Ensure Functioning Ecosystems

Ecosystem Functions, Services, and Baseline Conditions

Baseline

The San Juan Bay Estuary (SJBE) is home to a variety of species including more than 160 birds, 300 plants, 87 fish, and 20 amphibians and reptiles. At least 16 of these species are considered endangered, threatened, endemic to Puerto Rico, and/or rare (U.S. Environmental Protection Agency [USEPA], 2025). Estuary ecosystems are ecotones or transitional zones with a complex mix of salt and freshwater that enriches its biodiversity. The unique mix of these two environments provides for a wide range of conditions for organisms to seek opportunities to outcompete others as tides ebb and flow, rains come and go, and storms create rapid changes to this complex environment. Normally, this dynamic environment creates a sustainable diversity of species; however, when extreme events and pollutants alter the ecosystem, infectious bacteria, harmful algal blooms, and introduced species may become opportunistic in dominating the environment. The human development in the uplands and improper disposal of wastes have drastically changed ecosystem function, ecological services, and conditions in the SJBE.

Infrastructure needs are outlined in the Maintain and Improve Aging and Failing Gray and Green Infrastructure that Negatively Affects Water and Bottom Sediment Quality Action Plan, which also identifies actions that will be required to restore the conditions in the SJBE. While sewer systems, stormwater systems, and port and harbor infrastructure are visible and more easily recognized by most people, ecosystem function and biodiversity are less tangible. Furthermore, the complexity and effect of ecological services are difficult to quantify. Ecological services are the benefits that humans derive from ecosystems as well as the benefits that organisms within the ecosystem can provide to improve environmental quality. These include direct benefits, such as food and commodities, but also greenspace and improvements to water and air quality. In SJBE, these ecological services include fisheries, leisure activities, carbon sequestration, and sediments and benthic organisms' ability to retain nutrients to improve water quality. As the SJBE biodiversity declines, so do the ecological services.

The San Juan Bay Estuary Program Ecological Assessment – Biological Community and Habitat Characterization Report (Puerto Rico Department of Natural and Environmental Resources [DNER], 1997) provided a complete assessment of the biological community in 1995, with habitats divided into ten types. A historical perspective of the estuary was evaluated to establish a "benchmark time period" as a reference to the ecological baseline. While changes to the ecology of the estuary date back to the 1700s, significant changes to the system were not made until the mid-1800s and early 1900s.

An inventory of urban forests in the SJBE was completed in 2001 and 2011 and reported in the San Juan Bay Urban Forest Inventory (U.S. Department of Agriculture [USDA], 2014). This is a comprehensive inventory of the plant species found in the SJBE watershed, population and coverage of those species, and change in time from 2001 to 2011. This inventory also documented the land use over the same time period. This study identified an increase in commercial/industrial/transportation and wetland/water/ agriculture land uses over the ten-year period, and a decrease in institution/park, mangrove forest, moist forest, and vacant land uses, suggesting developed lands had taken over natural and green land use in the period from 2001 to 2011. Given this change in land use, one would anticipate a similar change in the coverage and population of the natural vegetation; however, this did not seem to be the case. There was a significant increase in tree and shrub cover in each land use category and nearly double the stored carbon, suggesting a general shift towards greener land use, and/or more mature plant species over the ten-year period. The study identified

that the number and species richness of the species also increased in every land use category except institution/parks. This increase in plant coverage provides a significant benefit for ecological services, due to sequestration of carbon, green space, recreational opportunities, and ecological refuge (USDA, 2014).

Seagrass and benthic studies have been conducted for specific areas and projects over the past 20 years. These studies include Condado Lagoon (Tetra Tech, 2011), but no comprehensive inventory has been compiled or compared through time. These data may inform management and trends for other species, such as the Antillean manatee. The Antillean manatee was formerly a subspecies of the West Indian manatee and is now a separate species (USFWS, 2024). In January 2025, the U.S. Fish and Wildlife Service (USFWS) proposed to remove the West Indian manatee from the threatened species list and add the Florida manatee (the other West Indian manatee subspecies) to the list as threatened and the Antillean manatee as endangered. The water quality and habitat destruction as well as increased severe storm activity and marine traffic have increased pressure on this species population (USFWS, 2024).

Noise pollution is another potential concern for manatees and other species in the SJBE (U.S. Geological Service [USGS], 2011). Harm to dolphins and whales from sonar and loud noises are well documented, but the effects on other organisms in the SJBE are not well understood. A recent study in Jobos Bay National Estuarine Research Reserve found that mangroves may be an effective natural barrier to anthropogenic noise (Castro-Rivera, 2024). As urban noise pollution is an increasing problem, mangroves may provide a valuable nature-based mitigation solution.

Urban light pollution is another growing issue that affects nesting sea turtles and limits the natural visibility of the night sky. Both direct light in the nesting areas and sky glow and glare can affect sea turtles. Reducing new light sources, ensuring lights are off when not needed, reducing the amount of lit area, and retrofitting existing light sources with full cutoff and mounted as low to the ground as possible may reduce the issues for sea turtles. These measures will also reduce energy needs and improve visibility of the natural night sky. When light sources are in direct line to sea turtle nesting areas, “turtle friendly” lighting should be used.

SJBE benthic systems are affected by water and sediment quality from anthropogenic activities in the high-density San Juan metropolitan area. Sediment quality is driven by dynamic circulation from dredging and filling, erosion and sedimentation from uplands, and bottom sediment resuspension (Estuario, 2000).

Historically, the bathymetry in portions of lagoons have been altered to allow for improved navigation. These alterations have had a significant effect on the ecological systems to the interconnected lagoons and channels that comprise much of the waterbody system. This has led to changes in water turnover from tidal influx due to increased depth from dredging. Additionally, hydrological alterations in the watershed such as proliferation of impervious surfaces, stream channelization, and alterations to watershed topography has increased stormwater discharge into the SJBE receiving waterbodies. This increase in urban runoff carries with it higher concentrations of pollutants of concern that directly affect benthic systems (Lugo and Bauzá-Ortega, 2024). The figure below depicts water flows for dry weather conditions in the SJBE.

Not all benthic systems are affected equally by environmental changes. Ramirez et al. (2012) theorized that the high proportion of diadromous fish, which have the ability to migrate between the ocean and freshwater, are able to continuously colonize urban streams and maintain populations if their associated marine environment is not severely degraded (Ramirez, 2012).

