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Wildlife Action Plan

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Volume 2:
Habitats and Species

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Acronyms used in text

ACoE	U.S. Army Corps of Engineers
APC	Area of Particular Concern
APHIS	Animal and Plant Health Inspection Service (USDA)
BUIS	Buck Island Reef National Monument (St. Croix)
BVI	British Virgin Islands
CAP	Conservation Action Planning
CBCC	Coral Bay Community Council
CDC	Center for Disease Control
CITES	Convention on International Trade in Endangered Species
CLCC	Caribbean Landscape Conservation Council
CORE	Caribbean Oceanic Restoration and Education Foundation
CWCS	Comprehensive Wildlife Conservation Strategy
CZM	U.S. Virgin Islands Division of Coastal Zone Management
DEE	Division of Environmental Enforcement
DEP	U.S. Virgin Islands Division of Environmental Protection
DFW	U.S. Virgin Islands Division of Fish and Wildlife
DNER	Department of Natural and Environmental Resources of Puerto Rico (Departamento de Recursos Naturales de Puerto Rico)
DOA	U.S. Virgin Islands Department of Agriculture
DOI	Department of the Interior
DPNR	U.S. Virgin Islands Department of Planning and Natural Resources
DPS	Distinct Population Segment
EAST	Environmental Association of St. Thomas and St. John
EPA	Environmental Protection Agency
EPSCOR	Established Program to Stimulate Competitive Research
ES	Endangered Species
ESA	Endangered Species Act
FIA	Forest Inventory Analysis
IAC	Inter-American Convention for the Protection and Conservation of Sea Turtles
IRF	Island Resources Foundation
IUCN	International Union for the Conservation of Nature
MBA	Magen’s Bay Authority
MCD	Marine Conservation District
MCDA	Multi-criteria Decision Analysis
MMES	Master of Marine and Environmental Science
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
NCRMP	National Coral Reef Monitoring Program
NESP	National Ecosystem Services Partnership
NGO	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service

NPS	U.S. National Park Service
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
PR	Puerto Rico
SEA	St. Croix Environmental Association
SGCN	Species of Greatest Conservation Need
SPAW	Specially Protected Areas and Wildlife
SPNWR	Sandy Point National Wildlife Refuge
STAR	Sea Turtle Assistance and Rescue
STEER	St. Thomas East End Reserves
STJ	St. John
STT	St. Thomas
STX	St. Croix
SWAP	State Wildlife Action Plan
SWG	State Wildlife Grant
TCRMP	Territorial Coral Reef Monitoring Program
TNC	The Nature Conservancy
TVIL	Trust for Virgin Islands Lands
UNEP	United Nations Environment Programme
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USVI	U.S. Virgin Islands
UVI	University of the Virgin Islands
VI	Virgin Islands
VICRNM	Virgin Islands Coral Reef National Monument
VICS	Virgin Islands Conservation Society
VIERS	Virgin Islands Ecological Research Station
VIMSIA	Virgin Islands Montessori School and International Academy
VINP	Virgin Islands National Park
WAP	Wildlife Action Plan
WCR	Wider Caribbean Region
WR	Wildlife Restoration
WRRI	Water Resources Research Institute

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Appendices

Chapter One
Habitats of the U.S. Virgin Islands

The U.S. Virgin Islands (USVI) are located at the northwest of the Lesser Antilles, a set of small islands in the eastern Caribbean basin. The archipelago comprises three main islands, St. Thomas, St. John and St. Croix, and more than 50 recognized cays and off-shore rocks to encompass a total land area of 346 km^2.

The islands share common features of geology, climate, and ecology (Acevedo-Rodriguez 1996). St. Thomas and St. John, on the north, are geologically part of the Puerto Rican bank and were connected in the past, but St. Croix, located 60 km to the south, has a different origin. It has been estimated that separation of the northern islands occurred some 8,000 to 10,000 years ago, at the end of the last Ice Age. St. Croix on the other hand, either has been isolated for much longer or was never connected to the other islands (Heatwole et al. 1981, Wiley and Vilella 1998). A sea channel more than 3,600 m deep separates St. Croix from the other islands.

The USVI are volcanic in origin but also contain limestone derived soils, particularly on St. Croix (NRCS 2000, Rankin 2002). The climate of the islands is classified as subtropical (Ewel and Whitmore 1973); although located south of the Tropic of Cancer, the annual mean temperature at sea level is below 24^{o}C (Wiley and Vilella 1998), with the surrounding seas having a cooling effect on the islands. The average rainfall ranges from 750 mm in the coastal areas and up to 1,400 mm in the higher elevations (Wiley and Vilella 1998, Corven 2008) and a distinct east-west precipitation gradient, with western areas receiving more rainfall than the eastern areas. Rainfall is heaviest from August to December and generally along the northern and central portions of the islands. There is a higher daily temperature difference than seasonal, with generally less than 10^{o}C difference between the mean temperatures of the coolest and warmest months. The highest temperatures are in August or September, and the lowest are in January or February. In addition, the climate is characterized by high evaporation rates due to continuous wind currents and the warm temperatures (NRCS 2000).

The landcover of the USVI had a similar history as many other Caribbean islands, including nearby Puerto Rico. In the 17th and 18th centuries during the colonization process by European settlers, one of the main drivers of landcover change was the plantation primarily of sugar cane (Dookhan 1974), with other crops, such as cotton, tobacco and coffee also important (Acevedo-Rodriguez 1996). Trees were harvested for building materials, and these activities left all three main islands highly deforested.

Recent estimates put landcover of the USVI as being between 50 – 67 % (Brandeis and Oswalt 2007, Chakroff 2010, Gould et al. 2013), comprising forests, woodlands, and shrublands. This appears to be an increase in forest habitats from historical deforestation levels; at the beginning of the 20th century about 90% of the forested lands had been cleared for agriculture, wood production or other uses, and estimated forest cover of the three major islands was around 45% in the mid-1970s (Somberg 1976). However, the majority of forested lands in the USVI are secondary growth and today’s forests are a biologically diverse mix of native and exotic species (Wiley and Vilella 1998, Brandeis and Oswalt 2007). Younger forest stands of less than 50 years are primarily dominated by the non-native leguminous tree *Leucaena leucocephala*, the most common tree in the USVI (Gould et al. 2013). Secondary forest succession in the USVI is a slow process that may even become stalled in highly impacted areas. Although land-cover has remained stable over recent years, these numbers do not reveal transition of pasture to early forests and loss of forests to urban development. St. John has the highest forest cover of the three islands with the most mature forest cover at around 20% (Brandeis and Oswalt 2007).

Differences in land use through time have created different forest landscapes in each of the major islands (Chakroff 2010). While St. Thomas natural habitats are experiencing more pressure from urban development and the tourism industry, St. Croix has undergone pressure from agricultural activities such as cattle grazing. Coastal development across all islands has increased at a fast pace over the last 50 - 60 years, leading to the degradation of half the mangrove cover and associated saline wetlands (McNair et al. 2006). The construction of an industrial complex and oil refinery brought about the destruction of one of the most important wetlands in St. Croix, Krause Lagoon, in the early 60’s (McNair et al. 2006). About 11.6 percent of the land in the USVI is developed or urbanized (Gould et al. 2013).

Two lifezones (*sensu* Holdridge 1967) have been described for USVI: subtropical dry, and subtropical moist forest zones (Ewel and Whitmore 1973). The landscape of the U.S. Virgin Islands is made up of a variety of ecosystems including forests, woodlands, shrublands, grasslands, wetlands, rocky shores, sandy beaches and urban environments.

The volcanic origin of the islands leaves steep topography and shallow soils, restricting the formation of natural wetlands primarily to coastal plains. Coastal salt ponds and mangroves are the dominant forms of wetlands. Stormwater flowing from uplands through riparian waterways either feed into salt ponds, basin ponds behind beach berms, or directly into the sea. Freshwater is limited in availability, and many of the waterways have been dammed to divert water for agricultural use, creating freshwater ponds (Platenberg 2006).

Within the waters surrounding the islands, mangroves, seagrass beds, and several types of coral reefs provide essential habitat for marine organisms. Connectivity between marine habitats allows interchange between species and ecosystem services, and marine systems both support and are supported by terrestrial coastal habitats. Currently there are 31 Marine Protected Areas established in USVI with 11 sites designated as no-take areas that allow human access and some uses, but prohibit the extraction or significant destruction of natural or cultural resources (NOAA 2009).

St. Croix

At about 220 km^2, St. Croix is the largest of the U.S. Virgin Islands (Fig. 1). Following an east-west axis, the island is about 34 km long and 9.6 km at the widest point. The maximum elevation is at Mt. Eagle (332 m). Eastern and western ranges in the northern part of the islands graduate to a broad and rolling expanse of coastal plain across the south (Thomas and Devine 2005). The narrow shelf surrounding the islands descends gradually allowing for growth of a long fringing reef around much of the coastline (Fig. 2). St. Croix has historically been the agricultural island due to large areas of flat arable land. Although not strictly a habitat type of high value, some species can be found in agricultural lands and it may be possible to work with stakeholders to derive conservation value. The most recent estimates give 57% total forest cover for St. Croix (Kennaway et al. 2008), with approximately 75% falling into the Holdridge Life Zone of subtropical dry forest and the remaining being subtropical dry forest (Ewel and Whitmore 1973, Chakroff 2010).

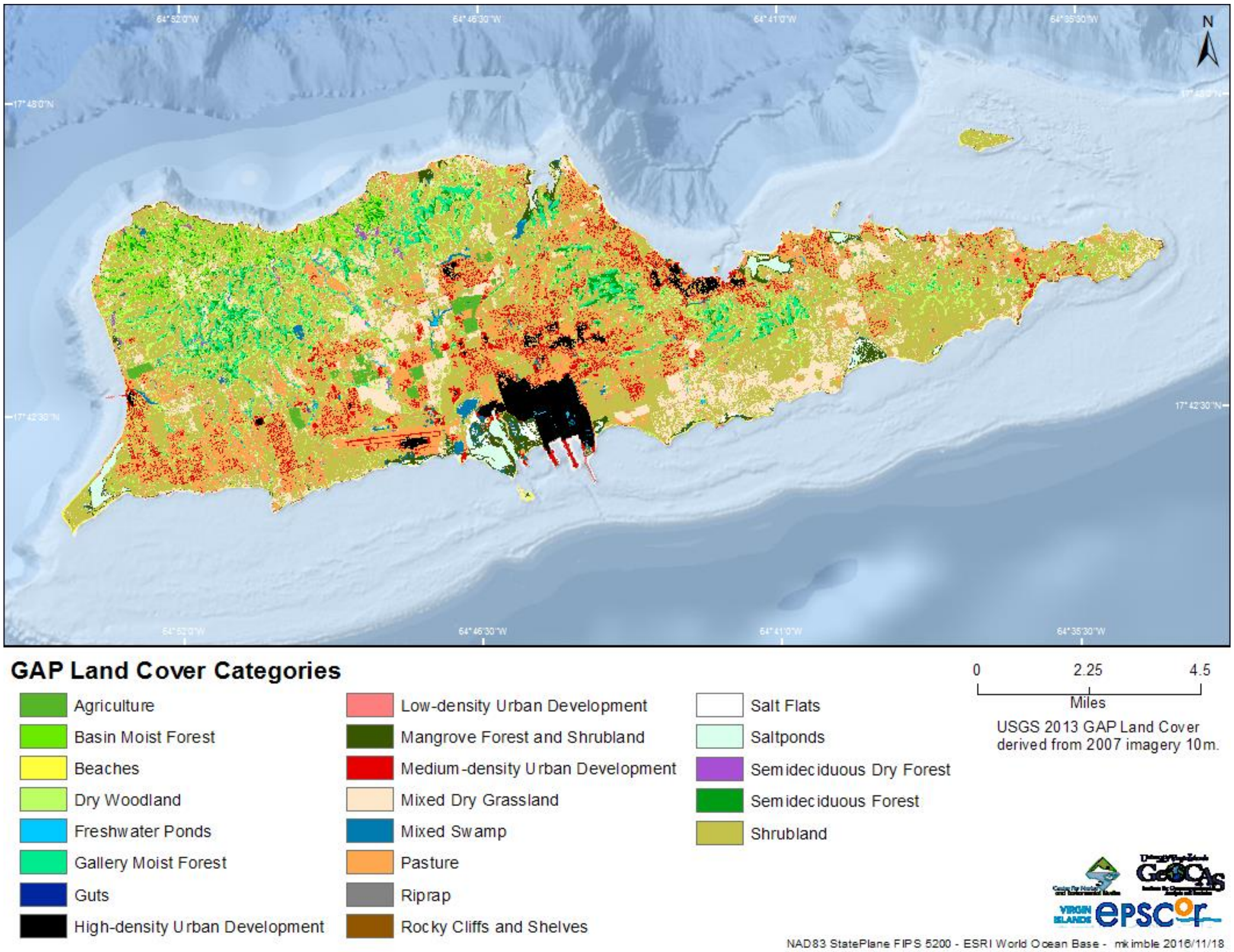

Figure 1. St. Croix land cover classes. (V. Brandtneris, CMES, 2018)

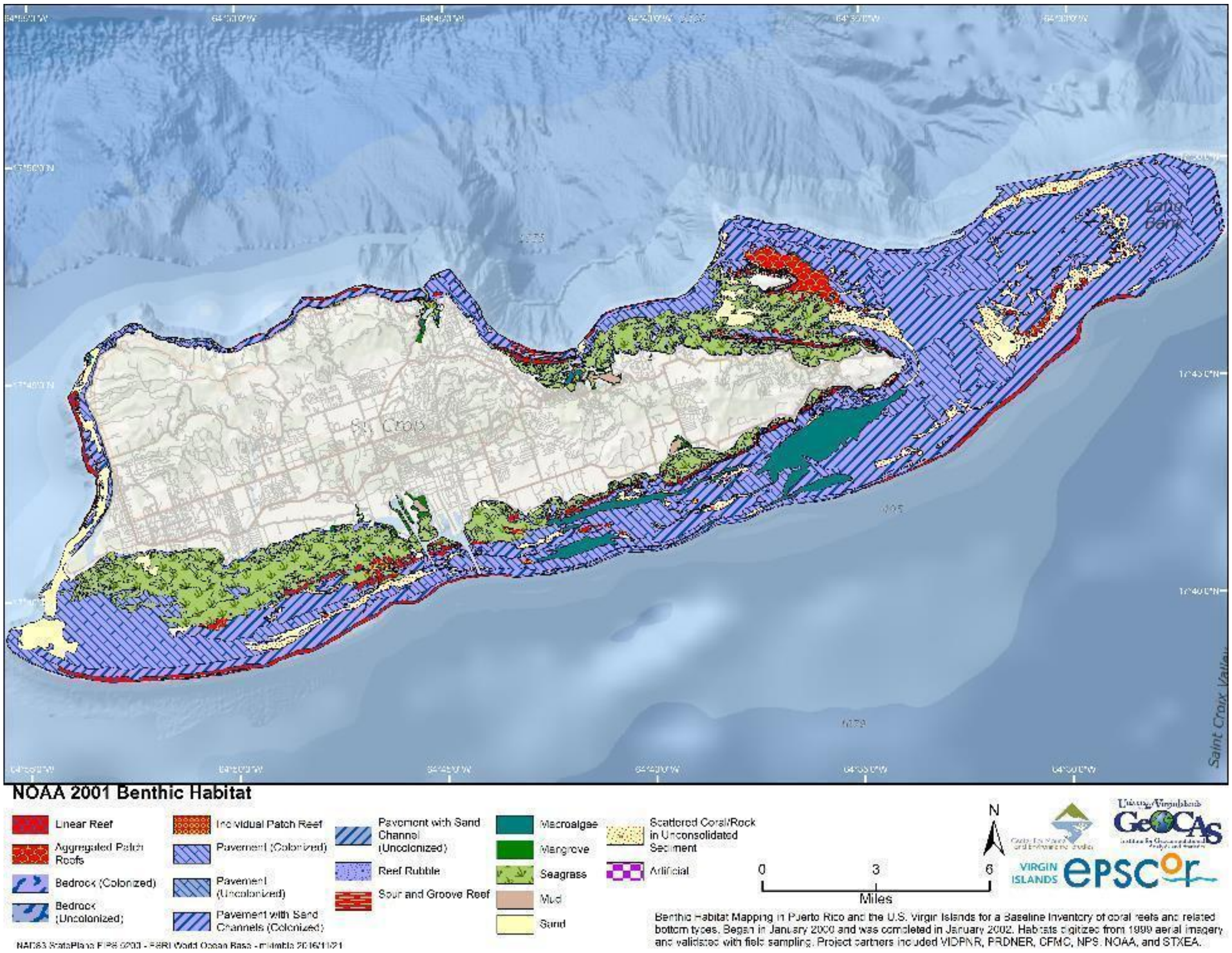

Figure 2. St. Croix benthic habitats. (M. Kimble, GeoCAS, 2016)

St. Thomas

St. Thomas is less than half the size of St. Croix, at 83 km^2. It measures about 19 km long by 5 km at its widest point (Fig. 3). The highest peak in the USVI is Crown Mountain, at 474m, where remnants of native upland moist forest can be found. Volcanic mountains with steep slopes dominate the landscape and coastal plains are few and limited to areas with deep embayments (Thomas and Devine 2005). St. Thomas has some agricultural history, although by the mid-1800s much of the large-scale agriculture was abandoned (Brandeis and Oswalt 2007, Chakroff 2010). Forest cover estimates range between 63% to 74%, with two-thirds of the island falling within the subtropical moist forest life zone and the rest being subtropical dry forest (Chakroff 2010). Steep topography that extends underwater limits reef growth to shallow locations along the irregular coastline (Fig. 4). St. Thomas is the main tourism hub for cruise ships and resort hotels, and suffers from dense urban overdevelopment (Thomas and Devine 2005).

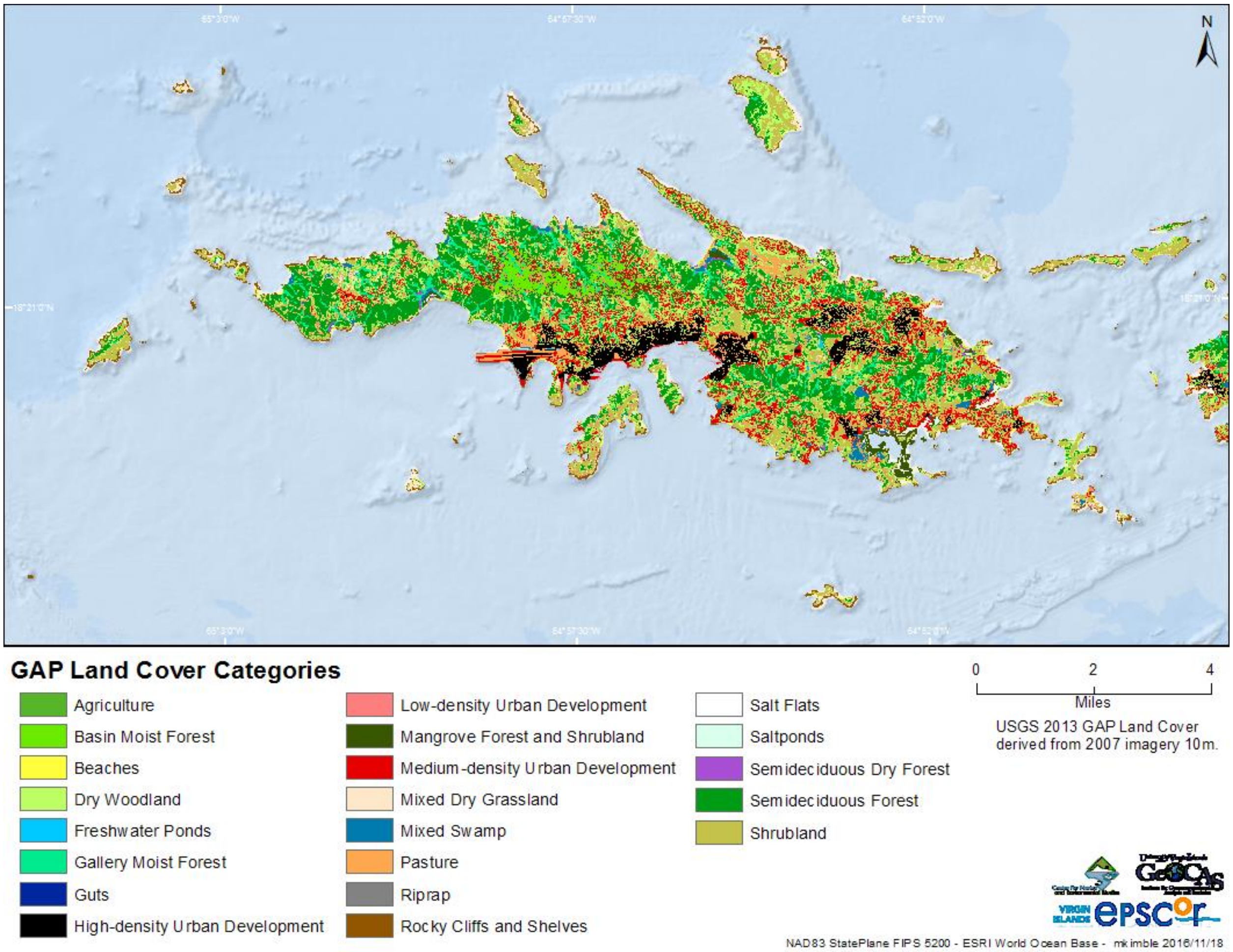

Figure 3. St. Thomas land cover classes. (V. Brandtneris, CMES, 2018)

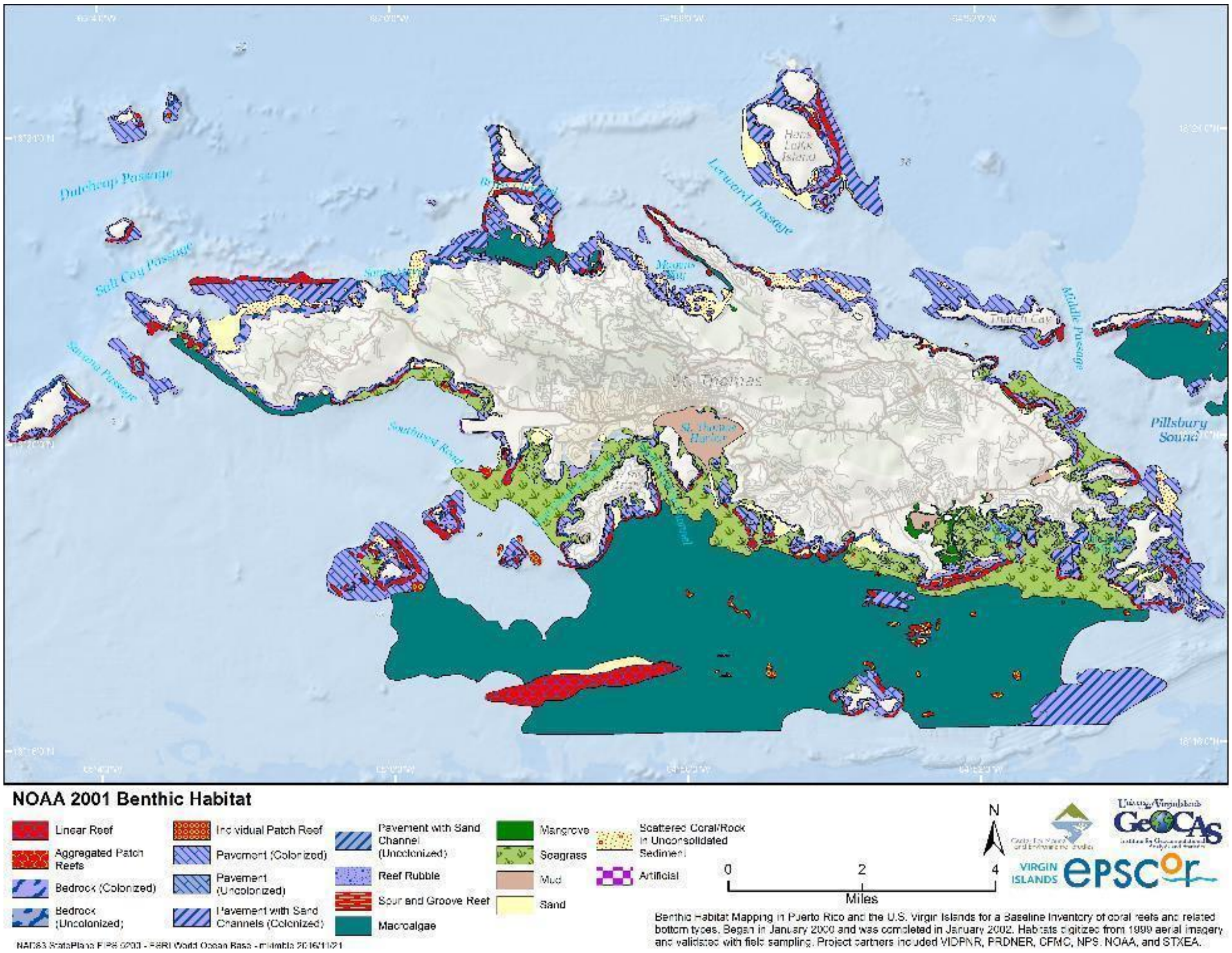

Figure 4. St. Thomas benthic habitats. (M. Kimble, GeoCAS, 2016)

St. John

St. John is 2 km to the east of St. Thomas, with an area of 49 km^2, measuring 13 km long and 4km wide (Fig. 5). Its highest peak is Bordeaux Mountain at 392 m. Like St. Thomas, the island has steeply sloped volcanic topography, with numerous bays and an irregular shoreline. Total forest cover is calculated at 89% (Kennaway et al. 2008), with 60% falling within the subtropical dry forest life zone (Chakroff 2010). The forest recovery in St. John has been attributed to its mountainous rugged terrain, and earlier abandonment of plantation agriculture. (Gould et al. 2013). St. John retained over 50% of its native forests and shrublands, contributing to a higher ability for regeneration of native forests in formerly disturbed areas (Gibney 2004). The island is surrounded by reef systems and seagrass beds interspersed with algal plains (Fig. 6) Change in ownership in 1917 to the United States eventually led to the formation of the Virgin Islands National Park in 1956.

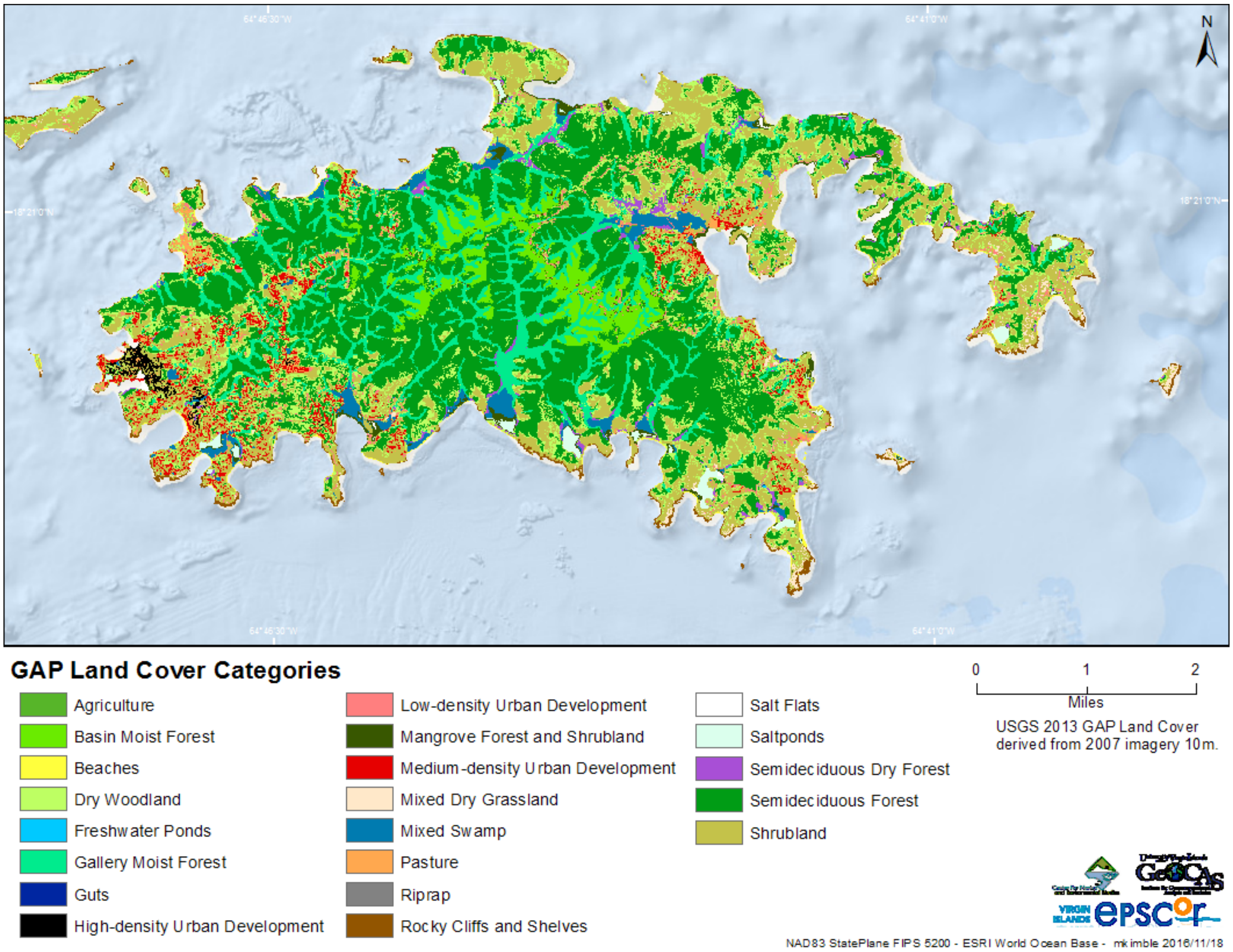

Figure 5. St. John land cover classes. (V. Brandtneris, CMES, 2016)

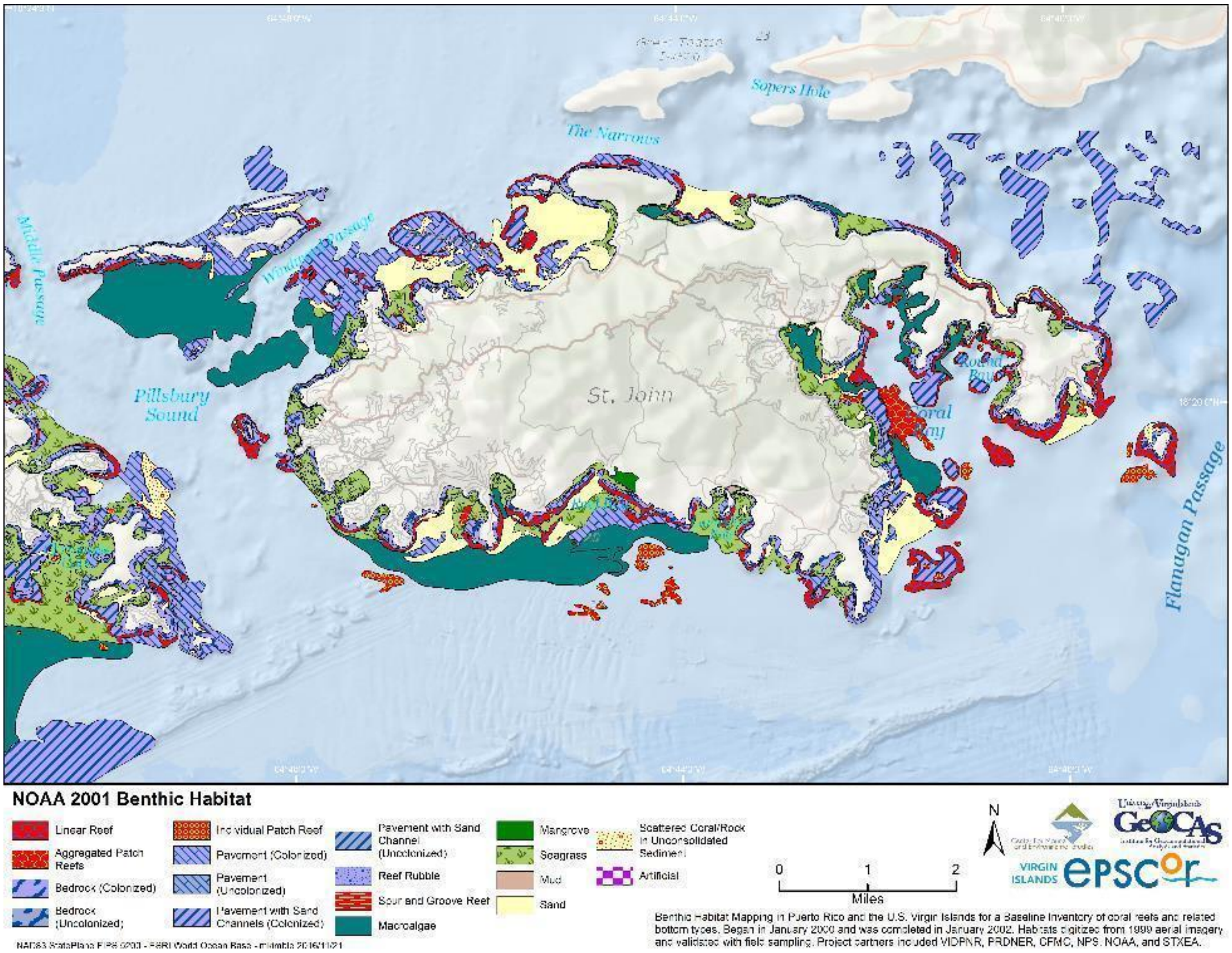

Figure 6. St. John benthic habitats. (M. Kimble, GeoCAS, 2016)

This section was adapted from: Gould et al. 2013. U.S. Virgin Islands Gap Analysis Project – Final Report. USGS, Moscow ID and the USDA FS International Institute of Tropical Forestry, Río Piedras, PR.

Contributor (2017): RJP

Banner photo: Saba Cay by R. Platenberg

1.1 USVI Habitats: Terrestrial Communities

Overview

The prevalent climate, soils, and topography of the Virgin Islands influence the growth and variation in terrestrial vegetation communities. With a subtropical climate, species are adapted to withstand seasonal drought that can last five months or longer, and to recover from recurrent disturbances from hurricanes. Due to easterly tradewinds, the islands exhibit an east-west moisture gradient with hot and dry conditions normal on the eastern ends, and more moisture influencing mesic vegetation communities moving west and along higher elevations.

The Virgin Islands are forested, except where extreme conditions limit growth to low scrubby shrublands and grasslands. The shorelines that fringe the islands are highly variable, from rocky cliffs to cobbly beaches to sand. Satellite cays are dotted around the larger islands, particularly along the northern USVI that lies on the Puerto Rican Bank. Terrestrial habitats not only offer habitat to a wide variety of resident and migratory species, but also play important roles in erosion control, climate regulation, and carbon storage.

Forests are the predominant habitat across the larger islands within the VI. These fall into two main categories, dry subtropical forest and subtropical moist forest, with the latter restricted to higher elevations and along riparian corridors. Tree cover stabilizes the soil and filters and slows the movement of stormwater. A high diversity and abundance of birds, frogs, reptiles, and invertebrates are found across a plethora of forest niches

Shrublands are low, bushy habitats found in environments that are stressed from extreme conditions, such as strong winds and salt spray, or disturbed by agriculture or land use change.

Shrublands and **grasslands** are a transitional stage as land becomes naturally reforested. They provide cover for ground nesting birds and play an important role in erosion control.

Beaches and Shorelines have unique assemblages of salt and wind tolerant plants that can survive in the nutrient poor conditions offered by sandy beaches and rocky shorelines. Sandy beaches offer nesting areas for sea turtles and migratory waterbirds, buffer coastal areas from storm energy while filtering sedimentation from upland runoff. Shoreline habitats merge with a highly dynamic intertidal zone.

The main threat to terrestrial habitats is loss of vegetation cover from residential and commercial development, which reduces not only habitat but also connectivity for movement and gene flow. Loss of forest cover reduces valuable ecosystem services, such as erosion control and carbon storage. Residential encroachment can alter behavior of wildlife and limit foraging potential. Invasive species quickly take hold in disturbed areas, sometimes predating on or crowding out natives. Climate change is altering forest phenology and changing weather patterns, resulting in prolonged dry seasons and more severe rainfall events that topple trees and wash away saturated soils. Sea level rise is impacting coastal habitats.

Priority actions for terrestrial habitats include protecting and restoring large forested areas and maintaining connectivity between forest patches. Reducing stressors, including impacts from invasive species, particularly on cays, allows for better resilience within upland communities.

Forests

Habitat Description

The dominant native forest ecosystems of the USVI are subtropical dry forests and, to a lesser extent, subtropical moist forests (Ewel and Whitmore 1973, Sombert 1976, Forman 1980, Thomas and Devine 2005). Native trees in the USVI are adapted to conditions where shallow soils overlie bedrock, such that roots either need to find rock fissures or grow through and over soil surface. Native vegetation is adapted to withstand storms, and will sway rather than topple, unlike non-natives (e.g., Genip commonly topples during storms, particularly when unprotected by surrounding forests, as alongside roads. This species is often problematic due to blocking roads and downing powerlines during storms). Native trees must also be able to withstand at least five to six months of annual drought during the spring dry season.

Forest types grade into one another and are generally difficult to delineate. The forest communities described herein are based on the classification systems of Gibney et al. (2000), Thomas and Devine (2005), and Gould et al. (2013).

Moist forest refers to seasonal evergreen forests with predominantly broad-leaved trees of which 70% or more species are evergreen. Some loss of foliage occurs during the dry season. These forests occur in watershed basins along the coast, in riparian areas associated with drainage guts and swales that transport runoff from upper elevations, and on elevated upland areas where rainfall exceeds 1200 millimeters per year. The forest is comprised of numerous species ranging in height from 10-30 meters. The taller formations typically possess three canopy layers whereas the shorter formations support only two layers. ***Upland moist forest*** is restricted to the summits and upper north-facing slopes of the taller mountains, where a continuous canopy is formed about 15 meters high and a sub-canopy layer at about 5-10 meters high. Emergent trees may exceed 25 meters in height. The abundance of shrubs, herbs, and epiphytes varies greatly, ranging from absent to very abundant, and is highest shortly after storm damage to the canopy. This habitat is uncommon across the islands, only occurring in isolated patches along mountain peaks and ridges (e.g., Mountaintop on St. Thomas, although most of this habitat has been removed for residential development). ***Gallery moist forest*** is a riparian habitat occurring in ravines and guts that drain larger upland watersheds. Those with the gentlest slopes support the tallest trees, which may exceed 30 m. Because of flash floods, younger trees are more frequent and stratification is less pronounced than in upland moist forest. The abundance of shrubs, herbs, and epiphytes in the shrub layer is highly variable. ***Basin moist forest*** develops in basins and lowland areas near the coast where water runoff collects from large upland watersheds. Emergent species may surpass 25 meters in height and the canopy is usually formed at 15-18 meters, with a sub-canopy at 5-10 meters, and a lower shrub layer. Herbs and vines are well represented, whereas epiphytes and ferns are relatively rare.

Dry forest occurs at lower elevations, typically below 300 meters, where annual rainfall ranges from 850-1000 millimeters. The height of climax vegetation may reach 15-20 meters, but is shorter on steep slopes, in areas subjected to strong winds, and where exposed to heavy salt spray. Usually only two canopy layers are formed. The foliage tends to be deciduous in more humid areas and sclerophyllous in drier areas. ***Semi-deciduous forest*** is the dominant climax vegetation throughout the USVI, varying greatly in physiognomy and composition. It occurs mostly on north-facing slopes on all main islands, the upper elevations of south-facing slopes below 250 meters, in basins of smaller watersheds, along minor guts and ravines, and mixed with dry deciduous forest on south-facing slopes. ***Semi-deciduous dry forest*** occurs at lower elevations below 250 meters, especially on south- and southwest-facing slopes toward the drier east side of islands, and on south- and west-facing slopes along the north side of islands. It resembles other dry forest types but is best distinguished during the dry season, when more than 75% of the species are deciduous.

