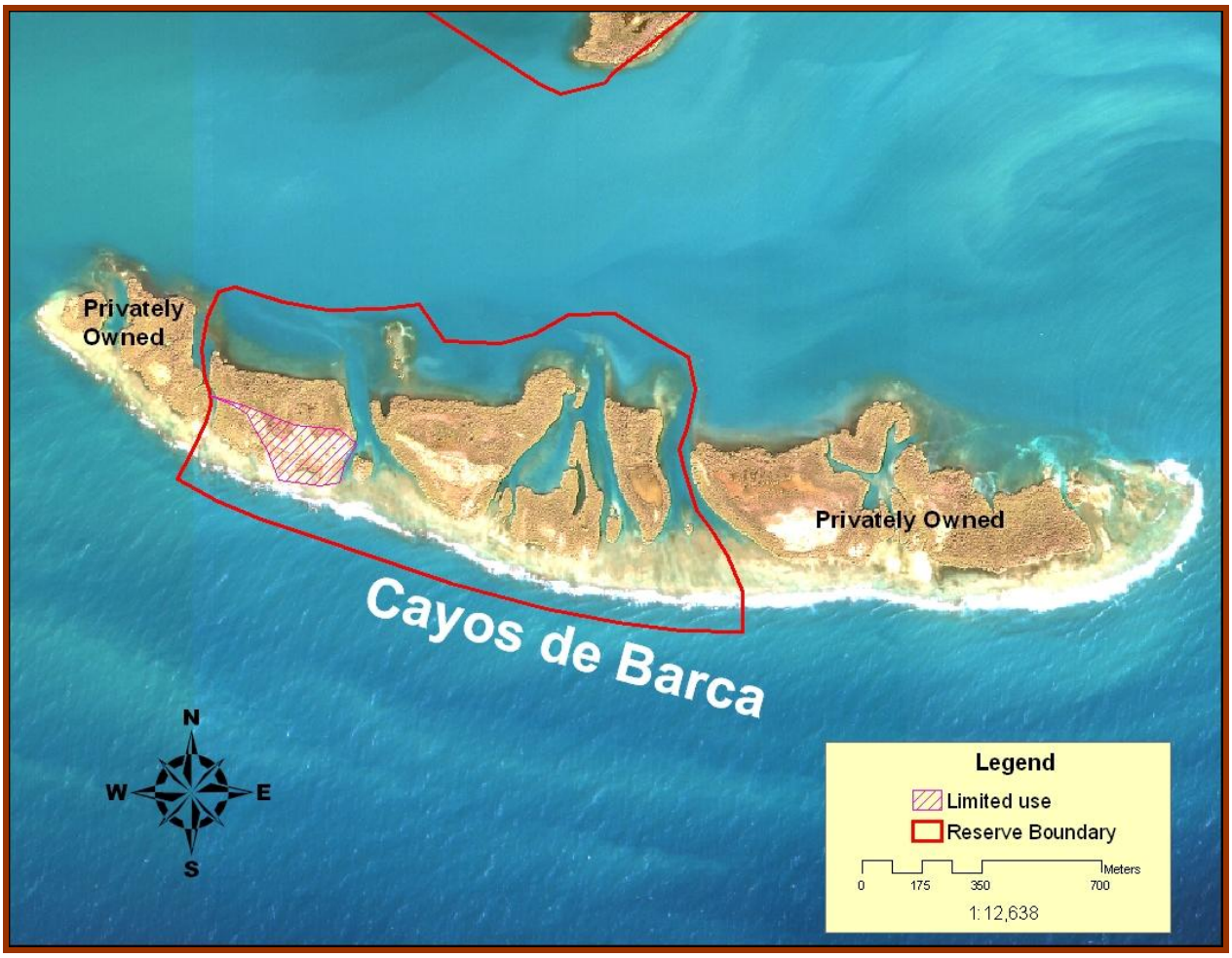


Figure 19. Cayos de Barca Unit

4) Cayos Caribe Unit

The Cayos Caribe Unit 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 (Figure 21). Fifteen (15) of the seventeen (17) islands are owned by the Reserve and the remaining two islands are owned by the Aguirre Forest. Therefore, all are effectively in PRDNER ownership and encompassed by the new Commonwealth SPA jurisdiction that designates the entire Jobos Bay ecosystem as a Natural Reserve. Of the fifteen (15) Reserve-managed

islands, one island, la Cabeza de Cayos Caribe, is designated for public access and includes a trail, observation tower and small pier. It is used for education, outreach and recreational use. With heavy public use impacts on the seagrass beds surrounding la Cabeza de Cayos Caribe, this area will be the focus of management strategies to guide boat traffic into designated areas, avoiding sensitive submerged resources and continue restoration efforts. No other islands in Cayos Caribe support facilities for public access. Thus, all islands in Cayos Caribe are designated as core habitat, except la Cabeza de Cayos Caribe, which supports public use and is designated as a limited use sector zoned as buffer.

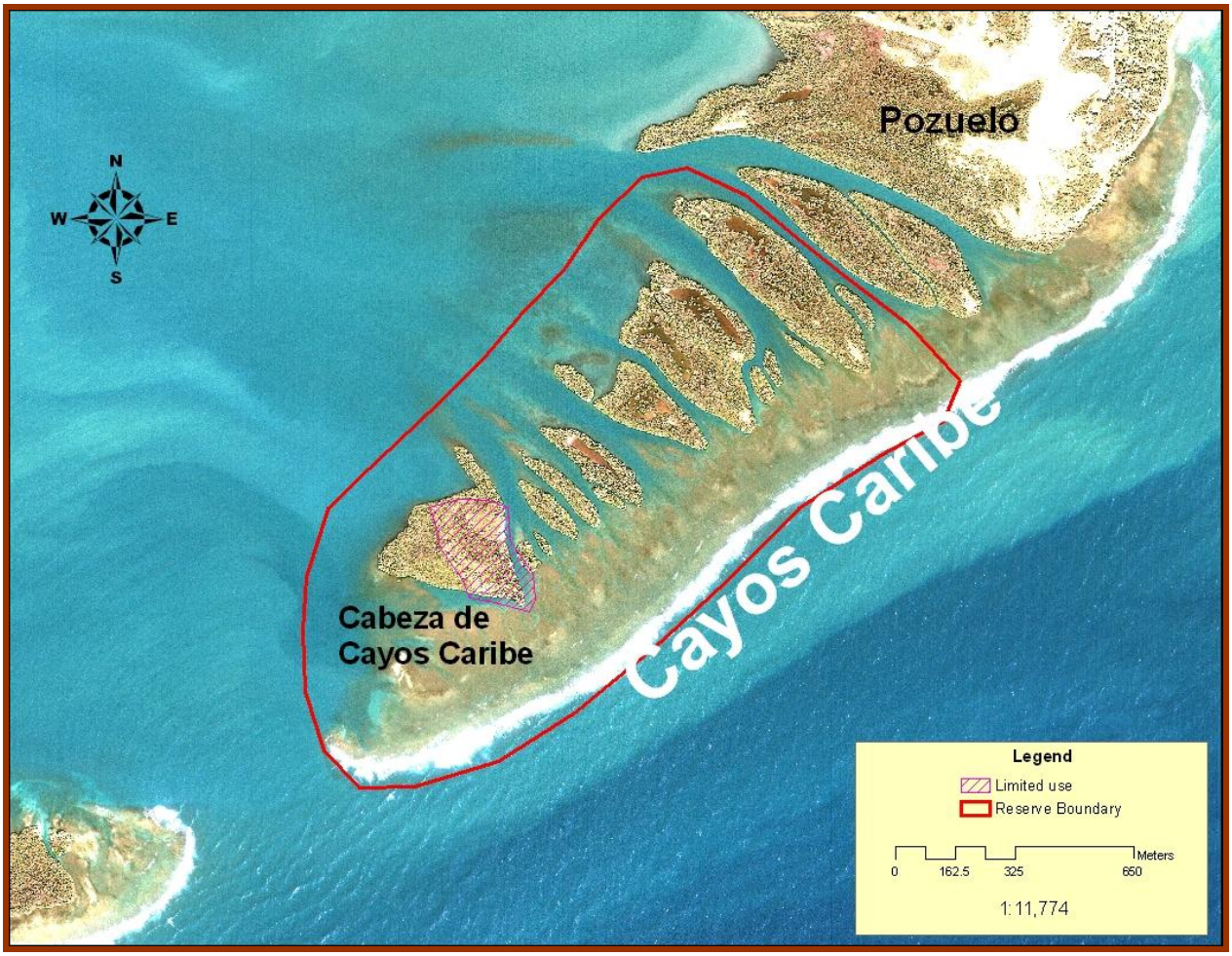


Figure 20. Cayos Caribe Unit

## 1.4 Coastal and Marine Management Issues

The priority issues affecting Jobos Bay will drive the Reserve's programmatic focus, development and implementation. The key issues to be addressed by this management plan align with the priorities of the NERRS: land use and population growth; habitat loss and alteration; water quality degradation; changes in biological communities; and, climate change.

**Jobos Bay NERR Priority Issues**

- Climate change impacts on coastal ecosystems and communities, including sea level rise, habitat migration and coastal resiliency;
- Landuse change impacts on coral and coral-related habitats, including sedimentation and pollutant impacts elucidated from recent research and monitoring; and,
- The interrelationship between ecological integrity and population centers in and around Jobos Bay, including long-range planning efforts, flooding impacts, water allocations and public access.

### 1.4.1 Spheres of Influence

These issues affect not only the Reserve and its adjacent communities, but are relevant to other areas of Puerto Rico and the broader Caribbean. For that reason, Jobos Bay NERR will work to affect change through each program across three 'spheres of influence': the Reserve and its local adjacent watersheds, the Commonwealth of Puerto Rico and the broader Caribbean. As an example, climate change impacts have become more noticeable with fluctuations in seasonal temperature and rain patterns across the island. Months that were traditionally rainy are now dry, and others in which rainfall was normally low are now receiving great amounts of rain. This change in pattern has also been observed with regard to temperature. Monitoring these factors and their changes not only within the Reserve, but in Puerto Rico and across the Caribbean will provide additional insight in how climate change will affect these areas.

- The Reserve and Its Local and Adjacent Watersheds

The watersheds of the Salinas and Guayama Wards provide freshwater flow into Jobos Bay and Mar Negro proper and can have direct impacts on their coastal and submerged resources. Hence, the Reserve has been working extensively within these watersheds to address coastal and marine impacts from agricultural and municipal practices. Recent observations from mapping efforts conducted by NOAA's National Center for Coastal and Ocean Science revealed that the corals offshore of Jobos Bay are being impacted by severe sedimentation impacts. Due to the prevailing North Equatorial Current on the southern side of Puerto Rico, it seems that sedimentation from watersheds to the east of the Reserve's immediate watersheds is impacting the Reserve's coastal resources. Thus, this Management Plan identifies not only the immediate watershed of Jobos Bay proper, but the adjacent watersheds to the east, as the 'watershed' sphere of influence.

Changes in land use practices and the interrelation with the ecological integrity of numerous habitats, including coral reefs, are widely known. Coral habitats in Jobos Bay, La Parguera, Guánica and Mayaguez have all shown significant signs of degradation, identifying pollutants and sedimentation as primary causes. Population growth, especially along coastal areas, has increased the need for longterm watershed and flood management planning. Coastal communities, many in flood zones, are becoming increasingly vulnerable to low lying flooding related to changes in sea level rise. Community resilience to climate change impacts will help guide future challenges and decision-making across the island. Jobos Bay NERR will work to address climate change, land use, and habitat protection in Puerto Rico and the broader Caribbean to the extent that resources allow.

- The Commonwealth of Puerto Rico

The island of Puerto Rico is of utmost importance, as the government is experiencing unprecedented economic challenges. Puerto Rico is cutting budgets, including staff and

programs, or seeking creative ways to maintain them. In an effort to assist the PRDNER, the Reserve's state partner, this Plan will identify strategies to maximize Reserve impact within the Commonwealth to provide education, training and management support for PRDNER programs and staff, including the Coastal Zone Management (CZM) and other protected area programs.

- The Caribbean Bioregion

The Caribbean consists of a myriad of small islands in chains and clusters. The significance and vulnerability of the area is, at times, difficult to grasp. Twenty-five (25) of the twenty-seven (27) NERRs are on or attached to the North American continent. Sapelo Island NERR, while accessible only by boat, is in close proximity to the mainland. The islands in the Caribbean, however, have no mainland protection or continuity and are, thus, a microcosm-like representation of the North American continent, with mountains, valleys, plains, deserts, rainforests and coastlines. Surrounded by water, these micro-continents are affected at an exponential scale, continentally-based reserves. This amplifies the importance of the programs conducted at the Jobos Bay Reserve and their application to the greater Caribbean.

The Reserve's watershed, land uses and habitats are characteristic of those found throughout the Caribbean (Figure 22). As such, the Reserve is a microcosm of the broader Caribbean and is ideal for serving as a 'sentinel site' for monitoring and researching the impacts of climate and anthropogenic stressors on coral and coral-related ecosystems. The NERRS' concept of 'sentinel site' establishment focuses on defining and implementing ecosystem-based protocols and standards to monitor and assess the ecosystem response of coastal vegetated habitats to sea level rise, relative to other drivers of vegetated habitat change, and ultimately to enable prediction of future habitat response. At Jobos Bay NERR, representative ecological communities, including mangrove forests, submerged aquatic vegetation (SAV) and coral habitats, will be monitored as components of the sentinel site establishment. This monitoring is further described in Chapter 4 – Research and Monitoring.

As the Reserve establishes itself as a sentinel site within the NERRS and builds out its infrastructure to accommodate programmatic growth, it will be poised to be a hub for research, education, training and stewardship across these three geographic spheres, maximizing programmatic impact within each region on coral and coral-related habitat protection, conservation, restoration and recovery.

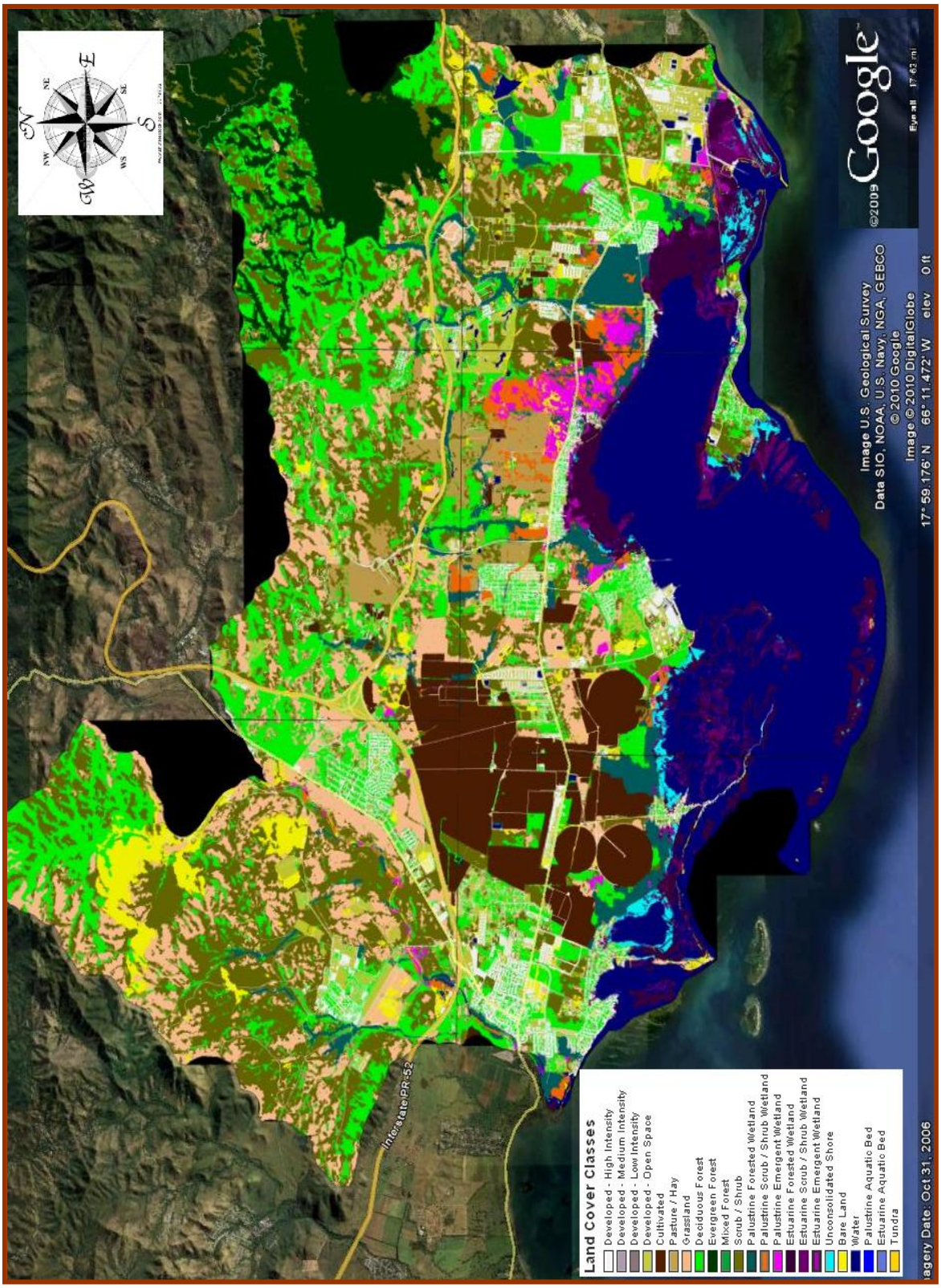


Figure 21. Jobos Bay Watershed and Land Use Classification *(NOAA-CSC 2007)*

## 2.1 Framework of the Plan

The management plan is organized in such a way that programmatic objectives address four overarching goals. Three of the goals mirror the Reserve System goals and one additional goal relates to Reserve administration. Within each program chapter, specific objectives are identified, mapped to the overarching Reserve goals and defined based on implementation in one or more 'spheres of influence'. Guiding principles will be reflected in Reserve programs.

Integration is a driving force in visioning Reserve operations for the next 5 years and beyond. To that end, the Action Plan for each Reserve program – Stewardship, Research, Education, Coastal Training Program, Administration and Facilities – is developed to be integrated and dependent upon the actions of the other programs.

Each programmatic Chapter identifies program specific objectives and associated strategies by geographic sphere of influence. A timeline for these strategies is provided for each program at the end of the respective chapters and serves to guide annual staff work plans. The timeline for annual activities has been established specifically to integrate issue-based activities sequentially across programs. For example, the construction of the laboratory facilities near the boat ramp, identified as a priority in the Facilities Plan, will occur after the inundation model, identified as a priority in the Research Plan, is developed. Following are summaries of program accomplishments and key future directions.

### 2.1.1 Vision, Mission, Goals and Guiding Principles

The **Vision** for the Caribbean is a region with healthy estuaries and watersheds where Caribbean coastal communities, corals and coral-related ecosystems thrive.

The **Mission** of the Jobos Bay NERR is to practice and promote coastal and estuarine stewardship through innovative research, monitoring, education, training and community involvement at the Jobos Bay NERR.

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 ability and willingness to make informed decisions and take responsible actions that affect coral and coral-related ecosystems; and,
- Enhance the administrative capacity and infrastructure of the Jobos Bay NERR to meet the stewardship, research, education and training challenges of the future.

The **Guiding Principles** that will be reflected within each program include:

- Implementation of Jobos Bay NERR programs will rely on strong partnerships and program alliances within the Puerto Rico Department of Natural and Environmental Resources (PRDNER), among Commonwealth and federal agencies, universities, non-governmental organizations (NGOs) and others.

- The Jobos Bay NERR will integrate science, education, training and stewardship to address relevant topics.
- The Jobos Bay NERR will serve as a catalyst and focal point for demonstrating and facilitating objective problem-solving and best management practices (BMPs) to conserve and restore coral and coral-related ecosystem resources.
- Evaluation of the effectiveness of Reserve programs will be an integral component of program implementation with measurables for program objectives identified.
- Green design and sustainable principles will be incorporated into all Reserve facilities.
- An ecosystem-based management approach will be implemented within Reserve programs.
- Reserve programs will reflect priorities of NOAA and PRDNER.

### 2.1.2 Program Accomplishments and Future Priorities

The Jobos Bay NERR has made substantial progress since the last management plan was approved in 2000. In addition to managing the core Research and Education Programs, major milestones include:

- addressing resource impacts on Reserve resources and establishing a Stewardship Program to focus on resource protection and restoration;
- implementing the Coastal Training Program and coordinating the program with key partners to set the standard for environmental training initiatives;
- integrating Reserve programs into the local communities, fostering involvement and pride in the neighboring areas; and,
- developing high resolution maps of the benthic habitats throughout the bay and offshore waters, as well as the watershed, providing the first comprehensive maps of the Jobos Bay ecosystem.

These achievements have fueled the Reserve's ambitious vision to look at the next five (5) years and beyond, developing a legacy that will remain part of the Reserve for future generations. More so than Jobos Bay NERR's past plans, this 5-Year Management Plan will guide the Reserve through a period of dynamic growth to support their expanding programs, setting the stage for the Reserve, their partners and the local communities to address key priority issues affecting the area into the future.

This Management Plan will advance the last plan in a few key ways:

- The boundaries are expanded to include the new acquisition areas.
- Facilities will be developed to accommodate the growth in Reserve programs.
- Reserve program reach and impact will be specified for geographic boundaries, including the Reserve and adjacent watersheds, the island of Puerto Rico, and the broader Caribbean Region.
- Program integration is a cornerstone of the Plan.

This agenda is planned during a challenging economic climate. Therefore, priority strategies are identified and timed to focus, in order of priority, on the Reserve proper, Puerto Rico, and the Caribbean, respectively.

Reserve activities are supported by six (6) programs: Stewardship and Public Access; Research and Monitoring; Education and Interpretation; Coastal Training; Administration; and,

Facilities. Each is explored in depth in their individual Chapters, with program summaries provided below.

## 2.2 Stewardship and Public Access

The Jobos Bay NERR Stewardship Program protects, restores and enhances Reserve habitats by acquiring critical lands, restoring and enhancing habitats, providing public access, developing contingency plans, improving law enforcement and tracking longterm change of Reserve habitats. Major Stewardship and Public Access accomplishments during the last plan include:

- Encroachment into the Reserve was highlighted in the Jobos Bay NERR Coastal Zone Management Act (CZMA) §312 Final Evaluation Accomplishments and Recommendations (Appendix 3) as a significant issue in the evaluation. In response, the Reserve has enhanced the demarcation of its boundaries with appropriate signage. The Reserve also strengthened its relationship with law enforcement staff to address prohibited use of motorized vehicles and illegal construction of docks and piers within the Reserve.
- The Reserve also addressed the CZMA §312 Final Evaluation Recommendation which involved encroachment by the Puerto Rico Land Authority on the north boundary of Mar Negro. The USEPA issued a Consent Order in 1997 for the illegal filling of wetlands and water diversion. In 2008, the wetland remediation and restoration were completed on the parcels. The buffer zone restoration is the only component of the Consent Order remaining for completion.
- Another CZMA §312 Final Evaluation Recommendation being addressed by the Reserve is the degradation of submerged resources, specifically seagrass beds, due to recreational prop scar damage in Cayos Caribe where the Reserve allows public access. With funding from the PRDNER's Fish and Wildlife Division, restoration of seagrass in some prop scars was initiated in 2006 as a pilot study with a workshop used as a training opportunity for natural resource managers throughout Puerto Rico. In the next five years, the Reserve will develop a plan to restore the remaining impacted seagrass beds, again using the restoration effort as a training opportunity for natural resource managers throughout Puerto Rico and the Caribbean.

During the next five (5) years, the Reserve will increase protection, restoration and enhancement of Reserve resources through land acquisition, improved law enforcement strategies, habitat enhancement, restoration of historic flowways, and development and implementation of a new Public Access Strategy. The Reserve will pursue strategies to engage the community to support Reserve stewardship activities, enhance public access and partner with other managed areas within the Commonwealth to support overall efforts.

## 2.3 Research and Monitoring

The Research Program is focused on providing a data-rich environment to support and attract research that explores the interactions of watershed, oceanic and climatic forcing on coral and coral-related environments. By implementing longterm water quality and biological monitoring programs, supporting visiting investigators, mentoring Graduate Research Fellows (GRF), and partnering with other university and governmental programs, the Research Program supports science in a 'Summit to Sea' approach. Major Research and Monitoring accomplishments during the last management plan include:

- The ecological characterization of the Reserve beyond its site profile has expanded through the Reserve's participation in the Conservation Effects Assessment Program (CEAP). The CEAP project at the Jobos Bay NERR is a partnership between NOAA and the US Department of Agriculture. A longterm water quality monitoring strategy is being developed by NOAA, NRCS and the Reserve to continue monitoring the impacts of agricultural BMPs into the future.
- NOAA's National Center for Coastal and Ocean Science (NCCOS) has mapped the benthic habitats in the Reserve and analyzed the sediments for contamination. In addition, a GRF has conducted a complementary contaminant study of Jobos Bay. The Coastal Services Center (CSC) mapped land use, land cover and elevation from high resolution imagery, including Light Detecting and Ranging (LIDAR) imagery, of the Reserve's watershed. This topographic and benthic characterization provides the first comprehensive baseline of the Reserve's habitats and land cover from the summit of the watershed to the sea.
- The Reserve has experienced a dramatic increase in its use by universities throughout Puerto Rico and the mainland US. As such, some universities have expressed interest in using the Reserve as a field station.

To implement the strategies identified in this plan, the Research Program will work closely with NOAA, Commonwealth and University partners to develop scientific models for application in coastal decision-making, implement broader habitat and water quality monitoring programs, develop a habitat mapping and change plan for longterm monitoring of climate and anthropogenic impacts, and establish formal relationships with universities to become a designated field station.

## 2.4 Education and Interpretation

The Jobos Bay NERR Education Program mirrors the National System's education priorities, focusing on students in grades 6-12 and community audiences. Education and interpretation involves a variety of programs and techniques that are tailored to K-12 students, teachers, university and college students and faculty. The Education Program's primary target audiences since the last management plan have been elementary, middle and high school students, local communities and universities, with elementary students comprising 40% of visitors in 2008. Program content focuses on the Reserve's key priority issues and incorporates science-based research and stewardship information. Major accomplishments of the education and interpretation programs during the last management plan include:

- The Education Program developed and implemented a summer camp program for elementary school grades 4-6 called *Guardians of the Estuary*. This camp, implemented each summer, is highly popular and teaches concepts of estuarine ecology, using student booklets and presentations to showcase their newly acquired knowledge. A Collaborative Agreement with the Metropolitan University was signed in 2007 to have a graduate student from the university's education program assist with the implementation of the middle school summer camp and the revision of the Reserve's field guide.
- Annual Teacher Training Workshops have attracted local and regional elementary, middle and high school teachers. Similar workshops were held for community organizations (including ECOMAR and the Las Mareas NGO), undergraduate students from the University of Puerto Rico (UPR)-Humacao's Department of Marine Biology, environmental groups from Maunabo and groups coordinated by Sea Grant College Program at UPR-Humacao to enhance natural resource knowledge, as many serve as

ecotourism guides at the Punta Tuna Reserve, also co-managed by PRDNER. In 2009, the Education team began employing GRFs to assist in teaching teachers about estuarine ecology.

- The Reserve has also been used annually by boy scouts and girl scouts in grades 6-12 to implement research projects about coastal reforestation, design interpretive signage and develop outreach materials for trails to receive a variety of merit badges. One project involved boy scouts from Caguas removing more than 1,000 lbs. of trash from Cayos Caribe and planting more than 200 red mangrove seedlings. This effort was also featured on a local TV program called 'Turismo en Borinquen'. Another project involved a girl scout who coordinated public visits to the Reserve one Saturday each month for 5 months. She was trained by Education staff and supervised while delivering oral presentations on the Reserve and conducting guided field trips for the weekend visitors.

To implement the strategies identified in this plan, the Education Program will partner with teachers, environmental education groups and local communities to raise awareness of priority issues affecting communities and their environments in the Reserve's watershed and Puerto Rico. The program will also be refreshing its strategies and themes using tools and information from the Research, Stewardship and Coastal Training Programs.