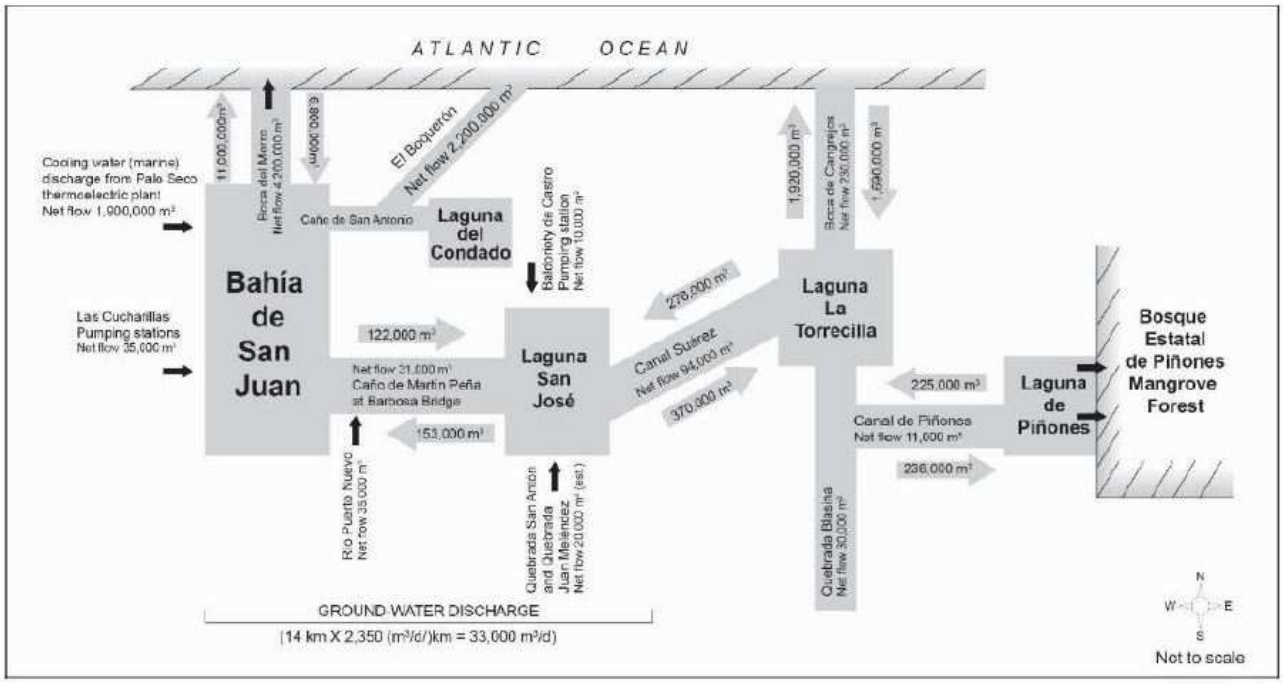

Figure 25. Average daily water flows for dry weather conditions in the San Juan Bay Estuary (Webb and Gómez Gómez 1998). This is a more comprehensive version of Figure 17. Reversing tidal flows dominate unidirectional flow. Flow from *río Grande de Loíza* into the mangroves is not shown.

From: Lugo and Bauzá-Ortega, 2024

Anthropogenic activities, such as wastewater treatment system discharges, are estimated to have a combined yield that is four times higher than other urban and rural-agricultural watersheds in Puerto Rico (Ortiz-Zayas et al, 2006). Benthic communities on the lagoon bottom were negatively affected by this increase in nutrient-rich urban runoff and wastewater treatment systems discharge, which overwhelmed the biotic capacity to process the nutrients leading to algal blooms that further distress benthic communities (Ortiz-Zayas et al, 2006).

Objectives

- Thoroughly understand novel ecosystems and their ecosystem services.
- Eliminate light pollution in the estuarine system, particularly along coastlines.
- Determine how noise pollution may affect estuarine organisms.

Actions

**NEW* FE-01 Complete a biodiversity (flora and fauna) inventory of ecological systems.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Continue to update and improve the Estuario species inventory.	Update the tables and report *List of the Flora and Fauna of the San Juan Bay Estuary System* (December 1996).	Updated species inventory.	Lead: Estuario Implementing partners: U.S. Army Corps of Engineers (USACE), National Marine Fisheries Service (NMFS), USFWS, DNER, municipalities, Conservation Trust of Puerto Rico, private conservation groups	Ongoing	0-2 years	TBD	DNER, USEPA
2. Integrate biodiversity considerations into planning and land use decisions.	Provide metrics for biodiversity in planning documents and evaluate effects on biodiversity in land use decisions.	Created metrics and evaluated effects on biodiversity.	Lead: Estuario Implementing partners: DNER, municipalities, Conservation Trust of Puerto Rico, private conservation groups, Planning Board	Pending	0-2 years	TBD	DNER, municipalities

Regulatory and Policy Requirements

Integration of biodiversity into planning and land use decisions will require advocacy to ensure biodiversity is a consideration for all planning documents and land use decisions in and around the SJBE.

FE-02 Recover the Antillean manatee population within the SJBE and establish manatee protection areas.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Perform surveys and use a network of public informers to document sightings and establish the total number of manatees within the SJBE system.	Complete data collection on the number of manatees that use the SJBE system.	Completed survey with locations and counts of manatee sightings.	Lead: DNER Implementing partner: USFWS	Pending	0-2 years	TBD	DNER
2. Establish manatee protection areas.	Manatee refuges and/or manatee sanctuaries are established and regulated to enforce boat use and speeds.	Created and enforced manatee protection areas.	Lead: USFWS Implementing partners: DNER, U.S. Coast Guard	Pending	0-2 years	TBD	USFWS
3. Continue Species Status Assessment Report for the Antillean Manatee.	Status Assessment Report for the Antillean Manatee completed every 5 years.	Completed the Species Status Assessment Report for the Antillean Manatee.	Lead: USFWS Implementing partners: DNER, U.S. Coast Guard	Ongoing	5+ years	TBD	USFWS

Regulatory and Policy Requirements

There are state regulated speed zones but increased enforcement is required. There are currently no manatee protection areas in Puerto Rico; however, USFWS has the authority to establish these areas for manatee refuge or sanctuaries. A manatee refuge is as an area where some waterborne activities and other restrictions are put in place to prevent the taking of a manatee. A manatee sanctuary is an area in which all waterborne activities are prohibited. Like the state regulated speed zones, once established these areas will require enforcement (USFWS, 2024).