Relatively open **woodlands**, characterized by separated crowns and a reduced canopy cover of about 25-60%, occur throughout the islands. The canopy height varies from 8-20 meters, depending upon human modifications, effects of hurricanes, and soil moisture. The majority of woodland area is considered **dry woodland**, but some limited patches of **moist woodland** do exist. Moist woodland results from extensive clearing of vegetation in guts and ravines at low elevations, appearing as strips of woodland in guts passing through cleared areas or sometimes as a coastal woodland separating salt ponds and salt flats from the sea.

Ecological Value

Forests in the USVI provide habitat for terrestrial species, including birds, bats, frogs, lizards, snakes, and innumerable invertebrates. The diversity of plant species and complex structure of forests provide a plethora of niches for forest-dependent species to find food, seek shelter, avoid predation, and reproduce.

Forests provide buffer areas and sediment retention. Sediment runoff into marine environments is a significant problem for coral reefs and associated habitats (e.g., Gray et al. 2012), and several studies have examined the land-based source of the sediment. A study on St. John identified unpaved and recently graded roads as being a primary contributor to sediment input (Ramos-Scharrón and MacDonald 2005, 2007). Forest cover, however, appears to filter stormwater flow and remove sediment (Benoit and Nemeth 2011), providing further justification for retaining as much forest cover as possible, and particularly where it can act as a buffer against upland disturbance.

VI forests, along with mangroves and seagrasses, are important for carbon sequestration. Forest floor woody debris is important for wildlife refugia, nutrient cycling, and in carbon sequestration (Brandeis and Oswalt 2007, Oswalt et al. 2008). Urban trees can aid in CO_2 absorption from vehicular exhaust, and perform other services such as shading, subduing noise, and absorbing heat from concrete.

Threats

The forest ecosystems in the USVI are periodically subjected to tropical storm damage, resulting in a dynamic mosaic of successional stages. This is a natural process that helps maintain the health of the forest. However, changes in storm frequency and intensity, as are predicted with climate change, could alter the distribution and extent of the different successional stages. Following the 2017 hurricanes, in which nearly all trees sustained some damage, many trees exhibited apparent rapid recovery through leaf growth, but died over the following year, leaving green forest growth with numerous protruding snags.

Virtually all of the primary tropical forest in the USVI was cleared for agricultural purposes, particularly the cultivation of sugarcane, by the early twentieth century (Wadsworth 1950, Little et al. 1974). Changes in global economics and the decline of the Caribbean sugar industry resulted in the abandonment of a large portion of these agricultural lands, allowing their reversion to secondary forest (Thomlinson et al. 1996, Rudel et al. 2000). These secondary forests now host a large component of tropical species introduced from throughout the world. “New forests” (a term coined in Lugo and Helmer 2004) have become established over much of these islands and are the subject of research regarding their species composition and ability to provide forest ecosystem services to island inhabitants (Brown and Lugo 1990, Chinea and Helmer 2003). New forests tend to be comprised of non-native weedy species such as tan tan (*Leucaena leucocephala*), that offer reduced value for habitat and ecosystem function. USVI forests also are comprised of very young trees, reflecting past and present land use and disturbances (Brandeis and Oswalt 2007).

In recent decades, the development of sprawling residential communities and commercial centers connected by a network of paved roads has resulted in considerable deforestation leading to degradation and fragmentation of the remaining forests. The adverse effects of deforestation to the environment are well known, including increased surface temperatures, increased erosion of soils, and increased sedimentation and eutrophication of wetlands and inshore marine habitats (e.g., Ramos-Scharrón and MacDonald 2005, 2007). The effects on wildlife include reduction of habitat and resource availability, decreased carrying capacity for wildlife populations, decreased dispersal and gene flow among fragmented populations, decreased genetic variability, increased genetic inbreeding, decreased effective population sizes, and increased risk of local extirpations. Reduction in habitat connectivity reduces the ability of species to migrate from areas impacted by climate change. The introduction of non-native plant species poses another threat to the native vegetation, which is often displaced. An estimated 21% of the flora of VINP is comprised of exotic species (Clark 2003).

In the USVI, it is typical for a parcel of land to be completely cleared prior to the design of building plans, to allow architects to assess the topography. If building does not immediately commence, the cleared land is left to fill in with weedy colonizers, such as tan-tan. Rains erode the soils away, which also reduces the native seed bank. Some of these parcels are never subsequently developed, resulting in a permanent replacement of native forest with non-native scrub. In cases where the land is developed, the native vegetation is typically replaced with non-native tropical ornamentals. Although DPNR encourages the clearing of only the footprint of the proposed structure, this recommendation is rarely heeded or enforced.

Long term cattle grazing, particularly on the East End of St. Croix has caused dry forest habitat to become primarily grassland and shrubland. Even in areas that are no longer grazed, periodic fires have prevented forest recovery. Fires occur regularly once dry conditions dominate and start naturally or in some cases, are the result of arson. Climate change may have an influence on forest communities after land use change (Brandeis et al. 2009).

A forest assessment identified increasing urbanization, forest fragmentation, biological threats including invasive species and potentially pathogens, wildfire, and climate change as being priority threats for USVI forests (Chakroff 2010).

Research and Management

The vascular flora of the USVI is well documented (e.g., see reviews and revisions by Millspaugh 1902, Britton 1918, Britton and Wilson 1923-1930, Little and Wadsworth 1964, Liogier 1965, 1967, Oakes 1970, Fosberg 1974, Little et al. 1974, Woodbury and Little 1976, Forman 1980, Liogier and Martorell 1982, Woodbury and Vivaldi 1982, Woodbury and Weaver 1987, Nellis 1994, Acevedo-Rodriguez 1996, Acevedo-Rodriguez and Strong 2005). The status of rare trees, including five species endemic to the Virgin Islands, was discussed by Little and Woodbury (1980). The plant species that are poisonous and injurious to humans have been identified (Oakes and Butcher 1962, Nellis 1997), as well as many species used frequently by wildlife (DFW 1988), and trees for urban use (Schubert 1979). A field guide to the native trees of St. John includes information on native uses (Gibney 2004). Several books on the value of trees, aimed at the general public, have also been published locally (Thomas 1997, Nicholls 2006, Karlsson 2016).

Research on forest ecosystems in the USVI has focused on: describing and mapping vegetation communities (Gibney et al. 2000, Thomas and Devine 2005), forest inventories (Weaver and Woodbury 1982, Matuszak et al. 1987, Earthart et al. 1988, Reilly et al. 1990, Brandeis and Oswalt

2007), forest structure (Forman and Hahn 1980, Ray and Brown 1995, Ray et al. 1998), forest phytosociology (Weaver and Chinea-Rivera 1987), forest growth rates (Weaver 1990), forest productivity (Weaver 1996), forest restoration (Brown et al. 1992, Brandeis and Woodall 2008), the effects of Hurricane Hugo (Askins and Ewert 1991, Reilly 1991, 1992, 1998; Weaver 1994, 1998), historical patterns of land use and forest fragmentation (Tyson 1987, Askins et al. 1992, Livingston 1995), and bromeliad faunas (Miller 1971a,b, Richardson 2012). Most of these studies have taken place in the VINP on St. John (see reviews by Weaver 1992, Rogers and Reilly 1998).

The VI Department of Agriculture Division of Forestry is tasked with the protection and management of forested lands and administers several programs aimed at protecting and enhancing forest resources. The **Urban and Community Forest Program** offers funding opportunities to community groups to reforest and rehabilitate urban parks, plant native trees, install irrigation systems, and educate the public. The **Forest Legacy Program** identifies and preserves forested lands through direct purchase of lands or easements, or deed restrictions that limit development. Under this program, six USVI priority areas have been identified under a stakeholder planning process: northwest and east St. Croix, north and west St. Thomas, and east and south St. John—these are areas that are predominantly privately owned and retain significant forest cover. This program has been successful at securing a 12-hectare conservation easement on St. Croix that is being managed by the Trust for Virgin Islands Lands, Inc. (VI-DOA, www.vifresh.com, 2017). The **Forest Stewardship Program** provides technical assistance to landowners with at least 3 acres (1.2 ha) who commit to long-term management of forest resources in exchange for a reduction in property taxes.

Native species are protected under the VI Endangered and Indigenous Species Act, as is riparian vegetation (12 VIC 2), although these protective measures are rarely enforced. Within DPNR, permitting conditions request that native trees above 15cm DBH be retained during earth change activities. Several agencies have worked to draft a VI tree law that will provide better guidance in protecting and permitting impact to individual trees.

Accomplishments Since 2005

Several studies have been conducted toward mapping land cover, estimating forest structure, and assessing habitat condition (Kennaway et al. 2008, Brandeis and Oswalt 2007, Chakroff 2010). Geographic Consulting LLC conducted a comprehensive roadside tree inventory and health assessment (Geographic Consulting 2012).

Several studies have evaluated land use change over time, including a comparison of the relative contribution of native and introduced species in forest communities on St. John, (Oswalt et al. 2006) and the effects of land use on subtropical dry forest structure on St. Croix, (Atkinson and Marín-Spiotta 2015). Weaver (2006) reported on 20 years of forest management within Cinnamon Bay gut on St. John.

Several native plant restoration efforts are underway on St. John, including restoration of beach vegetation and tree cover to protect turtle nesting grounds from erosion (R. Boulon, pers. comm.) and restoration of an endemic shrub that was recently listed under the ESA on private and NPS-owned lands (G. Ray, pers. comm.). Large tracts of forest (> 100 ha) have been protected and are managed by the DOA-Division of Forestry and TVIL, primarily on St. Croix. TNC is working to reestablish forest in the shrubby grasslands of Jack and Isaacs Bay Preserve.

St. Croix Environmental Association initiated Forest Field Days for fourth graders. This program offers all fourth grade classes the opportunity to spend a day at Estate Thomas Experimental Forest learning about Forest Ecosystems.

Conservation Priorities

Restoration Actions: A valuable restorative goal is to replace non-native species with natives. Several actions can be applied to accomplish this goal, including implementing stricter restrictions to control habitat removal, better enforcement of the VI Code with regards to vegetation clearance, and increasing the availability of native species for landscaping use. Education of landowners and local residents and businesses within reach of guts is called for to foster stewardship of this environment.

Protection Actions: Maintaining the integrity of forests in the USVI is vital for conserving wildlife resources. Earth Change permits should have an enforced condition that restricts permitted land clearing to the footprint of proposed development and access easement to reduce the practice of clearing the entire lot. Permits should also be required for all land clearing activities that are not associated with development. The creation of a policy to protect native forest communities (not just single trees), with enforcement capability, can support forest protection, and native habitat delineation protocols already developed for endangered species (Platenberg and Harvey 2010) can be modified for this purpose.

Acquisition Actions: Continue to seek opportunities to expand existing forest preserves, and to increase protected areas within forested habitats, and build connectivity between protected areas. Include protected areas into a Territorial Park System.

Education/Recreation Actions: Forests provide a valuable resource for ecotourism and educational activities. St. Croix and St. John offer numerous hiking opportunities through forested habitats, while on St. Thomas the popular Magen's Bay trail traverses upland forest habitats before descending into wetlands and through a mangrove swamp. These trails offer opportunities for bird watching and other types of wildlife viewing that are underutilized for educational purposes. Forest trails with easy public access should be rated according to difficulty and have educational kiosks installed. Education of landowners, local residents, and businesses can foster stewardship of this critical habitat.

Post-hurricane needs: Upland forests were severely affected by the 2017 hurricanes. The winds snapped, twisted, or shredded branches, which ultimately led to the mortality of many trees that remained standing after the storms. Tree health assessments would be useful towards identifying those species that were resistant to damage; adding these species into restoration projects may increase resilience of these systems.

Contributors (2005): FEH, DBM
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Banner photo: Dry forest canopy by R. Platenberg

Shrublands and Grasslands

Habitat Description

Shrublands and grasslands are widespread in dry lowland areas and some moist upland areas of the USVI, especially on St. Croix and cays, and provide an important resource for wildlife despite being greatly altered by the activities of humans and livestock. Fewer species of wildlife occur in shrublands and grasslands than in forest because of the lower diversity of plant species and simpler vegetative structure, although common species such as the Zenaida Dove (*Zenaida aurita*) may be abundant. Shrublands and grasslands can be thought of as a transitional stage as land becomes naturally reforested after agriculture or other land clearing. As species diversity and structure increase, so does the quality of wildlife habitat. The key to managing shrublands is to prevent fire, grazing and other disturbances so succession can continue unimpeded.

Shrubland and grassland formations are highly variable. Although several types of formations can be recognized, they grade into one another and are generally difficult to delineate. The shrubland and grassland communities described herein are based on the classification system in Thomas and Devine (2005).

Shrublands are often secondary forests in the early stages of succession (Lugo and Helmer 2004) and have a lower level of biodiversity and canopy structure than mature forests (Brown and Lugo 1990). They occur in dry locations at low elevations on all islands, including cays. Vegetative growth is potentially limited by thin soils, strong winds, and minimal moisture, resulting in a short canopy typically ranging in height from 0.5 to 5 meters. The vegetation is dominated by bushy, multiple-stemmed shrubs that are often thorny and have interlocking branches. Cacti and other succulents are often interspersed among the shrubs. Shrubland vegetation is often dense.

Several types of **grasslands** occur in areas with very low rainfall or that are subject to frequent disturbance by agriculture, grazing, fire, or mowing. Most are anthropogenic, representing early stages of succession. Grassland dominated communities with less than 10% cover from shrubs and trees are referred to as ***Pasture***, which is maintained by grazing or fire. Such communities covered 10-25% by shrubs and trees are referred to as ***pasture mixed scrub***, which usually results from succession when grazing and fire are discontinued. ***Mixed dry grassland*** is covered 25-50% by shrubs and trees, and usually results from selective grazing by livestock that shun spiny or poisonous plants.

Some terrestrial environments are sparsely vegetated or lack vegetation entirely, including: coastal cliffs, rocky outcrops, boulder fields, landslide areas, shorelines of sand, cobble, or gravel, and recently plowed agricultural areas and farm plots.

Ecological Value

Shrublands and herbaceous plant communities provide a range of ecological services, including wildlife habitat, though to a lesser extent than more mature plant communities (Lugo and Helmer 2004). Shrublands and secondary forests are able to regain much of their structure and species diversity in a matter of decades. The vegetation controls erosion and provides some generalist habitat to wildlife. Undisturbed coastal areas, steep slopes and other sites that experience extreme conditions may remain as shrublands indefinitely. Shrublands on cays provide critical nesting habitat for migratory seabirds, columbids, and other ground nesting birds.

Threats

Shrublands are an uncommon habitat on forested St. Thomas and St. John, but are dominant habitats on cays and previously disturbed sites. Within the territory, these habitats comprise approximately 34.12% of all habitat types (Gould et al. 2013). While shrublands are an abundant habitat on St. Croix, this is primarily an indicator of legacy land use from agriculture or pasture (B. Daley, pers. comm., 2017). The dynamics of various land uses on St. Croix that result in shrublands being created and then cleared again have been described (Daley 2009).

The extensive development of coastal and low elevation areas has displaced, degraded, or fragmented large areas of shrublands, resulting in increased surface temperatures, increased erosion of soils, and increased sedimentation and eutrophication of wetlands and inshore marine habitats. The effects of vegetation removal, degradation, and fragmentation of shrublands on wildlife include decreased carrying capacity for wildlife populations, decreased dispersal and gene flow among fragmented populations, decreased genetic variability, increased genetic inbreeding, decreased effective population sizes, and increased risk of local extirpations. Wildfires, especially on St. Croix, pose an increasing threat to these habitats under drought conditions, which are becoming more intense and prolonged.

Because of their low vegetative structure, shrublands and grasslands are less vulnerable than forests to damage from hurricanes, and recover more quickly when damaged. The introduction of exotic plant species poses another threat to the native vegetation, which is often displaced. An estimated 21% of the flora of Virgin Islands National Park is comprised of exotic species (Clark 2003, 2005), including many grasses and shrubs. The impact of non-native plants on wildlife is poorly known but their influence to alter habitat composition and structure could have significant impacts.

Research and Management

Shrubland and grasslands have been described and mapped at specific points in time (Thomas and Devine 2005, Brandeis and Oswalt 2007, Gould et al. 2013). The ongoing trend of decreasing land area in agriculture and corresponding increase in shrublands has been well documented for decades and continues. The U.S. Forest Service Forest Inventory Analysis (FIA) has documented the changing distribution, structure and size classes of the forests in the U.S. Virgin Islands (Brandeis and Turner 2013).

Accomplishments Since 2005

DFW has conducted vegetation management actions, to include removal of non-native plants, on cays with nesting seabird colonies. Removal of goats on cays has likely benefited shrubland cover.

Conservation Priorities

Protection Actions: Shrublands and Grasslands serve as habitats for many species and it is important to survey the larger shrublands and grasslands for the presence of wildlife sensitive species. Shrublands are known to be home to federally protected plant species, as well as harbor wildlife (Daley and Valiulis 2013). Identifying potential threats from development for the larger, more important patches of shrublands and grasslands will help protect these habitats. Implementing a fire management regime for shrublands and grasslands to prevent growth from becoming too dense, to benefit columbids, especially Zenaida Dove, White-winged Dove, and Common Ground Dove. Modification of the USVI FIA to capture the spatial distribution of shrublands and other forest types would allow for meaningful comparison to previous landcover mapping projects, including Kenneway et al. (2008).

Restoration Actions: Exotic plants and plant removal pose a threat to shrublands and grasslands. These habitats should be included in programs that reduce land taxes for private property owners who conserve or restore native shrublands and grasslands on their property.

Post-hurricane needs: These low-profile habitats were less affected by the 2017 hurricanes than other terrestrial systems. Surveys for and removal of non-native invaders is recommended.

Contributors (2005): FEH, DBM
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Banner photo: Coastal mixed shrubland by R. Platenberg

Beaches and Rocky Shorelines

Habitat Description

Marine and terrestrial ecosystems meet along the coast, where species composition often overlaps. The USVI coast consists of beaches and rocky shorelines, and makes up a large percentage of total area of the islands. St. Croix has 113 km of shoreline, St. Thomas 85 km, and St. John 80 km, for a total of 278 km. Adding in the shorelines of over 50 cays raises this figure to 376 km. Sandy beaches comprise 80 km, around 21% of the total shoreline (Dammann and Nellis 1992).

The beaches in the USVI comprise three types: sand, gravel, or coralline. Sandy beaches are made of a mixture of several materials, including coral particles, shell and urchin fragments, and algal plates. Gravel beaches are made of minerals or rocks that erode from cliffs and are carried to the shore by guts during torrential rainfall. Coralline rubble beaches are covered with pieces of coral skeleton broken by storm action.

The remaining coast is comprised of rocky shoreline and mangrove forest. Rocky shorelines generally consist of boulder talus or cliffs and are poorly vegetated. Mangroves, discussed more fully in another section, occur in inundated areas along the coast.

Coastal areas have unique assemblages of salt and wind tolerant plants that can survive in the nutrient poor conditions offered by sandy beaches and rocky shorelines. Common plants found in these habitats include sea grape (*Coccoloba uvifera*), inkberry (*Scaevola plumeieri*), nicker (*Caesalpinia bonduc*), sea purslane (*Sesuvium portulacastrum*), crab grass (*Sporobolus virginicus*) and beach morning glory (*Ipomoea pes-caprae*). Coastal trees include manchineel (*Hippomane mancinella*) marble tree (*Cassine xylocarpa*), Coconut palm (*Cocos nucifera*), and the invasive heiti-heiti (*Thespesia populnea*). Bare rock is often colonized by buttonwood mangroves

(*Conocarpus erectus*) and an assortment of cacti (e.g., *Mammillaria nivosa*, *Melocactus intortus*, and *Pilosocereus royenii*).

Shoreline habitats merge with an intertidal zone that extends from highest high tide down to the lowest low-water line (Toller 2003b). These zones are narrow in the USVI due to a lack of variation in tidal range (Zitello et al. 2009). This habitat is highly dynamic due to daily variations in exposure, salinity, light, temperature and wave action, and intertidal organisms are distributed within this zone according to tolerance of these conditions and competitive ability. The upper intertidal zone is occupied by barnacles and green algae, while the lower intertidal zone is characterized by crustose and turf algae. Between the two zones are an assortment of snails, limpets, chitons, crabs, urchins, and fish (Good 2004).

The following descriptions of vegetation types associated with landward coastal areas are from Gibney et al. (2000) and Thomas and Devine (2005) who also list plant species contained within each community.

Coastal Hedge is located on berms of beaches seaward of salt ponds and above rocky shoreline along eastern, southeastern, or northeastern coastal areas with exposure to prevailing winds. It consists of limited species within dense patch communities 1-3 m in height and is shaped by wind shear and salt spray.

Coastal Grassland consists of grasses adapted to extremes of wind, salt spray and low moisture.

Mangroves are associated with tidally influenced areas. Mangrove wetlands consist of trees that are adapted to quiet, shallow coastal habitats with broad ranges in salinity and anoxic soils. They are described in the wetlands section.

Rocky Cliffs and Shelves are composed of coastal cliffs and rocky outcrops with less than 10% vegetation cover. **Beaches** (sand, cobble, or gravel) also have less than 10% vegetation cover. **Carbonate Beachrock** is a common feature of high energy pocket beaches, and acts to stabilize and protect beaches from erosive waves and currents. Beachrock is generally at or below the waterline.

Ecological Value

Beaches provide habitat for a wide range of invertebrates, which in turn provide a food source for higher organisms, especially shorebirds. Sandy beaches offer nesting areas for sea turtles, Wilson's Plovers, Least Terns, and other species. Beaches also buffer coastal areas from storm energy, and filter sedimentation from upland runoff. Littoral plant communities perform the important ecosystem services of dune stabilization and protection of the shoreline from erosion. Intertidal organisms play a role in filtering sediment and improving water quality.

Threats

Coastal areas of the USVI are under extreme threat from development for resorts, condominium complexes, and private residences. Many of the mangroves and salt ponds have already been replaced, although these resources are now protected across the territory.

Detrimental beach activities include the construction of structures that affect the movement of beach sediments, thereby restricting the supply of new sand and causing beaches to disappear. Beach nourishment, the addition of sand to create man-made beaches by covering beachrock, can have severe impacts by altering sea turtle nesting habitat and reducing water quality through increased sedimentation from erosion of added sand (Peterson and Bishop 2005).

Structures and furniture on beaches can impede movement of nesting turtles, while beach lighting causes disorientation in hatchlings. Vehicular traffic, donkeys, and horses can crush turtle nests. Bonfires are common on many sea turtle nesting beaches (Goodson, unpublished MMES thesis data 2016). These bonfires attract sea turtle hatchlings that could be harmed by the fire and create obstacles and distractions for nesting females, and the fires themselves can destroy nests (Tisdell and Wilson 2005, Choi and Eckert 2009). Sedimentation from upland erosion or construction smothers coral and seagrass beds. Although it is illegal under the VI Code to drive vehicles or ride horses on beaches, most beaches are not sign-posted to this effect, and there is no enforcement. Donkeys are not prohibited from beaches. Many resorts operate small vehicles on the beaches to assist with beach cleanup and maintenance; this results in the loss of beach wrack that provides an important food source for shorebirds, as well as disturbance to sand. Camping is popular at the more remote beaches, which have no waste facilities, and people occasionally drive and park on these beaches and frequently leave behind garbage. In particular, Easter camping on St. Croix is a long-standing tradition that has the potential to have a large impact on the beaches if campers are not aware of best practices for beach protection.

Beach goers and tourists are often looking for souvenirs of their beach visit. As a result, tons of shells and sand have been removed from the VI beaches. Some of it is confiscated in customs and returned to VI waters by DFW staff. This mass removal of the beach contents results in a reduction in quality of habitat for much of the wildlife and occasionally results in the direct removal of beach flora or fauna attached to or living within shells or coal fragments.

Masses of sargassum seaweed washing up on beaches has been a recent phenomenon that has been attributed to climate change. While the piles of sargassum in bays and on beaches offer nutrient input to sandy beaches, increased foraging opportunities for shorebirds, and habitat for pelagic organisms, they have a negative impact by trapping hatchling sea turtles and preventing them from reaching the water. The piles of seaweed are also undesired at resorts, where they are considered unsightly and smelly, and management will bring in vehicles, such as bulldozers, to aggressively remove the sargassum (and everything living within it).

Climate change impacts are already being observed on coastal habitats in other ways as well, with increased erosion of beaches from severe and prolonged precipitation events, increasingly landward scarring of beaches from higher storm surges, and sea level rise. Climate impacts are likely to have severe impacts on sea turtle population demographics as nests are exposed to higher temperatures and increased chance of inundation.

Research and Management

Several beaches across all three islands are monitored for sea turtle nesting activity, primarily on St. Croix and within the national park on St. John (VINP 2015, Goodson, unpublished thesis data 2016).

Previous published accounts of USVI coasts include a shoreline guide (Boulon and Griffin 1999) and an atlas to the cays (Damman and Nellis 1992). Much of the research and monitoring of shorelines is conducted on the coral reefs and benthic environment (e.g., Macdonald 1997), which is discussed in the marine resources chapters.

Within the USVI, protection of the shoreline comes under the jurisdiction of CZM within DPNR. CZM is responsible for promoting development and growth within the coastal zone, as well as ensuring adequate protection for natural resources while maintaining recreational opportunities.

Accomplishments Since 2005

Trapping lines for mongoose were installed at Jack and Isaacs beaches and Sandy Point National Wildlife Refuge, which resulted in significant improvement in nesting success on those beaches (Valiulis 2011).

Monitoring of sea turtle nesting has increased on all three islands. DFW enlisted and trained community volunteers to conduct beach patrol monitoring for sea turtles on St. Thomas (ES Grant E-6-R-3 2012) in 2010 and 2011. This effort revealed beach nesting patterns on several northside beaches that were previously unknown. Additional monitoring surveys were conducted in 2016 that reconfirmed previously documented nesting on beaches on the northside, southside, and revealed a newly documented beach important to hawksbill nesting on the southside of St. Thomas (Goodson, unpublished MMES thesis data 2016). Monitoring efforts have increased on St. John with the establishment of internship and volunteer program Sea Turtle Monitoring and Protection Team funded by Friends of the National Park Service (VINP 2015). On St. Croix, sea turtle monitoring has been implemented at the Southgate Coastal Reserve (St. Croix Environmental Association) and at beaches on the East End (Friends of the St. Croix East End Marine Park and various west end and south shore beaches (DFW).

Beach profiles and characteristics of nesting sites for hawksbills have been measured on St. Thomas and St. John towards developing models for prioritizing shoreline areas for endangered species habitat protection (Goodson, unpublished MMES thesis data 2016).

Reef Fest events are held on St. Thomas and St. Croix that bring together environmental entities and the community to learn about coastal resources through fun activities. Regular beach cleanups have removed tons of trash and marine debris from USVI beaches These activities help to raise awareness within the community of the consequences of everyday behavior to vulnerable species and habitats and valuable ecosystem services.

St. Croix Environmental Association implemented the Coastal Field Days for 2nd graders. This program, available to all 2nd grade classes on St. Croix, brings students to protected coastal preserves (Southgate Coastal Reserve, Sandy Point National Wildlife Refuge, or Salt River) to participate in engaging educational activities about coastal ecosystems.

Priorities for Conservation Actions

Restoration Actions: Replacement of invasive vegetation with native species on sandy beaches improves both shoreline stability and habitat for shoreline wildlife.

Protection Actions: Continued effort to remove and control invasive predators and to limit vehicular access to beaches is a priority. Identify beachside developments (bars, hotels, residences) with high light pollution located on sea turtle nesting beaches and work with the owners to reduce light that can disorient turtles. The development of Habitat Conservation Plans with resorts, to include training of personnel on turtle nesting response protocols, can be tied in with certification incentives to increase compliance. Identify nesting sites for ground nesting birds such as Least Terns and Wilson's Plovers and implement seasonal protective measures for these habitats. Improvement of trash collection, permitting for bonfires, limiting beach nourishment, and better enforcement would contribute to the conservation of coastal and marine resources. Regulation of beach-cleaning vehicles should be implemented. Better guidelines and policy on sediment control and private waste-water treatment are also necessary to improve coastal resources.

Acquisition Actions: All shorelines have protected public access (Shoreline protection act). Most of the land immediately adjacent to shorelines, however, is privately owned and subject to significant development pressure. Acquisition or dedicated easements of these water access parcels should be a priority to protect key turtle nesting beaches from being lost to development. On St. Thomas, key undeveloped but potentially at-risk beaches that are surrounded by privately owned property include Stumpy, Santa Maria, Sorgenfrij, and Neltjeberg on the northside, and Abi, Scott, and Perseverance on the southside. All St. Croix beaches are used for nesting by sea turtles and should be included in a network for monitoring for acquisition/protection priority.

Education/Recreation Actions: Beaches are the single most visited habitat in the USVI, and only on rare occasions are visitors given an educational experience. Increased educational signage such as that found along access trails like Isaacs Bay and Sandy Point National Wildlife Refuge should be erected. Educational signage and visitor information is being designed for the Southgate Coastal Reserve and most beaches within the East End Marine Park. A few organizations, such as the VI

National Park on St. John, St. Croix Environmental Association, the East End Marine Park, and St. Croix Hiking Club, periodically offer educational beach walks to the community. Shoreline walks are also part of the educational program offered by DFW. Increased recreational activities such as these on all islands should be supported.

Post-hurricane needs: Sandy beaches across the USVI were affected by storm surge from the hurricanes in 2017 and again from a unprecedented surge resulting from the March 2018 Nor'easter storm, particularly along the north coasts of St. Thomas and St. John. The storms damaged vegetation structure, inundated root systems, and removed sand to expose the roots of coastal vegetation. Salt water intrusion caused a lingering impact that resulted in mortality to coastal vegetation. Invasive *Thespesia populnea* overgrew native *Coccoloba uvifera*. These systems should be assessed for long-term damage, with efforts to remove and control non-native species while replanting natives to increase ecological function.

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Banner photo: Sorgenfrij beach by R. Platenberg

1.2 USVI Habitats: Wetlands

Overview

Wetlands refer to areas with soils sufficiently inundated or saturated by water that support vegetation adapted for life in saturated soils. These areas provide 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 seagrass 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.

There are several different wetland habitat types in the USVI. Salt ponds and salt flats, typically fringed by mangroves, offer feeding and breeding habitat to wetland birds, while freshwater ponds and ephemeral streams, known as guts, provide a welcome source of drinking water to a variety of species, and habitat to fauna found in no other habitat.

Salt ponds are common coastal wetlands found throughout the USVI. These 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 ponds may maintain an influx of salt water either through tidal seepage or periodic breaching of the berm by the sea. Water salinity, oxygen content, and temperature are highly variable and dependent on rainfall and evaporative processes, and influence the fauna of these wetlands. **Salt flats** are low-lying estuarine areas that are periodically submerged by tidal waters. These areas are nonvegetated and typically muddy, although can dry out to form a hard crusty surface. Salt ponds and salt flats contain invertebrates that form an important prey base for shorebirds and other waterbirds. These areas also can serve as catchment basins for runoff, debris, and pollutants, thus protecting coral and seagrass beds in the marine environment.

Freshwater ponds harbor algae, submerged macrophytes, and emergent vegetation. A variety of herbs, woody shrubs, and trees grow along the edges and tolerate occasional inundation. Freshwater ponds in the USVI have been created through the intentional diversion of water from perennial stream systems for agricultural purposes, and numerous ponds have been dug on St. Croix for catchments for irrigation and livestock. These ponds provide an important habitat for many species, including indigenous waterbirds that prefer freshwater ponds, such as the Least Grebe (*Tachybaptus dominicus*).

Guts are natural drainages that have formed from stormwater erosion down steep slopes. These often contain gallery moist forest communities that differ from surrounding upland vegetation, although guts on the eastern ends of all three major islands and on the cays tend to contain dry forest. These semi-riparian corridors act as a conduit between upland terrestrial habitat and the marine environment and offer valuable freshwater resources and habitat to a variety of invertebrates, fish, and wildlife.

Because most wetlands occur along coveted coasts, the major threat 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 removal or replacement of wetland vegetation, habitat fragmentation and encroachment. Introduction of non-native invaders, pollution, sedimentation, and disturbance by human visitors increase the degradation of these important habitats. 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.

Priority actions for wetland conservation in the USVI include protecting and restoring these wetland systems, protecting or restoring ecosystem connectivity, reducing sediment and non-point source pollution and trash input, and increasing awareness of these habitats within the local community.

Banner photo: Hendriks freshwater pond by R. Platenberg

Guts

Habitat 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). Natural stormwater channels, known as “guts” in the USVI, that have formed from stormwater erosion down steep terrain, are 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 (VIC 12, Ch 3). These channels typically convert to basin sheet flow or drain into a salt pond or bay, and most streams do not maintain a permanent connection to the sea. Beach berms are occasionally breached after persistent heavy rainfall, which establishes temporary connectivity for movement of diadromous species. Some gut systems are stream-fed, resulting in reliably permanent pools that are connected by stream flow during the rainy season.

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, and consist primarily of broadleafed evergreen trees and wetland herbaceous species. Guts on cays and in the more xeric eastern sides of islands tend to contain dry forest vegetation that may be indistinguishable from surrounding habitat.

Ecological Value

Freshwater sources in the northern USVI are extremely limited due to steep topography and lack of flat land for ponding (St. Croix has more freshwater ponds due to more level areas). Water that collects in gut pools provides a rare freshwater habitat that is occupied by freshwater shrimp and anadromous fish. American eels (*Anguilla rostrata*) are occasionally found in these stream channels (D. Nemeth, pers. comm.). These riparian species have complex life cycles, migrating between downstream marine environment and upstream freshwater pools when connections between the two habitats are present. Bats and migratory birds, primarily warblers, use these ephemeral water resources, as do invasive species that require freshwater, such as the Cuban treefrog (*Osteopilus septentrionalis*), cane toad (*Rhinella marina*), and red-eared sliders (*Trachemys scripta*).

Vegetated guts also provide habitat corridors for wildlife, particularly in highly disturbed, urbanized areas. The federally endangered Virgin Islands tree boa (*Chilabothrus granti*) in particular benefits from these "green belt" corridors along guts on St. Thomas' east end.

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 stormwater runoff (Benoit and Nemeth 2011).

Threats

Despite statutory protection for gut vegetation (VIC 12 Ch 3), the habitats within these riparian corridors are often highly degraded. Many guts have been altered through habitat clearance, diversion of water flow, and encroachment. Unpermitted vegetation clearance reduces the ability of these systems to withstand erosion, and sedimentation occurs when soil is eroded from the land surface and transported by rainfall moving over ground surfaces. Unpaved roads and the failure to properly install effective silt control devices at construction sites are a major source of eroded soil (Ramos-Scharrón and MacDonald 2005). The sediment in rainfall runoff is added to by other contaminants from human activities, such as pesticides, nutrients, and toxic substances. Intermittent streams are often supplemented from gray water drainage in residential communities. 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 2007). Gardner (2008a) identified an inadequate policy framework with reference to gut management along with a lack of enforcement of existing regulations as being a contributory factor in the degradation of gut ecosystems (see also UVI 2010).

Macrobrachium shrimp in guts appear to be particularly vulnerable to anthropogenic activities. Overfishing, poisoning, channelization, culverts, and pollution (Hunter and Arbona 1995, 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). Man-made impediments, such as dams and roads, present barriers to movement of diadromous fish and shrimp in guts (K. Tennant, MMES unpublished thesis data, 2016). 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).

Historic accounts identify guts as having continuous flow (Loftus 2003; O. Davis, cited in Gardner 2008b); the water flow in guts has decreased or ceased entirely as a result of human activities, including the creation of dams to divert water flow, with additional loss of water availability attributed to rooftop rainfall collection into cisterns and loss of water-retaining topsoil (Gardner 2008b). These impacts have resulted in the decline and loss of biodiversity and ecosystem function in guts (Platenberg 2017).

Research and Management

The need for an assessment of these inland water sources was highlighted by Smith (1993), who discovered a new species of ectoproct (aquatic invertebrate) on St. John, simply because no one had ever looked for them there before. 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).

Several studies through the USGS Water Resources Research Institute (WRRI), administered through UVI, have focused on guts both as wildlife and social resources. Gardner (2008a,b) and Gardner et al. (2008) evaluated the hydrology and use of these water of these stream channels, and Nemeth and Platenberg (2007) assessed the biodiversity of fish and invertebrates in relation to level of watershed development. Benoit and Nemeth (2011) measured sediment transport in guts, and Platenberg (2017) identified wildlife use of guts in relation to presence or absence of water. At one time the USGS monitored stream water flow in selected locations, including Turpentine Run and Bonne Resolution (Dorothea) Gut on St. Thomas and Guinea Gut on St. John. This program is no longer in operation (waterdata.usgs.gov/vi/nwis/rt).

A comprehensive analysis of the six watersheds within the St. Croix East End Marine Park (EEMP) was completed in 2011 (Horsley Witten Group 2011). This analysis included recommendations for restoration of several guts within the EEMP. A watershed assessment was also conducted for sites on St. Thomas that recognized the value of guts in watershed management (STEER; Horsley Witten Group 2013). Several studies have been conducted to evaluate the runoff potential of guts, particularly on St. John (e.g., Whitall et al. 2014).

Guts are protected under the VI Code (Title 12, Ch3; 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 VI Department of Agriculture and DPNR DEP and CZM as efforts to protect soils and control non-point source pollution (see summary of water protections listed in Platenberg 2006).

Accomplishments Since 2005

Despite the importance to fish and wildlife resources of these natural freshwater systems, there have been few management initiatives for guts in the USVI. Gardner (2008b) evaluated the use of guts for agriculture and assessed human modifications of these watercourses, and produced a draft management plan for guts that identified policy and enforcement as being the main management areas in need of improvement (Gardner 2008a). Although guts were excluded from the 2005 CWCS, they were subsequently included in the Wetland Conservation Plan for St. Thomas and St. John (Platenberg 2006).

Benoit and Nemeth (2011) examined the response of guts to rain events. They determined that when it rains, water depth and turbidity increases, while Total Dissolved Solids (TDS) decreases due to dilution. Typical values for TDS in guts are high, similar to solutions that are 4% seawater, likely due to evapotranspiration that removes water yet leaves salts behind. The results of this study suggest that TDS might be a useful indicator for measuring stream discharge.

Gardner (2008b) identified that land use changes and development have increased surface runoff, thereby reducing groundwater recharge reduced flows in streams. Nemeth and Platenberg (2007) used the biodiversity of freshwater fish & invertebrates as an indicator to assess the level of disturbance to guts on St. Thomas, an idea that was further developed by Platenberg (2017) with the addition of bats and frogs as indicators of habitat integrity between guts with and without water resources. This study identified interactions between bats and guts, with dry guts seeming to provide transportation corridors, while guts with pools offer resources that attract the bats. Tennant (unpublished MMES thesis data 2016) evaluated elevational differences within guts systems and discovered that the presence of man-made or natural barriers in guts has a higher influence on species diversity than distance from the sea.

In 2016, Horsey Witten partnered with SEA, USDA-NRCS, and Geographic Consulting to stabilize the Green Cay Gut on St. Croix. The rapid erosion of this gut was a large contributor to sediment in the Southgate Watershed (for information on this project see http://geographicconsulting.com/2017/02/14/head-cut-repair-stabilizing-reforesting-stream-banks-bed-st-croix/). Unfortunately, much of this work was undone by Hurricane Maria in 2017.

Despite impacts from multiple sources, USVI guts offer unique habitat and migration corridors for wildlife species. These ecological functions are often preserved even when guts are impacted by invasive species and even contaminants. The majority of guts that retain spring-fed pools appear to maintain high levels of ecological function. Developing management regimes that would increase connectivity and water availability would be beneficial for gut ecosystems.

