Wetlands Conservation Plan
for St. Thomas and St. John, U.S. Virgin Islands

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Executive Summary

Situated near the eastern terminus of the Greater Antillean chain of islands in the northern Caribbean Sea, the United States Virgin Islands (USVI) comprise four major inhabited islands and more than 50 smaller offshore cays with a total land area of about 353 km^2. St. Thomas (74 km^2) and St. John (50 km^2) are the two major islands to the north, situated on the Puerto Rican Bank to the east of Puerto Rico and its eastern offshore islands (Culebra and Vieques), and west of the British Virgin Islands (BVI). Separated by a distance of roughly 3 km, both islands are mountainous (up to 477 m high on St. Thomas, 387 m on St. John). Their coastlines are irregular with numerous small bays and offshore cays. Water Island comprises a land mass of 2 km^2 located at the mouth of St. Thomas harbor. The more isolated St. Croix (217 km^2), about 64 km to the south, is generally flatter (up to 355 m high in the hilly northwest) and drier, with fewer bays and offshore cays. The offshore cays collectively comprise about 3% of the territory's area (12 km^2).

The demands for space by a rapidly growing human population of over 100,000 humans in the USVI have resulted in extensive loss and degradation of natural ecosystems, especially on densely populated St. Thomas. Sprawling residential communities and commercial centers have replaced or fragmented much of the native forest. Hotels, condominiums, and marinas have been constructed on coastal wetlands and marine recreational activities have damaged fragile mangrove swamps, coral reefs, and seagrass beds. The natural ecosystems are subject to the effects of short- and long-term wet and dry climatic cycles and to periodic disturbances from hurricanes, including the recent hurricanes Hugo in 1989 and Marilyn in 1995.

Although protected under federal and local regulations, the wetlands in the USVI are under pressure from encroaching development and stressed by upland sources of contamination and sediment loads. The VI Department of Planning and Natural Resources (DPNR) has the primary responsibility for managing these resources. Within DPNR, the Division of Environmental Protection (DEP) manages water quality and administers several programs for watershed protection. The Non-point Source Pollution Program aims to identify and reduce sources of contaminants in USVI coastal waters and wetlands and is jointly managed by DEP and the VI Coastal Zone Management (CZM) Program. The Division of Fish and Wildlife is mandated to protect the natural resources within these habitats.

In the USVI, there are four main types of terrestrial wetlands: mangroves, salt ponds, "guts" (riparian stormwater drainage ravines), and freshwater ponds. An additional wetland type, seagrass beds, is also present in the nearshore marine environment. Each resource has significant wildlife and cultural value and each suffers similar threats from encroachment, non-point source pollution, sediment, and alteration.

This plan identifies ten objectives for managing USVI wetlands defined by these broad headings: inventory, monitoring, data management, watershed management, pollution control, education, landowner participation, prioritization, and coordination. Actions and potential partners are identified, with a “first step” implementation priority of creating a wetlands working group. For each wetland type, specific threats and conservation actions are also identified.

As part of the process of developing this wetland conservation plan, a prioritization system was developed that examines the condition, value to wildlife, and threats for each wetland, and identifies potential conservation actions and opportunities. Based on these criteria, priority watersheds are identified based on conservation need and urgency, value of wetland systems contained within the watershed, and feasibility for action. The priority watersheds on St. Thomas are identified as Jersey Bay, Red Hook Bay, and Perseverance Bay. On St. John the priority watersheds are identified as Rendezvous Bay and Coral Bay. Two offshore islands were also identified: Great St. James and Little St. James.

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The maps were created using data provided by the VI Division of Environmental Protection, compiled by Chris Crawford from several sources including the Caribbean Data Center.

This document stemmed from the initial efforts of William Knowles and Cheri Amrani (both formerly of the VI Division of Fish and Wildlife), and the wetland inventory conducted by Carrie Stengel (also formerly of the VI Division of Fish and Wildlife, now with the VI National Park). Judy Pierce (VI Division of Fish and Wildlife) wrote the grant application for this project. Floyd Hayes (formerly of VI Division of Fish and Wildlife, now at Pacific Union College, California) began the initial effort on this document, and conducted many wetland bird surveys that were used to determine biological value of the wetlands sites. Doug McNair (formerly of VI Division of Fish and Wildlife) completed a wetlands conservation plan for St. Croix based on wetland bird surveys. Much of the literature review for this document was completed by Ron Sjoken and Roger Uwate (both formerly of the VI Division of Fish and Wildlife) as part of the development of the USVI marine resources and fisheries strategic and comprehensive conservation plan.

Many thanks to Denise Rennis (VI Water Resource Research Institute) for field trips and helpful discussion regarding wetlands and their management and conservation, and to Laurel Brannick (VI National Park) for taking me (and Floyd) to ponds on St. John and providing invaluable information on birds. Daniel Nellis showed me where the Northside St. Thomas ponds are located. Many thanks to Bill Rohring (VI Coastal Zone Management) and William Tobias (Division of Fish and Wildlife) for reading the draft conservation plan and providing critical comments on the text.

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Introduction

Geographical Context

Situated near the eastern terminus of the Greater Antillean chain of islands in the northern Caribbean Sea, the United States Virgin Islands (USVI) comprise four major inhabited islands and more than 50 smaller offshore cays with a total land area of about 353 km^2. St. Thomas (74 km^2) and St. John (50 km^2) are the two major islands to the north, situated on the Puerto Rican Bank to the east of Puerto Rico and its eastern offshore islands (Culebra and Vieques), and west of the British Virgin Islands (BVI). Separated by a distance of roughly 3 km, both islands are mountainous (up to 477 m high on St. Thomas, 387 m on St. John), thus attracting a modest amount of precipitation. Their coastlines are irregular with numerous small bays and offshore cays. Water Island comprises a land mass of 2 km^2 located at the mouth of St. Thomas harbor. The more isolated St. Croix (217 km^2), about 64 km to the south, is generally flatter (up to 355 m high in the hilly northwest) and drier, with fewer bays and offshore cays. The offshore cays collectively comprise about 3% of the territory’s area (12 km^2).

Ranging in latitude from 17^o 30’ to 18^o 30’ north of the equator, the islands are well within the tropics. Seasonal variation in temperature is relatively minor, with slightly cooler temperatures during winter. Seasonal variation in precipitation is more pronounced and highly variable from year to year, with a dry season from December to April. Rainfall averages 75 cm per year in coastal areas and up to 140 cm per year at the highest elevations.

Photo: R. Platenberg

North side of St. Thomas, showing several off-shore cays.

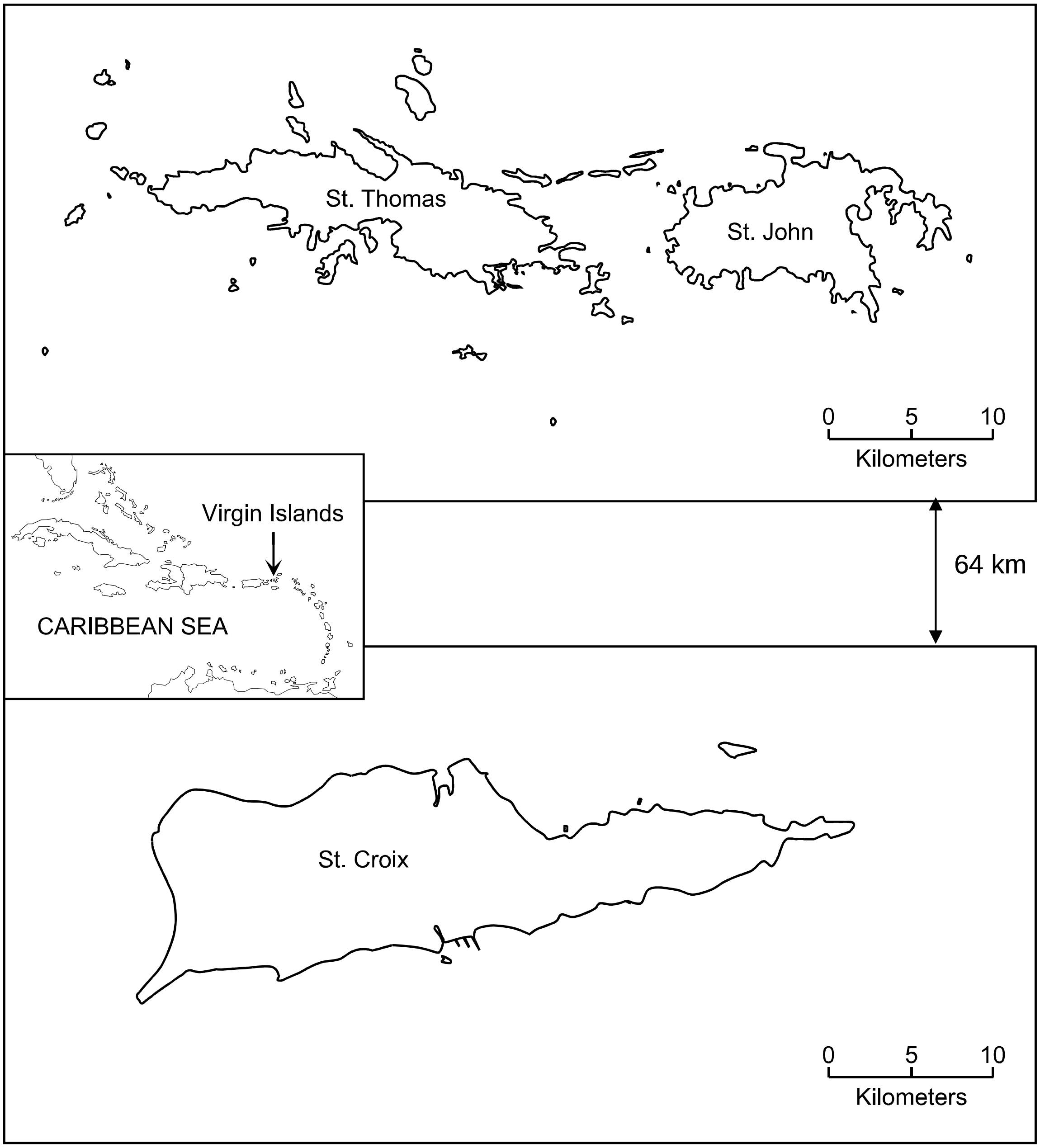
The demands for space by a rapidly growing human population of over 100,000 humans in the USVI have resulted in extensive loss and degradation of natural ecosystems, especially on densely populated St. Thomas. Sprawling residential communities and commercial centers have replaced or fragmented much of the native forest. Hotels, condominiums, and marinas have been constructed on coastal wetlands and marine recreational activities have damaged fragile mangrove swamps, coral reefs, and seagrass beds. The natural ecosystems are subject to the effects of short- and long-term wet and dry climatic cycles and to periodic disturbances from hurricanes, including hurricanes Hugo in 1989 and Marilyn in 1995.

Administrative Context

Within the USVI, the Department of Planning and Natural Resources (DPNR) is the government agency charged with conservation and management of marine and wildlife (including native plants) resources. Several divisions within the DPNR are involved in resource management. These include the Division of Fish and Wildlife (DFW), Division of Coastal Zone Management (CZM), Division of Environmental Protection (DEP), and Division of Environmental Enforcement (DEE). The DFW is the agency responsible for the assessment of marine and wildlife resources within the USVI. Water quality is assessed by DEP, and coastal resources fall within the authority of CZM. Other organizations involved in natural resource conservation and assessment include the Environmental Association of St. Thomas and St. John (EAST), the St. Croix Environmental Association (SEA), the Nature Conservancy (TNC), the Caribbean Data Center (CDC), and Island Resources Foundation (IRF). Federal agencies involved in wetlands protection include the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA).

Photo: R. Platenberg

The municipality of Charlotte Amalie, St. Thomas, the capitol of the U.S. Virgin Islands.



Geographic location of the U.S. Virgin Islands.

Background to the USVI Wetlands Conservation Plan

Previous research on wetlands in the USVI has focused on: inventories of important saltwater wetlands (Norton 1986, Knowles 1997, Stengel 1998, Boulon and Griffin 1999, Island Resources Foundation 2004, Kendall et al. 2005); the impact of sedimentation on salt ponds (Nichols and Brush 1988); salt pond hydrology and functions (Bossi and Rose 2003, Gangemi 2003, Rennis et al. 2006), a survey of fishes to assess the importance of mangroves as nurseries for recreational fisheries (Boulon 1990, Adams and Tobias 1994, Tobias 1996, 1998, 2001, Adams and Ebersole 2002); the use of saltwater wetlands by wildlife, especially birds (Norton et al. 1985, 1986a, 1986b, Knowles and Amrani 1991, Sladen 1992, Wauer and Sladen 1992, Knowles 1994, 1996, McNair 2005, McNair et al. 2005); environmental studies of Mangrove Lagoon/Benner Bay, St. Thomas (Grigg et al. 1971, Island Resources Foundation 1977, 1993; Nichols and Towle 1977, Nichols et al. 1979); a survey of freshwater ectoprocts (Smith 1993); and a survey of freshwater mollusks (Smith and Brousseau 1996). Jarecki (2003) completed a major ecological study of salt ponds in the BVI. Current efforts include a recent completion of surveys of breeding rare and uncommon wetlands birds to improve wetlands conservation efforts on St. Croix (McNair 2005, McNair and Cramer-Burke 2005, McNair et al. 2005).

The wetlands conservation planning effort for the USVI began in 1988 with a Pittman-Robertson Wildlife Restoration research project that inventoried and mapped the saltwater wetlands in the USVI greater than 2 ha. The inventory maps and first phase of data collection were completed in 1990 (Knowles and Amrani 1991). Stengel (1998) subsequently produced baseline data for 69 salt ponds on St. Thomas, St. John and the adjacent islands under a project funded by the EPA. A project was recently initiated by DEP and CZM through funding by the federal EPA to conduct an inventory of USVI wetlands and riparian areas. To date, however, there has not been a comprehensive wetlands conservation plan that identifies the wetlands of the USVI, determines status and threats, and identifies priorities for conservation action. This document was funded through a Pittman-Robertson Wildlife Restoration Grant (W-16) that was initially awarded in FY2002 and has passed through several principal investigators and undergone several project description amendments.

Photo: R. Platenberg

Tricolored Heron *Egretta tricolor*, a locally protected wetland species of concern.

Goals and Objectives of the Wetlands Conservation Plan

The goal of this document is to present a comprehensive Wetlands Conservation Plan that will prioritize wetlands on St. Thomas and St. John for protection, acquisition, restoration, and habitat enhancement. The overall goal of the strategy is to ensure that wetlands are managed as ecological assets within a greater watershed landscape for the benefit of present and future generations.

The primary objective of this document is to update the previous salt pond management plan (Stengel 1998) and to expand to include seagrasses, mangroves, stormwater drainages, and freshwater ponds. Since there have been recent projects and grants concerning USVI wetlands, this document aims to collate that information without attempting to reproduce it. The Wetlands Conservation Plan will provide the information necessary for the future implementation of protection options and wildlife habitat enhancement for St. Thomas and St. John wetlands. This will result in more properly focused and coordinated management activities for direct benefits to the public and to the wildlife that utilize the wetlands.

Photo: R. Platenberg

Mangrove-fringed salt pond on Capella Cay.

Wetlands in the USVI

USVI Wetlands

Wetlands refer to areas sufficiently inundated or saturated by water to support a prevalence of vegetation adapted for life in saturated soils. Wetlands are vital habitats for wildlife and fisheries, providing an array of goods and services including food, shelter from predators, protective nurseries, and filters of sediments and pollutants between landward human disturbances and sensitive coastal habitats including mangroves, coral reefs, and sea grass beds. Many wildlife species are dependent upon wetlands for their survival. Humans benefit from wetlands which slow down runoff, recharge freshwater aquifers, stabilize soils, offer a buffer protecting the land from storm surges, provide "hurricane shelters" for boaters and afford aesthetic areas for recreation.

Wetlands occur throughout the major islands and cays of the USVI. A recent GIS analysis identified 636 man-made and natural wetlands (with a minimum area of 150 m^2) in the USVI (Island Resources Foundation 2004). This analysis does not include the numerous wetlands, especially mangroves, already lost to development. Older topographic maps depict numerous salt ponds that no longer exist or have been severely altered by development. Of these extant wetlands identified, 371 are in St. Croix, 151 in St. Thomas, and 114 in St. John (including cays adjacent to each island). These wetlands have been grouped into five categories: salt ponds, salt flats, mangrove wetlands, mixed swamp, and freshwater ponds. For the purposes of this conservation plan, the wetland types that will be examined are: seagrass beds, mangroves, salt ponds, guts (stormwater drainages), and freshwater ponds. Locations of these watertypes on St. Thomas and St. John are depicted in Appendix 1. Because most wetlands in the USVI occur within coveted coastal areas, one

Photo: R. Platenberg

Salt pond at Chocolate Hole, St. John.

of the major threats to wetlands is filling, drainage, or alteration (e.g., opening to sea, dredging) for development. Many have already been destroyed or severely altered by development. Other major threats include pollution, sedimentation, and disturbance by human visitors. The introduction of exotic plants, fish (e.g., tilapia *Oreochromis mossambicus*), cane toads (*Bufo marinus*), and red-eared sliders (*Trachemys scripta*) may threaten native species of wildlife. Given the prospect of rising sea levels, the consequences of wetland loss may become more severe as coral reefs die and mangroves drown, thus exposing shores to the more frequent coastal storms predicted by current climate change models.

Wetland Types and definitions

The definition of a wetland is very precise and entails three characteristics: wetland hydrology, hydrophytic vegetation, and hydric soils. These are defined as:

Wetland hydrology: land that is periodically inundated or saturated to the surface at some time during the growing season. The presence of water has an overriding influence on vegetation and soils.

Hydrophytic vegetation: plant species that occur in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils. There are three types of wetland plants: Obligate: occur 99% of the time in wetlands; facultative: occur 34-66% of the time in wetlands; and facultative wetland: occur 67-99% of the time in wetlands.

Hydric Soils: saturated, flooded, or ponded long enough to develop anaerobic conditions that favor the growth of hydrophytic vegetation.

Standard methods for delineating wetlands have been prepared by the U.S. Army Corps of Engineers (1987).

Within the northern USVI there are five major types of wetlands that are included in this Wetlands Conservation Plan: seagrass beds, mangroves, salt ponds, “guts”, and freshwater ponds.

Wetland Functions and Benefits

Wetlands provide a number of beneficial functions including water flow regulation and flood control, protection against natural forces such as coastal erosion, hurricanes, and storm surge flooding, retention of sediments and nutrients, removal of toxins from effluents and polluted water, water transport, species and habitat conservation, and maintenance of ecosystem processing such as carbon cycling and microclimate regulation (Moser et al. 1996). Other benefits of functioning wetlands include opportunities for research, education, and recreation.

Protection of marine resources through the stabilization of coastal soils is a critical function of seagrasses and mangroves. Seagrasses form extensive plant carpets, thus diminishing the effects of strong currents, providing protection to fish and invertebrates, and preventing the erosion of bottom areas (Thayer et al. 1975, Delgado and Stedman 2004). By stabilizing the sediment and increasing deposition of suspended particles, seagrasses help to provide clear water for adjacent coral reefs.

Photo: R. Platenberg

Red mangrove *Rhizophora mangle* prop roots.

Mangrove communities have a variety of recognized roles in the larger ecosystem in which they occur. The most prominent role is the production of leaf litter and detrital matter that is exported, during the flushing process, to the nearshore marine environment (Snedaker and Getter 1985). Through a process of microbial breakdown and enrichment, the detrital particles become a nutritious food resource for a variety of marine animals. Soluble organic materials which result from decomposition within the forest also enter the near-shore environment where they become available to a variety of marine and estuarine filter feeders and benthic scavengers. The organic matter exported from the mangrove habitat is utilized in one form or another, including utilization by inhabitants of seagrass beds and coral reefs that may occur in the area (Snedaker and Getter 1985).

Although mangroves were originally thought to trap and gradually accumulate sediment and grow seaward, it appears that mangroves only stabilize regions of sediment deposition and that little offshore expansion occurs (Lugo and Snedaker 1974). Due to the global rise in sea level, mangroves have actually migrated landward in response to higher sea level (Cintron et al. 1978). However, on shorter time scales (several years), areas colonized by mangroves may fluctuate due to damage caused by storms or changes in patterns of seawater exchange within the mangrove as the result of creation and destruction of sediment barriers on the seaward fringe (Cintron et al. 1978).

In areas of annual cyclonic storm activity, the shoreline mangroves are recognized as a buffer against storm-tide surges that would otherwise have a damaging effect on low-lying land areas. Mangroves are noted for their ability to stabilize coastal shorelines that would otherwise be subject to erosion and loss (Saenger et al. 1983). Probably one of their more important roles is the preservation of water quality; because of their ability to extract nutrients from circulating waters, the eutrophication potential of nearshore waters is minimized. Also, the saline and anaerobic mangrove sediments have a limited ability to sequester and/or detoxify common pollutants (Snedaker and Brown 1981). For example, some heavy metals are sequestered as insoluble sulfides, and certain organic pollutants are oxidized or decomposed through microbial activity.

The documentation of mangroves as nursery areas for recreationally and commercially valuable species, and their prey species, provides impetus for including mangrove habitats in fisheries management plans (Thayer et al. 1987, Boulon 1992, Dennis 1992, Adams and Tobias 1994, Tobias 1996, 1998, 2001; Mateo 2001a, Mateo and Tobias 2001, Adams and Ebersole 2002, Mateo et al. 2002).

Salt ponds and their specialized mangrove and salt-tolerant vegetation communities perform a variety of biological, hydrologic and water quality functions. Capturing and retaining sediments is an important water quality function of coastal saline wetlands (Jarecki 2003, Rennis et al. 2006), helping to protect sensitive coastal resources, such as coral reefs and seagrasses, which can be adversely impacted from siltation. The indirect functions of salt ponds and their associated mangrove systems include the provision of storm protection, flood mitigation, shoreline stabilization, and shoreline erosion control (Jarecki 2003).

Salt ponds act as natural sediment traps for run off and pollutants (Lugo and Snedaker 1974). Rain washes debris, soil, chemicals, and other pollutants down the steep drainage. Sediment and debris then flows into the sea; degrading seagrass beds and coral reefs, both essential to marine ecology. Salt ponds and mangrove swamps located in these drainage basins function as natural filters and debris settles to the bottom of the pond or swamp instead of flowing freely into the ocean. This protects reefs and

Photo: J. Vasques

Mangrove roots below the water surface, showing accumulation of algae.

seagrass beds from harmful contaminants found in run off and promotes better water quality.

Salt ponds are also beneficial as an aid in flood control (Dahl and Johnson 1991). During storm surges, presence of salt ponds and their associated mangroves act to dissipate wave action. This lessens the effects of pounding waves and storm surge flooding on upland areas. The ponds provide a catchment basin for rising tides, holding flood waters at bay, and dampening damage to upland areas and preventing shoreline erosion.

Salt ponds provide an essential habitat for indigenous and migratory birds, many of which are either locally or federally threatened or endangered. It is estimated that 90% of the resident and migratory birds in the USVI are dependent on saline wetlands for feeding, nesting or roosting (Philibosian and Yntema 1977).

Upland man-made freshwater ponds in the USVI reduce the amount of non-point source pollution entering the marine environment by increasing the retention of runoff water in ponds, increasing biodegradation of pesticides and other pollutants, and retaining erosion (DEP 2004).

Wetland Value to Wildlife

USVI wetlands provide a rare and highly valuable habitat for wildlife. Steep slopes and shallow soils reduce opportunities of wetlands in the upland environment, restricting mesic areas to stormwater drainages along guts and adjacent habitats. The wetlands of lowlying coastal areas, i.e., salt ponds, mangroves, and seagrass beds, constitute the primary wetland habitats for wildlife in the USVI.

Seagrass beds are areas of high productivity important to fish and other organisms as a direct or indirect source of food. The leaves and leaf detritus represent a food resource for many other marine animals (e.g., certain reef fishes, sea turtles, and conch) that regularly visit seagrass areas for feeding and foraging on both the plants and their animal associates. Seagrasses also provide living space, refuge from predators, and essential nursery areas to commercial and recreational fishery species and to a great number of invertebrates that live within or migrate to these habitats.

Photo: J. Vasques

Queen Conch *Strombus gigus* grazing on algae in seagrass bed.

Mangrove ecosystems support a high diversity of fish, birds, and other wildlife. Mangrove lagoons are important habitat for juveniles of many fish species (Heald and Odum 1970, Austin 1971a, b, Austin and Austin 1971, Olsen 1972, 1973; Cintron-Molero 1987, Thayer et al. 1987, Boulon 1992, Tobias 1996). They can provide nursery areas for estuarine as well as reef fishes (Odum et al. 1982, Boulon 1985, 1992; Tobias 1996). Many juveniles use detritus and mangrove-associated invertebrates and fish as a food source (Zieman et al. 1984, Thayer et al. 1987). The complex prop-root habitat may also provide protection from predation (Orth et al. 1984, Sogard and Olla 1993).

Mangrove wetlands also support a variety of wetland and migratory birds (Wauer and Sladen 1992). A study of bird use of mangrove and salt pond wetlands on St. Croix found that of 121 species of birds recorded, nearly ¾ of them use mangrove habitats, with 26% using mangroves exclusively. Migratory warblers were noted to be the dominant species utilizing mangroves, joined by migratory shorebirds and waterfowl. A number of waders utilize mangrove trees for roosting, and waders, waterfowl, and shorebirds readily inhabit flooded mangrove forests (Knowles 1994).

Salt ponds with their associated mangrove ecosystems provide an essential habitat for indigenous and migratory birds, many of which are either locally or federally threatened or endangered (Wauer and Sladen 1992). It is estimated that 90% of the resident and migratory birds in the USVI are dependent on these wetlands for feeding, nesting or roosting (Philibosian and Yntema 1977). More species, higher levels of confirmed breeding, and greater numbers of waterbirds generally occur at salt ponds as compared with other saline site types, such as tidal lagoons (McNair, Yntema, and Cramer-Burke 2005a).

Mangrove wetlands around salt ponds and swamps are the primary habitat for the great land crab (*Cardisoma guanhumi*), an economically important Caribbean species. Although omnivorous, the crab feeds primarily on leaves of buttonwood and red and white mangroves (K. Hill, 2001. http://www.sms.si.edu/IRLspec/Cardis_guanhu.htm). This species is exploited locally as a food source. Fiddler crabs (*Uca* spp.) and blue crabs (*Callinectes sapidus*) are also common in salt ponds and provide valuable food resources for birds. Blue crabs are also consumed by humans.