**NEW* FE-03 Reduce anthropogenic noise and light sources in the SJBE watershed to protect estuarine organisms.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Study how noise and light affect estuarine organisms in the SJBE system.	Obtain a more complete understanding of how noise and light affect estuarine organisms.	Improved understanding of effects of noise and light on estuarine organisms in the SJBE.	Lead: Estuario Implementing Partners: USACE, NMFS, USFWS, DNER	Pending	3-5 years	TBD	National Oceanic and Atmospheric Administration (NOAA)
2. Prepare an exterior light management plan for the SJBE.	Prepare an exterior light management plan for the SJBE and have municipalities enforce the actions through local ordinance.	Prepared a light management plan for the SJBE and municipal ordinances in place.	Lead: Estuario Implementing Partners: Municipalities, NMFS, NOAA, USFWS, DNER	Pending	3-5 years	TBD	NOAA, DNER

Regulatory and Policy Requirements

Noise ordinances in the municipal areas need to be enforced to reduce anthropogenic noise around the SJBE. Percussive and other loud noises should also be considered in permit approval for construction in and around the SJBE. Municipalities should adopt turtle friendly lighting practices, and consider ordinances to eliminate direct lighting to the coastal sea turtle nesting areas, and reduce the sky glow.

**NEW* FE-04 Support research to better understand benthic community dynamics within the SJBE watershed. Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Establish partnerships with local universities and research institutions and organize workshops and training sessions to study benthic communities.	Set up meetings and forums for partners to meet and collaborate.	Established partnerships established and developed standardized methodologies.	Leads: Estuario, NOAA Implementing partners: University of Puerto Rico, Ponce Health Sciences University. Caribbean Coral Reef Institute, NMFS, Caribbean Fisheries Management Council, USFWS	Pending	0-2 years	TBD	NOAA
2. Identify stakeholders and funding sources for priority research.	Continue expansion of forums and meetings with partners to identify sources of funding.	Identified sources of funding.	Lead: Estuario Implementing Partners: University of Puerto Rico, Ponce Health Sciences University. Caribbean Coral Reef Institute, NMFS, Caribbean Fisheries Management Council, USFWS, NOAA	Pending	3-5 years	TBD	NOAA, USACE
3. Use research findings to inform management practices and policy decisions.	Continue expansion of forums and meetings with partners to present research findings and train partners.	Presented management practices and policy decisions to partners.	Lead: Estuario Implementing Partners: DNER, USACE, NOAA, NMFS, USFWS	Pending	5+ years	TBD	NOAA, USACE

Regulatory and Policy Requirements

Funding is required to continue research and drive data to fully understand the benthic community and the ecological services they provide for supporting ecology and water quality.

**NEW* FE-05 Gather data on critical habitats and species for protection in the proposed expanded study area.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Develop and implement a study on critical habitats and species in the proposed expanded study area including locations and conditions.	Gather information about habitats and species in the proposed expanded study area.	Completed study with data to develop plans.	Lead: Estuario Implementing partners: DNER, municipalities, academia, scientific community	Pending	0-2 years	TBD	USEPA, USFWS, U.S. Forest Service (USFS)

2. Develop maps showing the results of the habitat and species study in the proposed expanded study area.	Improve information on location and condition of critical habitats and species.	Developed maps showing habitats and species.	Lead: Estuario Implementing partners: DNER municipalities, academia, scientific community	Pending	3-5 years	TBD	USEPA, USFWS, USFS
3. Use the study results to identify projects and management strategies for critical habitats and species in the proposed expanded study area.	Improve condition of critical habitat and species in the proposed expanded study area.	Prepared project and management strategies list to improve habitat and species.	Lead: Estuario Implementing partners: DNER municipalities, academia, scientific community	Pending	5+ years	TBD	DNER, USEPA, municipalities

Regulatory and Policy Requirements

None for the study. The results will help inform regulatory and policy needs in the future.

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Resilience-Based Ecosystem Management

Baseline

The SJBE is a highly dynamic and complex ecosystem that integrates diverse coastal and urban habitats, such as mangroves, seagrasses, coral reefs, riparian corridors, beaches, beach thickets, sand dunes, and upland moist forests. Each of these habitats plays a distinct yet interconnected role in maintaining the ecological resilience of the estuary. However, the SJBE is increasingly challenged by the cumulative effects of urbanization, industrial development, pollution, habitat loss, and altered hydrology, all threats that undermine ecosystem functions, degrade water quality, and jeopardize the social and economic well-being of dependent communities (Lugo and Bauzá-Ortega, 2024).

These challenges underscore the urgent need for a resilience-based ecosystem management approach that comprehensively addresses the interdependencies among habitats, improves ecological quality, and ensures that ecosystems are managed according to their conservation designations. The complexity of SJBE's ecosystems demands a management framework that transcends isolated actions or single-issue responses and instead fosters cross-sector collaboration, science-based restoration, and adaptive strategies that can respond to ongoing environmental change.

SJBE's habitats function as interconnected ecological networks. Mangrove forests, for example, not only stabilize shorelines and sequester carbon but also provide essential nursery grounds for fish and shellfish species, including the blue land crab (*Cardisoma guanhumi*), which has experienced population declines due to overfishing and habitat degradation (Govender, 2019; Bauzá-Ortega, 2015). Seagrass beds function as underwater corridors linking mangroves with coral reefs and support over 150 aquatic species, including endangered fauna such as the Antillean manatee and green sea turtle (Bauzá Ortega, 2015; LG2 Environmental Solutions and CSA Ocean Sciences, 2021). Coral reefs and artificial habitats enhance biodiversity and fish abundance, providing critical ecosystem services and recreational opportunities (Wenger et al., 2017; Harris, 2009).

Riparian corridors connect terrestrial and aquatic ecosystems, offering habitat diversity and supporting water quality, yet these corridors are vulnerable to canalization and urban encroachment, which fragment habitats and reduce ecological functions (Lugo et al., 2011; de Jesús Crespo and Ramírez, 2011). Coastal features such as beaches, beach thickets, and sand dunes provide buffers for storms and habitat for unique flora and fauna, but they face accelerated erosion and "coastal squeezing" due to sea level rise and human disturbance (Lugo and Bauzá-Ortega, 2024; Bruun, 1962; Fish et al., 2005).