Conservation Priorities

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. On St. Croix, Caledonia Gut and Butler Bay Gut are popular hiking destinations, each with occasional running waterfalls as an attraction. 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. Gardner (2008b) identified recreational opportunities in guts.

Post-hurricane needs: The guts experienced significant stormwater flow during and after the 2017 hurricanes. This rapid water flow scoured the stream channels, broke through coastal berms separating these systems from the marine environment, and introduced large amounts of debris, both vegetative and anthropogenic. Loss of canopy cover that shaded these systems resulted in an increase in water temperature and algal growth, while the scouring removed the macroinvertebrate inhabitants that typically control algae and sediment. These systems maintained a connection to the sea for months before ocean currents infilled the sand to reform the beach berms, and during that time organisms migrated back into the guts. Surveys of freshwater fauna post-hurricanes are important for understanding migratory and reproduction needs of gut inhabitants, many of which are diadromous. Repeated surveys will indicate where actions toward re-establishing connectivity are needed. Additionally, debris removal (particularly trash and building materials) should be implemented.

This section was adapted and revised from the Wetland Conservation Plan for St. Thomas and St. John (Platenberg 2006).

2017 Contributor (2017): RJP

Banner photo: Neltjeberg Gut by R. Platenberg

Freshwater Ponds

Habitat Description

There are few natural freshwater ponds in the USVI; on the northern islands this is due to shallow non-porous soils and steep topography that offer no opportunities for water to collect, except in guts. Freshwater ponds are much more numerous on St Croix (n>130) largely due to the greater amount of relatively flat land and agriculture. Most of these ponds have been built either through the damming of guts or by excavating a large depression, and are used to provide water for livestock or crops. During the plantation era the guts were often 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 in depressions in a basin or slope. These ponds are often stocked with fish (e.g., Tilapia, *Oreochromis mossambicus*). A significant number of freshwater ponds have also been created as features in resorts and on golf courses. The large Granard Pond on the South Shore of St. Croix was created specifically to provide habitat to wildlife, particularly birds.

Although these ponds generally hold water year-round, they often do not exhibit the typical characteristics of wetlands, by often lacking wetland vegetation, although some ponds do harbor algae, submerged macrophytes, and emergent vegetation. In many cases, the pond vegetation is not native to the USVI, and many ponds are choked with invasive non-natives such as water hyacinth (*Eichhornia crassipes*). A variety of herbs, woody shrubs, and trees grow along the edges and can tolerate occasional inundation. Retention ponds built for storm water runoff containment on development projects can form temporary wetlands that offer habitat to wildlife.

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 and sediment in ponds and increasing biodegradation of pesticides and other pollutants (DEP 2004). Freshwater ponds provide valuable habitat for many species, including landbirds, indigenous and migratory waterbirds that prefer non-saline ponds, such as the Least Grebe (*Tachybaptus dominicus*; McNair et al. 2008), and those that use both fresh and brackish ponds (e.g., Blue-winged Teal *Spatula discors,* White-cheeked Pintail *Anas bahamensis,* and Green Heron *Butorides virescens*).. Freshwater ponds have, to some degree, compensated for the loss of salt pond habitat (McNair et al. 2005), particularly on St. Croix, which has lost at least 50% of its saline habitat through coastal development. Bats rely on these ponds as a rare source of freshwater, and are frequented by the Greater Bulldog Bat (*Noctilio leporinus*), The Antillean Fruit-eating Bat (*Brachyphylla cavernarum*), and the Jamaican Fruit-eating Bat (*Artibeus jamaicensis*), as do non-native mammals, including deer and mongoose. Invertebrates, particularly dragonflies, also utilize this habitat.

Threats

Freshwater ponds that remain active agricultural ponds may be maintained to some degree by farmers, however their focus is maximizing water retention and not wildlife management. Ponds that have been abandoned are no longer subject to clearing of vegetation and disturbance to nesting birds by frequent visits, and are often infilled by sediment and invasive plants and subsequent successional processes. Freshwater Ponds do retain upland runoff and agricultural contaminants, and temporary wetlands often form out of retention ponds built during major construction projects that are utilized by birds.

Freshwater ponds provide habitat for invasive, non-native species, such as the cane toad (*Rhinella marina*) and red-eared slider (*Trachemys scripta*). The threat to native species, particularly birds, from the introduction of exotic plants, fish (e.g., *Tilapia* spp.) is unknown.

The potential of invasives, such as the red eared sliders, cane toads, and water hyacinth, escaping from these ponds and invading nearby guts is high. Sliders have been observed in several guts, including Neltjeberg on St. Thomas and Fish Bay on St John, and cane toads are commonly encountered in Dorothea Gut on St. Thomas (Platenberg, pers. obs.).

The largest freshwater pond on St. Croix, Fredensborg Pond (2.95 ha) has become a popular location for racing miniature remote controlled boats. Viewing stands have been constructed and this sport is gaining in popularity. The impact of the boat racing has not been studied, but it is likely causing some disturbance to the considerable avian diversity of this pond.

Research and Management

The NPS conducted a survey of fishes in inland ponds and pools that identified 41 species of fish 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 (aquatic invertebrate) 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 et al. 2005, 2006a,b). Based on these studies, several ponds have been identified as high priority for conservation specifically, larger ponds such as Fredensborg and Granard Pond, and ponds in which Least Grebes and Coots use for breeding. Pond "complexes" are also high priority for conservation.

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. Volunteer groups will occasionally clear invasive vegetation from ponds, although there are no formal management policies in place for these systems.

Ponds that have a connection to the sea via a gut are considered jurisdictional wetlands and are therefore subject to federal wetland regulations. Ponds that exhibit wetland characteristic (hydric soils, presence of water, wetland plants) are protected under the federal Clean Water Act.

Accomplishments Since 2005

Freshwater ponds have been included in waterbird and bat surveys that contribute to conservation goals for these species (McNair 2005, Mc Nair et al. 2005, 2006a,b, 2008, Valiulis 2009). Management recommendations for freshwater ponds were included in a wetland management plan (Platenberg 2006).

Efforts have been made by community groups, guided by DFW biologists, to clear invasive vegetation from freshwater ponds. In many cases, these efforts were successful and these ponds have remained clear for several years.

Conservation Priorities

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.

Post-hurricane needs: Freshwater ponds received significant stormwater input from the 2017 hurricanes, along with increased sediment, nutrients, debris, and trash. These systems would benefit from restoration of vegetated margins. Bird use should be monitored.

This section was adapted and revised from the Wetland Conservation Plan for St. Thomas and St. John (Platenberg 2006).

Contributors (2017): RJP, JV

Banner photo: Dorothea Ag Pond by R. Platenberg

Salt Ponds and Salt Flats

Habitat 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 marine environment over time as storm-deposited materials form a berm. The resulting enclosed or mostly enclosed water bodies surrounded by coastal mangroves 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 often in excess of 50 parts per thousand (sea water is generally 35 ppt), although this fluctuates according to freshwater input. 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). These saline habitats contain invertebrates that form an important prey base for shorebirds and other waterbirds. These ponds, often situated at the base of steep hills, also act as catchment basins for runoff, debris, and pollutants, thus protecting coral and seagrass beds in the marine environment.

Salt ponds are characterized by the presence of mangroves and other salt tolerant plants. Hydrological processes can be predicted by the mangrove community present as well as the community composition of fiddler crabs (*Uca* spp); each species has a range of saline tolerance that limits distribution (Jarecki 2003, Thurman et al. 2010). 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).

Salt flats are level areas associated with mangroves, coastal ponds, or beaches that are seasonally or tidally flooded. These are often mature salt ponds that have infilled with muddy or sandy sediment and are often associated with black mangroves (*Avicenna germinans*), which have a high salt tolerance. Other plant cover is sparse if at all present, and typically only salt tolerant species such as sea purslane (*Sesuvium portulacastrum*) persist, although there may also be some alga cover. Salt flats are important feeding and breeding sites for shorebirds, particularly Least Terns and Wilson's Plovers.

With more than 60 ponds across the islands, 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).

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. This species is exploited locally as a food source and is particularly valued as a traditional dish during Carnival. Fiddler crabs (*Uca* spp.) and blue crabs (*Callinectes sapidus*) are also common in salt ponds and provide valuable food resources for birds.

These saline coastal wetlands 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 et al. 2006). The Perseverance Bay (STT), Great Pond (STX), and Southgate (STX) salt ponds have been identified as Important Bird Areas due to the diversity of waterbirds that occupy these habitats.

Salt ponds have always held high value to local people. 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. 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.

Threats

Salt ponds across the USVI display differing levels of successional advancement. Many salt ponds dry up completely outside of the rainy season, and some remain dry year-round. Some of these salt flat systems are starting to fill in with vegetation, offering increased habitat for coastal birds.

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). The Southgate pond in St. Croix was cut in half by the construction of Green Cay Marina. The largest mangrove system in the USVI, Krause Lagoon, was filled in for the construction of the oil refinery on St. Croix.

Accelerated sedimentation represents a significant indirect threat to salt pond ecosystems. Construction on hillsides loosens and exposes soil that is carried by runoff water into salt ponds and bays. Sediment yields have significantly increased on St. John since the 1950s as a result of unpaved road erosion (MacDonald et al. 1997, Ramos-Scharrón and MacDonald 2005). Sedimentation poses a serious threat to corals and seagrasses, and decrease the functional ability of salt ponds as filtration systems (Rennis et al. 2006).

Leaking septic tanks and discharge pipes lead to sewage being carried with runoff water to coastal areas. Sewage is a 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.

Mangroves may be affected by rising water levels as a result of global climate change. Human encroachment prevents the mangroves from inland migration. 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. Extended drought conditions are likely to result in increased mortality of mangroves. Sea level rise may see these coastal systems disappearing completely.

When water is very low or ponds are dried, driving on or through ponds or salt flats by ATVs or even cars and trucks has been an ongoing issue. This disturbance can cause direct harm by running over the nests of ground nesting birds or will cause adult birds that are caring for the nests to flee leaving the eggs susceptible to predation and daily temperature fluctuations.

Research and Management

An 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 fluctuations 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.

Monitoring of salt ponds in St. Croix is primarily through bird surveys. At the Southgate pond, regular (twice monthly) bird surveys are conducted and water level and salinity are also measured during these surveys. Other ponds are monitored less frequently, again, primarily for bird activity, but any noticeable changes in the pond ecology are noted. There are no regular monitoring activities for salt ponds on St. Thomas, St. John, or the cays.

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 (2005, 2006) 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 2006, McNair, et al. 2006ab, McNair and Sladen 2007, McNair et al. 2008) and elsewhere in the USVI (Norton et al. 1985, Norton et al. 1986a).

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)).

Accomplishments Since 2005

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).

Great Pond on STX is currently the subject of an extensive study to determine the effects of sediment infilling. This pond has been valued as a fisheries resource for centuries, and openings to the marine environment have been repeatedly constructed to allow movement of fish and water. These openings fill in over time with sediment and debris, and most recently, a mass accumulation of sargassum seaweed, and the pond has in recent decades received significant sediment input from upland development. Most in-pond mangroves at Great Pond are now dead and feeding, roosting, and breeding habitat for water and shorebirds has deteriorated, as has the value to fisheries. DPNR is considering options for restoring the pond as a lagoonal system.

Conservation Priorities

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.

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. Salt ponds should be considered among one of the highest value ecosystems and further disturbance and encroachment through development should not be permitted. Climate change adaptability should be considered in decisions that involve upland buffers to allow these systems to migrate inland.

Acquisition Actions: Salt ponds fall within the coastal zone and are 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. Bird blinds along with an interpretive trail are currently being constructed to access Southgate Pond on St. Croix. Boardwalks, bird blinds, and informational kiosks and leaflets can be installed at all these locations to enhance the experience.

Post-hurricane needs: Mangrove systems around salt ponds were significantly impacted and have been slow to recover. Additionally, the ponds received significant stormwater input that also introduced debris, nutrients, and other nonpoint source pollution. These systems should be monitored for recovery, with mangrove restoration conducted, if needed, at sites with key waterbird breeding populations.

This section was adapted from Wetland Conservation Plan St. Thomas & St. John (Platenberg 2006).

Contributors (2017): RJP, JV

Banner photo: Salt Cay Pond by R. Platenberg

1.3 USVI Habitats: Marine Habitats

Overview

Much of the focus on natural resource management in the USVI is on the marine environment. It provides an important food source for the community, including reef fish like grouper and snapper, open water deep sea fish like mahi-mahi and tuna, and invertebrates such as lobster, conch, and whelk. Commercial and recreational fisheries, and management of these resources, are important to the USVI economy. In addition, the azure ocean waters are the foundation of the tourist industry, a main contributor to the territory's GDP, encompassing recreational activities such as diving, snorkeling, boating, and on-water activities like kayaking, surfing, and paddle-boarding. Tourists come to the USVI for the beaches, and spend money in hotels, bars, transportation, and entertainment. Besides food provisioning, employment, and recreation, other ecosystem services provided by the surrounding water include carbon storage and climate regulation. Mangroves and coral reefs buffer shorelines from severe wave action.

Underwater there is a diversity of habitats and organisms that rivals tropical rainforests. Coral reefs provide physical structural complexity that is occupied by sessile and mobile organisms, and a variety of fish and invertebrates. Seagrass beds and mangroves offer shelter and support for juvenile fish that later live in the reef as adults, and a number of fish move between reefs and seagrass beds daily for refuge and to forage. Connectivity between habitats that allows for migration is as important as habitat integrity in these systems.

Coral reefs are the hardened mound of substrate formed by the deposition of calcium carbonate by reef building corals and other organisms. Most reefs are built by stony corals with colonies of filter-feeding coral polyps, and offer a complex habitat structure that is occupied by a wide diversity of organisms. Reefs require sunlight for photosynthesis by the coral symbionts, and corals are sensitive to environmental changes, particularly in turbidity and temperature.

Other nearshore benthic habitats that are occupied by reef species but are not actual reefs include colonized hard pavement, gorgonian dominated pavement, colonized bedrock, and colonized beachrock.

Seagrass beds are underwater grassy meadows found in sandy bays with shallow calm waters. These meadows are highly productive and offer food and shelter to a wide array of marine organisms including green turtles, juvenile fish, and invertebrates. They also play an important role in benthic surface stabilization and carbon sequestration.

Mangroves are the bridge between the land and sea with both terrestrial and marine communities formed around semi-permanently submerged coastal trees adapted to these saline conditions. There are four species of mangroves in the VI that form these coastal communities, but it is only the Red Mangrove (*Rhizophora mangle*) that grows in calm, shallow waters with muddy substrates. The prop roots of the Red Mangrove offer habitat for a wide variety of sponges, corals, and algae that support a diverse fish community. These habitats are important nursery areas for commercially important fish that seek protection from predators among the prop roots.

Another marine habitat that is becoming more abundant in nearshore USVI waters is the floating **sargassum mats**. These provide crucial resources to pelagic organisms but can become a threat to these same organisms when they over-proliferate and accumulate in bays and on beaches.

The main threat to these nearshore marine communities in the USVI are land-based input such as sediment, contaminants, and trash, as well as marine debris. Water turbidity is associated with prevalence of coral diseases. Boating activity can damage reefs and seagrass beds through anchor damage, prop scarring, and collisions with subsurface reefs. Invasive species, such as the lionfish and *Halophila* seagrass, are replacing natives and altering the trophic webs. Climate change is having severe and measurable impacts to these marine systems through increased water acidification and higher sea surface temperatures that cause coral bleaching and stress to seagrasses and mangroves.

Priority conservation actions for these marine systems are to reduce or eliminate anthropogenic stressors. Better sediment control practices and enforcement will reduce turbidity. Implementation of sustainable fishing practices that protect herbivorous fish will reduce algal overgrowth of corals. Establishing and maintaining mooring fields in high boat-use areas will reduce damage to seagrasses. A more challenging action is to reduce or eliminate the use of single-use disposable plastics, such as cups and straws, that frequently end up in the marine environment and are eaten by fish and sea turtles.

Banner photo: Chocolate Hole mangroves by R. Platenberg

Mangroves

Habitat Description

Mangrove wetlands are coastal forested wetlands that are periodically flooded. These wetlands form one of the most important intertidal plant communities found along low wave-energy shorelines in the tropics. As the interface between marine and terrestrial ecosystems, mangrove wetlands provide a unique and vital habitat as well as ecosystem services for both the upland and seaward environments. They are highly productive environments that support a variety of flora and fauna.

The term mangrove is used to loosely define members of approximately 12 plant families that contain more than 50 species that have converged in their adaptations for colonizing quiet, shallow coastal habitats with a broad range of salinities and relatively anoxic soils (Odum et al. 1982). These species are adapted to saline waters, which reduces competition from other vascular plant species. Tidal fluctuations allow mangroves to establish farther inland, transport nutrients and clean water, reduce sulfur compounds, prevent salinities from reaching lethal concentrations, and disperse mangrove propagules.

Mangroves are found in calm waters; high wave energy can prevent the establishment of propagules, destroy mangrove root systems, and prevent accumulation of fine sediments. Mangroves require temperatures above 19°C and thrive in water temperatures below 42°C, and they also require relatively low dissolved oxygen concentrations and low macronutrient (such as phosphorus) concentrations (Odum et al. 1982).

The four common mangrove species in the USVI are Red Mangrove (*Rhizophora mangle*), Black Mangrove (*Avicennia germinans*), White Mangrove (*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, with red found on the most seaward edge of land in shallow calm waters, black occurring in areas with salinity extremes, such as around salt flats and hypersaline ponds, and whites generally found further inland. Red and black mangroves have adaptations for oxygen exchange under saturated conditions, whites are less tolerant of saturated soils. All three species have mechanisms for removing excess salt.

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 and is not tolerant of wet soils. This species is, however, tolerant of variable conditions and can often be found on beaches and rocky shorelines, even in places where roots are tidally inundated (Platenberg, pers. obs.).

There are five mangrove communities in the USVI, based on the classification system of Gibney et al. (2000) and Thomas and Devine (2005). ***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 semi-permanent, tidally flooded shorelines and salt ponds. ***Mixed swamp*** refers to semi-permanent 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 the Mangrove Lagoon within the St. Thomas East End Reserves (STEER) on the southeast coast (Island Resources Foundation 1985, STEER 2011), and good mangrove cover is also found at Mandahl. St. John has shoreline mangrove systems within Hurricane Hole in Coral Bay and around numerous salt ponds. The largest mangrove system in the USVI at Krause Lagoon on St. Croix was destroyed in order to build an oil refinery in the 1960s. Other important mangrove systems on St. Croix include Altona Lagoon and Salt River.

Ecological Value

Mangroves offer critically important ecosystem services to terrestrial, coastal, and marine communities. Mangrove leaf litter and other organic matter flushed into nearby seagrass and reef habitat provide nutrient input for filter feeders and benthic scavengers (Snedaker and Getter 1985). Mangroves with extensive root systems trap sediment and debris (including trash) and play an important role in sequestering carbon, heavy metals, and other contaminants. Red mangrove propagules that float away can become established in soft-bottomed calm shallow water. These individuals can start to trap sediment and other propagules to eventually form manglar islands that are used as roosting sites by shorebirds and seabirds, such as herons and pelicans. Eventually, trapped sediments in the root systems may create conditions that become suitable for the establishment of black and white mangroves and associated species.

Mangroves support a wide range of biodiversity within the submerged root systems and among the trunks and canopy including sponge communities, shrimp, insects, fish, frogs, turtles, lizards, snakes, and birds (Kathiresan & Bingham 2001, Nagelkerken et al. 2001). Mangrove wetlands 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 75% 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). Resident waterbirds nest in mangroves along salt ponds (McNair et al. 2006).

Submerged red mangrove prop roots are colonized by a variety of organisms, including sponges, oysters, and an abundance of coral species among the prop roots (Rogers 2009). The complexity of these prop root communities support a range of fish species and are known as a nursery ground these commercially important species (Tobias 2001). Many juveniles use detritus and mangrove-associated invertebrates and fish as a food source (Zieman et al. 1984, Thayer et al. 1987), while the complex prop-root habitat provides protection from predation (Orth et al. 1984, and Sogard and Olla 1993). These highly diverse and abundant juvenile fish communities within mangroves are linked to high diversity on nearby reefs and other habitats (Nagelkerken et al. 2001, Mumby et al. 2003, Serafy et al. 2015). This relationship could provide more resilient reef habitats after a disturbance event by reducing additional stress from algae growth (Mumby and Hastings 2008).

An important role of mangroves is the preservation of water quality. The complexity of mangrove root structures makes them efficient at trapping and filtering nutrients from upland runoff and sediment brought in tidally (Alongi and McKinnon 2005, McLeod et al. 2011). Their ability to extract nutrients from circulating waters minimizes the eutrophication potential of nearshore waters. Mangroves also trap lethal heavy metals in the sediment, which has a limited ability to sequester and/or detoxify common pollutants (Lewis et al. 2011). Some heavy metals are sequestered as insoluble sulfides, while organic pollutants may be oxidized or decomposed through microbial activity. These heavy metals, increased sedimentation, and nutrient concentrations can be detrimental to nearshore coral reef habitats (Alongi and McKinnon 2005).

Mangroves provide shoreline stabilization and protection and reduce wave energy from coastal storms (Granek and Ruttenberg 2007, Alongi 2008). Although this protection can be highly dependent on tree density and other factors, mangroves mitigate the impact of storms to coastal habitats and coastal communities (Danielsen et al. 2005, Alongi 2008).

Mangroves are one of a few habitats that are extremely efficient at trapping and storing carbon within tree biomass and sediment (McLeod et al. 2011, Alongi 2012). Through tidal exchange mangroves trap and store allochthonous carbon, which contributes to mangroves as an important long-term carbon sink (McLeod et al. 2011). This is an essential process in that anthropogenic carbon dioxide emissions can be mitigated by natural systems.

Threats

Mangrove wetlands of the USVI have been impacted by natural as well as anthropogenic forces. Anthropogenic sources of stress to mangroves include siltation, surface runoff, oil pollution, sewage effluent, and cooling water discharge from power plants. The threat of pollution can come in the form of large marine debris, including derelict vessels and fishing gear, but also as soluble pollution such as oil and gas. Movement of abandoned vessels during storms harm prop roots and tree growth and can leak pollutants and trap wildlife (Lord-Boring et al. 2004). Oils and gases negatively impact mangrove health and seedling survival (Kathiresan and Bingham 2001). Increased nutrients from agricultural areas and sewage decreases mangrove root system growth (Lovelock et al. 2009).

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 a large 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, Margaritaville, and Sugar Bay Resort on St. Thomas sit on what were formerly mangrove wetlands. On St. Croix, the largest mangrove system in the VI was destroyed for the construction of the Hess Oil Refinery. Southgate Pond on St. Croix and the mangrove wetland at Benner Bay on St. Thomas have been substantially altered by marina construction. Clearing of mangrove habitat changes biotic processes, alters associated flora and fauna communities, and shifts water drainage and movement (Taylor et al. 2007). Mangrove clearing has sedimentary effects in which carbon dioxide is released from peat, converting mangroves from a carbon sink to a carbon source (Lovelock et al. 2011). Although regulations are now in place to protect these wetland resources, mangroves are often not able to persist in the face of short-sighted economic development.

The Bovoni Landfill is adjacent to the largest stand of mangrove forest on St. Thomas (Horsley Witten Group 2013). The leachates from this unlined and overfilled landfill are thought to be the cause of increased mangrove mortality (Horsley Witten Group 2013). In a recent study, it was found that surface, rather than ground, water was the main source of contaminant delivery to these mangrove forests, and contaminant delivery was correlated to high rain events, suggesting a connection to the Bovoni Landfill (Keller et al. 2017).

Climate change will likely affect mangroves through changes in temperature, changes in CO_2, increased precipitation, increased hurricane and storm frequency, and sea level rise (McLeod and Salm 2006). Mangroves can suffer from structural and sedimentary damage from storms (Smith et al. 2009). 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 subsequent storm 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). Many of the mangroves at Salt River were destroyed by Hurricane Hugo (Kendall et al. 2005). A large-scale restoration project was implemented in which volunteers planted over 10,000 mangroves in the bay, successfully restoring this important ecosystem.

Mangroves may not be able to keep pace with rapidly rising sea levels. Mangroves adapt to sea level rise by contributing soil volume and expanding the soil surface upward (Alongi 2008, Gilman et al. 2007, 2008, Mckee et al. 2007). However, when mangroves are faced with frequent flooding and excess runoff, root accumulation rates are reduced, energy used for root production is reduced, and root decomposition is accelerated (Krauss et al. 2013). It is unknown whether mangrove soil expansion can keep up with the increased rate of sea level rise. Even if mangrove sediment accumulation rates keep pace, mangroves will need to begin migrating landward to avoid anoxia (Gilman et al. 2008). Habitats with limited room for landward migration will be severely affected, particularly where urban development and clearing around mangroves has limited opportunity for mangrove migration. This may be especially pertinent to St. Thomas mangroves, which are often bordered by roads.

An increase in sea surface temperature changes phenological patterns and species composition (Gilman et al. 2008). These ecosystem wide alterations would have cascading consequences on the habitat and associated species. Currently, it is unknown to what extent ocean acidification affects mangroves (Cooley et al. 2009).

Research and Management

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. Benthic habitats, including mangrove extent, have been mapped, and guidance for monitoring of mangroves and their resources have been developed (Zitello et al. 2009).

There have been several studies to assess the value of mangroves as important nurseries for recreational and commercial fisheries (Heald and Odum 1970, Austin 1971a,b; Austin and Austin 1971, Olsen 1972, 1973; Cintron-Molero 1987, Thayer et al. 1987, Adams and Tobias 1994, Boulon 1990, 1992; Dennis 1992, Tobias 1996, 1998, 2001; Mateo 2001, Mateo and Tobias 2001, Volson et al. 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, Adams et al. 1998).

The St. Thomas East End Reserves (STEER) are areas that fall within the Benner Bay/Mangrove Lagoon Area of Particular Concern (APC) and have been designated as Marine Reserves and Wildlife Sanctuaries. These areas, however, had different rules and regulations that applied to them based on their value for fisheries and recreation and vulnerability to impacts. In 2008 the areas were renamed (STEER) to reflect their connectivity. A single management plan that encompassed all areas was drafted by a team from UVI, DPNR, TNC, and private stakeholders (STEER 2011). A watershed management plan developed for the Jersey Bay Watershed that feeds into STEER identified many infrastructural problems that result in the input of sediment and contaminants directly into these important marine areas (Horsley Witten Group 2013). The STEER management plan was never formally approved, however, and is now in need of updating.

Mangroves are locally protected through several sections in the VI Code (Title 12, Ch 2), which prohibits the cutting, pruning, removal and disturbance to mangroves, as well as no net loss of wetlands, unless permitted by DPNR. 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. DPNR is the principal agency requiring permit application for construction activities in the coastal zone, where wetlands usually form (USGS 1994). DPNR also comments on Federal permit applications to ensure consistency with the Coastal Zone Management Plan. When wetland 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.

Accomplishments Since 2005

Several studies focusing on mangroves have been completed to better understand these resources in the USVI. Rogers (2009) and Yates et al. (2014) documented over 30 coral species growing on or near mangrove prop roots in Hurricane Hole, St. John, and discovered that coral colonies shaded by mangroves suffered less bleaching than unshaded colonies, making mangrove habitats a possible refuge from climate change.

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 (Caribbean Data Center data, 2001).

An important collaborative project between several local entities, including TNC, DPNR, and UVI, developed a management plan for the St. Thomas East End Reserves (STEER), in which mangrove habitats were one of a set of conservation targets (STEER 2011). Several projects stemmed from that, including an assessment of contaminants in mangrove sediments (Pait et al. 2014). Colletti (2011) measured the distribution of fish in STEER in relation to habitat complexity. Keller et al. (2017) determined that surface water pathways may be more important in the delivery of contaminants to the mangrove fringe than groundwater pathways.

Several graduate students from the MMES program at UVI completed thesis projects contributing to mangrove research. Renchen (2012) studied microsatellite markers in red mangroves and found that there is genetic connectivity between St. Thomas and St. Croix populations but not between the USVI and systems further removed, i.e., Jamaica; this supports management based on local translocation of propagules between localities within the USVI. Forbes (2014) suggests that red mangroves can tolerate moderate concentrations of heavy metals and that biogeochemistry and phytomonitoring may be effective indicators for mangrove monitoring. Keller (2015) found that groundwater discharge from the Bovoni Landfill has elevated concentrations of heavy metals and nutrients in sections of the mangrove habitats in STEER (see also Keller et al. 2017).

The Virgin Islands Marine Advisory Service (VIMAS) currently has a mangrove restoration project in place that collects mangrove seedlings from Brewers Bay, Perseverance Bay, and Mangrove Lagoon and raises the seedlings in a nursery at the UVI on St. Thomas. VIMAS has planted at least 150 mangrove seedlings on Range Cay during 2016. Seedlings are planted during Environmental Learning Outside the Classroom events, Earth Day, or the Youth Ocean Explorers Summer Program, thereby enhancing community awareness and stewardship of this resource (H. Forbes, pers. comm., Oct 2016; http://www.uvi.edu/community/virgin-islands-marine-advisory-service/default.aspx).

Conservation Priorities

Stormwater and non-stormwater runoff is not treated to remove pollutants and nutrients, which then enter into mangrove ecosystems (Horsley Witten Group 2013). Retention ponds and water treatment facilities are methods that could be used to treat this runoff, and a method of measuring runoff would be to conduct water quality testing in mangrove ecosystems. Another way to reduce pollution and runoff in mangroves is to create vegetative upland buffers. Buffers around mangrove wetlands in Puerto Rico reduce sediment in mangroves by 24%, mangrove nitrogen levels by 31%, and mangrove phosphorous levels by 29% (Williams et al. 2013). In order to assess the effectiveness of vegetative buffers, heavy metal and pollutant concentrations need to be measured before and after buffer installation. With runoff also comes an increase of marine debris or land-based sources of trash. Marine debris can be reduced through more frequent trash collection and clean-up of guts and beaches. This can be measured by comparing coastal cleanup yearly data and tracking the removal of derelict vessels and gear that have sunken as a result of neglect. Runoff is also affected by impervious cover and can be reduced by better site design at the homeowner and business level. Improvements in building site design can be tracked by measuring the amount of impervious cover added each year.

In order to mitigate the effects of climate change, including sea level rise and increased storm prevalence and intensity, restoration projects can be used to increase mangrove habitats which will in turn diversify genetic materials and increase resiliency (Proffitt and Travis 2010). Larger and denser mangrove forests have been shown to reduce wave energy from coastal storms (Alongi 2008). Population surveys will be utilized to assess the effectiveness of planting projects over time. Additionally, establishing urban growth boundaries could be an effective measure for ensuring habitat for landward migration of mangroves. This measure will be assessed by tracking compliance with urban growth boundaries over time to see if it is an effective means to protecting necessary habitats in the face of rising sea level.

Restoration Actions: Mangroves can be replanted although high currents, wave action, and storm activity make mangrove restoration more complex than for terrestrial systems (Thorhaug 1990, Kaly and Jones 1998, Toledo et al. 2001). However, under the right conditions, mangrove restoration can be successful. Salt River was successfully restored through mangrove planting after Hurricane Hugo and several restoration projects on St. John, including Enighed Bay, have shown success. Reducing the impacts to mangroves from sedimentation and pollution must be accomplished prior to replanting in order to improve success rates.

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. Marine protected areas can be implemented to further protect mangrove ecosystems by not allowing development in these areas indefinitely. Installing retention basins around the Bovoni Landfill and other areas of high sediment input would reduce sediment and nutrient runoff originating in the landfill from reaching the mangroves. Better management of chemical contaminants in solid waste would also reduce wetland contamination.

Acquisition Actions: Mangroves are obligate wetland species, and as such, fall within EPA wetland delineation boundaries. Acquisition priority should be given to land parcels surrounding mangroves to protect vegetation buffers adjacent to mangroves.

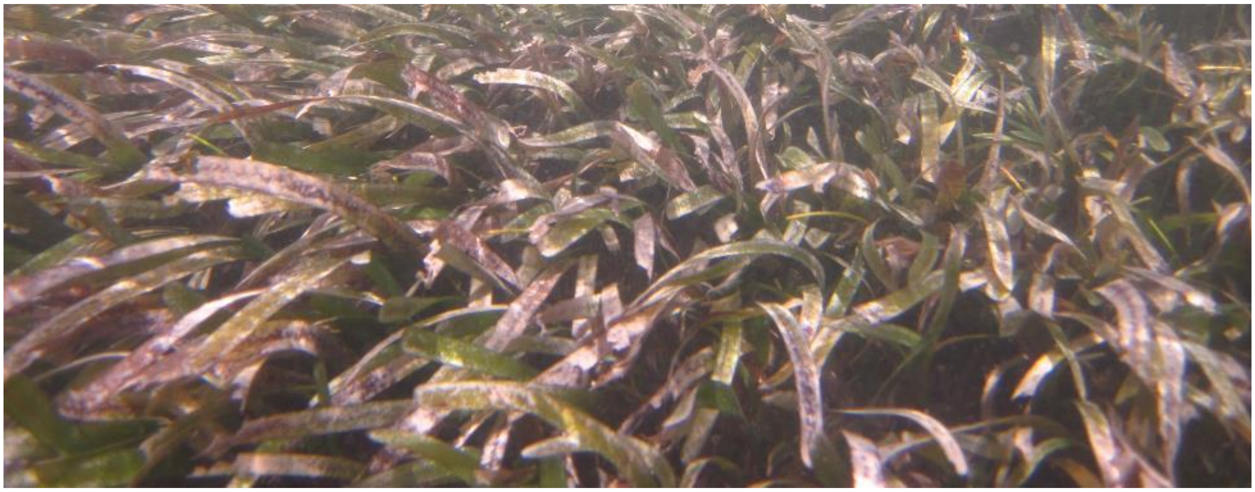
Education/Recreation Actions: Mangroves provide ample opportunity for bird watching. Several tour operators on all three islands offer kayak tours of mangrove systems, enabling easier access to wildlife viewing. School groups could be encouraged to utilize these resources. Boardwalks and bird blinds could be installed in the more accessible locations. Public awareness can be increased by creating education programs and opportunities for community members to volunteer in mangrove habitat restoration projects. Incentive programs such as tax breaks or monetary rewards can be used to increase a willingness to comply with regulations with stakeholders involved in construction or development practices.

Post-hurricane needs: Mangroves were severely impacted by the 2017 storms and have shown slow recovery. Removal of upland sources of stressors (i.e., sediment and nonpoint source pollution input) is important towards allowing these systems to recover. Although the trees appear to be dead, cutting and removal is not recommended. Restoration through tree planting in mangrove areas where minimal natural recovery is occuring, may be beneficial. These systems should be periodically monitored for recovery.

This section was adapted from Platenberg 2006 (Wetland Conservation Plan for St. Thomas and St John).

Contributors (2017): Katharine Egan, Alex Gutting, Amelie Jensen, and Elizabeth Brown.

Banner photo: *Rhizophora mangle* by R. Platenberg



Seagrass Beds

Habitat Description

Seagrass beds in the USVI are found in shallow bays with calm waters, and always associated with long sandy beaches that are protected from strong wave action. Seagrasses consist of a suite of photosynthetic marine plants that reproduce both vegetatively and through flowering and seed production (Williams and Heck 2001, Duffy 2006, Björk et al. 2008). In the USVI these habitats are important for various fish, invertebrates, and sea turtles.

Seagrasses have a narrow range of environmental requirements that include a shallow soft substrate and calm clear water. They require circulation for delivery of nutrients and removal of metabolic waste products, but are less tolerant of strong wave action. Seagrasses do not develop in shallow areas that are exposed at low tide, although they can survive brief exposure. They are commonly associated with coral reef communities because of their similar requirements for high water quality. Seagrasses can tolerate wide salinity ranges varying in concentration from brackish to hypersaline, allowing them to occupy a wide distributional range (Duarte 2002, Björk et al. 2008).

Three species of native seagrasses occur in the USVI (Delgado and Stedman 2004). **Shoal-grass** (*Halodule wrightii*) is an early colonizer of disturbed areas and usually grows in water too shallow for other species. It can be distinguished from other species by thin leaves that are flat in cross-section. **Manatee-grass** (*Syringodium filiforme*) is also an early colonizer of bare substrate; it is easily recognized by leaves that are round in cross-section. **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. Species of macroalgae (e.g., *Caulerpa* and *Halimeda*) are often interspersed between the grass blades, which themselves are colonized by epiphytes (Thayer et al. 1975). A recent invader, *Halophila stipulacea*, grows in open sandy areas, including blowouts; this species has short ellipsoid leaves and usually forms dense seagrass beds (Vera et al. 2014, Willete et al. 2014).

Ecological Value

Seagrasses play a major role in providing physical structure on bottom sediment (Duffy 2006, Worm et al. 2006). They filter suspended sediment and nutrients from coastal waters, maintaining a transparent water column and increasing light availability for the seagrasses and other benthic plants and adjacent coral reefs (Zimmerman et al. 1991, Short et al. 1996). Their extensive leaf canopies and rhizome networks allows seagrasses to modify currents patterns and dampen wave actions, which influences and stabilizes the structure of benthic communities, reduces erosion rates, and contributes to coastal protection. (Zimmerman et al. 1991, Short and Wyllie-Echeverria 1996, Björk et al. 2008).

As a benthic plant community, seagrass beds are extremely productive. They are associated with an abundance and variety of small fishes and invertebrates such as shrimp and crabs (Duffy 2006) and provide feeding grounds for green sea turtles, stingrays, conch, and others. 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 to forage on both the plants and their animal associates.

Sea turtles maintain biodiversity in sea grass beds through grazing, by preventing single species from becoming dominant (Duffy et al. 2003; Moran and Bjorndal, 2005). Some reef fish, such as snappers and parrotfishes, move into seagrass beds at night to forage (Delgado and Stedman 2004). Seagrasses also provide habitat, protection from predators, and essential nursery areas to commercial and recreational fishery species. In some cases, seagrass beds can provide alternative habitat for juvenile fishes when nearby mangrove forests have been damaged (Bologna 2014).

Threats

Native seagrass beds in USVI are in decline for many reasons, including boating activity damage, sediment input from terrestrial erosion, decreasing water quality, and impacts from invasives (i.e., *Halophila stipulacea*). Less widespread but severe threats include dredging and filling projects and unsustainable fishing practices (Duarte 2002, Duffy 2006, Orth et al. 2006).

Boating activity has affected seagrass beds, with boat propellers stirring up sediment and anchors scarring seagrass beds (Duarte 2002, Short and Wyllie-Echeverria 1996). Blow outs, which are bare sand depressions within seagrass beds, are common in areas with high boating and anchoring activity.

Although seagrasses are a hardy group of plant species, they are extremely sensitive to poor water quality. 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 environments (Tobias 1996, Duffy 2006, Orth et al. 2006). Siltation and shading reduce ambient light levels in the water, which reduces the rate of photosynthesis. Water pollutants can have toxic effects on the growth and development of seagrasses and their animal associates. Failing residential septic tanks have resulted in nutrient-rich runoff into the sea, particularly after high rainfall events. This causes short-term eutrophic conditions in various bays around St. Thomas and St. Croix. Prolonged nutrient enrichment of seagrass beds could result in the replacement of seagrass with phytoplankton or benthic algae that have rapid growth rates (Zieman 1982, Orth et al. 2006). Seagrasses are also sensitive to hot water discharges and are eliminated from areas subjected to effluents from power plants and brine disposal from desalination plants (Zieman 1970, Ogden and Gladfelter 1983).

Overharvest of fish and invertebrates in seagrasses causes changes in trophic interactions in these habitats (Duffy 2006), and reduces the health of the grasses themselves. Grazing by sea turtles (and manatees in other areas) maintains diversity and productivity of seagrass species in the beds by reducing competition and encouraging compensatory growth. Species that feed on epiphytic growth, such as conch (*Strombus* spp.), prevent overgrowth of algae that reduces photosynthetic capability. Additionally, harvest methods for these species are often unsustainable and damaging, particularly beach seining for small fish.