## 2.5 Coastal Training Program

The Jobos Bay NERR Coastal Training Program (CTP) 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 CTP is an essential provider of appropriate training in conservation and stewardship in the areas of land use planning, water quality degradation and sustainable use of coastal resources. In the current socioeconomically stressed times, CTP serves as a resource by providing cost-effective training for audiences include PRDNER, partner agencies, coastal stakeholders and community organizations. Major accomplishments of the Coastal Training Program during the last management plan include:

- The Jobos Bay NERR CTP started in 2003 after the successful completion of the Needs Assessment and Market Analysis with the hiring of the CTP Coordinator, facilitating a productive partnership with the University of Puerto Rico and certification of the CTP program by the NERRS.
- The CTP focused on training municipal stormwater managers in more than thirty (30) small municipalities on the development of USEPA-mandated municipal stormwater management plans and supporting environmental permits.
- The CTP assisted with implementation of the CEAP project, providing organizational capacity and training for farmers involved in the project.

Over the next five years, the CTP will focus on facilitating and demonstrating responsive stewardship activities that protect coral and coral-related systems. Partnering with regulatory agencies, agricultural interests, local municipalities, Commonwealth and Federal government agencies, and local communities, the CTP will implement and evaluate its ability to affect change in environmental quality based on implemented actions following training initiatives. Priority will be given to implementing training programs that support municipalities, government agencies and industries in developing and implementing green design and sustainable principles, long-range planning efforts, stormwater management, enhancing the organizational capacity of NGOs to more effectively accomplish community-based initiatives, and training

Reserve staff to apply needs assessments and market analyses to enhance the effectiveness of their programs.

## 2.6 Administration

The Administration Program is focused on enhancing the administrative capacity and infrastructure of the Jobos Bay NERR to meet the research, education, stewardship and training challenges for program implementation. 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 are components of the Reserve's Administration Program.

During the last management plan time frame, the Reserve successfully filled key staff positions with highly qualified individuals, including the Manager, 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, Research and Education Advisory Committees were established and have been effective in soliciting partner support in program development and implementation.

To implement the strategies identified in this plan, the Administrative Program identified the need for an Administrative Assistant and other programmatic staff, as well as formation of staff professional development plans and individual annual work plans linked to the annual goals identified in this Plan. In addition, the organizational structure will be re-aligned so that the Reserve Manager has direct supervision over program coordinators. The program coordinators will be empowered to supervise their respective program staff and be accountable for work plans developed to implement the strategies identified in this Plan.

## 2.7 Facilities

The Reserve's current facilities include a Visitor Center with exhibits, staff offices, a research laboratory, a small meeting room, kitchen and basic dormitory facilities. The Visitor Center complex is the restored Club House of the Aguirre Sugar Plantation, which retains its historic architecture. There is a small parking lot that supports staff and visitor vehicles, as well as Reserve vehicles, boats and trailers. Major Facilities accomplishments as a result of the last management plan include:

- The construction of a boat ramp and access pier for the Reserve and visiting investigators.
- The refurbishment of interpretive exhibits in the 2,800 square-foot space in the Visitors' Center, including interactive displays, photos, a watershed model, coral reef dioramas, and pictorial exhibits of key ecosystems, resources and the cultural history of Aguirre.

Over the next five years, the Facilities Program will focus on developing a suite of facilities to support the Reserve's expanding programs. Priorities include: modernized dorm facilities to handle the increasing demand for dorm space by students and researchers (University of Puerto Rico, Metropolitan University, University of Texas, University of Texas-A&M, University of Georgia-Kennesaw, Duke University, Columbia University, University of South Florida, Boston University, University of Cambridge-UK); relocation and expansion of laboratory facilities; enhancement of existing facilities to expanded office space for Reserve staff, visiting

researchers and partners; increased parking facilities; maintenance and storage facilities for vehicles, vessels and equipment; refurbishment of the Aguirre Train Station Building to house a surveillance officer, a community-volunteer office, and a welcome interpretive station for visitors to trails; exploration to further initiatives in developing training center capabilities. To implement the strategies identified in this Plan, the Facilities Program, in addition to some new construction, will re-purpose several existing structures and use green design principles to serve as a model for regional sustainable design.

## 2.8 Summary

The Chapters will provide an overview, define past accomplishments, discuss next steps for activities, outline challenges and identify primary partners for each program. The challenges identified in each chapter will be addressed with PRDNER, the respective programmatic advisory committees and partners, as well as by pursuing outside or competitive funds. As the Friends of Jobos Bay group develops, it will also provide a mechanism for fund raising for the identified program, planning and staffing needs. An Action Plan Table and a Timeline summarize programmatic activities and implementation strategies at the end of each Chapter. Drafts of the Management Plan were provided to partners and a presentation was held for the public to comment on elements within the plan. A summary of comments on the plan is provided in Appendix 9. Table 2 provides the Reserve's overarching vision, mission and goals, as well as specific objectives by program for each of the four goals.

Table 2. Reserve Vision, Mission and Goals

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| **VISION**<br>Healthy estuaries and watersheds where Caribbean coastal communities, corals and coral-related ecosystems thrive | |
| **MISSION**<br>**To practice and promote coastal and estuarine stewardship through innovative research, education and community involvement at the Jobos Bay NERR** | |
| **GOAL 1**<br>Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and education | |
| **Stewardship and Public Access** | Reserve resources will be protected through expanded Reserve boundaries<br><br>Impacts from illegal activities within Reserve are reduced<br><br>Reserve habitat quality will be improved through habitat restoration and enhancement<br><br>The restoration of Reserve habitats will generate useful data and research to support restoration strategies of coral and coral-related habitats<br><br>Public use of the Reserve increases without affecting habitat quality |
| **Research and Monitoring** | Watershed and circulation models will be developed to identify the likely sources and fates of land-based pollution into the Reserve<br><br>Inundation models will be developed to examine the impacts from projected sea level rise |
| **Education** | Coral and coral-related habitats of Jobos Bay NERR will be protected through the actions of local communities |

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| **Coastal Training Program** | Coastal-decision makers will implement strategies that will effectively protect coral and coral-related ecosystems |
| **Facilities** | Public access to Reserve facilities during non-working hours will be managed |
| **GOAL 2**<br>Increase the use of Reserve science and sites to address priority coastal management issues | |
| **Stewardship and Public Access** | Reserve resources are protected through watershed-based strategies that target reduction of anthropogenic impacts<br><br>Habitat restoration will be monitored for effectiveness through implementation of restoration science strategies<br><br>Multiple uses within Reserve's boundaries are managed to protect coastal resources |
| **Research and Monitoring** | The Reserve will be a data rich environment that supports research on the impacts of watershed, oceanic and climatic forcing on coral and coral-related environments<br><br>The Reserve will be a sentinel site within the NERRS network<br><br>Multiple audiences will have access to the Reserve's research and monitoring data<br><br>MOU's with universities will increase the use of the Reserve as a research field station |
| **Education** | Students in grades 6-12 improve their math and science performance through the application of Reserve science and technology to coastal management issues |
| **Coastal Training Program** | Local communities will implement strategies that effectively enable adaptation to projected climate change scenarios |
| **Facilities** | The Reserve will incorporate sustainable design concepts<br><br>The Reserve facilities will support research, trainings, workshops, conferences and seminars that attract people from throughout Puerto Rico and the broader Caribbean<br><br>Telecommunications infrastructure will be designed to facilitate access to information by multiple audiences |
| **GOAL 3**<br>Enhance people's ability and willingness to make informed decisions and take responsible actions that affect coral and coral-related systems | |
| **Research and Monitoring** | Decision support tools will be applied to support coastal management, training and education efforts |
| **Education** | The impact of island-wide environmental education that addresses climate change and anthropogenic stressors on coastal habitats will be strengthened through a coordinated network of environmental education providers<br><br>Visitors to the Reserve will receive information on climate change and watershed impacts on water quality, biological diversity and community resilience |
| **Coastal Training Program** | The communities within the Jobos Bay NERR and adjacent watersheds will be partners in protecting coral and coral-related environments<br><br>NGOs and other community-based organizations will be more active in the |

| | |
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| | management of natural resources through enhanced understanding and capacity to take action |
| **Facilities** | Reserve buildings are used as a demonstration of regional sustainable design concepts |
| **GOAL 4**<br>Enhance the administrative capability and infrastructure of the Jobos Bay NERR to meet the stewardship, research, education and training challenges of the future | |
| **Research and Monitoring** | Research staff and infrastructural capacity will efficiently and effectively meet research goals and objectives |
| **Administration** | Jobos Bay NERR organizational structure is diversified to promote leadership among Program Coordinators, achieving more efficient outputs by all Reserve staff and programs<br><br>Program growth is occurring as a result of stable and expanded staff support<br><br>A mechanism is developed to receive private funding to support Reserve programs |
| **Facilities** | Facilities are enhanced and developed that support the Reserve's long-term goals and its projected build-out needs<br><br>Facilities are provided that support local and regional needs |

This Management Plan will guide the activities of the Reserve for the next five years (2010-2015). It is an ambitious plan with a focused, integrated approach. If successful, Jobos Bay NERR will have the facilities, resources and staff to meet the coastal resource protection needs of its communities, its watersheds, the Commonwealth and the greater Caribbean at the end of this five-year period.

## 3.0 STEWARDSHIP AND PUBLIC ACCESS

The Jobos Bay NERR Stewardship Program protects, restores and enhances Reserve habitats to support research and education program priorities. Stewardship activities will address anthropogenic impacts from the watershed in its strategies to protect and restore coral and coral-related ecosystems. The Stewardship Agreement consists of representatives from: the Puerto Rico Department of Natural and Environmental Resources, Puerto Rico Planning Board, Puerto Rico Department of Agriculture, Puerto Rico Management of Regulations and Permits, Municipality of Salinas, Puerto Rico Environmental Quality Board, Puerto Rico Land Authority, Puerto Rico Housing Department, Municipality of Guayama, Puerto Rico Special Communities Office, and the Puerto Rico Police Department. Partners to the agreement will coordinate activities to support stewardship priorities of the reserve.

Strategies will include strengthening and modifying reserve boundaries, acquiring critical lands, restoring and enhancing habitats, revising public access strategies, evaluating the effectiveness of contingency plans, improving law enforcement and mapping longterm change of reserve habitats. Protection of reserve resources from activities outside its boundaries will involve mapping and modeling watershed processes, and engaging stakeholders using CTP strategies in watershed planning using the best available science, mapping, and planning tools. Over the next five years, this Stewardship Plan focuses predominantly on activities within the Reserve boundaries. Watershed actions that are necessary to protect reserve resources will be pursued in coordination with the CTP coordinator.

### 3.1 Past Stewardship Accomplishments

The Stewardship Program successfully accomplished several important milestones for the reserve during the last management plan period. These include:

- Acquisition

Four key areas were identified in the Reserve's 2001 Land Acquisition Plan for purchase and incorporation into the Reserve (Figure 23):

(1) El Batey de Aguirre - The mangrove forest parcel behind the Visitors' Center provides additional access to Reserve and opportunities for education and public access trails;

(2) Cayos de Barca – This parcel increases the amount of critical barrier island habitat (core area) in the Reserve;

(3) El Salitral - The salt flat on the western boundary of the Reserve increases the acreage of this rare habitat, while providing additional area for endemic and migratory bird populations; and,

(4) Secondary Forest - The upland forest parcel on the northern boundary above Mar Negro creates a buffer between in-production agricultural lands and the core protected areas of the Reserve.

The reserve acquired all identified lands with the exception of the Cayos de Barca. Only four (4) of the seven (7) islands were acquired. These purchases provide the Reserve with greater control over its resources and much-needed direct access to Jobos Bay's waterfront.

- Enhanced Enforcement of Illegal Activities within the Reserve

Addressing significant findings in the Jobos Bay NERR Coastal Zone Management Act (CZMA) §312 Final Evaluation Accomplishments and Recommendations (Appendix 3) conducted for the period from December 2001 thru December 2005, the Stewardship Program focused on illegal encroachment into the Reserve. Enforcement of illegal activities in the Reserve has been an on-going struggle. However, during this period, Reserve staff met with and coordinated the development of a surveillance and enforcement plan with local and federal agencies, making considerable progress toward halting resource degradation. This was especially apparent on the Reserve's western boundary in the vicinity of Camino del Indio and Las Mareas where several illegal piers have been removed and no new structures have been constructed. In addition, Jobos Bay NERR and the Puerto Rico Department of Natural and Environmental Resources (PRDNER) enhanced the demarcation of the Reserve's boundary, enhancing awareness of and coordination with relevant agency stakeholders and improved enforcement. The Reserve anticipates further strengthening of its relationship with law enforcement staff.

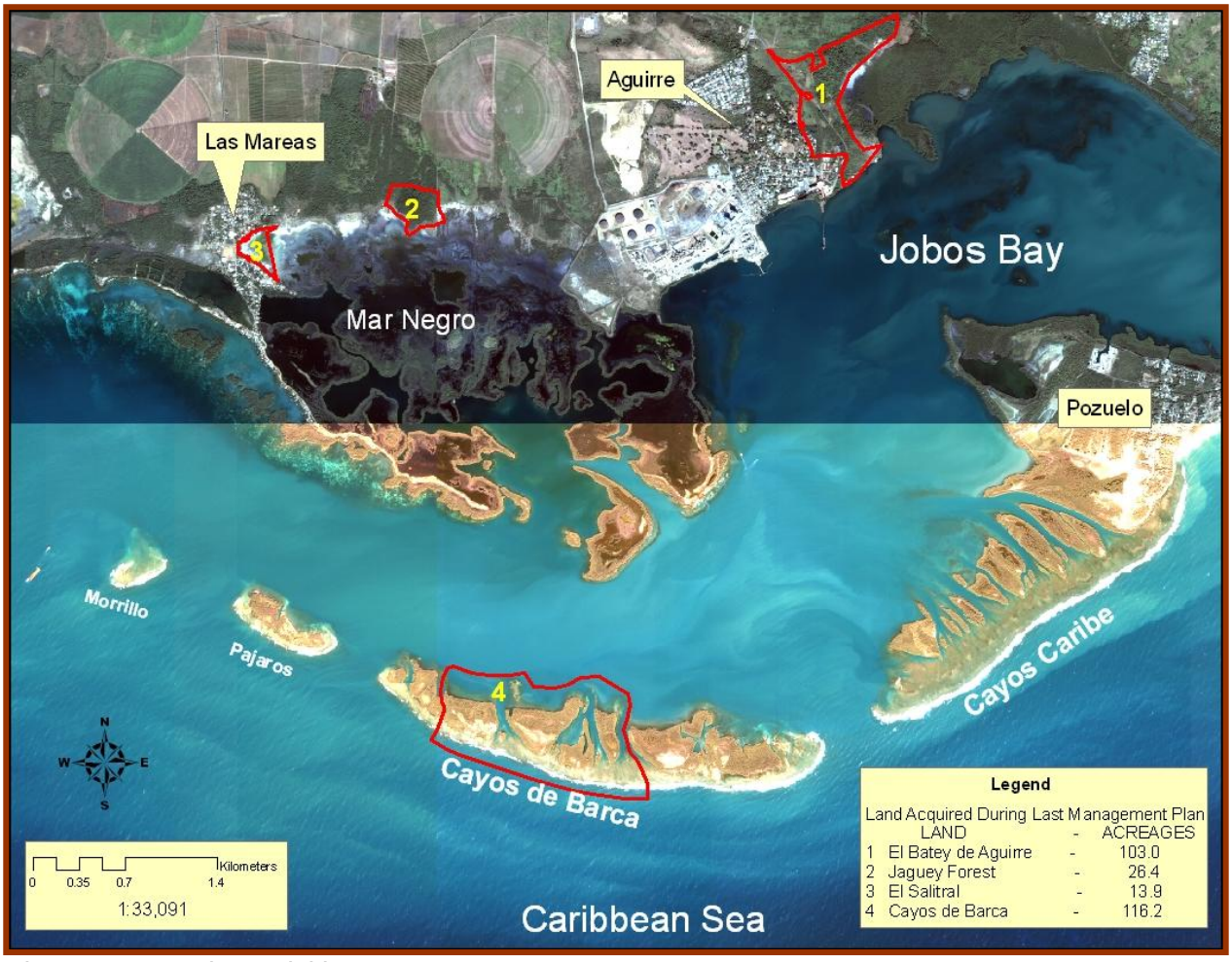


Figure 22. Land Acquisition 2000-2010

- Encroachment by the Land Authority into the Reserve

The Reserve also addressed the CZMA §312 Final Evaluation Recommendation which involved encroachment by the Puerto Rico Land Authority on the north boundary of Mar Negro. The US Environmental Protection Agency (USEPA) issued a Consent Order (Appendix 7) in 1997 for the illegal filling of wetlands and water diversion. In 2008, the wetland remediation and

restoration were completed on the parcels. The buffer zone restoration is the only component of the Consent Order remaining for completion and the Natural Resources Conservation Service (NRCS) is working with the Reserve to develop the planting strategy and anticipates completing this final requirement in 2011.

- Seagrass Restoration

Another CZMA §312 Final Evaluation Recommendation continuing to be addressed by the Reserve is the degradation of submerged resources, specifically seagrass beds, due to recreational prop scar damage in Cayos Caribe, where the Reserve allows public access. A pilot study for restoration of seagrass in selected prop scars was implemented in 2006, conducting a workshop for use as a training opportunity for natural resource managers throughout Puerto Rico. In the next five years, the Reserve will develop a plan to restore the remaining impacted seagrass beds, again using the restoration effort as a training opportunity for natural resource managers throughout Puerto Rico and the Caribbean.

- Stewardship Agreement

Recognizing the coordinated commitment needed to protect resources through ecosystem-based management, the Secretary of the PRDNER developed an interagency Stewardship Agreement to address comprehensive permitting, monitoring and enforcement at the Reserve. All parties committed to addressing existing enforcement problems at the Reserve, as well as preventing new problems from occurring. Additionally, the Agreement facilitated open communication among agencies that previously had not collaborated to address resource issues. Enforcement issues that occurred at Jobos Bay NERR since the Agreement was signed have been addressed expeditiously.

- Removal of Derelict Vessel

A derelict vessel off Cayos Caribe was removed.

## 3.2 Stewardship Priorities

Looking ahead, existing and anticipated pressures on Reserve resources require the staff to act proactively to adequately protect them. The Reserve's key issues – climate change, land use change, ecological integrity and community resilience – will drive the focus and effort of the Stewardship Program. Following are the immediate and anticipated pressures facing the Reserve:

**RESERVE KEY ISSUES**

- Climate change impacts on coastal ecosystems and communities
- Land use change impacts on coral and coral-related habitats
- The interrelationship between ecological integrity and community resilience

1) Increase in Reserve visitation resulting from anticipated growth in the Reserve's watershed, the Commonwealth's priority for promoting ecotourism along the south coast of Puerto Rico, and Reserve program growth

The Jobos Bay watershed is experiencing growth in urban development and corresponding conversion of agricultural lands to development (Figure 24). In addition, the Puerto Rico Tourism Company – a quasi-governmental Commonwealth organization charged with developing and managing tourism in Puerto Rico - has identified the south coast of the island as a target for ecotourism growth. While no formal current or targeted uses have been developed,

the dire economic climate in Puerto Rico will put pressure on the rapid development of ecotourism as a growth industry. The Jobos Bay NERR is seen as a resource to the island and local communities for generating increased ecotourism in the region. The Reserve will work with local partners and communities to accommodate and steer this growth, while balancing the need for resource protection.

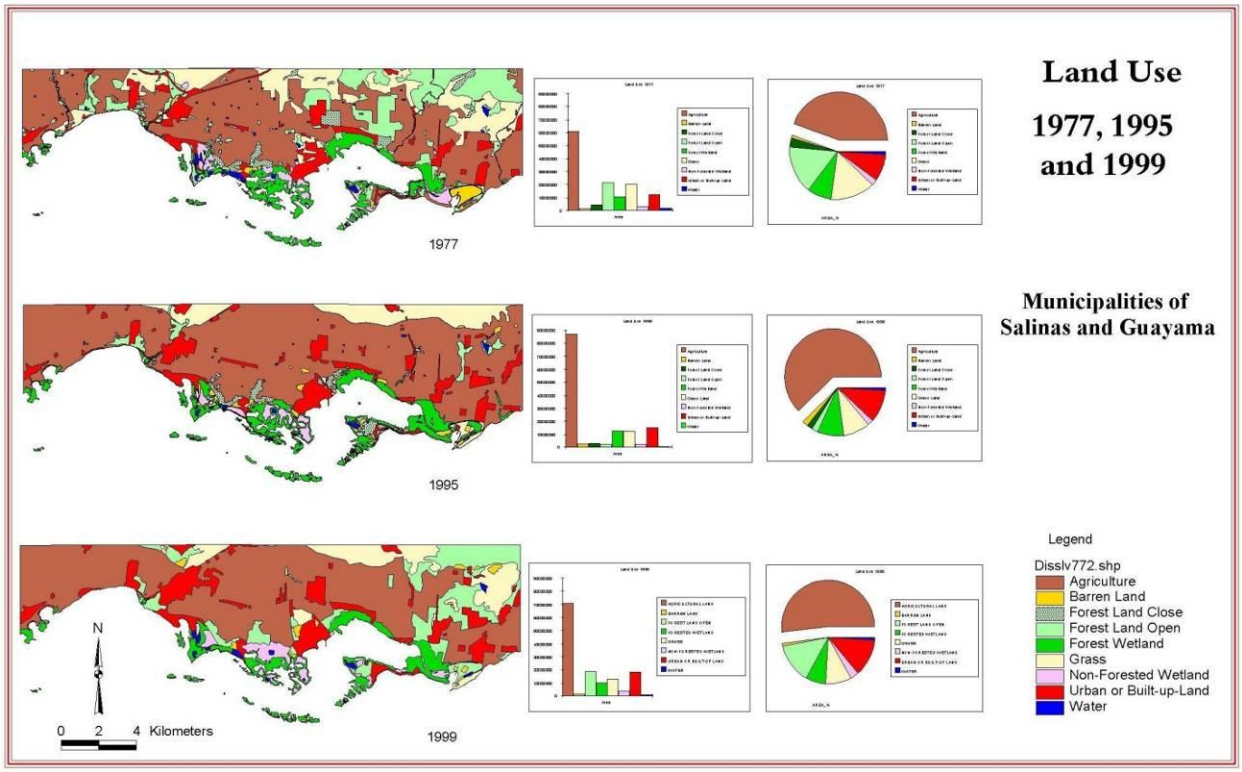


Figure 23. Land Use Change

2) Existing impacts from multiple uses of the Reserve, including boating, hiking, fishing and industry

There are a number of impacts on Reserve resources that staff needs to address, and, unless managed proactively, the impacts will intensify as use of the Reserve increases. Seagrass beds adjacent to Cayo Caribe are significantly impacted by boat traffic from recreational boaters that visit the island on weekends. Prop scars and larger blow holes, created when boat operators attempt to dislodge their vessels from groundings, are visible across the shallow seagrass beds. Trash is also present throughout the marine environment. Reserve trails are impacted from illegal use of off-road vehicles as evidenced by visible tire tracks on the trails. These vehicles can cause damage to vegetation and nesting shorebirds. Illegally set fishing nets within the Reserve have been recovered by Reserve staff. Industrial activities that directly impact the Reserve include the outfall pipe that discharges hot water from the thermoelectric plant within the Reserve, and the lighting from the electric plant that can affect nesting sea turtles.

This chapter presents a discussion of how Stewardship strategies will be implemented to address the current and anticipated pressures confronting the Reserve.

## 3.3 Allowable Uses

To promote multiple uses within the Reserve while, at the same time, protecting its special ecological attributes, a three-way Management Sector Classification, including Preservation, Conservation and Limited Use, was established by the Commonwealth, within which compatible uses will be allowed (Figure 25). The Commonwealth of Puerto Rico manages areas of the Reserve using these Management Sector classifications. The Preservation and Conservation classifications correspond to core areas of the Reserve and the Limited Use classification crosswalks with Reserve buffer areas. Therefore, the Aguirre area, and portions of Mar Negro, Cayos Caribe, and Jobos Bay below 33 ft (10 m) in depth correspond to Limited Use. The Mar Negro Unit, most of Cayos Caribe, Cayos la Barca and the Coral Habitat Units correspond to Preservation and Conservation uses. These Management Sector classifications align with Commonwealth regulations and are upheld by law enforcement officers.

The use of jet skis is prohibited in all areas of the Reserve. Anchoring in designated mooring areas around the Cayos and within the lagoons is limited to a maximum of three hours. Docking and mooring facilities will be established and appropriate signage posted. These measures will allow access to more users, while managing public use of these sites in a manner that will not threaten or significantly disturb the natural ecosystems.

*Preservation Sector (Core Area)*

These areas, primarily in the mangrove habitat of the Mar Negro Unit, the offshore Coral Habitat Unit and intertidal and submerged habitat within 33 ft (10 m) of shore require a high degree of protection due to their vulnerability, ecological importance, presence of flora and fauna, and/or cultural values. Physical and biological assessments have shown the need to designate Preservation Sectors in the Mar Negro Unit that meet these criteria. Many of the areas classified for preservation include coves, shallow semi-enclosed areas, seagrass beds, offshore cayos and fringing mangroves within the lagoon system. These are spawning areas and nursery grounds for valuable commercial fish species and habitat for endangered species. The preservation of these resource areas is vital to maintain the equilibrium and population dynamics of the estuary.

Historically, the island's coral reefs have been impacted by diverse users that found opportunities for commercial and individual sustenance, research, education and recreational activities. With the turn of the century, a general acknowledgement of the state of the world's coral reefs and their importance as ecological habitats, influencing global environment, has triggered new Legislation with regard to their use and management, Jobos Bay included.

Activities in designated preservation sectors will be limited to research and monitoring. All activities must be approved and registered at the Reserve. Fishing, hunting and the use of motor vehicles is not allowed in these areas.

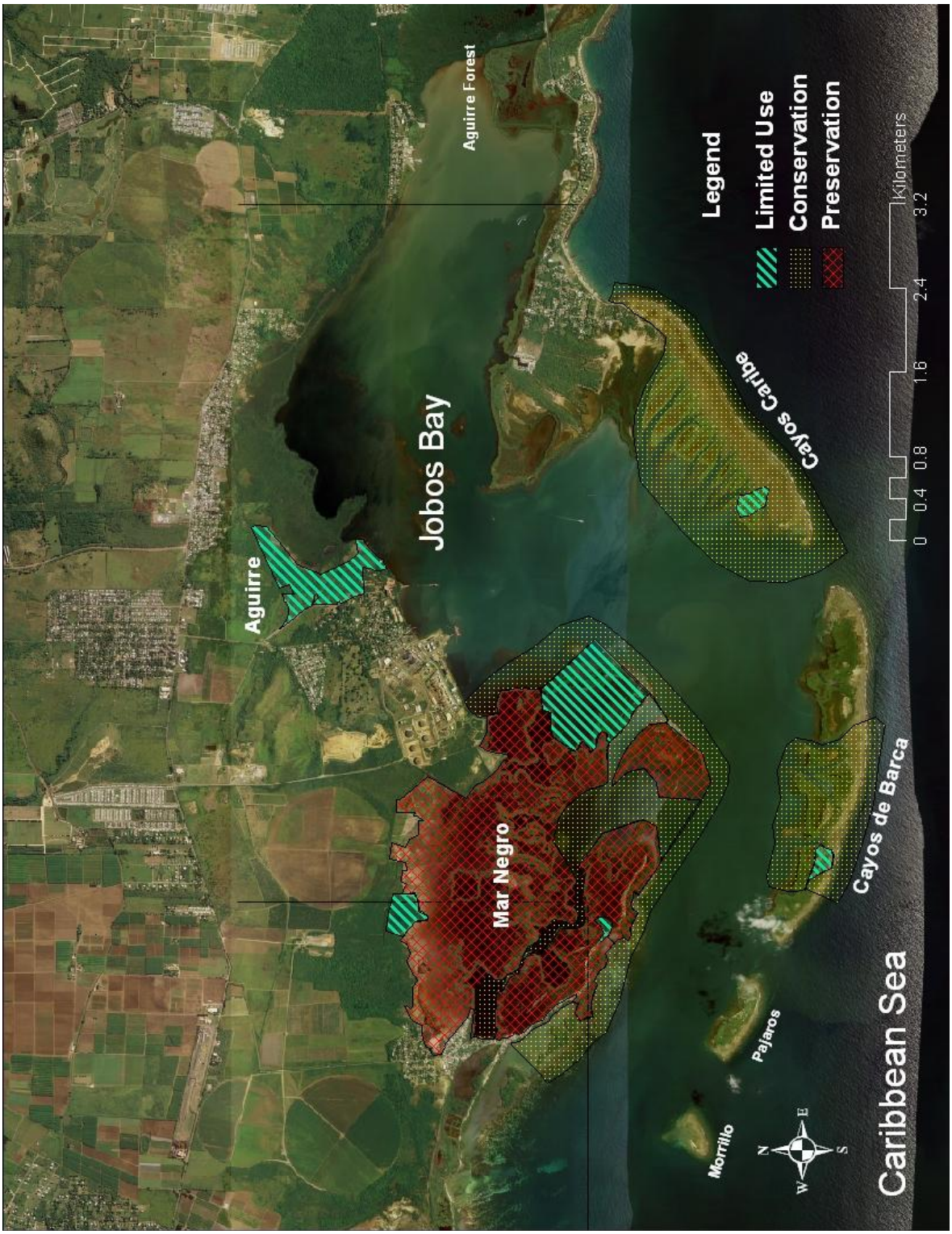

Figure 24. Management Sector Classifications

*Conservation Sector (Core Area)*

The vast majority of the Reserve, including Mar Negro, Cayos Caribe, Cayos de Barca, and the Coral Habitat Units, has been classified as a Conservation Sector. These are environmentally sensitive areas and include wetlands, mangrove areas and scenic outlooks that require protection against inappropriate or excessive use.