The interdependence of these habitats means that degradation or loss in one area cascades through the system, reducing overall resilience. For example, mangrove deforestation or altered tidal flows can diminish fish nursery habitats, reduce sediment trapping, and impair water quality downstream. Likewise, loss of seagrass beds can increase sediment resuspension and turbidity, further stressing coral reefs and benthic communities. Recognizing and managing these links is fundamental to sustaining the estuary's ecological functions and the services they provide.

The SJBE system is subject to multiple, interacting stressors. Urbanization and industrial development introduce pollutants, nutrients, heavy metals, and trash that impair water quality and aquatic life (USEPA, 2009). Infrastructure development alters hydrology, disrupting tidal flows and sediment transport, which leads to sediment accumulation and habitat degradation.

These overlapping threats reduce the estuary's capacity to absorb disturbances and recover, which are fundamentally core aspects of resilience. Without strategic, integrated management, the cumulative effects erode biodiversity, compromise ecosystem services, and threaten the livelihoods of local fishing, tourism, and coastal communities.

Integrated ecosystem management embraces the complexity of the SJBE system by coordinating across habitat types, sectors, and stakeholders to enhance connectivity, ecological functions, and adaptive capacity. This approach includes science-based habitat restoration, such as the deployment of artificial reefs that provide shoreline protection while enhancing habitats and supporting aquaculture and recreation (Harris, 2009). It prioritizes the conservation and restoration of mangroves, seagrasses, and riparian corridors to maintain critical ecosystem services and biodiversity (Bauzá-Ortega, 2015; Lugo and Bauzá-Ortega, 2024).

Moreover, integrated management recognizes the importance of managing ecosystems according to their designated ecological roles and regulatory frameworks, including species-specific protections like those for the blue land crab (*Cardisoma guanhumi*) (Govender, 2019). Adaptive management strategies are vital to respond effectively to ongoing and future environmental changes, such as sea level rise-induced habitat migration and storm-driven sediment dynamics (Bruun, 1962; Estuario, 2016).

Integrated ecosystem management also recognizes critical species in the SJBE. There are 17 plant species considered critical, including Arana (*Schoepfia arenaria*) and Cobana Negra (*Stahlia monosperma*), which are listed as endangered and threatened, respectively by the USFWS and DNER. The Torrecilla – Vacía Talega – Piñones area serves as habitat for 11 critical plant species, of which four are endemic and eight are not found anywhere else in the system. Four other critical species are restricted exclusively to Las Cucharillas Marsh: two vines (Whitejacket [*Aniseia martinicensis*] and hog slip [*Ipomoea tiliacea*]) and two herbaceous species (John Charles [*Hyptis verticillata*] and Egger's nutrush [*Scleria eggersiana*]). Most of the remaining critical plant species are restricted to the less affected areas of the estuary. These include a water fern (dwarf waterclover [*Marsilea polycarpa*]); an endemic shrub (Arana [*Schoepfia arenaria*]); endemic trees (uvero de monte [*Coccoloba sintenisii*], zapote de costa [*Manilkara pleeana*], and Maga wood [*Thespesia grandiflora]*); sea-purslane (*Sesuvium maritimum*); waterlily (*Nymphaea pulchella*); gray nickers (*Caesalpinia bonduc*); certain herbaceous species (twining screwstem [*Paronia paniculata*] and black sesame [*Hyptis spicigera*]); and intermediate arrowhead (*Sagittaria intermedia*) (Estuario, 2000).

A key objective of integrated management is to enhance ecosystem quality indicators that reflect ecological resilience. This includes improving water quality through pollution reduction, restoring habitat complexity to support diverse species assemblages, and increasing carbon sequestration via forest and wetland restoration (Brandeis et al., 2014). Monitoring these indicators provides feedback for adaptive decision-making and helps prioritize restoration efforts that yield the greatest ecological and social benefits.

SJBE's ecological richness and socio-economic importance hinge on the functions and resilience of its interconnected ecosystems. Given the multitude of anthropogenic and climatic pressures, resilience-based ecosystem management is not only necessary but imperative. By understanding ecosystem interconnections, improving critical ecological indicators, and effectively managing protected areas, stakeholders can enhance the estuary's capacity to withstand and adapt to change, safeguarding its natural resources and the well-being of its communities for generations to come.

Objectives

- Determine the current condition and monitor ecosystem quality as the basis for resilience-based management.
- Determine the current condition and monitor the population status of threatened and endangered species.
- Determine the current condition and monitor the ecosystem function of natural protected areas.
- Thoroughly understand ecosystem interconnections.
- Improve ecosystem quality indicators using tropical system metrics.
- Properly manage natural protected areas according to their designation.

ACTIONS

FE-06 RESTORE, ENHANCE AND CREATE MANGROVE FORESTS IN THE SJBE SYSTEM. ADAPTATION

ACTIVITIES

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Conduct a baseline assessment of existing mangrove populations to identify areas of degradation and prioritize conservation efforts.	Comprehensive mapping of mangrove populations.	Finalized baseline assessment.	Lead: DNER Implementing partners: Estuario, academia, local organizations	Pending	0-2 years	TBD	USEPA, DNER, municipalities
2. Develop guidelines for sustainable management practices and restoration techniques for mangrove ecosystems.	Identify best practices for sustainable management and restoration.	Summarized successful, sustainable mangrove management practices and restoration.	Lead: DNER Implementing partners: Estuario, USFWS, USEPA	Pending	3-5 years	TBD	USEPA, DNER, municipalities
3. Establish a monitoring program to track the growth of mangrove populations, including the effects of non-native species.	Identify performance indicators to easily identify mangrove growth.	Finalized monitoring program.	Lead: DNER Implementing partners: Estuario, USFWS, USEPA	Pending	3-5 years	TBD	USEPA, DNER, municipalities
4. Develop partnerships with stakeholders and environmental organizations to secure funding and resources for ongoing conservation efforts.	Increase level of partnerships with stakeholders.	Collaborated with partners to secure funding for conservation efforts.	Lead: Estuario Implementing partners: DNER, USFWS, municipalities, local organizations, academia	Pending	5+ years	TBD	USEPA, DNER, municipalities

5. Plant mangroves in identified priority locations.	Improve survival and growth rates of newly planted mangroves.	Increased number of mangroves.	Leads: DNER, USFWS, Natural Resources Conservation Service (NRCS) Implementing partners: local municipalities, local organizations, Estuario	Pending	3-5 years	TBD	DNER, USFWS, NRCS

Regulatory and Policy Requirements

Restoration of mangroves along the northern Caño Martín Peña has been a success story in the SJBE. Success will require continued legislative support to fund mangrove restorations and support from municipal and state officials to ensure existing mangroves remain and new development incorporates new mangrove buffers.