Seagrasses are also affected by natural threats such as hurricanes and intraspecies competition. Hurricanes affect seagrass habitats by exposing below ground parts, extensive seagrass detachment, seagrass burial under the sediment or in worst case scenarios, mortality due to salinity decrease (Cruz-Palacios and Van Tussenbroek, 2005). In ungrazed seagrass beds, it is common for *Thallasia testudinum* to outcompete *Syringodium filiforme* seagrass by reducing its light availability (Williams 1987).

In 2002, *Halophila stipulacea,* a seagrass species native to the Red Sea and Indian Ocean, was first detected at Grenada and has since spread northward along the Lesser Antilles (Willette and Ambrose 2009). It was first documented by NPS personnel in St. John in 2012, when they noticed that the sand halos around reef patches formed by grazing by reef occupants were starting to fill in with this invader (R. Boulon, pers. comm., July 2012). It was documented shortly thereafter in Brewers Bay, St. Thomas, and has only recently been discovered in Altona Lagoon, St. Croix (A. Farchette, pers. comm., February 2017).

In areas where it has become established, *H. stipulacea* displaces native seagrasses, reducing diversity and abundance, not only of seagrasses, but also of seagrass-associated species (Maréchal et al. 2013, Low-Décarie et al. 2014, Willette et al. 2014). Fish seem to actively avoid using *Halophila*-dominated seagrass beds (Green 2017), while some organisms will eat it but do not prefer it (e.g., green turtles and *Tripneustes* urchins; e.g., Jerris 2016). However, some have hypothesized that *Halophila* may serve as a more resilient substitute to native species that will not be able to tolerate the habitat alterations caused by climate change (Rogers et al. 2014).

Climate change is likely to result in changes to seagrass community structure and distribution (Short and Neckles 1999). Productivity will be affected by influences from increasing water depth and changes in ocean salinity and pH. Predicted changes in the frequency and intensity of extreme weather events, such as hurricanes, will increase disturbances that benefit invasives such as *Halophila*, while erosion from severe rain events increases eutrophication. Seagrasses are important in carbon sequestration and reductions in seagrass cover diminishes this valuable ecosystem service.

Research and Management

Seagrasses have been mapped under NOAA's Benthic Habitat Assessment Project that provides data on the distribution and abundance of important recreational fisheries habitat. This project monitors 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, Kojis et al. 2000, Zitello 2009). The NPS monitors seagrasses at Buck Island (STX) and around St. John (science.nature.nps.gov/im/units/sfcn/monitor /marine/seagrass.cfm).

A component of the VI-EPSCoR Mare Nostrum program focuses on the seagrass-dominated habitats of the Brewers Bay ecosystem on St. Thomas, with studies on fish, including Nassau Groupers and stingrays, and turtle movements in the bay and trophic relationships within the seagrass beds (epscorvi.wordpress.com).

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, including no anchoring and wake zones. Seagrasses are also protected as wetlands. Similarly, the Clean Water Act of 1972 applies to waters discharged into wetlands, and is geared towards restoring the chemical, physical, and biological integrity of national waters.

Accomplishment Since 2005

Several UVI research studies have focused on the invasive *H. stipulacea*, including distribution, influence of boating activity on the distribution of the species, and influences on native juvenile fish communities in St. Thomas. These studies indicate that there is an increase in *H. stipulacea* in areas where high boating activity occurs (Barry et al. 2015), and that there is a lower diversity of juvenile fish communities found in *H. stipulacea* compared with native seagrass communities (Olinger et al. 2016). These findings contribute toward a better understanding and management of this highly invasive species that is rapidly expanding across Caribbean waters.

An MMES thesis study assessed if heavy metals were preventing the growth of *Thalassia testudinum* in blowouts of Coral Bay, St. John; results indicated that while blowouts negatively affect seagrass beds, derelict vessels within them do not (deJarnett 2016).

Conservation Priorities

Restoration Actions: Seagrass beds can be restored by encouraging natural recolonization in areas that have experienced improvements in surface water quality. Removal or control of the invasive *Halophila* may be necessary. Seagrasses can be planted or transplanted, although the effort is labor intensive, requires extensive planning, and there is little evidence that it is effective (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 pump-out stations and install moorings to prevent anchor damage.

Acquisition Actions: Acquiring seagrass beds themselves is not applicable because submerged lands within three nautical miles of the shore belong to the VI Government, but 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. Involving the community in Citizen Science projects that involve seagrass monitoring can be an effective way not only to generate data but also to foster awareness. 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.

Post-hurricane needs: Seagrass beds were scoured by the hurricanes in 2017, leaving swaths of bare sand and areas where grasses were buried by large volumes of sand. These areas are at risk of invasion by *H. stipulacea*, which can result in a shift in ecological community. Seagrass beds should be periodically monitored for regrowth by native grasses as well as distribution of *H. stipulacea*, and research should be conducted on effective removal of this species.

This section adapted from Platenberg, R. J. 2006. Wetlands Conservation Plan for St. Thomas and St. John, U.S. Virgin Islands. Division of Fish and Wildlife, St. Thomas.

2017 contributors: Mareike Duffing Romero, RJP
Banner photo: *Thalassia testudinum* by R. Platenberg

Coral Reefs

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Habitat Description

Coral reef habitats are found around all islands and cays of the USVI, with shallow reefs covering an estimated area of 297.9 km² (Catanzaro et al. 2002). Deep reefs extending past 30 meters depth, also known as mesophotic coral reefs, have recently been mapped and, in the northern USVI, are more extensive than shallow reefs (T. Smith, pers. comm., 2017).

USVI coral habitats are made up of at least 57 species of living corals (Wilkinson 2004). Corals are sessile marine invertebrates, which are composed of identical polyps forming a colony system. These corals can be of two types, stony (scleractinian) or soft (alcyonacea), defined by the arrangement and number of tentacles, arrangement of skeletons, and the needs of zooxanthellae. Stony corals grow by drawing calcium from surrounding water and using it to build a calcium carbonate structure to house polyps. These reef-building corals are largely responsible for creating the exceptional living reefs that ring the USVI, protecting coastlines, nurturing fisheries species, creating sandy beaches, and providing the aesthetic beauty that increases tourism.

To survive, reef-building corals need clear water to allow sunlight penetration to their photosynthetic algal symbionts, *Symbiodinium*. Reef-building corals also require a stable water temperature ranging from 20^{o} - 32^{o} C (68° - 90° F) and good water quality. Corals are very sensitive to sediments and wastewater contamination that can kill corals directly and increase nutrient loads, resulting the overgrowth of benthic algae (Hauter 2016). Corals require pH levels between 8.2 – 8.4 for the rapid growth of their stony skeleton. Nourishment comes from particulate organic matter and plankton captured from seawater, but the majority of carbohydrates are typically gained from photosynthesis by the intracellular *Symbiodinium*. Mesophotic reefs show seasonal variability in nutrient access (Brandtneris et al. 2016).

There are seven reef structure types that occur in the USVI:

Fringing Reefs are nearshore linear reef systems, while **Barrier Reefs** are further offshore and are characterized by a deep lagoon separating the reef and shoreline. **Patch Reefs** are small isolated reefs separated from shore and from other reef systems by areas of sand, seagrass, or hard bottom. **Shelf Reefs** are near-surface reefs that form more than 5 kilometers from the shoreline, whereas **Submerged Shelf-Edge Reefs** occur offshore and their tops are greater than 15 meters deep. **Spur and Groove Reefs** are parallel ridges of coral growth that are separated by depressions of sediment and coral debris. These reefs vary from 8 to 65 meters in width and can be up to 10 meters in height.

Mesophotic Reefs in dimly lit waters from 30 to 100 m depth are the dominant reef structures around much of the USVI, yet are only recently being characterized by science. These reef systems are an extension of shallow water reef systems with an overlap in species of corals, algae, and sponges, but with increasing specialization of species below 60 m depth. These areas serve as essential fish habitat, they are important as fisheries areas, and fish spawning aggregation sites for commercially and ecologically important fishes.

Each zone of the reef offers different conditions, providing a mosaic of habitat types that support a large diversity of organisms. The **Reef Crest Zone** of near surface reefs is the shallowest area of reef within the high-energy wave zone, and is dominated by fire coral (*Millepora* spp.) and other wave-resistant invertebrates. The substrate is made up of coral, sand, and loose rubble.

The **Back Reef** is landward of the reef crest in an area protected from wave energy, often covered in large interlocking pieces of dead elkhorn coral (*Acropora palmata*), and colonized by patches of seagrass and algae. The substrate is primarily sand or coral rubble with little coral cover, but the area can serve as important settling sites for juvenile fishes.

The **Upper Fore Reef** is the seaward shallow area below reef crest that is typically occupied by highly branching elkhorn and other hard corals such as *Porites* spp. and agaricids. Elkhorn corals have undergone a substantial die-off since 1970, so the upper fore reef often only contains the skeletons of these corals. Substrate is fine grain sediments and coral rubble. This area serves as a daytime refuge for fish that forage on seagrass beds at night (grunts and snappers) and a nighttime refuge for species that rest in crevices and caves. The **Lower Fore Reef** is the seaward border of the reef systems where they descend into deeper water. The boulder star coral (*Orbicella annularis*) is a common inhabitant of these areas.

Ecological Value

Coral reefs of the U.S. Virgin Islands were estimated at a value of $210,000,000 in 2012 (Edwards 2013) and are the most economically valuable wildlife feature of the USVI (Beukering et al 2011). Coral reefs provide many ecological and economic benefits for coastal communities (Moberg and Folke 1999, Barker and Roberts 2004). Coral reefs provide an extremely biodiverse habitat supporting numerous coral species, algae, and seagrasses for invertebrates, fish, zooplankton, phytoplankton, and sponges. Many species of plants and animals that inhabit coral reefs are being prospected for human medical uses, such as easing labor, cancer, arthritis, asthma, ulcers, heart diseases, and much more (Erwin et al. 2010, Shah 2013). These habitats offer opportunities for foraging, spawning, breeding, nursery, and refuge for many organisms (Reaka-Kudla 1997). It is estimated that coral reefs house a third of all fish species found in the oceans (Moberg and Folke 1999). These habitats aid in shoreline protection by acting as a buffer against storm surges to protect against loss of life, property damage, and coastal erosion (NOAA 2008, Shah 2013). Lastly, many tourists visit the USVI because of the opportunities for recreation (diving and snorkeling) on the coral reefs.

Threats

Coral reefs in the USVI are considered degraded. Throughout the Caribbean, reefs have declined by approximately 80% over the last 30 years (Wilkinson 2004), and locally coral reefs have been steadily declining since before 2001 (Rothenberg et. al. 2008). Many reefs that had coverage of living stony coral greater than 50% in the 1970's only support a fraction of this today (Jackson et al. 2014). There have been severe declines in the major reef building coral species such as *Acropora palmata*, *Acropora cervicornis*, *Orbicella annularis*, and *Orbicella faveolata* (Wilkinson 2004, Smith et al. 2013). Along with coral decline, benthic macroalgae have increased (Jackson et al. 2014, Smith et al. 2016). These plants can compete with coral for space, inhibiting coral recovery after disturbance. In the USVI, shallow and nearshore reefs are the most disturbed, with increasing coral cover on reefs deeper and farther offshore (Smith et al. 2008). Fish communities on the offshore deeper reefs also show the highest abundances of large commercially important species (Kadison et al. 2006, Smith et al. 2016).

The main causes of coral reef degradation are believed to be from global factors, such as increasing sea surface temperatures, and local factors, such as overfishing of ecologically important species and increasing deposition of sediments and pollutants from land-based activities (Jackson et al. 2014). Global stressors include natural factors, such as hurricanes, and anthropogenically influenced factors, such as ocean acidification, sea level rise, and increasing ocean temperatures. Hurricanes are one of the most important natural stressors acting on the USVI reef ecosystems (Heron et al. 2008). Acute coral declines caused by the sheer power of hurricane waves are counteracted by the resilience of unstressed reefs systems within a few years. However, this resilience is lost with the influence of other global and local stressors. In general, when natural and anthropogenic pressure act together, these threats can accelerate damage to the reef system and slow recovery rates (Beets and Rogers 2000, Nemeth and Nowlis 2001, Catanzaro et al. 2002).

Climate change is producing a measurable impact on coral reef systems of the USVI. The 2005 bleaching event was caused by warm water that affected the northeastern Caribbean (Hoegh-Guldberg et al. 2007, Eakin et al. 2010) causing a 50-60% decline in USVI coral cover over 6 months (Miller et al. 2009, Smith et al. 2013) and was linked to human-induced climate change (Donner et al. 2007). Corals are sensitive to high temperatures even slightly above what they normally experience (Baker et al. 2008). This stress can cause a breakdown of the symbioses between the coral animal and its algal intracellular symbiont. The brown colored algae are lost and the white skeleton of the coral is seen beneath clear coral tissue. Without their algae, corals can rapidly die through starvation. This is currently among the direst stresses affecting coral reefs globally and given its link to human greenhouse gas emissions, more thermal stress events are on the horizon for USVI reefs.

Also linked to human changes to the atmosphere is ocean acidification. Marine waters are basic and this allows the precipitation of calcium carbonate (limestone) that is critical to forming the skeletons of marine organisms, such as corals, snails, and many others. Absorption of carbon dioxide from human emissions into surface ocean waters causes waters to become more acidic, slowing the process by which marine organisms make their skeletons (Feely et al. 2009, Veron et al. 2009). The Caribbean Sea is already seeing a steady increase in the acidity of seawater (Gledhill et al. 2008), with future impacts on corals and their ability to form reefs.

Overfishing removes ecologically important fish species, including key herbivore species that limit the abundance of benthic algae that compete with corals for space (Hodgson 1999). While reef fish are popular as food in the Virgin Islands and form part of the culture and economy, there are impacts from disruption of coral reef food webs. Fish populations in the USVI have declined markedly from historical baselines (Beets and Rogers 1990, Jackson et al. 2014). In some cases, the consequences of overfishing are known, such as removal of herbivorous parrotfish leading to increases in macroalgae and competition with stony corals (Mumby et al. 2006). In other cases, there are ecological surprises that also limit the functioning of coral reefs (McClanahan 2000). Extraction of fisheries species from coral reefs needs to be carefully managed to maintain populations that are able to perform their important ecological roles.

Invasive species are considered a major threat to coral reef health. The Indo-Pacific Lionfish, *Pterois* spp., was first encountered in St. Croix in 2009, and has since spread exponentially to occupy all coral reef habitats to depths beyond 100 m (Smith et al. 2016). Lionfish are voracious predators that can decimate populations of reef fishes by consuming small adults and juveniles (Côté et al. 2013). They have no natural predators in the Caribbean, which limits natural control. Directed culling and fishing have had some impact on lionfish populations in the USVI, but mostly in shallow water where the fish can be targeted (Smith et al. 2016). Lionfish are still extremely abundant on deep mesophotic reefs in the USVI. Another invasive species of unknown origin is an encrusting red alga *Ramicrusta* spp. that has been rapidly spreading in the USVI (Smith et al.

2016). The algae is able to directly overgrow corals and kill living coral tissue. In some monitoring sites, the algae now occupies 60% of the substrate and seems to prefer turbulent shallow waters, imperiling already threatened populations of elkhorn and staghorn corals.

Nearshore coral reefs of the USVI are also threatened with increasing levels of sediments and pollutants released from human development on the steep hillsides of the USVI (Rothenberger et al. 2008, Smith et al. 2008). The largest source of terrestrial sediments delivered to the marine environment come from road building and unpaved roads (Ramos-Scharrón and McDonald 2007). These fine silt and clay sediments are detrimental to exposed coral reefs through smothering, enhanced microbial activity, and elevation of nutrients. Coral reefs show negative health in areas of the USVI exposed to terrestrial sediments (Smith et al. 2008, Ennis et al. 2016)**.**

On a more local scale, physical damage from human activities can harm coral reefs. Increased popularity in dive and snorkel tourism due to the aesthetic nature of coral reef ecosystems (Chadwick-Furman 1996, Hawkins et al. 1999, Barker and Roberts 2004, Uyarra et al. 2009, Lyons et al., 2015) can cause direct harm to corals by diver breakage (Graham and Nash 2013), or via other means such as chemical contamination from sunscreen (Danovaro 2008). In addition, shoreline recreation activities can contribute to excessive marine debris (Rothenberger et al. 2008).

Coral disease has the ability to amplify the negative impacts of other stressors. Coral diseases affect many coral species in the USVI (Calnan et al. 2008) and some can be transmitted from colony to colony through the water (Clemens and Brandt 2015). Corals are also more susceptible to disease when impacted by other stressors, such as coral bleaching (Muller et al. 2008, Brandt and McManus 2009). Weakened corals can act as sites of initiation of some disease whose negative impacts are then multiplied by transmission from colony to colony. Prevention is best accomplished through prevention of coral stress that increases coral susceptibility to disease initiation.

Research and Management

In the USVI, the Department of the Interior, Department of Commerce and the Virgin Islands territorial government all have jurisdiction over the submerged land. At the highest level of management action seven coral species were listed as threatened under the U.S. Endangered Species Act (NOAA 2014). These include the elkhorn coral (*Acropora palmata*), the staghorn coral (*Acropora cervicornis*), the star corals (*Orbicella annularis*, *Orbicella faveolata*, *Orbicella franksi*), the pillar coral (*Dendrogyra cylindrus*) and the rough cactus coral (*Mycetophyllia ferox*). Each of these species is common to hyper-abundant in the USVI. The removal and/or harm of these critical species can result in fines and potential jail sentences. Under the local VI-code Title 12 Chapter 21 section 906 (B7), all corals including black corals are protected and require special permitting to collect. These laws protect coral species individually, however more management has been developed to protect coral reefs as an ecosystem.

In order to better conserve the state of these species and enforce jurisdiction by the federal and state departments, marine protected areas (MPA) and reserves have been established. MPAs limit human based activities to prevent physical destruction and provide a refuge for diversity to reduce potential algal competition (McLeod et al 2009). There are now over 30 MPAs in the USVI, under a variety of management entities and with a range of objectives that focus on managing human use (Pittman et al. 2014). Protected areas such as the St. Thomas East End Reserves (STEER), St. Croix East End Marine Park (EEMP), Virgin Islands Coral Reef National Monument, Virgin Islands National Park, and Buck Island Reef National Monument have shown a reduction in reef degradation, but no significant increase in fish biomass or coral cover (Pitman et al. 2014).

Coral monitoring programs are critical to determining if coral reefs are being impacted and which stressors, particularly those with local management potential, are the most important. The USVI has three major monitoring programs: The National Coral Reef Monitoring Program (NCRMP), the Territorial Coral Reef Monitoring Program (TCRMP), and the National Park Inventory and Monitoring Program (NPS I&M). The NCRMP was initiated in 2013 to comprehensively monitor U.S. coral reef resources in a way that is comparable between all jurisdictions. This program uses dozens of trained divers from federal and local agencies and the University of the Virgin Islands to assess the fish and coral populations on hard substrate habitats from the surface to 30m depth. This program is new and evolving, but will be one the best providers of fishery-independent information on fish populations in the USVI. The TCRMP was instituted in 2001 at selected sites across the USVI, and now encompasses 33 fixed locations from 5-65 meters depth. The TCRM has focused on the status of USVI coral reefs, changes in coral health in relation to specific stressors, understudied mesophotic reefs and threatened species, and the provision of data and advice to stakeholders. This program has significantly aided in identifying land-based sources of pollution, coral bleaching, and the status of fisheries in the USVI (Smith et al. 2016). The NPS I&M has monitoring programs at Buck Island National Park and Monument, Salt River National Monument, VI National Park, and the VI Coral Reef National Monument. This program has been in place since 1999 and monitors fixed sites for changes in coral condition.

Researchers in the USVI have collected some of the longest time-series data sets on coral reefs in the Caribbean, which date back decades (Catanzaro et al. 2002, Rothenberger et al. 2008, Jackson et al. 2014). Seminal coral reef research was conducted at the West Indies Laboratory on St. Croix (1969-1990), including many of the research topics that would occupy coral reefs research for the next few decades. Another important long-term research data set comes from Dr. Peter Edmunds, focused on the area of Lameshur Bay near UVI's Virgin Islands Ecological Resource Station (VIERS) on St. John. His research started in 1984 and is among the longest coral reef data sets in the world. The TCRMP is also major research program that forms the nexus for much of the coral reef research not conducted at UVI. Research is being done at Hurricane Hole, within Virgin Islands Coral Reef National Monument, to further investigate the remarkable diversity and abundance of corals that grow directly on and near the prop roots of red mangrove trees fringing the shorelines (Rogers 2016). Because of their sustained investigation and investments of the U.S. and local government, the coral reefs of the USVI are among the most important sites for coral reef research globally.

Accomplishments Since 2005

In addition to the research and monitoring detailed above, there are several programs designed to involve the community in coral reef conservation. TNC has established coral nurseries on St. Croix and St. Thomas to regenerate *A. cervicornis* and *A. palmata*, with over 1000 fragments outplanted by 2012, and is currently partnering with UVI to achieve outplanting goals. Reef Connect is a project that aims to build resiliency in coral reefs within the USVI through a multifaceted approach of reducing stressors. One component is the Reef Responsible Sustainable Seafood Initiative, a voluntary program designed to help create a sustainable seafood industry in the USVI, developed by TNC, NOAA's USVI Fisheries Liaison, The DFW, UVI, and St. Croix Reef Jam. Bleachwatch is citizen science program that trains community volunteers to recognize and document bleaching events.

UVI's VIMAS program runs a summer Youth Ocean Explorers, a 4 week, hands-on marine science program for middle to high school-aged students interested in studying coastal, marine and environmental science, natural resource management, and conservation. SEA holds a similar summer program for youth called the Coral Conservation Corps. St. Croix and St. Thomas hold popular Reef Fests annually that highlight the importance of local reef systems by providing interactive information on reef ecology. SEA holds free monthly snorkel clinics on St. Croix to teach the community to snorkel and thus better appreciate marine life. A key component is reminding attendees of their role in marine conservation.

Conservation Priorities

A coral reef management priorities plan has been instituted by NOAA (2010), through which goals for better management of coral reef habitats have been implemented. The top five priority goals are to 1) reduce impacts to coral reef ecosystems, 2) develop and implement a comprehensive education and outreach program, 3) increase the ability to effectively enforce existing rules, regulations and laws, 4) reduce fishing impacts on critical stocks, and 5) manage for resilience to climate change and related effects. These goals are described within the plan (https://www.coris.noaa.gov/activities/management_priorities/usvi_mngmnt_clr.pdf).

Some of these goals can be met by encouraging public involvement in reef protections through the use of "Reef safe" sunscreen and expansion of existing programs such as Reef Responsible and education opportunities. Enforcement of existing fishing regulations and implementation of a recreational fishing licensing program will reduce pressure on reefs from overfishing. The establishment of a lionfish fishery will not only increase revenue for local fishermen but also increase control of this problematic species.

Restoration Actions: Coral nurseries and outplantings have been shown to be beneficial towards coral restoration, and fish communities associated with outplantings show no difference between those at natural reef systems. Expansion of nurseries and outplanted areas is a valuable effort that can have an added benefit of increasing stewardship if the community is involved.

Protection Actions: Reef-building coral species are protected under the ESA, and critical habitat designations confer additional protection on these submerged areas. Enforcement of non-point source pollution and other erosional issues need to be enhanced. Eliminate boat discharge by establishing pump-out stations and install moorings to prevent anchor damage.

Acquisition Actions: Acquiring coral habitats is not applicable because submerged lands within three nautical miles of the shore belong to the VI Government, but acquisition of coastal lands and watersheds would ensure protection of reef habitats. The presence of reefs in coastal waters should be a priority factor in wetland acquisition decisions.

Education/Recreation Actions: Coral reefs are major tourism destinations for both snorkeling and diving, and the educational opportunities are limitless. Educational benefits could be enhanced by encouraging tour operators to provide information and become involved in coral restoration (i.e., outplanting) projects. Involving the community in Citizen Science projects that involve coral monitoring can be an effective way not only to generate data but also to foster awareness. Fact sheets and informational booklets should be prepared and disseminated to these user groups.

Post-hurricane needs: Many coral reefs were crushed by the hurricanes in 2017, leaving these systems vulnerable to impacts of disease and stressors from land-based sources of pollution and other human activities. Large amounts of sand from beaches was deposited on top of reefs, effectively choking them and beaches were covered with broken pieces of coral of all sizes. Coral monitoring post-hurricane has been initiated (M. Brandt, UVI, 2018), with particular emphasis on disease and macroalgae. Temporary removal of fishing pressure on herbivorous species would be beneficial towards increasing recovery and resilience of these systems.

Banner photo: R. Platenberg

Sargassum Mats

Habitat Description

Sargassum is a floating brown alga primarily comprised of two species: *Sargassum fluitans* and *S. natans*. It forms dense mats up to 3 meters deep in the open ocean, held to the water's surface by bladders filled with air. The seaweed is named after the Sargasso Sea, an approximately 5 million km^2 area of the North Atlantic between the Caribbean and the Azores. Characterized by calm, still waters, the Sargasso Sea is covered by giant mats of floating seaweed and other surface debris. Although itself calm, the sea is surrounded by major ocean currents, including the Gulf Stream, which transport these surface mats to other locations. While the giant seaweed mats were, up until recently, fairly rare in the Caribbean, they are a common feature of the Gulf of Mexico and off the U.S. South Atlantic Coast, where they attract large numbers of fish, including highly migratory species such as tuna and marlin, and are highly valued by the lucrative sportfishing industry. The floating mats in the Gulf of Mexico typically show a seasonal pattern of originating in the northwest Gulf of Mexico in the spring of each year and moving into the Atlantic (Gower and King 2011).

Sargassum has been included as a habitat type in the VI-WAP because of the value the natural system provides to larval fish, juvenile sea turtles, pelagic fish, seabirds, and host of other marine and coastal organisms. However, in recent years sargassum has shifted from a pelagic habitat towards a coastal nuisance. In 2011, the Caribbean saw its first major Sargassum influx (Schell et al. 2015). An unprecedented amount of seaweed accumulated in bays and on beaches throughout the Caribbean. The seaweed floated in and accumulated, forming piles up to five feet tall in some places. Bays and inlets were clogged with it, and as it decomposed it gave off noxious hydrogen sulfide fumes. Marinas and resorts were left struggling with how to deal with the problem of choked waterways and unsightly and smelly debris on beaches.

Organisms associated with the seaweed became trapped as the seaweed piled up, including hatchling sea turtles, as the mounds obstructed the hatchlings' access to the sea from nest sites and may alter thermal conditions if mounded over existing nests (Maurer et al 2015). Other organisms trapped in or attracted to the mounds fell victim to management that involved removal of the piles to the landfill. A particularly severe sargassum bloom in 2015 resulted in a shift in nesting by sea turtles. A large mat of sargassum formed along the south shore of St. Croix causing some key sea turtle nesting beaches to be unusable (Valiulis 2015). Other Caribbean islands reported high mortality of turtles that attempted to nest or that were feeding in nearshore water and became tangled in the sargassum mats.

St. Croix's Great Pond, a diversity hotspot for wildlife, has been profoundly altered by the accumulations of sargassum at the mouth of the pond. The exchange of water between the pond and the sea was important in maintaining water and salinity levels and served as a corridor for juvenile fish that relied on the pond as a refuge. When this corridor was blocked, the pond became hypersaline, killing many of the fish and invertebrates that lived in the pond and may have contributed, along with drought and disease, to mortality of the mangrove trees surrounding the pond (J. Farchette III, pers. comm. 2017). DPNR is currently looking into management solutions for Great Pond.

In 2011, no one could remember a time when this had happened before; now this is an annual event. It was at first thought that the trails of sargassum were coming from the Sargasso Sea, but satellite imagery confirmed that the Caribbean sargassum originates from the southern Atlantic near the mouth of the Amazon, signaling a major shift in distribution (Gower et al. 2013). These "blooms" may be attributed to higher sea surface temperatures and high nutrient levels in water.

Ecological Value

These mats are areas of high primary productivity and are the equivalent of nearshore seagrass beds and coral reefs, offering a floating habitat in an otherwise largely uninhabitable environment. The floating mats provide food and shelter for many oceanic organisms that would not otherwise be able to inhabit the open ocean: juvenile fish and sea turtles that float with the mats until they reach a size where they are safe from predators, crabs and other invertebrates that nestle among the seaweed and feed off the detritus the mats collect, specialized fish that have evolved to resemble their seaweed home, and large migratory fish, like tuna and marlin, that are attracted to the teeming mass of life associated with the sargassum mats.

The seaweed that accumulates on beaches provides important habitat for beach and intertidal invertebrates, and for the organisms that eat them, such as seagulls and shorebirds. Beach wrack offers an important invertebrate food source for *Ameiva polops* lizards on St. Croix's offshore cays. Built-up seaweed berms reduce beach erosion and provide structure and nutrients for dune plants. The organic matter is eventually covered in sand and decomposes, providing an important source of nutrient input into relatively nutrient-poor systems.

Sargassum also plays a large role in carbon sequestration and is of major importance for global scientific research and monitoring (Laffoley et al. 2011). Seaweeds bioaccumulate contaminants such as heavy metal and make effective indicators for pollutant levels (although it is difficult to know where the contaminants came from).

Threats

The sargassum that originates from the southern Atlantic appears to be a different morphological form that potentially offers a reduced ecological benefit to pelagic organisms due to lack of complexity (Schell et al. 2015). This form has been dubbed *S. natans* VIII, and may represent a different taxonomic unit when the genetic phylogeny has been examined. There is a concern that this form may be overtaking the more morphologically complex forms, which could have serious implications for the value of these floating habitats for zooplankton and other small organisms that rely on this habitat complexity.

Sargassum is at the mercy of currents, which also carry floating marine debris and other pollutants. It’s not unusual to see trash trapped in the floating mats or piles on beaches. The debris causes a direct threat to organisms feeding within the sargassum, which then can pass on ingested contaminants up the food chain.

Research and Management

Sargassum mats have a unique color profile that can be monitored remotely via satellite imagery, and efforts are underway to develop predictive tools for its movement. Medium Resolution Imaging Spectrometer (MERIS), developed by the European Space Agency, can be used to track sargassum (and chlorophyll a, a proxy for eutrophication; Beltrán-Abaunza et al. 2017) using specific color bands in satellite imagery. The Sargassum Early Advisory System (SEAS; http://seas-forecast.com/) is a tool that is being developed to predict sargassum landfall for coastal managers across the Gulf Coast and locations in the Caribbean, including Puerto Rico, to target management response effort (Webster and Linton 2013). Other tracking and prediction efforts include the Optical Oceanography Lab (http://optics.marine.usf.edu) that has been tracking sargassum since 2010 using satellite imagery and numerical models. Within the USVI, the Sargassum Seaweed Taskforce is charged with developing and implementing response plans for inundations.

Accomplishments Since 2005

The influx of sargassum is a new phenomenon and was not identified in the 2005 CWCS or Marine Plan.

Priorities for Conservation Actions

The main priority for sargassum within the USVI is to continue to develop a response protocol for large inundations that will not adversely affect organisms trapped within the mats and piles, particularly hatchling sea turtles.

Contributor (2017): RJP

Banner photo: South Atlantic Fish Management Council

Chapter Two

Wildlife Species of the U.S. Virgin Islands

Caribbean islands exhibit high levels of unique biodiversity resulting from a long history of species colonizations and adaptations to geographically isolated conditions. The U.S. Virgin Islands host unique assemblages of unique terrestrial species, many of which are endemic to these islands. The suites of species found on St. John and St. Thomas are similar both to each other and to neighboring Puerto Rico due to their proximity and shared geological history. St. Croix's distance from other islands and lack of connection to the Puerto Rican Bank has given rise to endemic species unique only to St. Croix.

The range of terrestrial habitats offer niches for a variety of reptiles, amphibians, bats, and resident land and waterbirds, and the islands are important stopping off sites, both as a destination and for short refueling visits, for summer and winter migratory birds. Cays offer refuges for ground-nesting birds while coastal saline wetlands and guts provide critical food resources.

The rich variation and connectivity within marine habitats, including coral reefs, mangroves, and seagrasses, offer habitat niches for an enormous variety of marine organisms, including fish, corals, molluscs, echinoderms, and others--too many to include in this document.

The variation between islands also means that species that are common on one island may be absent or in decline on other islands. White-crowned pigeons (*Patagioenas leucocephala*) are well-represented within St. Croix's mangrove and coastal woodland habitats, but absent on St. Thomas and St. John, while clapper rails (*Rallus crepitans*) are often observed at salt ponds on St. John, but are considered extirpated on St. Croix. Likewise, most seabirds take advantage of the habitat mosaics offered by St. Thomas/St. John cays, while least terns (*Sternula antillarum*) prefer St. Croix's expansive beaches and salt flats.

These distributional variations make territory-wide status assessments challenging. Additionally, geographic isolation combined with human-mediated species transport make it difficult to unravel biogeographic patterns. For example, genetic studies support the introduction of the frog *Eleutherodactylus antillensis* to St Croix from the Puerto Rican bank, but the origins and native distribution of the VI endemic *Eleutherodactylus lentus* are uncertain. The Puerto Rican Ground

Lizard (*Pholidoscelis exsul*) is native to St. Thomas and St. John but is introduced and invasive on St. Croix, thereby compounding territorial management objectives for this species. Localized threats may have significant impacts on isolated populations that potentially represent a significant portion of a species distribution within the region, but without consistent survey and monitoring effort across all islands, these differences are difficult to detect.

The focus of limited research and monitoring resources are distributed differently on each island, based on species distributions and personnel expertise. Seabird monitoring and habitat management have concentrated seabird funding toward St. Thomas, while those activities on St. Croix are concentrated on sea turtles, leaving the St. Thomas and St. John populations under-studied.

Terrestrial and marine species in the Caribbean have experienced high levels of population declines and extinctions due to habitat conversion and degradation, encroachment, and invasive species, coupled with stochastic events such as hurricanes and other disturbances. Many native mammals, such as the solenodons, were early extinctions, followed closely by ground dwelling or ground nesting reptiles and birds. Corals and other marine organisms are increasingly affected by rising ocean acidification and sea surface temperatures, and increasingly severe hurricanes, precipitation events, and droughts create unprecedented impacts to both marine and terrestrial species.

A comprehensive review of available publications and reports was conducted for these species accounts, although there is considerable information that has not been published or that only exists in reports that are not widely available; this information is included here to increase access. However, many species are poorly understood, such as marine and terrestrial invertebrates, and the paucity of information is reflected in the lack of coverage in this document.

Banner photo: Dermochelys coriacea by J. Valiulis

2.1 Freshwater Fauna

Despite being relatively rare habitats in the USVI, freshwater pools and streams in riparian corridors ("guts") contain an array of species, primarily decapods (shrimp and crabs) and catadromous fish. Insect fauna is poor, with only a few beetles (Coleoptera) and water striders (Hemiptera) apparent on or in the pools, with the occasional dragonfly (Odonata) nearby.

Within the freshwater stream systems in the USVI, there are three genera of shrimp from the families Palaemonidae (*Macrobrachium*) and Atyidae (*Atya* and *Xiphocaris*), comprising a total of five species (Nemeth and Platenberg 2007). Fish include Sirajo Goby (*Sicydium plumieri*), Mountain Mullet (*Agonostoma monticola*), Smallscaled Spinycheek Sleeper (Eleotris perniger). Catadromous American Eels (*Anguilla rostrata*) also occasionally occur in these systems, and brackish pools behind beach berms often hold an array of marine fish. Guppies (*Poecilia reticulata*) and other non-native fish are found in more impacted guts, where they have presumably been released. Tilapia (*Oreochromis* sp.) are African natives that have become widespread throughout the Caribbean where introduced for aquaculture; they are restricted to the freshwater ponds and streams with permanent flow (e.g. Turpentine Run, St. Thomas), where introduced. Various crab species are also associated with guts, but aside from Soldier (hermit) Crabs (*Coenobita clypeatus*), which are ubiquitous in guts (and most other terrestrial habitats), observations of crabs or signs of their presence are rare and possibly substrate-limited.

Many of these species are amphidromous and require connectivity between saltwater and freshwater habitats to complete their life cycles (Loftis 2003). All species of shrimp undergo migratory larval development. In Puerto Rico, it is known that adult females release planktonic larvae that drift downstream to the estuary, where they spend 2-4 months before migrating back upstream as metamorphosed post-larvae (March et al. 1998). In the USVI, however, the connection between freshwater guts and the marine environment is rarely achieved, and then only during heavy persistent rainfall that breaks through a sandy beach berm. These events may not happen on an annual cycle, and it is possible that these species in the VI are able to complete their life cycle within the closed gut system. Guts may also receive an in-migration of juvenile fish when connected to the seas, but without permanent pools the fish are unable to persist (Loftis 2003).

The reproductive strategy of the fish is also poorly understood. It is believed that the Mountain Mullet is also migratory, but researchers disagree as to whether they spawn in freshwater or the sea, and some researchers suggest the possibility of mixed strategies (NatureServe 2013). Loftis (2003) observed a strong response by mountain mullet to rainfall events, and suggests that freshwater input to gut pools is critical for the survival of these fish. Again, it may be possible for these species to undergo a complete reproductive cycle within the gut system if sufficient water is available.

Soldier crabs migrate to and from the sea in July or August to release eggs, and can travel several miles, often from very high elevations and often using guts as corridors. The presence of many thousands of these crabs in the guts in the summer months almost certainly has an influence on the amount of organic debris remaining in the system. Other crab species also migrate to the sea to release eggs but are not frequently observed in guts.

Shrimp are likely the dominant macroconsumers in these waterways, and can reach high densities. They play an important role in structuring stream communities. Atyid shrimp reduce sediment and algae cover in the guts, and alter insect and algal community composition (March et al 1998). *Macrobrachium* spp. are the top predators, and also affect the benthic community composition. Exclusion of shrimp in sites in Puerto Rico has resulted in a greater accrual of organic and inorganic material, Chlorophyll a (an indicator of primary productivity and water quality), and algae, with the algal community dominated by filamentous green algae (March et al. 2002), indicating that shrimp play an important role in nutrient cycling and maintaining water quality. Mountain mullet also contribute in this service, these generalist feeders consume mainly filamentous algae and aquatic insects, as well as detritus, snails, plant material, and small fishes (NatureServe 2013).

Ecological Value

Freshwater organisms, particularly shrimp, play an important role in maintaining water quality of freshwater systems by filtering suspended sediment and consuming algae. They are an important food source for bats and birds.

Threats

High nutrients and runoff from urbanization combined with potentially increasing water temperature from climate change are leading drivers of potential declines in macroinvertebrates and fish in guts (Mantyka-Pringle et al 2014). Non-point source pollution or the introduction of other contaminants may reduce the habitability of streams for certain native species, and streams with the greatest level of development have been found to have fewer fish and shrimp species (Nemeth and Platenberg 2007). Trash and leachate washing into guts from dumpster sites is a significant source of pollution. Even guts that are relatively undisturbed have trash in them, and many guts still have roofing material deposited by hurricanes.

Man-made or geomorphic barriers are also drivers of species distribution and persistence in guts. Freshwater fish and shrimp that inhabit these systems must ascend the channels from the sea as post-larvae or juveniles and impediments to access can affect the populations of those species

(Loftis 2003). Additionally, reduction in water flow from diversion of water from streams into ponds has effectively eliminated water in affected guts, also eliminating the freshwater fauna (Platenberg 2017). Rainfall collection into cisterns likely exacerbates this problem. Many guts on private properties are converted to swales through removal of gallery forested vegetation on private lands, often resulting in grassy ditches rather than functional stream channels.