Photo: R. Platenberg

Blue Crab *Callinectes sapidus* in salt pond.

Freshwater sources in the USVI are extremely limited because of a thin soil layer and low permeability of the underlying rock. Water that collects in gut pools therefore provides a rare opportunity for water resources. Shrimp of the genus *Macrobrachium* and freshwater and anadromous fish inhabit gut pools and streams. These species tend to have complex life cycles, migrating between downstream marine environment and upstream freshwater pools when connections between the two habitats are present. Some species are completely freshwater-dependent. Migratory birds, primarily warblers, use these ephemeral water resources, as do, unfortunately, invasive species that require freshwater, such as the Cuban treefrog (*Osteopilus septentrionalis*). Freshwater ponds formed as a result of damming guts are utilized by amphibians and indigenous waterbirds that prefer freshwater ponds, such as the territorially endangered Least Grebe (*Tachybaptus dominicus*). Invertebrates, such as dragonflies, also utilize this habitat. Non-native mammals, primarily deer and mongooses, also rely on these ponds as a rare source of freshwater. Vegetated guts also provide habitat corridors for wildlife, particularly in highly disturbed, urbanized areas.

Human Uses and Cultural Significance of Wetlands

There are many historical sites situated in the vicinity of salt ponds and mangrove swamps, which may have provided a source of water and food. Scientifically, the prehistoric sites are more valuable than the historical plantation sites because the history is held only in the archaeological artifacts. The prehistoric sites are primarily situated around the lowland wetland areas because early inhabitants relied on the sea and inland water resources. Mangrove branches and roots were used to make fish traps. The inhabitants opened channels between the salt ponds and the sea to allow fish in, while throwing refuse into the ponds to attract fish. They blocked the channel with the fish traps to capture retreating fish (D. Brewer, pers. comm.). Salt ponds have also been used, and still are to this day, for salt harvest. During the dry seasons when the ponds dry up, salt can be harvested by removing and drying the hypersaline water. A number of wetlands have culturally significant resources close by, including the Perseverance salt ponds and the Magen’s Bay, Santa Maria, and Botany Bay swamps on St. Thomas.

Threats to Wetlands of the USVI

The two major detrimental impacts to wetlands in the USVI and beyond are physical alteration (e.g., infilling, dredging, etc.) and input of contaminants (including sediment).

Reclamation has been the greatest threat to salt pond and mangrove systems within the USVI prior to strict regulations implemented by the EPA and CZM. In the USVI, mangrove wetlands are located on prime coastal real estate (Tobias 1996). As a result, they have often been threatened by commercial and residential development. Economic success and the burgeoning tourist industry have driven the construction of hotels, marinas, condominiums, and other developments in coastal areas. During the economic growth period of the 1960s and 1970s, approximately 14 wetland sites were altered on St. Thomas and St. John (U.S. Geological Survey 1994). A review of aerial photographs of the USVI revealed that an alarming portion of the mangroves have been lost in just the last few decades. The Virgin Grand Hotel (now the St. John Westin) at Great Cruz Bay on St. John and the Sapphire Beach Resort, Grand Palace, and Sugar Bay Resort on St. Thomas sit on what were formerly mangrove wetlands. Southgate Pond on St. Croix and the mangrove wetland at Benner Bay on St. Thomas have been substantially altered by marina construction. Although regulations are now in place to protect these wetland resources, mangroves, salt ponds, and seagrasses are often not able to stand in the way of short-sighted economic development.

Sedimentation poses a serious threat to salt ponds, coral, and seagrasses. Construction on hillsides loosens and exposes soils that are carried by runoff water into salt ponds and bays (Ramos-Scharrón and McDonald 2005). Sedimentation occurs when soil is eroded from the land surface and is collected by rainfall moving over the surface of the ground. The failure to properly install effective silt control devices at construction sites are a major source of eroded soil. Sediment yields on St. John have significantly increased since the 1950s as a result of unpaved road erosion (MacDonald 1997, Ramos-Scharrón and McDonald 2005).

Photo: R. Platenberg

Storm water runoff entering Vessup Bay in Red Hook, St. Thomas, after heavy rainfall.

Other sources of contamination that end up in wetlands and the marine environment include non-point source pollution. Rainfall runoff collects other contaminants from human activities, such as pesticides, nutrients, and toxic substances. Leaky septic systems and runoff from animal operations result in high loads of bacterial contamination present in gut streams, one of the main causes of contamination of beaches after rainfall events (DEP 2004). Leaking septic tanks and discharge pipes lead to sewage being carried with runoff water to coastal areas. Sewage is the most serious and widespread pollution problem in the Caribbean (Schumacher et al. 1996). Sewage effluent in salt ponds may be sequestered and processed by sediment bacteria, but the processing efficiency tends to decrease with increasing input. Toxic elements in wastewater accumulate in salt ponds through evaporation (Jarecki 2003). Waste oil from cars is frequently disposed of into the ground or sprayed on dirt roads to control dust (Jarecki 2003). Leaks in underground fuel tanks are generally not identified until fuel begins leaching into coastal waters. Rain can wash discarded or leaked petroleum through the soil and into ponds. In the USVI municipal trash collection dumpsters are almost invariably located on major roads where guts transect the road. There are no measures to prevent trash from being washed into the gut and contaminants leaching into the adjacent soils, resulting in certain guts being highly polluted with trash and residential contaminants. The role of guts in the transport of pollution from upland sources to the sea has largely gone ignored (Nemeth and Platenberg 2005).

USVI wetlands are also impacted by natural forces. Natural stresses include unseasonably low and high temperatures, changes in soil salinity due to changes in hydric regime, wind damage and sediment deposition resulting from storms and floods, sea level rise, coastal erosion, and damage due to grazing by insect herbivores. Mangroves may be affected by rising water levels as a result of global climate change. Human encroachment prevents the mangroves from moving up the shore. Hurricane effects from rising sea temperatures have had devastating impacts on mangroves and salt pond systems, and impacts from hurricanes Hugo (1989) and Marilyn (1995) are still visible today. Hurricane winds defoliated mangroves to such an extent that many died. In addition, a number of black and white mangroves were uprooted (Knowles and Amrani 1991).


Photo: R. Platenberg

The non-native Cuban Treefrog *Osteopilus septentrionalis* inhabits nearly every freshwater source in the USVI.

Invasive non-native aquatic species are also a serious threat to wetland ecosystems. Crayfish, freshwater mussels, and bullfrogs (*Rana catesbeiana*) are examples of introduced species that have wreaked havoc in wetlands in the US, impacting native populations through direct predation, competition for resources, and introduction of diseases. In the USVI, garden centers, pet shops, and container ships are common means of introduction of invasives. The deliberate release of unwanted pet red-eared sliders (*Trachemys scripta*) has lead to nearly every freshwater pond on St. Thomas supporting a non-native turtle population. The South American cane toad (*Bufo marinus*) is also present in freshwater ponds. The Cuban treefrog (*Osteopilus septentrionalis*) is ubiquitous in guts, ditches, and cisterns across both St. Thomas and St. John (Platenberg and Boulon 2006). Invasive aquatic plants can also have severe impacts, e.g., by choking waterways.

Conservation Framework for USVI Wetlands

National Wetlands Regulations

Five federal agencies share the primary responsibility for protecting wetlands (Votteler and Muir 2002). The duties of the Army Corps of Engineers (ACoE) are related to navigation and water supply. The Environmental Protection Agency (EPA) oversees the protection of wetlands primarily for their chemical, physical, and biological integrity. The U.S. Fish and Wildlife Service (USFWS) is responsible for managing fish and wildlife species and threatened and endangered species. The wetland authority of NOAA lies in its charge to manage coastal resources. The Natural Resources Conservation Service (NRCS) focuses on wetlands affected by agricultural activities (Votteler and Muir 2002).

There is an array of federal wetland protection programs and policies, covering aspects of protection, restoration, acquisition, and restoration of wetlands and watersheds, including the protection of associated natural resources (Votteler and Muir 2002). Certain policies, such as the Migratory Bird Acts and the Endangered Species Act, affect wetlands indirectly by protecting the species that utilize them. Four main statutes provide for the

Photo: R. Platenberg

Fresh water stock pond at Fortuna, St. Thomas. White-cheeked Pintail ducks (*Anas bahamensis),* a species of concern, can be observed swimming across the pond.

strongest protective measures. The Section 404 of the Clean Water Act is the primary vehicle for federal regulation of activities within wetlands. It aims to restore and maintain the chemical, physical, and biological integrity of waters in the U.S. It also controls discharge of dredged or fill material into wetlands and other waters. The “Swampbuster” Act (part of the Food Security Act of 1985 and 1990) removes federal incentives for agricultural conversion of wetlands. The Coastal Zone Management Act requires the conservation of natural resources, including wetlands and coastal waters, and environmentally sound development within coastal zones. The Coastal Barriers Resources Act denies federal subsidies for development within undeveloped and unprotected coastal barrier areas, including wetlands.

The national Coastal Zone Management Act, while noting the importance of the entire coastal zone, declares that certain areas are of yet greater significance (National Oceanic and Atmospheric Administration 1988). As a prerequisite to program approval, the Act requires inventory and designation of Areas of Particular Concern (Section 305(b)(3)). In addition, it requires that the management program makes provision for procedures whereby specific areas may be designated for the purpose of preserving or restoring them for their conservation, recreational, ecological, or esthetic value (Section 306(c)(9); National Oceanic and Atmospheric Administration 1988). Requirements set forth by floodplain and wetland protection orders further ensure protection and proper management of food plains and wetlands by federal agencies.

Wetland losses are protected under a number of regulations. In cases where the loss of a wetland cannot be avoided, mitigation measures are required to ensure no net loss. Mitigation measures aim to replace existing wetland or functions by creating a new wetland, restoring a former wetland, or enhancing or preserving an existing wetland to compensate for authorized destruction of an existing wetland (Votteler and Muir 2002).

An estimated 74% of US wetlands are on private lands (Votteler and Muir 2002), and many of the regulations regarding federal actions are not applicable. Several programs have been developed to offer incentives to private landowners to preserve their wetlands. The “Swampbuster” program and the Wetland Reserve Program are examples of such landowner incentive programs.

A complete list of federal programs and regulations affecting wetlands can be found at: http://water.usgs.gov/nwsum/WSP2425/legislation.html and http://ipl.unm.edu/cwl/fedbook/index.html. A summary of the main federal statutes concerning wetlands and wetland resources is contained in Appendix 2.

USVI Wetlands Regulations

A number of local regulations contained within the Virgin Islands Code protect wetland resources both directly and indirectly. The VI Code is the primary mechanism for promulgating legislative regulations, and can be accessed online (www.michie.com). Title 12 concerns the conservation of natural resources, although other sections also provide for environmental protection.

The USVI Division of Planning and Natural Resources (DPNR) is the principal agency requiring permits for construction activities in the coastal zone, where most wetlands in the USVI occur (U.S. Geological Survey 1994). This responsibility was granted to DPNR by the Coastal Zone Management Act passed in 1978, and the Division of Coastal Zone Management (VI-CZM) was established. In addition to evaluating permit requests, DPNR comments on federal permit applications to ensure consistency with the local Coastal Zone Management Plan. When mangrove losses are unavoidable, DPNR requires mitigation actions to ameliorate anticipated losses. DPNR also monitors wetlands to ensure that unpermitted activities are not taking place and that authorized activities are in full compliance with permit requirements.

Photo: R. Platenberg

Salt pond at Fortuna, St. Thomas. Salt ponds are dynamic systems that demonstrate fluxuating water and salinity levels.

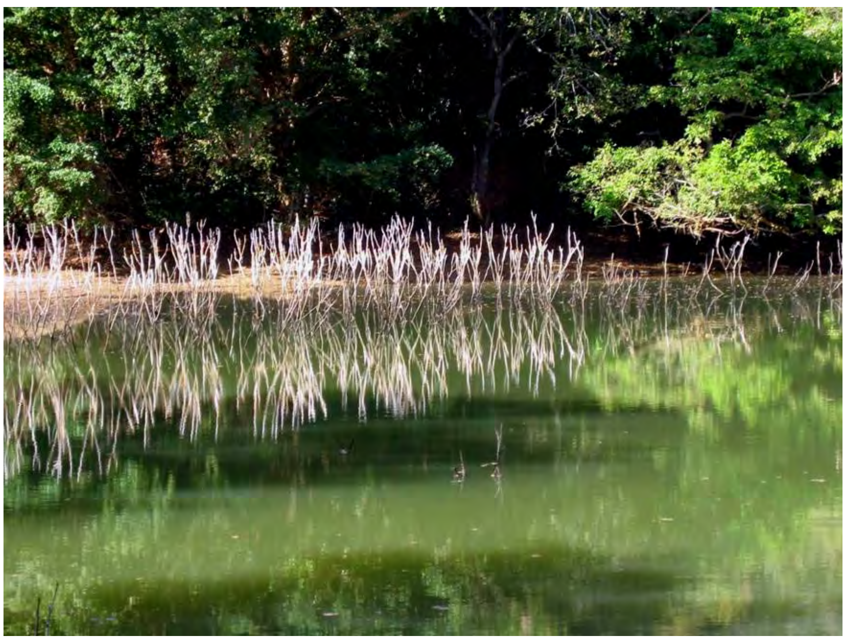
Various marine reserves have been designated in the VI Code and by the Commissioner of DPNR. In addition, 18 Areas of Particular Concern (APCs), although lacking management plans, have been designated under Federal and Territorial authority that include coastal salt ponds, mangroves, and seagrass beds (NOAA 1988). Marine reserves in the USVI include mangroves and seagrass beds, even though the reserves may not have been specifically created for these resources (NOAA 1981, Impact Assessment 1997, Hinds Unlimited 2003). The laws and rules and regulations for territorial waters are codified in the VI Code and VI Rules and Regulations, respectively. Additionally, the Territorial Legislature adopted the Indigenous and Endangered Species Act of 1990 (Title

12, Chapter 2, VI Code), which establishes a policy of “no net loss of wetlands” to the maximum extent possible.

One of the more promising aspects of the VI-CZM Program has been the prospect that Areas of Particular Concern (APC) management plans would provide needed conservation guidelines and site protection strategies for valuable resource features within each of the 18 identified APCs, all sited within the USVI coastal zone (NOAA 1988). However, owing to the unrealistic scope of these APCs and the huge amount of money that would be required to adequately plan and implement each of these APCs, this has not happened. Draft management plans for the 18 APCs were developed, although since they were never approved by the legislature these have become background documents. To date, no APC management plan has been approved by the Virgin Islands Legislature, a step required under CZM legislation prior to plan implementation (Towle 2003). As such, the APC designation has no “teeth” in determining appropriate development activities in these areas.

Under the provisions of the Territorial Pollution Control Act of 1972 (Title 12, Chapter 7, VI Code), the Virgin Islands Water Pollution Control Program is mandated to conserve, protect, preserve, and improve the quality of water for public use, and for the propagation of wildlife, fish, and aquatic life in the Virgin Islands. The role of this program is to facilitate the preservation and - where necessary - make improvements to water quality conditions so as to ensure that water quality standards are met; to monitor health; and to ensure that permitted discharges to waters of the VI meet effluent limitations. The DPNR/DEP is charged with the task of implementing and enforcing these provisions (DEP 2002).

Photo: R. Platenberg



Freshwater pond, Bordeaux, St. Thomas.

Local regulations affecting wetlands are listed in Appendix 3. Specific measures for individual wetland types are listed under individual sections.

Wetland Protection Measures

In addition to wetland protection legislation, other programs have been developed to promote the protection and conservation of wetlands and coastal waters through acquisition, pollution and sediment control (see management section, below), and wetland mitigation.

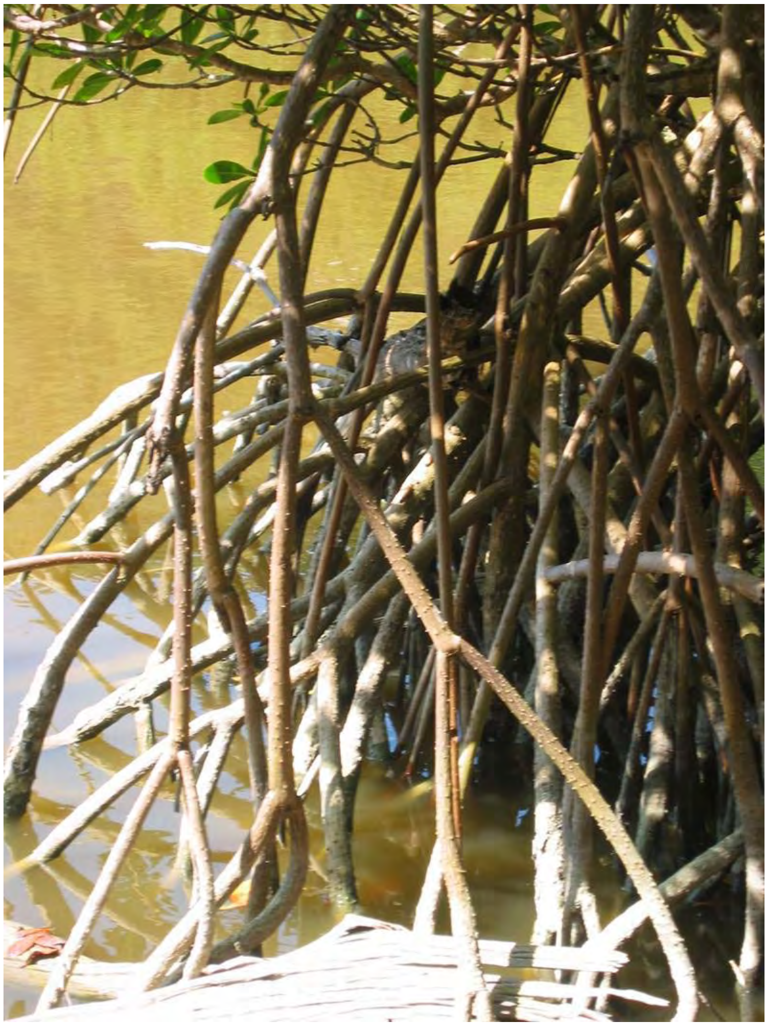


Photo: R. Platenberg

Red Mangrove *Rhizophora mangle* prop roots, fringing a salt pond.

Mechanisms such as the North American Wetlands Conservation Act and the National Coastal Wetlands Conservation Grant provide funding to promote long-term conservation of wetland ecosystems and waterfowl and other migratory birds, fish and wildlife that depend on such habitats. The Land and Water Conservation Fund, Federal Aid in Wildlife Restoration Act, and the Migratory Bird Conservation Act provide means for wetland acquisition. Although most of the wetlands within the USVI are owned by the territorial government under the Submerged Lands Act, the impacts to these wetlands are caused by activities outside of the wetland delineation and such lands could be justifiably acquired under wetlands protection programs.

Within the USVI, the CZM program aims to manage, enhance, protect, and preserve coastal resources including wetlands. In conjunction with VI-DEP, the CZM program manages the Coastal Non-point Source Pollution Program to improve the quality of waters surrounding the islands and cays of the USVI, including the wetland systems of mangroves and seagrass beds. National management measures to protect and restore wetlands and riparian areas for the abatement of non-point source pollution can be found at: www.epa.gov/nps/wetmeasures.

Wetland mitigation is an attempt to alleviate some or all of the detrimental effects arising from an authorized destruction of an existing wetland or functions by creating a new wetland, restoring a former wetland, or enhancing or preserving another existing wetland (Votteler and Muir 2002). Mitigation is conducted case by case, either by directly replacing a lost pond or through the mitigation banking system. A mitigation bank is a wetland that is created, restored, or enhanced to compensate for future wetland loss through development. Mitigation banks are paid for through the sale of credits to those who develop wetlands; developers pay a proportionate cost toward acquiring, restoring, maintaining, enhancing, and monitoring the mitigation bank wetland. There are problems with a readily available mitigation program, however. People are less inclined to retain and protect habitat if there is the supposition that it can be easily replaced. Wetland creation projects tend to have low success because of the difficulty of reproducing wetland hydrology. The mitigation wetland is often not the same type as that lost, thereby perhaps avoiding a net loss of wetland, but not preserving specific wetland functions. The lack of follow-up in mitigation program is always an issue; where monitoring is included in the initial mitigation plan, it is usually insufficient for determining long-term trends to allow for adaptive management mechanisms.

Photo: R. Platenberg

White Mangrove *Laguncularia racemosa* seed pods.

Wetlands Research in the USVI

There has been a considerable amount of work conducted on wetlands in the USVI, primarily on salt ponds and mangrove systems. Inventories of wetlands have been conducted on several occasions. Stengel (1998) described 69 salt ponds on St. Thomas, St. John, Water Island, and adjacent cays, and included lists of species observed and recommendations for conservation. For this project, pond size and location was measured from the 1982 USGS topographical maps (Stengel 1998). More recently, DEP contracted the CDC, ECC, and IRF to conduct an inventory of wetlands and associated riparian areas of the USVI, and to update and map wetlands previously identified through the Virgin Islands Rapid Environmental Assessment. In addition, the project aimed to design and test basic monitoring tools for the characterization of wetlands and to develop a method for assessing the impact of stressors using biological, chemical, and physical properties as indices of biological integrity (IBI; Devine 2004). The initial phases of this project were completed in 2005, resulting in geodata and IBIs for selected salt ponds and watersheds in highly disturbed, intermediate disturbed, and undisturbed areas. The cays were not included. This was a pilot project for a larger scale, long term wetlands monitoring program, which as yet has remained unfunded and therefore unimplemented. There is still a need to establish a relational database to manage and disseminate these data, and to produce a user-friendly product. To date, the Stengel (1998) inventory stands as the most complete for salt ponds of the northern USVI.

The Water Resources Research Institute (WRRI) at UVI conducts research on water resources and related areas, assists in training of students and water resources professionals, and provides information exchange on water resources locally, regionally, nationally, and internationally. Recent research activities include investigations of the hydrology of a small watershed for the purpose of developing guidelines for non-point source pollution management, development of management measures for sediment and pollution reduction (Virgin Islands Water Resource Research Insititute 2004), sediment retention functions of salt ponds (Rennis et al. 2006), and faunal indicators of water quality in guts (Nemeth and Platenberg 2005). Other research through UVI includes mangrove restoration at hurricane-damaged Lameshur Bay on St. John (http://marsci.uvi.edu/mangrove.htm). In the BVI, an extensive study on the ecosystem characterization of hydrological, chemical, and biological parameters of salt ponds was conducted (Jarecki 2003, Jarecki and Walkey 2006). This work identified the importance of salt pond complexes, because the salinity fluxuations were not synchronized across ponds, leading to shifting assemblages of aquatic populations. Waterbirds depend on these fluctuating prey populations and regularly move between ponds. Therefore, effective conservation measures must protect the range of waterbodies rather than individual ponds (Jarecki 2003). Gangemi (2003) conducted an ecological assessment of salt ponds on St. John to identify a range of indicators for determining water quality. Data were collected for 15 ponds on St. John and analyses determined that fiddler crabs (*Uca* spp.) are a useful indicator of salt pond function as they are the first species to abandon a disturbed system.

The parameters determining the effectiveness of salt ponds in sediment retention were assessed for 17 salt ponds in the USVI (Rennis et al. 2006). Salt ponds were determined to be highly variable in their potential to retain sediment and no single parameter was identified as being able to predict salt pond function. However, sediment trapping ability decreases as wetlands fill in, indicating that the protection of gut and watershed vegetation and the prevention of any increase in upland sediment loads are key to ensuring optimal salt pond function (Rennis et al. 2006).


Photo: R. Platenberg

The USGS gauging station in Turpentine Run, St. Thomas, is also a survey location for invertebrates, including freshwater shrimp.

Despite extensive work aimed at surveying, characterizing, mapping, and assessing functions of wetlands, there has been little attention paid to the aquatic portion of brackish and freshwater habitats. The NPS conducted a survey of fishes in coastal and inland ponds and pools that identified 41 species of fishes utilizing inland brackish- and fresh-water habitats on St. John (Loftus 2003, 2004). With the exception of two exotic species (Guppy *Poecilia reticulata* and Tilapia *Oreochromis mossambicus*), all fish species had colonized inland waters from the ocean (Loftus 2004). A current study through UVI is assessing the biodiversity of fish and crustaceans in guts as indicators for water quality (Nemeth and Platenberg 2005). The need for an assessment of these inland water sources was highlighted by Smith (1993), who discovered a new species of ectoproct on St. John simply because no one had ever looked for them there before.

The use of salt ponds and other wetlands as wildlife habitat has also been documented. Knowles and Amrani (1991) conducted surveys of wildlife at salt ponds on St. Thomas, St. John, and St. Croix, and Knowles (1996) documented species observed in saline wetlands on St. Croix. These works resulted in an initial conservation plan for saline wetlands (Knowles 1997). Norton et al. (1986b) assessed the distribution of waterfowl in the USVI, and Sladen (1992) compared waterbird populations in two types of habitats on St. Croix. As part of the wetland conservation plan for St. Croix, McNair, Yntema, and Cramer-Burke (2005a,b) utilized a prioritization scheme for saline and freshwater wetlands based on surveys of the waterbird communities. Other studies of birds in wetlands have been conducted on St. Croix (McNair 2005; McNair and Cramer-Burke 2005; McNair, Hayes, and Yntema 2005; McNair, Pierce, and Sladen 2005; McNair, Yntema, Cramer-Burke, and Fromer 2005; McNair, Yntema, Lombard, Cramer-Burke, and Sladen 2005) and elsewhere in the USVI (Norton et al. 1985, Norton et al. 1986a).

TNC conducted a biological inventory and created a management plan for the watershed within the Magen's Bay Preserve on St. Thomas, as part of a Landowner Incentive Program aiming to further watershed conservation on private lands (The Nature Conservancy 2005a,b). Species lists were compiled for birds, reptiles, amphibians, and plants according to habitat type within the preserve (The Nature Conservancy 2005a). The management plan highlighted minimized development, erosion control, and control of invasive species as important measures for the preservation of biodiversity, not only within the Magen's Bay Watershed but across the northern USVI (The Nature Conservancy 2005b).