FE-07 Enhance seagrass beds in the SJBE system. ADAPTATION

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Conduct baseline assessment of existing seagrass beds in the SJBE.	Enhance understanding of current distribution of seagrass.	Finalized baseline assessment.	Lead: DNER Implementing partners: Estuario, USEPA, academia	Pending	0-2 years	TBD	USEPA, DNER, municipalities
2. Create a restoration plan with strategies for enhancing seagrass beds.	Identify priority areas.	Finalized restoration plan.	Lead: DNER Implementing partners: Estuario, USEPA, municipalities, academia	Pending	3-5 years	TBD	USEPA, DNER, municipalities
3. Partner with stakeholders to conduct research on water quality and seagrass growth, using the findings to inform best management practices.	Establish formal partnerships with local universities and key stakeholders.	Completed a research proposal that outlines the objectives, methods, and expected outcomes of the study, and secured necessary approvals.	Lead: DNER Implementing partners: Estuario, municipalities, community groups, academia	Pending	3-5 years	TBD	DNER, USEPA

Regulatory and Policy Requirements

The protection of seagrass habitat requires the support of local and state government to plan for long-term funding for a programmatic approach to seagrass monitoring and protection.

FE-08 Implement Law No. 112 of 2013, which created the Condado Lagoon Estuarine Nature Reserve.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Implement public awareness and educational programs in the Condado Lagoon area to inform local communities.	Improve community understanding of key issues.	Conducted follow-up evaluations to assess the effectiveness of the programs implemented.	Leads: DNER, Estuario Implementing partners: community representatives, Municipality of San Juan, businesses	Pending	0-2 years	TBD	DNER, municipalities
2. Establish a monitoring and evaluation framework to assess the effectiveness of management actions in the Condado Lagoon Estuarine Nature Reserve Management Plan and compliance with Law No. 112.	Establish specific, measurable indicators to assess effectiveness.	Reviewed monitoring results and evaluated the effectiveness of management actions.	Leads: DNER, Estuario Implementing partners: community groups, community representatives, Municipality of San Juan, businesses	Pending	0-2 years	TBD	DNER, municipalities, USEPA

Regulatory and Policy Requirements

Continue to implement the law.

**NEW* FE-09 Enhance coral communities in the SJBE system. Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Assess existing coral communities in the SJBE.	Enhance understanding of current coral distribution.	Finalized baseline assessment.	Leads: USEPA, DNER Implementing partners: Estuario, academia	Pending	0-2 years	TBD	USEPA, DNER, municipalities, NOAA

2. Develop a restoration plan for the SJBE, in coordination with stakeholders, by evaluating options such as coral transplant salvaging and relocating existing coral fragments to degraded areas.	Identify priority areas.	Finalized restoration plan.	Leads: USEPA, DNER Implementing partners: Estuario, municipalities, academia, local organizations	Pending	3-5 years	TBD	USEPA, DNER, municipalities, NOAA
3. Establish a long-term monitoring program for coral communities in the SJBE.	Develop standardized monitoring protocols for coral assessment.	Provided regular submission of monitoring reports to stakeholders.	Leads: USEPA, DNER Implementing partners: Estuario, municipalities	Pending	3-5 years	TBD	USEPA, DNER, municipalities

Regulatory and Policy Requirements

Success will require support from municipal and state officials to ensure existing corals remain and new development incorporates features that can enhance and support new coral growth.

**NEW* FE-10 Continue to design and implement measures that restore degraded benthic habitats and promote the creation of benthic habitats and fish and shellfish nurseries. Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Assess benthic habitats to identify areas in need of restoration.	Increase understanding of the current condition and diversity of benthic habitats.	Integration of benthic habitat restoration strategies into broader ecosystem management plans.	Lead: DNER Implementing partners: Estuario, academia	Pending	0-2 years	TBD	DNER, USEPA
2. Conduct a feasibility study to identify locations for potential artificial structures in coordination with local stakeholders.	Identify suitable locations for artificial structures.	Finalized feasibility study.	Leads: DNER, USEPA Implementing partners: Estuario, academia, municipalities, local organizations	Pending	3-5 years	TBD	DNER, USEPA
3. Implement pilot projects to test installations of artificial structures (i.e., Taíno Reefs® and Biohuts).	Document ecological benefits observed from the pilot projects.	Completed installation of pilot artificial structures.	Leads: DNER, USEPA Implementing partners: Estuario, academia, municipalities, local organizations	Pending	5+ years	TBD	DNER, USEPA, municipalities, local organizations

Regulatory and Policy Requirements

Success will require support from municipal and state officials to ensure existing coral remain, and new development incorporates features that can enhance and support new coral growth, sustain sediment quality, and provide habitat for marine life.

**NEW* FE-11 Enhance and protect ecosystems in oceans (seascapes) and their connectivity. ADAPTATION*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Assess existing conditions and identify areas that need intervention.	Identify specific areas exhibiting signs of degradation or decline in conditions.	Finalized priority areas for intervention based on assessment data.	Leads: DNER, NRCS, USEPA, Estuario Implementing partners: municipalities, academia	Pending	0-2 years	TBD	USEPA, DNER, NRCS
2. Develop an enhancement plan for seascapes.	Develop strategies and actions for enhancement.	Finalized enhancement plan.	Leads: DNER, NRCS, USEPA, Estuario Implementing partners: municipalities, academia	Pending	3-5 years	TBD	USEPA, DNER, NRCS
3. Implement the proposed enhancement plan and establish monitoring and maintenance protocols.	Document improvements from implemented actions.	Executed enhancement actions.	Leads: DNER, NRCS, USEPA, Estuario Implementing partners: municipalities, academia	Pending	5+ years	TBD	USEPA, DNER, NRCS

Regulatory and Policy Requirements

Enhancing seascapes will require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level.