Research and Management

Very little attention has been paid to freshwater fauna in the USVI. Loftis (2003) conducted surveys of fish in coastal ponds and streams on St. John as part of the NPS Inventory & Monitoring program, and fish and shrimp were evaluated as potential indicators of habitat integrity (Nemeth and Platenberg 2007). A study evaluating faunal distribution based on an altitudinal gradient identified physical barriers as having a major influence on species distributions (K. Tennant, UVI MMES unpublished thesis data). Freshwater species were included in an inventory of invertebrates of St. John (Muchmore 1993). Water flow in gut systems has been monitored by the USGS and various studies have been conducted on sediment transport (Ramos-Scharrón and MacDonald 2007, Benoit and Nemeth 2011). There is a large body of work on macroinvertebrates in Puerto Rican streams (e.g., Covich et al. 1996, Pringle 1996, March et al. 1998, Crowl et al. 2001, March et al. 2002, March and Pringle 2003 Mantyka-Pringle et al. 2014).

Vegetation in guts is protected under the VI Code (Title 12, Ch3), which prohibits clearing and removal of vegetation within a limited buffer zone.

Accomplishments since 2005

Priority actions identified in the 2005 CWCS focused on inventory of invertebrates. While yet incomplete, several studies have contributed to the understanding of species occurrence and distribution in freshwater systems (Loftis 2003, Platenberg 2006, Nemeth and Platenberg 2007, K. Tennant, MMES unpublished thesis data 2016). An assessment of great land crab reproduction, habitat use, and harvest pressure was conducted by DFW to identify harvest parameters for development of regulations (Gordon 2011).

Conservation Priorities

All species of freshwater shrimp and fish in the USVI are data deficient. There is a good body of research on these taxa from Puerto Rico (e.g. March et al. 2002), where there is more permanent water flow and estuarine systems than in the VI. In particular, reproductive cycles and migration requirements are poorly understood, yet are critical for persistence of these species. These parameters should be the focus of continued research.

Freshwater fauna rely on a permanent source of clean freshwater and occasional access to the sea for reproduction. Reducing contaminants in guts by removing dumpster sites from roads or installing measures to prevent trash and contaminants entering watercourses from dumpsters will help reduce solid waste and leachate entering the stream channels. A number of actions can be applied towards reducing other sources of sediment and contamination into guts, 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.

The ecological function has been eliminated for many gut channels due to diversion of water or removal of vegetation. Replanting native riparian trees is important toward restoring function, buffering the habitat from encroachment, and mitigating negative effects of climate change. This could be accomplished in some areas through a community project supported by various grant schemes. Connectivity throughout the guts systems should be reestablished where there are barriers, such as roads or dams, to allow migration; installation of ladders or ramps can facilitate species movement. Water flow should be reestablished at water diversion sites.

Targeting educational outreach to landowners about the value of guts and gallery vegetation communities may increase stewardship on private lands, particularly in association with a financial incentive for restoration. Protection for these systems through permitting and enforcement needs to be a priority for DPNR.

Guts are considered jurisdictional wetlands, and a recent legal review established the precedent that access to guts on private lands by VIG personnel should not be considered trespass (W.T. White, Jr. and T.T Ankersen, unpublished legal brief, 2014). Therefore, access should not be an impediment to conducting studies in these gut systems.

Post-hurricane needs: The wetland systems were inundated with freshwater runoff after the 2017 hurricanes, which brought prolonged periods of sustained moisture. The guts were scoured by rapid water flow and many of the stream channel inhabitants were flushed out to sea. The extended rainfall allowed a persistent connection to the marine environment and within several months post-hurricane fish and shrimp had repopulated these systems. A lingering impact of the storms is an increase in nutrient input from decaying vegetation. Monitoring species presence, distribution, and abundance in these systems is important in understanding ecosystem recovery and resilience.

Species of Greatest Conservation Need

Common Name	Scientific Name	Status
American Eel	*Anguilla rostrata*	High Risk
Freshwater Crab	*Epilobocera sinuatifrons*	Data Deficient – At Risk
Terrestrial Crab	*Gecarcinus ruricola*	Data Deficient - At Risk
Thin-fingered Fiddler Crab	*Leptuca leptodactyla*	Low Risk
Blue Land Crab	*Cardisoma guanhumi*	Low Risk

Species Accounts

Fish

American Eels (*Anguilla rostrata*; Anguillidae) are present in guts with permanent pools in the USVI, although rarely observed. Young eels drift with ocean currents before migrating inland into streams, where they mature over decades before migrating back out to sea to reproduce. Small eels are extremely mobile and are apparently able to pass over vertical barriers, thereby accessing habitats that appear unavailable to them. Larger eels, however, are impeded by barriers. American eels are data deficient in the USVI but are identified as globally endangered as adults in their spawning ground under the IUCN Red List. Their main threats are barriers to dispersal and impacts from climate change, and their complex life cycle is a contributing factor that exposes them to multiple risks (Jacoby et al. 2014).

The **Sirajo Goby** (*Sicydium plumieri*) reaches a maximum total length of 7.5-10 cm, but the maximum size collected during a recent study was less than 5cm. Males in breeding coloration are iridescent blue, otherwise individuals are light gray in color. The pelvic fins are fused into a modified suction cup in the characteristic gobiid form, to assist the fish in holding its position on the benthos in flowing water. The Sirajo goby grazes on benthic algae. It is an amphidromous species, with a marine larval phase. The **Mountain Mullet** (*Agonostoma monticola*), another amphidromous species, can reach a total length of 21 cm. Mountain mullet are omnivorous, and in captivity are observed to consume guppies and juvenile shrimp (Nemeth and Platenberg 2007). Guppies (*Poecilia reticulata*) are native to Trinidad, but are common on many Caribbean islands where they were likely introduced for mosquito control.

Crabs

Freshwater Crabs (*Epilobocera sinuatifrons*; Pseudothelphusidae) are potentially present in USVI guts but have not been adequately documented. They are highly abundant on Puerto Rico in rivers and streams, and a limiting factor may be presence of cave habitats and availability of freshwater systems (Cumberlidge 2008). They exhibit measurable habitat niche changes in response to land use influences (Zimmerman and Covich 2003). They show genetic population structure that is intermediate to fully terrestrial species with no interactions and amphidromous species with highly connected populations (Cook et al 2008). They are data deficient in the VI and their rarity may reflect their limited dispersal ability rather than population declines.

Great Land Crabs (*Cardisoma guanhumi*; Gecarcinidae) are semi-terrestrial and commonly inhabit burrows in sandy or muddy substrate in coastal areas and mangrove wetlands. These are occasionally encountered in guts where water in pools is deep enough to for them to completely submerge themselves. Studies in the USVI indicate that spawning occurs from late May to end October, with peaks in July (Gordon 2011). This species is commonly harvested for food, especially during festivals.

Black Land Crabs (*Gecarcinus ruricola*; Gecarcinidae) are terrestrial and often encountered in forested habitats, although occasionally observed in or near guts. They are data deficient in the VI where their distribution and abundance is unknown. Studies of this crab elsewhere suggest populations are sensitive to environmental degradation and overharvest (Hartnoll et al. 2006).

Shrimp

Macrobrachium carcinus (Family Palaemonidae) are large predatory shrimp that are active at night and predominantly hide under rocks during the day. Rarely is more than one individual found in a stream channel pool, indicating that they are territorial and aggressive. During daytime surveys, often the only evidence that they are present is a freshly molted exoskeleton, although sometimes dead individuals are found. *M. carcinus* can reach a postorbital carapace length of more than 90mm, making it the largest shrimp species found locally. The smaller ***M. faustinum*** is more frequently encountered, often moving around in pools both day and night. *M. faustinum* reaches a maximum postorbital carapace length of about 18 mm.

Atya* spp**. (Atyidae) is distinguished from other St. Thomas shrimps by having the chelae of first and second pereiopods with tufts of long hairs, used in filter-feeding or for ‘mopping’ the substrate for organic particles. *A. lanipes* has a maximum postorbital carapace length of 28mm, while *A. innocous* has a maximum postorbital carapace length of 34 mm. ***Xiphocaris elongata (Xiphocarididae) is a small, slender shrimp often visible swimming in midwater. Maximum size is about 15 mm postorbital carapace length.

Contributor (2017): RJP

Banner photo: *Macrobrachium* spp. by R. Platenberg

2.2 Amphibians

The USVI has four native amphibians belonging to two families, the Rain Frogs and the Ditch Frogs. All species occur on St. Thomas and St. John (*Eleutherdactylus antillensis*, *E. cochranae*, *E. lentus*, and *Leptodactylus albilabris*), with three occurring on St. Croix (*E. antillensis, E. lentus*, and *L. albilabris*). An additional endemic, *Eleutherodactylus schwartzi*, is believed to be extirpated (see below). There are also three non-native amphibians that are found on all three islands (*Rhinella marina, Osteopilus septentrionalis*, and *Eleutherodactylus coqui*).

The "Rain Frogs" (Eleutherodactylidae) are typically arboreal and are highly dependent on seasonal precipitation. The start of their annual period of activity, as defined by the calling activity by males, is triggered by the first sustained rainfall in the early summer, and they continue to vocalize throughout the moist summer and wet autumn. Calling activity ceases during the dry spring, typically from January until mid-May. *Eleutherodactylus antillensis* and *E. cochranae* show a bimodal activity pattern during the active season (May through December), calling for several hours in the early evening and again just before dawn. *E. coqui* also shows this pattern, although this species can be heard chorusing throughout the year except during very dry periods (Platenberg 2011). The terrestrial *E. lentus* uses the relatively quiet period between the peak nightly chorusing of the other species for its vocalizing and calls are emitted sporadically (R. Platenberg, unpublished data). The "Ditch Frogs" (Leptodactylidae, represented in the territory by *L. albilabris*) are terrestrial rather than arboreal, and can be active throughout the year during moist periods; this species calls throughout the day and night, more intensely just after dusk, during wet weather or where shallow standing water persists. Although the choruses of all the frogs together can be deafening, each species has distinctive call characteristics that allow accurate identification.

Native frogs in the USVI are adapted to mesic conditions that tend to lack reliable sources of standing water. The Eleutherodactylids are all direct developers: they produce a small clutch of eggs that are guarded and kept moist by a parent while the tadpoles develop inside the egg, with tiny froglets emerging directly from the egg (Townsend 1989, Townsend and Stewart 1994). Conversely, *L. albilabris* breeding adults typically lay a small number of eggs in a foam nest in a crevice; tadpoles remain in the foam until washed into a waterbody that can be as small as a tire rut puddle (Dent 1956).

Ecological Value

Amphibians play an important role in pest control. They eat an enormous amount of insects, with estimates of a single species consuming up to 114,000 invertebrates per ha per night (Stewart and Woolbright 1996). Control of insect populations affects plant growth (through reduction in herbivory) and nutrient cycling (Sin et al. 2008). Frogs are also an important food resource for birds and snakes, although they also provide a food resource for invasive non-native mammals that pose a threat to all wildlife species (Beard and Pitt 2005).

Threats

Threats to amphibian populations in the USVI include habitat loss, alteration, and fragmentation and predation and competition from introduced species. Amphibians are likely preyed upon by the introduced Small Indian Mongoose (*Herpestes auropunctatus*), rats (*Rattus rattus*), and cats (*Felis cattus*). Henderson (1992) discusses the impact of predators and habitat destruction on West Indian amphibians. The impacts of habitat alteration from exotic plants are unknown. Introduced diseases are also a potential problem in addition to the unknown impacts from climate change.

The Cane Toad (*Rhinella marina*) and Cuban Treefrog (*Osteopilus septentrionalis*) have become established in the USVI (Owen and Perry 2005, Waddle et al. 2005, Platenberg 2007), and are implicated in the decline of native frogs, through direct predation (Platenberg 2012) or by competition with tadpoles (in the case of *L. albilabris* only; Smith 2005). The Puerto Rican Coquí (*E. coqui*) was relatively recently introduced, probably through transport in horticultural plants (Platenberg 2007). This frog likely has a disproportionate impact on native frogs through niche overlap and the potential to introduce the infectious chytrid fungus.

Globally, amphibian populations are declining at an alarming rate. Infection from the chytrid fungus (*Batrachochytrium dendrobatidis, Bd*) is a significant cause of these global declines. The fungus has been detected in the Caribbean, where it has caused significant amphibian declines in Puerto Rico (Burrowes et al. 2004, Malhotra et al. 2007) and contributed to the rapid near extinction of the "Mountain Chicken" (*Leptodactylus fallax*) in Dominica and Montserrat (Hudson et al. 2016). *Bd* has also been documented in Hawaii from coqui frogs introduced from Puerto Rico (Beard and O'Neall 2005) that have also been introduced to the USVI. While the fungus tends to be associated with higher elevations and/or cooler temperatures than those found in the USVI, the proximity to Puerto Rico and the presence of a known pathogen vector (*E. coqui*) indicated a need to test frogs in the USVI for the presence of the fungus. Testing in 2011 and 2012 revealed the presence of fungal spores within the Eleutherodactylid frogs in on St. Thomas (Platenberg 2012). Testing has not been conducted on St. John or St. Croix. This is a cause for concern, as studies on Puerto Rico have shown mortality leading to significant declines with *Bd* present in amphibian populations without showing widespread effects (Longo et al. 2013).

The USVI has been experiencing changing weather patterns that are difficult to predict year to year and may be indicative of climate change. In 2014 and 2015, the region experienced a longer than usual seasonal dry period, with the early summer rains not occurring until the end of summer, and the frogs remained inactive throughout that time until the onset of the fall rains (R. Platenberg, pers. obs.). Recent years, however, have been moister, and amphibian monitoring since 2008 has detected changes in species distributions, abundance, and communities (Platenberg 2012). Climate predictions for the Caribbean region are for a slightly moister climate, with more intense rainfall events, and rainfall during typically dry periods (Khalyani et al. 2016). Moister conditions provide ideal conditions for both *E. coqui* (non-native invasive) and *L. albilabris* (native habitat specialist), and the expansion of both of these species in recent years has been detected (Platenberg 2012). Increased populations of *E. coqui* increase competition with *E. antillensis* and *E. cochranae*, resulting in shifts in microhabitat use and potentially driving the latter species to localized extirpation. More rainfall events can result in extended breeding seasons for all amphibian species, thereby causing a general increase in populations. Drier periods between rainfall events may also suppress breeding and make it harder for amphibians to locate water. In this case, *O. septentrionalis* will do well because this species is extremely effective at conserving water.

Research and Management

The amphibians of the USVI have been inventoried on the major islands (Schmidt 1928, Grant 1937, Grant and Beatty 1944, Underwood 1962, Schwartz and Thomas 1975, Philibosian and Yntema 1976, 1977, 1978, MacLean et al. 1977, Schwartz et al. 1978, Heatwole et al. 1981; MacLean 1982, Mayer and Lazell 1988; Schwartz and Henderson 1991, Rice et al. 2004, Platenberg 2011). Phylogeographic relationships within family groupings has been conducted for *Eleutherodactylus* (Hedges 1989, Joglar 1989, Velo-Antón et al. 2007, Barker et al. 2012). DFW initiated a herpetofauna conservation program to study and monitor amphibian populations (see next section). A Citizen Science project to survey frogs across the VI (including the BVI) is being developed at UVI (Platenberg et al. 2016).

Accomplishments since 2005

Amphibian monitoring

Frogs are informative ecosystem indicators because they are extremely susceptible to the effects of habitat loss and fragmentation, contaminants, diseases, and climate change. VI frogs are ideal subjects for monitoring as they exhibit extended breeding seasons, typically from early summer until Dec/Jan, and produce extremely loud advertisement calls to attract females over great distances; these methods have also been effective in Puerto Rico (Fogarty and Vilella 2001). This makes them particularly suitable for monitoring using aural surveys along road transects because the frogs are widespread, not restricted to a single habitat, and their calls can be heard from a distance and distinguished between species (Platenberg 2011). The aural survey method is not effective for detecting *Osteopilus septentrionalis* or *Rhinella marina*; these tend to call only during rainy periods and then only sporadically. There is no effective method for detecting *E. lentus*; this species can be observed on the ground at night during damp weather or under rocks in damp areas during the day, but encounters are rare. Surveys conducted in the spring and summer do not accurately capture presence: frogs may be inactive rather than not present.

DFW established frog monitoring protocols for all three islands, based on road-driving surveys used by the North American Amphibian Monitoring Program (USGS; www.pwrc.usgs.gov/naamp/). Survey routes allowed sampling at a range of habitats and elevations. Road transect monitoring was initiated in 2008 (SWG grant T7; Platenberg 2011) and continued through 2012 (SWG grant T9; Platenberg, 2012). Surveys were conducted across five seasons on St. Thomas, but only over one season on St. Croix and on one occasion on St. John, due to logistics and available personnel. The repeated surveys detected an expansion in the range of *E. coqui* and weather-related activity variation for *L. albilabris* across sites surveyed (Platenberg 2011).

Genetic Analysis

Genetic samples were collected with the assistance of DFW from *O. septentrionalis*, *L. albilabris*, and *E. antillensis* (Platenberg 2011). These were assessed for phylogenetic relationships, which are discussed further in the species accounts.

Chytrid Diagnostics

The presence of the chytrid fungus *Batrachocytrium dendrobatidis* (*Bd*) was confirmed in St. Thomas amphibian populations in 2011 (Platenberg 2012). Testing was conducted at nine locations on St. Thomas in 2011 and 2012; three sites (Dorothea Gut, Mountaintop, Northstar Village) tested positive within pooled samples of *Eleutherdactylus antillensis* and *E. coqui*. Although present in the USVI, *Bd* is not widespread; repeated sampling failed to produce positive results indicating that the pathogen is not spreading quickly through the population although further sampling is required for all three islands.

Impacts of Invasives

A study was conducted on the biology of Cuban treefrogs on St. Thomas to assess impact on native species (Platenberg 2011). Frogs were found at all sites surveyed, showing no preference for habitat. Results from dissections showed that females are gravid throughout the year, with over 70% of all females captured being gravid. The frogs showed a low diversity of prey selection, with beetles, grasshoppers, and cockroaches comprising around two-thirds of all identifiable prey items; around half of the individuals examined had nothing in their stomachs or intestines. Cuban treefrogs were also found to have ingested Eleutherodactylid frogs. Toe samples from frogs collected and nucleotide sequence data were compared between frogs from their native and introduced range (Platenberg 2012). Phylogenetic analyses trace the origin of *O. septentrionalis* to at least two Cuban sources, one probably a remote peninsula in western Cuba. The frogs arrived in the Florida Keys, and from there dispersed through Florida and on into the Caribbean (Heinicke et al. 2011). This provides evidence of an invasion pathway, in that the frogs were introduced to the USVI from an established population, itself invasive, in Florida, undoubtedly via container ships. Cargo inspections would prevent some of these introductions.

Conservation Priorities

Amphibians are effective indicators of climate change impacts and annual monitoring should continue. A citizen science approach and/or the use of bioacoustics may expand the scope of survey effort and should be developed, including data processing and storage capacity. Amphibians will benefit from protection of large forested tracts. Impacts of invasive species are likely to have deleterious effects on native populations and should be monitored.

Post-hurricane needs: Amphibians were not adversely affected by the 2017 hurricanes, although the storms may have allowed the expansion or introduction of non-native amphibians. The distribution and activity patterns of amphibians should be monitored using acoustic methods.

Species of Greatest Conservation Need

Common Name	**Scientific Name**	**Status**
Virgin Islands Coqui	*Eleutherodactylus schwartzi*	High Risk - possibly Extirpated
Yellow Mottled Coqui	*Eleutherodactylus lentus*	Low Risk

Species Accounts

Species of Concern

The **Virgin Islands Coqui** (*Eleutherodactylus schwartzi*; Eleutherodactylidae) is endemic to St. John and BVI and is also listed as Endangered on the IUCN Red List, due to small geographic range, ongoing loss of habitat, and impacts from the invasive *O. septentrionalis* (Hedges and Thomas 2010b). It is apparently extirpated from the USVI (Philibosian and Yntema 1977). The USFWS has determined that this species does not warrant protective status under the Endangered Species Act primarily because part of its range in the BVI has been protected from further habitat modification (USFWS 2016).

There is a close similarity between the VI Coqui and the introduced Puerto Rican Coquí (*E. coqui*) in size, appearance, and habitat, and the calls of the two species are indistinguishable by ear. These similarities may be masking its presence in the USVI; frogs at several locations on St. Thomas (e.g., Mountaintop) where there are robust E. coqui populations display color patterns more similar to those of *E. schwartzi* than of *E. coqui* (R. Platenberg, unpublished data), and there is a question about the genetic identity of these two species within the territory. This deserves further study, particularly with the expansion of *E. coqui* populations. *E. schwartzi* is still, apparently, abundant in the BVI, and preliminary studies have been conducted on their distribution on Jost van Dyke, BVI (R. Platenberg, JVDPS unpublished data, 2015). Due to its Red List status and potential presence on St. Thomas this species has been identified as a Species of Concern for the USVI, although this status is likely to be adjusted based on verification of presence. Priority actions include genetic studies to reveal the taxonomic relationship between *E. schwartzi* and *E. coqui* to identify potential management units.

The VI endemic **Yellow Mottled Coqui**, or **Mute Frog** (*E. lentus*; Eleutherodactylidae) has a limited distributional range that is restricted to the Virgin Islands. It can be abundant under appropriate conditions. This species is terrestrial and is found only in moist conditions in a range of habitats (moist forests, guts, agricultural areas), sheltering under surface debris that provides a damp microhabitat during the day. It can often be found moving in the open at night (Platenberg 2005). Contrary to its common name, this frog does have a voice, which can be heard in the middle of the night, sandwiched between the peak chorusing periods of the other Eleutherodactylid frogs. It is larger than the other VI Eleutherodactylid species, at around 5cm in length. It is believed that this frog originated as the sole amphibian species on St. Croix, and has since been introduced to other islands in the VI archipelago (McLean 1982). It is still restricted to the Virgin Islands, but has been documented on Jost van Dyke (Perry 2009), as well as St. Thomas and St. John (Platenberg and Boulon 2006). This species is listed as endangered by the IUCN Red Data list due to its restricted distributional range and ongoing habitat modification (Hedges and Thomas 2010a). There is a need to determine the relationship between populations on different islands to identify management requirements.

Other Species

The **Red-eyed Coqui**, or **Antillean Frog** (*Eleutherodactylus antillensis*; Eleutherodactylidae) is widespread and abundant across all three islands. This arboreal species inhabits woodlands and forests, both dry and moist, and is common in less developed areas but not in urbanized areas. This species was recorded from all locations surveyed on St. Thomas (Platenberg 2012). During the day it hides under rocks and in grass roots, tarantula burrows, and other refugia, and on damp evenings it perches and calls from low bushes and branches, usually hidden within leafy vegetation. Microsatellite analysis of frogs collected with the assistance of DFW personnel revealed differentiated populations across the entire PR Bank, suggesting that populations persisted in the eastern region of the bank and remained isolated from the larger land mass of Puerto Rico during periodic flooding events of interglacial periods prior to the Pleistocene. The eastern populations of the Virgin Islands show little variation, suggesting more recent interaction between populations, likely from human-mediated dispersal. The St. Croix population is most closely related to the populations on St. Thomas and Virgin Gorda (Barker et al. 2012).

The **Whistling Coqui**, or **Cochran's Treefrog** (*E. cochranae*; Eleutherodactylidae) is widespread and abundant on St. Thomas and St. John, but is absent from St. Croix. This species is arboreal and inhabits more xeric woodlands, often sheltering in bromeliads where available. This species occurs higher in the tree canopy than the Red-eyed Coqui where they are sympatric. This species tends to occur in drier habitats, including areas without much forest structure, and tends to be active even during periods with no significant rainfall during the active season.

The **White-lipped Treefrog** (*Leptodactylus albilabris*; Leptodactylidae) is a medium-sized frog native to Puerto Rico, USVI, and BVI where it is abundant and widespread. This semi-aquatic species occupies habitats near streams, ditches, marshes, and other freshwater sources. It is active day and night during rainfall events, calling at ground surface from crevices or from submerged or emergent vegetation. If there is no standing water available, it deposits eggs in a foam nest under surface debris, which await rainfall to wash the tadpoles into a water body.

Non-Native Species

The **Puerto Rican Coquí** (*E. coqui*; Eleutherodactylidae) was introduced to the USVI, most likely as a stowaway in ornamental and agricultural plant containers. This large frog inhabits the canopy of mesic broadleaf forests to 1200 m elevation. It has been able to successfully colonize new locations and poses a serious threat to native ecosystems in Hawaii (e.g., Kraus et al. 1999, Hedges et al. 2008), and may have significant effects on invertebrate populations, thereby altering ecosystem processes, wherever these frogs occur (Beard et al. 2003). Although the impacts of this species in the USVI are unknown, it probably competes with native frogs for food and nesting resources (Platenberg 2007). This species is particularly common around an agricultural area on St. Thomas (Platenberg 2005). On St. Croix, it is found throughout much of the forested northwest, and in isolated pockets in other parts of the island, likely the result of several introductions (J. Valiulis, pers. obs., 2017).

The **Cuban Treefrog** (*Osteopilus septentrionalis*; Hylidae) is introduced and highly invasive, native to Cuba and the Bahamas. Its current distribution in the Caribbean includes St. Croix, St. Thomas, and St. John, as well as BVI, Puerto Rico, Anguilla, Bonaire, Florida, and possibly other locations not yet documented (Schwartz and Henderson 1991, Owen and Perry 2005, Waddle et al. 2005). Unfumigated ornamental plants and construction materials transported from Florida and Puerto Rico are the likely forms of introduction. This frog is easily distinguished from all native frogs by its large size, with females reaching lengths of 140 mm and males 90 mm, dorsal toxin glands, and prominent round toe disks. It is widespread in mesic areas, but is also capable of inhabiting drier areas, and tolerating brackish water. This species requires water in which to breed, and tadpoles are frequently found in cisterns, ponds, ditches, and pools in guts, and can breed year-round. Adults congregate in cisterns and around water sources, often in great numbers. This frog eats beetles, roaches, crickets, bugs, moths, caterpillars, small crustaceans, other frogs, lizards, and anything else it can catch. It is a strong leaper, and if unable to avoid capture by leaping, it produces a noxious skin secretion that causes burning and itching on contact with mucus membranes. On St. Thomas they occupy nearly all areas of the island, and are also widespread and abundant on St. John and St. Croix. They are present on at least two off-shore cays with ponds: Great St. James and Inner Brass (Platenberg 2011).

The **Cane Toad** (*Rhinella marina*; Bufonidae) is a giant toad, up to 225 mm in length. Native to Central and South America, this species has been successfully introduced throughout the West Indies and Florida, Hawaii, Australia, Japan, Guam, and many locations in the South Pacific (Solís et al. 2009). This highly adaptable species occurs in a variety of habitat types including lowland and upland forests, grasslands, coastal scrub, beaches, agricultural pastures, and urban areas, sheltering under surface debris. It breeds in still or slow-moving water of ponds, ditches, temporary pools, reservoirs, and streams. Tadpoles can survive in brackish water and have a high heat tolerance (Schwartz and Henderson 1991) and are competitive with and highly toxic to other tadpoles (Crossland 2000, Smith 2005). Clutch size is between 8,000-17,000 eggs, with one to two breeding seasons per year (Solís et al. 2009). Their impact on native wildlife, particularly in Australia, has been devastating (e.g., Phillips et al. 2003). The impact of the cane toad to native wildlife in USVI is unknown.

Species of Conservation Potential

The **Puerto Rican Crested Toad** (*Peltophryne lemur*; Bufonidae) is a medium sized toad (to 120 mm) inhabiting semi-arid rocky areas in lowlands within restricted sites in Puerto Rico. This species is listed on the Red List as Critically Endangered throughout its range (Angulo 2010), and is Threatened under the US Endangered Species Act. It has been extirpated from much of its previous range including the USVI and BVI. One account of this toad occurring on St. John has been published (Norton 1997, 1998), but this sighting has not been confirmed by any other sightings and the species is not known to occur in the USVI. There may be an interest in establishing new populations within its former range.

Contributor (2005): RJP
Contributor (2017): RJP

Banner photo: *Eleutherodactylus antillensis*, by R. Platenberg

2.3 Terrestrial Reptiles

There are 23 extant species of terrestrial reptiles in the USVI: 13 lizards (3 non-native, 4 endemic to the VI), seven snakes (3 non-native, 2 endemic), two terrapins (both presumably non-native), and one tortoise (presumed introduced). This taxon represents the highest endemism of terrestrial vertebrates in the VI, but also high numbers of non-native invasives.

Caribbean terrestrial herpetofauna exhibit high endemism among islands, contributing to the overall biodiversity richness of the region, although that high species richness is diminishing across the region due to impacts from human activities (Myers 2000); terrestrial reptiles are disproportionately affected from habitat loss and introduced predators.

Much of the Antillean herpetofauna originated from ancestral species that dispersed into the region from South America, with subsequent radiation into unique species. The most well-known example is that of the Anolis lizards that not only diversified between islands but also within habitats, to the point of unique species partitioned within ecotomes, often on the same tree (Roughgarden 1995).

This diversification continues among isolated populations, and newer and cheaper genetic tools have revealed interesting patterns of colonization and speciation, even within the same island groups. It was once assumed that the Caribbean skink *Mabuya sloanii* was the same species across the Caribbean (Schwartz and Henderson 1991), but a phylogenetic evaluation revealed that insular populations have diverged towards speciation, such that each island group, and even islands within groups, have unique skink species, giving the Virgin Islands two new genera (*Spondylurus* and *Capitellum* to replace *Mabuya*) and four distinct species (Hedges and Conn 2012), although it is unknown if all four are extant. Genetic analyses have revealed similar patterns in genetic drift driving evolutionary processes within the USVI in *Ameiva* (*Pholidoscelis*) *polops* and Puerto Rican bank boas *Chilabothrus* (formerly *Epicrates*; Hurtado et al. 2012, Rodríguez-Robles et al. 2015). These differentiations have implications for management of genetically distinct management units.

Ecological Value

Lizards play an important role in the control of insect biomass, while also providing nutrient input into nutrient-poor tropical terrestrial ecosystems. Lizards, in turn, provide a critical food resource for snakes (VI boa, PR racer, and garden snake) and birds, especially kestrels (*Falco sparverius*). Snakes are high in the food chain and maintain trophic balance and biodiversity in terrestrial forested systems. Herbivorous reptiles, such as iguanas and tortoises, provide valuable seed dispersal services.

Threats

The major factors implicated in declines of terrestrial reptiles in the USVI include habitat loss, degradation and fragmentation from human development, introduced mammalian predators (Small Indian Mongoose *Herpestes auropunctatus*, feral cats *Felis catus*, and rats *Rattus* spp.), persecution by humans, and road mortality.

The absence of certain species from the main islands has been attributed to predation, primarily by the mongoose (Platenberg and Boulon 2006), which has contributed to the decline and extirpation of reptiles elsewhere in the West Indies (Powell and Henderson 2005). Evidence to support impacts of mongoose on herpetofauna in the VI include an abundance of native Puerto Rican racers (*Borikenophis portoricensis*) on the mongoose-free but human-inhabited Water Island, but few to no racers on St. Thomas and St. John, which have high populations of mongooses (R. Platenberg, unpublished data). The St. Croix Ground Lizard (*Ameiva polops*) has persisted and thrived on offshore cays where mongoose are absent, but have been extirpated from the large island where mongoose are present. Mongoose were also the cause of an unsuccessful translocation of the St. Croix Ground Lizard to Buck Island in 1968 (Philibosian and Ruibal 1971, Philibosian and Yntema 1976).

Habitat loss is having a significant impact on remaining herpetofauna populations. The demand for realty property on the USVI for development for tourism, housing, and commercial interests make this a critical concern for populations on these islands. There is an immediate need to protect remaining habitat for populations threatened with extirpation, particularly the endangered Virgin Islands Tree Boa (see below), which has a known distribution in the USVI that is restricted to the east end of St. Thomas.

Several reptiles have been introduced to the USVI. The Corn Snake (*Pantherophus guttatus*) may represent intermittent unsuccessful introductions (Perry et al. 2003). The Puerto Rican Ground Lizard (*Ameiva exsul*), which is native to St. Thomas and St. John, has been introduced to St. Croix and is known to prey on native lizards and invertebrates (Treglia et al 2013). The *Boa constrictor* is a relatively new introduction to St. Croix and its effects on the native wildlife could be potentially devastating. The effects on native wildlife of predation and competition for resources by introduced reptiles have not been quantified.

Climate change is likely to have a disproportionate impact on endemic reptiles. Reptiles are ecothermic, and may experience challenges in thermoregulating as temperatures achieve thermal maxima. Species that are vulnerable to desiccation, such as tiny dwarf geckos and fossorial amphisbaenids, may be especially hard hit (Allen and Powell 2014). Species may experience thermoregulatory challenges depending on habitat occupied, with xeric habitat occupants potentially undergoing more stress than those in mesic habitats. A limiting factor may be the availability of suitable microhabitats (Gunderson and Leal 2012), resulting in increased competition for limited resources. Thermoregulatory response and habitat use studies can help predict climate impacts (e.g., Blair 2009, Gifford et al. 2012).

Research and Management

The terrestrial reptiles of the USVI have been inventoried on the major islands (Schmidt 1928, Grant 1937, Grant and Beatty 1944, Underwood 1962, Schwartz and Thomas 1975, Philibosian and Yntema 1976, 1977, 1978, MacLean et al. 1977, Schwartz et al. 1978, Heatwole et al. 1981, MacLean 1982, Mayer and Lazell 1988, Schwartz and Henderson 1991, Powell and Henderson 1999, 2003, Rice et al. 2005, Platenberg 2005, 2011b, Platenberg and Boulon 2006). A recent consolidation of information provides a thorough list of species for each island (Mayer 2012). Several species have undergone taxonomic revision (*Alsophis* and *Arrhyton*: Hedges et al. 2009; *Mabuya*: Hedges and Conn 2012; *Epicrates*: Reynolds et al. 2013, Rodríguez-Robles et al. 2015; *Typhlops*: Hedges et al. 2014; *Ameiva*: Goicoechea et al. 2016, Tucker et al. 2016). A comprehensive collection of natural history accounts for Caribbean reptiles can be found in Henderson and Powell (2009).

Several studies examining regional patterns of biogeography using genetic material have revealed unique species on the Puerto Rican Bank, and even between PR and the islands within the Virgin Islands archipelago. Ground Lizards (*Ameiva* spp.) in the West Indies diverged from the mainland ancestors 25-30 million years ago, based on a single fortuitous dispersal event over water from the south. Radiation within the West Indies occurred 10-15 million years ago (Hower and Hedges 2003), although there is still poor resolution within the group (Tucker et al. 2016). The Caribbean *Ameiva* have been reclassified as *Pholidoscelis* to acknowledge the distinction between the South American and Caribbean species (Goicoechea et al. 2016). A review of the West Indian *Alsophis* snakes (Racers) has revealed that the racers of the Puerto Rican Bank are genetically distinct from the racers of other islands, significantly enough to warrant assignment to a new genus, *Borikenophis* ("Boriken" is the Taino word for Puerto Rico; Hedges et al. 2009). The Virgin Islands Tree Boa has been elevated to species status as result of genetic analysis that revealed divergence between the two species previously considered subspecies (Reynolds et al. 2013, 2015, Rodríguez-Robles et al. 2015).

Previous studies in the USVI have focused on the endangered St. Croix Ground Lizard (see below), the Anolis lizards (Ruibal et al. 1972, McManus and Nellis 1973, Ruibal and Philibosian 1974 a,b, Philibosian 1975, Mortensen 1998), and the endangered Virgin Islands Tree Boa (Nellis et al. 1983, Tolson 1988, 1989, 1990, 1992a,b, 1994, 2004, Chandler and Tolson 1990, Harvey and Platenberg 2009, Platenberg and Harvey 2010, Reynolds et al. 2015).

The St. Croix Ground Lizard has been the focus of much recent research, including population studies (Treglia 2010, Valiulis 2011a, 2012; N. Angeli, unpublished data) and genetics (Hurtado et al 2012, 2014, Santamaria et al 2011). This build on a large body of previous research (Philibosian and Ruibal 1971, Dodd 1978, Wiley 1982, Furniss 1984, Zwank 1987, Meier et al.

1993, Knowles 1997, McNair 2003, McNair and Coles 2003, McNair and Lombard 2004, McNair and Mackay 2005, Mackay 2007). Translocation efforts include an assessment of suitable habitat at Ruth Island (Yntema and Sladen 1987); successful translocation of animals to Ruth Island (Knowles 1990, 1997); and failed translocations to Buck Island because of failure to exterminate the mongoose (Philibosian and Ruibal 1971, Philibosian and Yntema 1976; DFW, unpublished data).

Accomplishments Since 2005

DFW initiated a herpetofauna conservation program with objectives for population and habitat surveys and ecological studies (SWG T5, T7, and T9). Surveys have been conducted for reptiles across all major islands and most cays (Platenberg 2005, Platenberg and Boulon 2006, Platenberg 2011b). Efforts have been taken to reverse population declines in VI tree boas and St. Croix ground lizards, and to better understand the conservation needs of all VI reptiles.

In 2005 DFW developed a predictive habitat occupancy model for VI tree boas that identified potential areas for protection (Harvey and Platenberg 2009), which was used to develop a habitat delineation protocol for planning purposes (Platenberg and Harvey 2010). A Five Year Review of the status of the VI tree boa was completed in 2009 (USFWS 2009), which proposed a downlisting of status from Endangered to Threatened due to accomplishments in establishing new insular populations, rat eradication on potential introduction sites, and stability of insular populations. However, the review did not consider the dire situation of the St Thomas population. In response to an outdated Recovery Plan (USFWS 1986), a local conservation plan was drafted to address ongoing habitat loss and persecution (Platenberg 2011a).

In 2008, after many years of preparation, 57 St. Croix Ground Lizards were translocated to Buck Island. The goal of this effort was to increase the population of this highly endangered lizard and expand its range to another island already under federal management and protection. This translocation was highly successful and the population at Buck Island now outnumbers those of all the other islands combined (Fitzgerald et al. 2015).

DFW initiated an education program through SWG called “Do One Thing For Wildlife” that produced monthly newsletters on different wildlife topics, frequently focusing on herpetofauna (Platenberg 2011b). DFW also worked with the Virgin Islands Montessori School and International Academy (VIMSIA) to develop a tree boa conservation program that centered around community outreach. The St. Croix ground lizard has also received attention within the local community. SEA conducts popular outreach events focused on Crucian reptiles, and is currently (in 2017) doing outreach and education focused on the St. Croix Ground Lizard through a grant from DFW. A children’s book about the St. Croix Ground Lizard is currently being developed and is expected to be published in the near future.

Conservation Priorities

Terrestrial reptiles within the USVI will benefit from habitat protection and control of invasive species, particularly feral cats. Protection of forest cover and soils will provide support for subterranean *Antillotyphlops* and *Amphisbaena* that are likely to experience disproportionate impacts from long-term climate changes that include longer periods of drought. Restoration of habitat and establishing connectivity between forested areas on St. Thomas' east end will benefit the tree boa and other forest species. Surveys for distribution that include population genetic analysis should be maintained, and priority should be given to locating and evaluating populations of *Chilabothrus* and *Spondylurus*. The *Ameiva exsul* population on St. Croix should be managed and controlled or eliminated.

Public education is critically important for long term conservation benefit of herpetofauna. These species have a large "ick factor" within the USVI community, and snakes in particular have an additional layer of animosity stemming from cultural beliefs. These attitudes need to be addressed in early education and periodically reinforced.

Post-hurricane needs: The snakes, particularly the VI tree boa, were possibly adversely affected by mechanical removal of vegetation debris piles into which they had sought refuge. Storms have the potential of moving reptiles across water thereby introducing them to new locales. Distributional surveys of all reptilian species are needed.