One of the most important, as well as the most disturbed, mangrove system on St. Thomas, Benner Bay-Mangrove Lagoon, has been subject to a number of water quality and ecological studies in the 1970s (Grigg et al. 1971, Nichols and Towle 1977, Nichols et al. 1979). The background documentation for the Benner Bay-Mangrove Lagoon APC designation has been prepared (Island Resources Foundation 1993), although the management plan has yet to be completed. There have been few, if any, follow-up studies on these initial findings. The use of mangroves nursery areas for commercial and recreational fishes is well documented (Thayer et al. 1987, Boulon 1990, 1992; Dennis 1992, Adams and Tobias 1994, Tobias 1996, 1998, 2001; Mateo and Tobias 2001, Adams and Ebersole 2002, Mateo 2001, Mateo et al. 2002). Wauer and Sladen (1992) identified mangroves as important areas for migratory birds. Current research on mangroves is being conducted through UVI, to include the importance of mangrove and seagrass beds as nursery habitats for fisheries production, and mangrove restoration to repair hurricane damaged systems. Further information on these and other projects can be found at: http://marsci.uvi.edu/research.htm.

Although few studies have been conducted specifically on seagrass beds in the USVI, they have been mapped under the Benthic Habitat Assessment Project that provides data on the distribution and abundance of important recreational fisheries habitat and aims to monitor changes by installing permanent transects at sites that characterize the predominate shallow water benthic habitats, including seagrass beds, in the USVI (Chapman et al. 1996, Adams et al. 1998, and Kojis et al. 2000).

Photo: R. Platenberg

Salt pond at Privateer Bay, St. John during a dry phase.

Management, Monitoring, and Other Wetlands Programs in the USVI

Coastal wetlands fall under the jurisdiction of CZM, although the VI-DEP holds the primary responsibility for wetland protection and management in the USVI. They are responsible for the administration of the Clean Water Act, by conducting ambient monitoring of water quality, developing water quality standards, and establishing and monitoring acceptable contaminant levels. The Non-Point Source Pollution (NPSP) Management Program, administered jointly between CZM and DEP, aims to protect ground water and coastal waters by mitigating both land and marine NPSP sources, such as ineffective silt control devices during construction, storm water run-off from unpaved roads, failure of sewage disposal systems, and unpermitted industrial discharge. CZM addresses the effects of coastal NPSP through the development of rules and regulations.

The Virgin Islands Non-point Source Pollution Conference is an annual event that provides education and outreach about non-point source pollution issues in the USVI to increase awareness, knowledge levels, and skills resulting in behavior and practice changes by government, industry, and residents in order to improve water quality throughout the USVI. The conference brings together scientists, agency personnel, community and home-owners associations, non-governmental agencies, local industry, and students to examine environmental issues. More information on the conference can be found online at http://usvircd.org/NPS/VINPSconf2005.index.html.

Several other programs administered through DEP aim to manage, protect, and restore wetlands and watersheds. The Integrated Watershed Management Plan evaluates all natural systems within a watershed, to identify and locate pollutant sources, estimate contaminant contribution of pollutant source, and measure the assimilative capacity of the watershed by establishing and monitoring Total Maximal Daily Load (TMDL) limits. This program also aims to collaborate with DPNR divisions to streamline and improve the permitting process to better address watershed management, particularly by implementing land-based restrictions within impaired watersheds. The Watershed Education Program promotes environmental stewardship by residents, government agencies, non-profit organizations, and private businesses. Special watershed educational programs are being developed for students and teachers in grades 6-12. The Wetlands Program aims to update existing inventories and maps of wetlands in the USVI, and develop monitoring tools to assess effects of stressors on wetland areas based on indices of biological, chemical, and physical data. Pilot studies for this program have been conducted under EPA funding, but the program itself remains unfunded (A. Hutchins, pers. comm.).

Photo: R. Platenberg

Freshwater pond at Bolongo, St. Thomas.

Goals, Objectives, and Actions for USVI Wetlands

Goals

The overall goal of a cooperative wetlands conservation program for the USVI is to manage wetlands ecological assets for the benefit of present and future generations of Virgin Islanders. The intrinsic ecological value and benefits to wildlife and fisheries resources will ultimately provide benefit to the local community in increased water quality, reduced non-point source pollution, protection of commercial and recreational marine resources, and opportunities for recreation and education.

Objectives and Actions

The goal of a wetlands conservation program in the USVI may be achieved through the realization of the following listed objectives. Some of the actions required to meet these objectives, and potential partners and stakeholders, are described. Some of the listed actions have been completed or are ongoing and are included to produce a comprehensive list of needs. Because wetland systems are dynamic and the agencies charged with their protection and management are variable in terms of staff, expertise, funding, etc., these objectives require periodic assessment and revision. Without a coordinated effort among agencies and stakeholders efforts are likely to be overlooked and/or replicated. The acronyms used are listed at the end of the chapter.

- **Inventory**:
  - Conduct inventory of wetlands, to include size of wetland and location.
  - Characterize wetland habitat.
  - Identify wetland functions.
  - Map locations of wetlands.
  - Develop and maintain a territory wide georeferenced wetland inventory.
  - Identify landowners of adjacent properties.
  - Conduct literature review of research on local and regional wetlands.
  - Identify potentially problematic invasive species.

Partners: ACoE, CDC, CZM, DEP, DFW, ECC, EPA, IRF, UVI, VI-DOA, VINP

- **Monitoring**:
  - Research and develop techniques for monitoring health of wetlands.

- Identify wetland indicators.
- Monitor sentinel species and metrics (e.g., mangrove populations, fiddler crabs).
- Establish adaptive management feedback mechanisms to determine effectiveness of conservation actions.
- Monitor presence, distribution, and spread of invasive species.
- Monitor contaminant levels in impaired and unimpaired watersheds.

Partners: CDC, CZM, DEP, DFW, ECC, IRF, TNC, UVI, VINP

- **Data management**:
  - Create relational database for wetlands information.
  - Coordinate access to data and for data deposition for other entities.
  - Manage GIS data and metadata.

Partners: CDC, CZM, DEP, DFW, ECC, IRF, TNC, UVI

- **Watershed management**:
  - Integrate wetlands management and conservation into the watershed level, thus incorporating upland land use practices that may impact wetlands (e.g., erosion, non-point source pollution).
  - Coordinate efforts and information to ensure that unimpaired wetlands do not become impaired.
  - Establish a single-tier system within the territory that assesses upland development using coastal zone policy.
  - Develop a land and water use plan that considers the protection of wetlands and watersheds in future development projects.
  - Include wetlands and watersheds in all resource management plans.
  - Encourage local agencies to operate on a watershed basis.
  - Establish Best Practice Management protocols for watershed protection.

Partners: CZM, DEP, DFW, DPNR, EPA, NOAA-NMFS, NRCS, VI-DOA, VINP

- **Pollution control**:
  - Research and develop techniques for preserving and restoring water quality and pollutant control.
  - Establish and enforce best practice management policies for development projects that will prevent contaminants from impacting watersheds.
  - Improve coordination of permitting to ensure best practice management in erosion and sediment control in development projects.
  - Research and develop techniques for reducing soil erosion.
  - Improve waste management practices.
  - Establish a rigorous inspection regime of septic systems and other sewage treatment methods.

- Improve enforcement of environmental violations.
- Review and refine recommendations for water quality standards in all territorial wetlands.
- Work with farmers to reduce contaminants washing into guts and gut pools.

Partners: ACoE, CZM, DEE, DEP, EPA, NOAA-NMFS, NRCS, TNC, UVI, VI-DOA

- **Education**:
  - Develop information and education programs on wetland resources.
  - Conduct workshops on wetland resources for teachers and agency personnel.
  - Disseminate information to landowners and developers regarding best management practices in watershed protection.
  - Develop wetland resource materials for use by teachers.
  - Prepare information for developers regarding watershed protection.
  - Establish wetlands viewing sites, to include trails, boardwalks, and bird blinds, to provide outdoor education resources.
  - Increase recognition of the significance of wetlands for coastal protection, flood defense, cultural heritage, and scientific research.
  - Provide materials regarding the impacts of release of non-native species, including plants.

Partners: CZM, DEP, DFW, EAST, IRF, SEA, TNC, UVI, VINP

- **Landowner participation**:
  - Provide technical assistance to landowners to allow for the conservation, protection, enhancement, or restoration of wetlands on private lands on a watershed level.
  - Identify methods for reducing erosion and non-point source pollution originating from private properties.
  - Establish a Landowners Incentive Program to address watershed issues on private properties, including methods for reducing erosion and contaminant sources.
  - Provide technical assistance to farmers to protect and enhance agricultural ponds.
  - Produce wetland resource information and outreach materials for private landowners.
  - Examine the feasibility of granting tax incentives for landowners with wetlands or watershed resources on their property as a tool for conserving watershed resources on private property.

Partners: CZM, DEP, DFW, DPNR, IRF, NRCS, TNC, VI-DOA

- **Prioritization**:
  - Establish a prioritization scheme for wetlands that identifies and weighs wildlife and fisheries value, restoration need, and feasibility of potential actions.

- Identify and prioritize wetland sites for acquisition, restoration, and/or enhancement.
- Provide coordination of existing federal, local and private wetlands acquisition programs to increase buffer areas around jurisdictional wetlands.
- Maintain updated information on wetland-dependent rare and endangered species.

Partners: CDC, CZM, DEP, DFW, IRF, NRCS, UVI, VINP

- **Coordination**:

  - Promote the coordination of wetlands management among stakeholders and agencies within the territory and regionally.
  - Identify personnel within coordinating agencies to establish a commitment to wetlands and watershed management.
  - Establish a wetlands working group, with representatives from all stakeholders.
  - Establish a committee based of members of different divisions within the VI government to jointly assess development impacts on watersheds and wetlands.
  - Improve enforcement of wetlands protection measures by increasing resources and training for enforcement personnel.
  - Identify an entity to coordinate data collection among stakeholders and local agencies.
  - Identify funding through existing federal, local and private mechanisms for wetlands and watershed management.
  - Increase staffing levels within agencies

Partners: all

- **Conservation**:

  - Establish buffer zones to protect wetland species that rely on upland habitat for cover, nesting, foraging, and migration, and to insulate wetlands from human activity impacts.
  - Reduce soil erosion and other contaminants in watersheds.
  - Identify mechanisms for protecting, enhancing and restoring wetlands and buffers.
  - Identify financial resources for wetlands acquisition.
  - Include wetlands in all resource management plans.
  - Establish a mitigation bank.
  - Eradicate or control non-native species in wetlands and watersheds.
  - Establish a net gain wetlands policy with a no net loss (including mangroves and seagrass beds) on all development projects.

Partners: CZM, DEE, DEP, DFW, DPNR, EAST, EPA, IRF, NOAA-NMFS, NRCS, SEA, UVI, TNC, VINP

Recommendations for Implementation—the next step

One of the major stumbling blocks for wetlands management and conservation in the USVI is the lack of coordination among agencies, organizations, and relevant individuals. As detailed in previous chapters, there is a considerable amount of interest and expertise in the community that can be corralled into a cohesive unit. The establishment of a Wetlands Working Group is a critical initial measure to ensuring informed and prioritized decision-making. A lead agency that has an appropriate funding mechanism in place needs to be identified, and key personnel across all entities identified as coordinators. Once this working group has been established, decisions can be made as to funding opportunities and priorities for action. There are three methods for the establishment of this working group:

- The Commissioner of DPNR can appoint an interdepartmental task force to further build on the objectives outlined in the Wetlands Conservation Plan. An example of this method can be found in the East End Marine Park Advisory Committee, which was established when the Commissioner invited members of the public, the research community, non-governmental organizations, and agencies within DPNR to participate in developing a management plan for this protected area.

- An agency within DPNR can take the lead on wetland issues and establish an interdepartmental advisory committee. DEP has already taken initial steps by conducting watershed management workshops within government agencies, which could be extended to the larger wetland community to include UVI and non-governmental organizations.

- A workshop can be convened to draw together all relevant parties and formalize a working group. An example of this is the GIS conference held in St. Croix in 2006, during which relevant individuals and key agency personnel were identified and joint projects were initiated.

Acronyms used:

ACoE	Army Corps of Engineers
CDC	Caribbean Data Center (UVI)
CZM	Division of Coastal Zone Management (DPNR)
DEE	Division of Environmental Enforcement (DPNR)
DEP	Division of Environmental Protection (DPNR)
DFW	Division of Fish and Wildlife (DPNR)
DPNR	Department of Planning and Natural Resources
EAST	Environmental Association of St. Thomas and St. John
ECC	Eastern Caribbean Center (UVI)
EPA	Environmental Protection Agency
IRF	Island Resources Foundation

NOAA-NMFS	National Oceanic and Atmospheric Administration - National Marine Fisheries Service
NRCS	Natural Resources Conservation Service
SEA	St. Croix Environmental Association
TNC	The Nature Conservancy
UVI	University of the Virgin Islands
VI-DOA	Virgin Islands Department of Agriculture
VINP	Virgin Islands National Park

Photo: R. Platenberg

The control of sediment runoff is likely the single most effective action for protecting and restoring wetlands. Although sediment control regulation falls under the jurisdiction of DPNR, it requires a concerted effort by a variety of stakeholders to accomplish.

Wetland Types: Seagrass Beds

Description

Seagrasses are seed-producing, flowering marine plants (halophytes) that occur in shallow, nearshore, temperate, and tropical waters (Snedaker and Getter 1985). Worldwide, there are approximately 45 species of marine seagrasses (Tetra Tech 1992). They are able to reproduce by vegetative spreading in addition to the annual production and dispersal of seeds. As a benthic plant community, they are extremely productive and are associated with an abundance and variety of small fishes and invertebrates such as shrimp and crabs (Thorhaug 1981), and provide feeding grounds for sea turtles. Seagrasses dominate environments with a suitable shallow substrate, clear water with high transparency, and relatively free of strong wave action (Snedaker and Getter 1985). Their broad distributional range is further attributable to the fact that seagrasses, as a whole, can tolerate wide salinity ranges that vary in concentration from brackish to hypersaline (Thayer et al. 1975).

Photo: R. Platenberg

Manatee Grass *Syringodium filiforme*, an early colonizer of disturbed sandy areas.

The basic habitat requirements for seagrasses are a shallow, soft substrate and water of high transparency (Thayer et al. 1975). In addition, they require circulation of the overlying water to deliver nutrient and substrate material and remove metabolic waste products. In the regions where they occur, seagrasses do not develop in shallow areas that are exposed at low tide, although they can survive brief exposure during periods of low tide. They are commonly associated with coral reef communities because of their similar requirements for high water quality.

Three species of seagrass are dominant in the USVI (Delgado and Stedman 2004). Turtle-grass (*Thalassia testudinum*) is the most common of the local grasses and characteristically has deeper root structures than the other seagrasses. This is a later colonizer to bare substrate and becomes the dominant species. The leaves are ribbon-like and can be over a foot long. Shoal-grass (*Halodule wrightii*) is an early colonizer of disturbed areas and usually grows in water too shallow for other species. The leaves are thin and flat in cross-section. Manatee-grass (*Syringodium filiforme*) is also an early colonizer of bare substrate; it is easily recognized because the leaves are round in cross-section. Often, species of macroalgae (e.g., *Caulerpa* and *Halimeda*) are interspersed between the grass blades, which themselves are colonized by epiphytes (Thayer et al. 1975). Seagrass beds may consist of a single species or more than one species together.

Ecological Value

Seagrasses form extensive plant carpets, thus diminishing the effects of strong currents, providing protection to fish and invertebrates, and preventing the erosion of bottom areas (Thayer et al. 1975, Delgado and Stedman 2004). By stabilizing the sediment and increasing deposition of suspended particles, seagrasses help to provide clear water for adjacent coral reefs.

Value to Wildlife

Seagrass beds are areas of high productivity and are important to fish and other organisms as a direct or indirect source of food. The leaves and leaf detritus represent a food resource for many other marine animals (e.g., certain reef fishes, sea turtles, conch) that regularly visit seagrass areas for feeding and foraging on both the plants and their animal associates. The queen conch (*Strombus gigas*) and some fish species eat the grass blades directly, while other fish feed on detritus from decomposing leaves, invertebrates, small fish, and/or shellfish that can be found attached to their leaves or living within the plants. Some snappers and parrotfishes, for example, move to seagrass beds at night to feed on small fishes, crustaceans and other organisms (Delgado and Stedman 2004). Seagrasses also provide living space, refuge from predators, and essential nursery areas to commercial and recreational fishery species and to a great number of invertebrates that live within or migrate to these habitats.

Photo: R. Platenberg

Southern Stingray *Dasyatis americana*, a common inhabitant of seagrass beds.

Photo: R. Platenberg

Queen Conch *Strombus gigas* peering out of shell.

Human Use

Aside from the role of seagrass beds as habitat for commercial and recreational fisheries, seagrass beds are traditional harvest grounds for conch, which had high value for prehistoric peoples (D. Brewer, pers. comm.) and are still valued today. Sea turtles have also been harvested from this habitat.

Threats

Seagrasses in USVI are disappearing due to many reasons, including dredging and filling projects, soil erosion, and increased levels of water pollution (Tetra Tech 1991). Although seagrasses are a hardy group of plant species, they are extremely sensitive to excessive siltation, shading, water pollution, and fishing practices that use bottom trawls that scrape the beds (Zieman 1975). Siltation and shading reduce ambient light levels in the water, resulting in a reduction or elimination of the rate of photosynthesis. Certain pollutants in water have toxic effects on the growth and development of not only seagrasses, but also many of their animal associates. In the USVI the proliferation of residential septic tanks has resulted in high soil loading which, during high rainfall, generates nutrient-rich runoff into the sea (Ogden and Gladfelter 1983). This has caused short-term eutrophic conditions in various bays around St. Thomas and St. Croix. Excessive nutrient enrichment of seagrass beds could result in the replacement of seagrass with phytoplankton or benthic algae (Zieman 1982). Seagrasses are also sensitive to hot-water discharges and are usually eliminated from areas subjected to effluents from power plants as well as brine disposal from desalination plants (Zieman 1970, Ogden and Gladfelter 1983). Other physical disturbances include anchor and propeller damage.

For reasons that are not clearly established, seagrasses only slowly, if at all, re-vegetate areas that have been dredged (VanEepoel et al. 1971). Waters need to have contamination sources eliminated for seagrass regeneration (Fonseca et al. 1998). Typically, when a seagrass community is eliminated, its marine animal associates also disappear from the area.

The animal communities of seagrass beds are readily over-fished because of their accessibility and visibility (Ogden and Gladfelter 1983). Beach-seining for little fishes is very destructive. Conch (*Strombus* spp.) and edible echinoid populations (*Tripneustes* spp.) have been drastically reduced in some parts of the Caribbean (Ogden and Gladfelter 1983). However, an assessment of the shallow water reef fish in the U.S. Caribbean showed declining trends of inshore fisheries resources that cannot be attributed to over-fishing alone (Appeldoorn et al. 1992). In general, unregulated development of upland

and coastal areas has resulted in increased sedimentation rates and the introduction of pollutants that have degraded the water quality of coastal environs (Tobias 1996).

USVI Regulations

Regulations regarding territorial waters under the VI Code and the VI Rules and Regulations apply to seagrass beds. Seagrass beds within marine reserves have additional protection. Seagrasses are also protected as wetlands.

Research, Management, and Monitoring in the USVI

Although few studies have been conducted specifically on seagrass beds in the USVI, they have been mapped under the Benthic Habitat Assessment Project that provides data on the distribution and abundance of important recreational fisheries habitat and aims to monitor changes by installing permanent transects at sites that characterize the predominate shallow water benthic habitats, including seagrass beds, in the USVI (Chapman et al. 1996, Adams et al. 1998; and Kojis et al. 2000).

Potential for Conservation Action

Restoration Actions: Seagrass beds can be restored by encouraging natural recolonization in areas that have experienced improvements in surface water quality. In addition, seagrasses can be planted or transplanted, although the effort is labor intensive and requires extensive planning (Fonseca et al. 1998). The initial action in any seagrass restoration project is to eliminate and prevent upland sources of sedimentation and other contaminants.

Protection Actions: The status of seagrasses as EPA-designated wetlands within the USVI, making them federally protected, needs to be emphasized. Enforcement of non-point source pollution and other erosional issues need to be enhanced. Eliminate boat discharge by establishing pumpout stations and install moorings to prevent anchor damage.

Acquisition Actions: Although the potential of acquiring seagrass beds themselves is not applicable, since submerged lands within three nautical miles of the shore belongs to the VI Government, acquisition of coastal lands and watersheds would ensure protection of seagrasses. The presence of seagrass beds in coastal waters should be a priority factor in wetland acquisition decisions.

Education/Recreation Actions: Seagrass beds are popular snorkeling locations due to the opportunity to observe sea turtles and other marine organisms, and several tour operators are already utilizing this resource. An extensive seagrass bed off Buck Island National Wildlife Refuge near St. Thomas is possibly the most visited location by day sail operators, and snorkellers are always rewarded with multiple sightings of foraging green turtles (*Chelonia mydas*). Educational benefits could be enhanced by encouraging tour operators to provide accurate information. Fact sheets and informational booklets should be prepared and disseminated to these user groups. This habitat is underutilized by local school groups, which could be increased by providing school groups with snorkeling equipment and instruction on coastal visits, in conjunction with educational materials produced by DFW.

Species Associated with Seagrass Beds

The following is a list of species associated with seagrass beds. Both common and rare species are listed, although these are not comprehensive lists due to a lack of a complete inventory for all taxa. The list has been compiled from Delgado (2004), DFW (2005), and personal observation.

Vegetation

Family	**Species**	**Common Name**
Cymodoceaceae	*Halodule wrightii*	Shoal Grass
Cymodoceaceae	*Syringodium filiforme*	Manatee Grass
Hydrocharitaceae	*Thalassia testudinum*	Turtle Grass

Invertebrates

Strombidae	*Strombus gigas*	Queen Conch
Oreasteridae	*Oreaster reticulatus*	Cushion Sea Star
Callianassidae	*Callianassa* spp.	Ghost Shrimp
Alpheidae	*Alpheus normanni*	Green Snapping Shrimp
Palunuridae	*Panulirus argus*	Spiny Lobster

Fish

Labridae	*Halichoeres poeyi*	Blackear Wrasse
Epinephelinae	*Epinephelus striatus*	Nassau Grouper
Bothidae	*Bothus lunatus*	Peacock Flounder
Scorpaenidae	*Scorpaenopsis grandicornis*	Grass Scorpionfish
Pomacentridae	*Abudefduf saxatilis*	Seargeant Major
Mullidae	*Pseudupeneus maculatus*	Spotted Goatfish
Dasyatidae	*Dasyatis americana*	Southern Stingray
Heterocongrinae	*Heteroconger halis*	Garden Eel

Reptiles

Cheloniidae	*Chelonia mydas*	Green Turtle

Birds

Sulidae	*Sula leucogaster*	Brown Booby
Pelecanidae	*Pelecanus occidentalis*	Brown Pelican
Laridae	*Larus atricilla*	Laughing Gull

Wetland Types: Mangroves

Description

The term mangrove is used to loosely define members of approximately 12 plant families that consist of more than 50 species (Odum et al. 1982). Mangroves are unrelated trees that have converged in their adaptations for colonizing quiet, shallow coastal habitats with a broad range of salinities and relatively anoxic soils. Mangrove forests, which are coastal forested wetlands that are periodically flooded, are one of the most important intertidal plant communities found along low wave-energy shorelines in the tropics (Lewis 1983). They are highly productive environments that support a variety of flora and fauna. Mangroves produce large quantities of organic detritus that may support the high secondary productivity observed in nearshore open waters and embayments (Aiken and Moli de Peters 1988).

Seven species of mangrove trees are found in the Caribbean region (Cintron and Schaffer-Novelli 1983), four of which occur in the USVI. Red mangrove (*Rhizophora mangle*) is the most common, followed by black (*Avicennia germinans*) and white mangroves (*Laguncularia recemosa*), and buttonwood (*Conocarpus erectus*). Each of these species of mangroves has special ecological requirements and adaptations that determine their distribution, areal extent, and response to pollution stressors (Cintron and Schaffer-Novelli 1983). These adaptations are reflected by the distinctive zonation patterns observed within mangrove forests.


Photo: R. Platenberg

Red mangrove *Rhizophora mangle* propagule.

The red mangrove is usually the first species to colonize a new area, due to its tolerance of high water and seed dispersal mechanism. Red mangroves are found on the most seaward edge of land, where water levels are more stable (Barnes 1980). They are recognized by the branched vine-like stilt or prop roots that are often submerged up to a meter deep into the substrate. Red mangroves are known as land forming mangroves, because accumulation of sediment and organic matter in the roots creates conditions that become suitable for the establishment of black and white mangrove species. The elongated tapered seedlings of the red mangrove are released into the water and can float for up to a year until the tapered end becomes water logged and sprouts roots. The seedlings take root in shallow sheltered areas where currents cannot uproot them.

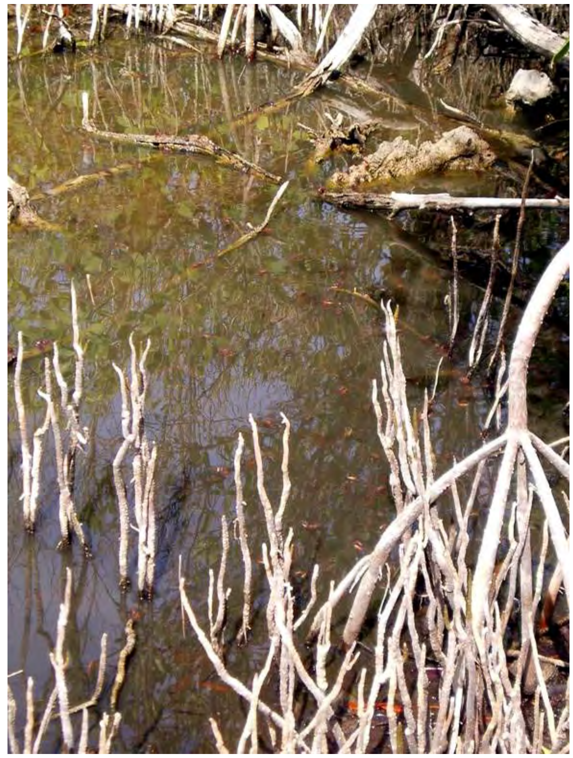


Photo: R. Platenberg

Black mangrove *Avicennia germinans* pneumatophores

Black mangroves are the most salt tolerant of the mangroves, often seen in areas with salinity extremes. They are found at the waters edge and, unlike red mangroves, their root systems cannot tolerate continuous submergence. Black mangroves are characterized by finger-like projections called pneumatophores that extend upward from the root system to allow for oxygen exchange.