FE-12 Establish management measures within the SJBE system for the land crab Cardisoma guanhumi.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify critical habitats and needs for the species, including land needs and conservation.	Assess current threats to habitats.	Completed data collection to map critical habitats and species distribution.	Leads: DNER, USEPA, NRCS Implementing partners: Estuario, academia, municipalities, local organizations	Pending	0-2 years	TBD	DNER, USEPA, NRCS

2. Develop a management plan and establish a monitoring program to track conditions.	Collect stakeholder input and increase monitoring.	Finalized management plan.	Leads: DNER, USEPA, NRCS Implementing partners: Estuario, academia, municipalities, local organizations	Pending	3-5 years	TBD	DNER, USEPA, NRCS

Regulatory and Policy Requirements

Species management will likely require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level.

FE-13 Continue to implement a sea turtle recovery plan.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify areas within the SJBE as potential nesting areas.	Increase collaboration with stakeholders on collecting data.	Identified potential nesting areas.	Lead: DNER Implementing partners: USFWS, municipalities, Estuario, Siete Quillas, local organizations	Ongoing	3-5 years	TBD	DNER, USEPA, USFWS
2. Enhance the population of the leatherback sea turtle.	Increase nesting activity.	Implemented protective measures for the species.	Lead: DNER Implementing partners: USFWS, municipalities, Estuario, academia, Sieta Quillas, local organizations	Pending	5+ years	TBD	DNER, USEPA, USFWS
3. Coordinate with stakeholders to educate the public on the importance of protecting sea turtle species.	Increase awareness of sea turtle conservation among the public.	Developed educational materials.	Lead: DNER Implementing partners: USFWS, municipalities, Estuario, Siete Quillas, Condado Collection, local organizations	Ongoing	0-2 years	TBD	DNER, USEPA, USFWS

Regulatory and Policy Requirements

Species management will likely require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level.

FE-14 Protect existing populations of endangered and threatened bird species and protect and restore their habitat within the SJBE system. *Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Enforce existing regulations regarding bird species and their habitat to protect breeding and nesting areas.	Increase compliance among stakeholders with existing regulations.	Conducted training sessions for regulatory agencies on laws and regulations.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities, regulatory agencies	Ongoing	3-5 years	TBD	DNER, USFWS
2. Develop measures to control the introduction of non-native species into the SJBE.	Review current regulations and practices and identify areas for improvement.	Increased stakeholder awareness regarding risks of non-native species.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities	Ongoing	5+ years	TBD	DNER, USFWS
3. Educate the public to increase awareness about management measures and regulations.	Increase public understanding of management measures and regulations.	Collaborated with stakeholders to promote outreach efforts.	Leads: DNER, USFWS Implementing partners: Estuario, local organizations	Ongoing	3-5 years	TBD	DNER, USFWS

Regulatory and Policy Requirements

Species management will likely require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level.

FE-15 Enhance and protect critical threatened and endangered plant species within the SJBE.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Develop nurseries to supply critical plant species.	Strengthen partnerships between nurseries and stakeholders.	Improved inventory of critical plant species.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities, local nurseries	Pending	0-2 years	TBD	DNER, USFWS
2. Develop management plans for critical species.	Establish measurable indicators to assess effectiveness of management plans.	Finalized management plans for critical plant species.	Leads: DNER, USFWS Implementing partners: Estuario	Pending	3-5 years	TBD	DNER, USFWS
3. Establish protection zones to support propagation.	Identify areas as potential protection zones.	Created guidelines to protect and manage protection zones.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities	Ongoing	3-5 years	TBD	DNER, USFWS

4. Educate the public on the importance of critical species.	Increase public awareness of critical plant species and their ecological roles.	Created educational resources focusing on the importance of critical species.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities, local community organizations.	Ongoing	0-2 years	TBD	DNER, USFWS

Regulatory and Policy Requirements

Management will likely require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level to ease permitting requirements for projects incorporating critical plant species.

FE-16 Determine historic and present recreational fishing areas in the SJBE and develop a plan to adequately manage recreational fishery resources. Adaptation

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Identify areas used by recreational and commercial fisherman and determine perceived challenges regarding fishery resources.	Increase understanding of fish species catch and popular fishing areas.	Discussed commonly fished areas and usage patterns with sport fishers.	Lead: DNER Implementing partners: Estuario, USFWS, NMFS, Sea Grant Puerto Rico, community groups, Caribbean Fishery Management Council	Ongoing	0-2 years	TBD	DNER
2. Identify areas in need of support regarding protection and management.	Comprehensive mapping of vulnerable habitats that require additional protection and management efforts.	Conducted field assessments to gather data on habitat conditions.	Lead: DNER Implementing partners: Estuario, Sea Grant Puerto Rico, community groups, Caribbean Fishery Management Council	Pending	0-2 years	TBD	DNER

Regulatory and Policy Requirements

Fisheries management may require changes to seasonal and geographical size and bag limits to some fish species. Education and enforcement of new and existing fishing regulations will also be critical.

**NEW* FE-17 Enhance, restore, and create coastal dunes, coastal forests, and beach thickets. Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Assess existing conditions and identify areas that need intervention.	Identify specific areas exhibiting degradation or decline in condition that require intervention.	Analyzed collected data to identify specific areas of concern and assess severity of degradation.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities, academia, scientific community, environmental nongovernmental organizations (NGOs) and consultants. U.S. Geological Survey	Pending	0-2 years	TBD	DNER, USFWS, municipalities
2. Develop plans to enhance, restore, and create coastal habitats.	Establish measurable indicators to assess the effectiveness of enhancement actions.	Incorporated stakeholder input and finalized habitat enhancement plan.	Leads: DNER, USEPA Implementing partners: Estuario, municipalities, academia, scientific community, environmental NGOs and consultants	Pending	TBD	TBD	DNER, USEPA, municipalities
3. Implement developed plans to enhance, restore, and create coastal habitats and establish monitoring and maintenance protocol.	Improve habitat and information gathered through monitoring.	Secured necessary resources to conduct enhancement activities and monitoring outlined in plan.	Leads: DNER, USEPA Implementing partners: Estuario, municipalities, academia, scientific community, environmental NGOs and consultants	Pending	5+ years	TBD	DNER, USEPA, municipalities

Regulatory and Policy Requirements

Management will likely require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level to limit development and increase buffers around these critical areas.