Species of Greatest Conservation Need

Common Name	**Scientific Name**	**Status**
Virgin Islands Tree Boa	*Chilabothrus granti*	High Risk
Virgin Islands Skinks	*Spondylurus* spp. (2 spp)	High Risk
St. Croix Ground Lizard	*Ameiva (Pholidoscelis) polops*	High Risk
Virgin Islands Amphisbaena	*Amphisbaenia fenestrata*	High Risk
Virgin Islands Blindsnake	*Antillotyphlops richardii*	High Risk
Puerto Rican Racer	*Borikenophis portoricensis*	Low Risk
Ground Snake	*Magliophis exiguus*	Low Risk
St Croix Dwarf Gecko	*Sphaerodactylus beattyi*	Data Deficient -At Risk

Species Accounts

Species of Concern

The **Virgin Islands Tree Boa** (*Chilabothrus granti* (formerly *Epicrates monensis granti*); Boidae), listed by the USFWS as an endangered species in 1979 (USFWS 1980), is a semi-arboreal nocturnal snake with an extremely disjunct distribution indicative of a long history of extirpation and decline. In the USVI it is restricted to eastern St. Thomas (Nellis et al. 1983, Harvey and Platenberg 2009). Elsewhere, it has been recorded from several locations on Puerto Rico and satellite cays, Tortola, Great Camanoe, and Virgin Gorda and unconfirmed on Guana and Necker Islands (Nellis et al. 1983, Mayer and Lazell 1988, Tolson 1992a). Its optimal habitat is subtropical dry forest with an interlocking canopy (Harvey and Platenberg 2009), where it forages at night on lizards sleeping in trees and seeks refuge during the day in termite nests, tarantula holes, or under rocks and debris.

The boa's long-term survival within its natural range of the highly developed and densely populated eastern end of St. Thomas is unlikely (Platenberg and Boulon 2006, Platenberg and Harvey 2010). Relatively unrestricted development severely alters or destroys essential habitat and features, and there is little connectivity between remaining essential habitat patches. An increasing volume of vehicular traffic has resulted in high numbers of road fatalities. Encounters with humans often result in wanton killing or movement of individuals to suboptimal locations. Furthermore, the boa is susceptible to predation by burgeoning populations of feral cats, which thrive in developed areas and are under the protection of well-meaning community members who maintain feral cat colonies through feeding stations.

The boa's reproductive strategy of high female longevity, biennial reproduction, live birth, and small clutch size render its population highly vulnerable to increasing threats and population fragmentation. The species is uncommon and declining, and genetic analysis from road- and cat-killed specimens reveal little genetic diversity across its range (Reynolds et al. 2015), which pose significant challenges for adaptive ability in the face of an ecosystem changing in climate, habitat structure, and species assemblages that include uncontrollable non-native invasives.

The recovery plan developed by the USFWS for the listed species mandated evaluation of potential sites for release and reintroduction of the boa within its historical range (Nellis et al. 1986). High densities of snakes on cays off Puerto Rico indicate that suitable reestablishment sites are uninhabited, predator-free islands with substantial dry forest. Several populations of boas have been established on cays both off Puerto Rico and the USVI through a captive breeding program (Tolson 1989, 1990, 1994, 2004) but these snakes are likely at their carrying capacity, and have received little if any genetic management through the introduction of new alleles into these isolated populations.

Although the translocations of boas led to the establishment of a small isolated population of around 165 individuals (Tolson 2004), this situation is not ideal for long-term survival of the species in the USVI because the population is extremely vulnerable to stochastic events. Surveys of cays within the USVI were unable to locate new release sites that matched the strict criteria identified above (P. Tolson, unpublished data).

Therefore it is critical to address *in situ* threats acting on boas within the largest extant population on St. Thomas. Protection of essential habitat from cumulative impacts of uncoordinated development and ensuring the existence and protection of effective migration corridors are critical needs that must be met if this species is to survive on St. Thomas. A niche occupancy model was developed to identify essential habitat areas for protection of the boa (Harvey and Platenberg 2009). The model identified intact tracts of dry forest, thicket/scrub, and mangroves, which are also important habitats for *Borikenophis* and other species of concern (e.g., migratory birds). This work was conducted under a Section 6 Endangered Species Recovery Grant (VI-E-4-R) in 2005. Since then, additional distributional data and updated aerial photographs spurred an update to both the GIS land use layer and the habitat model (Platenberg 2011b). The updated land use layer indicated a land use conversion towards development, with a 27% increase in development within the east end from 2000 to 2007 (Harvey 2010).

Habitat delineation protocols were developed using these habitat maps, with the intention that these can be used in a similar manner to wetland delineations to protect key areas, although the use of these has been sporadic at best (Platenberg and Harvey 2010). Despite that the boa is an endangered species and essential habitat is a requirement for its survival, there has been little effort to protect this habitat within the Territory.

A conservation plan for boa populations within the USVI was drafted (Platenberg 2011a). It identified the key recovery needs include removal of predators and increasing community awareness of the boa. Removal of cat feeding stations in the areas where boas are still observed is a first step toward reducing and controlling feral cats that impact the few remaining boas. The population established on the cay contains both captive bred individuals and individuals that were recovered from different locations on St. Thomas, and may represent the most genetically diverse population of any. In addition to seeking new locations, a release program to augment existing St. Thomas populations combined community education would be a positive action to support both the extant population and reduce carrying capacity of the established population. A mechanism that may prove successful for boa conservation is the Habitat Conservation Plan (HCP) program, where several landowners can collaborate to initiate protective measures.

Previous studies on the boa include status and biogeography (Nellis et al. 1983, Mayer and Lazell 1988, Tolson 1992a), ecology and behavior (Tolson 1988, 1992b, 1994; Chandler and Tolson 1990), and captive breeding (Tolson 1989, 1990, 1992b), and habitat use (Harvey and Platenberg 2009).

The endemic, strictly terrestrial **St. Croix Ground Lizard** (*Ameiva polops*; Teiidae), listed by the USFWS as an endangered species in 1977, has been extirpated from the main island of St. Croix where it was once widespread along the coast (last present in Frederiksted in 1968; Philibosian and Ruibal 1971). Extant populations occur on two of St. Croix's cays: Protestant Cay (1.2 ha), and Green Cay (5.7 ha) off the northeastern coast, and populations have been established on Ruth Island (7.5 ha), a dredged-spoil cay off the southern coast, where lizards were introduced in the early 1990s and Buck Island (71.2 ha), where it was recently (2008) introduced. All four cays are currently free of the Small Indian Mongoose (*Herpestes auropuntatus*), the lizard's primary predator, but the ground lizard remains highly vulnerable because of its limited distribution, small population size, and susceptibility to accidental or deliberate introductions of the mongoose (Platenberg 2016a). The ground lizard was extirpated on St. Croix and Buck Island by the mongoose (Philibosian and Ruibal 1971, Henderson 1992).

After a multi-decade, multi-agency effort, the St. Croix Ground Lizard was introduced to Buck Island, St Croix. An attempt to introduce *Ameiva* to Buck Island in 1968 was initially successful but ultimately failed, presumably due to predation by mongoose (Philibosian and Ruibal 1971, Philibosian and Yntema 1976), and since that effort the NPS put considerable effort into ensuring that rats and mongoose were eradicated from the island before the latest translocation (Witmer et al. 2002). Genetic population analyses were conducted to determine the appropriate source population, and it was determined that lizards exclusively from Green Cay would be most appropriate. A total of 57 lizards were captured on Green Cay and transported to Buck Island where they were held and observed in enclosures to ensure immediate survival and to study any possible impacts they might have in the invertebrate community of Buck Island before full release.

Regular follow up surveys have confirmed their survival, reproduction and dispersal throughout the island (Fitzgerald et al 2015, Angeli, unpublished data).

Protestant Cay and Green Cay have been designated critical habitat under Section 7 of the Endangered Species Act of 1973. Nonetheless, the status of the ground lizard on developed Protestant Cay (owned by the territorial government) remains precarious because of a long-term population decline (ca. 45 yr) associated with deleterious landscaping practices. The natural habitat on the cay has almost entirely been displaced by a hotel, associated infrastructure, and non-native landscaping vegetation. The practice of raking and removal of litter is particularly damaging to the habitat available to the lizard (McNair and Coles 2003). A Partnership Grant between the hotel, USFWS, and DFW was initiated in 2004 to improve habitat conditions for the lizard on Protestant Cay. Although successful at first, changes in management and lack of commitment by the hotel caused this partnership to languish. Periodic efforts to work with the hotel have met with varying levels of success. In 2011 a plan was put together with specific achievable recommendations for restoration of *Ameiva* habitat on Protestant Cay (Valiulis 2011b). In conjunction with the plan, native trees were donated and planted throughout the island. However, a change in management resulted in not only the abandonment of the plan, but also large scale bulldozing of *Ameiva* habitat. As a settlement action, the management removed the mahogany trees that were providing roost sites for Cattle Egrets (*Bubulcus ibis*) that were preying on the lizards.

Green Cay (owned by USFWS) is protected and managed specifically for the St. Croix Ground Lizard. Lizard numbers may have declined from indirect effects of hurricanes since Hugo in 1989 that have altered habitat structure (McNair 2003, McNair and Lombard 2004). Expanding patches of hurricane grass (*Andropogon pertusus*) may be reducing the amount of available habitat and isolating habitat patches. Rats have recently been eradicated from the island. The population on undeveloped Ruth Island has increased since the initial introduction in 1990 and now occupies all apparent suitable habitat (McNair and Mackay 2005), although patches of hurricane grass also occupy potential habitat area.

Hurricanes periodically impact the beach and dry forest habitats that the St. Croix Ground Lizard prefers and because of this the lizards can tolerate a considerable amount of natural and unnatural disturbance. Key habitat components comprise bare ground (including sandy, exposed areas), high densities of leaf and tidal litter, woody debris, scrub, and forest with intermediate to high woody stem densities that permit dappling of sun and shade (canopied and exposed areas), and burrows including crab burrows (Philibosian and Ruibal 1971, Wiley 1982, Meier et al. 1993, McNair 2003, McNair and Coles 2003, McNair and Lombard 2004, McNair and Mackay 2005). The ground lizard thrives in dry, rocky coastal areas with sandy soils.

Conservation plans for the St. Croix Ground Lizard include restoration of the quality and amount of habitat on Protestant Cay, removal of exotic vegetation throughout its range and establishing movement corridors to protect them from predation (Valiulis 2011b).

Genetic analysis revealed that the Green Cay ameivas make up one population while Ruth Island and Protestant Cay lizards are a second population (Hurtado et al. 2012). Each are considered independent evolutionary units and are different enough to be considered subspecies. To stop further differentiation of the Ruth Island and Protestant Cay populations that may eventually result in a third subspecies, DPNR has planned a reciprocal translocation scheduled to happen in 2017. In addition to the translocation, population monitoring will occur on Protestant Cay and Ruth Island, both of which have not been surveyed in several years. Finally, the project also includes an education component to be carried out by SEA.

The **Virgin Islands Bronze Skink** (*Spondylurus* (formerly *Mabuya*) *sloanii*; Scincidae) is one of a complex of related and previously cryptic endemic species found within the Virgin Islands archipelago. It was once assumed that the Caribbean skink *Mabuya sloanii* was the same species across its entire distribution from the Turks and Caicos through Jamaica, Hispaniola, Puerto Rican Bank and down into the Lesser Antilles (Schwartz and Henderson 1991), but a phylogenetic evaluation revealed that insular populations have diverged towards speciation, such that each island group, and even islands within groups, have unique skink species, giving the Virgin Islands two new genera (*Spondylurus* and *Capitellum* to replace *Mabuya*) and four distinct species (Hedges and Conn 2012), although it is unknown if all four are extant. All are critically endangered under IUCN (Hedges 2013), and a petition has been submitted to the USFWS for consideration for listing under the ESA (Center for Biological Diversity 2014).

Surveys have been conducted within most of the suitable habitat for skinks on cays, and populations have been documented in several new locations, including Great St. James, a privately-owned island that is under pressure of development (Platenberg 2005, and pers. comm.). However, repeated visits to two locations where skinks could reliably be observed have been fruitless—there are no records of skink observations after around 2006 (R. Platenberg, pers. comm.). The apparent absence of this species from the major islands is likely due to the presence of the small Indian mongoose, although this doesn't adequately explain its apparent disappearance from the cays without mongoose and from which rats have been eradicated. This species is considered critically endangered throughout its range, and should be prioritized for immediate effort to document and manage existing populations.

This lizard is found in low, dense vegetation on the beaches and lower slopes of cays, sheltering in grass and brush litter, under rocks and other surface debris, in rocky fissures, and on branches of low shrubs. It feeds on insects.

The **St. Croix Dwarf Gecko** (*S. beattyi*) is endemic to St. Croix and restricted to certain regions, possibly due to interactions with *S. macrolepis,* although it appears to inhabit more xeric habitats than does *S. macrolepis* (MacLean 1982, Schwartz and Henderson 1991). This small lizard reaches a maximum snout-vent length of 30 mm. The distribution of this species is poorly understood and its ecology data deficient. This species is listed as Endangered in the IUCN Red List due to limited distribution and continued decline in available habitat and an apparent decline in abundance in areas where previously common (Platenberg and Angeli 2016), and in the VI it is considered data deficient and potentially at risk due. Sphaerodactylids are vulnerable to desiccation, and undergo rapid changes in body temperature in response to changes in leaf litter conditions (Allen and Powell 2014). This may make them particularly susceptible to climate change impacts.

The **Virgin Islands Amphisbaena** (*Amphisbaena fenestrata*; family Amphisbaenidae), also known as the Worm Lizard, is a legless lizard. It retains rudimentary shoulder and pelvic girdles, and can move both backwards and forwards. This fossorial species is rarely found, and only under stones and rocks in moist wooded areas. The abundance and distribution within the USVI is not fully known because it is difficult to locate. Observations of this species are limited to mesic habitats at mid to higher elevations, although it can also be found at lower elevation in coastal areas, particularly on St. John (R. Platenberg, pers. obs.). This species is highly susceptible to desiccation and does not survive for more than a few hours on exposure. A changing climate that results in prolonged drought poses a significant risk from drying and compacting soils. Increased precipitation could result in individuals being forced from flooded underground refugia, exposing them to desiccation and predation. For these reasons, coupled with limited distribution due to endemism to the VI, and continuing habitat loss from development, this species has been listed as Endangered under the IUCN Red List (Platenberg 2016b).

The **Blind Snake** (*Antillotyphlops* (formerly *Typhlops*) *richardii*; Typhlopidae) is a small, highly secretive, and fossorial snake. This species is present on all three major islands of the USVI, including satellite islands, and across the Puerto Rican Bank in both xeric and mesic wooded areas, although it probably prefers xeric woodland habitats with sandy soils (Platenberg and Boulon 2006). It burrows in loose dirt, and shelters under rocks, boards, and other surface refugia, feeding on termite and ant pupae, larvae, eggs, and adults. Almost nothing else is known about its ecology; this species is rarely encountered in the USVI. Free-ranging cats are effective predators of this species, which is also likely to be vulnerable to climate change impacts, particularly drought and extended periods of dry soils. This species is listed as Near Threatened on the IUCN Red List due to limited distribution and ongoing loss of habitat (Platenberg 2016c).

Other Species

Lizards

The **Common Ground Lizard** (*Pholidoscelis* (formerly *Ameiva*) *exsul*; Teiidae) is abundant on St. Thomas and St. John, with stable populations (Platenberg et al., 2016b). It is found primarily in the lower to mid elevations in xeric open areas with sandy soils, leaf litter and scrubby vegetation. The distribution of this species includes Puerto Rico, BVI, and nearby cays. It is omnivorous, and feeds on a variety of insects and other arthropods, earthworms, snails, lizard eggs, other lizards, and even table scraps (Schwartz and Henderson 1991). They adapt well to human presence, and are often observed foraging on beaches and around houses and basking on roads. Habitat modification may actually increase available habitat for this species, by opening up areas previously too densely vegetated for occupation. The main threat to this species is predation from feral animals. Where sympatric with predators (cats and mongooses), individuals tend to be small in size, but can achieve total lengths of 25-30 cm where predation risks are reduced (R. Platenberg, pers. obs.).

This lizard was introduced to St. Croix, likely through importation of goods from Puerto Rico or St. Thomas. The introduction likely occurred in the early 2000s although lizards appeared to be limited to the general area around the mid-island introduction area, known as Five-Corners. Surveys and *ad hoc* reports show that the range of this lizard is rapidly expanding to the surrounding neighborhoods (Treglia et al. 2013, J. Valiulis, pers. comm., 2017). Stomach content analysis of Common Ground Lizards from St. Croix found that they consume native lizard species and invertebrates, indicating that they are a threat to native fauna and could be especially damaging if they reached one of the offshore cays where the native St. Croix Ground Lizard is found (Treglia et al. 2013). For this reason, they have been identified as being an introduced species of management concern for St. Croix (Appendix 1).

Previous studies of this common species of Puerto Rico have been conducted on various ecological parameters such as reproduction, body size, and diet (Lewis 1986, Lewis and Saliva 1987, Lewis 1989, Rodriguez-Ramirez and Lewis 1991, Rivera-Vélez and Lewis 1994, Tirado and Lewis 1997, Bofill and Lewis 1999, Lewis et al. 2000). Recent research in the USVI focused on the distribution, habitat use, and population status on St. Thomas, St. John and the adjacent cays (Platenberg and Boulon 2006).

Four species of ***Anolis***, one of the most diverse and abundant lizard genera in the Caribbean, occupy the USVI. Three species occupy St. Thomas and St. John, the Crested (*Anolis cristatellus*), Barred (*A. stratulus*), and Grass anoles (*A. pulchellus*), while St. Croix only has the St. Croix Anole (*A. acutus*). The primary threat to *Anolis* in the USVI is predation from native and feral animals; it is a common food source for a range of predators including American Kestrels (*Falco sparverius*) and all three native snakes. Previous studies of the *Anolis* of the USVI have investigated territorial behavior, habitat use, evolution, reproduction, physiology, locomotion, and other ecological parameters (e.g. Ruibal et al. 1972, McManus and Nellis 1973, Ruibal and Philibosian 1974a,b, Philibosian 1975, Reagan 1991, Leal and Rodríguez-Robles 1997, Mortensen 1998, Perry et al. 2000, Genet 2002, Jensen 2002, Perry et al. 2004, Rios-López 2004). An extensive review of Caribbean *Anolis* and their evolution was published by Roughgarden (1995).

The **Crested Anole** is one of the most abundant and best-studied lizards on the Puerto Rican Bank (e.g. Philibosian 1975, Chandler and Tolson 1990, Leal and Rodríguez-Robles 1997, Perry et al. 2000, Genet 2002, Jensen 2002, Perry et al. 2004). It is present on St. Thomas, St. John, Water Island, and most of the adjacent cays, as well as Puerto Rico and the BVI. Defined as a "trunk-ground ecomorph" (Williams 1983), this species occupies a habitat niche that consists of the lower halves of large tree trunks, rocks, shrubs, and ground. This is primarily a forest dweller, although it also inhabits coastal areas and is common around human habitation. This species is found almost everywhere in the northern USVI, including mesic forests in the higher elevations, to 850 m (Schwartz and Henderson 1991). The crested anole is very territorial, and will defend its home range using a combination of posturing, signaling with its colorful dewlap, and chasing away intruders. Although moderately large in size (up to 75 mm snout-vent length), it is preyed upon by snakes, birds, and cats. It in turn preys upon most types of invertebrates and smaller lizards (Schwartz and Henderson 1991). This species appears to be shifting both morphologically and behaviorally in response to increasing urbanization on Puerto Rico (Kolbe et al. 2015, Tyler et al. 2016, Winchell et al. 2016).

The **Barred Anole** is a trunk-crown anole, occupying the higher limbs and trunk. This lizard occurs in xeric to mesic forests to an elevation of 365 m, feeding on ants, beetles, spiders, and other invertebrates. It is also known to feed on nectar (Rios-López 2004). The distribution of this species extends from Puerto Rico, USVI, and BVI (Schwartz and Henderson 1991). This species is fairly common within the northern USVI, and it is commonly associated with building structures away from more urbanized areas.

The **Grass Anole** is a grass-bush ecomorph, inhabiting open, exposed grassy areas with some scrub layer to 630 m elevation. This lizard exhibits little vagility within small home ranges, and usually rests 1.2-2 m above the ground (Schwartz and Henderson 1991). It feeds on ants, snails, millipedes, spiders, flies and other insects. The distribution for this species encompasses Puerto Rico, USVI, and BVI, and it is present on St. Thomas, St. John, Water Island, and some of the adjacent cays.

The abundant **St. Croix Anole** (*Anolis acutus*) is a trunk anole that forages on the ground and perches on tree trunks from just above the ground to 3 m. The only anole on St. Croix, it inhabits a wide range of habitat types and structures. Adults are sedentary, showing little vagility, and once its territory is established, it rarely leaves the home tree (Schwartz and Henderson 1991). Previous studies on this species have focused on population biology, behavior, and physiology (McManus and Nellis 1973, Ruibal and Philibosian 1974a, 1974b, Philibosian 1975).

The common **Dwarf Gecko** (*Sphaerodactylus macrolepis;* Sphaerodactylidae) occurs on all larger islands and many of the cays, as well as Puerto Rico, BVI, and down into the Lesser Antilles (Platenberg and Boulon 2006). It primarily inhabits mesic forested habitats in leaf litter (Schwartz and Henderson 1991). This small (snout-vent length 30 mm) dark lizard is often referred to as a “salamander” because of the way it moves through leaf litter. Population densities on Guana Island, BVI, may reach 67,000 individuals per hectare, one of the highest densities known for any lizard (Rodda et al. 2001). This species is abundant throughout its range (Platenberg et al. 2016a).

Snakes

The **Puerto Rican Racer** (*Borikenophis portoricensis,* formerly *Alsophis portoricensis*; Dipsadidae) was apparently extirpated from St. Thomas and St. John although these snakes are regularly observed on Water Island and are abundant on cays around St. Thomas (Platenberg and Boulon 2006). Its distribution encompasses Puerto Rico, USVI, and BVI, although it is not present on St. Croix. This snake has been repeatedly observed on the east end of St. Thomas since 2008 (Platenberg 2017), which almost certainly reflects an overwater dispersal from nearby cays; mongoose populations on St. Thomas’ east end appear to be low enough to allow persistence and even dispersal of this species.

The Puerto Rican Racer can reach lengths up to a meter, and is generally uniformly gray, tan, or olive colored. This snake is an active diurnal forager, preying primarily on *Anolis* lizards, as well as geckos, ground lizards, small iguanas, and frogs. It is both ground dwelling and arboreal, and is frequently encountered basking during the hotter parts of the day in xeric habitats. When threatened, this snake will rear up and flatten its neck similar to a cobra as a defensive mechanism. Few studies have been conducted on this racer, and those mostly on feeding behavior (Rodríguez-Robles 1992, Rodríguez-Robles and Leal 1993, Leal and Thomas 1994). Another racer, the **St. Croix Racer** (*Borikenophis sanctaecrucis*) is believed to be extinct (Philibosian and Yntema 1977, Platenberg and Powell 2016).

The small **Ground Snake** (*Magliophis exiguum*; Dipsadidae) is widespread across the Puerto Rican Bank, although absent from St. Croix. It rarely reaches lengths of 438 mm snout-vent length (Schwartz and Henderson 1991). This species occurs in coastal woodlands and moist upland forest under logs, rocks, and surface debris. Diurnal or crepuscular, the species is occasionally encountered as it travels along the forest floor or along roads and is more frequently encountered during rainy periods. Its diet consists of small vertebrates: frogs, dwarf geckos, and anoline lizards. Populations are stable in the USVI (Platenberg et al. 2016c).

Non-Native Species

The **Green Iguana** (*Iguana iguana*; Iguanidae) is a large, charismatic lizard that is a popular tourist icon. It is fairly common in the USVI, particularly around restaurants and tourist beaches where it basks in trees and readily accepts handouts, although it is also common in forested and agricultural areas where fruit and palatable vegetation (i.e., crops) are available. Primarily herbivorous, the iguanas are also opportunistic feeders that will take kitchen scraps, eggs, small vertebrates, and carrion (Conant and Collins 1998). This species is well adapted to human presence, and can often be found basking alongside roads and foraging in gardens.

Iguanas inhabit both xeric and mesic habitats to 800 m, occupying mangroves, bushes, trees, open rocky ground, cliffs, and rocky crevices. It is present on the main islands, but notably absent from most of the uninhabited cays (Cas, Whistling, and Steven cays being exceptions). Iguanas breed late January to early March, during which time many individuals are crushed on the roads. Eggs are laid in burrows under logs or other surface debris or in sand, and females can lay up to 75 eggs (López-Torres et al. 2012). Incubation lasts around 3 months. Young and adults are preyed upon by cats and dogs, although this species is abundant and widespread.

Green Iguanas are almost certainly introduced, although the origin and date of introduction is unknown. This species is native to Central and South America, and its present distribution extends across Puerto Rico, USVI, BVI and the Lesser Antilles. It is thought that this species was introduced to the islands by Pre-Colombian Indians, possibly to replace the native stout iguana as a food source (MacLean 1982). This species is a popular pet that is occasionally intentionally or unintentionally released; problematic populations of *I. iguana* in Puerto Rico were introduced in the 1970s as a result of the pet trade (López-Torres et al. 2012). There have likely been several introductions of this species from different locations over time.

Iguanas in the USVI are considered by many to be a pest species. Their interest in fruit, particularly ground fallen mangos, crops, and young vegetative growth attracts them in large numbers to these resources when available, and common complaints from farmers and resort landscapers are that the iguanas ate the entire crop or newly laid landscaping material in a single day. Additionally, their nest site excavations can undermine structures such as driveways and they pose a safety risk on runways in Puerto Rico where they are considered to be of high management concern as invasives (Engeman 2005). Previously this species was protected under local regulations, although this protection was rescinded in 2013 (30th Legislature of the Virgin Islands Bill No. 30-0277, 29 October 2013).

The **Tropical House Gecko** (*Hemidactylus mabouia*; Gekkonidae) is widely distributed across the West Indies and eastern South America, most likely introduced from Africa (Schwartz and Henderson 1991). This nocturnal species primarily occurs in and around houses where it forages for insects under artificial lighting, although it can also rarely be encountered in natural areas. Another introduced lizard, the **Turnip-tailed Gecko** (*Thecadactylus rapicauda*) is native to Central and northern South America, and is only present on St. Croix (Schwartz and Henderson

1991). It is unknown what possible impact these species may have on native reptile and amphibian populations.

The terrestrial **Red-footed Tortoise** (*Chelonoidis carbonaria*; Testudinidae) is widespread across St. Thomas, where it was likely introduced by Pre-Columbian colonizers centuries ago (MacLean 1982), and potentially augmented by introductions by early European settlers and more recent introductions as discarded or escaped pets (Schwartz and Henderson 1991). It has since become naturalized in the USVI. It inhabits forests and grasslands and consumes a diet of fruits, leaves, and flowers (Malhotra and Thorpe 1999). In the USVI this species is a popular pet, being easy to maintain in captivity where it breeds readily. It is likely that individuals are being released in various locations around the islands, with a potential of introducing diseases from captive stock to wild populations. The status of this species is unknown in the USVI, where it has not been studied.

The **Red-eared Slider** (*Trachemys scripta*; Emydidae) is a highly invasive freshwater turtle from the south-central U.S. It was most likely introduced to USVI via the pet trade. This species typically grows to approximately 20 cm, about the size of a dinner plate (Conant and Collins 1998). This turtle is highly adaptable and can withstand considerable temperature fluctuations and can tolerate brackish water. In the USVI this species is restricted to aquatic habitats, primarily freshwater ponds, including agricultural ponds and the ornamental ponds associated with resorts; it has also been observed in guts with permanent pools. It will eat anything from fish, frogs, insects, snails, crustaceans, vegetation, and human kitchen refuse. Some individuals are predated by dogs. This species can introduce diseases and where introduced elsewhere has had a significant deleterious impact on native ecosystems (e.g., Lovich 1996, Cadi and Joli 2004). The species can be controlled by trapping and destruction of eggs and hatchlings.

The **Antillean Slider** (*Trachemys stejnegeri*; Emydidae) is indigenous to the Antilles and is occasionally encountered on St. Thomas. One individual was retrieved from Brewers Bay, where it was observed floating on the water's surface near a dock (J. Stout, pers. comm., 2016). Others have been observed at agricultural ponds on St. Thomas' north side (R. Platenberg, pers. obs., 2006). It is unknown how these individuals arrived on the island or if they represent sustainable populations; it is known to occur on the islands of Vieques in Puerto Rico (Hedges 2016).

The **Corn Snake** (*Pantherophis guttatus*; Colubridae) has been present on St Thomas since at least the mid-1990s, likely arriving via cargo shipments. It appears to maintain a small population around Subbase on St. Thomas around the vicinity of the cargo docks, with occasional sightings more or less on a yearly basis. Despite one record of a gravid (dead) female in Smith Bay on the eastern side of St. Thomas (Platenberg 2007), the population appears to be restricted by roads to Subbase.

Boa Constrictors (*Boa constrictor*; Boidae) have recently become established on St. Croix, possibly in response to the closure of the Hovensa Refinery in 2012 when former refinery employees relocated off island and possibly released pets (Ellis 2017). Most of the more than 40 recovered *B. constrictor* were found on St. Croix's western part of the island. There is also a burgeoning population of *B. constrictor* on Puerto Rico that also originated from released pets.

The **Brahminy Blind Snake**, or Flowerpot Snake (*Indotyphlops braminus;* Typhlopidae) is a small (6.4 – 16.5cm) blind snake from southeastern Asia widely introduced to many topical localities through transportation in the soil of imported plants (Krysko and King 2010). They have a similar ecology to the VI Blind Snake and may perhaps be mistaken for them. Very little is known of their ecology or distribution in the USVI.

Species of Conservation Potential

The **Stout Iguana** (*Cyclura pinguis*, family Iguanidae) is native to Anegada, BVI, although its historical range may have included the entire Puerto Rican Bank. It is known from one fossil remain in a midden at Magen's Bay, St. Thomas (Pregill 1981), although there is some controversy as to whether this species ever inhabited the USVI (Platenberg 2006). This large stocky lizard, with male snout-vent lengths reaching over half a meter, inhabits dry, limestone areas. It is primarily herbivorous. Reasons for the decline of the species is due to predation by cats, with additional stresses caused by habitat modification, habitat and nest trampling by livestock, and predation by dogs and humans (Goodyear and Lazell 1994, Bradley and Gerber 2005). Successful translocations from Anegada to Guana Island and other islands in the BVI have occurred (Goodyear and Lazell 1994). Although there are currently no plans to release Stout Iguanas in the USVI, this should not be ruled out as a possibility.

Contributors (2005): RJP, FEH, DBM
Contributors (2017): RJP, JV

Banner photo: *Pholidoscelis polops* by J. Valiulis

2.4 Landbirds

Landbirds in the Virgin Islands consist primarily of songbirds, doves and pigeons, cuckoos, and raptors. More than half of the landbirds breeding in North America migrate southward to winter in the Caribbean, Central America, or South America. Collectively termed Nearctic migrants (Hayes 1995), these species exploit seasonal feeding opportunities throughout the year. Many Nearctic migratory landbirds, especially warblers, winter regularly within the USVI where they can be found in mature forest, mangroves, and occasionally shrubland habitat. Intratropical migratory landbirds comprise a small number of species that breed in the USVI and elsewhere in the Caribbean and migrate southward for the winter. In general, their wintering ranges are poorly known.

Because of their seasonal movements, migratory landbirds are vulnerable to adverse weather, predation, and navigational hazards during migration, and are sensitive to habitat reduction, fragmentation, and degradation in their breeding and wintering ranges and along their migratory pathways. The dramatic loss of habitat through activities such as forest clear cutting for plantations and wetland destruction or alteration for development have greatly reduced bird populations in the Virgin Islands (Raffaele 1989). A recent study, however, found that the maturation of forest is causing a return in community composition from shrubland species to forest species (Steadman et al. 2009).

Many birds that have generally been considered safe from decline or extinction will be affected by climate change. A recent study predicted that for each degree of warming, 100-500 additional bird extinctions will occur, 89% of which will be birds in the tropics (Şekercioğlu et al. 2012). The majority of birds that are found in the VI are migratory so they will be affected by climate change in all the locations through which they travel. Migratory birds that begin their journey based on temperature cues are likely to change the timing of their migrations, leaving them vulnerable to starvation if their refueling ground or destination does not have adequate food in synchrony with their arrival. Monitoring not only of birds, but also changes to key habitats will be important to tracking and possibly mitigating the impacts of climate change. It will also be important to monitor species that are on the fringes of their range to indicate large scale changes in distribution.

The bird species that are not migratory also face serious risk from climate change because they are adapted to a very specific set of habitat conditions. In fact, among landbirds, predictions are that range contractions will have a higher effect on tropical species, largely because tropical birds tend to have smaller ranges (Jetz et al. 2007). The well-established high degree of endemism in the tropics will be imperiled as birds attempt to change their ranges to find conditions to which they are adapted. As species assemblages are shuffled, the birds that are highly specialized to their unique island environments are unlikely to survive.

Ecological Value

The resident landbird community is composed of a diverse group including hummingbirds, raptors, doves and pigeons, cuckoos, songbirds, flycatchers, a mockingbird, a thrasher, a warbler, a bananaquit, and several finches. This suite of birds plays a key role in maintaining island habitats through seed dispersal, pollination and insect control. In island ecosystems such as the VI that do not have large native predatory mammals or reptiles, the large birds of prey, such as the red-tailed hawk (*Buteo jamaicensis*) are the apex predators, playing a key role in controlling the populations of lower trophic levels. Hummingbirds and the bananaquit are essential pollinators for many flowering plants. The mangrove cuckoo (*Coccyzus minor*), gray kingbird (*Tyrannus dominicensis*) and smooth-billed ani (*Crotophaga ani*) are so effective at insect control that they are a welcome sight on organic farms (L. Gasperi, pers. comm. 2017). The seed and fruit eaters such as the columbids, finches, and pearly-eyed thrasher (*Margarops fuscatus*) are key seed dispersers for all habitats, but forests in particular.

Threats

The loss, fragmentation, and degradation of habitat remains the primary threat to all birds in the USVI. Habitat destruction from development and agriculture results in the conversion of forests or wetlands to less diverse, less complex habitat. Invasive plant species also reduce landscape complexity or outcompete specialized plants necessary for habitat health. The White-crowned Pigeon is especially sensitive to habitat destruction because it is dependent upon coastal habitats for nesting, where development is most intense, and upland habitat for foraging for fruits and berries.

Other threats include predation, especially of eggs and young, by non-native predators including the feral cats (*Felis catus*) and the Small Indian Mongoose (*Herpestes auropunctatus*), collisions with vehicles and man-made structures, wanton destruction of nests by humans, and poisoning by insecticides, herbicides, and other chemicals. Tall, lighted structures cause considerable mortality during migration, especially on cloudy nights when birds often fly into them or their supporting structures. The increased popularity of wind energy could be harmful to landbirds if wind towers are placed in corridors or hotspots, while the increase in cellular towers in the USVI has an unknown impact.

The recent introduction of the Boa Constrictor (*Boa constrictor*) to St. Croix is a new threat to the island's avian community. On the Caribbean island of Aruba, birds composed the largest percentage of the introduced boas' diet (Quick et al. 2005). No stomach content analysis has been conducted on the boas on St. Croix and this should be a high priority action item to assess the impact of this invasive species on the island's avifauna.

Research and Management

For over a decade, refuge biologists at SPNWR have been mist netting and banding landbirds at the refuge. Data analysis for this long-term project is currently underway, but results are expected to reveal species diversity and seasonal breeding patterns (Lombard pers. comm. 2017).

Previous studies of migratory landbirds in the USVI have examined their abundance on different islands (Pashley 1988, Pashley and Martin 1988) or in different habitats (Askins et al. 1992, Wauer and Sladen 1992, Wunderle and Waide 1993), the impact of Hurricane Hugo on their abundance in these habitats (Askins and Ewert 1991, Wauer and Wunderle 1992), and flocking behavior (Ewert and Askins 1991). Each study focused primarily on the warblers, which represent the most species rich and conspicuous assemblage of migratory landbirds. Previous studies of intratropical migrants have only examined the abundance of Black-whiskered Vireos in different habitats (Robertson 1962, Wauer and Sladen 1992).

Other than these Nearctic migrants and some columbids, little is known about the population status of resident or migrant landbirds beyond general surveys of species composition and abundance, sometimes in broadly defined macrohabitat types such as moist forests or dry woodlands (Newton and Newton 1859a-d, Beatty 1930, Danforth 1930, Nichols 1943, Robertson 1962, Pashley 1988, Askins and Ewert 1991, Knowles and Amrani 1991, Wauer and Sladen 1992, Wauer and Wunderle 1992, Knowles 1996).

Studies on resident landbirds other than columbids in the USVI include the impact of Hurricane Hugo on species composition, abundance, and distribution on St. John (Askins and Ewert 1991) and St. Croix (Wauer and Wunderle 1992, McNair 2008.); the effects of introduced Roof Rats (*Rattus rattus*) on landbird diversity on offshore cays (Campbell 1991); the foraging ecology of nectivores (Leck 1973, Askins et al. 1987); the status of the Northern Mockingbird (*Mimus polyglottos*; Griscom 1921), the parasites of the Bananaquit (*Coereba flaveola*; Williams 1982) and the recovery of forest avian community composition as forests mature (Steadman et al. 2009).

Columbids have been the subject of numerous studies in the USVI because of their status as game species. There have been numerous studies on their general biology, status, and population estimates (e.g., Seaman 1949a, b, 1950, 1954c; Robertson 1962, Dammann 1977, Arendt et al. 1979, Norton 1979, 1980, Knowles 1999, Bancroft and Bowman 2001, McNair 2004, 2006), with other studies on the impact of Hurricane Hugo on populations (Askins and Ewert 1991, Wauer and Wunderle 1992), food (Seaman 1953a, b, 1954a, b), and parasites (Seaman 1954b). For White-crowned Pigeons, studies have focused on population estimates and breeding ecology (Knowles 1994, 1995, 1997; McNair and Lombard 2006, McNair, 2006, McNair 2008), post-fledgling distribution (Norton and Seaman 1985), and food (Seaman 1959); for Zenaida Dove, population estimates and breeding ecology (Nellis et al. 1984, McNair 2005) and food studies (Yntema and Sladen 1986); and for Bridled Quail-Dove, food studies (Seaman 1954c, 1966) and nesting (Chipley 1991).

Accomplishments since 2005

On St. Croix, a cooperative effort between the VI-DOA, Division of Forestry and TVIL to preserve the forested northwest of the island has resulted in the protection of large tracts of habitat for forest birds. This is a huge step forward in protection of landbirds for St. Croix.

Education and outreach opportunities focusing on avian conservation have increased in the Virgin Islands. At the time that this document is being completed, SEA is building a bird blind to provide wildlife viewing opportunities for the public at the Southgate Coastal Reserve. SEA has also partnered with BirdsCaribbean (a group focused on Conservation of Caribbean Birds) to do trainings for educators. Participants in these trainings learn about biology and conservation and are given a suite of activities to present to their students.

Nine sites in the Virgin Islands were recognized for their importance to international bird diversity by being declared "Important Bird Areas" by Bird Life International. These sites are The Northwest Cays (STT), Perseverance Bay Lagoons (STT), Brewer's Bay (STT), Saba Island and Cays (STT), Magen's Bay (STT), Mangrove Lagoon (STT), the entire island of St. John (STJ), Southgate and Green Cay (STX), and Great Pond (STX) (Corven 2008).

Conservation Priorities

Expand bird banding beyond SPNWR to include multiple sites and habitats on St. Croix. This will reveal habitat specific diversity patterns and may also identify bird movements between habitat patches. This information can further be used to protect movement corridors. Bird banding can also be expanded to St. Thomas and St. John to reveal movements between islands.