White mangroves are found in moist soils adjacent to ponds or open ocean. Less tolerant of saturated soils than either red or black mangroves, whites are generally found further inland. White mangroves can also produce shallow prop roots and pneumatophores if conditions require. White mangroves are recognizable by two large pores found at the base of each leaf to facilitate salt excretion. White as well as black mangroves are generally more tolerant of higher salinities.

Photo: R. Platenberg

Buttonwood *Conocarpus erectus* displaying eponymous seeds

The buttonwood mangrove tends to be found along the upland fringe of a mangrove area, or in coastal areas where other mangrove trees do not occur. Buttonwood is the most inland of the mangroves. It is not tolerant of wet soils and prefers drier or upland soils where it can withstand periods of drought. Buttonwood is named for the appearance of the rounded fruit which resembles Victorian shoe buttons.

There are five mangrove communities in the USVI, based on the classification system of Gibney et al. (2000). ***Mangrove forest*** is dominated by the red mangrove and to a lesser extent by black mangrove, white mangrove and buttonwood, forming a closed canopy. ***Mangrove woodland*** is similar but with a more open canopy and dominated by mangrove species other than the red mangrove. ***Mangrove shrubland*** occurs in stressful, nontidal areas where sparse thickets dominated by red mangrove are less than 5 meters tall and usually 0.5-2 meters tall. ***Fringing mangrove*** occurs along semipermanent, tidally flooded shorelines and salt ponds. ***Mixed swamp*** refers to semipermanent and tidally flooded vegetation communities comprised of a mixture of mangroves and wetland trees and shrubs. Mangroves yield to dry forest, shrublands, or grasslands on higher ground.

The largest mangrove system on St. Thomas is found in Mangrove Lagoon/Benner Bay on the southeast coast (Island Resources Foundation 1985). Several cays within the bay are mangrove-covered, and mangroves fringe the shoreline in some areas. These mangroves are threatened with further encroachment of the human inhabitants and human-induced pollution stresses (Grigg et al. 1971, Phillip 1993).

Photo: R. Platenberg

Mangrove Lagoon, St. Thomas, showing Bovoni cay and several manglar islets.

Ecological Value

Mangrove communities have a variety of recognized roles in the larger ecosystem in which they occur. The most prominent role is the production of leaf litter and detrital matter that is exported, during the flushing process, to the nearshore marine environment (Snedaker and Getter 1985). Through a process of microbial breakdown and enrichment, the detrital particles become a nutritious food resource for a variety of marine animals. Soluble organic materials that result from decomposition within the forest also enter the near-shore environment where they become available to a variety of marine and estuarine filter feeders and benthic scavengers. The organic matter exported from the mangrove habitat is utilized in one form or another, including utilization by inhabitants of seagrass beds and coral reefs that may occur in the area (Snedaker and Getter 1985).

Although mangroves were originally thought to trap and gradually accumulate sediment and grow seaward, it appears that mangroves only stabilize regions of sediment deposition and that little offshore expansion occurs (Lugo and Snedaker 1974). Due to the global rise in sea level, mangroves have actually migrated landward in response to higher sea level (Cintron et al. 1978). However, on shorter time scales (several years), areas colonized by mangroves may fluctuate due to damage caused by storms or changes in patterns of seawater exchange within the mangrove as the result of creation and destruction of sediment barriers on the seaward fringe (Cintron et al. 1978).

In areas of annual cyclonic storm activity, the shoreline mangroves are recognized as a buffer against storm-tide surges that would otherwise have a damaging effect on low-lying land areas. Mangroves are noted for their ability to stabilize coastal shorelines that would otherwise be subject to erosion and loss (Saenger et al. 1983). Probably one of their more important roles is the preservation of water quality; because of their ability to extract nutrients from circulating waters, the eutrophication potential of nearshore waters is minimized. Also, the saline and anaerobic mangrove sediments have a limited ability to sequester and/or detoxify common pollutants (Snedaker and Brown 1981). For example, some heavy metals are sequestered as insoluble sulfides, and certain organic pollutants are oxidized or decomposed through microbial activity.

The documentation of mangroves as nursery areas for recreationally and commercially valuable species, and their prey species, provides impetus for including mangrove habitats in fisheries management plans (Thayer et al. 1987, Boulon 1992, Dennis 1992, Adams and Tobias 1994, Tobias 1996, 1998, 2001; Mateo and Tobias 2001, Mateo 2001a, Mateo et al. 2002, Adams and Ebersole 2002).

Value to Wildlife

Mangrove ecosystems support a high diversity of fish, birds, and other wildlife (Ogden and Gladfelter 1983). Mangrove lagoons are important habitat for juveniles of many fish species (Heald and Odum 1970, Austin 1971a,b; Austin and Austin 1971, Olsen 1972, 1973; Cintron-Molero 1987, Thayer et al. 1987, Boulon 1992, Tobias 1996). They can provide nursery areas for estuarine as well as reef fishes (Odum et al. 1982, Boulon 1985, 1992, Tobias 1996). Many juveniles use detritus and mangrove-associated invertebrates and fish as a food source (Zieman et al. 1984, Thayer et al. 1987). The complex prop-root habitat may also provide protection from predation (Orth et al. 1984, and Sogard and Olla 1993).

Photo: R. Platenberg

Fiddler Crab *Uca* spp., a valuable mangrove resource for migratory birds.

Mangrove wetlands also support a variety of wetland and migratory birds (Wauer and Sladen 1992). A study of bird use of mangrove and salt pond wetlands on St. Croix found that of 121 species of birds recorded, nearly ¾ of them use mangrove habitats, with 26% using mangroves exclusively. Migratory warblers were noted to be the dominant species utilizing mangroves, joined by migratory shorebirds and waterfowl. A number of waders utilize mangrove trees for roosting, and waders, waterfowl, and shorebirds readily inhabit flooded mangrove forests (Knowles 1994).

Mangrove wetlands are the primary habitat for the great land crab (*Cardisoma guanhumi*), an economically important Caribbean species. Although omnivorous, the crab feeds primarily on leaves of buttonwood and red and white mangroves (K. Hill, 2001. http://www.sms.si.edu/IRLspec/Cardis_guanhu.htm). This species is exploited locally as a food source.

Human Use

Of particular concern to fisheries managers are economically important species, such as those targeted by recreational and commercial fishermen (Tobias 1996). The utilization of mangrove habitats by these economical species and their prey species is important (Robertson and Duke 1987). The documentation of mangroves as nursery areas for recreationally and commercially valuable species, and their prey species, provides impetus for including mangrove habitats in fisheries management plans and designating these areas as essential fish habitat (Tobias 1996).

In addition to their ecological role in coastal areas, mangrove forests are a source of many different products having commercial and domestic importance (Snedaker and Getter 1985). In many parts of the world, where direct dependency on local resources is the basis for survival, human populations heavily rely upon products from this habitat. In recent times, as resources have become scarcer, the mangrove habitat and forests have become recognized as resources for commercial utilization for such products as timber, pulpwood, and chips, fuel wood and charcoal, honey production, and various domestic products (Snedaker and Getter 1985). Where it is recognized that societal lifestyle and survival are dependent upon a functioning mangrove system, care is usually taken by the inhabitants to protect it. It is the various uses of mangrove forest products and the plant and animal materials associated with them that lead to pressures concerning their utilization. Integrated planning, which involves simultaneous attention to all sectors and considers the maximum sustained yield of each resource, is an approach which is especially important in the management of mangrove forests (DFW 2005).

Threats

In the USVI, mangrove wetlands are located on prime coastal real estate (Tobias 1996). As a result, they are often threatened by commercial and residential development. A review of aerial photographs of the USVI revealed that an alarming portion of the mangroves have been lost in just the last few decades. The Virgin Grand Hotel (now the St. John Westin) at Great Cruz Bay on St. John and the Sapphire Beach Resort, Grand Palace, and Sugar Bay Resort on St. Thomas sit on what were formerly mangrove wetlands. Southgate pond on St. Croix and the mangrove wetland at Benner Bay on St. Thomas have been substantially altered by marina construction. Although regulations are now in place to protect these wetland resources, mangroves are often not able to stand in the way of short-sighted economic development.

Mangroves wetlands of the USVI have been impacted by natural as well as anthropogenic forces. Natural stresses include unseasonably low and high temperatures, changes in soil salinity due to changes in hydric regime, wind damage and sediment deposition resulting from storms and floods, sea level rise, coastal erosion, and damage due to grazing by insect herbivores. Hurricane Hugo, which passed directly over St. Croix in September 1989, was the last major storm event to significantly alter the wetlands of the islands, although several other hurricane events have also contributed. Hurricane winds defoliated mangroves to such an extent that many died. In addition, a number of black and white mangroves were uprooted (Knowles and Amrani 1991). Additional sources of stress that are unique to mangroves include fire, alterations in drainage patterns, application of herbicides, and harvesting. Anthropogenic sources of stress to mangroves include siltation, surface runoff, oil pollution, sewage effluent, and cooling water discharge from power plants. Although recovery might be slow (perhaps as long as 50 years), the impacted wetlands should become re-established if properly managed.

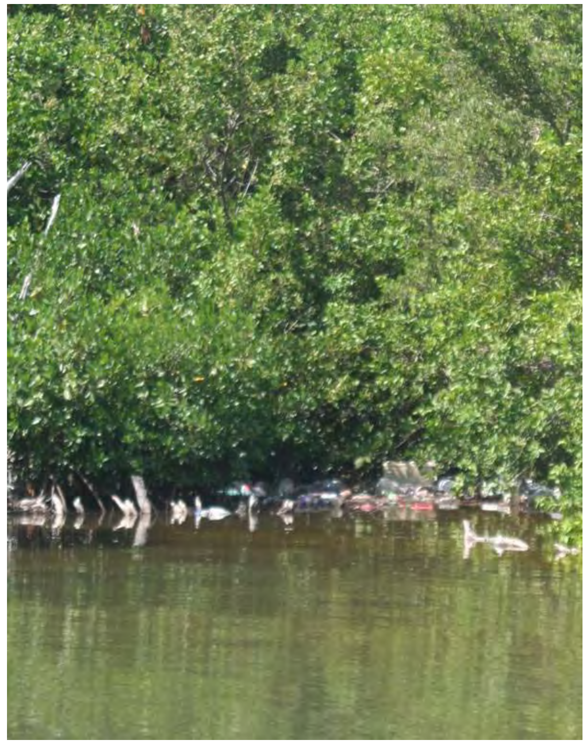


Photo: R. Platenberg

Floating trash collected in mangroves.

USVI Regulations

Mangroves are locally protected through several sections in the VI Code. Title 12, Chapter 2, prohibits the cutting, pruning, removal and disturbance to mangroves, as well as no net loss of wetlands, without express written permission from the Commissioner. Mangroves are also protected under Title 12, Chapter 21 in assurance that activities in or adjacent marine resources of unique productivity are designed and carried out so as to minimize adverse effects on marine productivity, habitat value, storm buffering capabilities, and water quality of the entire complex.

Research, Management, and Monitoring in the USVI

Aside from the protection of mangroves from disturbance, there are few conservation and management programs in place in the USVI. DPNR is responsible for monitoring wetlands to guarantee that unpermitted activities are not taking place and that authorized activities are in full compliance with permit requirements, although lack of sufficient enforcement resources means that many violations go unnoticed.

There have been several studies to assess the value of mangroves as important nurseries for recreational and commercial fisheries (Thayer et al. 1987, Adams and Tobias 1994, Boulon 1990, 1992; Dennis 1992, Tobias 1996, 1998, 2001; Mateo 2001a, Mateo and Tobias 2001, Mateo et al. 2002, Adams and Ebersole 2002). Environmental studies have been conducted on the Mangrove Lagoon/Benner Bay, St. Thomas (Grigg et al. 1971, Olsen 1972, 1973; Island Resources Foundation 1977, 1993; Nichols and Towle 1977; and Nichols et al. 1979).

One of the most cost effective technologies for monitoring percent cover and the overall health of mangroves, as well as other marine habitats, could be through the use of conventional aerial photo interpretation assisted with GIS based image analysis. Aerial photographs were used to develop the Benthic Habitats of the Florida Keys digital data atlas and just recently, a similar effort was performed for the USVI and Puerto Rico as part of the National Ocean Service's continuing effort to document coastal resources (Kendall et al. 2001). Aerial photographs were used to create maps of the region's coral reefs, seagrass beds, mangrove forests, and other important habitats. Mangrove wetlands were also mapped for the Virgin Islands Vegetation Communities data set (CDC 2001 data).

Potential for Conservation Action

Restoration Actions: Mangroves can be replanted, although the success rate is low. High currents, wave action, and storm activity make mangrove restoration more complex than for terrestrial systems, although success can be improved with advance planning (Thorhaug 1990, Kaly and Jones 1998, Toledo et al. 2001). Reducing the impacts to mangroves from sedimentation and pollution must be accomplished prior to replanting in order to achieve any measure of success.

Protection Actions: Mangroves are protected from disturbance in the USVI, although illegal cutting still occurs. Enforcement efforts should be increased by providing appropriate training and resources to enforcement personnel.

Acquisition Actions: Mangroves are obligate wetland species, and as such fall within EPA wetland delineation boundaries. However, upland vegetation adjacent to mangroves provides important foraging, breeding, or resting habitat for some wetland species, and as such should be considered in wetlands acquisition proposals.

Education/Recreation Actions: Mangroves provide ample opportunity for bird watching. Several tour operators on St. Thomas and St. John offer kayak tours of mangrove systems, enabling easier access to wildlife viewing. School groups could be encouraged to utilize these resources. Boardwalks and bird blinds could be installed in the more accessible locations.

Species Associated with Mangroves

The following is a list of species associated with mangroves. Both common and rare species are listed, although these are not comprehensive lists due to a lack of a complete inventory for all taxa. The list has been compiled from Boulon (1990), Jarecki (2003), Platenberg et al. (2005), The Nature Conservancy (2005a), Thomas and Devine (2005), L. Brannick (pers. comm.), and personal observations.

Vegetation

Family	**Species**	**Common Name**
Rhizophoraceae	*Rhizophora mangle*	Red Mangrove
Verbenaceae	*Avicenna germinans*	Black Mangrove
Combretaceae	*Laguncularia racemosa*	White Mangrove
Combretaceae	*Conocarpus erectus*	Buttonwood
Combretaceae	*Bucia burceras*	Gris-gris / Black Olive
Acanthaceae	*Justicia carthaginensis*	Blue Justicia
Malvaceae	*Thespesia populnea*	Seaside Maho
Polygonaceae	*Coccoloba uvifera*	Seagrape
Annonaceae	*Annona glabra*	Pond Apple

Invertebrates

Gecarcinidae	*Cardisoma guanhumi*	Great Land Crab
Ocypodidae	*Uca* spp.	Fiddler Crab
Grapsidae	*Aratus pisonii*	Mangrove Crab
Portunidae	*Callinectes sapidus*	Blue Crab
Palunuridae	*Panulirus argus*	Spiny Lobster
Ostreidae	*Crassostrea rhizophorae*	Mangrove Oyster

Fish

Muraenidae	*Gymnothorax funebris*	Green Moray
Lutjanidae	*Lutjanus apodus*	Schoolmaster
Lutjanidae	*Lutjanus griseus*	Gray Snapper
Lutjanidae	*Lutjanus analis*	Mutton Snapper
Lutjanidae	*Ocyurus chrysurus*	Yellowtail Snapper
Clupeidae	*Jenkinsia lamprotaenia*	Dwarf Herring
Gerreidae	*Eucinostomus argenteus*	Spotfin Mojarra
Haemulidae	*Haemulon aurolineatum*	Tomtate
Haemulidae	*Haemulon flavolineatum*	French Grunt
Haemulidae	*Haemulon sciurus*	Bluestriped Grunt
Sparidae	*Archosargus rhomboidalis*	Sea Bream
Chaetondontidae	*Chaetodon capistratus*	Foureye Butterflyfish
Sphyraenidae	*Sphyraena barracuda*	Barracuda

Labridae	*Halichoeres bivittatus*	Slippery Dick
Tetraodontidae	*Canthigaster rostrata*	Sharpnose Puffer
Tetraodontidae	*Sphoeroides testudineus*	Checkered Puffer
Elopidae	*Megalops atlanticus*	Tarpon

Amphibians

Leptodactylidae	*Leptodactylus albilabris*	White-lipped Frog

Reptiles

Polychrotidae	*Anolis cristatellus*	Crested Anole
Iguanidae	*Iguana iguana*	Green Iguana
Teiidae	*Ameiva exsul*	Common Ground Lizard

Birds

Ardeidae	*Bubulcus ibis*	Cattle Egret
Ardeidae	*Ardea herodias*	Great Blue Heron
Ardeidae	*Ardea alba*	Great Egret
Ardeidae	*Egretta caerulea*	Little Blue Heron
Ardeidae	*Nycticorax nycticorax*	Black-crowned Night-Heron
Ardeidae	*Nyctanassa vilacea*	Yellow-crowned Night-Heron
Cuculidae	*Coccyzus minor*	Mangrove Cuckoo
Parulidae	*Dendroica petechia*	Yellow Warbler

Photo: R. Platenberg

Land Crab *Cardisoma guanhumi*

Wetland Types: Salt Ponds

Description

Salt ponds are small bodies of saltwater that form into intertidal basins. Originally open to the sea as bays or inlets, they become isolated from the sea over time as storm-deposited materials form a berm. The resulting enclosed or mostly enclosed water bodies occurring within coastal mangrove wetlands maintain an influx of salt water either through tidal seepage or periodic breaching of the berm by the sea. Salt ponds are typically hypersaline, with water salinities typically in excess of 50 parts per thousand (sea water is typically 35 ppt). Water salinity, oxygen content, and temperature are highly variable and dependent on rainfall and evaporative processes, and influence the fauna of these wetlands (Jarecki 2003). Salt ponds contain invertebrates that form an important prey base for shorebirds and other waterbirds. These ponds also act as catchment basins for runoff, debris, and pollutants, thus protecting coral and seagrass beds in the marine environment.

Photo: R. Platenberg

Eastern salt pond on Saba cay.

Salt ponds are characterized by the presence of mangroves and other salt tolerant plants. Salt pond hydrological processes can be predicted by the mangrove community present (Jarecki 2003). Red mangroves are characteristic of wetlands with more stable water levels (Barnes 1980). Black mangroves are indicative of a more saline environment, while white mangroves indicate a salty yet drier substrate. Buttonwood is not tolerant of moist soils (Stengel 1998).

With more than 60 ponds on St. Thomas, St. John and the adjacent cays, salt ponds are the dominant form of waterbodies found in the USVI (U.S. Geological Survey 1994) and across the Caribbean (Jarecki and Walkey 2006).

Ecological Value

Salt ponds and the specialized salt-tolerant vegetation communities that they support perform a variety of biological, hydrologic and water quality functions. Capturing and retaining sediments is an important water quality function of wetlands (Jarecki 2003, Rennis et al. 2006), helping to protect sensitive coastal resources, such as coral reefs and seagrasses, which can be adversely impacted from siltation. The indirect functions of salt ponds and their associated mangrove systems include the provision of storm protection, flood mitigation, shoreline stabilization, and shoreline erosion control (Jarecki 2003).

Value to Wildlife

Salt ponds and associated mangrove ecosystems provide an essential habitat for indigenous and migratory birds, many of which are either locally or federally threatened or endangered (Wauer and Sladen 1992). It is estimated that 90% of the resident and migratory birds in the USVI are dependent on wetlands for feeding, nesting or roosting (Philibosian and Yntema 1977). A study of bird use of mangrove and salt pond wetlands on St. Croix found that migratory warblers were noted to be the dominant species utilizing mangroves, joined by migratory shorebirds and waterfowl (Knowles 1994). More species, higher levels of confirmed breeding, and greater numbers of waterbirds generally occur at salt ponds as compared with other saline site types, such as tidal lagoons (McNair, Yntema, and Cramer-Burke 2005a).

Photo: R. Platenberg

Fiddler Crab *Uca* spp., a common salt pond inhabitant.

Salt ponds and mangrove wetlands are the primary habitat for the great land crab (*Cardisoma guanhumi*), an economically important Caribbean species. Although omnivorous, the crab feeds primarily on leaves of buttonwood and red and white mangroves (K. Hill, 2001. http://www.sms.si.edu/IRLspec/Cardis_guanhu.htm). This species is exploited locally as a food source. Fiddler crabs (*Uca* spp.) and blue crabs (*Callinectes sapidus*) are also common in salt ponds and provide valuable food resources for birds.

Human Use

Salt ponds have always held high value to local peoples. Areas around such ponds and swamps often show evidence of prehistoric habitation, and historic Danish plantation ruins are also frequently located in these low-lying areas. Scientifically, the prehistoric ruins in the USVI are highly valuable cultural resources; without written history every insight into this life must be gleaned from the archaeological record, which in this case is scattered just below the substrate. Salt ponds were used for a food source of waterbirds, crabs, and fish. Channels were opened to create a connection to the sea, and domestic refuse thrown into the ponds. As fish entered to feed on the refuse, traps were placed across the channel opening (D. Brewer, pers. comm.). Mangrove branches and roots have historically been used to make fish traps. The water from the ponds may have been used for domestic purposes, and salt is still harvested by locals from some hypersaline ponds, such as Salt Pond on St. John.

Photo: R. Platenberg

Salt Pond, St. John. The white swirls along the shoreline are salt crystals forming as the saline water evaporates.

Threats

Reclamation has been the greatest threat to salt pond systems within the USVI prior to strict regulations implemented by the EPA and CZM. Economic success and the burgeoning tourist industry has driven the construction of hotels, marinas, condominiums, and other developments in coastal areas. The infilling of salt ponds and associated wetlands was a common practice. During the economic growth period of the 1960s and 1970s, approximately 14 wetland sites were altered on St. Thomas and St. John (U.S. Geological Survey 1994).

Accelerated sedimentation represents a significant indirect threat to salt pond ecosystems. Construction on hillsides loosens and exposes soil that are carried by runoff water into salt ponds and bays. MacDonald (1997) showed that sediment yields on St. John since the 1950s have significantly increased as a result of unpaved road erosion. Sedimentation poses a serious threat to salt ponds, coral, and seagrasses.

Leaking septic tanks and discharge pipes lead to sewage being carried with runoff water to coastal areas. Sewage is the most serious and widespread pollution problem in the Caribbean (Schumacher et al. 1996). Sewage effluent in salt ponds may be sequestered and processed by sediment bacteria, but the processing efficiency tends to decrease with increasing input. Toxic elements in wastewater accumulate in salt ponds through evaporation (Jarecki 2003).


Photo: R. Platenberg

Improperly maintained sediment fence along salt pond shore.

Waste oil from cars is frequently disposed of into the ground or sprayed on dirt roads to control dust (Jarecki 2003). Leaks in underground fuel tanks are generally not identified until fuel begins leaching into coastal waters. Rain can wash discarded or leaked petroleum through the soil and into ponds.

Mangroves may be affected by rising water levels as a result of global climate change. Human encroachment prevents the mangroves from moving up the shore. Hurricane effects from rising sea temperatures have had devastating impacts on mangroves and salt pond systems, and impacts from hurricanes Hugo (1989) and Marilyn (1995) are still visible today.

USVI Regulations

Salt ponds are “lands beneath tidal waters” or “submerged lands”, and the title to the lands is vested in the USVI government, i.e., salt ponds fall under the ownership and jurisdiction of the VI territorial government. The territorial legislature adopted the Indigenous and Endangered Species Act of 1990, which establishes a policy of “no net loss of wetlands” to the maximum extent possible (section 104(e)). Mangroves are locally protected through several sections in the VI Code. Title 12, Chapter 2 prohibits the cutting, pruning, removal and disturbance to mangroves, as well as no net loss of wetlands, without express written permission from the Commissioner. Mangroves are also protected under Title 12, chapter 21 in assurance that activities in or adjacent marine resources of unique productivity are designed and carried out so as to minimize adverse effects on marine productivity, habitat value, storm buffering capabilities, and water quality of the entire complex.

Research, Management, and Monitoring in the USVI

A comprehensive inventory of salt ponds on the northern USVI was completed (Stengel 1998) that stands as the most comprehensive atlas for these waterbodies. In the BVI, an extensive study on the ecosystem characterization of hydrological, chemical, and biological parameters of salt ponds was conducted (Jarecki 2003, Jarecki and Walkey 2006). This work identified the importance of salt pond complexes, because the salinity fluxuations were not synchronized across ponds, leading to shifting assemblages of aquatic populations. Waterbirds depend on these fluctuating prey populations and regularly move between ponds. Therefore, effective conservation measures must protect the range of waterbodies rather than individual ponds (Jarecki 2003). Gangemi (2003) conducted an ecological assessment of salt ponds on St. John to identify a range of indicators for determining water quality. Data were collected for 15 ponds on St. John, and analyses determined that fiddler crabs (*Uca* spp.) are a useful indicator of salt pond function as they are the first species to abandon a disturbed system.

The parameters determining the effectiveness of salt ponds in sediment retention were assessed for 17 salt ponds in the USVI (Rennis et al. 2006). Salt ponds were determined to be highly variable in their potential to retain sediment and no single parameter was identified as being able to predict salt pond function. However, sediment trapping ability decreases as wetlands fill in, indicating that the protection of gut and watershed vegetation and the prevention of any increase in upland sediment loads are key to ensuring optimal salt pond function (Rennis et al. 2006).

The use of salt ponds and other wetlands as wildlife habitat has also been documented. Knowles and Amrani (1991) conducted surveys of wildlife at salt ponds on St. Thomas, St. John, and St. Croix, and Knowles (1996) documented species observed in saline wetlands on St. Croix. These works resulted in an initial conservation plan for saline wetlands (Knowles 1997). Norton et al. (1986b) assessed the distribution of waterfowl in the USVI, and Sladen (1992) compared waterbird populations in two types of habitats on St. Croix. As part of the wetland conservation plan for St. Croix, McNair, Yntema, and

Cramer Burke (2005a,b) utilized a prioritization scheme for saline and freshwater wetlands based on surveys of the waterbird communities. Other studies of birds in wetlands have been conducted on St. Croix (McNair 2005; McNair and Cramer-Burke 2005; McNair, Hayes, and Yntema 2005; McNair, Pierce, and Sladen 2005; McNair, Yntema, Cramer-Burke, and Fromer 2005; McNair, Yntema, Lombard, Cramer-Burke, and Sladen 2005) and elsewhere in the USVI (Norton et al. 1985, Norton et al. 1986a).