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. Local fishermen are the primary users of this waterway. Boat size is limited to a maximum of 22 feet, and speed is limited to five knots (5.7 mph).

Hook and line fishing is allowed, but with emphasis on the importance of releasing small or immature individuals to ensure sustainability. Pot and net fishing is not allowed inside the Mar Negro area. Hunting of aquatic birds is allowed in designated areas, complying with the regulations established for their management.

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

Passive recreation activities, such as bird watching, snorkeling, kayaking and diving, will be promoted as part of Reserve's education plan. The existing kayak trail will be re-routed for security and public safety reasons.

Coral Habitat Unit

In compliance with Law 147, of June 15, 1999, better known as the Law for the Protection, Conservation and Management of Coral Reefs in Puerto Rico; and in accordance with Law 278 of November 29, 1998, known as Puerto Rico's Fisheries Act; this Management Plan clearly defines a Coral Habitat Unit for the Jobos Bay National Estuarine Research Reserve. Activities regulated in this sector are as follow:

Permitted Activities

1. Line Fishing.
2. Snorkeling and Diving.
3. Anchoring on Mooring Buoys.
4. Guided tours for educational and research purposes within identified areas.
5. Collection of coral and other related species for scientific purposes with granted prior authorization as established in the Law.
6. Removal or protection of any sick or contaminated marine species with required permits and under guidance by Jobos Bay authorized personnel.
7. Use of dead coral for artisanal applications. Artisans should be registered in the Artisan Register of the Puerto Rico Economic Development Company and comply with the required permitting process.
8. Collection of shoreline debris with guidance by Jobos Bay authorized personnel
9. Photographs and memories.

Not Permitted Activities

1. Pot, net, harpoon fishing.
2. Use of any kind of chemical and explosive fishing practices.
3. Collection or extraction of corals and related species, including aquarium fishes.
4. Walking on or touching of corals.

5. Anchoring without using mooring buoys.
6. Waste discharge.
7. Jet skis or other similar motorized water bikes.

*Limited Use Sector (Buffer Area)*

These are areas primarily dedicated to public access including the trails along the northern boundary of Mar Negro, the boat ramp in the Aguirre Unit, and on Cabeza de Cayos Caribe. Interpretative trails, boardwalks, limited docking piers for public use and minimum facilities will be constructed as necessary.

Anchoring in designated areas around the Cayos and within the lagoons is limited to a maximum of three hours. Docking and mooring facilities will be established and appropriate signage posted. These measures will allow access to more users, while managing public use of these sites in a manner that will not threaten or significantly disturb the natural ecosystems.

Passive recreation, including bird watching, hiking, swimming, and snorkeling, is encouraged.

## 3.4 Law Enforcement

Primary responsibility for enforcement of Commonwealth laws rests with PRDNER, working with the Department's Ranger Corps and Legal Division. Jobos Bay NERR has the same level of protection against violations as natural reserves, state forests and other PRDNER-designated protected areas. Appendix 4 summarizes the primary laws and regulations used by the Department to exercise authority for the planning and management of protected areas, based on the following legal framework:

1. The Organic Act
2. The Underwater Archaeological Resources Act
3. The Caves, Caverns and Sinkholes Act
4. The Coralline Resources Regulation
5. The Fishing and Fishery Industry Resources Act
6. The Forest Resource Act
7. The Mineral Resources Law
8. The Earth Crust Mineral Resource and Dunes Act
9. The Recreation Act
10. The Puerto Rico Natural Patrimony Act
11. The Ranger Corps Act
12. The Water Resources Act
13. The Wildlife Act
14. The Uniform Administrative Procedures Act
15. The Maritime Zone Regulation
16. The Law for the Protection, Conservation and Management of Puerto Rico Coral Reefs

These regulations are provided in their entirety on the Reserve's website (www.jbnerr.org) .

To discourage both inadvertent and intentional violations, additional signs were installed to demarcate the Reserve boundaries. Surveillance and enforcement has decidedly improved with the assignment of ten (10) Rangers to the Reserve, patrolling the area by boat and vehicle. These Rangers report directly to the Reserve Manager through their supervisor, responding to complaints and observations, as well as conducting routine patrols of areas with a history of violations. For example, the north boundary of the Mar Negro area is frequented by illegal motorized vehicles and Mar Negro proper is the site of illegal fishing activities. These areas require regular patrols which raise the visibility of enforcement in the Reserve.

Continuing efforts are being made to improve communication and cooperation between Jobos Bay NERR and the Ranger Corps, with the Reserve including the needs of law enforcement in their facility planning efforts. One such example is the opportunity to use the Reserve's wireless infrastructure to support cameras for remote surveillance of both high traffic and remote areas. The benefit of fostering this longterm relationship will also be strengthened as the Reserve's new facilities are constructed. By providing an on-site office for law enforcement, the Reserve facilities will have enhanced, around-the-clock security.

Additional surveillance has been accomplished through active community non-governmental organization (NGO) involvement, such as the Las Mareas NGO, who contacts the Reserve or Rangers if they observe or encounter a violation. As the local communities have embraced and become involved with the Reserve, their self-policing, in conjunction with the assignment of Rangers to the Reserve, has resulted in a substantial reduction in resource violations.

## 3.5 Land Acquisition

Several areas have been identified for future acquisition and ultimate inclusion in the Jobos Bay NERR boundary (Figure 26). These island 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 hawksbill sea turtle and West Indian manatee. In addition, the island acquisitions will complete comprehensive Commonwealth ownership of the three (3) island chains, providing for holistic management and enforcement for longterm resource protection. The mainland components are either in-holdings or located along the Reserve's current boundary. Acquisition priorities include both core (preservation and conservation sector) and buffer (limited use sector) lands.

The areas outlined in red, are lands currently owned by the state and under management by Jobos Bay NERR. The Reserve boundary has been recently expanded as part of the revision process. In addition, the new acquisitions and Jobos Bay's designation as a Marine Protected Area (MPA) are also recognized. Along the western boundary of the Reserve, along Camino Del Indio, the Reserve recognizes a non-controversial boundary that lays on the east side of Camino del Indio and excludes all residential structures on the west side of the road. It also recognizes that there is a loop area that extends south from the last standing house that is currently under legal title determination. PRDNER will reconsider all permitting activities along this boundary, while the case is settled. A new Reserve boundary will be published in the Federal Register as part of the approval for this Management Plan.

There are many areas within (Cayos) or adjacent to this new boundary that have been identified as areas of interest for potential future acquisition. A number of the identified sites will offer greater protection to sensitive habitats, while others, will be invaluable in providing access and support for Reserve activities and program development. Examples include Cayos de Barca,

Isla Pajaros, Cayo Morrillos, a mangrove forest by Mar Negro, two mangrove uplands behind the Visitor's Center, the Sucesión Vázquez parcel and the Finca Salitral parcel, among others.

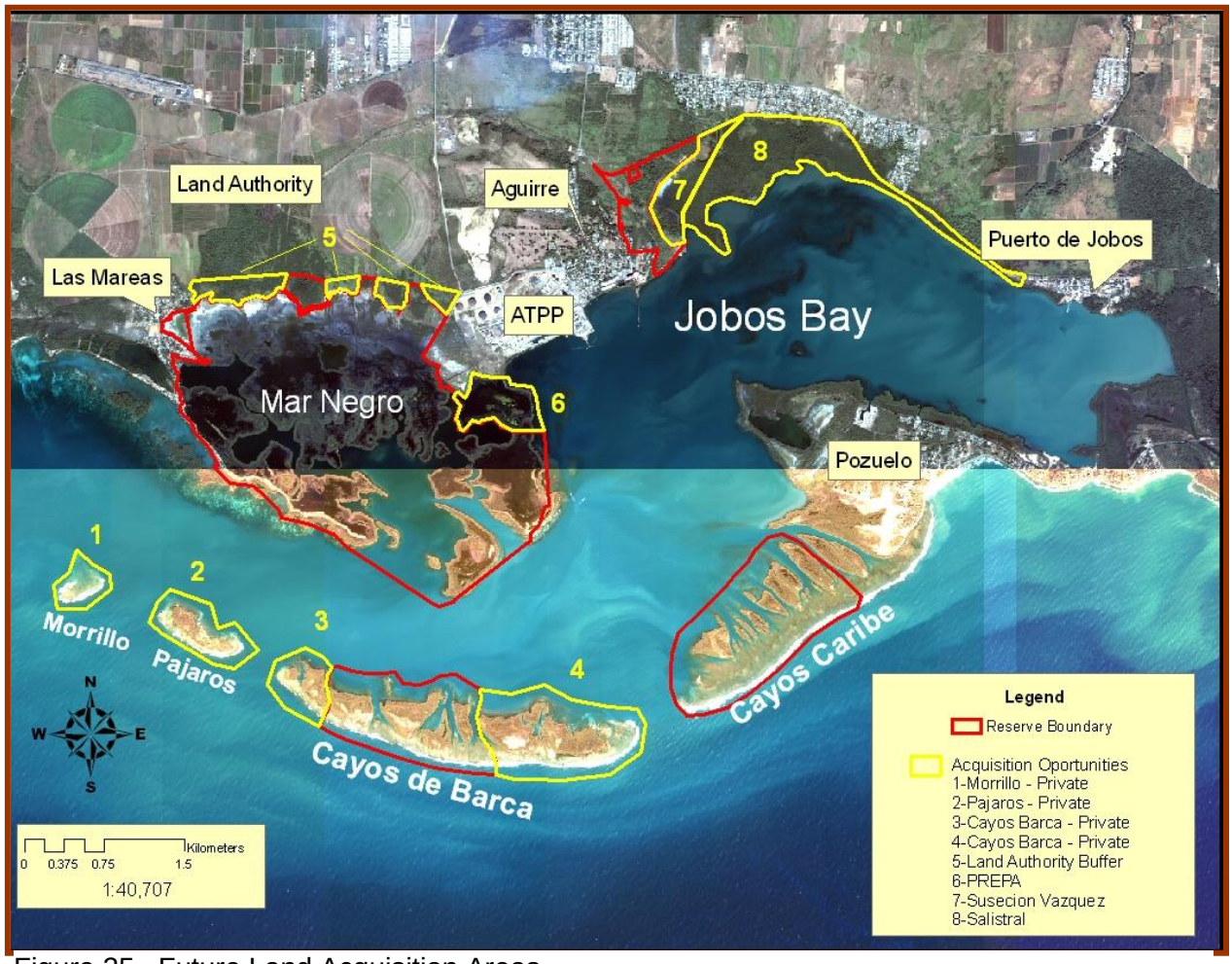

Figure 25. Future Land Acquisition Areas

They are described as follows:

Island Components

The islands identified below consist primarily of red and white mangrove fringe, with limited coastal strand communities in the interior. All parcels will become core areas.

- Cayo Morrillo, west of Cayo Los Pajaros and Barca - Core
- Cayos de Los Pajaros, west of Cayos de Barca - Core
- Cayos Caribe island, east end of island chain - Core
- Cayos de Barca parcels, east and west end - Core

Mainland Components

The mainland components identified below consist of red, black, white and buttonwood mangrove forest, salt flats, subtropical dry forest and coastal bluff habitats. At this time, the parcels remain undeveloped or unoccupied. Several parcels along the north

boundary of Mar Negro are currently managed by the Puerto Rico Land Authority and present an opportunity for inclusion in the Reserve's boundaries.

- Forested in-holding on the north and east boundary, behind Visitor's Center - Sucesión Vázquez and Finca Salitra parcels – Buffer
- Forested in-holding on north boundary of Aguirre Unit – Land Authority – Buffer
- Coastal forest parcels, north and east of the Mar Negro Unit – PREPA – Buffer

The Reserve will prioritize acquisition of core habitat placing a high priority on acquiring the Sucesión Vázquez and Finca Salitral parcels to facilitate public access, facility construction and coordination between the Jobos Bay NERR and the Aguirre Forest. The opportunities for land acquisition do not always present themselves in the Reserve's order of highest land acquisition priorities. Therefore, Jobos Bay will act to purchase any parcel identified in this plan, either in fee simple or through a conservation easement, as they become available. In addition to their ecological value, the Cayos remain high priority for acquisition due to tourism impacts from lack of management of these coastal habitats. There are no facilities or bathrooms, and as a result large amounts of trash are found on the beaches, in mangrove roots and along waterways around the island.

Another tourism-related issue of great concern with regard to public use of the Cayos is direct damage to mangroves, coral reef and seagrass habitats. For example, in Isla Pajaros, during a field inspection, small amounts of garbage, evidence of cooking stations, a makeshift shelter, and a small dock built onto mangroves were found. As a management approach, one of the islands of Cayos de Barca will serve as a buffer habitat for ecotourism and passive recreation, while the others will become reference sites or core habitats with a greater degree of protection. Interpretative field trips will be facilitated in the buffer habitat within the Cayos de Barca and longterm monitoring programs will be encouraged in both buffer and core habitats within these islets to monitor public use impacts.

The mainland acquisitions of Sucesión Vázquez and Finca Salitral parcels, located behind the Visitor's Center, will provide numerous benefits for the Reserve as it integrates management with the Aguirre State Forest. These land parcels will serve as an ecological corridor, connecting Jobos Bay NERR to the Aguirre State Forest. This will facilitate the coordination of education and public access strategies between the two programs. These mangrove forests, salt flats and lagoons, augment the Reserve's current habitats with their diversity of flora and fauna and serve as buffer areas to Jobos Bay. These habitats, besides being a valuable addition to Jobos Bay NERR, would contribute in preserving the unique habitats of southern Puerto Rico.

Table 3 provides information related to these properties and estimated costs, using the transaction for Cayos de Barca as a guide. The estimate for the Finca Salitral parcel is based on an actual price.

Law 268 (Legacy Lands Act) was passed by the Puerto Rico Legislature in 2003, and 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. The Legacy Lands Act represents a potential source 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. This strategy will drive the acquisition of Cayo Pajaros, where the owner has expressed his willingness to sell and sent the Reserve a letter to initiate the transaction.

Other strategies, such as Conservation Easements, will be used for the Sucesion Vazquez-Bruno parcel, as the owner does not wish to sell the property, but wants to engage in a longterm protection arrangement with the Reserve.

**Table 3. Future Land Acquisition Areas**

| *Property Name* | *Title Owner* | *Total Area (acres)* | *Upland Area (acres)* | *Estimated Cost* | *Status* | |
|---|---|---|---|---|---|---|
| | | | | | *DNER priority* | *Willingness* |
| Cayo Morrillos | Blas Buono | .7 | 0 | $17,000.00 | medium | Unknown |
| Cayo Pajaros | Ines Nadal | 22 | 1.5 | $368,940.00 | medium | Yes |
| Cayo de Barca A-B | Hector A. Vargas | 57 | 4.2 | $955,890.00 | medium | Yes |
| Cayo de Barca G | Blas Buono | 8 | 1.7 | $134,160.00 | medium | Unknown |
| Land Authority Buffer | Government | 78 | 78 | Settlement | medium | Unknown |
| PREPA Buffer | Government | 75 | 75 | Settlement | high | Unknown |
| Sucesión Vazquez-Bruno | Rafael Guzman Vazquez, others | 72 | 0 | $1,207,440.00 | high | No - fee simple purchase Yes- Conservation Easement |
| Finca Salitral | Jorge Gonzalez | 100 | 100 | 550,000.00 | high | Yes |

## 3.6 Restoration and Enhancement

A number of restoration and enhancement projects have been identified within the Reserve's managed area (Figure 27). A Restoration Science Strategy will be developed by the Reserve and applied to those restoration activities as appropriate.

By engaging the Restoration Committee, questions, implementation techniques and monitoring strategies will be incorporated into restoration projects. Of particular interest will be restoration effectiveness of seagrass and coral habitats. The Research Program will steer restoration science approaches within restoration efforts and will also identify and/or implement restoration reference sites within or outside of the Reserve. Following are the restoration and enhancement priorities of the Reserve.

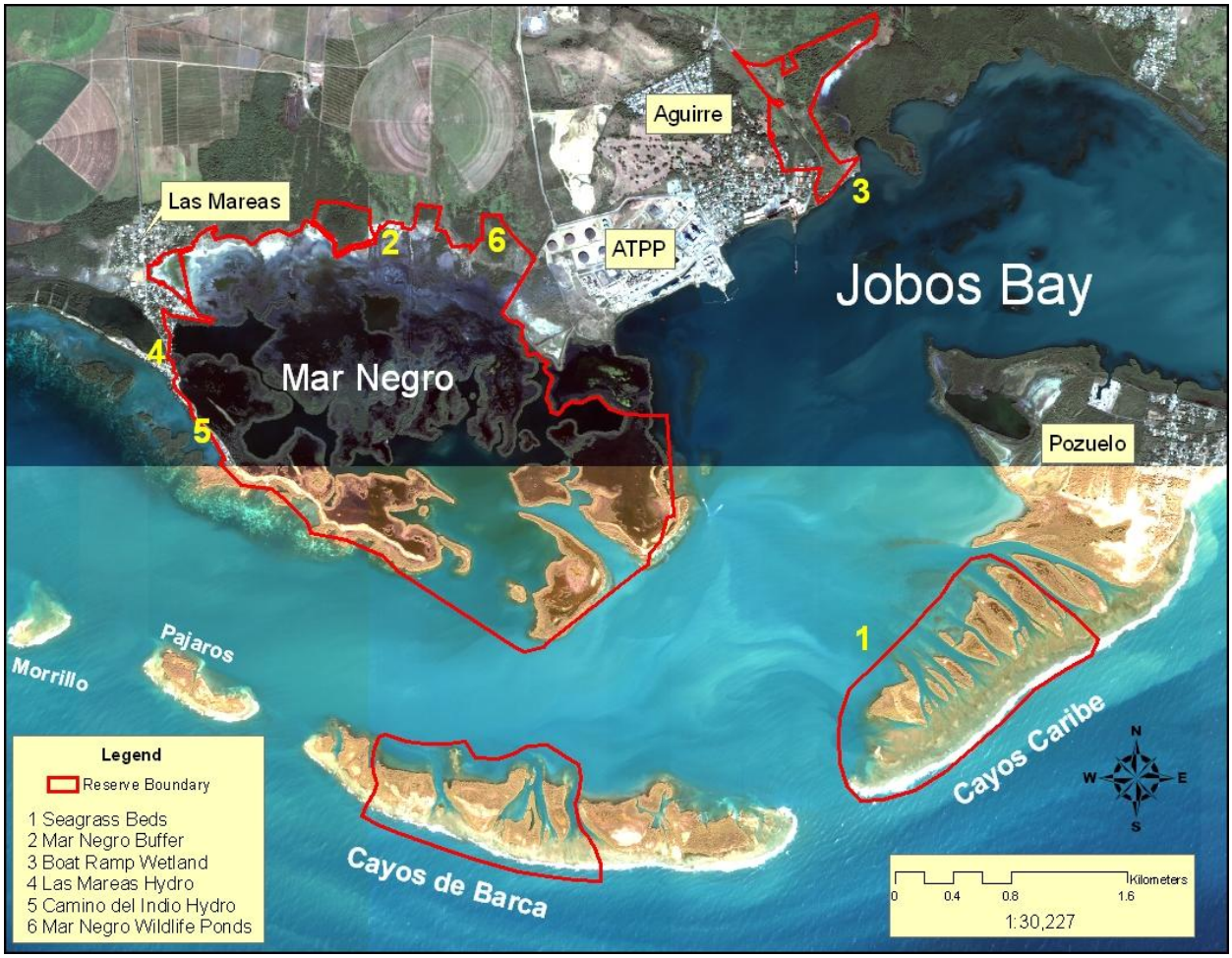

Figure 26. Restoration Sites

Seagrass Restoration – Seagrass beds are extensive in Jobos Bay and are generally in very good condition. However, there are areas with intense impacts from recreational boating. The direct impacts include prop scars and blow holes resulting from boat groundings, as well as the indirect impacts of trash, especially in the vicinity of Cayos Caribe. The Reserve has partnered with a consultant in Florida to restore seagrass beds damaged by prop scars, while simultaneously training stewardship staff from other PRDNER protected areas in seagrass restoration. The Reserve plans to map out the remaining seagrass restoration opportunities and complete restoration of seagrass beds in the target areas. A restoration science strategy will be integrated into the plan, including establishment of a reference site that will be implemented as part of the System-Wide Monitoring Program's biological monitoring strategy (Chapter 4 – Research and Monitoring).

Buffer strip on north boundary of Mar Negro – The north boundary of the Mar Negro Unit was severely impacted in 1993 when lands managed by the Puerto Rico Land Authority, including mangroves in the Reserve, were illegally bulldozed to drain leased agricultural fields to the north. As a result of an enforcement action by the USEPA, a Consent Order (Appendix 7) required the Puerto Rico Land Authority to restore the mangrove habitat and create an agricultural buffer strip planted with specific plants that will effectively uptake nutrients that would otherwise flow into Reserve waters. The mangrove habitat is in the process of

restoration. The Reserve is working with NRCS to determine suitable plant material and design for the buffer zone. This final part of the Consent Order is anticipated to be completed by 2011.

Boat Ramp Wetland - Located in the Aguirre Unit of the Reserve, the area adjacent to the boat ramp and pier was a wetland prior to filling during historic sugar cane mill operations. The goal for this site is to restore a portion of these wetlands, in conjunction with construction of the future Research and Education Facilities, as outlined in Chapter 8 - Facilities.

Las Mareas Hydrologic Restoration – Tidal flushing between Mar Negro and Jobos Bay was severed by road construction. The Stewardship Program will pursue funding through competitive sources, including the US Fish and Wildlife Service (USFWS) and NOAA's Restoration Center, to restore the historic hydrologic connection by strategically placing culverts under the roadway.

Camino del Indio Hydrologic Restoration - Squatter developments and illegal filling have seriously impacting mangrove stands on the western end of the Reserve. Tidal flushing between Mar Negro and Jobos Bay was severed by road construction, which blocks water circulation and may be contributing to a change in salinity at the western end of Mar Negro. The Stewardship Program will pursue funding through competitive sources, including the USFWS and NOAA's Restoration Center, to restore the historic hydrologic connection by strategically placing culverts under the roadway.

Mar Negro Pond Wildlife Enhancement – Originally constructed to filter water discharged from the thermoelectric plant, the Mar Negro Pond Wildlife Enhancement area consists of one constructed pond and an adjacent disturbed area. 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, incorporating a trail, observation tower and parking area.

## 3.7 Watershed Management

The Reserve's watershed is experiencing a substantial increase in conversion of agricultural land to urban development, primarily residential subdivisions. Reserve staff are copied by PRDNER on all development permits in the watershed and comment on how the developments will impact Reserve resources. The Reserve will work with the NRCS and CSC to apply the Non-Point Source Pollution and Erosion Comparison Tool (N-SPECT) and the Soil and Water Assessment Total (SWAT) models to examine impacts and habitat fragmentation from proposed developments, and to develop a system-wide approach for longterm habitat conservation (Figure 28). N-SPECT is used to investigate potential water quality impacts from development, other land uses and climate change, while SWAT considers runoff production, percolation, evapotranspiration, snowmelt, channel and reservoir routing, lateral subsurface flow, groundwater flow, sediment yield, crop growth, nitrogen and phosphorous, and pesticides. In addition, the Habitat Priority Planner decision support tool will be used to examine how future growth in the watershed can be steered to maintain and enhance habitat connectivity. The Stewardship Agreement partners will be a target audience for this watershed-based strategy: the Puerto Rico Department of Natural and Environmental Resources; Puerto Rico Planning Board; Puerto Rico Department of Agriculture; Puerto Rico Management of Regulations and Permits; Municipality of Salinas; Puerto Rico Environmental Quality Board; Puerto Rico Land

Authority; Puerto Rico Housing Department; Municipality of Guayama; Puerto Rico Special Communities Office; and, the Puerto Rico Police Department.

A key outcome of the Stewardship Program will be the development of a Watershed Management Plan that addresses impacts of population growth and climate change on habitats and communities. Information gathered from each of these tools will be combined with land use, land cover and future planning information to develop a comprehensive Watershed Management Plan. Addressing nonpoint source pollution, emergency response and storm impacts on and from land uses within the watershed, the plan will identify strategies to mitigate projected social and ecological impacts from land use and climate change, as well as incorporating an evaluation methodology. Coordination with the local municipalities, decision-makers and industries is essential and will be conducted in conjunction with the CTP. As the plan is developed and decision points are encountered, CTP will assist with facilitating discussions and tracking changes implemented through these coordinated efforts to creatively protect resources across the watershed.

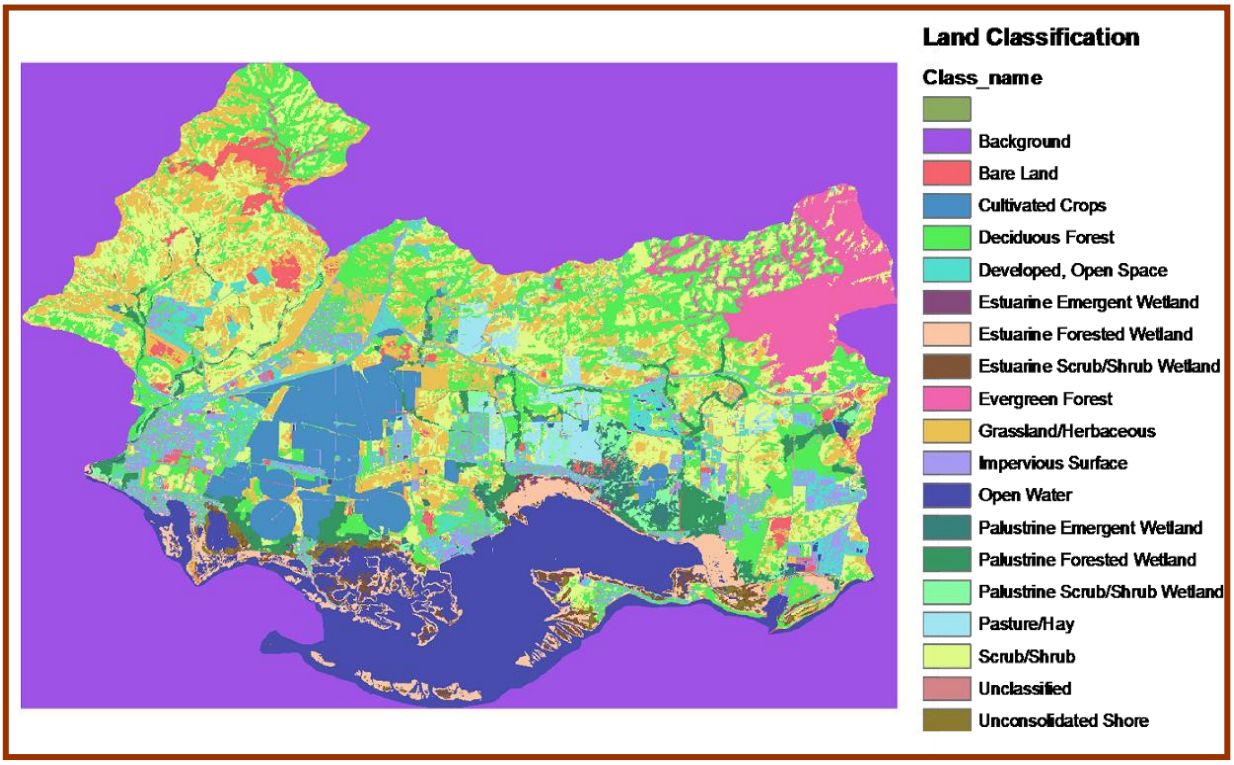


Figure 27. Watershed Land Use Classifications

Using watershed modeling tools (Chapter 4 – Research and Monitoring), Reserve staff will complete an assessment of Jobos Bay and adjacent watersheds to identify sources of sediments and nutrients that impact coral and coral-related habitats in the Reserve. The Reserve will draw upon its integrated capacity to work with the Puerto Rico Coral Reef Conservation and Management Program staff and local municipalities to implement applicable best management practices (BMPs) to address the sediment and nutrient sources.