Much of the research and monitoring on St. Thomas has focused on seabirds, which are indeed the priority species for that island and its surrounding cays. However, given the rapid and ongoing development of natural areas on St. Thomas, monitoring and prioritization of breeding sites, wetlands and forested areas should also be included. Monitoring on all three islands should be ongoing through regular standardized surveys. The online bird survey data reporting site, ebird Caribbean (http://ebird.org/content/caribbean/) should be used to record and share bird observations.

The effects of the introduction and establishment of the red-tailed boa to St. Croix are unknown but should be a high priority for assessment. Stomach content analysis of boas and periodic bird surveys in areas of high snake density should be initiated immediately. Reducing the use of single-use plastics in the community and better solid waste management is needed to protect birds from ingesting plastic debris.

There are several protected areas where bird habitat has been degraded by conversion of forest to grassland, including the Southgate Coastal Reserve and Jack and Isaac Bay Preserve. Reforestation of areas such as these will increase available bird habitat on St. Croix.

Ecotourism and bird watching enterprises that focus on habitat conservation is a potential untapped source of revenue in the territory. Protection of forests, wetlands and ocean habitats can all be incorporated into visitors' desire to see rare and endemic species. Coordinate with BirdsCaribbean to extend the Caribbean Bird Trail to the USVI.

Post-hurricane needs: Frugivorous birds, such as the Scaly-naped Pigeon (*Patagioenas squamosa*) were significantly affected by food shortages after the 2017 hurricanes. It was a full three months after the storms before the native trees were even flowering, and the scaly-napes were collapsing on roadways and being crushed by cars (R. Platenberg, pers. obs). Nectivorous birds such as hummingbirds and bananaquits were also severely impacted and as of, one year after the storm, populations remain low. Population assessments should be completed for all landbirds. Habitats can be made more resilient by planting native fruit-bearing trees, such as pigeonberry (*Bourreria succulenta*).

Species of Greatest Conservation Need

Common Name	Scientific Name	Status
White Crowned Pigeon	*Patagioenas leucocephala*	High Risk
Bridled Quail Dove	*Geotrygon mystacea*	High Risk
Scaly-naped Pigeon	*Patagioenas squamosa*	Low Risk
Antillean Nighthawk	*Chordeiles gundlachii*	High Risk
Adelaide's Warbler	*Setophaga adelaide*	Data Deficient - Risk
Peregrine Falcon	*Falco peregrinus*	Low Risk
Caribbean Martin	*Progne dominicensis*	High Risk
Antillean Mango	*Anthracothorax dominicus*	Data Deficient - Risk
Antillean Crested Hummingbird	*Orthorhyncus cristatus*	Data Deficient - Risk

Species Accounts

There are seven hawks (families Accipitridae and Falconidae) recorded in the USVI, two residents, the **American Kestrel** (*Falco sparverius*) and the **Red-tailed Hawk** (*Buteo jamaicensis*). The other species, **Osprey** (*Pandion haliaetus*), **Northern Harrier** (*Circus cyaneus*), **Sharp-shinned Hawk** (*Accipiter striatus*), **Merlin** (*Falco columbarius*), and **Peregrine Falcon** (*Falco peregrinus*) are Nearctic migrants.

The **Peregrine Falcon** (*Falco peregrinus*) was formerly listed as federally endangered, although its populations have been recovering from the adverse effects of DDT, a banned pesticide, on its reproductive biology. It preys primarily on shorebirds, seabirds and waterfowl and thus is mostly found in wetland habitats. They are generally uncommon to rare in the VI and do not breed here.

The **American Kestrel** (*Falco sparverius*) is a permanent resident of North and South America from Alaska and Canada south to Tierra del Fuego, and across the West Indies. It is generally absent from heavily forested areas. It nests in tree cavities, crevices of buildings, and readily uses artificial nest boxes. It prefers open ground where it can easily hunt from high perches. American

Kestrel populations have declined in the Virgin Islands due to the loss of nesting habitat from development and hurricanes. During the breeding season, from February when the eggs are laid through to fledging, the kestrels are very aggressive towards intruders and perceived threats. DFW receives many complaints from the public during this time regarding attacks by these birds when they have nested in cavities in houses or nearby trees. The installation of artificial nest boxes away from the house and sealing the cavity reduce the likelihood of attacks. DFW has a program for installing nest boxes for kestrels in cases of nuisance animals.

The Virgin Islands subspecies of the **Puerto Rican Screech Owl** (*Megascops nudipes newtoni:* Strigidae) is thought to be extirpated from the USVI, and possibly extinct, with the possible exception of a few individuals on Culebra. This subspecies is distinct from the birds on the main island of Puerto Rico, which remain common. The Puerto Rican subspecies may be a candidate for reintroduction to the USVI, but further research into the status of the VI subspecies and the factors that caused its decline are necessary before such action is undertaken.

Pigeons and doves ("columbids"; family Columbidae) are an avifaunal feature of tropical and subtropical islands. Of ten species recorded in the USVI, seven have established populations: **Rock Pigeon** (*Columba livia*), **Scaly-naped Pigeon** (*Patagioenas squamosa*), **White-crowned Pigeon** (*P. leucocephala*), **White-winged Dove** (*Zenaida asiatica*), **Zenaida Dove** (*Z. aurita*), **Common Ground-Dove** (*Columbina passerina*), and **Bridled Quail-Dove** (*Geotrygon mystacea*). Scaly naped Pigeons suffered significant losses in the hurricanes of 2017 and have been slow to recover, thus the listing of data deficient and potentially at risk.

The **White Crowned Pigeon** (*Patagioenas leucocephala*) nests and roosts in mangroves and littoral forest on larger islands and cays (McNair and Lombard 2004, McNair and Lombard 2006, McNair 2006, McNair 2008). It forages mostly in littoral forest and less often in upland forests. Although once hunted, the White-crowned Pigeon has been protected in the USVI for over 40 years and should remain protected because of its pronounced long-term population decline and general low numbers in the Caribbean where large numbers are still shot, e.g., Dominican Republic (Robertson 1962, Dammann 1977, Arendt et al. 1979, Seaman 1980, 1993; Norton and Seaman 1985, Bancroft and Bowman 2001). Limited poaching may still occur on St. Croix, but has not been documented in over a decade. The White-crowned Pigeon is locally uncommon to common in St. Croix, but rare in St. John and on St. Thomas where it breeds at Mangrove Lagoon / Benner Bay.

The **Bridled Quail-Dove** (*Geotrygon mystacea*) resides in the forest interior of all three major islands, occurring at all elevations. It is fairly common on St. John, uncommon on northwestern St. Croix, and rare and local in forest guts of western St. Thomas. Its inter-island movements in response to hurricane effects remain undocumented, unlike many intra- and inter-island movements of other columbids (such as Scaly-naped Pigeons), yet quail-doves have reestablished a small population in northwestern St. Croix where they were thought to have become extirpated following Hurricane Hugo in 1989 (Wauer and Wunderle 1992).

The **Antillean Nighthawk** (*Chordeiles gundlachii*; family Caprimulgidae) is an intratropical migrant that is a rare to uncommon, local resident of open areas on the three main islands in the USVI, near the eastern periphery of its breeding range. St. Croix is the only island where they have been confirmed to nest, with a population of probably around ten pairs (McNair et al. 2005), but a pair likely breeds in St. Thomas (P. Dinisio and F. E. Hayes unpubl. data).

The **Caribbean Martin** (*Progne subis*; family Hirundinidae) is an uncommon, local intratropical migrant occurring throughout the USVI, where it breeds in cliff crevices along promontories, on a few cays (Nichols 1943), and in cavities in man-made structures (e.g., at the tip of the Frederiksted Pier on St. Croix; McNair et al. 2005).

The **White-necked Crow** once ranged throughout Puerto Rico and St. Croix, but has been extirpated from both territories and now can only be found on Hispaniola (Raffeale 1989) where it is declining. Its decline has been attributed to habitat alteration and hunting, although there is some thought that the spread of the nest-robbing Pearly Eyed thrasher has had a disproportionate impact on this species (Wiley 2006).

Three hummingbirds (family Trochilidae) are resident in the USVI. The nectivorous **Green-throated Carib** (*Eulampis holosericeus*) and the **Antillean Crested Hummingbird** (*Orthorhyncus cristatus*) are widely distributed and fairly common to forests and woodlands. However both species were significantly impacted by the hurricanes of 2017. The Antillean Crested Hummingbird is listed as data deficient and potentially at risk due to the combined impacts of the hurricane and the potential to be outcompeted by the Green-throated Carib. The **Antillean Mango** (*Anthracothorax dominicus*), listed as territorially endangered, is a relict Greater Antillean species restricted to the northern USVI. It is probably now extirpated, possibly through competition with the widespread and common Green-throated Carib (Robertson 1962).

Within the USVI 30 species of warblers (family Parulidae) are Nearctic migrants. Many of these warblers winter regularly within the USVI where the best habitat is mature continuous forest on St. John (Askins and Ewert 1991, Askins et al. 1992), and formerly, mature mangrove forest at Sugar Bay on St. Croix (Wauer and Sladen 1992). The most common wintering species include the **Northern Parula** (*Parula americana*), **Prairie** (*Dendroica discolor*) and **Black-and-white** (*Mniotilta varia*) **warblers**, **American Redstart** (*Setophaga ruticilla*), and **Northern Waterthrush** (*Seiurus noveboracensis*). Some other species such as the **Blackpoll** (*D. striata*) and **Connecticut** (*Oporornis agilis*) **warblers** occur primarily in the USVI and elsewhere in the eastern Caribbean as autumnal migrants (Arendt 1992, McNair et al. 2002, 2005). The **Adelaide's Warbler** (*Setophaga adelaidae*), an endemic species of Puerto Rico and Vieques, may be expanding its range into the northern U.S. Virgin Islands. A minimum of 14 individuals have been observed on St. Thomas or St. John between March 2012 and January 2016 (Rune and Conlon 2016, Veit et al 2016). The **Yellow Warbler** (*Dendroica petechia*) is a resident, inhabiting mangroves, lowland open woodland and scrub.

Contributors (2005): DBM, FEH, RJP
Contributor (2017): JV

Banner photo: *Orthorhyncus cristatus* by J. Valiulis

2.5 Waterbirds

The Virgin Islands hosts a rich diversity of waterbirds found in marshes, open water habitats and along shorelines. The majority of species found in the VI and throughout the Caribbean are migratory, most of which breed in North America and then fly south to the Caribbean, Central America or South America for the winter. Flocks of migratory waders rely on salt and freshwater ponds for winter survival or refueling along their migratory journey, feeding on fish, fiddler crabs, and other invertebrates or aquatic vegetation.

A significant loss of habitat through activities such as wetland destruction and alteration for development has greatly reduced wetland bird populations in the Virgin Islands (Raffaele 1989). The large flocks of waterbirds described as common by naturalists in the early 1900s (Seaman 1973) are now rarely seen and a number of species have been extirpated from the islands altogether. Although saline wetland habitats have decreased due to extensive development along the coast, man-made freshwater wetland habitat has increased, especially on golf courses and agricultural areas where ponds may provide a seasonal or year-round supply of freshwater.

Marshbirds include a heterogeneous assemblage of families: grebes (Podicipedidae), waders (Ardeidae, Threskiornithidae, and Poenicopteridae), and rails, gallinules, and coots (Rallidae). Shorebirds (families Charadriidae, Haematopidae, Recurvirostridae, and Scolopacidae) are long-billed, long-necked, and long-legged birds that typically feed on invertebrates along or near the shoreline or in short grasslands. Twenty-tree species of waterfowl (family Anatidae) have been recorded within the USVI, but only three have been documented to breed here. Non-breeding waterfowl comprise two groups: Nearctic migrants (15 species), which breed in North America and regularly or rarely winter during the non-breeding season in the USVI, and Intratropical migrants (four species), rare visitors that breed elsewhere in the Caribbean or South and Middle America.

In 2009 a whimbrel with a satellite tracking device was observed at Great Pond on St. Croix. A search for the research group that applied the transmitter revealed that this whimbrel named "Hope" was part of a study being conducted by the Center for Conservation Biology at the College of William and Mary, along with the Nature Conservancy in Virginia, in which satellite tracking devices were attached to Whimbrels to better understand their migration patterns. Whimbrels (*Numenius phaeopus*) are long-legged, brown shorebirds that migrate long distances with summer breeding grounds as far north as the Arctic Circle and wintering grounds as far away as southern South America. Hope's four day migration, from South Hampton Island in the northern Hudson Bay of Canada to St. Croix was the longest continuous flight ever recorded for a Whimbrel. Hope has overwintered at Great Pond nearly every year since 2009. Hope's annual journey to St. Croix has highlighted the importance of the wetlands of the VI to migratory birds and also the value of satellite tracking in revealing migratory patterns that could not be detected simply by banding birds.

Ecological Value

Waterbirds play key functional roles in wetland ecosystems, including as predators, herbivores and seed dispersers. They are also important in nutrient cycling. Many other organisms gain benefit from the sentry services of waterbirds that vocalize at potential predation threats (Green and Elmberg 2014). Waterbirds maintain the diversity of other organisms, control pests, and can be effective bioindicators of ecological conditions.

Threats

The loss, fragmentation, and degradation of wetland and shoreline habitat remains the primary threat to waterbirds in the USVI. The loss of mature mangrove forest on St. Croix, from the irreplaceable man-made destruction of Krause Lagoon in the early 1960s and natural elimination at Sugar Bay (part of the Salt River Bay system) by Hurricane Hugo in 1989 (McNair 2008) has seriously diminished species composition and abundance of Nearctic migrants on the big island. Other threats to waterbirds include collisions with vehicles and man-made structures, destruction of nests by humans, and poisoning by insecticides, herbicides, and other chemicals.

Wetland habitat can become degraded through water quality impairment from input of toxic pollutants and suspended sediment. Common sources of these pollutants include failing sewage infrastructure, road runoff, and development with poor or non-existent sediment control. Although regulations exist to prevent contamination of wetlands, they are rarely enforced. Invasive water plants such as water lettuce (*Pistia straitotes)* and water hyacinth (*Eichhoria crassipes)* can rapidly render healthy freshwater wetland habitat degraded and unusable for wetland birds. These plants form a thick blanket over the water's surface, acting as a physical barrier to access and can also alter the hydrology and the chemistry of the pond. Unfortunately, these plants are sold as ornamentals at some garden stores, despite being identified as invasives with high priority of control.

Other threats include predation, especially of eggs and young, by non-native predators including the Domestic Cat (*Felis catus*) and Small Indian Mongoose (*Herpestes auropunctatus*). The recent introduction of the Boa Constrictor (*Boa constrictor*) to St. Croix is a new threat to the island's avian community. On the Caribbean island of Aruba, birds composed the largest percentage of the introduced boas' diet (Quick et al. 2005). No stomach content analysis has been conducted on the boas on St. Croix and this should be a high priority action item to assess the impact of this invasive species on the island's avifauna.

Migratory birds are vulnerable to adverse weather, predation, and navigational hazards during migration, and are sensitive to habitat reduction, fragmentation, and degradation in their breeding and wintering ranges, and along their intervening migratory pathways, including the Eastern Caribbean (McNair et al. 2002). Loss of critical resources from development or land use change at stopping over sites diminishes survival prospects of these birds. Tall, lighted structures cause considerable mortality during migration, especially on cloudy nights when birds often fly into them or their supporting structures. The impact of proliferating cellular towers across the Territory is unknown, although USFWS guidelines for migratory birds were incorporated into the permitting process at an early stage. Although hunting of waterbirds is no longer legal in the USVI, it is still permitted on other islands and in other regions along migratory pathways with varying levels of regulation of bag limits. Flocks of migrating birds can be decimated if they land in the wrong wetland, particularly in an area with no hunting limits or limited enforcement. This underscores the need to participate in Caribbean-wide conservation efforts such as the working groups organized through *BirdsCaribbean*.

Many birds that have generally been considered safe from decline or extinction will be affected by climate change. A recent study predicted that for each degree of warming, 100-500 additional bird extinctions will occur, 89% of which will be birds in the tropics (Şekercioğlu et al. 2012). The majority of birds that are found in the VI are migratory so they will be affected by climate change effects in all the locations that they travel. Migratory birds that begin their journey based on temperature cues are likely change the timing of their migrations, leaving them vulnerable to starvation if their refueling ground or their destination does not have adequate food in synchrony with their arrival. Birds that rely on arctic nesting grounds, such as whimbrels, will have to move or will die out. Changes in ocean currents will change patterns of prey for birds that feed on marine life. Sea level rise may inundate salt ponds and mangroves, eliminating or reducing the amount of available habitat for the birds that rely on these habitats. Monitoring of birds and also changes to key habitats will be important to tracking and possibly mitigating the impacts of climate change. It will also be important to monitor species that are on the fringes of their range to indicate large scale changes in distribution.

The birds species that are not migratory also face serious risk from climate change because they are adapted to a very specific set of habitat conditions. The well-established high degree of endemism in the tropics will be imperiled as birds attempt to change their ranges to find conditions that they are adapted to. As species assemblages are shuffled, the birds that are highly specialized to their unique island environments are unlikely to survive.

Research and Management

Ornithological research in the Virgin Islands has focused primarily on species population status and distribution with periodic summaries and updates of ongoing monitoring. In recent years, research has been concentrated on breeding locations and habitats, especially on St. Croix, (McNair et al. 2005ab, McNair et al. 2006ab, Valiulis 2009). Breeding of American Coots was confirmed at Southgate Coastal Reserve (McNair and Cramer-Burke 2006). The status of the Least Grebe and Ruddy Duck was assessed, including breeding records (McNair et al. 2006b, McNair et al. 2008). The status and historical records of Cattle Egrets in the Virgin Islands were reviewed, including management concerns (McNair and Sladen 2007).

Previous studies of waterbirds in the USVI have focused on year-round surveys of non-breeding populations in saline environments (Norton et al. 1985, Norton, Yntema, and Sladen 1986; Norton, Sladen, and Yntema 1986; Knowles and Amrani 1991, Sladen 1992, Wauer and Sladen 1992, Knowles 1994, 1996), summaries of shorebird surveys (Norton 1982, 1983, 1984, 1985, 1986a-c, 1987), localities of the American Oystercatcher (Erdman 1964), the nesting ecology of the White-cheeked Pintail (Meier et al. 1989), the short-term impacts of Hurricane Hugo on waterbird populations (Wauer and Wunderle 1992), and the food habits of the Cattle Egret (Gassett et al. 2000).

Accomplishments since 2005

Regular monitoring of waterbirds has increased and is primarily conducted by a group of independent birders, including both professionals and unpaid experts. In addition, birders in St. Croix participate in the Caribbean Waterbird Census, a Caribbean wide effort to monitor the status and detect trends of birds in the region. These periodic surveys supplement the long standing Christmas Bird Count surveys that have been conducted for many decades on St. John and St. Croix. Least tern nesting is sporadically surveyed throughout St. Croix.

Education and outreach opportunities focusing on avian conservation have increased in the Virgin Islands. At the time that this document is being completed, SEA is building two bird blinds to provide wildlife viewing opportunities for the public at the Southgate Coastal Reserve. SEA has also partnered with BirdsCaribbean (a group focused on Conservation of Caribbean Birds) to do two trainings for educators. Participants in these trainings learn about biology and conservation and are given a suite of activities to present to their students. “Hope”, a whimbrel that has overwintered at Great Pond in St. Croix for multiple years while being satellite tracked for a study on long distance migration has served as an important outreach focus. The return of this bird each year to St. Croix is documented in the media and an award-winning children’s book about Hope and her travels has brought the importance of wetland conservation to a broad audience (Kessler 2013).

Nine sites in the Virgin Islands were recognized for their importance to international bird diversity by being declared “Important Bird Areas” by Bird Life International. These sites are The North-west Cays (STT), Perseverance Bay Lagoons (STT), Brewer’s Bay (STT), Saba Island and Cays (STT), Magens Bay (STT), Mangrove Lagoon (STT), the entire island of St. John (STJ), Southgate and Green Cay (STX), and Great Pond (STX) (Corven 2008).

Conservation Priorities

Suitable wetland habitats must be preserved, especially for shorebirds that require refueling during migration. Surveys on St. Croix identified priority sites for conservation of resident breeding waterbirds (McNair et al 2005b, McNair et al 2006a). Prioritization should extend to migratory species as well and surveys and prioritization should occur in St. Thomas and St. John.

Satellite tracking of migratory species reveals foraging areas and migration pathways, and can reveal movement patterns within and between islands This information can be used to identify key overwintering areas and stopover sites for protection.

Colonies of other ground nesting waterbirds, such as Wilson's Plovers, should be identified and managed to limit negative impacts from invasive predators, human disturbance and any other threats.

The focus of much of the research and monitoring on St. Thomas has been on seabirds, which are priority species for that island and its surrounding cays. However, given the rapid and ongoing development of natural areas on St. Thomas, monitoring and prioritization of breeding sites, wetlands and forested areas should also be included. Monitoring on all three islands should be ongoing through regular standardized surveys. Participation in Caribbean wide efforts, such as the Caribbean Waterbird Census will help regional efforts at conservation. The online bird survey data reporting site, ebird Caribbean (http://ebird.org/content/caribbean/) should be used to record and share bird observations.

The effects of the introduction and establishment of the red-tailed boa to St. Croix are unknown but should be a high priority for assessment. Stomach content analysis of boas and periodic bird surveys in areas of high snake density should be initiated immediately.

Enhanced community awareness of sensitive breeding areas on cays and in wetlands, along with increased enforcement should be initiated to limit visitation to these important areas during the breeding season. The reduction in the use of single-use plastics in the community and better solid waste management is needed to protect birds from ingesting plastic debris.

Ecotourism and bird watching enterprises that focus on habitat conservation is a potential untapped source of revenue in the territory. Protection of forests, wetlands and ocean habitats can all be incorporated into visitors' desire to see rare and endemic species. Coordinate with BirdsCaribbean is developing a Caribbean Bird Trail that could be extended to the USVI. The possibility of reintroducing extirpated species such as the West Indian Whistling Duck should be explored.

Post-hurricane needs: Mangroves and other wetland systems were severely impacted by the 2017 hurricanes. Because mangroves are slow to recover, some mangrove restoration may be required for more severely affected systems. Population assessments are required for waterbirds. However, many resident waterbirds benefited from full ponds and flowing guts after the hurricanes and had an extremely successful breeding season.

Species of Greatest Conservation Need

Common Name	Scientific Name	Status
Ruddy Duck	*Oxyura jamaicensis*	Low Risk
Masked Duck	*Nomonyx dominicus*	Data Deficient - Risk
Black-crowned Night Heron	*Nycticorax nycticorax*	Low Risk
Great Blue Heron	*Ardea herodias*	Low Risk
Great Egret	*Ardea alba*	Low Risk
Least Bittern	*Ixobrychus exilis*	Data Deficient - Risk
Snowy Egret	*Egretta thula*	Low Risk
Tri-colored Heron	*Egretta tricolor*	Low Risk
American Oystercatcher	*Haematopus palliatus*	High Risk
Red Knot	*Calidris canutus rufa*	Data Deficient Risk
Least Grebe	*Tachybaptus dominicus*	High Risk
Clapper Rail	*Rallus crepitans*	High Risk
Whimbrel	*Numenius phaeopus*	Low Risk
Willet	*Tringa semipalmata*	Low Risk
Semipalmated Sandpiper	*Calidris pusilla*	Low Risk
Piping Plover	*Charadrius melodus*	High Risk
Snowy Plover	*Charadrius nivosus*	High Risk
Wilson's Plover	*Charadrius wilsonia*	High Risk
Killdeer	*Charadrius vociferus*	Data Deficient - Risk

Species Accounts

The **White-cheeked Pintail** (*Anas bahamensis:* Anatidae) breeds on cays, especially those with salt ponds, and at or near a variety of wetlands on major islands. Its numbers appear to be increasing (McNair et al. 2005a), and they are increasingly found near resorts where they are fed by tourists, thus posing potential health risks in swimming pools and restaurants. Individuals tagged and banded in Puerto Rico and Culebra (Collazo and Bonilla-Martinez 2001) have been seen in St. Thomas, and one banded on Guana Island was recovered in the USVI (J. Lazell, pers. comm.), suggesting that genetic exchange may be frequent among island populations.

The **Ruddy Duck** (*Oxyura jamaicensis:* Anatidae) are rare breeders in the Virgin Islands (McNair et al 2006b). Recent drought conditions appear to have limited the available breeding habitat at Southgate, their primary known breeding site.. Non-breeding Ruddy Ducks, though rare, regularly visit the USVI year-round.

The **Masked Duck (***Nomonyx dominicus:* Anatidae*)* was first observed breeding in St. Croix in 2011, although there are other infrequent records of non-breeding masked ducks (Yntema et al 2017). They have been primarily observed in freshwater ponds at multiple locations on St. Croix. Given their tendency to prefer dense vegetation, their breeding population may be larger than previously thought.

The **Least Grebes** (*Tachybaptus dominicus:* Podicipedidae) breeds in freshwater ponds and a few salt ponds throughout the major islands of the USVI. They appear to require high water levels for breeding, but can breed in any month and will respond quickly when water levels become acceptable. Least Grebes are especially vulnerable to destruction and disturbance of breeding habitat (McNair et al 2008).

A suite of wading birds (family: Ardeidae) that rely on healthy wetland habitat may be vulnerable to the degradation and loss of this habitat. They are therefore considered vulnerable and should be monitored for evidence of decline. These include: **Great Blue Heron** (*Ardea herodias*), **Great Egret** (*A. alba*), **Snowy Egret** (*Egretta thula*), **Black-crowned Night-Heron** (*Nycticorax nycticorax*), and the **Tricolored Heron** (*E. tricolor*). The **Least Bittern** (*Ixobrychus exilis*) is a very rare visitor to the VI wetlands.

American Oystercatcher (*Haematopus palliatus:* Haematopodidae) – The Oystercatcher is a ground nesting shorebird regularly seen in the VI, although in small numbers. Nesting has been confirmed on St. Croix on Ruth Island (Valiulis pers. comm. 2017) and likely occurs at other locations with the stony rubble that they prefer. Little is known about the status of the American Oystercatcher in the VI, but like many other ground nesting birds it is vulnerable to predation and disturbance.

Willet (*Catoptrophorus semipalmatus:* Scolopacidae) - Raffaele (1989) reported that most willets recorded in the archipelago are migrants, with abundances ranging from rare to common on St. Croix depending on the time of year, very uncommon on St. Thomas, and rare on St. John year-round. A single willet nest has been observed during summer months in most recent years at Ruth Cay of the coast of St. Croix (Personal communication, C. Lombard, US Fish and Wildlife Service 2014). Willets nest on the ground nearby or along the fringes of wetlands. Maintaining and where possible expanding conservation efforts around potential habitat locations are the top priorities for this species.

Wilson's Plover (*Charadrius wilsoni:* Charadriidae*)* – Wilson's Plovers lay nests along beaches, berms, dry bottoms of salt ponds, and salt flats. As ground nesting birds, they are particularly vulnerable to depredation by mongoose, dogs, cats, rats and to impact by human intrusion into nesting colonies. An estimated 40 pairs of Wilson's Plover nest at ca. 17 sites on St. Croix (McNair, unpublished data), which is ca. 5% of the mainland United States breeding population (Morrison et al. 2001). Thus, the wetlands of St. Croix are of regional importance for the conservation of Wilson's Plover. Wilson's Plovers also nest in the northern USVI where they probably number no more than 15-20 pairs.

The federally endangered **Piping Plover** (*C. melodus:* Charadriidae) has occurred as a non-breeding vagrant during winter. Although it does not occur often enough in the VI to warrant specific targeted conservation measures, it will benefit from actions taken to protect similar species such as Wilson's Plovers.

Although they appear in the same family as waterbirds, **Killdeer (***Charadrius vociferous:* Charadriidae***),*** are terrestrial birds that prefer open areas and are often seen doing a "broken-wing" display to lure potential predators away from nests. As with other ground nesting birds, their eggs are susceptible to predation from whole host of predators including mongoose, dogs and cats. In addition, they are often found nesting in manicured lawns, leaving their nests susceptible to damage from lawn mowers. Although still fairly common in St. Croix, they have become extremely rare in the northern VI (L. Brannick, pers. comm. 2017). That, in conjunction with dramatic worldwide declines (Sauer et al 2013), leads to the local listing of data deficient. Killdeer are rarely found in popular bird observation areas and so we do not have sufficient data on their local status.

Species of Conservation Potential

The globally endangered **West Indian Whistling-Duck** (*Dendrocygna arborea:* Anatidae) formerly bred in St. Croix (Beatty 1930, Seaman 1993), but unregulated hunting and poaching have extirpated it from the Virgin Islands, although they still breed elsewhere in the Greater Antilles, the Bahamas, and some of the Lesser Antillean islands and populations are increasing (BirdLife International 2016). St. Croix has sufficient wetlands to support reintroduction of this species.

Contributors (2005): DBM, FEH, RJP
Contributor (2017): JV

Banner photo: *Nyctanassa violacea* by J. Valiulis

2.6 Seabirds

The USVI archipelago offers an important mosaic of protected insular habitats for resident and migratory seabirds. Of 39 species of seabirds recorded in the USVI, 15 breed here. Boobies (Sulidae), pelicans (Pelecanidae), and frigatebirds (Fregatidae) are resident year-round, although seasonal in their nesting activities. Most petrels and shearwaters (Procellariidae), storm-petrels (Hydrobatidae), tropicbirds (Phaethontidae), and jaegers, gulls, and terns (Laridae) are migratory, and present only during breeding or while migrating through. The pelagic distribution of many of these species is poorly known.

Most seabirds nest on cays where they are relatively protected from anthropogenic stressors. They can form large colonies: up to 30,000 pairs of mixed species breeders have been recorded on Saba Cay alone (Pierce 2009). Because of the importance of these insular habitats for seabirds, all the VI Government-owned cays have been designated as wildlife refuges and many of these habitats are managed specifically to enhance seabird breeding success. Due to habitat differences and availability of nest sites, different bird species nest on different cays. For example, Saba and Flat Islands harbor active rookeries during the summer months with nesting gulls and terns, while Cockroach is known for its winter-nesting boobies and tropicbirds.

Many seabird species are long-lived and are characterized by delayed maturity, single annual clutches, and low reproductive rates, so time scales for population processes are very long. With the exception of some tern species, most seabirds nest at the same colony site year after year, and rarely form new colonies. A single disturbance event, such as a hurricane, has the potential of destroying the entire reproductive output in a single year, but these events are infrequent and populations can withstand periodic losses. Site fidelity becomes a problem when the site is affected by a persistent threat, such as predation by introduced rats. Seabirds are primarily piscivorous except for storm-petrels, which predominantly forage on zooplankton, making them vulnerable to changes or declines in fish populations.

Ecological Value

Seabirds are important in the allochthonous transfer of nutrients from marine environments to nutrient poor soils on cays.

Threats

Seabird populations on cays of the USVI are threatened by a variety of factors. Seabirds tend to be ground nesting, which renders their nests vulnerable to predation and trampling from introduced rats and goats. Despite the relative inaccessibility of nest sites, intentional or unintentional human disturbance can have significant impacts. Seabirds may experience negative interactions with fishers, and declines in fish stocks can have significant impacts towards resource availability. Seabirds are also somewhat indiscriminate in what they eat, which can lead to bacterial infections, poisoning, or ingestion of plastics.

Introduced predators within nesting colonies, especially rats (*Rattus* spp.) are a significant cause of mortality to eggs and chicks, and clutch loss reduces overall nest success and ultimately recruitment. Introduced goats trample nests and vegetation; they are also selective browsers and will completely alter habitat structure, which can make the habitat unsuitable for nesting. The presence of fire ants (*Solenopsis* spp.) in seabird colonies is a major concern as these aggressive ants will feed on pipping eggs and chicks (Plentovich 2009). Minimal human disturbance, including even approaching the colony by boat, may result in exposure of eggs and small chicks to sun and high temperatures, causing mortality. Persistence of rats or other disturbances in seabird colonies over multiple breeding seasons may lead parents to abandon colonies altogether.

Other threats to seabirds include declining fish stocks, which may be partially due to overfishing as well as degradation of marine habitats. Entanglement in fishing line, embedded hooks, or ingestion of fishing gear cause prolonged decline in condition and typically lead to mortality. Pelicans, boobies, and frigatebirds are particularly susceptible to these impacts.

While there is little data on bioaccumulation of toxins, ingestion of plastics, and similar threats in the USVI, these are impacts that affect seabirds elsewhere and there is no reason to believe they are not causing harm here. Laughing Gulls succumb to environmental toxins but the impact of this threat on populations has not been studied.

Natural threats to seabirds include predation from Peregrine Falcons and Laughing Gulls. These are natural impacts that can potentially have a negative impact on populations that are already in decline due to other factors. This impact should be monitored and quantified but not managed unless the reduction of this stressor would significantly allow a population to rebound. Peregrine Falcons and Laughing gulls are both protected under the Migratory Bird Treaty Act, 1918.

Climate change is likely to have wide-ranging impacts on seabirds that affect food availability, timing of breeding and migration events, and exposure to storms or coastal erosion. Rising sea surface temperatures and increasing eutrophication may result in increased algal blooms and related algal toxicity, which may be underreported among seabirds (e.g., Shearn-Bochsler et al. 2014). Brevetoxin and saxitoxins from algal blooms has been suspected as the cause of mortality in the Lesser Scaup and seabird species, including terns and gulls, while cyanobacterial toxicosis has been suspected in mortalities of waterbirds and some gulls (US Geological Survey 1999). Diagnostic tools are limited, and it is difficult to discern the symptoms of these toxins from those of botulinum toxicity.

Migratory birds are vulnerable to adverse weather, predation, and navigational hazards during migration, and are sensitive to habitat reduction, fragmentation, and degradation in their breeding and wintering ranges, and also along their intervening migratory pathways, including the Eastern Caribbean (McNair et al. 2002).

Hurricanes and tropical storms potentially destroy nesting and roosting trees of some species, and alter wetland habitats, but their effects on waterbird populations are poorly known (Wauer and Wunderle 1992). Although storms are naturally occurring events, the ability of birds to recover after a storm is diminished by the influence of other threats.

Other threats include predation, especially of eggs and young, by non-native predators including the Domestic Cat (*Felis catus*) and Small Indian Mongoose (*Herpestes auropunctatus*), collisions with vehicles and man-made structures, wanton destruction of nests by humans, and poisoning by insecticides, herbicides, and other chemicals. Tall, lighted structures cause considerable mortality during migration, especially on cloudy nights when birds often fly into them or their supporting structures.

Research and Management

The DFW has eradicated rats from five cays thus far (Saba Island, Dutchcap Cay, Congo Cay, Buck Island and Capella Island) and monitors the presence of rats (the effectiveness of the eradication) by periodically trapping islands where rats have been eradicated as well as other islands with important seabird breeding colonies. When the presence of rats is detected, an action plan is in place to contract USDA-Wildlife Services to conduct eradication. Periodic rat control has occurred on Ruth Island (off of St. Croix) a nesting site for least terns.

Breeding seabirds in the USVI have been the subject of ongoing but somewhat sporadic long-term studies for several decades, primarily on their population status (e.g., Dewey and Nellis 1980, Halewyn and Norton 1984, Pierce 1996a, Chardine et al. 2000a, b, Jackson 2000, Lee 2000, Lindsey et al. 2000, Norton 2000, Saliva 2000a, b, Shreiber 2000, Walsh-McGehee 2000). Other studies include: the distribution of Pelecaniiformes at sea (Norton 1988b); the association of seabirds and game fish (Erdman 1978); the breeding biology of the Red-billed Tropicbird (Pierce 1992), Brown Booby (Nellis and Pierce 1990), Least Tern (Sladen and Pierce 1988), Sooty Tern (Pierce 1996b, 1997), and Brown Noddy (Orton-Palmer 1990); cross-fostering of Masked Booby with Brown Booby (Nellis and Pierce 1991); and botulism in the Laughing Gull (Norton 1986). Studies on pelicans include breeding surveys (Agardy et al. 1982, Nellis 1984, Van Halewyn and Norton 1984, Collazo and Klaas 1986, Pierce 1996a, Collazo et al. 1998, 2000), offshore distribution (Norton 1988b), nesting success and contaminant residues (Collazo et al. 1998), foraging behavior (Coblentz 1986), and mortality (Williams et al. 1992). Previous studies of Roseate Terns in the USVI have focused on population surveys and intercolony movements (USFWS 1987, 1993; Pierce 1996c, 2001; Douglas 2000, 2002; Saliva 2000), recoveries of individuals banded in the USVI on their wintering grounds (Hays et al. 1999), and aspects of their breeding biology (Norton 1988a). A recovery plan was developed for the Caribbean population (USFWS 1993).

Nesting and ecology of least terns on St. Croix has been the focus of research and conservation (Lombard et al 2010). Conservation measures such as construction of nesting platforms, fencing and signage around nesting grounds have been implemented with mixed success.

Accomplishments since 2005

DFW continues to monitor for the presence of rats and goats on cays with important seabird colonies. Rats have persisted on Congo Cay, despite considerable effort to eradicate them. Genetic analyses were conducted on Congo and three nearby cays to understand population origin and pathways of invasion of the rats; results suggest that rats are reinvading from nearby islands, implying that management should include simultaneous predator control on island groups (Savidge et al. 2012). Invasive vegetation was cleared from Cockroach in 2009 (Pierce 2012, W-23). Population surveys were conducted for pelicans, boobies, and Roseate Terns on several cays (Pierce 2012, W-23).

Efforts to reduce seabird entanglement in monofilament fishing line included targeted surveys and outreach to fishers (Pierce 2010, W-23). A project is currently ongoing to track regional movements of frigatebirds to determine foraging patterns to better target conservation messaging (Zaluski and Soanes 2015).

Brown Pelicans were delisted from the Endangered Species list in 2009 due to recovery across their range (USFWS 2009). The species had been on the ES list since 1970. The removal of this species represents a significant recovery of populations due to the removal of the organophosphate pesticide DDT and better protection for individuals and habitats. However, less than 5 months after the delisting, the BP Deepwater Horizon oil spill occurred in the Gulf of Mexico, which caused significant mortality to coastal and pelagic seabird populations. While the Caribbean populations of Brown Pelicans and other seabirds were relatively unscathed from this event, it presented a significant disturbance with lengthy repercussions. Some of the settlement funds have been committed towards seabird conservation within the Caribbean.

One direction that the BP settlement funds has gone is increasing capacity for seabird management across the region. The Caribbean Region currently lacks a coordinated, multi-stakeholder approach to seabird conservation through invasive species eradication. Although invasive vertebrates have been eradicated from 59 seabird islands, providing protection for at least 100 breeding colonies of 18 species across the Caribbean (Island Conservation 2015), the selection of individual islands for invasive species eradication is often driven by multiple factors including: funding constraints, jurisdictional mandates, availability of capacity, etc. Thus, invasive vertebrate eradications have been more opportunistic than targeted towards greatest need. A Structured Decision Making process was conducted in 2015 to identify priority ranking of cays for seabird conservation. The process focused on four priority species: Audubon's Shearwater, Bridled Tern, Red-billed Tropicbird and White-tailed Tropicbird, and, using the West Indian Breeding Seabird Atlas and (http://www.wicbirds.net/index.html) and expert consensus, identified the high value islands for these species that also have the highest feasibility for rat eradication. Congo Cay was the only island identified for the USVI (Island Conservation 2015).

Nine sites in the Virgin Islands were recognized for their importance to international bird diversity by being declared “Important Bird Areas” by Bird Life International (Corven 2008). These sites are The North-west Cays (STT), Perseverance Bay Lagoons (STT), Brewer’s Bay (STT), Saba Island and Cays (STT), Magen’s Bay (STT), Mangrove Lagoon (STT), the entire island of St. John (STJ), Southgate and Green Cay (STX), and Great Pond (STX).

Conservation Priorities

Seabird colonies require ongoing monitoring and management of invasive species, specifically rats, mice, goats, and plants that alter habitat structure. Colonies of other ground nesting birds, such as Wilson’s Plovers, should be identified and similarly managed for invasive predators and human disturbance. Habitat mapping and monitoring changes in vegetation structure can be used to trigger habitat management action.