There are currently no monitoring initiatives in the USVI for saline wetlands. Breeding bird use, sentinel species such as fiddler crabs and mangroves, submerged aquatic vegetation, pond depth, and water quality are parameters than can measure salt pond health and function (Gengemi 2003, Jarecki 2003, Rennis et al. 2005).

Potential for Conservation Action

Restoration Actions: The function of salt ponds as catchment basins means that they are the primary receptors for sediment and non-point source pollution from upland sources. The single most valuable restorative goal is to reduce or eliminate sources of sediment and contamination into salt ponds. A number of actions can be applied to accomplish this goal, including implementing stricter restrictions to control upland erosion, better enforcement of the VI Code with regards to vegetation clearance, septic tanks, and other non-point source pollutants, and installing measures to prevent trash and contaminants entering watercourses. Education of landowners and local residents and businesses within reach of guts is called for to foster stewardship of this environment.

Once upland sources of sedimentation have been addressed, there are additional restoration actions that may be taken, including dredging, creating new retention ponds, and opening a channel to the sea, all with varying degrees of ecological value. The removal of built-up fill material through dredging is a viable option, providing the pond can be deepened to a depth and shape according to reference ponds (Rennis et al. 2005). The temporary loss of benthic sediments and vegetation may be justified by the benefits of restoring the pond to a functioning system (D. Rennis, pers. comm.). The creation of a new catchment system by digging a new pond may be another viable option, however, planning must be conducted to ensure that the newly created pond is not merely a hole that fills up with water, thus becoming an unproductive pond that serves only to catch contaminants and provide a breeding ground for mosquitoes. Creating an opening in the berm to allow for the flushing out of the salt pond is the least beneficial choice. This could have detrimental impact to sensitive in-shore coastal resources, including coral and seagrass beds, as a result of polluted and highly turbid runoff from the terrestrial watershed (D. Rennis, pers. comm.). The retention function of the salt pond would be altered when a channel is opened. Additionally, the ecology and hydrology of the pond is changed; the fluctuating water level, salinity, and temperature are part of the unique salt pond ecosystem that would be lost when a channel is created.

Protection Actions: Salt ponds are protected as wetlands under the various national and local regulations that prevent infilling. The associated mangroves are protected from disturbance, although illegal cutting still occurs. Enforcement efforts should be increased by providing appropriate training and resources to enforcement personnel. Addressing sources of upland sedimentation and non-point source pollution is the single most important action for protecting salt ponds.

Acquisition Actions: Salt ponds fall within the coastal zone and connected to the sea, making them jurisdictional wetlands and therefore owned by the territorial government. Adjacent lands, however, provide valuable foraging and breeding habitat for wetland species, as well as buffering impacts from nearby development. Because of the protection afforded to salt ponds and other coastal wetlands, extending to coral reefs and seagrass beds, justification can be made for acquisition of upland habitat within watersheds in the USVI to protect these resources.

Education/Recreation Actions: Salt ponds provide unique opportunities for bird and wildlife watching, since a high proportion of wildlife utilizes this habitat (Knowles 1994). Examples of ponds used for this purpose include Frank Bay on St. John, which has been adopted by the local Audubon Society, Perseverance Bay on St. Thomas, and the eastern pond on Saba cay, where a bird blind was erected but has since fallen into disrepair. Boardwalks, bird blinds, and informational kiosks and leaflets can be installed to enhance the experience.

Species Associated with Salt Ponds

The following is a list of species associated with salt ponds. Both common and rare species are listed, although these are not comprehensive lists due to a lack of a complete inventory for all taxa. The list has been compiled from Stengel (1998), Loftus (2003, 2004), Jarecki (2003), Platenberg et al. (2005), Thomas and Devine (2005), L. Brannick (pers. comm.), F. Sibley (pers. comm.), and personal observations.

Vegetation

Family	Species	Common Name
Rhizophoraceae	*Rhizophora mangle*	Red Mangrove
Combretaceae	*Laguncularia racemosa*	White Mangrove
Verbenaceae	*Avicenna germinans*	Black Mangrove
Combretaceae	*Conocarpus erectus*	Buttonwood
Malvaceae	*Thespesia populnea*	Seaside Maho
Polygonaceae	*Coccoloba uvifera*	Seagrape
Aizoaceae	*Sesuvium portulacastrum*	Sea Purselane
Annonaceae	*Annona glabra*	Pond Apple
Poaceae	*Sporobolus virginicus*	Seashore Rush Grass
Ruppiaceae	*Ruppia maritima*	Wigeongrass

Invertebrates

Gecarcinidae	*Cardisoma guanhumi*	Great Land Crab
Ocypodidae	*Uca* spp.	Fiddler Crab

Grapsidae	*Aratus pisonii*	Mangrove Crab
Portunidae	*Callinectes sapidus*	Blue Crab
Artemiidae	*Artemia franciscana*	Brine Shrimp
Corixidae	*Trichocorixa reticulata*	Water Boatman
Hydrophilidae	*Berosus* spp.	Water Scavenger Beetle
Lestidae	*Lestes forficula*	Rainpool Spreadwing
Coenagrionidae	*Ischnura rumburii*	Rambur’s Forktail
Libellulidae	*Orthemis ferruginea*	Roseate Skimmer

Fish

Elopidae	*Megalops atlanticus*	Tarpon

Reptiles

Polychrotidae	*Anolis cristatellus*	Crested Anole
Iguanidae	*Iguana iguana*	Green Iguana

Birds

Anatidae	*Anas discors*	Blue-winged Teal
Anatidae	*Anas bahamensis*	White-cheeked Pintail
Pelecanidae	*Pelecanus occidentalis*	Brown Pelican
Ardeidae	*Egretta caerulea*	Little Blue Heron
Ardeidae	*Butorides virescens*	Green Heron
Charadriidae	*Pluvialis squatarola*	Black-bellied Plover
Charadriidae	*Charidrius alexandrinus*	Snowy Plover
Charadriidae	*Charidrius wilsonia*	Wilson’s Plover
Charadriidae	*Charidrius semipalmatus*	Semipalmated Plover
Recurvirostridae	*Himantopus mexicanus*	Black-necked Stilt
Scolopacidae	*Tringa melanoleuca*	Greater Yellowlegs
Scolopacidae	*Tringa flavipes*	Lesser Yellowlegs
Scolopacidae	*Actitis macularia*	Spotted Sandpiper
Scolopacidae	*Arenaria interpres*	Ruddy Turnstone
Scolopacidae	*Calidris pusilla*	Semipalmated Sandpiper

Photo: R. Platenberg

Green Iguana *Iguana iguana* basking on rocks.

Wetland Types: Guts

Description

In the USVI rainfall tends to run down hillsides over the surface rather than through the ground because the soil layer is thin and the underlying rock has low permeability (Jarecki and Walkey 2006). “Guts” are the natural channels that have formed from storm water erosion down steep terrain, defined as any stream with a reasonable well-defined channel, which includes streams that have a permanent flow as well as those that result from the accumulation of water after rainfall (VI Code, Title 12, Chapter 3). Native plant communities along guts, classified as gallery moist forest (Thomas and Devine 2005), consist of corridors of vegetation that are more mesic than the surrounding upland vegetation. This community consists primarily of broadleafed evergreen trees and wetland herbaceous species. Natural springs are generally located in guts, resulting in reliably permanent pools of freshwater. Intermittent streams are often supplemented from gray water drainage in residential communities. Only a very few of these guts have an aquatic connection to the sea, except during storm induced discharge.

Photo: R. Platenberg

Neltjeberg Gut, St. Thomas.

Ecological Value

The gallery vegetation in guts holds soil to prevent erosion and protects marine and salt pond water quality by filtering sediment and absorbing pollutants from storm water runoff.

Value to Wildlife

Freshwater sources in the USVI are extremely limited because of a thin soil layer and low permeability of the underlying rock. Water that collects in gut pools therefore provides a rare opportunity for water resources. Shrimp of the genus *Macrobrachium* and freshwater and anadromous fish inhabit gut pools and streams. These species tend to have complex life cycles, migrating between downstream marine environment and upstream freshwater pools when connections between the two habitats are present. Migratory birds, primarily warblers, use these ephemeral water resources, as do, unfortunately, invasive species that require freshwater, such as the Cuban treefrog (*Osteopilus septentrionalis*).

Photo: R. Platenberg

Freshwater shrimp *Macrobrachium* sp.

Vegetated guts also provide habitat corridors for wildlife, particularly in highly disturbed, urbanized areas. The federally endangered Virgin Islands tree boa (*Epicrates monensis granti*) in particular benefits from the “green belt” corridors along guts on St. Thomas’ east end.

Human Use

Historically, guts were used to contain and channel freshwater. During the plantation era guts were dammed and the resultant pools were directed down terraced irrigation channels. Guts are still dammed to create freshwater ponds for agricultural irrigation or stock ponds. Freshwater shrimp have been traditionally harvested from gut pools, often with the use of gigging, trapping, and in some instances the use of piscicides (Garcia and Hemphill 2002). Guts are also used for access through dense upland forest.

Threats

Sedimentation occurs when soil is eroded from the land surface and is collected by rainfall moving over the surface of the ground. The failure to property install effective silt control devices at construction sites are a major source of eroded soil. The sediment in rainfall runoff is added to by other contaminants from human activities, such as pesticides, nutrients, and toxic substances. Leaky septic systems and runoff from animal operations result in high loads of bacterial contamination present in gut streams, one of the main causes of contamination of beaches after rainfall events (DEP 2004). In the USVI municipal trash collection dumpsters are almost invariably located on major roads where guts transect the road. There are no measures to prevent trash from being washed into the gut and contaminants leaching into the adjacent soils, resulting in certain guts being highly polluted with trash and residential contaminants. The role of guts in the transport of pollution from upland sources to the sea has largely gone ignored (Nemeth and Platenberg 2005).

Macrobrachium shrimp in guts appear to be particularly vulnerable to anthropogenic activities. Overfishing, poisoning, channelization, culverts, and pollution (Hunter and Arbona 1995, cited in Garcia and Hemphill 2002) were found to contribute to the decline in the abundance of these predatory shrimp in Puerto Rico. The effects of migration barriers such as dams, the entrainment of eggs and larvae, and loss of habitat quality and area can influence shrimp assemblages at the population, community, and ecosystem levels (Garcia and Hemphill 2002).

USVI Regulations

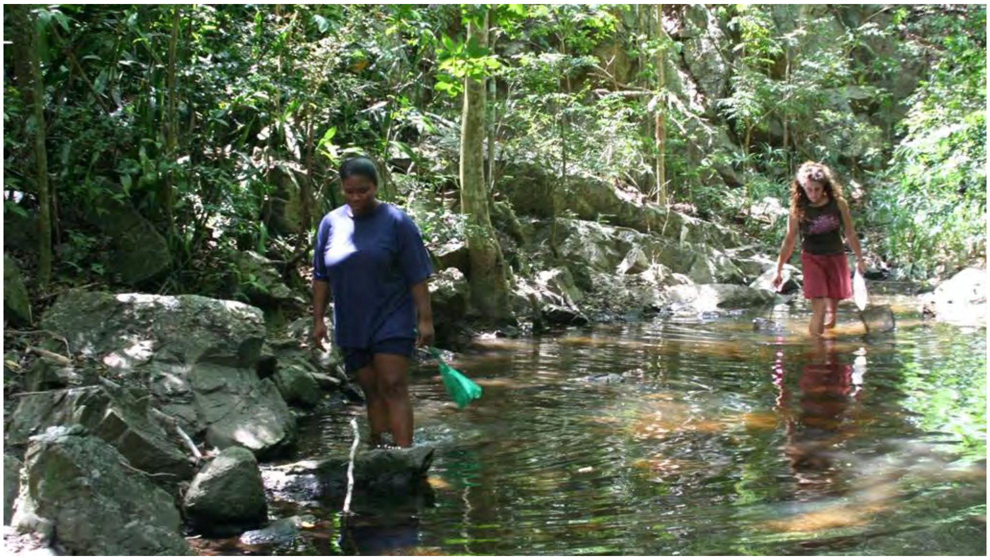
Guts are protected under the VI Code, Title 12, Chapter 3 (Trees and Vegetation Adjacent to Watercourses), which prohibits the cutting or injury of any tree or vegetation within 30 feet of the center of any natural watercourse or 25 feet from the edge, whichever is greater, without written permission from the Commissioner. This aims to protect the unique gallery forest vegetation community only found along guts in the USVI. Additional protection to guts comes from the DEP and CZM efforts to control non-point source pollution.

Research, Management, and Monitoring in the USVI

The NPS conducted a survey of fishes in coastal and inland ponds and pools that identified 41 species of fishes utilizing inland brackish- and fresh-water habitats on St. John (Loftus 2003, 2004). With the exception of two exotic species (Guppy *Poecilia reticulata* and Tilapia *Oreochromis mossambicus*), all fish species had colonized inland waters from the ocean during periods of high stormwater inundation (Loftus 2004).

A current study through UVI is assessing the biodiversity of fish and crustaceans in guts as indicators for water quality (Nemeth and Platenberg 2005). The need for an assessment of these inland water sources was highlighted by Smith (1993), who discovered a new species of ectoproct on St. John, simply because no one had ever looked for them there before.

The USGS monitors stream water flow in selected locations, including Turpentine Run and Bonne Resolution Gut on St. Thomas (for more information about Turpentine Run, see chapter on Priority Wetlands), and Guinea Gut on St. John (http://waterdata.usgs.gov/vi/nwis/current/?type=flow).



Researchers from UVI collecting samples in Turpentine Run gut.

Potential for Conservation Action

Restoration Actions: The function of guts as stormwater drainages means that they are the primary channel for sediment and non-point source pollution to lowland wetlands and the marine environment. The single most valuable restorative goal is to reduce or eliminate sources of sediment and contamination into guts. A number of actions can be applied to accomplish this goal, including implementing stricter restrictions to control upland erosion, better enforcement of the VI Code with regards to vegetation clearance, septic tanks, and other non-point source pollutants, and installing measures to prevent trash and contaminants entering watercourses from dumpsters. Education of landowners and local residents and businesses within reach of guts is called for to foster stewardship of this environment.

Protection Actions: Vegetation within guts is protected from cutting and clearing, however, enforcement of this and non-point source pollution regulations is lacking. Strengthening the enforcement of these regulations can improve protection of the gut environments.

Acquisition Actions: Guts fall within the definition acceptable for wetlands acquisition grants, and adjacent lands within watersheds should be assessed for acquisition potential. A high priority watershed/gut acquisition proposal is the Perseverance Bay Watershed, described in the Priority Wetlands chapter.

Education/Recreation Actions: Guts provide a relatively open access through the dense, impenetrable forest that occurs on the steep slopes of the northern USVI. Without the means of extensive brush clearance, travel along guts is the only ingress into upland forest habitats. As such, they provide a valuable resource for ecotourism and educational activities. On St. Thomas the popular Magen's Bay trail follows a gut channel for much of its route, as does the little known Perseverance Bay Trail. The Neltjeberg Gut is popular for hiking and bird-watching. There are often historical structures, including wells and terrace walls, alongside guts that provide a unique opportunity to observe and learn about cultural resources. The variety of landforms and ease of access to guts provide a range difficulty levels for education and recreation opportunities to suit most people. Guts with easy public access should be rated according to difficulty and have educational kiosks installed. Education of landowners and local residents and businesses within reach of guts can foster stewardship of this critical habitat.

Species Associated with Guts

The following is a list of species associated with moist riparian gallery forest. Both common and rare species are listed, although these are not comprehensive lists due to a lack of a complete inventory for all taxa. This list was compiled from Avecido-Rodríguez (1996), Loftus (2003, 2004), Platenberg et al. (2005), Thomas and Devine (2005), The Nature Conservancy (2005a), L. Brannick (pers. comm.), and personal observations.

Vegetation

Family	Species	Common Name
Cyperaceae	*Cyperus* spp.	Flatsedge (Papyrus)
Cyperaceae	*Carex spp.*	Sedge
Annonaceae	*Annona glabra*	Pond Apple
Combretaceae	*Bucida burseras*	Gris-gris / Black Olive
Bombacaceae	*Ceiba pentandra*	Kapok
Euphorbiaceae	*Hura crepitans*	Sandbox
Euphorbiaceae	*Rincinus communis*	Castor Bean
Sapindaceae	*Melicoccus bijugatus*	Genip
Rutaceae	*Zanthoxylum monophyllum*	Yellow Prickle
Arecaceae	*Coccothrinax alta*	Tyre Palm
Boraginaceae	*Cordia collococca*	Manjack
Boraginaceae	*Heliotropium angiospermum*	Scorpiontail
Capparaceae	*Capparis amplissima*	Burro
Acanthaceae	*Barleria lupulina*	Hophead Philippine Violet
Rutaceae	*Murraya paniculata*	St. Patrick Bush

Invertebrates

Coenobitidae	*Coenobita clypeatus*	Soldier Crab
Palaemonidae	*Macrobrachium* spp.	Freshwater shrimp

Corixidae	*Trichocorixa reticulata*	Waterboatmen
Hydrophilidae	*Berosus spp.*	Water Scavenger Beetle
Dytiscidae	*Eretes stricticus*	Diving Beetle
Lestidae	*Lestes forficula*	Rainpool Spreadwing
Coenagrionidae	*Ischnura rumburii*	Rambur's Forktail
Libellulidae	*Orthemis ferruginea*	Roseate Skimmer

Fish

Anguillidae	*Anguilla rostrata*	American Eel
Cichlidae	*Oreochromis mossambicus*	Mozambique Tilapia
Mugilidae	*Agonostomus monticola*	Mountain Mullet
Gobiidae	*Sicydium plumieri*	Sirajo Goby
Poeciliidae	*Poecilia reticulata*	Guppy

Amphibians

Leptodactylidae	*Eleutherodactylus antillensis*	Antillean Frog
Leptodactylidae	*Eleutherodactylus cochranae*	Whistling Frog
Leptodactylidae	*Eleutherodactylus lentus*	Mute Frog
Hylidae	*Osteopilus septentrionalis*	Cuban Treefrog

Reptiles

Polychrotidae	*Anolis cristatellus*	Crested Anole
Polychrotidae	*Anolis stratulus*	Barred Anole
Iguanidae	*Iguana iguana*	Green Iguana
Testudinidae	*Geochelone carbonaria*	Red-footed Tortoise

Birds

Ardeidae	*Egretta caerulea*	Little Blue Heron
Ardeidae	*Butorides virescens*	Green Heron
Columbidae	*Zenaida aurita*	Zenaida Dove
Columbidae	*Geotrygon mystacea*	Bridled Quail-Dove
Mimidae	*Margarops fuscatus*	Pearly-eyed Thrasher
Parulidae	*Seiurus motacilla*	Louisiana Waterthrush
Parulidae	*Dendroica caerulescens*	Black-throated Blue Warbler

Wetland Types: Freshwater Ponds

Description

There are no natural freshwater ponds in the northern USVI, due to shallow non-porous soils and steep topography. The few freshwater ponds that occur have been created through the damming of stormwater drainages to provide water for livestock or crops. These ponds form in depressions in a basin or slope where water drainages and guts have been dammed. Although these ponds generally hold water year round, they often do not exhibit the typical characteristics of wetlands, often lacking wetland vegetation, although some of these ponds do harbor algae, submerged macrophytes, and emergent vegetation. Most of the pond vegetation present is not native to the USVI. A variety of herbs, woody shrubs, and trees grow along the edges and that can tolerate occasional inundation.

Photo: R. Platenberg

Freshwater pond in agricultural area on St. Thomas, created by damming the gut.

Ecological Value

Man-made ponds in the USVI reduce the amount of non-point source pollution entering the marine environment by increasing the retention of runoff water in ponds, increasing biodegradation of pesticides and other pollutants and retaining erosion (DEP 2004).

Value to Wildlife

The freshwater ponds provide valuable habitat for many species, including amphibians and indigenous waterbirds that prefer non-saline ponds, such as the territorially endangered Least Grebe (*Tachybaptus dominicus*). Invertebrates, such as dragonflies, also utilize this habitat. Non-native mammals, primarily deer and mongooses, also rely on these ponds as a rare source of freshwater.

Photo: R. Platenberg

Waterbird nest along edge of freshwater pond.

Human Use

During the plantation era the guts were dammed and water was channeled along terraces built into the slope to irrigate crops. These dams tended to be small and result in pools alongside guts. More recently, large earthen berms have been created that effectively create freshwater ponds. These ponds irrigate crops and provide a water source for domestic stock and waterfowl, and are generally stocked with fish (e.g., Tilapia, *Oreochromis mossambicus*).

Threats

The freshwater ponds in the northern USVI have been created largely for agricultural purposes, and are therefore subject to local stewardship by the farmers that rely on this resource. However, they do retain upland runoff and agricultural contaminants, and provide refuge for invasive, non-native species, such as the cane toad (*Bufo marinus*) and red-eared slider (*Trachemys scripta*).

USVI Regulations

Ponds that have a connection to the sea via a gut are considered jurisdictional wetlands and are therefore subject to federal wetland regulations.

Research, Management, and Monitoring in the USVI

The NPS conducted a survey of fishes in inland ponds and pools that identified 41 species of fishes utilizing inland brackish- and fresh-water habitats on St. John (Loftus 2003, 2004). Freshwater ponds and pools were generally occupied by two exotic species (Guppy *Poecilia reticulata* and Tilapia *Oreochromis mossambicus*). The need for an assessment of these inland water sources was highlighted by Smith (1993), who discovered a new species of ectoproct on St. John, simply because no one had ever looked for them there before. The use of these wetlands by indigenous waterbirds has been documented with management recommendations (McNair, Yntema, and Cramer-Burke 2005a,b).

The agricultural ponds at Bordeaux and Dorothea on St. Thomas are managed and maintained by the local farmers in conjunction with the Department of Agriculture.

Photo: R. Platenberg

Cow near stock pond in agricultural area on St. Thomas.

Potential for Conservation Action

Restoration Actions: The single most valuable restorative goal is to reduce or eliminate sources of sediment and contamination into ponds. A number of actions can be applied to accomplish this goal, including implementing stricter restrictions to control upland erosion, better enforcement of the VI Code with regards to vegetation clearance, septic tanks, and other non-point source pollutants. Education of landowners, farmers, and local residents is called for to foster stewardship of this resource.

Protection Actions: Due to protection afforded to vegetation within guts the erosion runoff that ends up in these ponds is reduced. Enforcement of gut protection and non point source regulations is generally lacking. Strengthening the enforcement of these regulations can improve protection of freshwater environments.

Acquisition Actions: Ponds that are connected to the sea by a watercourse are jurisdictional wetlands, and are, therefore, territorially owned. However, ownership does not extend to surrounding habitat, which generally provides critical wildlife habitat yet suffers high levels of degradation. There may be opportunities to acquire adjacent lands to create wetland buffers.

Education/Recreation Actions: Freshwater ponds provide a unique opportunity in the USVI to observe waterbirds that prefer freshwater over saline habitats. Benches, boardwalks, bird blinds, and information kiosks can enhance the educational and recreational value of these habitats. Education of landowners and local residents and businesses within reach of guts can foster stewardship of this critical habitat.

Species Associated with Freshwater Ponds

The following is a list of species associated with freshwater ponds. Both common and rare species are listed, although these are not comprehensive lists due to a lack of a complete inventory for all taxa. The list has been compiled from Loftis (2003, 2004), Platenberg et. al. (2005), F. Sibley (pers. comm.), and personal observations.

Vegetation

Family	**Species**	**Common Name**
Lemnaceae	*Lemna* spp.	Duckweed
Pontederiaceae	*Eichhornia crassipes*	Water Hyacinth
Typhaceae	*Typha* spp.	Cattail

Invertebrates

Corixidae	*Trichocorixa reticulata*	Waterboatmen
Dytiscidae	*Eretes stricticus*	Diving Beetle
Lestidae	*Lestes forficula*	Rainpool Spreadwing
Coenagrionidae	*Ischnura rumburii*	Rambur’s Forktail
Libellulidae	*Orthemis ferruginea*	Roseate Skimmer

Fish

Cichlidae	*Oreochromis mossambicus*	Mozambique Tilapia
Mugilidae	*Agonostomus monticola*	Mountain Mullet

Amphibians

Leptodactylidae	*Eleutherodactylus lentus*	Mute Frog
Leptodactylidae	*Leptodactylus albilabris*	White-lipped Frog
Hylidae	*Osteopilus septentrionalis*	Cuban Treefrog
Bufonidae	*Bufo marinus*	Cane Toad

Reptiles

Emydidae	*Trachemys scripta*	Red-eared Slider
Iguanidae	*Iguana iguana*	Green Iguana
Polychrotidae	*Anolis cristatellus*	Crested Anole
Teiidae	*Ameiva exsul*	Common Ground Lizard

Birds

Anatidae	*Dendrocygna arborea*	West Indian Whistling Duck
Podicipedidae	*Tachybaptus dominicus*	Least Grebe
Podicipedidae	*Podilymbus podiceps*	Pied-billed Grebe
Rallidae	*Rallus longirostris*	Clapper Rail
Rallidae	*Gallinula chloropus*	Common Moorhen
Rallidae	*Fulica americanus*	American Coot
Rallidae	*Fulica caribaea*	Caribbean Coot

Photo: R. Platenberg

Red-eared slider *Trachemys scripta* basking on log in freshwater pond at Dorothea, St. Thomas.

Priority Wetlands of the Northern USVI

Wetland Prioritization

In order to better direct resources towards the most effective conservation action for wetlands in the USVI, a measure for priority must be determined and applied. A typical indicator for measuring the ecological condition of a wetland is the number and type of birds and other wildlife using said wetland (e.g., O'Connell et al. 2000, Bryce et al. 2002). Wildlife communities are commonly utilized to classify and prioritize wetlands (e.g., Turner 1991). Such methods can be applied to certain wetland types, but cannot be applied equally to all wetland types within a greater landscape level. Within small insular groups, landscape elements are much more integrated than on a continental scale, and, as such, need to be managed as a unit with the assumption that single actions will impact several systems simultaneously. Therefore, in the USVI it is important to manage a system of several wetlands on a watershed level rather than focusing on individual ponds or wetlands.