## 3.8 Contingency Planning and Emergency Response

Given the location in the Caribbean, Jobos Bay NERR is seasonally subjected to tropical storms and has established plans to protect Reserve facilities and resources, to the extent possible, from damaging winds and water.

Spills of oil, chemicals or hazardous materials shipped to industrial facilities in Jobos Bay threaten habitats throughout the ecosystem. In the recent past, an oil spill off Puerto Rico missed the Reserve, but damage was limited more by the spill location and prevailing winds than it was by oil spill protection strategies. This warning sign was a prompt for the Reserve to reestablish active participation on the regional emergency response task force, as well as to revisit contingency plans. Vessel groundings can also result in localized discharge of hazardous materials and will be included in the contingency planning effort. The Reserve's SWMP weather station provides real time conditions that can be used by the Reserve, other agencies and local responders to plan emergency response activities.

In addition to planning for industrial spills, there is a shipping channel in Jobos Bay that is maintained through periodic dredging. The Aguirre Navigational Channel (Figure 29) is the most distinct bottom feature in Jobos Bay. At 30 ft to 45 ft (10-15 m) deep, the channel is open to the Caribbean Sea on the west between Cayos de Ratones and Cayos de Pajaros, and runs east until it reaches Central Aguirre (Zitello et al. 2008). Dredging operations,spoil disposal and turbidity control need to be coordinated through the Reserve to minimize adverse impacts.

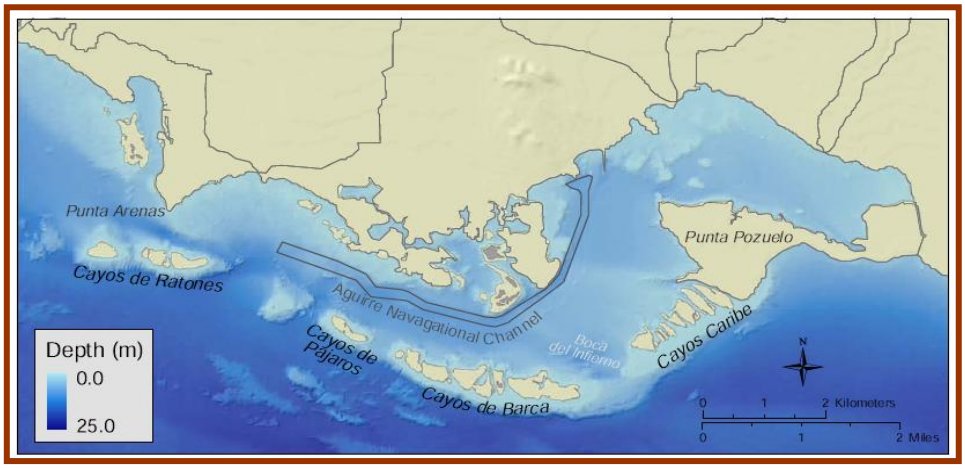


Figure 28. Bathymetry of Jobos Bay *(Zitello et al. 2008)*

## 3.9 Habitat Mapping

With the National Estuarine Research Reserve System (NERRS) priority on mapping habitat change over time in all reserves and the linkages between habitat change, climate and land use impacts, the Reserve will be developing a comprehensive habitat mapping and change strategy for the Jobos Bay NERR. The strategy will include mapping land use and land use change in the Jobos Bay NERR watershed and surrounding watersheds at high resolution using NOAA's Coastal Change Analysis Program (C-CAP) classification on five-year intervals. High resolution habitat mapping of specific Reserve representative habitats, including mangroves, seagrass beds, salt flats and corals, will occur at intervals determined by input from the Research Advisory Committee (Chapter 4 – Research and Monitoring). The protocols will be consistent with those specified in the NERRS habitat mapping and change plan, and will apply the NERR habitat classification scheme.

Updating the Commonwealth's geodetic datum and acquisition of updated elevations throughout the island, including establishment of vertical control and elevations within the Reserve, provides an ideal opportunity to establish the Jobos Bay NERR as a sentinel site for monitoring climate change over the longterm. The NERRS' concept of 'sentinel site' establishment focuses on defining and implementing ecosystem-based protocols and standards to monitor and assess the ecosystem response of coastal vegetated habitats to sea level rise, relative to other drivers of vegetated habitat change, and ultimately to enable prediction of future habitat response.

In addition, NOAA's Coast Survey anticipates the development of V-Datum by the fall of 2010. V-Datum is a free software tool being developed jointly by NOAA's National Geodetic Survey (NGS), Office of Coast Survey (OCS), and Center for Operational Oceanographic Products and Services (CO-OPS). V-Datum is designed to vertically transform geospatial data among a variety of tidal, orthometric and ellipsoidal vertical datum's - allowing users to convert their data from different horizontal/vertical references into a common system and enabling the fusion of diverse geospatial data in desired reference levels. This tool will enable the Reserve to integrate all of its geospatial data into a seamless topo-bathymetric database which can then support higher accuracy inundation and climate change modeling. The outcomes of the habitat mapping and change effort over the next five years will be:

- Establishment of vertical control within the Reserve, including a geodetic connection established between one or more NERR SWMP data loggers and the National Spatial Reference System and an integration of all local monitoring instruments into a high accuracy local reference network. The Reserve staff will work with NOAA's National Geodetic Survey (NGS) and Center for Operational Oceanographic Products and Services (CO-OPS) to establish and maintain this network.
- Identification of areas targeted for longterm monitoring.
- Development of a mapping strategy that identifies the temporal and spatial mapping requirements.
- Development of maps with corresponding Federal Geodetic Control Subcommittee (FGDC) required metadata that are available through the Centralized Data Management Office (CDMO) and the Reserve's website.

Stewardship staff will work with the Research Advisory Committee (Chapter 4 – Research and Monitoring) and partners in the research community to identify the mapping, and corresponding *in-situ* monitoring, strategies for the habitat mapping and change plans. The *in-situ* plan will incorporate elements of the abiotic and biotic monitoring protocols of the NERRS, as detailed in Chapter 4 – Research and Monitoring Plan. It is anticipated that the full implementation of the System-Wide Monitoring Program (SWMP), will position the Reserve as a node in the NERRS national network of sentinel sites.

## 3.10 Current Stewardship Staffing

The Jobos Bay Stewardship Program is currently managed by the Reserve Manager who oversees field laborers. This position also coordinates with PRDNER law enforcement officers. Supported by other staff as needed, he manages all stewardship activities associated with trail development and maintenance, public access, law enforcement, boundary demarcation, mapping, contingency planning and restoration.

## 3.11 Challenges

Primary challenges to achieving the stewardship strategies outlined above are as follows:

- Funding must be acquired to support restoration activities, including restoration planning, implementation and monitoring.
- A Geographic Information Systems (GIS) strategy is needed to develop and integrate maps, classify habitats, work with remotely sensed imagery and run geospatial modeling.
- Storage for field-based stewardship equipment is needed.
- Office space for law enforcement staff is needed to allow for close coordination on Reserve-based issues.
- Appropriate vehicles are needed for field-based activities.

## 3.12 Partners

The Stewardship Program works across municipal and organizational boundaries to manage natural resources as functional ecosystems. Coordination with adjacent and regional land managers is critical for the longterm protection of Reserve resources, as well as for planning and information exchange. Comprehensive public access planning, community involvement, law enforcement and mapping require working with several partners to assure that activities are synchronized and implemented to maximize effectiveness and efficiency. Close and thoughtful coordination can result in complementary and holistic efforts that benefit all. Some of the primary Stewardship partnerships include:

- Friends of Jobos Bay NERR – It is anticipated that the 'Friends' will support a volunteer program that will be available to assist with restoration activities.
- Local Communities – The Stewardship Program plans to strengthen ties to the community, especially through the NGOs, to work with them on efforts to decrease illegal activities, participate in restoration projects and develop a longterm conservation ethic.
- Puerto Rico Coastal Zone Management Program - The Puerto Rico Coastal Management Program protects coastal lands, dunes, waters, wetlands, mangroves, coral reefs and other natural resources through a variety of initiatives. The Program directs a multiagency effort to manage Special Planning Areas, including Jobos Bay NERR, and has oversight of permitting, development review and enforcement, natural reserves designation and management, public education and outreach, coastal access, coral reef management and coastal nonpoint pollution management.
- Puerto Rico Department of Forestry – The Stewardship Program will work closely with Forestry staff to implement holistic management of the Jobos Bay ecosystems.
- Puerto Rico Land Authority - The Stewardship Program will work closely with Land Authority staff to implement holistic management of the Jobos Bay ecosystems.
- NOAA – Several offices within NOAA will be important partners in developing the reserve as a sentinel site within the NERRS.
- US Department of Agriculture (USDA), Natural Resource Conservation Service - A primary partner on the CEAP project, NRCS works with Jobos Bay NERR and agricultural interests to implement BMPs to protect Reserve resources.

## 3.13 Action Plan

| Table 4. Stewardship and Public Access | | | |
|---|---|---|---|
| **Goal 1 - Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and education** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Reserve resources will be protected through expanded Reserve boundaries | Acquire priority lands within future acquisition boundary | Priority lands are acquired and Jobos Bay Boundary is expanded | Watershed |
| Impacts from illegal activities within the Reserve are reduced | Implement remote surveillance strategy on trails to evaluate and detect violations using wireless infrastructure<br><br>Design and modify law enforcement strategy that includes 24-hour surveillance in key areas of Reserve | Number of law enforcement actions decrease over time due to fewer impacts on Reserve resources | Watershed |
| Reserve habitat quality will be improved through habitat restoration and enhancement | Implement the habitat restoration priorities identified in the Restoration Science Strategy by developing detailed habitat restoration plans for individual projects and securing funding to implement restoration and enhancement activities | Acres of seagrass habitat will be restored / Acres of bird habitat will be created/restored<br><br>Nutrient levels in Mar Negro will be reduced | Watershed |
| The restoration of Reserve habitats will generate useful data and research to support restoration strategies of coral and coral-related habitats | Develop the Restoration Science Strategy by engaging the Research Advisory Committee<br><br>Design and implement a network of reference sites representing key habitat types within the Reserve, involving teams of experts for specific habitats to identify key habitat attributes and protocols that will be useful as reference data<br><br>Disseminate reference site data and research information generated by the Reserve to target audiences | Reference data is being generated, disseminated and utilized by restoration practitioners working in coral and coral-related habitats<br><br>Evaluate forests for invasive species and develop appropriate management strategies to address identified needs<br><br>Reference data is submitted to the NOAA Restoration Center restoration portal | Watershed<br>Puerto Rico<br>Caribbean<br><br>Watershed<br><br>Puerto Rico<br>Caribbean |
| Reserve resources are protected through watershed-based strategies that target reduction of anthropogenic impacts | Facilitate development of a Watershed Management Plan for Jobos Bay NERR with measurable outcomes<br><br>Complete a watershed assessment of Jobos and adjacent watersheds to identify sources of sediments affecting water quality<br><br>Work with CTP to identify strategies to target sources of watershed pollution<br><br>Develop and implement a monitoring strategy to evaluate effectiveness of | A comprehensive Watershed Management Plan is developed with priority actions identified, and a monitoring program developed and implemented<br><br>BMPs are implemented at the sources of sediments and nutrients, decreasing impacts on Reserve resources<br><br>Indicators of success are revealing a positive trend in response to stewardship actions | Watershed<br><br>Watershed |

| | | | |
|---|---|---|---|
| | protection strategies | | Watershed |
| | | | |
| **Goal 2 - Increase the use of Reserve science and sites to address priority coastal management issues** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| The Reserve will be a sentinel site within the NERRS network | A Habitat Mapping and Change Strategy will be developed to monitor change of key habitats within the Reserve | Maps will be published that are FGDC compliant and made available on CDMO website and Reserve website | Watershed |
| Multiple uses within Reserve's boundaries are managed to protect coastal resources | Engage partners in developing a marine spatial plan for Jobos Bay and offshore waters of new Commonwealth Natural Reserve.<br><br>Contingency plans are developed, evaluated and enhanced as necessary in partnership with users of Reserve resources | A marine spatial plan is developed and signed by participating agencies<br><br>Contingency plans are developed and implemented | Watershed |
| | | | |
| **Goal-3 Enhance the administrative capability and infrastructure of Jobos Bay NERR to meet the stewardship, research, education and training challenges of the future.** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Existing trails, boardwalks, and interpretative signs are enhanced to address current users and visitors needs. | Evaluate Jagüeyes, Cayo Caribe, and Kayak Trails, develop enhancement plans and implement as identified. | Enhancement Plans developed.<br><br>Access facilities are improved. | Watershed |
| Public Access facilities within the Reserve are expanded to address and advance Reserve's program growth. | Develop a Reserve Public Access Plan in harmony with the Reserve's Master Facility Plan.<br><br>Develop construction and interpretation plans for new facilities.<br><br>Identify funding opportunities and submit proposals for funding.<br><br>Management of construction contracts and/or construction partnerships. | Public Access Master Plan is developed.<br><br>Construction and Interpretation Plans developed.<br><br>Trail and access infrastructure is enhanced and expanded. | Watershed |
| Public use of the Reserve increases without affecting habitat quality | Incorporate monitoring of public access areas to evaluate impact of visitor use<br><br>Identify opportunities for collaboration to support public access and habitat protection priorities among partners in the Stewardship Agreement | Visitor use increases /Extent of trail network increases<br><br>Habitat Indicators are identified and used to track habitat change and impacts from climate and human use. Impacts to resources are minimal | Watershed |
| Stewardship staff and infrastructural capacity will efficiently meet stewardship goals and objectives | Develop skills in leadership, fiscal management, fund raising and program development for Stewardship Agenda. | Programs are expanded through collaboration strategies with stakeholders and other partnerships | Watershed |

## 4.0 RESEARCH AND MONITORING [§921.50]

The Reserve System provides a mechanism for addressing scientific and technical aspects of coastal management problems through a comprehensive, interdisciplinary and coordinated approach. Research and monitoring programs, including the development of baseline information, form the basis of this approach. Reserve research and monitoring activities are guided by the Reserve System Research and Monitoring Plan 2006-2011, which identifies goals, priorities and implementation strategies. This approach, when used in combination with the education and outreach programs, will help ensure the availability of scientific information that has longterm, system-wide consistency and utility for managers and members of the public to use in protecting or improving natural processes in their estuaries. Research within the reserves is designed to fulfill the Reserve System goals as defined in program regulations. These include:

- 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; and
- Conduct and coordinate estuarine research within the System, gathering and making available information necessary for improved understanding and management of estuarine areas.

### 4.1 Reserve System Research Funding Priorities

Federal regulations, 15 CFR Part 921.50 (a), specify the purposes for which research funds are to be used:

- Support management-related research that will enhance scientific understanding of the Reserve ecosystem,
- Provide information needed by reserve managers and coastal ecosystem policy-makers, and
- Improve public awareness and understanding of estuarine ecosystems and estuarine management issues.

The Reserve System has identified the following five priority research areas to complement the funding priorities outlined above:

1. Habitat and ecosystem processes
2. Anthropogenic influences on estuaries
3. Habitat conservation and restoration
4. Species management
5. Social science and economics

## 4.2 Reserve System Research Goals

The Reserve System research and monitoring goals are embedded in Goal 2 of the Reserve System Strategic Plan 2005-2010, 'Increase the use of reserve science and sites to address priority coastal management issues,' and are outlined in the 2006-2011 Reserve System Research and Monitoring Plan. They include:

- Biological, chemical, physical and ecological conditions of reserves are characterized and monitored to describe reference conditions and to quantify change;
- Scientists conduct research at reserves that is relevant to coastal management needs and increases basic understanding of estuarine processes;
- Scientists have access to NERRS datasets, science products and results; and,
- The scientific, coastal management and education communities, as well as the general public, use data, products, tools and techniques generated at the NERRS.

Currently, there are two reserve system-wide efforts to fund estuarine research. The Graduate Research Fellowship (GRF) Program supports students to conduct high quality research in the reserves, with funding for 1-3 years to conduct their research, as well as an opportunity to assist with the research and monitoring program at a reserve. Projects must address coastal management issues identified as having regional or national significance; relate them to the reserve system research focus areas; and, be conducted at least partially within one or more designated reserve sites. Proposals must focus on the following areas:

- Eutrophication, effects of nonpoint source pollution and/or nutrient dynamics;
- Habitat conservation and/or restoration;
- Biodiversity and/or the effects of invasive species;
- Mechanisms for sustaining resources within estuarine ecosystems; or,
- Economic, sociological and/or anthropological research applicable to estuarine ecosystem management.

Students work with the research coordinator or manager at the host reserve to develop a plan to participate in the reserve's research and/or monitoring program. Students may be asked to provide up to fifteen (15) hours per week of research and/or monitoring assistance to the reserve. This assistance may take place throughout the school year or may be concentrated during a specific season.

Secondly, research is funded through the NERRS Science Collaborative, a program designed to integrate science and management for the protection of coastal natural resources. In 2009, following a competition run by NOAA, the University of New Hampshire was awarded a five-year cooperative agreement to administer this program. The program is overseen by NOAA and administered by the University of New Hampshire. The annual budget for the program is approximately $5.2 million. The NERRS Science Collaborative is designed to enhance the system's ability to impact decisions affecting coastal resources through a science-based collaborative process that engages intended users and stakeholders.

## 4.3 System-Wide Monitoring Program

It is the policy of the Jobos Bay NERR to implement each phase of the System-Wide Monitoring Plan initiated by the Estuarine Reserves Division (ERD) in 1989, and as outlined in the Reserve System regulations and strategic plan:

- Phase I: Environmental Characterization, including studies necessary for inventory and comprehensive site descriptions;
- Phase II: Site Profile, to include a synthesis of data and information; and,
- Phase III: Implementation of the System-Wide Monitoring Program.

SWMP provides standardized data on national estuarine environmental trends, while allowing the flexibility to assess coastal management issues of regional or local concern. The principal mission of the monitoring program is to develop quantitative measurements of short-term variability and longterm change in the integrity and biodiversity of representative estuarine ecosystems and coastal watersheds for the purposes of contributing to effective coastal zone management. The program is designed to enhance the value and vision of the reserves as a system of national references sites. The program focuses on three different ecosystem characteristics.

1. Abiotic Variables: The monitoring program currently measures pH, conductivity, salinity, temperature, dissolved oxygen, turbidity, water level and atmospheric conditions. In addition, the program collects monthly nutrient and chlorophyll *a* samples and monthly diel samples at one SWMP data logger station. Each reserve uses a set of automated instruments and weather stations to collect these data for submission to a centralized data management office.

2. Biotic Variables: The Reserve System is focusing on monitoring biodiversity, habitat and population characteristics by monitoring organisms and habitats, as funds are available.

3. Watershed and Land use Classifications: This component attempts to identify changes in coastal ecological conditions with the goal of tracking and evaluating changes in coastal habitats and watershed land use/ land cover. The main objective of this element is to examine the links between watershed land use activities and coastal habitat quality.

These data are compiled electronically at a central data management 'hub', the Centralized Data Management Office (CDMO) at the Belle W. Baruch Institute for Marine Biology and Coastal Research of the University of South Carolina. They provide additional quality control for data and metadata. They also compile and disseminate the data and summary statistics electronically via the internet (http://cdmo.baruch.sc.edu), where researchers, coastal managers and educators can readily access the information. The metadata meets the standards of the Federal Geographic Data Committee (FGDC).

## 4.4 Jobos Bay NERR Research and Monitoring Priorities

The Jobos Bay NERR Research Program complements the National System's research priorities and uses SWMP as a foundation for research in the Reserve. The Research Advisory Committee (RAC) guides research and monitoring initiatives. The representatives include: US Department of Agriculture (USDA), International Institute of Tropical Forestry; US Fish and Wildlife Service (USFWS), Coastal Program;

**RESERVE KEY ISSUES**

- Climate change impacts on coastal ecosystems and communities
- Land use change impacts on coral and coral-related habitats
- The interrelationship between ecological integrity and community resilience

University of Puerto Rico (UPR, School of Public Health, Computing Engineering Department, Marine Sciences Department); Puerto Rico Department of Natural and Environmental Resources (PRDNER), Coastal Zone Management Program; and, the Caribbean Regional Association (CARA). Focused on addressing the priority issues of the Reserve and through integration with other Reserve programs, the Research Program incorporates the watershed, bay and nearshore environments in a 'Summit to Sea' approach. This approach is further expanded to include the three spheres of influence: Jobos Bay NERR and adjacent watersheds; the island of Puerto Rico; and, the greater Caribbean.

### 4.4.1 Past Accomplishments

The Research Program has accomplished several milestones during the last management planning period. Included among these are:

- **The completion and publication of the Reserve's Site Profile.** This document serves as an introduction to the history, ecology, climatology, research and monitoring activities at the Reserve (Robles et al. 2002).

- **Establishment of a Research Advisory Committee (RAC**) The RAC is composed of local experts from federal and Commonwealth agencies and academia. The committee meets annually and maintains close contact with the Research Coordinator via email, providing guidance on projects within the Reserve and its watershed. The Reserve also collaborated with local universities and nationwide programs to develop student internship opportunities. Students not only participate in Jobos Bay NERR's monitoring program, including SWMP, but may develop their own research projects as well. Interns have represented NOAA's Hollings Scholarship Program, Interamerican University and Pontifical Catholic University.

- **Implementation of a Robust Graduate Research Fellowship Program**. Since 2000, the reserve has hosted 11 Graduate Research Fellows (GRFs) and received 19 proposals from 9 universities within Puerto Rico and the US mainland. Jobos Bay NERR's Research and Monitoring Program supported eight (8) GRFs during the last management plan period. Table 5 provides GRF projects at Jobos Bay NERR by the five priority research areas. Final reports of all GRF research projects are posted on the Reserve's website.

**Table 5. Jobos Bay NERR Graduate Research Fellowship Projects**

| Name<br>Research Topic | Year | University | Habitat & Ecosystem Processes | Anthropogenic Influences on Estuaries | Habitat Conservation & Restoration | Species Management | Social Science & Economics |
|---|---|---|---|---|---|---|---|
| **Ermelindo Banchs Plaza**<br>Status of the Groundwater Quality of the Jobos Bay Estuary Reserve | 1997 | UPR-M | | X | | | |
| **Carlos Altieri**<br>Determination of Pesticides in Surface and Interstitial Water Samples Discharged into JBNERR | 1997 | UPR-MC | | X | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Amanda Jones-Demopoulos**<br>Black Mangrove Benthic Community Structure, Seedling Growth and Survival, and Sediment Characteristics in Anthropogenically Disturbed and Pristine Habitats | 1999 | Univ. Hawaii | X | | | X | |
| **Abnery Picon**<br>A Protocol to Apply BASINS to Assess Non-point Sources of Pollution | 2000 | | X | | | | |
| **Jennifer Bowen**<br>Contrasting Nitrogen Retention Rates in Watersheds: Using Nitrogen Isotopes to Compare Temperate and Tropical Estuarine Systems | 2001 | Boston Univ. | X | | | | |
| **Carlos Garcia-Quijano**<br>Resisting Extinction: The Value of Local Ecological Knowledge for Small-Scale Fishers in Southeastern Puerto Rico | 2003 | UPR-M | | X | | | X |
| **Ylva Olsen**<br>Distribution and Control by Nutrients and Manatees of Seagrasses in Jobos Bay, PR | 2004 | Boston Univ. | X | X | | X | |
| **Yogani Govender**<br>A Multidisciplinary Approach Toward Understanding the Distribution, Abundance and Size of the Land Crab *Cardisoma guanhumi* in PR | 2004 | UPR-RP | X | X | X | X | X |
| **Michael Martinez**<br>Pollutants and Foraminiferal Assemblages in Jobos Bay: An Environmental Micropaleontology Approach | 2007 | USF | X | X | | | |
| **Suhey Ortiz-Rosa**<br>Photochemical Response and Optical Properties of Colored Dissolved Organic Matter (CDOM) | 2007 | UPR-M | X | | | | |
| **Maytee Rodriguez**<br>Diversity and Distribution of Sulfate-Reducing Bacteria at the Jobos Bay Reserve | 2009 | Turabo Univ. | X | X | | | |
| **Ivelisse Rodriguez**<br>Inference of habitat connectivity via habitat use by resident and migratory birds between secondary dry forest and mangroves in Jobos Bay NERR. | 2010 | Turabo Univ. | X | | X | | |
| **Virginia Schutte**<br>Effects of nutrients pollution on mangrove ecosystem functioning | 2010 | Univ. Georgia | X | X | | X | |

- **Initiation of Several monitoring projects**. The Reserve initiated two water quality monitoring projects: (1) interstitial pore water in Mar Negro - Coastal Secondary Forest to monitor salinity concentrations and fluctuation in a mangrove area affected by a mass mortality and (2) abiotic parameters, such nutrients and conductivity, in canal and creek surfacewater to establish current conditions. A plankton monitoring pilot study characterized primary components within the bay, established baseline data and was used to develop a longterm monitoring strategy for implementation during this management plan. Evaluation of Hydrologic Conditions and Nitrate Concentrations in the Río Nigua de Salinas Alluvial Fan Aquifer, Salinas, Puerto Rico (Rodríguez 2003), was conducted after the Reserve's watershed monitoring program noted elevated levels of nutrients. The Conservation Effects Assessment Program (CEAP) monitoring project, a partnership between NOAA, Jobos Bay NERR and the US Department of Agriculture was also initiated to document changes in water quality based on implementation of agricultural best management practices (BMPs). While too early for definitive results, initial data has clearly shown a pulse in nutrients and pesticides following rain events.

- A number of land use/land cover characterization projects have been completed, including development of 10 meter contour topographic maps and 10 meter resolution land cover maps of the watershed produced by the NOAA Coastal Services Center (CSC), and benthic habitat and bathymetry maps of Jobos Bay and offshore coral habitat produced by NOAA's National Center for Coastal and Ocean Science (NCCOS), as part of the Conservation Effects Assessment Program.

### 4.4.2 Future Research Priorities

Over the next 5 years, Jobos Bay NERR's Research Program will primarily focus on the Reserve and its watershed. All research activities will target the priority issues of the Reserve articulated in this plan, including local impacts of climate change and anthropogenic stressors in the watershed on coral and coral-related ecosystems, habitat alteration, water quality degradation and biological integrity. The priority activities of the Research Program are listed and described below with an expanded description following:

- Develop a longterm monitoring strategy and produce decision support tools
- Develop the Reserve as a Field Station in the Caribbean
- Implement the Restoration Science Strategy
- Disseminate scientific information generated by the Jobos Bay NERR

- *Develop a long-term monitoring strategy and produce decision support tools*

  The products from the recent independent efforts of NCCOS and CEAP will be combined to provide a holistic view of the Reserve's resources, as well as a data-rich baseline from which multiple research, monitoring and modeling projects can be initiated. The Reserve will apply the recently completed products, including topographic maps, benthic characterizations and bathymetry, to develop several models and support planning longterm monitoring of Reserve habitats. Specifically, development of watershed runoff, inundation, and estuarine and offshore circulation models will be priority decision support tools that the Reserve and its partners will attempt to develop.

Inundation Model

An inundation model will address climate impacts on Reserve habitats, Reserve infrastructure and local communities. Using high resolution Light Detection and Ranging (LIDAR) and land use data, inundation models can project sea level rise impacts on communities and habitats, develop storm surge scenarios, provide local leaders with information for future zoning and planning, and monitor habitat migration. The outputs from inundation models can be used in the Coastal Training Program's (CTP) Emergency Response and Climate Change workshops, as well as in Reserve facility planning.

Watershed Model

The watershed model will address how land use within the watershed results in runoff of nutrients, contaminants and sediments. The Reserve is experiencing significant conversion of agricultural lands to urban development. This conversion alters the amount of percolation, filtration and runoff occurring in the watershed, as well as the delivery of freshwater to the Reserve. The Reserve has data that can be used as a foundation for the development of a watershed model that specifically characterizes island ecosystems. Using the CEAP monitoring data and the associated agriculture monitoring plan developed with NRCS in 2009, the detailed aquifer model developed by the USGS, and N-SPECT developed by the CSC as starting points, the Reserve will facilitate development of the watershed model to characterize surface and sub-surface hydrologic flows that influence the transport and delivery of sediment, nutrients and contaminants entering the Reserve.