**NEW* FE-18 Enhance and protect forests and landscape connectivity in the watershed. Adaptation*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources

1. Assess existing conditions and identify areas that need intervention.	Identify specific areas exhibiting degradation or decline in condition that require intervention.	Analyzed collected data to identify specific areas of concern and assessed severity of degradation.	Leads: DNER, USEPA Implementing partners: Estuario, municipalities, academia, scientific community	Pending	0-2 years	TBD	DNER, USEPA, municipalities
2. Develop plans to enhance upper watershed forests and landscape connectivity.	Establish measurable indicators to assess the effectiveness of enhancement actions.	Incorporated stakeholder input and finalize the habitat enhancement plan.	Leads: DNER, USEPA, NRCS Implementing partners: Estuario, municipalities, academia, scientific community	Pending	3-5 years	TBD	DNER, USEPA, municipalities, USFS, USFWS, NRCS
3. Implement plans to enhance upper watershed forests and improve landscape connectivity and establish monitoring and maintenance protocol.	Improve landscape connectivity and information gathered through monitoring.	Secured necessary resources to conduct enhancement and monitoring activities.	Leads: DNER, USEPA, NRCS Implementing partners: Estuario, municipalities, academia, scientific community	Pending	5+ years	TBD	DNER, USEPA, municipalities, USFS, USFWS, NRCS

Regulatory and Policy Requirements

Management will likely require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level to limit development and increase buffers in and around these critical areas.

**NEW* FE-19 Enhance and Protect Herbaceous Wetlands. ADAPTATION*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Assess existing conditions and identify areas that need intervention.	Identify specific areas exhibiting degradation or decline in condition that require intervention.	Analyzed data to identify specific areas of concern and assess the severity of degradation.	Lead: DNER Implementing partners: Estuario, municipalities, academia, scientific community, environmental NGOs and consultants	Pending	0-2 years	TBD	DNER, USEPA, municipalities

2. Develop plans to protect, enhance, and create herbaceous wetlands.	Establish measurable indicators to assess the effectiveness of enhancement actions.	Incorporate stakeholder input and finalize the plan.	Lead: DNER Implementing partners: Estuario, municipalities, academia, scientific community, environmental NGOs and consultants	Pending	3-5 years	TBD	DNER, USEPA, municipalities
3. Implement plans to protect, enhance ,and create herbaceous wetlands and establish monitoring and maintenance protocol.	Improve herbaceous wetlands and information gathered through monitoring.	Secured necessary resources to conduct enhancement activities as outlined in the plans.	Lead: DNER Implementing partners: Estuario, municipalities, academia, scientific community, environmental NGOs and consultants	Pending	5+ years	TBD	DNER, USEPA, municipalities

Regulatory and Policy Requirements

Management will likely require cooperation from municipalities through creation and enforcement of ordinances. Management strategies may also recommend legislation at the state and federal level to limit development and increase buffers in and around these critical areas.

**NEW* FE-20 Implement a project to incentivize and recognize individual property owners that manage their yards as part of a biodiversity conservation area.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Assess areas that could potentially be identified as a biodiversity conservation area.	Identify specific properties and their owners.	Analyzed data to identify areas with high biodiversity value and assess the ecological condition of potential conservation areas.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	0-2 years	TBD	DNER, USEPA, municipalities
2. Develop plans to incentivize proper maintenance of properties.	Establish measurable indicators to inform property owners of proper maintenance.	Finalized incentive plans with stakeholder input.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	3-5 years	TBD	DNER, USEPA, municipalities
3. Implement developed plans to incentive biodiversity and establish monitoring and maintenance protocols.	Improve biodiversity and information gathered through monitoring.	Secured necessary resources to conduct enhancement activities.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	5+ years	TBD	DNER, USEPA, municipalities

4. Educate the public to increase the use of native plant species for ornamental purposes.	Increase public awareness native plant species use and their ecological role.	Guidelines for native species use.	Lead: DNER Implementing partners: Estuario, USFS	Pendin g	0-2 years	TBD	USFS

Regulatory and Policy Requirements

Establishment and recognition or requirement of "Puerto Rico Friendly" plants in development permits may assist in supporting this action. Establishing local ordinances for fertilizer bans and other management practices may also assist in this effort.

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Public Policy for Resilience-Based Ecosystem Management

Baseline

Law No. 112 established the Condado Lagoon Estuarine Nature Reserve in 2013. By establishing a commission for community management and a conservation plan for the development and conservation efforts, this law establishes an approach for resilience-based ecosystem management within the legislative structure in Puerto Rico.

There are many protected natural areas and urban forests within the SJBE, as outlined in Table 3. These areas provide critical refuge for threatened and endangered species, greenspace within metropolitan centers, and education for nature-based solutions. The Piñones State Forest is one of the earliest examples of recognition for the preservation of natural space in Puerto Rico. Located to the east of Torrecilla Lagoon and home to Puerto Rico's largest mangrove forest, the area has been a prime target for large-scale development since the 1970s. The local community has blocked multiple hotel developers in the area. Recently, Mayor Julia Nazario Fuentes stated that "At Loíza we believe in development, but sustainable development, in total harmony with the environment, that generates jobs for our people. The formula must improve the collective infrastructure and there must be a component of social commitment" (El Sol de PR Newspaper, 2025). This is an excellent example of preservation and management of natural ecosystems in what would have otherwise given way to eastern urban sprawl of the San Juan metropolitan area. Connectivity of these spaces is important to allow species to migrate without threat from urban centers. The San Juan Ecological Corridor was established in 2003 to provide this connectivity.

Table 3. List of Protected Natural Areas and Urban Forests within the SJBE.

Name	Year Established
Piñones State Forest	1919
Botanical Garden of the University of Puerto Rico	1971
Las Cucharillas Swamp Nature Reserve	1976
San Patricio Urban Forest	1998
Karst Conservation Area	1999
Urban Forest of the New Millennium	2003
Doña Inés Mendoza Urban Forest	2003
San Juan Ecological Corridor	2003
Martin Peña Canal Nature Reserve	2003
Old Aqueduct of the Piedras River	2006
Los Frailes Protected Natural Area	2006
Sendra Sisters Protected Natural Area	2011
Condado Lagoon Nature Reserve	2013
Green Island Reef Marine Reserve	2014
Buffer Zone of the Ciénaga Las Cucharillas River	Not applicable

Coral reefs are critical ecosystems that provide numerous ecological, economic, and social benefits in the SJBE. Coral communities contribute significantly to marine biodiversity and the overall functioning of coastal environments. Coral communities in the SJBE are found in various locations, with their most significant presence occurring where the estuary connects to the ocean. Key sites include Dos Hermanos in Condado and Boca de Cangrejos in Torrecilla, as well as along the coastline from Cataño to Loíza (Rodríguez et al.