Within a greater watershed level, there are three main priorities for management: addressing and correcting impaired watersheds, protecting unimpaired watersheds, and identifying watersheds that are currently under threat or in the process of impairment, and to establish measures to prevent further degradation. The highest priorities for action are those watersheds that have several waterbodies composed of a combination of water types.

As with any conservation action, there are several considerations to be made prior to implementation. Feasibility, urgency, biological significance, opportunity, and measurable outcomes are some criteria used to determine priority of a given action. A prioritization scheme that identifies opportunity for action, ecological value, urgency based on threat, and benefits gained from enhanced education/recreation opportunities for individual wetlands and wetland systems was developed by DFW under the process of creating this plan. This scheme assesses individual wetlands according to ecological function (biodiversity, hydrology, and sediment retention), measures current and potential threats, identifies potential restoration actions, examines recreation and educational opportunities, and ranks wetlands according to proximity to next nearest wetland system.

Priority watersheds on St. Thomas have been identified as Jersey Bay, Red Hook Bay, and Perseverance Bay. Rendezvous Bay and Coral Bay are priority watersheds on St. John. Each of these watersheds has salt or freshwater pond systems, guts, significant marine resources, opportunity for restoration, and a level of urgency.

The cays adjacent to St. Thomas and St. John display a mosaic of habitat types, including salt pond wetlands with varying hydrological regimes. Salt, Saba, Capella, Dog, Great St. James, Little St. James, Patricia all support one or more salt ponds. The choice of habitat types is especially valuable for resident and migratory wetland birds. Many of the cays are owned and managed by the VI Government as wildlife reserves. Seabird nesting colonies on the cays are protected from disturbance and egg collecting. The lack of disturbance from development protects the wetlands from the stressors experienced by the wetlands on the major islands. The privately-owned cays, however, are threatened with housing and resort development leading to an alteration in the hydrological processes and associated vegetation. Two such cays with wetlands have been identified as priority concerns: Great St. James and Little St. James.

Jersey Bay, St. Thomas

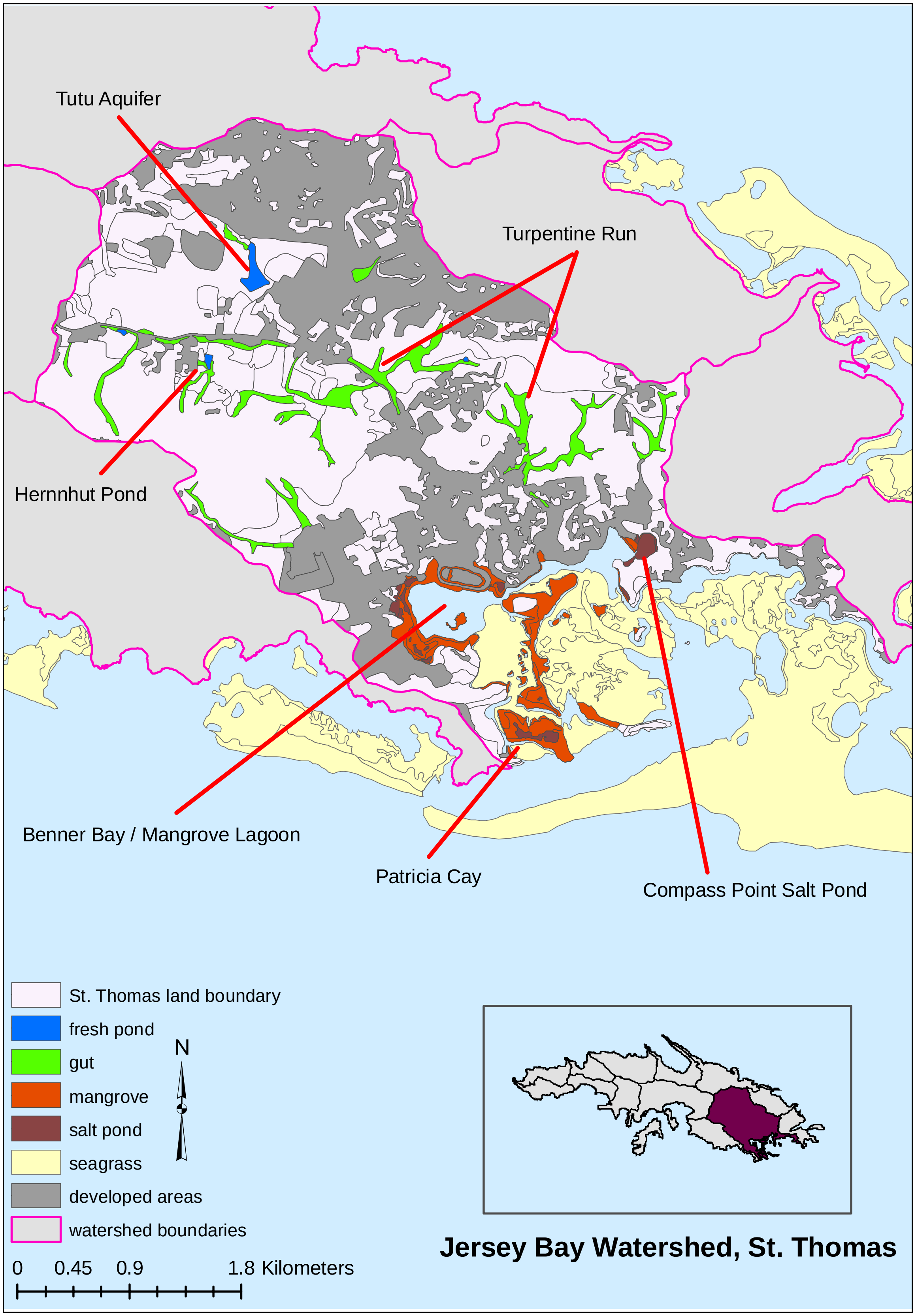
Description:

The Jersey Bay watershed extends from the central Tutu valley capturing runoff from the Tutu aquifer, the residential areas of Red Hook, Nadir, and Bovoni, and channeling it down the Turpentine Run gut and several smaller drainages. The watershed is comprised of steep topography with one significant stream, Turpentine Run, that feeds into the eastern edge of the Mangrove Lagoon, located on the southeastern shore of St. Thomas. The Mangrove Lagoon/Benner Bay consists of two embayments that are linked by a narrow passageway, the Bovoni Channel, allowing water flow to form a single hydrological and biotic system. Two narrow reaches connect the lagoon system to the open ocean, although shoals built up at the mouths of these inlets restrict the rate of flow that passes through these entrances. The mangrove-lined shores provide nursery area for fish, and protect the shoreline from erosion and flooding. The hydrology of the bay is described in Nichols and Towle (1977). The Benner Bay/Mangrove Lagoon has been declared an Area of Particular Concern, and is located within the Inner Mangrove Lagoon, Cas Cay/Mangrove Lagoon, and Compass Point Marine Reserves and Wildlife Sanctuaries.

Wetland Types:

Mangrove Lagoon and Benner Bay are fringed with mangrove wetlands and the bay itself protects four mangrove cays (Bovoni, Rotto, Cas, and Patricia). Manglars within the lagoon comprise several hectares (Dammann and Nellis 1992). Patricia Cay supports a large salt pond system. There are extensive seagrass and algal beds within the lagoon.

The Compass Point salt pond is located at the northeastern edge of Benner Bay. This is a large (1.9 ha) pond open to the sea by a narrow, 2 m channel through a rocky berm (Stengel 1998).


Tutu Aquifer
Turpentine Run
Hernnhut Pond
Benner Bay / Mangrove Lagoon
Patricia Cay
Compass Point Salt Pond
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
developed areas
watershed boundaries
N
0 0.45 0.9 1.8 Kilometers
Jersey Bay Watershed, St. Thomas

Turpentine Run is the largest perennial stream on St. Thomas with a connection to the sea at the Mangrove Lagoon. The lower reaches of the gut support a freshwater swamp of large pond apple trees and extensive mangrove forests.

Two freshwater ponds occur along the Raphune Hill highway at Hernnhut. One pond lies directly adjacent to the highway, and is located along the boundary of the site of the new Humane Society facility.

Threats

Due to the protection offered by the bay and to slow-moving waters, the lagoon is popularly used for moorings and marinas by both liveaboards and casual sailors. Significant human population growth within the watershed has led to increased stressors to this ecosystem. Due to rapid development and associated activities, these coastal embayments no longer meet local water quality standards. Discharges from municipal sewers, marina and liveaboard discharges, private sewer overflow, and septic system failures combine with agriculture and urban runoff to cause this water quality degradation (Tetra Tech 2005). DEP measures Total Maximum Daily Load (TMDL) for fecal coliform at several locations in the lagoon.

Portions of the western upper arm of Turpentine Run were, until recently, largely in its natural state, although channelization has altered much of this habitat. Since the 1960s, development of the watershed and shoreline has proceeded virtually unchecked. Intense development in the upper drainage basin in Tutu has drastically increased impervious surfaces, resulting in increased runoff and channel flow. Increased sediment loads add to the input of often polluted water that flows down the channel, eventually entering Mangrove Lagoon. The Turpentine Run was so polluted at one point that it was designated as an EPA Superfund site, which led to the installation of waste water treatment plants to reduce the pollution impacts to the wetland. This resulted in the loss of a water flow through the southern reach of the gut, except for intermittent stormwater flow, but an increase of water in the northern reach from residential and commercial sources in Tutu.

Compass Point salt pond has been considerably altered from its natural state and has repeatedly been subject to plans for marina development. The ownership of the land surrounding the pond is in dispute, leading to an uncertain future for the area. The pond is no longer effective at sediment retention (Rennis et al. 2006). An increase in island-derived sediment in the surface layer of the salt pond has been linked to deposition due to development with in the watershed (Brooks et al. 2004).

Actions Needed

- Reduction in non-point source pollution entering the gut, salt pond, and bay.
- Reduction of contaminants in Turpentine Run.
- Restoration of functionality of Compass Point salt pond.

- Restoration of mangroves around Compass Point salt pond to create a buffer between nearby developed areas.
- Enhancement of the Herrnhut pond to promote access, recreation, and education.
- Enhancement of vessel wastewater management in the bay through pumpout facilities.
- Increase in sewered networks to reduce bacterial from failing septic tanks, with regular inspections of existing septic systems.

Potential Partners

DEP, DFW, UVI, DEE, Humane Society of St. Thomas (for the Herrnhut pond)
(see page 30 for list of acronyms)

Red Hook Bay, St. Thomas

Description

The Red Hook Bay watershed consists of the north eastern corner of St. Thomas and contains the residential area of Red Hook, Benner Hill, Nazareth, and Cabrita Point. Several resorts and marinas are within the Red Hook Bay watershed.

Wetland Types

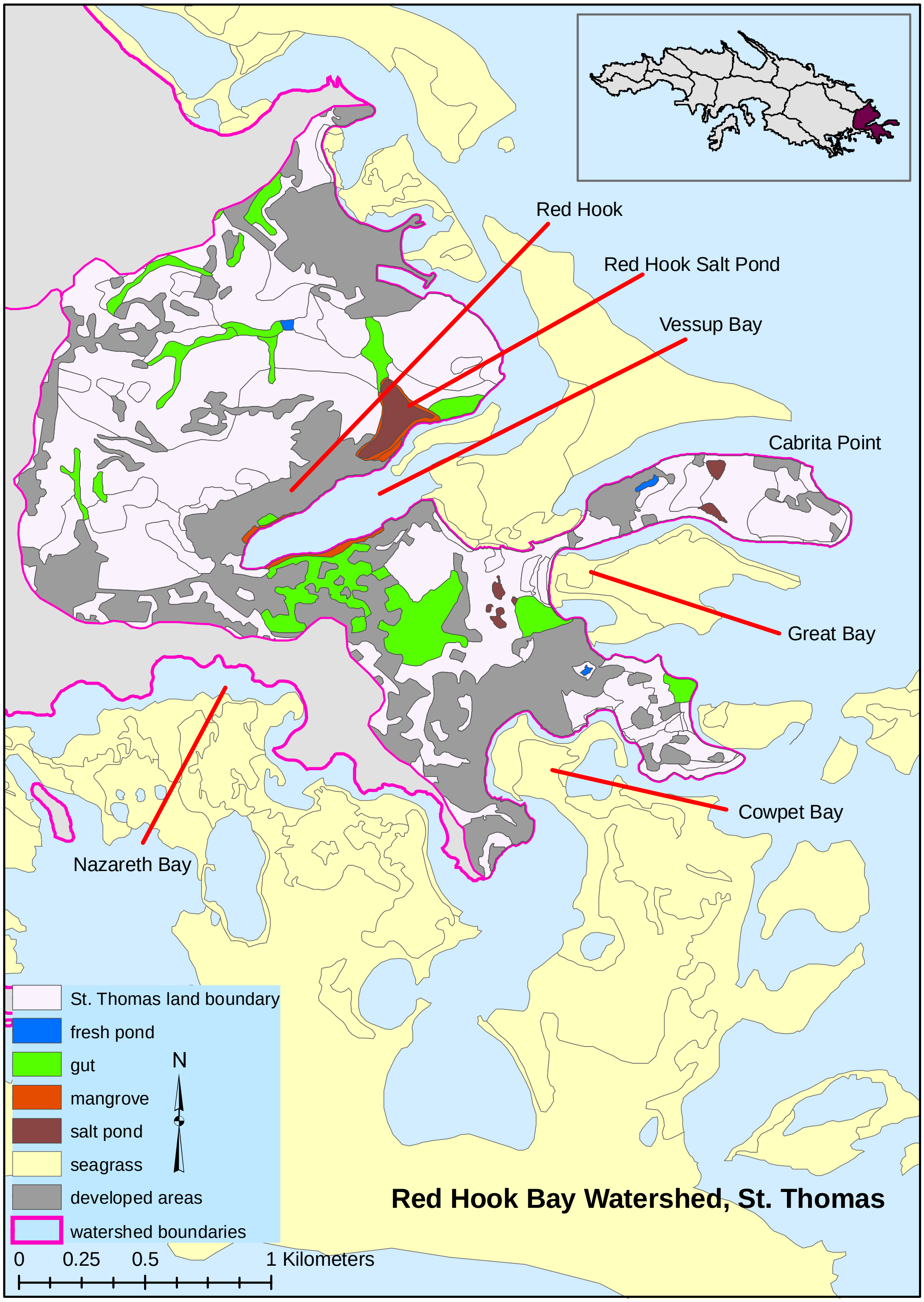
There are seven salt ponds and one fresh water pond located within the Red Hook Bay watershed. An extensive and disturbed mangrove swamp wetland occurs behind Vessup beach.

Threats

The Red Hook Bay watershed is highly impaired. Sediment, road run-off, and trash flow into the Red Hook pond each time it rains. Sediment also flows freely into Vessup Bay from the temporary parking area by the Eudora Kean High School. Several of the salt ponds have been completely altered from development that did not restrict mangrove removal.

Actions Needed

- Restoration of functionality of Red Hook salt pond.
- Reduction in pollution levels entering Red Hook salt pond from road run-off.
- Creation of buffer around Red Hook salt pond.
- Enhancement of Red Hook salt pond for educational and recreational use.
- Reduction in lighting on Great Bay salt pond system from nearby resorts and residences.
- Mangrove restoration of Cabrita Condo salt pond.
- Protection of the north and south Cabrita Point ponds from encroachment from development.



Red Hook
Red Hook Salt Pond
Vessup Bay
Cabrita Point
Great Bay
Cowpet Bay
Nazareth Bay
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
developed areas
watershed boundaries
N
0
0.25
0.5
1 Kilometers
Red Hook Bay Watershed, St. Thomas

Potential Partners

CZM, DEP, DEE, DFW, EPA, Red Hook Community Association, local landowners, residents, and resorts

Perseverance Bay, St. Thomas

Description

The Perseverance Bay watershed is located on the southwest side of St. Thomas west of the airport. The watershed is entirely undeveloped. It contains valuable historic ruins in the form of terraces and a rum factory consisting of a great house, mill, and well. The locally endangered Bridled Quail Dove can be observed on the trail that runs alongside one of the four guts. The bay supports a high quality, healthy fringing reef and extensive seagrass beds. With the recent development of Botany Bay and associated degradation of the marine and terrestrial resources, Perseverance Bay remains the last pristine ecosystem on St. Thomas.

Wetland Types

There are four guts that empty in to the bay, and two large salt ponds are located along the beach. All four types of mangroves are found around the salt ponds, which support a high diversity of wildlife. The ponds are noted for their value to wetlands birds, and the location has been nominated as an Important Bird Site (J. Corven, pers. comm.). The high ecological value of the site is due to the unimpaired nature of the watershed. The bay contains significant coral reefs and seagrass beds.

Threats

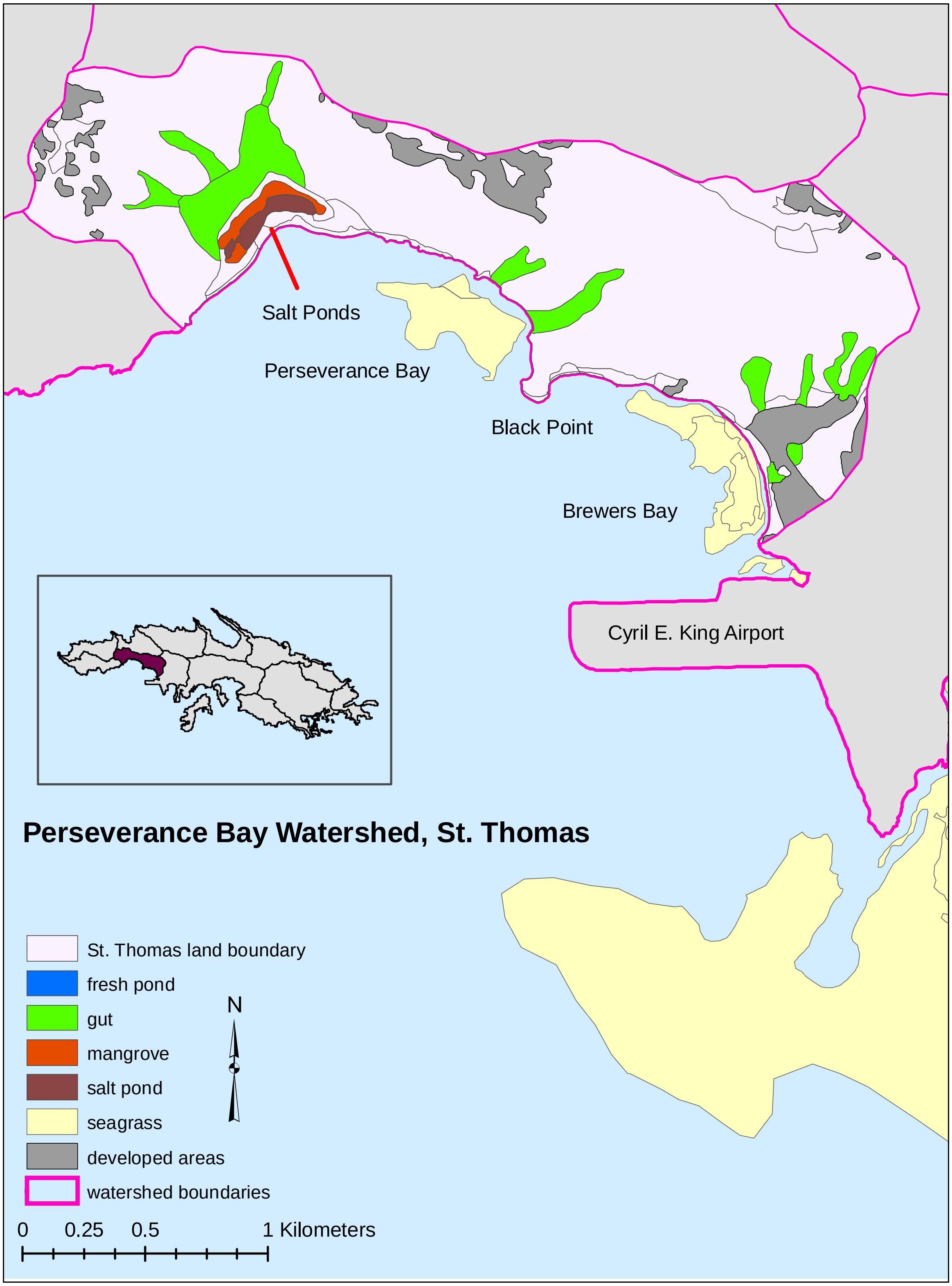
The valuable marine resources and salt ponds are likely to become impaired if any development occurs in the watershed.

Actions Needed

Perseverance Bay watershed needs to be acquired by the VI Government, UVI, or another entity as a Wildlife Refuge. The current landowners should be engaged in a habitat easement agreement if unwilling to sell. Only very limited development with strict environmental controls should be allowed in this pristine ecosystem.

Potential Partners

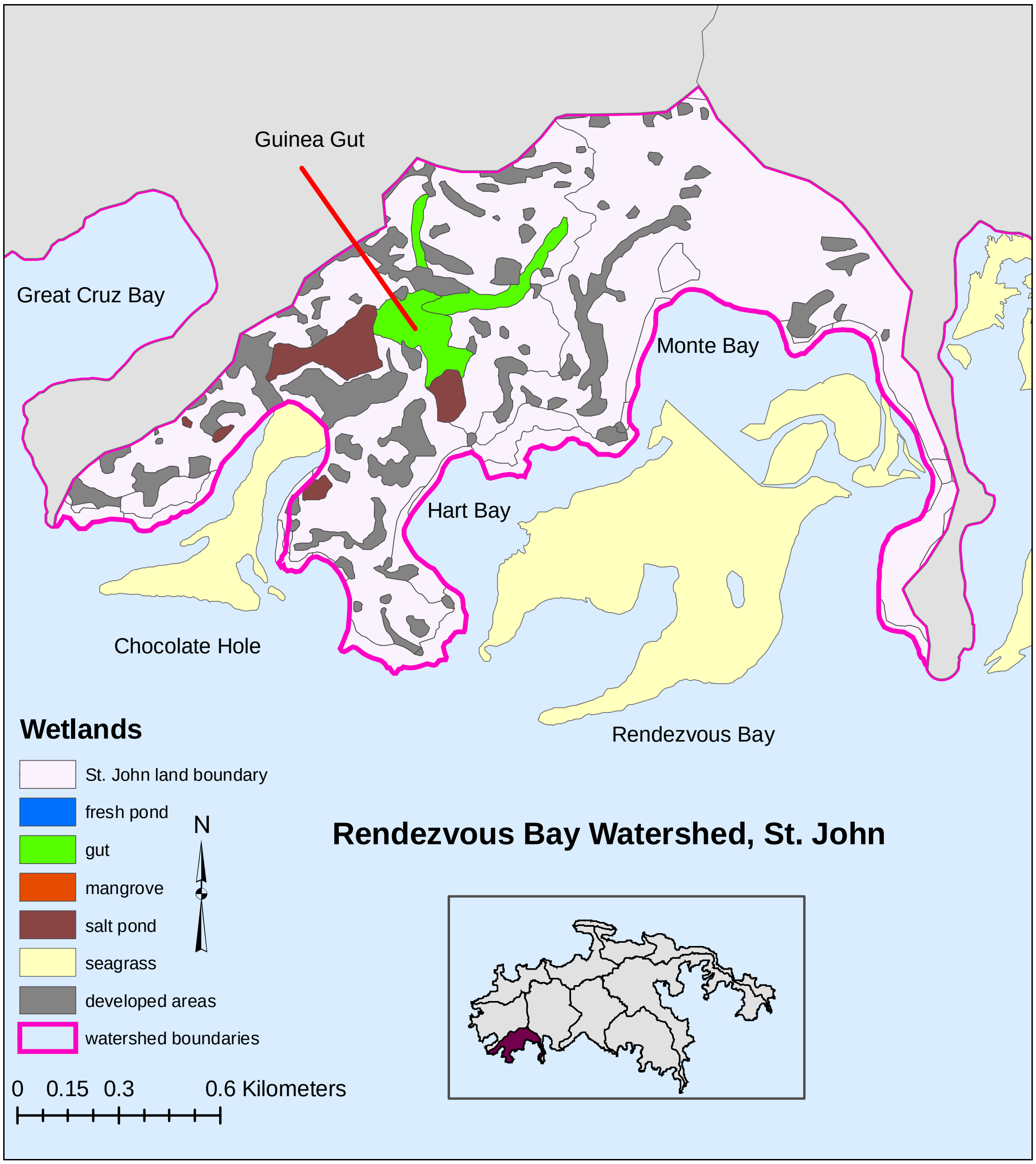
CZM, DEP, DFW, UVI, TNC, landowners


Salt Ponds
Perseverance Bay
Black Point
Brewers Bay
Cyril E. King Airport
Perseverance Bay Watershed, St. Thomas
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
developed areas
watershed boundaries
N
0
0.25
0.5
1 Kilometers

Rendezvous Bay, St. John

Description

The Rendezvous Bay watershed is located to the east of the main commercial area on St. John, Cruz Bay. The watershed encompasses Chocolate Hole and Rendezvous Bay, summiting at Gift Hill.



Wetland Types

There are two salt ponds and a large lagoon created by opening a channel from a salt pond to the sea at Chocolate Hole, and a salt pond and mangrove swamp at Hart Bay.

Threats

High levels of development in this area have increased the sediment and non-point source pollution loads into the ponds and bay. Plans for an extensive up-scale resort located between the beach and lagoon have the potential for completely altering the ecosystem.

Actions Needed

- Management of non-point source pollution and sediment levels from residential development.
- Protection of ponds from encroachment.

Potential Partners

CZM, DEP, DEE, DFW, TNC, local area residents

Coral Bay, St. John

Description

The Coral Bay watershed extends from the eastern tip of Ram Head Point across to the south western portion of the east end, and includes Drunk Bay, Johns Folly Bay, Friss Bay, Coral Bay, Hurricane Hole, Round Bay, and Privateer Bay. It includes the residential areas of Carolina and Coral Bay and the residences along Hurricane Hole.

Wetland Types

There are 14 salt ponds, two freshwater ponds, and extensive mangrove wetlands and seagrass beds within the Coral Bay watershed. Eight of the salt ponds lie within the National Park boundary.