Through the CEAP project and working with the NRCS, the Puerto Rico Land Authority and private agricultural interests, the Reserve is monitoring agricultural practices in its watershed, including: pesticide application, type and frequency; fertilizer application, type and frequency; irrigation practices; and, crop rotations. Over the course of the study, applicable BMPs – including nitrogen-fixing crop rotations, alternate pesticides and fertilizers, and drip irrigation systems – are being identified and implemented to detect changes in water quality as it enters the Reserve. The longterm monitoring plan for CEAP is being developed and, if no new monitoring funds are allocated by NOAA or NRCS to continue monitoring, the Reserve will explore its ability to adopt the monitoring functions, while relying on the NRCS' continued support for longterm data analysis.

Two recent observations have raised development of the watershed model as a priority:

1. Investigators from the USDA Agricultural Research Service recently detected a pesticide spike in water samples taken at the Jobos Bay SWMP Station after a storm event, implying a direct link from nonpoint source runoff from the watershed and water quality in the Reserve. Successful coupling of watershed and circulation models will provide a comprehensive perspective of the source, transport, fate and impacts of watershed-based contamination of coastal habitats within the Reserve.

2. The nearshore waters along Cayos Caribe and Cayos La Barca contain the Reserve's primary coral reef systems and include the federally endangered elkhorn coral (*Acropora palmata)*, which require special protection. Recent observations show degraded coral habitat, with high mortality in much of the area. Initial investigations indicate that sediments carried by long-shore transport from the adjacent watershed have impacted the health of the corals. Using the Jobos Bay NERR watershed as a reference, managers can apply the models to adjacent watersheds to help identify point

and nonpoint sources of pollution that may be contributing to the turbidity impacting coral ecosystems. By beginning biological monitoring of the coral environment prior to application of BMPs in the watersheds, the Reserve will be in a position to evaluate, over the longterm, the impacts of the implemented BMPs.

Circulation Model

Circulation and runoff models will be developed and applied to assess transport and fate of land-based sources of pollution from Jobos Bay and adjacent watersheds. The projections from the models will inform the CTP regarding where to target training efforts to reduce the impacts of contaminants and sediments from adjacent watersheds and will be used by the Education Program in production of targeted outreach materials.

To be developed in partnership with the CaRA and the Caribbean Coastal Ocean Observing System (CariCOOS), a circulation model will: 1) aid in defining the long-shore transport component that delivers sediment 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) identify habitats impacted by the Thermoelectric Plant's thermal discharge delivered by an outfall pipe into the center of Jobos Bay.

Development of the circulation model within and outside the Bay may require water quality monitoring beyond the current SWMP and CariCOOS monitoring infrastructure. The Reserve will work with local experts, the University of Puerto Rico and the Caribbean Monitoring Association to develop a monitoring strategy development and validation of a circulation model of the bay and offshore waters. A Water Quality Monitoring Plan will be developed to drive funding and data acquisition strategies to support model development.

- *Develop the Reserve as a Field Station in the Caribbean*

In recent years, the interest among universities in conducting research in the Reserve has increased exponentially from universities throughout Puerto Rico, in Virginia, Texas, Florida, New Jersey and others. For many of the researchers, the Reserve offers one of the most data-rich, stable and equipped protected areas for conducting research in the Caribbean. Yet, it has become apparent that the logistics and facilities necessary to support this interest are far more than the Reserve can effectively handle at the current time. Therefore, the Reserve will work to formalize its role as a field station for universities that would like to have a more stable and longterm partnership by developing Partnership Agreements. These Agreements will outline the data, staff, logistical support and facility needs of participating universities, as well as the reciprocal expectations of the Reserve needs from universities, such as funding support for maintaining extra data loggers for longterm monitoring, fund raising for facility construction and/or collaborative research efforts. The formalization of these Agreements will be an attempt to build-out the monitoring infrastructure with additional funding support, expand the reach of the GRF Program, and foster a more coordinated and attractive environment for visiting researchers.

- *Implement the integrated Restoration Science Strategy*

  The Jobos Bay NERR has a number of restoration priorities that are addressed in Chapter 3 – Stewardship and Public Access. These include: hydrologic restoration of Mar Negro where construction of an unpaved road on Camino del Indio restricted tidal exchange between Mar Negro and Jobos Bay; restoration of prop scars in seagrass beds near Cayos Caribe; restoration of corals impacted by sedimentation; and, monitoring of habitats naturally stressed by climate change impacts.

  The Reserve will develop a Restoration Science Strategy, re-visit its restoration targets, identify specific priorities and actions, and pursue restoration accordingly through dedicated funds and competitive sources. However, select restoration activities will integrate a Restoration Science Strategy, resulting in an evaluation of techniques, implementation and monitoring of longterm reference sites within the Reserve. The reference sites will be identified in the Habitat Mapping and Change Plan (discussed in the Monitoring section of this Chapter), and, ultimately, the Reserve will disseminate this information through publications in the scientific literature, as well as in research workshops and other venues in the Caribbean.

- *Disseminate scientific information generated by the Jobos Bay NERR*

  Three main drivers require 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 current funding from the NERRS to construct a wireless network within the Jobos Bay NERR to deliver data in real and near-real time via the internet. Each of these items is addressed below.

  <u>Expansion of data generated at the Jobos Bay NERR since the last management plan</u>
  The Reserve is fortunate to have a wealth of historical and current data characterizing Reserve habitats. These products include the Reserve's site profile, numerous studies conducted in the 1970's associated with the construction of the Thermoelectric Power Plant, eight (8) GRF theses, and research and monitoring conducted by Reserve partners. The integration of this data can have powerful analytic capability. 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. Updating and maintaining the Reserve's research website will be a key priority of the Research Program.

  <u>Interest among universities, management staff and educators in working at the reserve and using data to enhance their work</u>
  Given the high level of research activity at the Reserve, it is of extreme importance to understand who is conducting research, what the research involves and where the research is occurring. In an effort to coordinate and complement visiting investigator studies, without impacting or compromising ongoing work, a database will be developed to provide this information to Reserve staff and interested researchers. A Geographic Information System (GIS)-based map of research sites will be developed and populated with attributes such as: contact information – which can be used by the other Reserve programs to provide expert speakers; research topic; estimated duration; and, other

project-relevant information. The database will allow the Research staff to introduce researchers conducting similar or complementary studies, or working in the same geographic area of the Reserve, as well as to disseminate GRF notifications. This database will also be used by the Stewardship and Education Program staff to discourage public access near research sites.

Current funding from the NERRS to construct a wireless network within the Jobos Bay NERR

In 2009, the NERRS provided funding for the development of a wireless network within the Reserve to deliver data in real and near-real time via the internet, supplemental to the SWMP telemetry system. This network will enable telemetric monitoring infrastructure to deliver the data on established time intervals. This will be a powerful tool to deliver data to researchers at any location worldwide and will be valuable to facilitate university partnerships. Of immediate interest is transmitting data from the SWMP data loggers and weather station, groundwater monitoring equipment established by the NRCS and US Geological Survey (USGS) as a result of the CEAP project, and groundwater monitoring throughout the watershed. Further, interest in establishing a submerged monitoring network to monitor the use of Reserve habitats by marine mammals and fish is another application of this network that can shed light on the interrelationship between offshore coral and estuarine habitats. A group from the University of Puerto Rico plans to begin a marine mammal monitoring project using this type of monitoring network in the next few months (http://arbimon.com/).

Disseminating this data via the internet can support model development and research opportunities and leverage data investments from numerous agencies. This network will also be a valuable asset to educators, decision-makers, managers and tourists, who can benefit by having this information readily available.

The Research Program will also facilitate information exchange by sponsoring and participating in a research symposium. The Reserve will host on a bi-annual basis a research symposium on topics that address the linkages between anthropogenic and climatic stressors of estuarine and coral communities of the Caribbean. This symposium will provide a platform to share local research and disseminate relevant coastal research and management information. Research staff will identify current topics, invite researchers and GRFs who have or are conducting research at Jobos Bay NERR and related environments (Mission Aransas and Rookery Bay NERRs) for presentations and provide a forum for public participation. Proceedings, in the form of abstracts and articles from the presenters, will be compiled and disseminated via the Reserve's website. The Research Coordinator will also plan to participate in forums throughout the Caribbean that focus on similar scientific exchange.

### 4.4.3 Graduate Research Fellowship Program

The GRF Program is an important component of Jobos Bay NERR's Research and Monitoring Program, providing a good opportunity to engage graduate students in research at the Reserve, with the Research team providing guidance and support, as needed. Using the Reserve's programmatic integration as a platform, GRFs have also worked with the Education Program to assist with Teacher Training Workshops. This integration provides the GRF with an opportunity to explain basic science concepts, natural resources and their own research to a non-scientific audience, while the participants have the opportunity to work with actual researchers. Although several outstanding GRFs have worked at the Reserve, the Research Program plans to

increase the visibility of the GRF Program by distributing notifications through the researcher database to continue attracting high-quality student researchers.

At the end of this 5-year Management Plan, the Research Program will have tools developed and locally tested to support all Reserve programs. The Research Program intends to position itself as a hub of applied research, targeting issues of anthropogenic and climate impacts on estuarine and coral communities in the Caribbean by (1) applying data to address coastal management issues relevant to Puerto Rico and the broader Caribbean region, (2) enhancing the capability to both provide on-site support for visiting researchers, students and universities, and (3) disseminating information.

### 4.4.4 Monitoring Program

The Jobos Bay NERR Monitoring Program includes implementation of the three components of the NERR System-Wide Monitoring Program, as well as the monitoring and mapping conducted by Reserve partners, including the USGS, NRCS, CariCOOS, and NOAA's Coastal Services Center and NCCOS. These monitoring programs are detailed below.

**System-Wide Monitoring Program**

- Abiotic Variables – Water Quality and Weather

The Jobos Bay NERR has implemented the SWMP according to the NERR SWMP protocols since 1995 and is committed to doing so as a core element of Reserve implementation. The Reserve collects temperature, conductivity, salinity, turbidity, dissolved oxygen, pH, depth and chlorophyll *a* at four (4) locations within the Reserve: Mar Negro – Inner Coast (Station #9); Mar Negro – Outer Coast (Station #10); Inner Jobos Bay (Station #19); and Cayos Caribe (Station #20) (Figure 30). 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,

Figure 29. SWMP Monitoring Stations

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 between VIMS and PRDNER.

All data is quality assurance/quality control (QA/QC) processed before being delivered to CDMO. During this next management plan time frame, SWMP implementation will continue and the existing SWMP network will be integrated within a broader water quality monitoring network to support model development.

By streamlining the administrative capacity for SWMP implementation, delivery of SWMP data to CDMO will be timelier.

During this planning period, the Research Program will also explore establishing aquifer water quality monitoring at two sites within Mar Negro with two instrumented piezometers to track groundwater quality.

- Weather Variables

In 2001, as part of SWMP, Jobos Bay NERR established a longterm weather station located at the Visitor's Center. The principal objective of the weather station is to record longterm meteorological data and track changes in meteorological conditions that can be associated with changes in estuarine habitats and conditions both locally and regionally. A secondary objective is to promote the access and use of reliable baseline information by federal and local agencies, universities, researchers, educators and local communities to enhance the decision-making processes in their daily activities. This data is also used in the identification and development of future monitoring and research activities.

Another meteorological weather station is located approximately 1300 ft (0.40 km) off the Jobos Bay coast and records data on the conditions affecting the estuary. The station is designed to evaluate the relative contributions of climate on coastal forcing and watershed inputs to hydrodynamics, nutrient dynamics and other ecological processes within the estuary. The data is used as a reference of atmospheric conditions for ongoing research projects at the Reserve, as a support from Jobos Bay NERR and for other short and longterm environmental monitoring projects within the Reserve. The station collects data at 15-minute intervals and transmits data in near-real-time each hour through the NOAA GOES satellite, as part of the Integrated Ocean Observing System (IOOS).

- Biotic Variables

During the next five years, the Research Program will design and implement a targeted biological monitoring program. The recent characterization of land use/land cover, elevation, benthic habitat and bathymetry provide the baseline upon which a comprehensive biological monitoring program can be designed. In synergy with the priorities of the Reserve, the biological monitoring program will monitor short-term variability and longterm change to assess anthropogenic and climate impacts on the following Reserve habitats:

1. 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. The Research Program will use this system as an indicator to track alteration of freshwater inflows from the watershed, as well as impacts from sea level rise, by monitoring parameters such as diameter at breast height (DBH), canopy cover, leaf litter and growth rate.

2. Submerged Aquatic Vegetation: The presence and health of Submerged Aquatic Vegetation (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 (Figure 31). Protocols adopted for SAV monitoring will be consistent with those developed by Moore et al. 2002.

Figure 30. Seagrass Monitoring

3. Coral Reefs: The coral reef system off the coast of the Reserve is already in peril from water quality degradation. It is important to note that while the reefs have been impacted by sediments entering the system, researchers have not found disease or other stressors in the few remaining colonies. This implies that coral recovery may be feasible if the turbidity issue is addressed. An evaluation of the current status and feasibility study for the recovery of this critical system will be completed. Longterm monitoring transects will be established to track short- and longterm trends in coral re-colonization - including diversity, density and growth rate - and the ultimate recovery of the reef. Protocols for longterm monitoring will be consistent with commonly accepted protocols in the region for biodiversity assessments of coral habitat.

4. Water Column: 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 impacts. The Reserve will seek internal and external support to establish longterm monitoring stations co-located with one or more water quality data loggers that will conform to SWMP biomonitoring protocols for plankton monitoring.

5. 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.

The Reserve staff will solicit the expertise of the Research Advisory Committee and outside experts to assist in developing a comprehensive biological monitoring program for the Reserve. Implementation of a biological 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 protocols used will be submitted to the NERRS SWMP guidance committee for approval. High QA/QC and statistical power will be the cornerstone of all biological monitoring. The identification of monitoring reference sites will also be designed to support restoration priorities and associated restoration science strategies within the Reserve.

- Land Use and Habitat Change

The NERRS is moving forward with establishing itself as a network of sentinel sites to monitor climate change impacts on estuarine habitats. The sentinel site framework requires implementation of SWMP and its connection to the National Spatial Reference Network, as well as the infrastructure to monitor changes in the quality and geographic extent of key estuarine habitats over time. In essence, complete implementation of the three components of SWMP - abiotic, biotic, and habitat mapping and change - manifest into a sentinel site for monitoring habitat change in relation to anthropogenic and climate impacts. Implementation of the Habitat Mapping and Change Plan, combined with abiotic and biotic monitoring, will position the Reserve as a sentinel site. This will also incorporate a compilation of historical information on spatial and temporal distribution of habitats, providing background on changes over time that are of value in reviewing longterm habitat change patterns.

As mentioned previously, for the first time, the Jobos Bay NERR has high resolution land cover, land use and bathymetric maps extending from the watershed to the outer coral habitats. These maps form the baseline upon which detection of change and extent of change for land use and habitats can be monitored. In addition, NOAA's National Geodetic Survey (NGS) is in the process of updating the vertical datum for Puerto Rico and the vertical control infrastructure from which to establish elevations. NGS will be installing geodetic benchmarks connecting the Reserve to the island's network and updating elevations on these benchmarks. Further, NOAA's Coast Survey is planning on developing a V-Datum transformation tool for Puerto Rico in September 2011. This will enable the development of a seamless topo-bathymetric map from the watershed summit to the outer shelf area. As a result, it will be possible to improve the Reserve's ability to model inundation relative to climate change, storm surges and coastal flooding. With this available infrastructure, the Reserve will position itself as a sentinel site for longterm climate change in the Caribbean.

The Reserve's watershed, land uses and habitats are characteristic of those found throughout the Caribbean. As such, the Reserve is a microcosm of the broader Caribbean and is ideal for serving as a 'sentinel site' for monitoring and researching the impacts of climate and anthropogenic stressors on coral and coral-related ecosystems. The NERRS' concept of 'sentinel site' establishment focuses on defining and implementing ecosystem-based protocols and standards to monitor and assess the ecosystem response of coastal vegetated habitats to sea level rise, relative to other drivers of vegetated habitat change, and, ultimately, to enable prediction of future habitat response. At Jobos Bay NERR, representative ecological communities, including mangrove forests, submerged aquatic vegetation (SAV) and coral habitats, will be monitored as components of the sentinel site establishment.

In preparation for this eventuality, the Reserve will be using its current base layers to identify habitats that will be monitored for extent and quality from 2009 in perpetuity for submission

to scientific literature on habitat change in the Caribbean. The resulting Habitat Mapping and Change Plan (HMC Plan) will conform to the established NERR protocols, and 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 the developing abiotic, biotic and restoration monitoring plans to form an integrated monitoring strategy.

## 4.5 Current Research Staffing

The Research Program is managed by a Research Coordinator, who has a SWMP Technician and a Lab Technician to support data acquisition. The Research Coordinator develops the long-range vision for the program and oversees all aspects of research, monitoring and visiting investigator coordination. The SWMP Technician collects, maintains and submits the abiotic data associated with the SWMP Program, including data logger maintenance and database management. The Lab Technician manages lab space and equipment use for staff, graduate students and visiting researchers, as well as analyzing samples collected for the interstitial pore water and watershed monitoring programs.

## 4.6 Challenges

Primary challenges to achieving the research strategies outlined above are as follows:

- Staff positions, especially those involved with SMWP and monitoring programs, need to be stabilized since the personnel receive extensive training for program implementation.
- Boat Operator alternatives need to be evaluated to assist with the current and anticipated use of Reserve resources by visiting investigators. This is especially important in relation to the remote field station partnerships.
- Research facilities need to be constructed. This will include: wet and dry laboratories with space for staff, GRFs and visiting researchers; comfortable dorm facilities for visiting researchers and students, especially as the field station component is developed; and, storage space for visiting investigators.
- Vehicle support is needed for launching vessels.
- Small boats with outboard motors are needed to support visiting researchers and GRF activities throughout the Reserve.

## 4.7 Partners

The Research Program works across ecosystems to define and monitor the health of the Reserve's resources. The wide range of potential research topics opens up an opportunity to develop a broad network of partnerships. Some of the existing and potential Research partnerships include:

- Caribbean Coastal Ocean Observing System (CarICOOS) - The observation arm of the Caribbean Regional Association for Integrated Coastal Ocean Observing (CaRA), Jobos Bay NERR collaborates with a CarICOOS intern to analyze SWMP data and add a climatology element from the CarICOOS webpage. Jobos Bay NERR has also installed CarICOOS telemetry equipment on one of the SWMP stations for transmission of water quality parameters in near real time.

- Caribbean Regional Association (CaRA) - The administrator of the regional Coastal Ocean Observing System in the northeastern Caribbean, CaRA provides observations and products to detect and predict climate variability and consequences; preserve and restore healthy marine ecosystems; ensure human health; manage resources; facilitate safe and efficient marine transportation; develop coastal hazard management response; and, predict and mitigate against coastal hazards.
- Various Universities within Puerto Rico and the US have expressed interest in initiating the development of MOUs whereby the University will use Jobos Bay NERR as a field station. Through these MOUs, the Reserve will have an opportunity to increase research and establish longterm monitoring projects.
- The NERRS Science Collaborative is a new NERRS program that links research with decision-making and the application of science and technology in the coastal zone. The 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 coastal pollution and habitat degradation in the context of climate change.
- NOAA-Coastal Services Center – With a myriad of tools, Jobos Bay NERR has received excellent support from NOAA-CSC. Recently CSC started processing digital imagery to provide remotely-sensed data products, such as land use/land cover and impervious surfaces, using their Coastal Change Analysis Program (C-CAP). This nationally standardized database of land cover and land use change information is another tool for use in coastal decision-making and future research projects.
- NOAA-National Center for Coastal Ocean Science (NCCOS) - As part of CEAP a series of projects has been taking place at Jobos Bay NERR. NCCOS is collaborating on assessments of water quality, coral reefs, seagrass beds and fishes. They have also developed a high resolution habitat mapping product that will be available for Jobos Bay. These products were identified by the RAC as critical for future research and monitoring projects.
- 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). This will increase the vertical accuracy of all benchmarks from 3 meter vertical resolution to 2-5 centimeter vertical accuracy. The NGS will tie Jobos Bay NERR benchmarks into this network, allowing the Reserve to monitor sea level changes at SWMP stations and mangrove forest uplands. A local vertical control network will be implemented enabling millimeter level accuracy within the network and establishment of tidal datum's at the reserve using the SWMP data loggers.
- Research Advisory Committee (RAC) - The RAC advises the full Citizen Advisory Committee and Reserve Manager on research and monitoring projects in the Reserve and its watershed.
- USDA-Natural Resource Conservation Service (NRCS) – A primary partner on the CEAP project, NRCS works with Jobos Bay NERR and agricultural interests to implement BMPs to protect Reserve resources.

## 4.8 Action Plan

| Table 6. Research and Monitoring Program | | | |
|---|---|---|---|
| **Goal 1 - Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and education** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Watershed and circulation models will be developed to identify the likely sources and fates of land-based pollution into the Reserve | Complete an analysis of monitoring needs for circulation and watershed modeling by a team of modeling experts to identify monitoring gaps | Monitoring strategies are implemented<br><br>Models are developed which identify sources, fate and transport of watershed pollutants into the Reserve | Watershed<br><br>Watershed |
| Inundation models will be developed to examine the impacts from projected sea level rise | Through a partnership with the CSC, apply a simple inundation model to existing data sets to explore potential impacts from projected sea level change<br><br>Develop a more sophisticated inundation model of the region, following installation of vertical control infrastructure, update of the geodetic datum of Puerto Rico and development of V-Datum tools | Models are developed and predictions of community and habitat impacts are generated | Watershed |
| | | | |
| **Goal 2 - Increase the use of Reserve science and sites to address priority coastal management issues** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| The Reserve will be a data rich environment that supports research on the impacts of watershed, oceanic and climatic forcing on coral and coral-related environments | Design and implement long-term abiotic monitoring plan to support research and development of watershed and circulation models<br><br>Design and implement biological monitoring plan<br><br>Design and implement a habitat mapping and change plan<br><br>Formalize partnerships that create a field station relationship between participating universities and the Reserve<br><br>Implement the GRF Program | Abiotic, biotic and long-term habitat monitoring and change analysis is being developed and disseminated on the Reserve's website and at CDMO<br><br>Applications from a broad spectrum of institutions result in funding two GRF's per year to conduct research in the Reserve<br><br>Support the Stewardship Program's development of the Restoration Science Strategy | Watershed<br>Puerto Rico<br>Caribbean<br><br>Puerto Rico<br>Caribbean |
| Multiple audiences will have access to the Reserve's research and monitoring data | Develop, maintain and make accessible a research database on the Reserve's website<br><br>Develop a database of former and ongoing research projects for use by Reserve staff and visiting researchers<br><br>Sponsor a research symposium by the | The Reserve's website is used as a portal for data and research on habitats within the Reserve<br><br>Research symposiums are held and well attended at the Reserve | Watershed<br><br>Puerto Rico<br>Caribbean<br><br>Watershed<br>Puerto Rico<br>Caribbean |

| | | | |
|---|---|---|---|
| | Reserve that serves as a forum to share research results on anthropogenic and climatic impacts on coral and coral-related ecosystems in the Caribbean<br><br>Design the wireless infrastructure to integrate weather and water quality monitoring data from throughout the watershed into an internet-based dissemination strategy<br><br>Acquire and submit NERRS SWMP data to the CDMO in a timely manner | The Reserve is current on all data required by the CDMO<br><br>GRF theses will be disseminated | Watershed<br><br>Watershed<br>Puerto Rico<br>Caribbean |
| Develop MOUs with universities to enhance the use of the Reserve as a research field station | Work with interested universities to develop MOUs that define the long-term research partnership | The Reserve is established as a research field station | Watershed |
| | | | |
| **Goal 3 – Enhance people's ability and willingness to make informed decisions and take responsible actions that affect coral and coral-related systems** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Decision support tools will be applied to support coastal management, training and education efforts | Support the use of decision support tools for use in coastal resource protection, management and education | Reserve decision tools are used in coastal management applications, education programs and training workshops | Watershed |
| | | | |
| **Goal 4 - Enhance the administrative capability and infrastructure of the Jobos Bay NERR to meet the stewardship, research, education and training challenges of the future** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Research staff and infrastructural capacity will efficiently and effectively meet research goals and objectives | Develop skills in leadership, fiscal management, fund raising and program development for Research Agenda<br><br>Ensure that professional trained staff support SWMP | The Research and Monitoring Programs are expanded through collaboration strategies with universities and other partnerships<br><br>Reserve is able to complete the priorities established by this plan | Watershed<br><br>Watershed |

## 5.0 EDUCATION AND INTERPRETATION [§921.13(A)(4)]

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 in the reserves incorporates a range of programs and methodologies that are systematically tailored to key audiences around priority coastal resource issues and incorporate science-based content. Reserve staff members work with local communities and regional groups to address coastal resource management issues, such as nonpoint source pollution, habitat restoration and invasive species. Through integrated research, stewardship and education programs, the reserves help communities develop strategies to deal successfully with these coastal resource issues.

Formal and non-formal education and training programs in the NERRS target K-12 students, teachers, university and college students and faculty, as well as coastal decision-maker audiences, such as environmental groups, professionals involved in coastal resource management, municipal and county zoning boards, planners, elected officials, landscapers, eco-tour operators and professional associations.

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. Reserve education activities are guided by national plans that identify goals, priorities and implementation strategies for these programs. Education and training programs, interpretive exhibits and community outreach programs integrate elements of NERRS science, research and monitoring activities, and ensure a systematic, multi-faceted and locally focused approach to fostering stewardship.

### 5.1 Reserve System Education Goals

The NERRS's mission includes an emphasis on education, interpretation and outreach. Education policy at the Jobos Bay NERR is designed to fulfill the Reserve System goals as defined in the regulations (15 CFR Part 921(b)). Reserve System Education goals include:

- Enhance public awareness and understanding of estuarine areas and provide suitable opportunities for public education and interpretation; and,

- Conduct and coordinate estuarine research within the system, gathering and making available information necessary for improved understanding and management of estuarine areas.

1. People understand how human choices and natural disturbances impact social, economic and estuarine ecological systems.
2. People apply science-based information when making decisions that could impact coastal and estuarine resources.

The Reserve's Education Program has been focused on two primary audiences: K-12 students and local communities. The K-12 programs are modeled after the NERRS K-12 Estuarine Education Program (KEEP) initiative, helping 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. Local communities have been engaged through outreach programs and activities to understand the Reserve's resources and their importance, laying the foundation for community support of Reserve efforts.

The local economic climate has affected education through budget cuts, personnel layoffs and restructured programs. The Reserve will support local teachers to address their internet infrastructure inadequacies, develop familiarity with using the Reserve's science-based data in routine lessons and foster a field-based learning network for teachers and students. Along this path, the Reserve's Education Program can work to achieve a continual learning environment using products and services from the Reserve to address science standards in schools through their school programs, pilot projects and science camps.

Several K-12 schools in the municipalities of Salinas and Guayama are on the Commonwealth's list for "Scholar Improvement for 2009-2010", due to poor student performance on academic progress tests http://www.de.gobierno.pr/deportal/descargas/Escuelas%20en%20mejoramiento%20escolar%202009-2010.pdf. The Jobos Bay NERR Education Program will include some of these schools in the Jobos Bay NERR Estuarine Literacy for Schools pilot project. With a distance learning focus on the SWMP data, experiential field trips and hand-on activities, the program targets increasing student interest in science and math through the exploration of estuarine ecosystems and science-based information. Several teachers from Jobos Bay watershed, including Coquí Middle School, Urbana Nueva Salinas High School, among others, will continue to participate in Teacher Training Workshops and the Education Advisory Committee, as well as working with the Reserve to create a plan to improve the student's education achievement.

In addition to the school programs and teacher trainings, the Reserve has partnered with the Sea Grant College Program, University of Puerto Rico (UPR)-Humacao and UPR-Rio Piedras Education Programs to improve the quality of Jobos Bay NERR education products. These products, including topic-based lessons and the new education guide, will use inquiry-based initiatives to encourage learning through the study of Jobos Bay NERR ecosystems and will be available on the Jobos Bay NERR website (www.jbnerr.org).