1992). These areas are characterized by a unique blend of estuarine and marine influences, which support diverse coral species. Part of this chain of fringe coral reefs is protected within the marine reserve known as Isla Verde Marine Reserve, where two threatened reef-building coral species are found: *Acropora palmata* (elkhorn coral) and *Orbicella annularis* (boulder star coral). The protection of these species is crucial, as they play a significant role in reef structure and function.

In 2008, Estuario initiated a project to enhance marine biodiversity by placing 45 artificial reefs on the bottom of the Condado Lagoon. This goal of this initiative was to create an underwater corridor that would support marine life. Within two years of construction, the project had documented 49 species of fish, and the fish population in this part of the lagoon had doubled. Additionally, approximately 2,500 colonies of coral now grow on the surfaces of these artificial reefs, demonstrating the potential for habitat restoration and enhancement in the SJBE (Bauzá-Ortega, 2015).

Coral reefs are a vital component of the SJBE system, providing essential ecological services and supporting diverse marine life. However, they are increasingly threatened by environmental stressors and human activities. Understanding the specific dynamics of coral reefs in this watershed is crucial for stakeholders to implement effective conservation strategies. Prioritizing coral communities, identifying and designating marine protected areas, and creating and implementing management plans in these areas, can help ensure the resilience of these ecosystems and the myriad benefits they provide to the SJBE.

Objectives

- Strengthen public policy that supports resilience-based ecosystem management.
- Increase the number of natural protected areas.

Actions

**NEW* FE-21 Complete an inventory of natural protected areas in the San Juan Metro Region and ensure each has and is implementing a Comprehensive Management Plan.*

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Review existing management plans, in coordination with local stakeholders, to assess their effectiveness and identify gaps or areas needing improvement.	Increase understanding of threats to biodiversity in natural protected areas.	Understand needs and gaps in existing management plans.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities, academia, scientific community, environmental NGOs and consultants	Pending	3-5 years	TBD	DNER, USEPA, NOAA, municipalities

2. Develop or update comprehensive management plans for each protected area.	Ensure management plans adhere to environmental regulations and policies.	Finalized management plans.	Leads: DNER, USFWS Implementing partners: Estuario, municipalities, community groups, academia, scientific community, environmental NGOs and consultants	Pending	5+ years	TBD	DNER, USEPA, NOAA, municipalities

Regulatory and Policy Requirements

The success of this action will require that established protected areas receive the funding required to manage the area in accordance with the legislative mandates that established these areas.

FE-22 Evaluate the feasibility of designating the Torrecilla Alta-Vacia Talega area as part of the Piñones State Forest Nature Reserve.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Conduct a detailed ecological and property assessment of the Torrecilla Alta-Vacia Talega.	Assess the ownership, condition, valuation, and quality of different habitat types within the area.	Finalized ecological assessment.	Lead: DNER Implementing partners: Estuario, municipalities, academia, scientific community	Pending	0-2 years	TBD	DNER
2. Develop a formal proposal for the designation.	Include detailed ecological assessment findings that support the need for designation.	Finalized designation proposal.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	3-5 years	TBD	DNER
3. Collaborate with stakeholders to navigate the regulatory processes.	Improve knowledge among stakeholders regarding the regulatory requirements and processes.	Collaborated with stakeholders to compile and draft necessary documentation .	Lead: DNER Implementing partners: Estuario, municipalities, regulatory agencies	Pending	3-5 years	TBD	DNER

Regulatory and Policy Requirements

This action will require a legislative action to designate this area as part of the Piñones State Forest Nature Reserve. Champions in the local communities and legislature will be required to achieve this designation.

FE-23 Identify areas in the SJBE to be designated marine protected areas and continue coral reef restoration projects.

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Perform a detailed ecological assessment to identify critical habitats, biodiversity hotspots, and areas that would benefit from protection.	Evaluate the condition and stability of identified habitats.	Analyzed data to identify critical habitats and biodiversity hotspots.	Lead: DNER Implementing partners: Estuario, NOAA, municipalities, academia, scientific community, environmental NGOs and consultants	Pending	0-2 years	TBD	DNER, USEPA, NOAA
2. Implement reef and coral restoration projects and create a monitoring and evaluation framework to assess the effectiveness.	Increase in fish and invertebrate populations associated with restored reefs.	Established regular monitoring schedule to assess coral growth, condition, and associated biodiversity.	Lead: DNER Implementing partners: Estuario, NOAA, academia, scientific community, environmental NGOs and consultants	Pending	3-5 years	TBD	DNER, USEPA, NOAA

Regulatory and Policy Requirements

Legislative action will be required to designate marine protected areas. Champions in the local communities and legislature will be required to achieve this designation. Success will require support from municipal and state officials to ensure existing coral remain, and new development incorporates features that can enhance and support new coral growth, sustain sediment quality, and provide habitat for marine life.

FE-24 Approve a management plan for the San Juan Ecological Corridor

Activities

Activity	Performance Measures	Milestones	Responsible Stakeholder(s) and Partner(s)	Status	Timeframe	Estimated Costs	Potential Funding Sources
1. Conduct a comprehensive review of existing ecological data and needs in coordination with stakeholders and local communities.	Clear documentation of gaps in existing ecological data.	Conducted a thorough literature review of existing studies, reports, and databases.	Lead: DNER Implementing partners: Estuario, municipalities, community groups	Pending	0-2 years	TBD	DNER, USEPA, NOAA, municipalities
2. Draft management plan.	Effective incorporation of feedback and suggestions.	Finalize draft management plan.	Lead: DNER Implementing partners: Estuario, municipalities, community groups	Pending	3-5 years	TBD	DNER, USEPA, NOAA, municipalities

3. Implement management plan, including buying land in the San Juan Ecological Corridor.	Enhance stakeholder awareness and support for the management plan and land purchases.	Finalized final management plan.	Lead: DNER Implementing partners: Estuario, municipalities	Pending	3-5 years	TBD	DNER, USEPA, NOAA, municipalities

Regulatory and Policy Requirements

In 2024, the requirement for DNER to prepare a Conservation Management Plan was established by law (12 L of PR § 216i). The law required DNER to establish a committee and furnish the committee with materials and office space. DNER was required to prepare an Integrated Conservation and Management Plan in coordination with the committee.

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