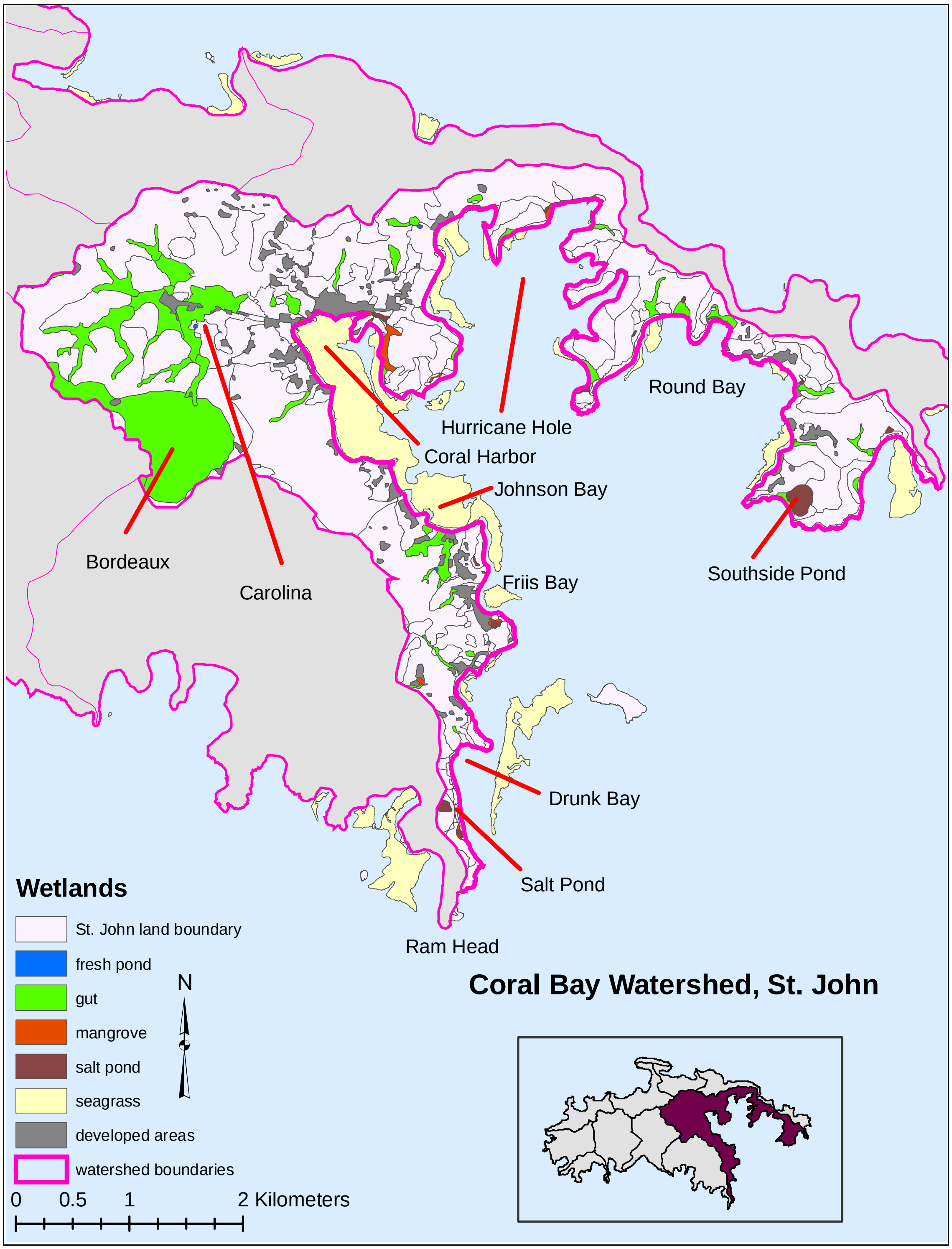
Threats

The Coral Bay area is under extreme development pressure for residences, services, and a marina. Several extensive developments are planned or underway, such as a residential development at Calabash Boom and the Coral Bay Marina.

Actions Needed

- Protect seagrass beds from degradation from increased sediment loading as a result of unpaved roads and development.

- Protect mangroves from illegal disturbance.
- Utilize more stringent sediment control methods in all development projects.
- Enhance of vessel wastewater management in the bay through pumpout facilities.



Potential Partners

CZM, DEP, DEE, DFW, NPS, TNC, Coral Bay Community Council and local area residents

Great St. James Cay

Description

Great St. James is comprised of 63 ha, located off the eastern edge of St. Thomas. The size and proximity of the island to St. Thomas enables it to support the biota of the larger islands (Dammann and Nellis 1992). The federally endangered VI tree boa, the locally threatened Puerto Rican racer, and other sensitive species occur on this island. The island is completely contained within the St. James Marine Reserve and Wildlife Sanctuary.

Wetland Types

There are four salt ponds on this island. Three are hypersaline and surrounded by buttonwood, the fourth is more tidally influenced and supports black mangroves (Stengel 1998). Seagrass beds are extensive in the nearshore environment.

Threats

This island is privately owned, and, as such, is subject to development. Current plans are underway to subdivide the island, establish a network of roads, and sell of parcels for residential development. Any development on this island would severely alter the delicate insular ecosystem, adding the threats of sedimentation input into the ponds and the introduction of exotic plant and animal species, including mammalian predators such as cats.

Actions Needed

- Protection against development pressure.
- Protection from introduction of non-native species.

Potential Partners

CZM, EPA, DEP, DFW, landowners and residents

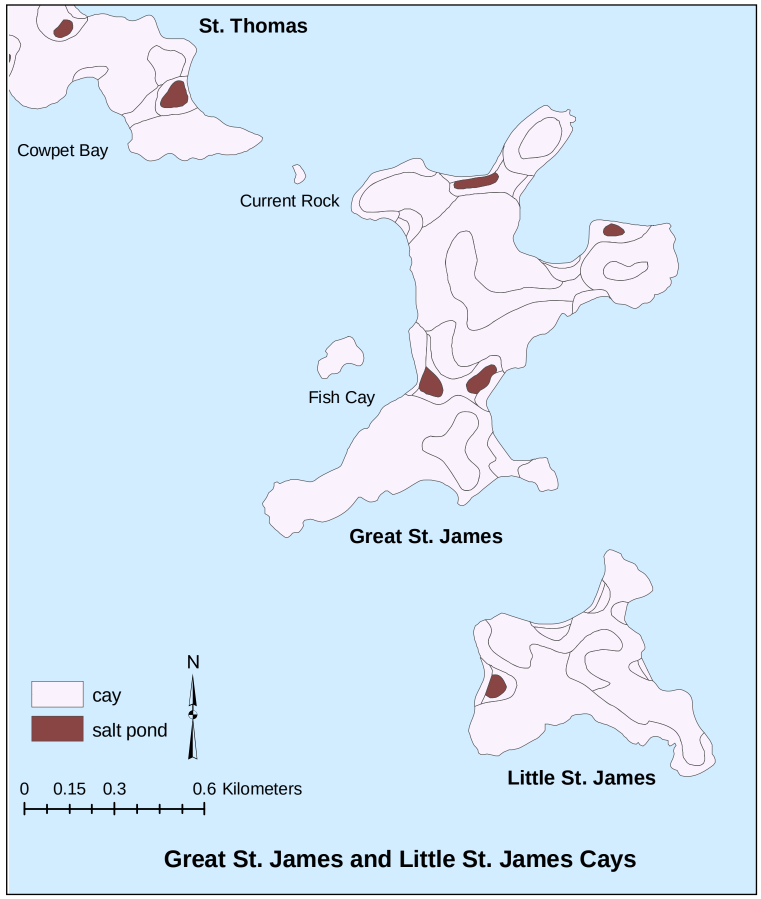
Little St. James Cay

Description

This island consists of 28 ha, located on the eastern side of St. Thomas. It has two salt ponds, one of which suffered extensive mangrove damage from hurricanes and the other has been severely altered as a result of adjacent housing development. The western edges of the island are within the boundaries of the St. James Marine Reserve and Wildlife Sanctuary .

Wetland Types

There are two ponds, one a mangrove-fringed salt pond, the other an altered remnant pond. The altered pond once supported mangroves that were lost after Hurricane Marilyn. The pond now holds freshwater, as evidenced by the presence of Cuban treefrog tadpoles (pers. obs.). Seagrass beds are present to the west of the island.



Threats

The remnant pond is subject to alterations by the landowner to enhance the aesthetics of the pond. The hydrology of the pond has been altered such that it now is primarily freshwater. The large salt pond has an unpaved road running alongside, and is subject to increased sediment loads.

Actions Needed

- Reduction in sediment loads to the large salt pond by paving the adjacent road.
- Restoration of mangroves along large salt pond.
- Restoration of natural hydrological processes at remnant pond.
- Protection of ponds from alteration through the addition of fountains and other water features.

Potential Partners

CZM, DEP, DFW, EPA, landowner and residents

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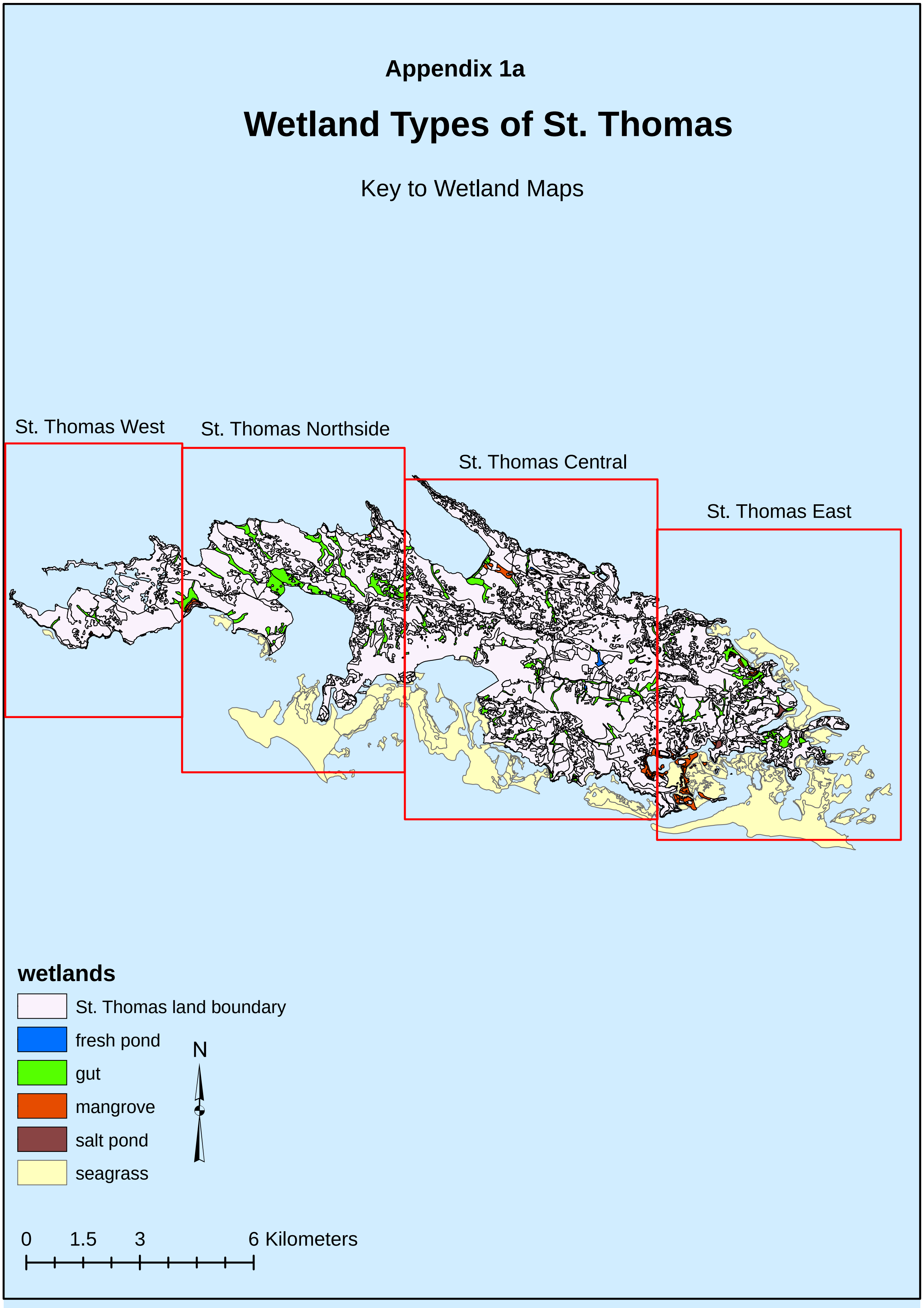
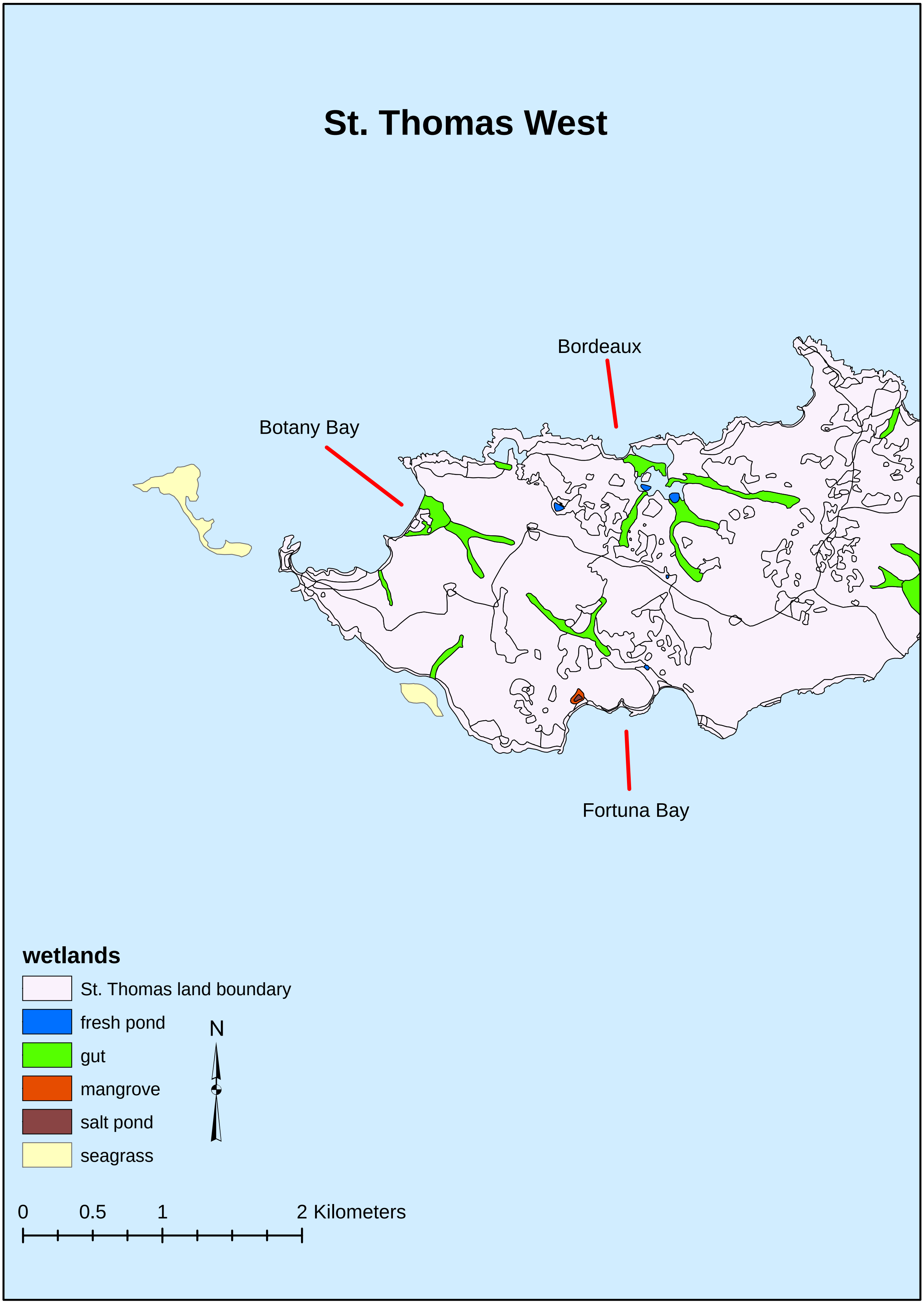
Photo: R. Platenberg

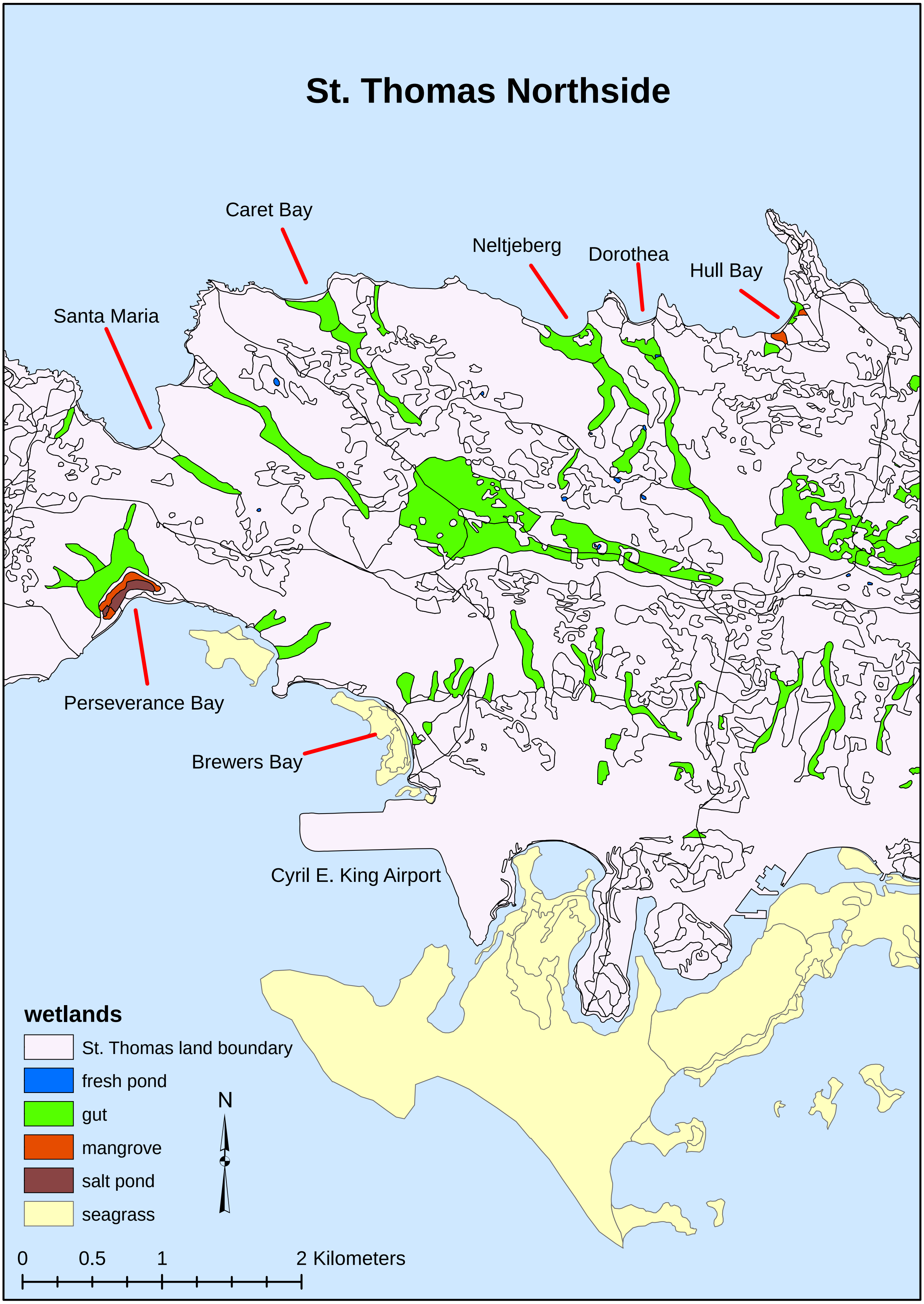
Salt pond on Dog Island, with St. Thomas in the background.

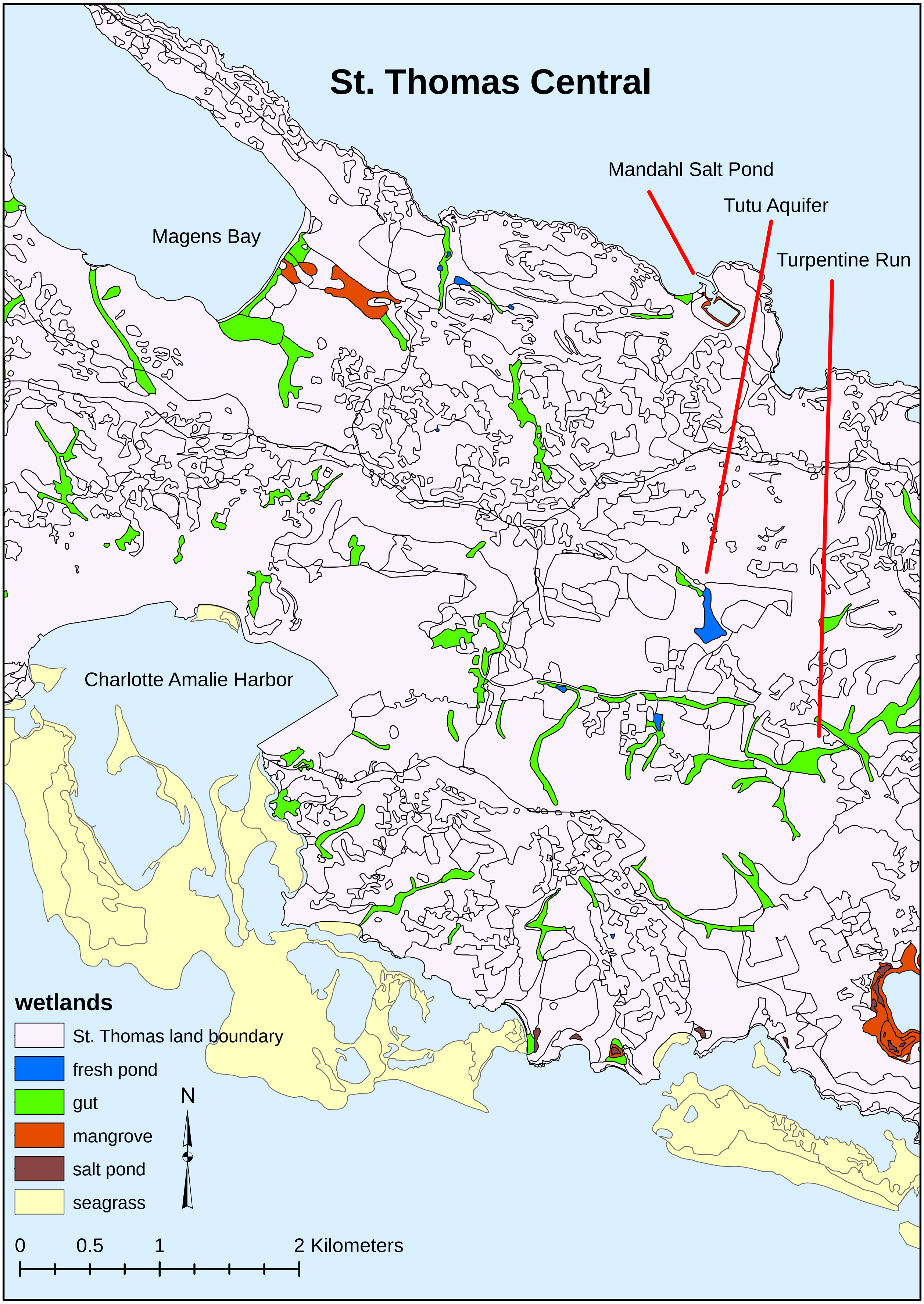


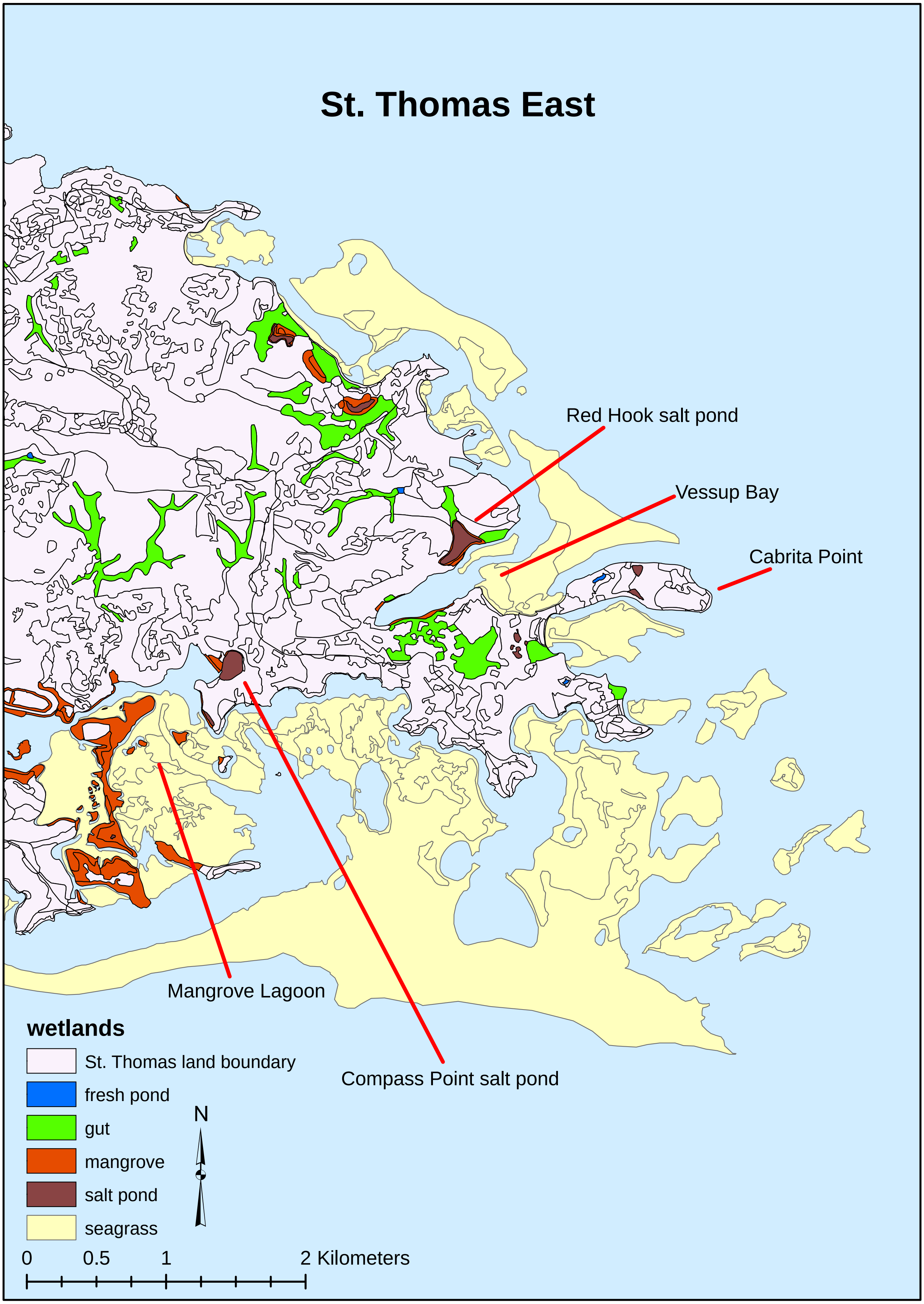
Appendix 1a
Wetland Types of St. Thomas
Key to Wetland Maps
St. Thomas West
St. Thomas Northside
St. Thomas Central
St. Thomas East
wetlands
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
N
0
1.5
3
6 Kilometers