## 5.2 Jobos Bay NERR Education and Interpretation Priorities

**RESERVE KEY ISSUES**

- Climate change impacts on coastal ecosystems and communities
- Land use change impacts on coral and coral-related habitats
- The interrelationship between ecological integrity and community resilience

The Jobos Bay NERR Education Program mirrors the National System's education priorities, focusing on students in grades 6-12 and community audiences. The Education Advisory Committee (EAC) guides education and outreach efforts, with representatives from: the University of Puerto Rico-Sea Grant College Program, Metropolitan University, Turabo University, Urbana Nueva High School (Salinas), Adela Brenes Texidor High School (Guayama), Sabana Llana Middle School (Salinas), Simón Madera Middle School (Guayama), José de Choudens Middle School (Arroyo), Woodrow Wilson Elementary School (Aguirre) and Educational Services Network Corporation (EDNET). All educational programs will target the priority issues of the Reserve articulated in this plan, including local impacts of climate change, anthropogenic stressors in the watershed, land use change, ecological integrity and community resilience on

coral and coral-related ecosystems. Education programs will involve cross-sector support from the Research, Stewardship and CTP Programs.

Over the life of this next management plan, Jobos Bay NERR's Education Program will: 1) enhance and expand the target audience within the Jobos Bay watershed among teachers and students in grades 9-12; 2) implement more efficient and accessible outreach strategies to the general public; 3) provide educational support to the local community; 4) expand the geographic scope of its educational audiences within Puerto Rico; and, 5) provide depth to topics it will cover. The Reserve will broaden the number of students ultimately impacted through expanded Teacher Training Workshops and partnerships with environmental educators through a Commonwealth-based Environmental Education Alliance. The Reserve will also delve deeper into topics and field-based learning opportunities by integrating the priority issues of climate change, land use, ecological integrity and coastal resiliency throughout its K-12 and community outreach programs.

Not only will the Reserve be implementing current and expanded programs to 6-12 audiences, but it will do so in such a way that effectiveness of the Reserve's education programs will be evaluated with measurable outcomes linked to student achievement in reaching math and science standards. The Education Advisory Committee will be tasked with identifying measurable outcomes and designing evaluation methodologies, working with universities and other experts.

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. The Reserve will pursue a new role for itself within Puerto Rico as a facilitator for island-wide environmental education. Currently, there are numerous environmental education programs throughout the island, yet there is little or no mechanism for these programs to coordinate towards integrated goals and educational impact. The Reserve's Education Program will position itself as a leader, participating in an Education Alliance for island-wide environmental education. By undertaking market analyses and needs assessments, educational gaps and opportunities will be identified to enhance the educational system in Puerto Rico for K-12 academic achievement and community outreach. This vision for the Education Program is described in more detail below.

### 5.2.1 Past Accomplishments

During the last management planning period, the Education Program strengthened its relationships with implementation of new K-12 school programs and middle school summer camp programs and outreach to the community through community-based presentations. Figure 32 reflects involvement in reserve programs in 2009 with local tourists and K-12 programs comprising the majority of the audiences receiving reserve programs. Since the last management plan (2001), the Education Program has delivered strong K-12 education programs focused on stewardship and conservation at the Reserve to more than 380 school groups (11,358 K-12 students) from throughout Puerto Rico.

A total of 842 college students visited the Reserve and 340 teachers participated in workshops. Students participated in educational field trips and activities designed to raise their environmental awareness.

Guided field excursions have been offered through Reserve trails, and printed materials have been developed to support self-guided tours, including the Kayak Trail. Recently, the Education Program developed and implemented Teacher Training Workshops that apply both locally developed and the NERRS Estuaries 101 curriculum, and summer camps to target grades 6-12 audiences. In 2009, a Graduate Research Fellow was successfully utilized to support lectures and field activities for the Teacher Training Program.

The Education Program refurbished the interpretive exhibits in the 2,800-ft$^2$ Visitor Center, including interactive displays, photos, a watershed model, coral reef dioramas, and pictorial exhibits of key ecosystems, natural resources and the cultural history of Aguirre. These are now outdated and are in need of upgrading to reflect the current priorities of the reserve.

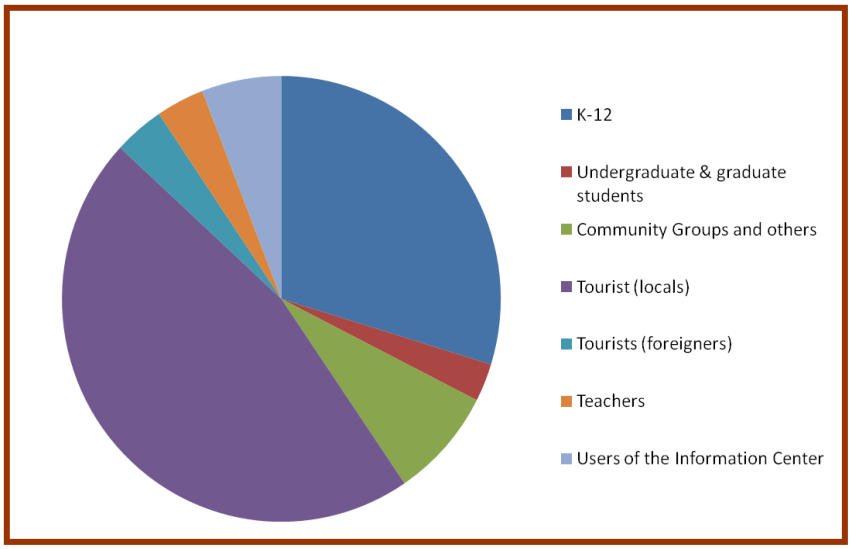


Figure 31. Jobos Bay NERR Visitation 2009

### 5.2.2. Current Education Program Priorities

The objective of the K-12 education program for this next five years is to enhance outreach to K-12 school teachers and students and expand programs to target teachers and students in grades 9-12 within the Jobos Bay watershed and throughout Puerto Rico. K-12 school audiences will be targeted through implementation of K-12 science curricula involving teacher training workshops and associated field-based activities, and through summer camp programs. Following is a description of the programs that will be prioritized for each target audience.

- K-12 School Program (ongoing)

The Reserve's Education Program has traditionally targeted K-12 school students. The Reserve's '*Guardians of the Estuary'* summer program was developed in response to a community need for a locally-based school summer program. Due to transportation constraints the program targeted students primarily from the adjacent communities of Aguirre, Coquí and Las Mareas. Specifically, this has been accomplished by providing local schools with presentations on topics, such as the Jobos Bay estuary and its ecosystems, endangered animals and global warming. In addition to the reserve's K-12 school curriculum, the NERRS Educators have developed the Estuaries 101 curriculum that targets high school students. In 2010, the curriculum will be adapted to meet the science standards for middle school students as well. The reserve will use both the *Guardians of the Estuary* and *Estuaries 101* Curriculum to deliver science education to middle and high school students through Teacher Training Workshops and site-based activities. The reserve will incorporate the key issues addressed by this management plan into all curricular activities. Education staff will increase participation of local teachers in their Teacher Training Workshops (Figure 33) and transition into a paradigm of program implementation in which

teachers are responsible for leading their students in field-based tours and activities using Reserve curricula. This will free up reserve education staff to focus on program development, coordination and leadership.

Figure 32. Teacher Training Workshop

"*Guardians of the Estuary*" Summer Camps (ongoing) - Another strategy of engaging school students in estuarine science has been to host elementary and middle school summer camp programs at the Reserve for students from the local community during the last 6 consecutive years. These have been highly successful and represent an important connection between the Reserve and local communities. An estimated twenty-eight (28) students spend a week exploring the Reserve, 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 is updated annually to incorporate new information and will continue with content modification to include issues associated with climate change, habitat alteration, human impacts on the marine environment and estuarine dynamics. The summer camp will also expand its program to offer more field-based activities, depending on the success of the Reserve in acquiring a much needed educational vessel.

- School Pilot Programs

With the completion of the NERRS *Estuaries 101* Curriculum and the enhanced information base characterizing the Reserve's ecosystem from the watershed to the sea, the Jobos Bay NERR has an exciting opportunity to expand its programs to grades 9-12 and offer more sophisticated educational programs. The focus of the next five years will be to develop and implement a high quality program that integrates both Reserve facilities and programmatic resources, resulting in a measurable positive impact on student achievement. The approach will be piloted with schools in close proximity to the Reserve.

Schools Interactive Estuarine Literacy Pilot Project - Local schools suffer from inadequate connections to the internet, limiting access to data, information about Teacher Training opportunities, available curriculum and networking opportunities among teachers. With a wireless network being developed at the Reserve and much of its research and monitoring data accessible on the internet, it is critical to the Education Program to have schools reliably connected to the internet. Many schools have internet access either sporadically or not at all, making accessibility to the *Estuaries 101* curriculum and reserve data difficult. The education staff will pilot internet-based classroom programs that incorporate a field component with selected schools to determine feasibility, ease of data integration for schools and expanded teacher training opportunities, either using the Reserve's wireless infrastructure or other internet options. To support the internet infrastructure, the Education Program will initiate a pilot partnership with (1-3) local middle school and/or high schools.

Schools will be selected across the Reserve's watershed in Salinas (Las Mareas, Coquí, Aguirre) or Guayama. This pilot partnership will allow the Jobos Bay NERR Education Program to define the roles and expectations of the Reserve and the respective school/teacher. *Estuaries 101* and other Jobos Bay developed curricula will be used to integrate SWMP and other research data into the classroom. The participating math and science teachers from each school will be required to participate in expanded Teacher Training Workshops to integrate SWMP and research data into math and science programs. The teachers will be encourage in seeking secure funds for the internet infrastructure, while Reserve staff provides the training and support for the acquisition of the internet infrastructure through training workshops on grant writing and capacity building. An evaluation strategy will be an integral component of the pilot project.

The priority issues of climate change, watershed/land use change, habitat alteration, water quality degradation and biological integrity will be incorporated into all Reserve programs. GRFs and other researchers and graduate students working at the Reserve will be sought out to participate in the Teacher Training Workshops.

Summer Camps – In response to the enthusiasm of the elementary/middle school summer camp participants in seeking out further educational opportunities as they mature and the added emphasis of the Reserve's educational programming on grades 9-12, the Reserve plans to add a high school summer camp program.

It is envisioned that the middle/high school summer camp will be a 1-3 week in-depth program targeting students from local middle/high schools. Students will participate in actual data collection, mapping and restoration activities, including working on a project that will be enhanced or completed during the camp time frame. Possibilities include, but are not limited to, CEAP buffer restoration monitoring, global positioning system (GPS) and GIS training, and plankton tows for biological monitoring.

New education facilities will be developed to further enhance education activities at the Reserve and will include a student laboratory with work spaces and microscopes, lockers and a mud room. This facility will be a major milestone for the education program for the local school system, and for the other school systems throughout Puerto Rico.

### 5.2.3 Public Outreach

The objective of the public outreach efforts is to more efficiently and effectively deliver reserve information to local and foreign tourists and to stakeholders in the local community. The reserve is a popular destination for both residents on the island, as well as off-island tourists. This is evidenced both by the visitation numbers recorded during the last planning period and the geocache messages left in canisters within the reserve. There are a number of issues that have become apparent with respect to general outreach within the Reserve. Many people within Puerto Rico and abroad lack access to information about the Reserve and the opportunities it provides for recreation, such as hiking, kayaking and snorkeling, from traditional informational networks. In fact, the Reserve and other ecotourism destinations are not identified as destinations in rental car GPS units. With the integration of the Reserve into the larger Commonwealth SPA, there is an excellent opportunity to enhance the Reserve's visibility to the general public. This can also help stimulate the local economy, as local concessionaires can benefit from enhanced visitation. Education staff will explore opportunities with the Office of Tourism to enhance outreach to promote the reserve as a tourist destination for ecotourism

based activities. Brochures for hotels, pamphlets for natural area destinations, kiosks at the airport and GPS unit destination sites are some strategies that may be pursued developed. The Reserve will also strategically enhance its geocaching 'stations' in key habitats throughout the Reserve to guide visitors through representative habitats. Targeting the general public is a valuable way to inform about key issues impacting the Reserve and coastal environments throughout the Caribbean and about the broader NERRS network of sites. However, this outreach will be done carefully to ensure that tourism impacts do not negatively impact reserve resources or programs.

Exhibits at the Reserve lack updated information on the local impacts of climate change, watershed/landuse change, habitat alteration, water quality degradation or changes in the integrity of biological communities. During this management plan, the Education Program will modernize its outdoor and indoor exhibits to reflect the key priorities of the Reserve. Priority will be given to the exhibits that enhance current management issues, as the facilities undergo expansion for the longterm.

A key strategy that will be pursued during this next planning period is to actively engage the community in reserve programming to augment staff capabilities and to invest the community in the reserve.

The Education Program currently develops community presentations on marine resources for associations and the public, including religious groups, boy scouts and tourists. These programs will be updated to focus on the Reserve's priority issues. Outreach programs will be strategically targeted towards both local communities and the broader general public of Puerto Rico. Currently, the Reserve does not have a volunteer program. However, a plan will be developed to involve community members in hosting guided tours. These community members will be required to participate in a targeted training program on Reserve resources. These may be either volunteer docent positions supported by the Reserve's 'Friends' group or private concessionaires that then become 'certified' by the Reserve. The educational staff will work with the community to identify the most effective way to engage citizens in supporting outreach within the Reserve.

Outreach will also be targeted to support stewardship efforts to develop a recycling program in communities within the watershed. Outreach strategies will be developed for local governments and community participants to articulate the benefits of recycling. This strategy will be implemented in partnership with Stewardship and Coastal Training Program (CTP) staff.

On a broader scale, the Reserve will develop a communication strategy to (1) disseminate information related to the key issues of climate and anthropogenic stress on coral and coral-related environments and (2) outline strategies to support a more sustainable environment and economy. Target audiences may include agency and political leaders, municipal governments and general audiences throughout the Caribbean. Communication outlets may include radio stations, newspapers, or hotel and airplane magazines.

### 5.2.4 Education Providers in Puerto Rico

There are numerous environmental educational programs in Puerto Rico, many sponsored by non-governmental organizations (NGOs) and protected area systems on the islands; yet, there is little coordination between these programs. There is a great deal of benefit that could be realized by enhancing the network and capacity of education providers on the island. A market

analysis is planned as part of the KEEP initiative, aiding in identifying a full inventory of education providers in Puerto Rico. Given the needs for coordination, as well as the results of the market analysis, the Reserve will initiate two somewhat inter-related actions to reach out to the education community in Puerto Rico: 1) promote an Education Alliance among interested education providers and 2) expand teacher training opportunities to educators throughout Puerto Rico and the broader Caribbean, as feasible.

- Education Alliance - The Education Program will explore and, if supported, facilitate the dialogue between island-wide Informal Environmental Educators to develop a unified vision for and collaborative implementation of environmental education for children and adults audiences in Puerto Rico. The initial planning efforts of this Alliance will involve key representatives of the environmental educational community in Puerto Rico to identify a vision, mission, coordinated themes, programs, opportunities and desired impacts from the Alliance. The longterm integrated efforts of the Alliance will support environmental education of the general public and K-12 island-wide. The Jobos Bay NERR will encourage that climate change and anthropogenic stressors on Puerto Rico's diversity of habitats is adopted as a priority theme addressed by nearly all environmental education providers. Another benefit to the Alliance will be the centralization of information on opportunities such as Teacher Training Workshops, tours, availability of curricula and other professional training opportunities. The Jobos Bay NERR sees this Alliance as a key target audience of its Teacher Training Program. The Environmental Education Alliance will offer a portal to environmental education providers and teachers throughout the island and region for participation.

- Puerto Rico Teacher Training Workshops – As mentioned earlier, the Reserve conducts teacher training workshops for science teachers in grades 6-12. The education policy will be revised such that participation in teacher training workshops will be required in advance of classroom site visits to prepare teachers to develop pre-visit classroom activities, maximize teacher capacity, and minimize demand on staff time. Most of the teachers that have participated in these workshops are from the local watershed, with limited participation by teachers from San Juan. As a result of these teacher trainings, at the end of this management plan 10-15 teachers from Jobos Bay watershed will participate in a special Teacher on the Estuary (TOTE) Program. TOTE is a NERRS initiative where educators learn at a NOAA National Estuarine Research Reserve, work with local scientists and experienced estuarine and coastal educators, explore coastal habitats, practice field-based studies, learn how to use estuary data and guide student investigations, and explore the new *Estuaries 101* Curriculum.

  Jobos Bay NERR TOTE will also encourage this selected group of teachers to understand and use Jobos Bay NERR educational products in their classrooms, apply estuarine literacy principles and use Jobos Bay as a natural laboratory for field trips and other experiential learning activities. This expansion of the teacher training programs will be phased in over the course of this management plan following the construction of more appropriate facilities to handle increased demand. Specifically, the Reserve requires a teaching lab, classroom and conference room facilities, enhanced overnight accommodations and an educational boat to support field activities in the Reserve. The teacher training workshops will be based on feedback from an assessment to determine teacher needs, such as continual learning for math, science and technology. GRFs, other researchers and graduate students will be employed to assist with these workshops, keeping the content current.

## 5.4 Current Education Staffing

The Jobos Bay Education Program is managed by an Education Coordinator, who has one Education Assistant to support program generation and implementation. The Education Coordinator develops the long-range vision for the program and oversees all aspects of program development and delivery, interpretive exhibits and coordination with other Reserve programs. The Education Assistant develops and delivers presentations for schools, organizations and community groups, as well as leading field-based education activities.

## 5.5 Challenges

Primary challenges to achieving the education strategies outlined above are as follows:

- Additional personnel via partnerships to support the Education Alliance, assist with implementing the middle school summer camp program, and develop and implement the high school summer camp program.
- A Volunteer Coordinator position is needed to support reserve volunteers and community NGO's in offering guided tours through the Reserve.
- Education facilities need to be constructed, including an education laboratory with space for students, a classroom, and a mud room for teachers and students.
- A large van (15 passengers) to transport teachers and students to various parts of the Reserve is needed for educational field activities.

## 5.6 Partners

As the primary exporter of Reserve information, the Education Program networks with many of the partners from the other Reserve programs. Some of the current and potential Education partnerships will include:

- Education Advisory Committee (EAC) – The EAC advises the full Citizen Advisory Committee and Reserve Manager on education, outreach and interpretation projects in the Reserve and its watershed.
- Education Alliance – This future partnership will involve leading environmental educators in Puerto Rico, including G-Works, PRDNER Education Program and Sea Grant College educators.
- Local Communities – The Initiative for the Economic Development of Jobos Bay (IDEBAJO) from Las Mareas, Salinas and Eco-Mar NGO's from Puerto de Jobos, Guayama have MOUs with the Reserve. These communities, trained by the Reserve, conduct field excursions and disseminate Reserve information.
- Puerto Rico Tourism Company – The Reserve collaborates with the Puerto Rico Tourism Company to disseminate ecotourism opportunities for visitors.
- University of Puerto Rico, Río Piedras and Sea Grant – The Reserve Education Program works across school districts and communities to provide locally relevant information to teachers, students and the public. In partnership with the Education Faculty at the University of Puerto Rico, Río Piedras (UPR-RP) and the Sea Grant Education Coordinator at the University of Puerto Rico, Humacao, the Jobos Bay NERR Education Program will continue to work with undergraduate education students from UPR-RP (pre-service teachers) to adapt and enhance NERRS *Estuaries 101* for the Jobos Bay NERR Education Program. The pre-service education students and their professors will participate in a series of workshops at Jobos Bay NERR to learn about the Jobos Bay

estuary, the Reserve and the NERRS *Estuaries 101* Curriculum, Estuaries & Climate Literacy Principles and Concepts, and KEEP component activities, including field-based estuarine science and the use of SWMP data for a technology-oriented approach. The University students will create inquiry-based learning activities for K-12 teachers to implement with their students. These activities will align with Puerto Rico's education standards.

## 5.7 Action Plan

| Table 7. Education and Interpretation Program | | | |
|---|---|---|---|
| **Goal 1 - Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and education** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Coral and coral-related habitats of Jobos Bay NERR will be protected through the actions of local communities | Disseminate information to the local communities about the impacts of climate change, landuse and degradation of water quality on community resilience<br><br>Support programs that involve and train local community members and organizations in Reserve operations | Reserve messages are delivered through multiple media outlets at the local, commonwealth and regional levels.<br><br>Requests for Reserve programs from the community increases | Watershed<br><br>Watershed<br><br>Watershed |
| | | | |
| **Goal 2 - Increase the use of Reserve science and sites to address priority coastal management issues** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Students in grades 6-12 improve their math and science performance through the application of Reserve science and technology to coastal management issues | Provide summer camps, refreshing science data each year<br><br>Develop and implement a high school summer camp to encourage continual math and science learning into the university level<br><br>Formalize a partnership between the Reserve and 1-3 middle and/or high schools in local area to support 8-12 grades in math and science education through application of Reserve science and technology, evaluating impact of partnership | Elementary summer camp and middle/high school summer camp will have full attendance with positive and constructive evaluations<br><br>Participation by math and science teachers in Teacher Training Workshops will be increased within local community, throughout Puerto Rico and the greater Caribbean<br><br>Student academic performance will improve with the local middle-high school pilot program<br><br>Number of topics provided for Teacher Training Workshops will increase | Watershed<br><br>Watershed<br>Puerto Rico<br>Caribbean<br><br>Watershed<br>Puerto Rico<br>Caribbean |
| | | | |
| **Goal 3 – Enhance people's ability and willingness to make informed decisions and take responsible actions that affect coral and coral-related systems** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| The impact of island-wide environmental education that addresses climate change and anthropogenic stressors on coastal habitats will be strengthened through a | Support the dialogue among environmental educators in Puerto Rico to provide new partnerships and coordinated strategies to address issues of climate change and human impacts on island ecosystems | The Environmental Education Alliance will support JBNERR Education Program with activities based on integrated themes, including climate change and human impacts on Puerto Rico's natural | Puerto Rico |

| | | | |
|---|---|---|---|
| coordinated network of environmental education providers | Support environmental and capacity building training workshops for members and partners of the Environmental Education Alliance and throughout the Caribbean<br><br>Expand and continue the offerings of Teacher Training Workshops based on the application of Reserve science and the needs assessments of math and science teachers<br><br>Promote Teacher Training Workshops throughout Puerto Rico and Caribbean region | resources<br><br>Participation in Jobos Bay NERR's education programs increase with enhanced representation from educators throughout Puerto Rico and Caribbean<br><br>10-15 teachers from local schools will incorporate Jobos Bay and NERRS educational materials in their classrooms and/or curricula.Participation in Jobos Bay NERR's education programs increase with enhanced representation from educators throughout Puerto Rico and Caribbean | Watershed Puerto Rico Caribbean<br><br>Watershed<br><br>Watershed Puerto Rico Caribbean |
| Education staff and infrastructural capacity will efficiently and effectively meet education goals and objectives | Develop skills in leadership, fiscal management, fund raising and program development for Education Agenda. | Programs are expanded through collaboration strategies with stakeholders, universities, and other partnerships | Watershed |
| Visitors to the Reserve will receive information on climate change and watershed impacts on water quality, biological diversity and community resilience | Increase visitation to the Reserve by including the Reserve and other protected areas in GPS units of rental cars, building out the geocache network within the Reserve and highlighting the Reserve in other traditional ecotourism information networks<br><br>Develop outdoor exhibits that address key resources and associated management issues<br><br>Develop self-guided tours using the wireless network and printed materials that highlight Reserve resources and management issues<br><br>Support a network of Reserve guides within the community that are trained to understand the Reserve's ecosystem and associated management issues<br><br>Expand and continue support and implementation of outreach activities such as Estuary Day, Coastal Cleanup Day, and other activities for general public | Management priorities will be integrated into all Reserve outreach materials<br><br>Number of visitors will increase<br><br>Visitors will support the 'Friends' group through direct donations and memberships<br><br>The community will be integrated in JBNERR Education and Outreach Programs<br><br>Increase environmental awareness among general public through outreach for education activities | Watershed Puerto Rico Caribbean<br><br>Watershed<br><br>Watershed<br><br>Watershed<br><br>Watershed Puerto Rico Caribbean |

# 6.0 COASTAL TRAINING PROGRAM

## 6.1 Reserve System Coastal Training Program

The Coastal Training Program (CTP) provides up-to-date scientific information and skill-building opportunities to coastal decision-makers who are responsible for making decisions that affect coastal resources. Through this program, National Estuarine Research Reserves work to ensure that coastal decision-makers have the knowledge and tools they need to address critical resource management issues of concern to local communities.

Coastal Training Programs offered by reserves address relevant coastal issues, such as land use, coastal habitat conservation and restoration, biodiversity, water quality and sustainable resource management, integrating reserve-based research, monitoring and stewardship products and activities in support of coastal decision-making. These programs target specific decision-maker audiences, such as land use planners, elected officials, regulators, land developers, community groups, environmental non-profits, businesses and applied scientific groups. In addition to providing scientific or skill-based information, each training program provides opportunities for professionals to network across disciplines and develops new collaborative relationships to solve complex environmental problems. Furthermore, the CTP provides a critical feedback loop to ensure that professional audiences provide input to local and regional science and research agendas. Across the NERRS, CTP activities are implemented using a variety of formats ranging from seminars, hands-on skill training, participatory workshops, lectures and technology demonstrations. Participants benefit from opportunities to share experiences and network in a multidisciplinary setting, often with a reserve-based field activity.

Partnerships are important to the success of the program. Reserves work closely with State Coastal Zone Management Programs, Sea Grant College extension and education staff, and a host of local partners in determining key coastal resource issues to address, as well as the identification of target audiences. Partnerships with local agencies and organizations are critical in the exchange and sharing of expertise and resources to deliver relevant and accessible training programs that meet the needs of specific groups.

The Coastal Training Program requires a systematic program development process, involving periodic review of the reserve niche in the training provider market, audience assessments, development of a three to five year program strategy, a marketing plan and the establishment of an advisory group for guidance, program review and perspective in program development. The Coastal Training Program implements a performance monitoring system, wherein staff report data in operations progress reports according to a suite of performance indicators related to increases in participant understanding, applications of learning and enhanced networking with peers and experts to inform programs.

## 6.2 Jobos Bay NERR Coastal Training Program Framework

The Jobos Bay NERR Coastal Training Program complements the National System's CTP priorities and uses the nationally implemented structure to frame project progression from needs assessment through evaluation. The Jobos Bay NERR CTP started in 2003 after the successful completion of the Needs Assessment and Market Analysis. The priorities identified in the CTP strategic plan, updated in 2008, are reflected in this next five-year planning period. The CTP

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 CTP is an essential provider of appropriate training in conservation and stewardship in the areas of land use planning, water quality degradation and sustainable use of coastal resources. In the current socioeconomically stressed times, CTP serves as a resource by providing cost-effective training for audiences that include PRDNER, partner agencies and community organizations.

**RESERVE KEY ISSUES**

- Climate change impacts on coastal ecosystems and communities
- Land use change impacts on coral and coral-related habitats
- The interrelationship between ecological integrity and community resilience

The Jobos Bay Coastal Training Program is managed by a full-time CTP Coordinator, hired through a Cooperative Agreement with the Pescadería Mar Negro Inc. (Appendix 13). Signed in 2008, the Agreement strives to accomplish the following: "to guarantee the collaboration and integration among both entities in means of joining efforts to promote preservation, conservation, citizens education, mitigation actions in natural areas, and socioeconomic sustainable development, among others." Jobos Bay NERR CTP funds are managed through the Agreement using an account created at the Finance Office of Affirmative Personal and Family Community Center Inc. (CCAP FI). Funds are used for the development and implementation of activities stipulated by Jobos Bay NERR grant rules, and in agreement with Jobos Bay NERR Manager and the CTP Strategic Plan.

The CTP Advisory Committee provides guidance to the CTP coordinator who implements the program for Jobos Bay. The agencies represented on the Advisory Committee are: Comite Dialogo Ambiental; US Environmental Protection Agency (USEPA); US Department of Agriculture's (USDA), Natural Resources Conservation Service (NRCS): Puerto Rico Coastal Zone Management Program, University of Puerto Rico (Agricultural Extension Service, Center for Interdisciplinary Studies, Sea Grant College Program) and Jobos Bay NERR.

Based on the findings of the Jobos Bay NERR CTP Needs Assessment (2003), the priority issues have been: 1) land use planning and population growth (community planning and development, sustainable socioeconomic development and socio-economic monitoring in the Jobos Bay NERR watershed); 2) water quality degradation (industrial and stormwater management); and, 3) habitat loss and alteration (agricultural BMPs, and residential and infrastructure development). These issues remain relevant during this next five year planning horizon. The target audiences for the Reserve's CTP typically include local elected officials, natural resource managers, field technicians, biologists, engineers, planners, private consultants, social science specialists, farmers, coastal decision-makers and NGOs. Generally, trainings are delivered primarily through workshops with hands-on experience, seminars and conferences (Figure 34).

Figure 33. CTP Workshop

### 6.2.1 Past Accomplishments

The Jobos Bay NERR Coastal Training Program has been an excellent instrument to expand education beyond the traditional educator and school-based interests. Since its inception, CTP has delivered education and training activities to elected officials, natural resources managers, decision-makers, farmers and law enforcement officials on topics related to resource protection, conservation, restoration and stewardship. Thousands of participants and more than 2,000 training hours have been conducted since the program's inception in 2003.

CTP has worked extensively with USEPA to train local municipalities in developing recently mandated municipal stormwater management plans, as well as in obtaining the required permits to support the plans. Also instrumental in the partnership-based Conservation Effects Assessment Program (CEAP) project, CTP is working with local agricultural interests in the watershed to implement best management practices (BMPs), reducing nonpoint source inputs to the Reserve and coastal waters.

## 6.3 Jobos Bay NERR CTP Priorities

The Jobos Bay NERR Coastal Training Program mission is to improve coastal resource management at local and regional levels in the Commonwealth of Puerto Rico through the use of education and capacity building. CTP is an essential provider of appropriate training in conservation and stewardship in the areas of land use planning, water quality degradation and sustainable use of coastal resources. With a watershed once dominated by a monoculture of sugarcane, the area is now fragmented by many smaller farms. This makes outreach to a sprawling community more complex, while the impacts are more widespread and diffuse.

Given the current community layout of population centers, agriculture and industry adjacent to sensitive habitats, Jobos Bay NERR CTP intends to promote and increase public participation in the stewardship of coastal environments through innovative training and capacity building activities. The Jobos Bay NERR CTP Needs Assessment (2003) identified the following priority issues for CTP for the next three years. These CTP priorities succinctly overlap with overall Reserve priorities, as provided in brackets below.

A. Land use planning and population growth: provide capacity building and technical assistance in community planning and development, sustainable socioeconomic development, and socioeconomic monitoring in the watershed. [Land use change impacts on coral and coral-related habitats; The interrelationship between ecological integrity and community resilience]
B. Water quality degradation: the program will be conducting training activities in stormwater management and water quality monitoring with the reserve stewardship program. [Land use change impacts on coral and coral-related habitats]
C. Habitat loss and alteration: Jobos Bay NERR CTP will conduct several training activities in the areas of agriculture management practices, and residential and infrastructure development. [Climate change impacts on coastal ecosystems and communities; Land use change impacts on coral and coral-related habitats]

### 6.3.1 Land Use Planning and Population Growth

Emergency Response

In an effort to provide critical safety information to local communities, the CTP will provide information and training on tools developed and/or implemented through the Research Program, such as the inundation and watershed models. The inundation model can be used by local communities to examine storm surge events, while the watershed model will highlight high probability flood zones. In combination, these models can assist local governments and emergency responders with disaster response planning. Technical training to engage local leaders and emergency responders in developing emergency response plans will be provided.

Local Community Involvement

Las Mareas is a small, economically depressed fishing community on the west end of Jobos Bay. In an effort to help the community through challenging economic times, several displaced fishermen banded together to form a community action group focused on improving their community and protecting Jobos Bay's resources.

While newly established, this community non-governmental organization (NGO) has energy and an interest to partner on Reserve management. They want to develop a cooperative agreement with Jobos Bay to assist with habitat restoration, management strategies, public access, and implementation and enforcement of fishery management plans.

The Las Mareas NGO has organized community-based mangrove clean-ups using kayaks and supported interpretive trail maintenance. The NGO is working with the Reserve to re-route the Kayak Trail to start from Mar Negro in Las Mareas, a safer route than the current trailhead at the boat ramp on Jobos Bay. The NGO is also interested in serving as a kayak concessionaire at the new trailhead.

The Las Mareas NGO has actively partnered on a NOAA-American Recovery and Reinvestment Act (ARRA) proposal for seagrass restoration with Seagrass Recovery, Inc. In the future, Seagrass Recovery Inc. will train the NGO and its volunteers on seagrass ecology, impacts and restoration techniques to continue their support for habitat restoration within the Reserve.

Eco-Mar is another NGO associated with the Puente de Jobos community at the east end of the Bay near Pozuelo. Eco-Mar has a Cooperative Agreement with Aguirre Forest and Jobos Bay NERR (Appendix 13) to conduct ecotourism within the managed boundaries with controlled permission to access some natural areas. As a component of the partnership, Eco-Mar maintains trails, conducts surveillance, collects trash and assists with restoration activities. Since the Education Program has already provided education programs to Eco-Mar on Reserve ecosystems, Eco-Mar is already implementing education programs and initiatives geared toward sustainable development and are disseminating the Reserve's interpretive material. Eco-Mar continues to participate in a variety of Reserve activities, including those to support other communities in developing collaborative efforts with the Reserve.

With these active local communities in the watershed, the Reserve is looking to enhance their existing partnerships with these NGOs through local community capacity building. CTP plans to conduct a needs assessment to determine the capacity needs of local communities and NGOs. CTP also plans to explore an 'Ecotourism Operators Certification Course', instructing

ecotourism operators within the watershed and Puerto Rico on relevant resource-based topics, such as manatee protection, submerged aquatic vegetation (SAV), shorebird identification, habitat restoration and others.

### 6.3.2 Climate

The CTP will provide training using outputs from the inundation and watershed models to enhance local municipality and community understanding of climate change issues. The inundation model can be used by local communities to examine sea level rise and inundation changes over time to identify local impacts from sea level rise. In combination, these models can assist local governments with planning and zoning efforts to address these challenges.

The CTP will conduct a needs assessment to determine local municipality and community understanding of the impacts of climate change. Green design and sustainable principles will be promoted and piloted through the CTP program. Technical training to encourage local leaders to proactively plan to adapt to changes in climate and the potential longterm effects on local communities will be provided, including the NERR's 'Planning for Climate Change' workshop.

The first Puerto Rico Climate Change Conference to be conducted in 2010 may offer a platform to introduce the CTP at the Commonwealth level. Sponsored by the Puerto Rico Sea Grant, the Conference will offer emergency response tools, new technologies, sea level rise model demonstrations and public policy needs to elected officials, emergency officials, reserve managers and others in Puerto Rico for application in confronting climate change impacts. Follow-up program development and implementation will be designed to respond to the expressed needs. The climate change program will be piloted locally and exported to a broader stakeholder community throughout Puerto Rico and the Caribbean

### 6.3.3 Water Quality Degradation

<u>Stormwater</u>

**Municipal Stormwater** – Approximately two years ago, the USEPA mandated small municipalities in Puerto Rico and other US territories to develop municipal stormwater plans and obtain relevant USEPA permits for plan components. Over the last two years, the Reserve's CTP has conducted training on municipal stormwater planning, as well as the Coastal Services Centers' (CSC) 'Coastal Development and Impacts' training, for approximately forty (40) small municipalities across Puerto Rico. Since this initiative was developed through USEPA for island-wide application, there was no initial watershed-based pilot of the program. CTP's involvement with the Stewardship Program to facilitate development of a watershed management plan with the municipalities in the Jobos Bay NERR and adjacent watershed will serve as a pilot to demonstrate the implementation and evaluation of stormwater plans and permits.

**Industrial Stormwater** – The USEPA is mandating industries to develop industrial stormwater plans and obtain relevant USEPA permits for plan components in Puerto Rico and US Territories. The Reserve's CTP will conduct training on industrial

stormwater planning for industries throughout Puerto Rico. The Reserve's recently developed database on contaminants provides an excellent resource as part of CTP training activities on industrial stormwater planning to target the appropriate industry-specific audiences. The database has been compiled by both a GRF and as part of the habitat characterization conducted by NOAA's National Center for Coastal and Ocean Science (NCCOS). As evident by Figure 35, preliminary unpublished data identify high concentrations of metals in sub-watersheds characterized by high concentrations of industrial development.

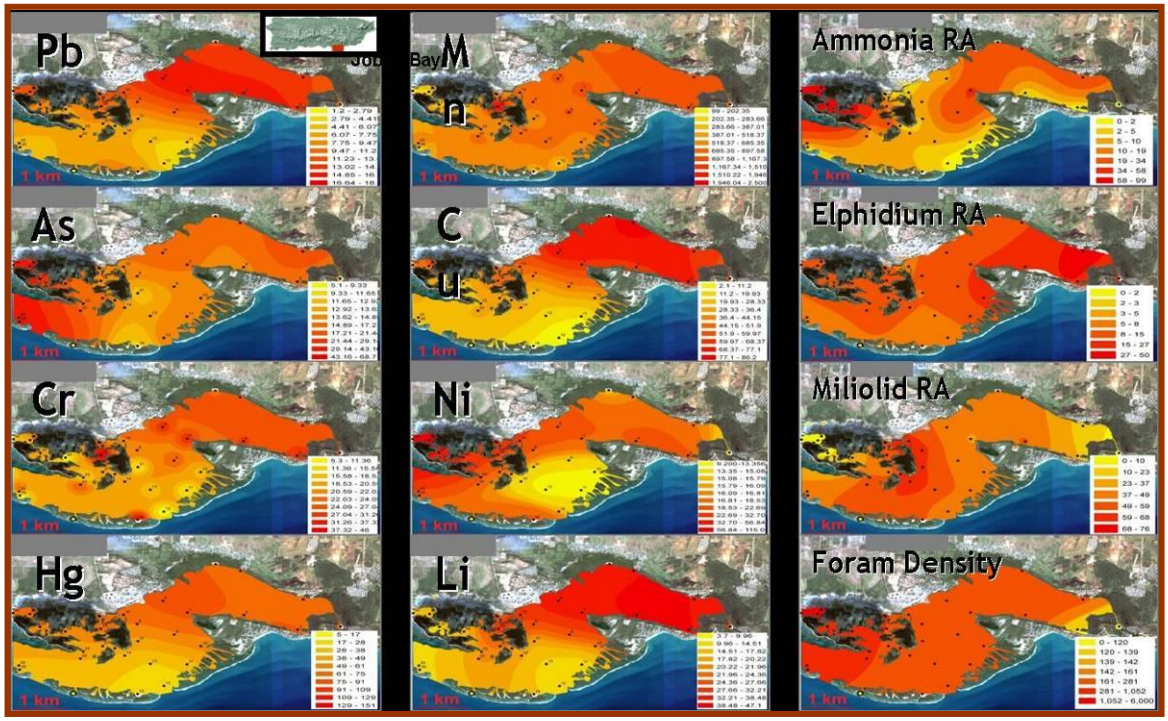


Figure 34. Heavy Metals in Jobos Bay *(from Michael Martinez, 2009 GRF)*

CTP plans to assess industry leaders and regulators to determine the capacity building necessary to complete these industrial stormwater plans, with a pilot study focused on the watershed prior to island-wide implementation. In addition, technical training will be provided and programs implemented in the watershed will be evaluated. Watershed strategies will be integrated into the watershed management plan.

### 6.3.4 Habitat Loss and Alteration

Agriculture

Agriculture - including row crops, fruit plantations, range cattle operations and poultry farms - comprises approximately 52% of land use in the Reserve's watershed (Figure 36). The impacts of agricultural pesticides and fertilizers on water quality are well documented. However, environmental benefits from the implementation of Best Management Practices (BMPs) on corals and coral-related environments are not well documented. To this end, the NOAA-USDA-Jobos Bay NERR Conservation Effects Assessment Project (CEAP) pilot study was initiated to monitor the effect of agricultural practices in the Reserve's watershed on coral habitat within the Reserve. Agencies worked with a local farmer to pilot applicable BMPs – such as nitrogen-

fixing crop rotations, alternative pesticides and fertilizers, and more efficient drip irrigation systems. Some of these conservation measures were put into practice. There is a need to establish a longterm monitoring protocol to monitor change over time.

While it will likely take several years to detect an impact from BMPs implemented on this single

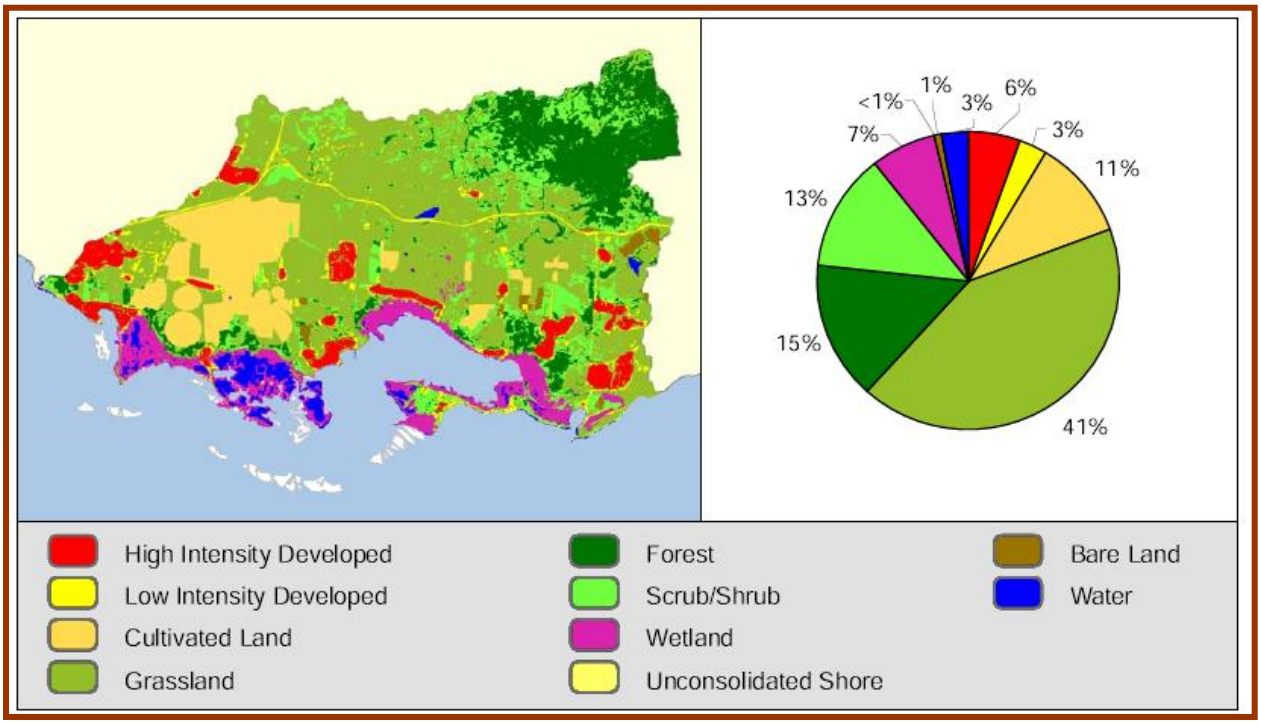


Figure 35. Jobos Bay NERR Watershed Land Uses *(Zitello et al. 2008)*

farm, the CTP will continue to coordinate with the participating agencies to disseminate information about agricultural BMPs, including ecological and economic impacts of these methodologies. The CTP will also be working to encourage additional farmers to participate in the effort. Implementation measures and an evaluation of program impacts will be identified within the watershed as the project's scope is broadened. Participation strategies will be integrated into the watershed management plan. The pilot program will be disseminated to stakeholders island-wide.

## 6.4 Current CTP Staffing

The Jobos Bay Coastal Training Program is managed by a full-time CTP Coordinator, hired through Jobos Bay Collaborative Agreement with the Puerto Rico Water Resource Institute (Appendix 15).

## 6.5 Challenges

Primary challenges to achieving the Coastal Training Program strategies outlined above are as follows:

- Additional resources/support is needed to implement the ongoing trainings developed to support stormwater initiatives, assist with needs assessments and compile evaluation information.
- Training facilities are needed including a computer laboratory, small and large conference rooms, and comfortable dorm facilities for workshop participants.
- A large van (15 passengers) to transport workshop participants to various parts of the Reserve is needed for field training components.

## 6.6 Partners

The CTP works across sectors, organizations and government levels to provide training. This broad-based networking results in a myriad of partnerships, many grounded in the targeted training topic. Some of the primary partnerships include:

- Local Communities – CTP has been an essential provider of technical assistance and advisory services for the Jobos Bay NERR watershed communities regarding their sustainable socioeconomic development, as well as the conservation and restoration of the Reserve.
- NOAA-Coastal Services Center (CSC) – The Coastal Services Center has been an essential provider and collaborator in trainings related to natural resource management.
- Puerto Rico Coastal Zone Management Program (CZMP) - The CTP provides capacity building and technical assistance to the Puerto Rico CZMP staff to address management and restoration issues.
- University of Puerto Rico, Sea Grant College Program – The University of Puerto Rico, Sea Grant College Program has a formal Collaborative Agreement to provide support to the collaboration of the Jobos Bay NERR CTP. It supports CTP by providing Sea Grant facilities, as well other resources from the University of Puerto Rico, for development of the CTP.
- USDA-Natural Resource Conservation Service – The Natural Resource Conservation Service has a formal partnership with Jobos Bay NERR to conduct the CEAP project, with CTP providing outreach capacity building to farmers and agencies participating in the project.
- USEPA - USEPA provides collaboration and technical information for the coordination and implementation of the stormwater management training series.

## 6.7 Action Plan

| Table 8. Coastal Training Program | | | |
|---|---|---|---|
| **Goal 1 - Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and education** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Coastal decision-makers will implement strategies that will effectively protect coral and coral-related ecosystems | Continue implementing and disseminating the CEAP project | All project components are implemented and monitoring protocols adopted | Watershed |
| | Work with local municipalities and industries within the JBNERR watershed to develop industrial stormwater management plans. | Stormwater and industrial management plans are developed for the JBNERR watershed and incorporated into the watershed management plan; municipal agency representatives are trained | Watershed |
| | Work with local municipalities, agencies, industries, and communities to develop and incorporate green design and sustainable principles in infrastructure plans. | Green design and sustainable principles are incorporated in JBNERR, DNER, local municipalities, industries, and community planning. | Watershed |
| | | | |
| **Goal 2 - Increase the use of Reserve science and sites to address priority coastal management issues** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Local communities will implement strategies that effectively enable adaptation to projected climate change scenarios | Apply scientific data to address issues associated with emergency response, sustainable development and climate impacts | Local community emergency response plans are developed and implemented | Watershed |
| | | Local communities develop plans to address climate change impacts | Watershed |
| | | | |
| **Goal 3 – Enhance people's ability and willingness to make informed decisions and take responsible actions that affect coral and coral-related systems** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| The communities within the Jobos Bay NERR and adjacent watersheds will be partners in protecting coral and coral-related environments | Develop resource knowledge base for community partners to implement sustainable ecotourism | Community partners develop sustainable ecotourism ventures | Watershed |
| NGOs and other community-based organizations will be more active in the management of natural resources through enhanced understanding and capacity to take action | Develop fund raising capacities for NGOs and local governments to implement community-based programs | Communities in the JBNERR watershed will be engaged and involved in co-management issues in the Reserve | Watershed |

## 7.0 ADMINISTRATION

The Administration section of the Management Plan outlines Jobos Bay NERR's organizational structure and the operational framework necessary to address the priority issues, goals and objectives of the Reserve across all programs (Figure 37). This framework promotes the professional development of staff and develops mechanisms to streamline procedures for overall Reserve management. To fully address the issues of climate change, watershed/land use change, biological integrity and coastal resilience, the Reserve will implement proactive, creative strategies to advance their administrative capacity (Table 9).

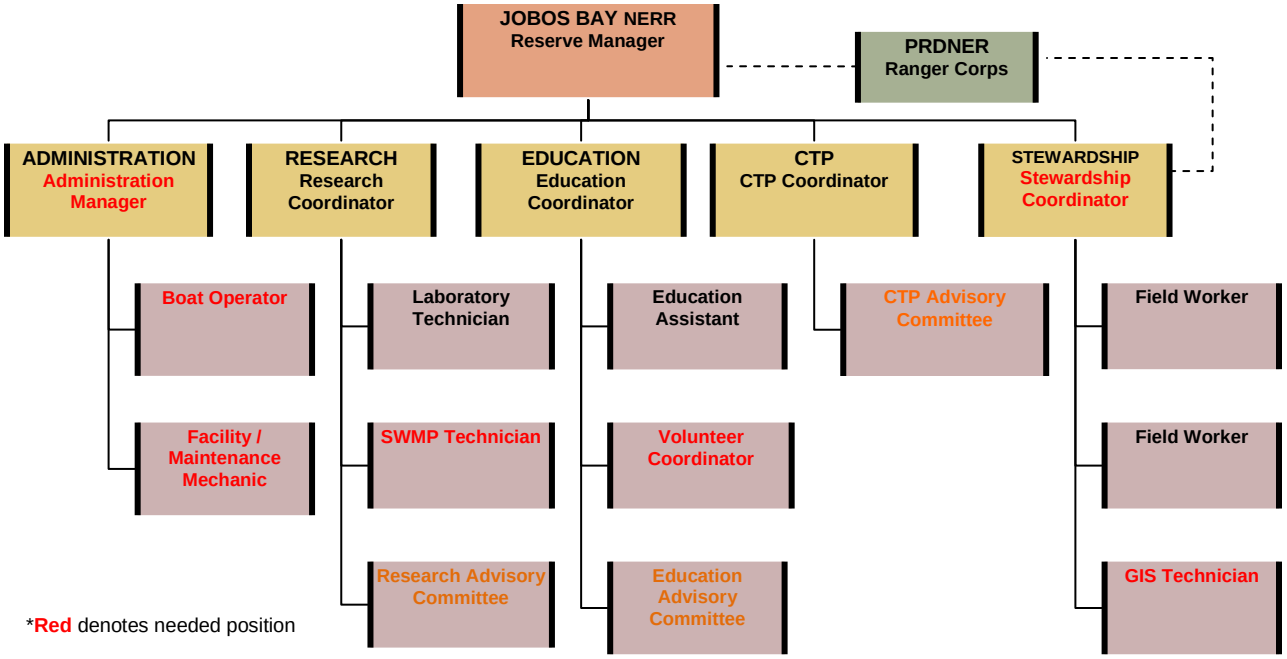


Figure 36. Program Organization Chart

| Table 9. Staff Positions and Responsibilities | |
|---|---|
| **Position** | **Responsibilities** |
| Reserve Manager<br><br>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 state, federal and private funds. Prepares required quarterly and annual reports for NOAA. Supervises Program Coordinators, and administrative and facilities staff. Represents Jobos Bay NERR at the national level. |
| Ranger Corps Officers<br><br>100% PR funding | Ten law enforcement officers are assigned to Jobos Bay NERR. Conduct routine patrols and respond to resource violations affecting Reserve resources. Ensure that signs and boundary markers are in place, and periodically inspect areas frequented by visitors, including boaters. Also responsible for assisting in surveillance and enforcement of rules. |

| | |
|---|---|
| Fieldworkers<br>90% PR funding<br><br>10% NOAA funding | Two positions responsible for maintaining facility grounds, ensuring that signs and boundary markers are in place. Periodically inspects areas frequented by visitors. Responsible for general maintenance and management of outdoor facilities. Assists with surveillance and enforcement. |
| Research Coordinator<br><br>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 to be made available to the general public. Serves as 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 NERRs System-wide Monitoring Program. Prepares required reports for NOAA. Provides outreach, working with the Education Coordinator, universities, NGO's, and other agencies. Administers the reserve's Graduate Research Fellowship Program. |
| Laboratory Technician<br><br>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<br><br>100% NOAA funding | Directs the Reserve's education program, designing and carrying out educational and interpretive 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, especially research and volunteer programs. Provides outreach to area schools, college, 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. |
| Education Assistant<br><br>100% NOAA funding | Responsible for operating an information center that responds to the information requests of visitors. Assists in the maintenance of educational materials, development of presentations and group activities within the Visitor Center. Provides field support in educational activities and volunteer programs at Reserve sites. Maintains a record of visitors, information requests, educational materials, publications and audio visual materials. Maintains and organizes library holdings, maps, and photographs. |
| CTP Coordinator<br><br>100% NOAA funding | Coordinate and implement the Reserve's CTP in conjunction with the CTP Advisory Committee. Identify and develop partnerships. Market and promote professional training programs and services to target audiences, including coastal managers and decision-makers. Provide instructional design, program development and facilitation services. Develop and distribute training materials. Evaluate programs. Maintains and submits performance measures to the Estuarine Reserves Division. |

## 7.1 Reserve Staffing Plan

The total number of Reserve employees has grown to include permanent, full-time staff for all core positions, as well as support positions for programs, administration and facilities (Figure 37). This has enabled Reserve programs to develop and mature. At the current level of annual federal funding and Commonwealth support, it is not possible for the number of Reserve staff to increase further. While new positions are needed to continue growing the programs, the reserve will pursue Commonwealth funding, partnership alliances, and community or volunteer support for them.

Following are the positions that are needed for the reserve.

*SWMP Technician*
This position assists the Research Coordinator in monitoring duties of the System-Wide Monitoring Program and facilitation of research at the Reserve. Duties of the position would 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, and preparation of data to send to CDMO in South Carolina.

*Stewardship Coordinator*
This position plans, directs and oversees the implementation of resource management projects in the Reserve. It develops strategies for the protection and restoration of resources at Jobos Bay; works with local governments, industry groups and associations to promote resource protection and respond to environmental problems requiring enforcement action and/or communication with appropriate agency personnel; researches suitable lands for acquisition in the Jobos Bay watershed and implements acquisition procedures and protocols to successfully acquire lands, and coordinates with Reserve education staff to develop and implement outreach programs and public access areas.

*Administration Manager*
This position will be established to manage grants and contracts, and coordinate all fiscal issues with PRDNER headquarters and NOAA.

*Volunteer Coordinator*
This person will foster the Reserve's volunteer program. 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 Reserve needs, tracking volunteer contributions, recruiting and training additional volunteers, and supporting various volunteer activities.

*GIS Technician*
This position would be responsible for all mapping activities in support of reserve programs. Expertise in image acquisition, classification, spatial analysis, proficiency in GPS, maintaining and disseminating databases, and conducting modeling would be skills that this position would provide to the reserve.

*Boat Operator*
This position is in flux, but provides an important function that supports reserve programs, especially because so much of the reserve is accessible only by boat. This position needs to be stabilized to support research, education and stewardship programs by providing access for reserve staff and visiting researchers and program participants.

*Facility / Maintenance Mechanic*
This position would be responsible for maintaining vehicles and boats. It would be responsible for general maintenance and management of outdoor facilities, as well as assisting with surveillance and enforcement.

## 7.2 Advisory Committees

Several committees support the Reserve and its programs. Populated by agencies, universities, specialists, private organizations, stakeholders and citizens, these committees provide, when required, valuable input and guidance on the Reserve's overall vision and programmatic direction.

**Citizen Consult Council**
This Council is structured to assure that public concerns are considered. Its members include a variety of stakeholders. Meeting twice a year, members are assigned by their respective groups and/or agencies.

The Citizen Consult Council provides input, guidance and support for programmatic direction and management of the Reserve. The Citizen Consult Council is comprised of representatives from the following: USDA-Natural Resource Conservation Service, USEPA, USGS, USFWS, Puerto Rico (Electric Power Authority, Land Authority, PRDNER), Municipality of Guayama, Municipality of Salinas, Agricultural Workers Association, Fishermen Association, Hunting and Shooting Association, Chevron-Phillips Corporation, Environmental Dialogue Committee, Puerto Rico Institute of Water, Soil Conservation Supervisors Board, UPR-Sea Grant College Program and members of the surrounding communities.

**Research Advisory Committee**
The Research Advisory Committee (RAC) guides research, monitoring, restoration science initiatives. The representatives include: USDA-International Institute of Tropical Forestry, USFWS-Coastal Program, University of Puerto Rico (School of Public Health, Computing Engineering Department, Marine Sciences Department), PRDNER-Coastal Zone Management Program and the Caribbean Regional Association. The RAC meets at least twice a year or as needed to assist with special topics.

**Education Advisory Committee**
The Education Advisory Committee (EAC) guides education and outreach efforts, with representatives from: the University of Puerto Rico-Sea Grant College Program, Metropolitan University, Turabo University, Urbana Nueva High School (Salinas), Adela Brenes Texidor High School (Guayama), Sabana Llana Middle School (Salinas), Simón Madera Middle School (Guayama), José de Choudens Middle School (Arroyo), Woodrow Wilson Elementary School (Aguirre) and Educational Services Network Corporation (EDNET). The EAC meets at least twice a year or as needed to assist with special topics.