St. Thomas West
Bordeaux
Botany Bay
Fortuna Bay
wetlands
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
N
0
0.5
1
2 Kilometers


St. Thomas Northside
Caret Bay
Neltjeberg
Dorothea
Hull Bay
Santa Maria
Perseverance Bay
Brewers Bay
Cyril E. King Airport
wetlands
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
N
0
0.5
1
2 Kilometers

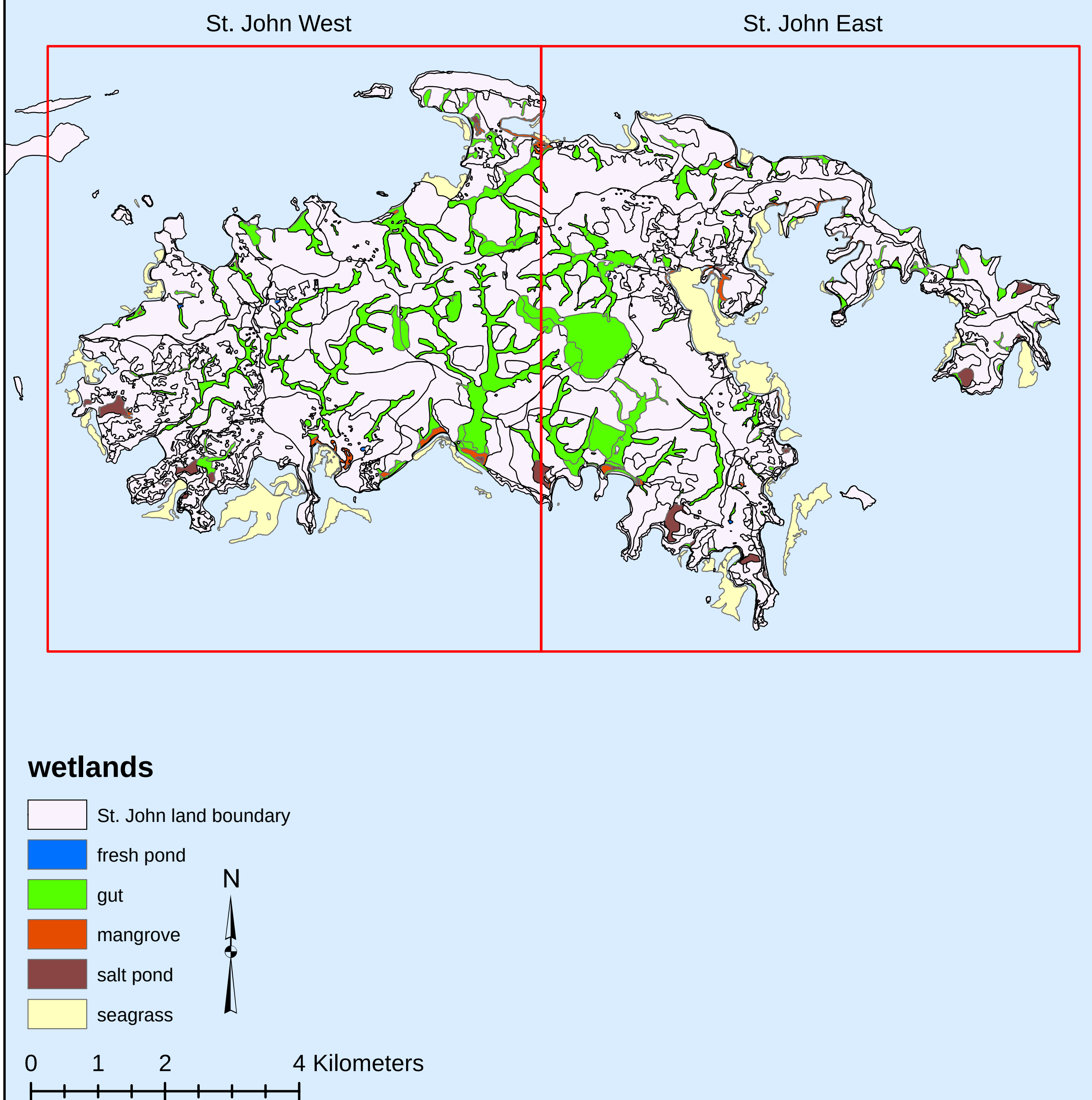

St. Thomas Central
Mandahl Salt Pond
Tutu Aquifer
Turpentine Run
Magens Bay
Charlotte Amalie Harbor
wetlands
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
N
0
0.5
1
2 Kilometers


St. Thomas East
Red Hook salt pond
Vessup Bay
Cabrita Point
Mangrove Lagoon
Compass Point salt pond
wetlands
St. Thomas land boundary
fresh pond
gut
mangrove
salt pond
seagrass
N
0
0.5
1
2 Kilometers

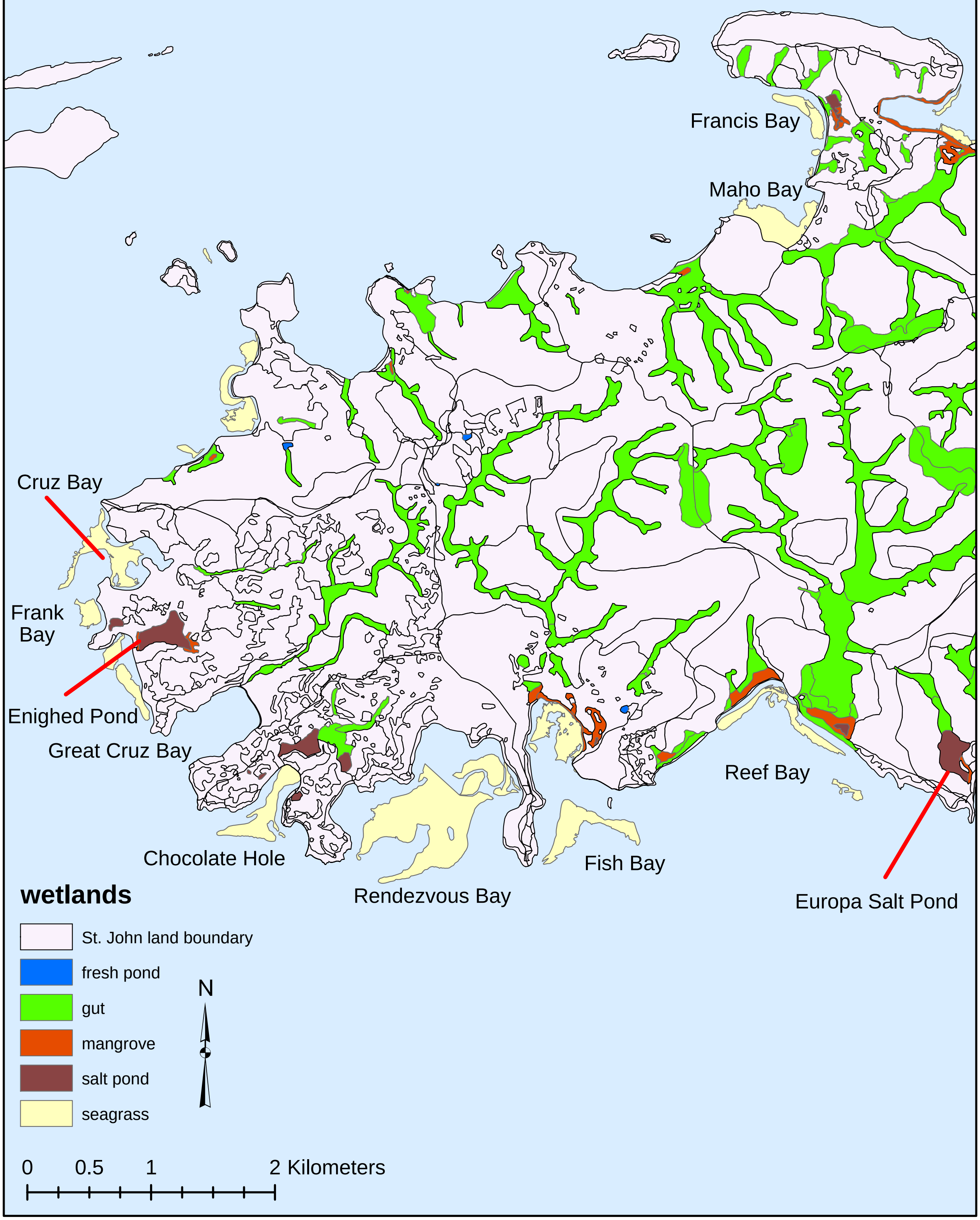
Appendix 1b

Wetland Types of St. John

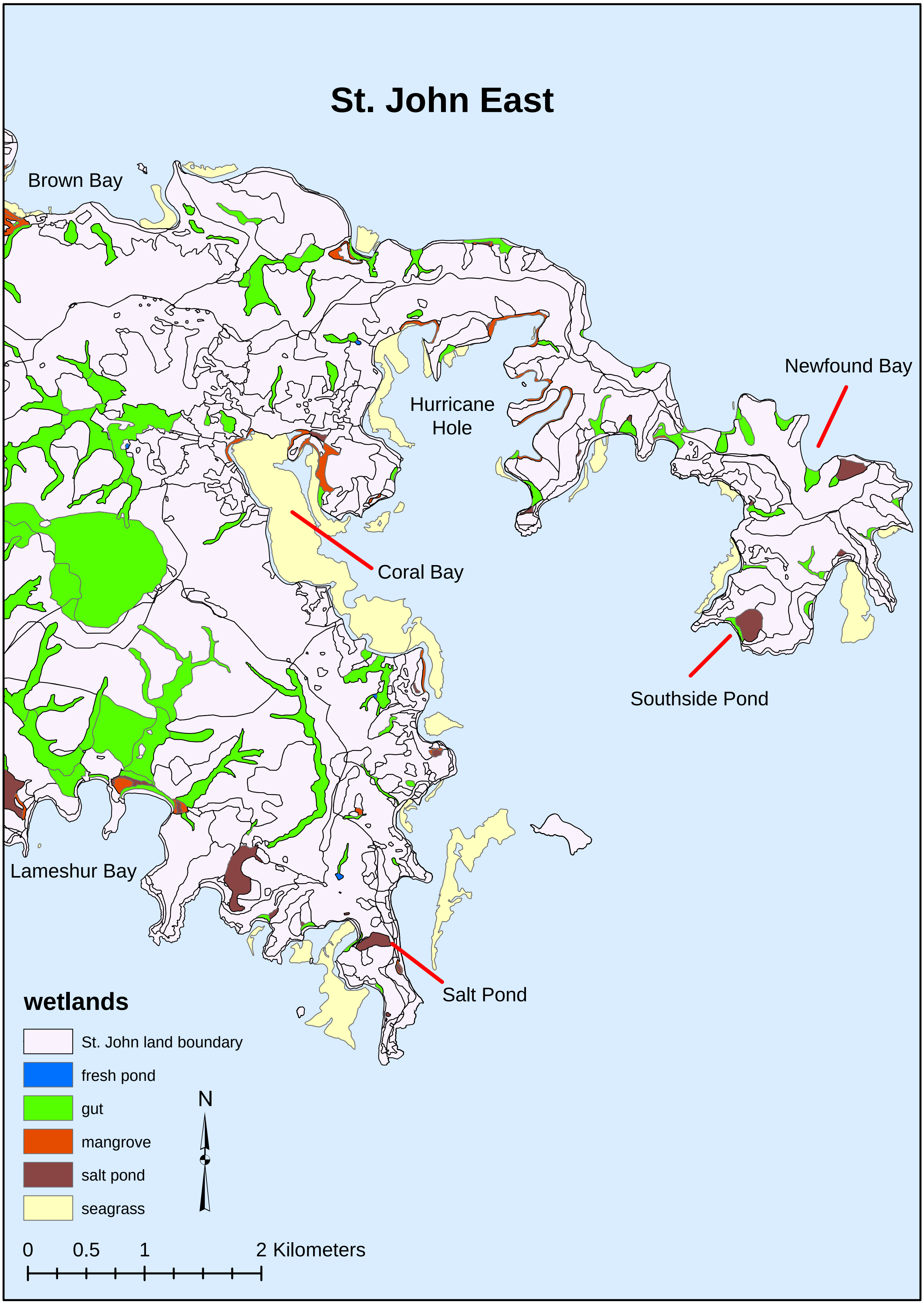
Key to Wetland Maps



St. John West



Francis Bay
Maho Bay
Cruz Bay
Frank Bay
Enighed Pond
Great Cruz Bay
Chocolate Hole
Rendezvous Bay
Fish Bay
Reef Bay
Europa Salt Pond
wetlands
St. John land boundary
fresh pond
gut
mangrove
salt pond
seagrass
N
0
0.5
1
2 Kilometers



St. John East
Brown Bay
Newfound Bay
Hurricane Hole
Coral Bay
Southside Pond
Lameshur Bay
Salt Pond
wetlands
St. John land boundary
fresh pond
gut
mangrove
salt pond
seagrass
N
0
0.5
1
2 Kilometers

Appendix 2

National Wetlands Regulations

Numerous federal statues call for the protection, restoration, and management of wetlands, watercourses, watersheds, and associated wildlife resources. Four main statutes provide for the strongest protective measures. The Clean Water Act is one of the most rigorous statutes protecting wetlands on a national level. It aims to restore and maintain the chemical, physical, and biological integrity of waters in the U.S. It also controls discharge of dredged or fill material into wetlands and other waters. The “Swampbuster” Act removes federal incentives for agricultural conversion of wetlands. The Coastal Zone Management Act requires the conservation of natural resources, including wetlands and coastal waters, and environmentally sound development within coastal zones. The Coastal Barriers Resources Act denies federal subsidies for development within undeveloped and unprotected coastal barrier areas, including wetlands.

A complete list of programs and regulations affecting wetlands can be found at: http://water.usgs.gov/nwsum/WSP2425/legislation.html and http://ipl.unm.edu/cwl/fedbook/index.html. The following is a summary of the main federal statutes concerning wetlands and wetland resources.

Coastal Barrier Resources Act 1982, 16 U.S.C. §§ 3501-3510
This Act protects undeveloped coastal barriers and related areas by prohibiting direct or indirect federal funding of projects in these areas. It aims to minimize the loss of human life, reduce damage to fish and wildlife habitats, and reduce wasteful expenditure of federal funds. Lands included do not qualify for federal flood insurance.

Coastal Wetlands Planning, Protection, and Restoration Act 1990, 16 U.S.C. §§ 3951-3956
This Act supports and funds coastal wetland restoration and conservation projects, with a particular emphasis on the state of Louisiana. It also provides funding under the National Coastal Wetlands Conservation Grant to carry out coastal wetland conservation projects that will be administered for long term conservation of lands, waters, and dependent fish and wildlife.

Coastal Zone Management Act 1972, 16 U.S.C. §§ 1451-1465
This Act establishes a federal grant program to encourage coastal states to develop and implement coastal zone management programs. Activities that affect coastal zones must be consistent with approved state programs. The Act also establishes a national estuarine reserve system. The Protection of Coastal Waters Program requires states to submit a Coastal Non-point Source Pollution Control Program that includes development and implementation management measures for non-point source pollution.

Emergency Wetlands Resources Act 1986, 16 U.S.C. §§ 3901-3932
This Act aims to promote wetlands conservation for the public benefit and to help fulfill international obligations in various migratory bird treaties and conventions. It authorizes the purchase of wetlands from Land and Water Conservation Fund monies, and transfers funds from import duties on arms and munitions to the Migratory Bird Conservation Fund. It further requires a National Wetlands Priority Conservation Plan and requires states to include wetlands in their comprehensive outdoor recreation plans.

Estuarine Areas Act 1968, 16 U.S.C. §§1221-1226
This Act calls for a federal study and inventory of estuaries, authorizes management and development through federal and state agreements, and requires consideration of these areas in federal projects.

Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act) 1937, 16 U.S.C. § 699
This Act provides federal aid to states for management and restoration of wildlife. Funding raised through an excise tax on sporting arms and ammunition may be used to support a variety of wildlife projects, including acquisition and improvement of wildlife habitat.

Federal Water Pollution Control Act (Clean Water Act) 1972, 33 U.S.C. §§ 1251-1387
This is a comprehensive statute aimed at restoring and maintaining the chemical, physical and biological integrity of the nation's waters. The primary authority for implementation and enforcement is with EPA. An important provision for wildlife and wetlands is the requirement of a permit to dispose of dredged and fill materials into navigable waters.

Fish and Wildlife Conservation Act 1980, 16 U.S.C. §§ 2901-2911
This Act encourages states to develop conservation plans for non-game fish and wildlife of ecological, educational, aesthetic, cultural, recreational, economic, or scientific value.

Fish and Wildlife Coordination Act 1934, 16 U.S.C. §§ 661-667.
This Act mandates that whenever waters or a channel of a body of water are modified by a department or agency of the U.S., the department or agency must first consult with the USFWS and the head of the agency exercising administration over wildlife resources of the state with a view to the conservation of wildlife resources. Land, water and interests may be acquired by federal construction agencies for wildlife conservation and development.

Lacey Act 1900, 16 U.S.C. § 701
This Act adopts measures to aid in restoring game and other birds in parts of the U.S. where they have become scarce or extinct, and to regulate the introduction of birds and animals in areas where they had not previously existed.

Land and Water Conservation Fund Act 1965, 16 U.S.C. § 460
This Act regulates admission and special recreation user fees to establish a fund to subsidize state and federal acquisition of lands and waters for recreational and conservation purposes. The purpose is to assist in preserving, developing, and assuring accessibility to outdoor recreation resources and developing land and water areas and facilities.

Marine Protection, Research, and Sanctuaries Act: Part 1 – Marine Sanctuaries 1974, 16 U.S.C. §§ 1431-1445
This Act provides for the designation and management of national marine sanctuaries based on specific standards. The purposes of the Act are to identify and designate status of national marine sanctuaries those marine areas of special national significance, to provide authority for conservation and management of these marine areas, and to support research, monitoring, and educational function of these areas.

Migratory Bird Conservation Act 1929, 16 U.S.C. § 715
This Act provides for the approval of areas of land for acquisition as reservations for migratory birds.

Migratory Bird Treaty Act 1918, 16 U.S.C. §§ 703-712
This Act implements various treaties and conventions between the U.S. and Canada, Japan, Mexico and states of the former Soviet Union for the protection of migratory birds. This Act makes the taking, killing or possessing of migratory birds illegal.

National Coastal Monitoring Program 1992, 33 U.S.C. §§ 2801-2805
The primary purpose of this program is to identify and analyze the environmental quality of the nation's coastal ecosystems. An additional purpose is to provide state programs authorized under the Coastal Zone Management Act of 1972 with information to design land use plans and coastal state regulations.

North American Wetlands Conservation Act 1989, 16 U.S.C. §§ 4401-4414
This Act provides funding for the implementation of the North American Waterfowl Management Plan in Canada, USA and Mexico, and establishes the North American Waterfowl Conservation Council to recommend wetlands conservation projects to the Migratory Bird Conservation Commission.

Soil and Water Resources Conservation Act 1977, 16 U.S.C. §§ 2001-2009
This Act provides for a continuing appraisal of U.S. soil, water and related resources, including fish and wildlife habitats, and a soil and water conservation program to assist landowners and land users in furthering soil and water conservation.

Submerged Lands Act 1953, 43 U.S.C. §§ 1301-1315
The Act grants coastal states title to submerged and offshore lands within their historic boundaries, generally up to three miles from the coastline, as well as the rights to the natural resources on or within those lands. The federal government relinquishes its claims

to the lands and resources, but maintains the right to regulate offshore activities for national defense, international affairs, navigation, and commerce.

Submerged lands are defined as lands beneath navigable waters, to include all lands covered by nontidal waters that were navigable at the time the state became a member of the Union or acquired sovereignty over the lands and waters, all lands permanently or periodically covered by tidal waters, and all filled in, made, or reclaimed lands which formerly were lands beneath navigable waters.

Water Bank Act 1970, 16 U.S.C. §§ 1301-1311
This Act promotes the preservation of wetlands by authorizing the Secretary of Agriculture to enter into land-restriction agreements with owners and operators in return for annual federal payments.

Water Resources Development Act 1986, 33 U.S.C. §§ 2201-2330
This Act contains omnibus provisions covering all features of water resources in development and planning, including environmental assessment and mitigation requirements.

Wetlands Loan Act 1961, 16 U.S.C. § 715 k3-5.
This Act authorizes an advance of funds against future revenues from the sale of duck stamps as a means of accelerating the acquisition and maintenance of migratory waterfowl habitat.

Appendix 3

USVI Wetlands Regulations

A number of local regulations contained within the Virgin Islands Code protect wetland resources both directly and indirectly. The Virgin Islands Code is the primary mechanism for promulgating legislative regulations, and can be accessed online (www.michie.com). Title 12 concerns the conservation of natural resources, although other sections also call for environmental protection. The following regulations concern wetlands or watershed impacts.

Title 12, Chapter 2: Protection of Indigenous, Endangered, and Threatened Fish, Wildlife and Plants

The VI Endangered and Indigenous Species Act protects native species of flora and fauna from injury, death, and harassment. It also specifically prohibits the cutting, pruning, removal and disturbance to mangroves, as well as no net loss of wetlands, without express written permission from the Commissioner. Mangroves are also protected under Title 12, chapter 21 (see below) in assurance that activities in or adjacent marine resources of unique productivity are designed and carried out so as to minimize adverse effects on marine productivity, habitat value, storm buffering capabilities, and water quality of the entire complex.

Title 12, Chapter 3: Trees and Vegetation Adjacent to Watercourses

This act prohibits the cutting or injury of any tree or vegetation within 30 feet of the center of any natural watercourse or 25 feet from the edge, whichever is greater, without written permission from the Commissioner.

Title 12, Chapter 7: Water Pollution Control

The Virgin Islands Water Pollution Control Program is mandated to conserve, protect, preserve, and improve the quality of water for public use, and for the propagation of wildlife, fish, and aquatic life in the USVI. The role of this program is to facilitate the preservation and - where necessary - make improvements to water quality conditions so as to ensure that water quality standards are met; to monitor health; and to ensure that permitted discharges to waters of the VI meet effluent limitations. The DPNR/DEP is charged with the task of implementing and enforcing these provisions (DEP 2002).

Title 12, Chapter 9A: Commercial Fishing

This act establishes the territorial ownership of all beds and bottoms of navigable rivers, streams, lagoons, lakes, inlets, bays, harbors, oceans, sea or other bodies of water within the jurisdiction of the territory. These lands cannot be sold. This act stipulates that all species of fish, mollusks, crustaceans, animals, plants, etc. in these waters are the property of the government of the USVI, and of common ownership and public use.

Title 12, Chapter 13: Environmental Protection

This act establishes an environmental protection program to prevent improper development of land and harmful environmental changes in order to prevent watershed conditions leading to erosion and sediment deposition on lower lying lands and in tidal waters, increased flooding, gut drainage filling and alteration, pollution and other harmful environmental changes to such a degree that fish, marine life, and recreational and other private and public uses of land and waters are being adversely affected

Title 12, Chapter 21: Virgin Islands Coastal Zone Management

This act establishes the Department of Coastal Zone Management to protect, maintain, preserve, enhance, and restore overall quality of the environment in the coastal zone, to include submerged lands. It outlines the conservation of ecologically significant resource areas for marine productivity and value as wildlife habitats, the preservation of the function and integrity of reefs, marine meadows, salt ponds, mangroves, and other significant areas, and the maintenance of coastal water quality through the control of erosion, sedimentation runoff, siltation, and sewage discharge.

Title 7, Chapter 3: Soil Conservation

The Soil Conservation Act allows for the conservation of soil and water resources in order to prevent erosion and sedimentation.

Appendix 4

Internet Links

Organizations

Center for Watershed Protection	www.cwp.org
Environmental Protection Agency	www.epa.gov
Island Resources Foundation	www.irf.org
Natural Resources Conservation Service	www.nrcs.usda.gov
NOAA-National Marine Fisheries Service	www.nmfs.noaa.gov
UVI Marine Science Center	http://marsci.uvi.edu
VI-Coastal Zone Management Program	www.viczmp.com
VI-Department of Planning and Natural Resources	www.dpnr.gov.vi
VI-Division of Environmental Protection	www.dpnr.gov.vi/dep/home.htm
VI-Division of Fish and Wildlife	www.vifishandwildlife.com
Virgin Islands Water Resources Research Institute	http://rps.uvi.edu/WRRI/wrri.htm

Regulations

Clean Water Act	www.epa.gov/region5/water/cwa.htm
Federal Wildlife and Related Laws Handbook	http://ipl.unm.edu/cwl/fedbook/index.html
Federal wetland protection programs and policies	http://water.usgs.gov/nwsum/WSP2425/legislation.html
Virgin Islands Code	www.michie.com

Other Resources

Invasive aquatic plants in Florida	http://aquat1.ifas.ufl.edu/guide/invplant.html
Environmental Laboratory Wetlands	http://el.erdc.usace.army.mil/wetlands/
Virgin Islands Non-Point Source Pollution Conference	http://usvircd.org/NPS/VINPSconf2005.index.html
Global Programme of Action for the Protection of the Marine Environment from Land-based Activities	www.gpa.unep.org