**CTP Advisory Committee**
The CTP Advisory Committee provides guidance to the CTP coordinator who implements the program for Jobos Bay. The agencies represented on the Advisory Committee are: Comite Dialogo Ambiental, USEPA, USDA-NRCS, Puerto Rico Coastal Zone Management Program, University of Puerto Rico (UPR-Agricultural Extension Service, Center for Interdisciplinary

Studies, Sea Grant College Program) and Jobos Bay NERR. The CTP Advisory Committee meets at least twice a year or as needed to assist with special topics.

**Stewardship Restoration Science Committee**
The Stewardship Restoration Science Committee consists of representatives from the Stewardship Agreement: the Puerto Rico Department of Natural and Environmental Resources, Puerto Rico Planning Board, Puerto Rico Department of Agriculture, Puerto Rico Management of Regulations and Permits, Municipality of Salinas, Puerto Rico Environmental Quality Board, Puerto Rico Land Authority, Puerto Rico Housing Department, Municipality of Guayama, Puerto Rico Special Communities Office, and the Puerto Rico Police Department. The Committee provides guidance to support restoration priorities of the reserve.

## 7.3 Administration Priorities

Since the last management plan revision, the Reserve has achieved a full complement of program coordinator positions. In addition, Research, Education and CTP Advisory Committees were formed and Stewardship's Restoration Science Committee was revitalized.

**RESERVE KEY ISSUES**

- Climate change impacts on coastal ecosystems and communities
- Land use change impacts on coral and coral-related habitats
- The interrelationship between ecological integrity and community resilience

Over the life of this management plan, (1) more Commonwealth resources will be sought to support core positions; (2) an Administration Manager position will be established to manage grants and contracts, and coordinate all fiscal issues with PRDNER headquarters and NOAA; (3) a 'Friends' Group will be fostered with a mechanism to accept private funds, hire positions and support programs; (4) additional staff will be identified to support stewardship, research, education and CTP; and, (5) organizational partnerships will be diversified for alternative staffing options and support to limit staff vulnerability in unstable economic times. Creative techniques to maintain, train and provide incentives for staff will be explored, including staff exchanges with other PRDNER managed areas to transfer knowledge and maximize effectiveness in a fiscally sound manner.

Due to the uncertain fiscal climate of Puerto Rico, the Reserve must enhance its administrative efficiency, its ability to secure outside funding and positions, as well as its impact on education, research and management. The Reserve will be focusing on enhancing program integration across sectors, streamlining on-site reporting, project management and budget accountability, and enhancing capacity to seek outside funding.

## 7.4 Challenges

Primary challenges to achieving the Administration Program strategies outlined above are as follows:

- Due to the current economic climate, there is an uncertainty to staff stability, generating a need to diversify organizational partnerships for alternative staffing options and support.

## 7.5 Partners

Comprehensive administrative support involves coordination with several partners to assure that required protocols and processes are completed in an efficient, effective and timely manner. Development of a foundation of cross-programmatic knowledge can result in streamlined efforts that maximize productivity. Administrative partners include:

- Puerto Rico Department of Natural and Environmental Resources - As the State sponsor, PRDNER provides administrative support, as well as some operational funds for research, monitoring, outreach and watershed-based issues. (www.drna.gobierno.pr)
- A Jobos Bay NERR Friend's Group will be developed to support reserve programs.

## 7.6 Action Plan

| Table 10. Administration Program | | | |
|---|---|---|---|
| **Goal 4 – Enhance the administrative capability and infrastructure of the Jobos Bay NERR to meet the stewardship, research, education and training challenges of the future** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Jobos Bay NERR organizational structure is diversified to promote leadership among Program Coordinators, achieving more efficient outputs by all Reserve staff and programs | Realign organizational structure so that program leads are supervising their respective staff | Program leads are supervising staff | Watershed |
| | Develop annual work plans | Annual work plans are being completed | Watershed |
| | Provide leadership and fund raising training to enhance staff capabilities | Integration is occurring across all programs | Watershed |
| | Develop targeted individual development plans to support plan implementation | Reserve staff are pursuing outside funding sources to support program activities | Watershed |
| Program growth is occurring as a result of stable and expanded staff support | Work with DNER to obtain the services of an Administration Manager to support Reserve Manager in grants management duties | Program objectives are being met | Watershed |
| | Develop staff individual development plans that support program plan objectives | Financial and progress reports are being submitted in a timely manner and funds are being expended efficiently and effectively | |
| | Seek outside partnerships to solicit support for Education and CTP and Volunteer Programs | Outside services are being obtained to support program implementation | Watershed |
| | Pursue partnership with PRDNER Law Enforcement on shared Boat Operator | More funds are available in reserve operations funds to support program implementation. | |
| | DNER is supporting a portion of core reserve staff | | |
| A mechanism is developed to receive private funding to support Reserve programs | Establish a 'Friends' Group for the Reserve | Friends Group is established and supporting Reserve programs | Watershed |
| | Enhance fund raising capacity | Community support and involvement for the Reserve increases | Watershed |

## 8.0 FACILITIES

There can be no programmatic growth at the Reserve unless issues relating to facilities are addressed. The large number of decaying structures around the Reserve's current facilities, as well as the marginal operational facilities, constrains effective program implementation and program growth. The Reserve will need, in this next five years, to develop and implement a strategy that balances the unique historical character of its structures and the need for sustainable design infrastructure to meet the challenges of the future. The Reserve is dotted with numerous historic structures that are remnants of the Aguirre Sugar Plantation – some that offer great opportunities and others that have decayed beyond repair. Hard choices will have to be made and a Facilities Master Plan will be an immediate priority of the Reserve to guide facility development. This chapter outlines the needs, opportunities and recommendations for facilities to support program growth. These recommendations could change with further analysis conducted as part of the Facilities Master Plan.

In addition to the Reserve's Visitor Center, offices, dormitories and boat ramp, several historic structures are located on Reserve lands. These concrete structures, part of the historic Aguirre Sugar Mill complex, are registered with the Puerto Rico Office of Historic Conservation. 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 longterm needs of the Reserve's programs.

Given the history of the Aguirre area and the impact of the historic Aguirre Sugar Mill on the local community, the Reserve intends to incorporate salvageable structures into its Facilities Master Plan, re-purposing structures to meet program needs, while retaining the historic flavor. Creating a 'campus-like' atmosphere, the Reserve will connect the new or re-purposed facilities with walk paths for non-motorized access throughout. Re-using the historic main gate as the Reserve's new entry way, will encourage a 'sense of place' and destination for visitors arriving at the Reserve's Headquarters. These facilities will include offices for law enforcement staff, and a boat and storage facility with maintenance shops. Ultimately, the Reserve envisions hosting island-wide and Caribbean-wide workshops, using the facilities of the Conference Center that will be created by restoring and re-purposing the historic 'hotel'.

Developing this infrastructure will establish the Reserve as a Caribbean 'hub' for coastal research, education, stewardship, training and management information transfer and dissemination. New research and education facilities will be constructed that will, among other things, support a wet lab and classroom.

On Puerto Rico Land Authority parcels adjacent to Reserve lands, there are many metal structures that were also part of the Aguirre Sugar Mill complex. The majority of these structures have decayed beyond repair and are in the process of being removed by the Puerto Rico Land Authority. Not only will the removal of these metal structures enhance the aesthetics of the Reserve's Headquarters area, it will also remove potential liability from accidental injury.

## 8.1 Existing Operational Facilities

**RESERVE KEY ISSUES**

- Climate change impacts on coastal ecosystems and communities;
- Land use change impacts on coral and coral-related habitats; and,
- The interrelationship between ecological integrity and community resilience.

The current facilities include a Visitor Center with exhibits, staff offices, a small meeting room, a small lab, kitchen and basic dormitory facilities that support 12 individuals (3 rooms @4 beds/room). There is a small, but inadequate, parking lot that supports staff and visitor vehicles, as well as Reserve vehicles, boats and trailers. Parking often overflows into the street. The Visitor Center complex is a restored Club House of the Aguirre Sugar Plantation, which retains its historic architecture. However, the exhibits are outdated. Staff offices are spread throughout the building with no connectivity. The meeting room is situated in the center of the exhibit space and is too small to handle the necessary meetings and education programs. The dormitories have wireless internet access, but are not comfortable for longterm use by visiting researchers and students. Rules relating to facility use are provided in Appendix 13.

In the past, the Reserve has developed reliable and consistent internet access, critical in this age of digital information transfer. In 2009, a T1 line was installed to meet the internet, email and access needs of Reserve programs, as well as for improved communications with PRDNER, NOAA and Reserve partners. Access to the internet will eventually be enhanced in all reserve facilities.

The research laboratory located in the Visitor Center has been suitable for current uses and applications. However, as the Reserve's research and monitoring agenda expands towards the future, adequate facilities that include a wet lab, visiting researcher lab space and a controlled environment for precision analytical equipment will be developed.

There are a boat ramp and dock in close proximity to the Visitor Center that were recently completed and are used by Reserve staff.

## 8.2 Existing Opportunities

Graduate students from the Polytechnic University of Puerto Rico's Landscape Architecture Program completed green and sustainable design concepts for the re-purposing of the Aguirre Sugar Mill abandoned buildings, developing campus-like settings and using the historic hotel as a science facility for conferences, workshops and other activities Caribbean-wide. These non-traditional students used the Reserve as a setting to explore green and sustainable design concepts in their chosen field of study. Their products, exhibited in the Visitor Center, stimulated excitement and energy in staff and visitors who saw potential and value in re-purposing the historic structures.

A Facilities Master Plan will be developed by the Reserve to detail future improvements. This plan will be based on an energy audit of current and anticipated future facility use. A feasibility component within the Facilities Master Plan will evaluate the potential uses for existing structures, as well as provide a cost-benefit analysis that compares the re-purposing of existing

facilities with the construction of new facilities. New or restored facilities at Jobos Bay NERR 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 landscapes 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 extent possible.

The local community of Aguirre recently approved the construction of a local sewage treatment plant with service lines into the local community. The Reserve staff will be working with local officials to ensure the incoming infrastructure is developed to support the future facility build-out described in the Facilities Master Plan.

## 8.3 Reserve Facility Requirements

Following are the facility needs required to support current and future programming at the Reserve:

Offices – Currently, Reserve staff have limited available office space. Scattered throughout the Visitor Center and near the dormitories, staff offices will be incorporated in several locations, separate from the public:

- The Boat House, a structure requiring renovation behind the Visitor Center, will incorporate office space for maintenance staff. In addition, office space will become available once the laboratory equipment located in current boat house is transferred to new building.
- The new Research Laboratory to be located in the new Dormitory building will accommodate office space for research and technical staff.
- Housing for visiting researchers and graduate students will be added adjacent to the existing dormitory at the Visitor Center complex and will include office space and comfortable living quarters.

Wireless Infrastructure – In 2009, the Reserve received funding to design and install a wireless infrastructure to support Reserve programs. The goals of the Jobos Bay's telemetry-based wide area network are to:

- Link all facilities operated by the Reserve, including the primary education facility at the Reserve, to 21st century telecommunications technology.
- Meet the pressing need for the Reserve to provide reliable field-based real-time voice communications, image and data file transfers, including field-based internet access for education and research.
- Provide an integrated area network that will expand upon the design of the SWMP telemetry system by providing the capacity to support additional sensors and deployment locations.

The objectives of this project are to:

- Enable wireless two-way transfer of field acquired and archived data at research and educational sites throughout the Reserve.
- Expand upon point-to-point, data-only telemetry investments currently focused only on supporting the SWMP water quality stations, enabling Reserve-wide voice and data transfer for research, education, stewardship and operations.

- Enable the research, stewardship, education, training, facilities and administration programs at the Reserve to communicate via a common network.
- Provide Internet access for visiting investigators.
- Provide enhanced emergency response and logistics communications capability.

Reserve staff and partners are assessing needs to identify requirements of the infrastructure based on the applicable programmatic uses. Some initially identified needs include:

- law enforcement for resource protection
- research and monitoring stations
- threshold alerts for emergency response

The design for the wireless infrastructure should be complete in mid- to late 2011, with installation and operation by the end of the year.

Parking – Currently, parking is severely limited, with the Reserve's vehicles and vessels sharing space with staff and visitor vehicles in a small parking lot. During reserve events parking overflows into the street. Parking will be accommodated in several locations:

- once constructed, the Boat House will house Reserve vehicles and vessels, as well as maintenance staff vehicles, freeing up parking for the Visitor Center
- an additional parking lot will be constructed next to the new dormitory building to accommodate visiting investigators and graduate students
- a larger parking area will be constructed at the Reserve entrance next to the Train Station Welcome Center to accommodate group and event parking

All parking facilities will be designed with cutting edge sustainable design features to minimize runoff impacts to the bay.

Dormitories – A new dormitory will be completed to accommodate visiting researchers and graduate students. It will be constructed off the north corner of the existing dorm and oriented towards the east. Since the existing dorm is situated on a hill, the new building will take advantage of site topography to create a well ventilated facility with green building design. The profile of the completed laboratory dormitory facility will lead to a common area and courtyard. A common area will provide living and kitchen facilities for interaction and relaxation.

Boat House – The Boat House facility will involve the re-purposing of an existing structure. With a series of large bays already in place, this structure is ideal for office space for maintenance staff, housing and maintenance of Reserve vehicles and vessels, and providing storage space for visiting investigators. Located east of the Visitor Center, offices, Conference Center and dormitory, the Boat House removes fleet and facility maintenance from the main campus and provides secure facilities for equipment and operations.

Laboratory – The Laboratory Facility will accommodate the needs of the Research Program. The Research section will provide dedicated lab space for visiting investigators and Graduate Research Fellows (GRFs). Space will be set aside for sample storage, including cold storage and freezer space.

Education Center – Currently, Education office space and a small conference room are imbedded within the footprint of the Visitor Center exhibits. After the new Laboratory and Interpretative buildings are constructed and exhibits removed, the current Visitor's Center will become the Education Center. The Education Center section will include a student laboratory with work spaces and microscopes, a big conference room with computer capability for

Education and Coastal Training Program enhancement. The existing Information Section will be revamped and all education staff will be housed in this building.

Interpretative/ Exhibit Center – The new interpretative center will involve the re-purposing of an existing structure known as the hotel restaurant. This facility will have two main rooms; the first will provide interpretative exhibits for our visitors and general public. The second room will incorporate the use of emerging technologies such as, NOAA Science on Spheres, enhancing our K to 12 education programs. The Education staff will revamp existing exhibits and develop new exhibits to focus on the Reserve's priority issues, providing information based on the models created through the Research Program and restoration projects completed through the Stewardship Program. Some of the exhibits will be interactive to show habitat changes over time, inundation scenarios and predicted watershed/land use changes. Additional computer access will be created to accommodate learning stations.

Exhibits – The Reserve will modernize its outdoor exhibits to reflect the key Reserve priorities. There may be opportunities to use the wireless infrastructure to augment exhibits by transmitting real-time video or auditory sounds from the field directly into the exhibits.

Filed Station/ Conference Center – The Conference Center will be developed by re-purposing the historic Aguirre Hotel facilities. There are various universities from Puerto Rico and the United States, joining to develop a Field Station in with they may be able expand their field courses and experiences in interdisciplinary disciplines. The primary role for NOAA will be in the planning, design and installation of green infrastructure for the facility. Fundraisers, contributions from partners and competitive grants will be sought to fund the construction.

Two additional existing structures will be used as housing/ apartment support facilities for faculty use, continuing the campus appeal from the Visitor Center.

It is expected that the Friends of Jobos Bay will be an active partner in scheduling and managing the Conference Center facilities. While the primary use will be to support Reserve programs, it can also be used by PRDNER and partner agencies for workshops, to host annual meetings for community-based businesses and to host community meetings, especially given their growing involvement. It can also be a key resource for Puerto Rico and the Caribbean. The reserve will facilitate planning and development with an advisory committee of potential partners.

Train Depot – The historic Train Depot terminal is situated at the new entrance to the Reserve campus. The Train Depot's renovation will incorporate offices for law enforcement staff, a welcoming interpretive office for visitors entering the Reserve and office space for Jobos Bay Friends and Volunteer Groups.

Facilities Master Plan

The Facilities Master Plan, funded with the Reserve's FY2010 Facilities proposal, will evaluate the costs/benefits of using the existing facilities (as opposed to constructing new ones), identify priority needs, opportunities, limitations, and timing of construction. This plan will incorporate cost estimates, as well as background studies, including an energy audit, sustainable energy options, sustainable design options and a model for carbon footprint determination to guide sustainable engineering designs.

## 8.4 Reserve Fleet Requirements

### Vehicles

Currently, to support the fleet needs of all Reserve programs – management, research, education, training and maintenance – the Reserve has one (1) sport utility vehicle and one (1) extended cab pick-up truck. To meet the needs of the Reserve's expanding programs, the following vehicle additions will be necessary and pursued by looking into available infrastructure within PRDNER and use of operations funds, as well as competitive and creative funding opportunities:

- a hybrid vehicle - for longer trips, including to San Juan
- a ¾ ton truck, with dump bed – for maintenance activities
- a 15 passenger van – for education activities and group visits
- a 4X4 extended cab truck - for field activities and boat launching
- a 4X4 mule - for field access
- a large tractor, with mower deck and other attachments – for site and trail maintenance
- a larger chipper – for site and trail maintenance

### Vessels

Currently, to support water access and activities, the Reserve has one (1) 17' whaler and one (1) 22' whaler. Additional vessels needed to support the Reserve's expanding programs. The following vessels are needed to support Reserve programs and will be pursued by looking into available infrastructure within PRDNER and use of operations funds, as well as competitive and creative funding opportunities:

- 5 kayaks - for remote site access
- an Education boat - a 25' boat to support 15 people for field-based education activities .

## 8.5 Public Access Strategy

The Reserve provides upland and aquatic trails for the public.

*Land Access*.
The major access road to the Reserve is State Highway 3, which can be reached from San Juan via the Las Americas and 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.

*Water Access*.
There are six port or docking facilities within Jobos Bay: one at Puente de Jobos; two in Las Mareas; one at Pozuelo Marina; and, two in Aguirre. Mar Negro, Cayos Caribe and Cayos de Barca are accessed by boaters originating from these facilities. The Aguirre Thermoelectric Power Plant also has a pier that serves industrial facilities. Recently, Jobos Bay NERR completed construction of a boat ramp and pier for Reserve and visiting investigator access. The Reserve will pursue co-management alternatives to provide water access opportunities for the local community in support of guided tour activities.

The location and policies of current trails, planned trails and access points are driven by use demands and balanced with ecosystem protection requirements. To support the anticipated growth of Reserve programs and expansion of facilities, the Reserve is proposing upgrades to existing trails and the addition of two new trails (Figure 38). The Reserve will explore funding opportunities to maintain upgrades and additions through Commonwealth partnerships, NOAA


Figure 37. Existing and Future Trails

construction funds, the USFWS and other competitive grant sources. With 80% of the Jobos Bay coast in public ownership (Jobos Bay NERR and Aguirre Forest), public access is a priority for the elected officials of Salinas and Guayama. Thus, it is important to provide compatible public access to specified areas of the Reserve for the community and general public, while incorporating green design strategies to the extent possible. Attention will be given to passive recreation, including bird watching, nature photography, recreational fishing, snorkeling and low impact boating, such as kayaking. The Reserve will pursue public access strategies that involve trained personnel from the local community for guided tours (Chapter 6 – Coastal Training Program).

The details for the Reserve's public Access Strategy will be integrated with the Facilities Management Plan. The Overall Facilities Plan will provide the reserve with detailed strategies for implementing the public access priorities of the reserve. The comprehensive Public Access Strategy will:

- refine the plans for existing trails, as well as the planned upgrades and new trails (Figure 38);
- identify strategies to minimize illegal access by motorized vehicles, including gate/baluster installation and wireless remote camera surveillance;
- determine trail management strategies to balance public use with habitat conservation;
- outline trail interpretive sign upgrades and accommodate designs for easy, cost-effective future changes that convey the Reserve's priority issues;

- detail communication and marketing strategies to enhance trail usage; and,
- identify partnerships and funding sources for the priority list of public access opportunities.

Following is a description of the key elements of the Reserve's public access strategy:

- Sugar Mill Trail - The Sugar Mill Trail, located near the Reserve's dock, is frequently accessed by education groups. Over the next five years, the Reserve will work with the Stewardship Agreement partners and the local communities to extend this trail to the east along the footprint of the old railroad corridor, connecting to the Aguirre Forest Trail. Aguirre Forest has a network of trails and camping facilities on the southeast side of Bay. As part of the trail planning process, additional trail loops will be explored through the Puerto Rico Land Authority parcel on the north boundary of the Aguirre Forest. Ingress and egress access to the trailhead will be developed to minimize after-hours access near the Reserve's proposed future Research and Education Laboratory Facility. Upon completion, this extensive network of trails will support hiking and non-motorized biking within the Aguirre Forest and Jobos Bay NERR.

- Jagüeyes Trail – The 0.75-mile (1.2-km) Jagüeyes Trail borders farmlands on the north boundary of Mar Negro and includes an observation platform. Named for the white jagüey tree, this trail through a secondary dry forest skirts mangroves, salt flats and a seasonal lagoon. The seasonally dry lagoon provides critical nesting habitat for the highest diversity of protected migratory shorebirds in the region.

  Future plans for the Jagüeyes Trail include the development of an additional boardwalk for closer observations, as well as a raised section to accommodate seasonal water levels. This extension will be planned to minimize impact on nesting shorebirds and may be closed during nesting season. An extension of this trail to the west, towards the Las Mareas Community, will be evaluated and designed to restrict motorized vehicle access. The Las Mareas NGO has expressed interest in partnering on trail maintenance and surveillance activities, which will assist local law enforcement with ongoing illegal vehicular access. This is especially important during shorebird nesting season, as the birds make use of various debris and flotsam to build nests on the salt flats, sometimes within the currently undefined trail path along the mangrove fringe. Reserve staff will begin defining the trail footprint using driftwood edging to discourage off-trail exploration during nesting season and install signage alerting trail users to the seasonal presence of these shorebirds.

- Wildlife Enhancement Ponds Trail – While there is a short existing trail in this area, the trail system needs to be enhanced to accommodate future restoration activities. A parking area, trail signage, observation tower and access strategies (gates/balusters) will be included in the planning for this public access site. The Wildlife Enhancement Pond Trail will link visitors to the Jagüeyes Trail and highlight other stewardship activities developed in the area.

- Reserve Headquarters Trail – The planned new entry to the Reserve through the northern boundary and the historic train station, provides an opportunity for visitors to access the Reserve campus. The main road (PR-705) along the front of the Visitor Center is heavily used by the community. As a primary road, motorized vehicular traffic competes with pedestrian and bike traffic. The Reserve Headquarters Trail will provide

an opportunity for pedestrian and bike traffic to weave through the Reserve's campus on their walk, enjoying the interpretative trail system, eco-tourism efforts, community-based activities and newly established native landscapes following facility construction. To avoid conflicts, this Trail will not be accessible during facility construction activities.

- Cayo Caribe Trail - Located on la Cabeza de Cayos Caribe, the 0.68-mile (1.1-km) Cayo Caribe Trail is only accessible by water. Traversing mangrove forests, seagrass beds and coral reefs, the Trail also highlights the barrier island's coastal strand community. There is an observation tower that provides a vista of the local communities, as well as the bays and reefs surrounding the islands. Snorkeling around the islands is permitted. This area is accessed by ecotour operators, including Eco-Mar, which assists with trail maintenance and site stewardship activities. No extensions of this existing trail are planned.

- Cayos de Barca Trail – A small footpath trail (0.5 miles; 0.87 km) is planned for the west end of the Cayos de Barca island chain at *Dos Palmas* to showcase the island's coastal resource communities.

- Kayak Trail – The Reserve's Kayak Trail now originates at the Reserve's boat ramp on Jobos Bay. Given the open, unprotected nature of Jobos Bay and the frequent choppy sea state, the Reserve plans to re-route the Kayak Trail. The new trailhead will begin in Las Mareas, with the development of several routes based on the paddler's level of expertise. The protected waters of Mar Negro provide opportunities for calm exploration, while more adventurous paddlers will be able to traverse the open waters of Jobos Bay to access the Cayo Caribe Trail. The Las Mareas NGO has expressed an interest in serving as a concessionaire for the Kayak Trail, providing kayak rentals, information and guided tours.

## 8.6 Current Facilities Staffing

The Jobos Bay Facilities Program is currently managed by the manager who has one Facility / Maintenance Mechanic and two Fieldworkers to maintain the existing facilities. The maintenance staff conduct preventative maintenance and repairs on the Reserve's vehicles, vessels and buildings. The Fieldworkers maintain the landscape around the Reserve's facilities.

## 8.7 Challenges

Primary challenges to achieving the Facilities Program strategies outlined above are as follows:

- Funding for facilities needs to be actively pursued through federal, state and competitive sources, as well as program partnerships (NOAA construction funding, National Science Foundation, universities that are interested in investing in a field lab relationship with Jobos Bay NERR, PRDNER and others).
- Some green design strategies may be cost prohibitive.

## 8.8 Partners

Comprehensive facilities planning involve coordination with several partners to assure the programmatic needs of staff and partners are accommodated and contributions from partners are solicited. Inclusive planning can result in partnerships for funding opportunities, as well as sustained use of the facilities for the longterm. Current and potential partners for facilities development include:

- NOAA, Estuarine Reserves Division (ERD) - As a component of the national system, the Jobos Bay NERR participates in system-wide programs that further NOAA's goals and objectives, while the Reserve receives operational and construction funds annually to support facilities and ongoing research, education and stewardship efforts. This partnership has been, and will continue to be, strong.
- Puerto Rico Department of Natural and Environmental Resources - As the State sponsor, PRDNER provides administrative support, as well as some operational funds for research, monitoring, outreach, and watershed-based issues. They also coordinate management strategies with the Puerto Rico Land Authority.
- Universities – University of Puerto Rico and others have talked positively about investing in programming and facilities at Jobos Bay NERR. These entities have access to construction funds and can partner with the Reserve on facility-specific needs.
- Other federal and Commonwealth natural resource agencies, such as NOAA's MPA Center, USFWS, USGS.

## 8.9 Action Plan

| Table 11. Facilities Program | | | |
|---|---|---|---|
| **Goal 1 - Strengthen the protection and management of the Jobos Bay NERR to advance estuarine conservation, research and education** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Public access to Reserve facilities during non-working hours will be managed | Provide office space for law enforcement staff working for the Reserve | Illegal entry is minimized | Watershed |
| | | | |
| **Goal 2 - Increase the use of Reserve science and sites to address priority coastal management issues** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| The Reserve will incorporate sustainable design concepts | Incorporate regionally-appropriate green design principles for each facility to the extent possible | The Reserve demonstrates a suite of green design alternatives for the region | Puerto Rico Caribbean |
| The Reserve facilities will support research, trainings, workshops, conferences and seminars that attract people from throughout Puerto Rico and the broader Caribbean | Develop dormitories, a Conference Center and classrooms, meeting rooms, labs, training center. | Use of Reserve facilities for regional trainings, workshops, conferences and seminars increase. | Watershed Puerto Rico Caribbean |
| Telecommunications infrastructure will be designed to facilitate access to information by multiple audiences | Develop a wireless infrastructure | Information access and exchange is enhanced | Watershed Puerto Rico Caribbean |
| | | | |
| **Goal 3 – Enhance people's ability and willingness to make informed decisions and take responsible actions that affect coral and coral-related systems** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Reserve buildings are used as a demonstration of regional sustainable design concepts | Provide tours and trainings on the application of sustainable design building in the Caribbean | The Reserve offers on-site trainings, focusing on sustainable design | Watershed Puerto Rico Caribbean |
| | | | |
| **Goal 4 - Enhance the administrative capability and infrastructure of the Jobos Bay NERR to meet the stewardship, research, education and training challenges of the future** | | | |
| **Objectives** | **Strategies** | **Measurable** | **Sphere** |
| Facilities are enhanced and developed that support the Reserve's long-term goals and its projected build-out needs | Develop and implement the Facilities Master Plan | Comprehensive Facilities Master Plan is developed<br><br>Reserve Facilities are constructed to support long-term program needs | Watershed<br><br>Watershed |
| Facilities are provided that support local and regional needs | Develop facilities and provide opportunities for visitors and the general public | Reserve facilities provide a indoor and outdoor educational experiences | Watershed Puerto Rico Caribbean |

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