Population structure and habitat use of colonies should continue to be monitored. Individual birds may be banded, with annual reports submitted to the bird banding network. Bird banding can be used to identify bird movements between habitat patches and between islands. This information can further be used to protect movement corridors. Banding programs should be discontinued or re-evaluated if banding activities result in large-scale negative impacts to the study populations. For example, there is some concern about the impact of banding on Masked Boobies, a species that has seen a steep decline in nesting in the VI (Nellis pers comm 2018). Alternative methods for monitoring colonies should be explored Satellite tracking of migratory species reveals foraging areas and migration pathways, information that can be used to develop spatial analyses of breeding populations to enhance a metapopulation approach to management that is also cross-jurisdictional. This information can also be used to identify key locations for targeting outreach efforts to reduce hunting, bycatch, and egg poaching threats.

Studies suggest that seabird management should target sites harboring large colonies because they have higher nest success and higher probability of site use in subsequent seasons (Lombard et al. 2010). Migration between colonies is likely for many species, indicating a need for coordinated management among populations on neighboring islands using a metapopulation approach. Estimates of age-specific survival and connectivity between sites are research priorities to develop appropriate management actions.

Enhanced community awareness of sensitive breeding areas on cays and in wetlands, along with increased enforcement should be initiated to limit visitation to these important areas during the breeding season. Ecotourism and bird watching enterprises that focus on habitat conservation is a potential untapped source of revenue in the territory. Protection of forests, wetlands and ocean habitats can all be incorporated into visitors’ desire to see rare and endemic species. Coordinate with BirdsCaribbean to extend the Caribbean Bird Trail to the USVI.

Reducing the use of single-use plastics in the community and better solid waste management is needed to protect birds from ingesting plastic debris. Working with the fishing community to reduce broken and cut monofilament lines will reduce impacts to birds accidentally hooked that then become entangled. Efforts to support local fish stocks by working with local fishers will benefit seabirds.

Post-hurricane needs: Most of the seabirds breed during the summer months, and the summer migrants had either departed or were ready to depart at the time the 2017 hurricanes arrived. Some individuals may have been affected by inclement weather in transit. The hurricanes likely altered the vegetation structure across the breeding grounds with the potential of allowing mammalian predators (rats) to increase. It is likely that the Frigatebirds on Tobago Island in the BVIs were severely affected because juveniles remain under parental care for a year or more, and they are unlikely to have been able to escape the storms. Replanting native shrubs (e.g., seagrapes *Coccoloba uvifera*) and conducting predator control and monitoring are key activities toward supporting seabirds in the USVI.

Species of Greatest Conservation Need

Common Name	**Species Name**	**Status**
Magnificent Frigatebird	*Fregata magnificens*	High Risk
Least Tern	*Sternula antillarum*	High Risk
Roseate Tern	*Sterna dougallii*	High Risk
Royal Tern	*Thalasseus maximus*	Low Risk
Sandwich Tern	*Thalasseus sandvicensis*	Low Risk
Red-billed Tropicbird	*Phaethon aethereus*	High Risk
White-tailed Tropicbird	*Phaethon lepturus*	High Risk
Masked Booby	*Sula dactylatra*	High Risk
Brown Booby	*Sula leucogaster*	High Risk
Red-footed Booby	*Sula sula*	High Risk
Audubon’s Shearwater	*Puffinus lherminieri*	High Risk
Brown Pelican	*Pelecanus occidentalis*	Low Risk

Species Accounts

The **Magnificent Frigatebird** (*Fregata magnificens*; Fregatidae) is a large seabird easily identified by its long forked tail. Frigatebirds are aptly named, after their propensity to mob other birds to steal their catch, and they rely on their agility to capture fish from the water’s surface, rather than plunge diving as do other seabirds. Frigatebirds have the longest reproductive period of the USVI seabirds, with an extended maternal investment of a year or more and delayed sexual maturity of up to eight years. Chicks and fledglings remain in the breeding colony being fed by both parents initially, then only by the female, who breeds at intervals of two or more years. The only current nesting colony in the region is on Tobago Island, BVI, where approximately 500-600 pairs nest (Lindsey et al. 2000, Pierce 2009).

Frigatebirds have declined across their range, presumably due to loss of breeding sites to coastal development. This doesn't adequately explain the extirpation of colonies, however, since a former nesting site in the USVI is Dutchcap Cay (30 pairs; Nichols 1943), an undeveloped island that has been designated and managed as a wildlife refuge. The presence of rats may be a more significant contributing factor.

The Tobago colony is threatened by the presence of goats that trample and remove vegetation leading to erosion and landslides within the breeding colony. Rats are also present on the island. A greater threat, however, to the Tobago colony is entanglement in fishing line. Frigatebirds will often following fishing vessels, occasionally snatching surface lures attached to monofilament line, particularly in cases of longline fishing. Experienced fishers will pull the bird in and extract the hook, but often the line is simply cut, and the bird flies off with an embedded hook trailing the line. The frigatebirds (as well as boobies and pelicans) trail the line back to the nesting colony where it accumulates in the habitat, snaring adults and young. On several monitoring visits to Tobago Island, personnel from DFW, BVI National Parks Trust, and the Jost Van Dyke Preservation Society have counted as many as of 60 dead frigatebirds on a single visit, entangled in fishing line at the breeding colony (Zaluski and Soanes 2015, J. Pierce, unpublished data,). The loss of so many birds may eventually overcome their reproductive potential to maintain a viable population in the USVI.

Efforts are underway to raise awareness of the implications of cutting fishing line (S. Zaluski, pers. comm.), and an important part of targeting effort in managing this threat is to understand the birds' foraging patterns. A project funded by UK Darwin Plus led by the University of Liverpool and the Jost Van Dykes Preservation Society in partnership with the Virgin Islands National Parks Trust and BVI Department of Conservation and Fisheries has been tracking the movements of the Tobago Frigatebirds (Zaluski and Soanes 2015). GPS tracking devices attached to several birds have been revealing patterns both of localized foraging and long-range movements; these birds regularly foraging across the USVI and the eastern and southern coasts of Puerto Rico, with males venturing as far as Cuba and Colombia on extended trips (http://www.atlanticseabirds.org/mafr-maps; S. Zaluski, pers. comm. 2016).

Audubon's Shearwaters (*Puffinus lherminieri*; Procellariidae) are migratory and pelagic, with a large range across Atlantic and Caribbean waters (BirdLife International 2016). Shearwaters are nocturnal and have strong nest site fidelity. In the USVI they nest primarily in natural cavities or self-excavated burrows in soft soils, usually under some form of shelter from vegetation. Nesting begins in December with chicks fledging in the summer. Chicks fledge at night and disoriented fledglings are periodically encountered on St. Thomas (Pierce, unpublished data). Small numbers (less than 50 pairs; Pierce 2009) currently nest on Cockroach Cay, Flat Cay, Saba Island, Sula Cay, and Frenchcap Cay (Pierce 1996a, Lee 2000), although the breeding distribution is not well known because active nesting burrows are difficult to locate and have not been systematically surveyed. The occurrence of additional nesting on other islands may be overlooked.

Across its range, declines have been attributed to predation by introduced species and by human consumption and loss of nesting sites to development (BirdLife International 2016), but little historical data is available for comparison. A report by Nichols (1943) of approximately 150 pairs on Saba Cay, where young were traditionally harvested for food by fishermen, suggests a significant decline locally. Audubon's Shearwaters have been identified regionally as a priority species for conservation action to evaluate status and increase numbers of breeding pairs (Lee 2000, Nytch 2015).

Two species of Tropicbirds (Phaethontidae) breed in the USVI; both have wide distributional ranges across tropical waters, but locally are identified as species of concern. The **White-tailed Tropicbird** (*Phaethon lepturus*) breeds primarily on Congo Cay, Hans Lollick Island, and Water Island off St. Thomas where the current population is thought to number less than 50 pairs (Pierce 1996a, Walsh-McGehee 2000). One or two pairs nest at cliff sites on the southside of St. Croix. Nichols (1943) reported 20 pairs nesting on Cas Cay; they no longer nest here suggesting a reduction in occupied nesting sites. The **Red-billed Tropicbird** (*Phaethon aethereus*) is more abundant, breeding on at least 14 cays off St. Thomas and St. John, with a current population estimate of 225-350 pairs (Walsh-McGehee 2000, Nytch 2015). There is little competition between species for nest sites due to non-overlap in breeding seasons in the USVI: White tailed tropic birds breed from April through August, Red-billed Tropicbirds breed from October through May; Pierce 1992) and a there are differences in nest site preference. Both species have strong nest site and mate fidelity.

The **Roseate Tern** (*Sterna dougallii dougallii*; Laridae) is a migratory species whose Caribbean populations are listed as Threatened under the ESA (USFWS 1987). Roseate Terns are ground nesters and Caribbean populations nest in open areas near vegetation, on narrow rock ledges, on steep slopes, or among coral rubble. Breeding populations in the USVI fluctuate between 500-2300 pairs (Pierce 2009). Although the breeding range of the Caribbean population is from Florida through the Caribbean to islands off Central America and northern South America, the largest colonies occur on the Puerto Rican Bank, in Puerto Rico and the Virgin Islands (Gochfeld et al. 1998, Saliva 2000). Roseate Terns may choose a suitable nesting location in one year and ignore it in other years, or they may choose the same islands in successive years. In the USVI, certain cays tend to be favored, including Kalkun Cay, Shark Island, Saba Island, and Pelican Cay off St. Thomas, and Leduck Island off St. John. None of the 17 breeding sites recorded in the USVI since 1987 has been used in every year. Banding studies in the early 1990s showed that individuals selected annual breeding sites within a range along the PR Bank, including cays off Puerto Rico, Culebra, USVI, and BVI, with resulting annual variation at each site. This supports a management regime that considers colonies stretching more than 60 kilometers of the Puerto Rican Bank from western Puerto Rico to the eastern BVI as a single management unit. This management need is being addressed by the CLCC Cays Conservation Action Team through the development of a management framework across jurisdictions that prioritizes metapopulation dynamics across these insular areas (Carruba et al. 2015).

Banding data have also revealed that some birds from Puerto Rico and the USVI spend the non-breeding season in Brazil, indicating a need to strengthen international collaboration in addressing threats to migratory birds.

Although small numbers of **Royal** (*S. maxima*) and **Sandwich Terns** (*Sterna sandvicensis*) from North American populations overwinter in the USVI, the remaining species depart from the USVI after the breeding season. The Sandwich and Royal Terns usually nest together in densely-packed colonies on several cays in the USVI. The Sandwich Terns (ca. 50-700 pairs) far outnumber the

Royal Terns (65-160 pairs). Both terns lay 1 egg and may nest on different islands in successive year. Previously, Dog Island, Turtledove Cay, and Pelican Cay supported most of the breeding populations, however these species have been reduced to almost exclusively relying on Dog Island for nesting. There have been no colonies on Pelican Cay since 2014 and only 12 Royal tern nests were recorded on Turtledove Cay in the 2017-2018 season (D. Nellis, pers. comm 2018). Once chicks are several days old, they crèche, or group together and are highly vulnerable to disturbance (Pierce, pers. obsv.). The **"Cayenne" Tern** (*S. s. eurygnatha*), currently considered a South American race of the Sandwich Tern, nests in small numbers among colonies of the Sandwich Tern, with which it hybridizes; the systematic relationship between the two taxa is poorly understood (Norton 1984, 2000, Hayes 2004).

The **Masked Booby** (*Sula dactylatra*; Sulidae) is the least common booby in the Virgin Islands and nests only at Cockroach Cay and adjoining Sula Cay where 45-75 pairs breed (Pierce 2009). The largest of the three booby species, the Masked Booby requires cleared areas in which to take flight, usually into the prevailing wind. Vegetation encroachment of sedge into nesting areas on Cockroach Cay appears to be gradually reducing nest sites. Masked Boobies lay two eggs per clutch but only raise a single chick, with the second egg acting as a type of insurance policy for loss of the first egg. Attempts to establish a second colony on Frenchcap Cay began in 1981, with one of the two eggs periodically transferred to Brown Booby (*S. leucogaster*) nests. The cross-fostering experiment achieved limited success with at least two pairs of Masked Boobies continuing to nest at Frenchcap Cay (Pierce 1996a, unpubl. data).

Despite being the most common and widely distributed Sulid in the Virgin Islands, local populations of the ground-nesting **Brown Booby** (*S. leucogaster*) appear to be steeply declining. Brown Boobies once nested on four offshore cays, with an estimated breeding population of 1000 pairs (Pierce 1996a). More recent counts indicate nesting numbers of less than 200 pairs (D. Nellis, pers. comm. 2018). Despite being in decline globally, Brown Boobies are listed by the IUCN as being of least concern (BirdLife International 2017). However local declines of this species have been far more drastic than worldwide declines. Continued monitoring is essential for this species, as is identification of local threats that may be mitigated.

The **Red-footed Booby** (*Sula sula*; Sulidae) is the smallest of the three booby species that nest in the USVI. The status of this species is uncertain and in fact have been locally extirpated (Nellis, pers comm. 2018). Red-footed Boobies were last known to breed on Dutchcap Cay, off St. Thomas where previously 100-150 pairs bred (Pierce 2009). A small number of Red-footed Boobies (2-21 nests) began nesting on Frenchcap Cay in the early 1980s (Pierce 1996a) but lost nesting habitat after Hurricane Marilyn (September 15, 1995) and nesting ceased in the late 1990s. The species has two color morphs, brown and white, but the white tail is a diagnostic feature that distinguishes this species from the Masked Booby in flight (similar to white morph) and sub-adult Brown Booby (similar to brown morph).

The **Brown Pelican** (*Pelecanus o. occidentalis*; see Shields 2002 for taxonomic summary) was the only seabird in the USVI listed as Endangered by the USFWS; it was delisted in 2009 due to recovery. Surveys within the territory have been conducted irregularly since the late 1970s. Breeding colonies occur on many cays mostly around St. Thomas and St. John, but also in smaller numbers off of St. Croix (Pierce 1996a, Collazo et al. 2000, C.D. Lombard and D.B. McNair, unpubl. data). Pelicans normally nest in trees and shrubs but after hurricanes may nest on fallen vegetation or on the ground (Pierce 1996a).

Non-breeding pelicans are widely distributed (Collazo and Klaas 1985, Collazo et al. 1998). In St. Croix, many birds are concentrated along the southwest coast where more food is apparently available. Large numbers of post-breeding birds apparently disperse from the USVI to Puerto Rico (Collazo et al. 1998). Small numbers occasionally roost at freshwater wetlands. The factors affecting the non-breeding abundance and distribution of Brown Pelicans in the USVI remain poorly studied.

Because of their large size, pelican eggs and chicks are more resistant to predation by the Roof Rat (*Rattus rattus*; Atkinson 1985, Campbell 1991). Nevertheless, removal of rats from cays where pelicans nest will undoubtedly benefit pelicans (J.J. Pierce, unpubl. data). The causal factors of population decline are apparently unrelated to roosting and nesting habitat loss or chemical contamination (Collazo et al. 1998), and have yet to be identified.

Least Tern (*S. antillarum antillarum*; Laridae) populations within the US interior are listed as Endangered on the ESA (USFWS 1985), but Caribbean populations are excluded under this listing. This species primarily nests on St. Croix, where the breeding population is currently 300-600 pairs (Nytch et al. 2015), although there are also nest sites on St. John and potentially on cays. On St. Croix, the Least Terns nest in various habitat types, including beaches, salt flats, dredge spoil piles, gravel parking lots, and the containment areas around storage tanks and roads at the former HOVENSA oil refinery. Predation by dogs, cats, and mongoose and human disturbance, including recreational driving on salt flats, are responsible for most nest failures. Available data suggest that the population has suffered a serious decline in St. Croix, and management effort includes fencing nest sites to protect from disturbance.

The **Brown Noddy** (*Anous stolidus*) is a fairly common breeding seabird. In the USVI, it nests in three habitat types: cliff ledges and small rock outcroppings, trees (only at Frenchcap Cay) and on the ground. Noddies lay a single egg at a time. An estimated 600-800 pairs of noddies nest at numerous cays with suitable habitat; the largest colonies are found on Saba Island and Frenchcap Cay. Brown Noddies exhibit a high degree of mate and nest site fidelity (Morris and Chardine 1992).

The widely-distributed **Laughing Gull** (*Larus atricilla*; Laridae) is the only gull that breeds in the USVI. The first migratory breeder to appear in the USVI during late March, nests are found from May through August on many of the cays; the estimated breeding population in the USVI is 2000-3000 pairs (Pierce 1996a, Chardine et al. 2000b).

Laughing Gulls routinely feed on food discarded by humans and have thus benefited from human activities, although they are also prone to botulism infections from feeding on decaying matter or maggots harboring *Clostridium botulinum*. Botulism poisoning causes paralysis and death. Early signs are inability of birds to hold their head up or take flight (USGS 1999). Gulls may be able survive mild infections if they are able to find a shaded location free of predation risk with access to clean water, and gulls respond positively to human intervention. In recent years, however, there have been several reports from members of the public of “hundreds” of dead Laughing Gulls in breeding colonies. Whether this mortality is caused by botulism or algal poisoning due to increasing eutrophication, or even if this is a normal level of mortality, is unknown.

Contributors (2005): JJP, FEH, DBM
Contributors (2017): RJP, JV

Banner photo: *Pelecanus occidentalis* by R. Platenberg

2.7 Terrestrial Mammals

Due to geographic isolation, the USVI is inhabited by few native species of terrestrial mammals, all of which are bats. At least two extinct mammalian species are known to have occurred on the Virgin Islands based on fossil records found in archaeological deposits: the Indian Hutia *Isolobodon portoricensis* (Morgan and Woods 1986, Woods 1996) and the insectivorous Puerto Rican Island Shrew *Nesophontes edithae* (Woods 1996).

The extant native terrestrial mammal fauna in the USVI is limited to six species of bats (Lindsay et al. 2008). Among terrestrial mammals, bats are the most successful colonists of small, isolated islands because of their strong dispersal abilities, small body sizes, and low trophic level. Bats provide important ecosystem services that benefit habitats, other species, and humans. Many locally important tropical fruits, such as banana, mango, soursop, mamey, guava, and seagrape are either pollinated or dispersed by bats (Kunz et al. 2011). Bats play an important role in forest regeneration through seed dispersal, particularly after hurricanes or other disturbances (Gannon and Willig 1994). Insectivores consume substantial numbers of insects nightly, many of which are agricultural pests or threats to human health (e.g., mosquitos that transmit diseases such as dengue fever, chikungunya, and zika, all of which have infected USVI residents and visitors). Bats in the USVI do not themselves transmit diseases to humans: no cases of rabies or other infectious diseases have been documented among bats in the USVI (Centers for Disease Control Travelers' Health, pers. comm., Oct 2015).

Bats occupy all terrestrial environments in the USVI. Important habitats are those that include water resources (natural and man-made freshwater ponds and spring-fed pools in guts), as well as a variety of flowering and fruiting trees and shrubs (garden centers and plant nurseries are particularly favored) (Lindsay et al. 2008). Roosting sites include caves, crevices in rocky cliffs, trees (both inside trunk cavities and amongst leaves in canopy), abandoned buildings and ruins, and in the roofs and walls of occupied human structures.

Other terrestrial mammals have been introduced into the Virgin Islands and across the Caribbean region throughout history. Early indigenous people brought guinea pigs and agoutis from South or Central America (and possibly tortoises and iguanas), Spanish and other European settlers introduced domesticated animals such as dogs, cats, goats, pigs, cattle, horses, and donkeys. They also brought pests: rats and mice were inadvertently introduced as hitchhikers. More recently species have been introduced as biocontrol, such as the mongoose that is widely accepted to have been introduced to control rats in the sugar cane plantations, but did a much more thorough job on island endemics instead.

Ecological Value

Bats are keystone species. They are key pollinators of tropical fruits and are important at maintaining forest diversity by dispersing seeds and nutrients. Insectivores consume an enormous amount of insects nightly, including mosquitos that carry diseases such as dengue.

Threats

Members of the community report that their bats "are missing"; there are many anecdotal accounts of people in the past watching a multitude of bats in the night, and now they claim that they don't see the bats anymore. Results from long-term monitoring on St. Thomas from 2009 show a decline over time in the number of bats observed, with annual and seasonal fluctuations (Platenberg 2012a and unpublished data). The primary cause of bat population declines is the loss, fragmentation, and degradation of habitat. Large bat roosts are vulnerable to disturbance or destruction by humans. While fruit-eating bats were previously considered pests to fruit growers, and previously experienced high levels of persecution (e.g., Bond and Seaman 1958), increasing public awareness in the community is showing shifting attitudes towards an appreciation of bats as important pollinators (J. Valiulis, pers. comm., Oct 2016).

Climate change is likely to have a significant impact on bats: the subtropical dry forests found in the USVI are highly dependent on seasonal precipitation and observed changes in weather patterns may result in a decrease of critical flower and fruit resources and potentially a reduction in forest cover (Rodríguez-Durán 2016). A shift towards renewable energy sources could potentially have a devastating effect on local species: a study conducted at a wind farm in western Puerto Rico found that all six species of bats found in the VI suffered mortality by wind turbines (Rodríguez-Durán and Fliciano-Robles 2015).

The non-native mammal species are not themselves of conservation concern, but they are of considerable management concern due to their negative impact on native systems. They pose threats to ground nesting species, including seabirds, shorebirds, sea turtles, and terrestrial reptiles, through direct predation (mongoose, rats, pigs, and dogs), trampling, or alteration of vegetation structure through selective grazing/browsing. Cats kill an enormous number of birds, frogs, lizards, and snakes, including the federally endangered VI Tree Boa (Platenberg and Boulon 2006, Platenberg 2016). Mongooses, like cats, will chase down an array of wildlife, and are frequently observed wrestling with iguanas (themselves non-native) much larger than themselves (R. Platenberg, pers. obs.).

Research and Management

Studies on bat populations on St. Thomas were initiated in 2006 by DFW (Platenberg 2008, 2012a, W-22 and W-24) and are currently being conducted at UVI (Platenberg, unpublished data). Previous studies of bats in the Virgin Islands include comments on their identification, distribution, and ecology (e.g., Starrett 1962, Koopman 1975, Lazell and Jarecki 1985), studies on the ecology, behavior, and physiology of the Antillean Fruit-eating Bat (Bond and Seaman 1958, Nellis 1971, McManus and Nellis 1972, Ehle 1977, Nellis and Ehle 1977) and Jamaican Fruit-eating Bat (Ehle 1977), and the evaluation of bat detectors and radio tracking for studying bats (Knowles 1992a, b). More recent surveys have been conducted on St. Thomas and St. John (Gannon 2003, Lindsay et al. 2008), and St. Croix (Kwiecinski 2012). Bat responses to natural disturbances and hurricanes have been studied on Puerto Rico (Gannon and Willig 1994, Jones et al. 2001). Gannon et al. (2005) provide a thorough discussion of the bats of Puerto Rico, including USVI species.

Studies on mongooses within the USVI include general biology (Nellis and Everard 1983, Hoagland and Kilpatrick 1999), predation impacts (Nellis and Small 1983, Nicolaus and Nellis 1987), social behavior (Mulligan and Nellis 1975), control (Coblentz and Coblentz 1985a, Nicolaus and Nellis 1987, Pollock and Hairston 2013), reproduction (Coblentz and Coblentz 1985b), population dynamics (Horst et al. 2001), and disease and parasite transmission (Townsend and Powers 2014, L. Keats, unpublished data, 2016). Considerable effort has been expended within the USVI to study and eradicate rats, especially from the cays (Seaman 1955, Boulon and Nellis 1985, Witmer et al. 1998, VINP 2002, Witmer et al. 2002, Varnham 2003, Pierce 2003, Savidge et al. 2012). USDA-APHIS has had a permanent presence in the USVI since around 2005 and have been involved in many of the control efforts on all three islands and surrounding cays, including within national park areas (e.g., VINP 2002).

Accomplishments since 2005

Prior to 2005 there was very little focus on bats in the USVI. The CWCS prioritized having a better understanding of the biology and ecology of local bats in order to address conservation needs. To this end, DFW contracted Island Resources Foundation (IRF) to conduct a study on the distribution of bats and their habitat associations and population parameters (Platenberg 2008, W-22). At the end of this three-year study, DFW continued conducting research on bats based on the recommendations from this initial study, to include an evaluation of bat house use in the VI and monthly monitoring of bat populations at the Magens Bay Watershed Preserve on St. Thomas (Platenberg 2012a, W-24). DFW also offered technical guidance to homeowners about bats inhabiting roof spaces. This work is now being conducted by the St. Thomas Bat Team, a voluntary group made up of community volunteers and UVI researchers. Research using bioacoustics is being conducted through UVI to assess bats as bioindicators of ecosystem health (Platenberg 2017).

Another important objective identified in the CWCS was to establish an educational program to inform the general public of the benefits of protecting bats and correcting misconceptions about bats. Since 2006 there have been public outreach events aimed at increasing public awareness and appreciation of local bats. On St. Thomas, the annual “Meet The Bats” is held at Magens Bay each October; this event started with a handful of participants and has grown to an event that showcases the value of local bats and the research conducted on them in the USVI, with attendance by over 150 participants that are guided by UVI student volunteers. SEA also conducts bat outreach at the Barren Spot Bat Tower on St. Croix, and the Friends of the VI National Park has included a bat night in their popular seminar series.

The control of non-native species was a high priority for most resources in the 2005 CWCS, and considerable effort has gone towards control and in some cases eradication of invasive mammals, although focused to areas of conservation concern. Rat control and monitoring on cays with seabird colonies is ongoing (USFWS Grants W-23, T-6). Under the ES programs funds were channeled toward mongoose control on Sandy Point and other turtle nesting beaches on St. Croix (Platenberg 2012b; USFWS Grant E-6). A study to develop methods for population estimation of deer was conducted on St. Croix (USFWS Grant W-23).

Conservation Priorities

Bats in the USVI will benefit from conservation of large forested tracts with connectivity. Land use planning and permitting that protects habitat surrounding proposed development, with an emphasis on forest communities rather than single large trees, will have a positive impact for a range of wildlife resources. Education within the community towards the value of bats and their ecosystem services towards dispelling fears are ongoing activities that should be supported. This includes providing training to pest control services to reduce inhumane destruction of roosts associated with human habitations, as well as reduction in pesticide use overall. A thorough assessment of conservation needs for bats within the USVI can be found in Lindsay et al. (2009).

Research on ecological parameters and species responses to stressors is limited, and some basic information such as locations of roost sites and use of habitat features is lacking. Data collection should be coordinated across agencies (DPNR, NPS, and USFWS) to optimize available resources. Climate change adaptation for bats may include establishing and protecting artificial water sources, increasing native fruit trees, and maintaining connectivity between forested areas. The increased use of power-generating wind turbines may result in increased mortality to bats, and these impacts need to be assessed.

Challenges in management of non-native mammals include an aversion from the community towards their eradication. There have been strong community responses on St. John towards efforts to control donkeys and deer (R. Boulon, pers. comm.; S. McKinley, pers. comm.), and similar responses from the local community towards the removal of goats on cays (J. Pierce, pers. comm., S. Zaluski, pers. comm.). Feral cats are a particular problem to control; feral populations are maintained by well-meaning individuals who are exceptionally passionate about their well-being (i.e., survival). The highest priority is to continue to control non-native species in areas of conservation concern, such as turtle nesting beaches and seabird colonies. The farming community is an important stakeholder, as farmers are adversely affected by crop damage by deer and they can be called upon to help restrict free-range movement of goats and cattle. NPS, APHIS, and DFW should coordinate efforts to develop a plan to reduce and control deer populations across the Territory. More research is required towards directing a control program for mongoose.

Post-hurricane needs: The frugivorous bats were severely affected by the 2017 hurricanes. The native fruit-bearing trees did not start flowering until three months after the storms, and there was little in the way of alternative food sources. *Brachyphylla cavernarum* were reported as entering houses searching for food, and responded to provisioning by people leaving fruit out. On St. Croix *Artibeus jamaicensis* were also reported as taking advantage of food provisioning. Post-hurricane mist-net surveys failed to locate any fruit eaters for the first eight months, and then only *A. jamaicensis*. Known bat roosts remained unoccupied months after the storms. A monitoring program across all three islands should be supported to gain information on recovery and resilience of these important species. Replacing non-native trees with native fruit trees (e.g., pigeonberry *Bourreria succulenta*, kapok *Ceiba pentandra*, royal palm *Roystonea borinquena*, and pig turd *Andira inermis*) is highly recommended to increase resilience of forests and increase provisioning capability.

Species of Greatest Conservation Need

Common Name	**Scientific Name**	**Status**
Red Fig-eating Bat	*Stenoderma rufum*	High Risk
Jamaican Fruit-eating Bat	*Artibeus jamaicensis*	Low Risk
Antillean Fruit-eating Bat	*Brachyphylla cavernarum*	Low Risk
Pallas's Mastiff Bat	*Molossus molossus*	Low Risk
Greater Bulldog Bat	*Noctilio leporinus*	Low Risk

Species Accounts

Species of Greatest Concern—*Stenoderma rufum*; Phyllostomidae

While there is much that is unknown about the population status of bats in the USVI, only *Stenoderma rufum* is considered an SGC due to limited geographic distribution, declining habitat availability, and low observation rates. It is listed as Near Threatened by the IUCN (Rodríguez-Durán 2016). There are no reliable estimates of population abundance of this species for any of the islands in the USVI, and most of what is known about this species is based on studies conducted at the Luquillo Experimental Forest in Puerto Rico (Gannon et al. 2005).

Although *Stenoderma* has been captured under mist-net effort on all three main USVI islands (Lindsay et al. 2008, Kweicinski and Coles 2007, R. Platenberg, unpublished data), it is rarely encountered and appears to be restricted to large undeveloped forested tracts that offer freshwater resources in the form of ponds and guts with spring-fed pools (R. Platenberg, unpublished data). This bat roosts alone in the forest canopy, possibly with little site fidelity (Gannon et al 2005). On St. Thomas the species has only been observed on the north-side, despite survey effort at other freshwater sites mid-island. The home range is reportedly small, about 2.5 hectares on average (Gannon et al 2005). Pregnant females have been captured on Puerto Rico in January, March, June, July and August; lactating bats are known from March, May, June and July in Puerto Rico (Gannon *et al.* 2005), and July, October, and December on St. Thomas (R. Platenberg, unpublished data). Only three individuals were encountered under intensive survey effort on St. Thomas between 2009 and 2015 (R. Platenberg, unpublished data).

The **Antillean Fruit-eating Bat** (*Brachyphylla cavernarum*; Phyllostomidae) is distributed in the Lesser Antilles, from Puerto Rico south to St. Vincent and Barbados (Rodriguez and Dávalos 2008). In the USVI it is rare across all habitats; population trends are unknown but likely stable. This species has experienced significant persecution in the past (Bond and Seaman 1958), but now receives better protection. This species roosts primarily in caves and will also use enclosed buildings, preferring more enclosed spaces with lower light exposure, such as inner rooms surrounded by walls rather than more open outer rooms. There are several known roost sites on St Croix in plantation mill and well towers, including the Barren Spot Bat Tower managed by SEA. There is also a colony inhabiting the Old Brugal Rum Factory, where *Artibeus* roost in the outer room and *Brachyphylla* in the darker inner room. On St. Thomas one known colony inhabits a coastal cliff crevice, and they are also known to inhabit sea caves.

This bat is encountered around pools, in guts, upland forests, and coastal woodlands. Pregnant females have been encountered in March, and lactating females in June and July, with young flying pups encountered in July. *Brachyphylla* roost sites are vulnerable to human disturbance. This species has a low tolerance for disturbance, and bats will fly in response. One maternity roost in a sea cave is known by charter boat captains who bring tourists in to experience the cave. The presence of human visitors to the cave during the breeding season disturbs the bats and results in the death of many of the pups (Platenberg, pers. obs.).

The **Jamaican Fruit-eating Bat** (*Artibeus jamaicensis*; Phyllostomidae) is native to Central and South America, and from the Bahamas throughout the Caribbean. The species is widespread and abundant across all habitats in the USVI, and its population trend is stable although potentially declining due to continued habitat loss. Climate change induced habitat change is likely to be an upcoming threat.

Artibeus typically roosts in large colonies in caves or cave-like structures, including Danish Plantation ruins. In the USVI, known roosts include the Reef Bay Rum Factory Ruins on St John and the Brugal Rum Factory on St Croix. None of the colony roost sites on St Thomas have been located; they likely roost in forested habitats in trees that offer sheltered roosting opportunities, such as dead hanging palm fronds (R. Platenberg, pers. obs.). Their diet consists of fruit, nectar, and pollen from both native and cultivated trees. They are wide-ranging foragers, and will congregate around rich food sources: fruiting trees will have many bat visitors nightly until the resource is depleted. They are often found in association with water such as swimming pools, ephemeral streams, and freshwater ponds (Lindsay et al. 2008). *Artibeus* is known for taking food to night roosts as well as the day roost, and as such play an important role in seed dispersal. In the Virgin Island *Artibeus* seems to undergo two distinct breeding seasons in mid-winter and summer (Platenberg 2012a), although it is unknown if females are able to breed twice a year.

The **Pallas's Mastiff Bat** (*Molossus molossus*; Molossidae) is widely distributed across the Caribbean, Central America, and South America. It is widespread and abundant across all habitats in the USVI, with a population trend that is likely declining, due to pesticide use and habitat loss. This species has also been impacted by evictions from roofs of occupied buildings.

This species roosts in small crevices, including cliff walls and roof cavities. Larger colonies (~20 individuals) tend to be found in more open spaces, such as attics, whereas individuals or small groups (presumably bachelor males) are often found in tight spaces, e.g., behind roof fascia. Corrugated metal roofs are popular roosting sites, bringing this species into conflict with humans. The diet of *Molossus* is insects, with moths and beetles being the preferred prey (Gannon et al. 2005). Each bat feeds nightly and typically consumes up to half its body weight, approx. 5-6g of insects nightly.

In the VI female *Molossus* are pregnant in June, synchronously giving birth to a single pup by the second week of July, with the first flying pups appearing in September (R. Platenberg, unpublished data). Lactation occurs from birth in July until November. Juvenile females are sexually mature within their first year, and are pregnant in their first summer. The reproductive timing is critical when conducting exclusions for bats living in roofs, as pups are left behind when females exit the roost to forage. Any exclusion between May and September is likely to affect survival and fitness of pregnant, lactating, and neonatal bats.

The **Greater Bulldog Bat** (*Noctilio leporinus*; Noctilionidae) has a wide distribution across the Caribbean, Central America, and South America; In the VI it is common across coastal habitats; populations are stable although abundance is lower in the VI than for populations elsewhere. Limiting resources are likely to be suitable roosting sites more than diet. This species roosts in colonies comprised of one to several males and a number of females and juveniles (Gannon et al. 2005). They roost in caves and hollow trees. This species exhibits a large home range that may traverse the island, and tagged individuals have been observed at different sites across the northside of St Thomas (Platenberg, unpublished data). Single roost sites are critically important to the population. This species is associated with coastal habitats and can also be encountered in stream channels and at freshwater ponds. These bats are a frequent visitor to swimming pools near beaches. Females are pregnant in the spring and summer, from April to July. Very pregnant females have been encountered in May and June/July, which suggests two breeding periods. Lactating females are encountered in January, February, April, and July (R. Platenberg, unpublished data).

The **Brazilian Free-tailed Bat** (*Tadarida brasiliensis*; Molossidae) is a widely distributed migratory species that occurs across the Caribbean and Central and South America. This insectivorous species has been recorded in the USVI on only rare occasions, and its presence is best explained as a vagrant from neighboring islands. The limiting factor for this species in the USVI is the absence of large cave systems; this species typically roosts in large colonies in large cave systems. It has been captured under mist-net surveys on one location on St. John (Lindsay et al. 2008), but not on St. Thomas or St. Croix (Kwiecinski 2012). It is unlikely that the small islands within the USVI have sufficient resources, particularly roosting sites, to support populations of both insectivorous *M. molossus* and *T. brasiliensis.*

Twelve species of mammals have established feral or free-ranging populations: Small Indian Mongoose (*Herpestes auropuncatus*), Black Rat (*Rattus rattus*), Brown Rat (*Rattus norvegicus*), Wild Hog (*Sus scrofa*), White-tailed Deer (*Odocoileus virginianus*), Goat (*Capra hircus*), Donkey (*Equus asinus*), Horse (*Equus caballus*), as well as Domestic Cat (*Felis catus*), Domestic Dog (*Canis familiaris*), Cow (*Bos taurus*), and House Mouse (*Mus musculus*).

The **Small Indian Mongoose** (*Herpestes auropunctatus*) was initially introduced to the Caribbean in 1872 via Jamaica, as a biological control for rats (*Rattus rattus*) in sugar cane plantations (Espeut 1882). Due to apparent early success at rat control, the mongoose was soon introduced to all cane-growing islands (Nellis and Everard 1983). However, its diurnal habits, versus the nocturnal ones of rats, and the ability of rats to climb high in trees, while mongoose were stuck on the ground, rendered its role of rat catcher ineffective. This small carnivore has flourished where introduced, and has had severe detrimental impacts on native species. The presumed extinction of the St. Croix Racer (*Borikenophis sanctaecrucis*) and extirpation of the St. Croix Ground Lizard (*Ameiva polops*) from St. Croix are both attributed to the mongoose (Nellis and Everard 1983, Platenberg and Powell 2016), although widescale deforestation was almost certainly a contributing factor. They are known to prey on sea turtle eggs (Nellis and Small 1983, Valiulis and Mackay 2011). Barbour (1930) listed Water Island, among others, as being mongoose free, which may explain the presence of the Puerto Rican Racer (*Borikenophis portoricensis*) on that island but not on the other main inhabited islands of the USVI (Platenberg 2005, Platenberg and Boulon 2006). Mongooses have had devastating impacts on herpetofauna throughout the West Indies (Powell and Henderson 2005). Mongoose are known to be a reservoir for rabies in Puerto Rico (Everard and Everard1992), although rabies has not been isolated from specimens in the USVI. Mongoose in Grenada were found to have been exposed to *Toxoplasma gondii* and may, like cats, be a local vector for transmission (Choudhary et al. 2013).

Two species of rats have colonized the USVI, the **Black Rat** (*Rattus rattus*) and the **Brown Rat** (*R. norvegicus*). The black rat arrived with the early European explorers and settlers, whereas the brown rat is a more recent invader, most likely transported via cargo ships. Although commensal with humans, rats can survive away from human habitation, and have successfully established populations on the cays in the USVI (see sections on cays and seabirds). Rats are omnivorous and will opportunistically eat eggs, chicks, fledglings, small birds, lizards, snakes, and frogs when encountered. These animals have had a serious negative impact on insular wildlife populations (Campbell 1991).

Wild Hogs (*Sus scrofa*) were first introduced to the West Indies by Christopher Columbus in 1493, and the Danes brought hogs to St. John in 1718 when they colonized the island. Wild hogs have established breeding populations in all habitat types, particularly within the VINP (VINP 2003).

The success of wild hogs on St. John can be attributed to the lack of natural predators, prolific reproduction, and their omnivorous diet. There are no practical methods to census wild hogs and the populations can fluctuate drastically with available food resources. The population on St. John is known to oscillate widely between climatic episodes. During drought years, hog numbers have been estimated to be between 200 and 300 within the VINP, and in years with normal rainfall, numbers have been estimated to be as high as 800 animals (VINP 2003). The distribution and population abundance on St. Thomas and St. Croix have not been assessed. NPS and APHIS have been steadily working toward reducing those population numbers and subsequent impacts.

The effects of wild hogs on natural resources result from their movements, habitat utilization and food habits (Ackerman et. al. 1978; Barrett and Stone 1983). They have both direct and indirect effects on plant species, including some that are rare, threatened, endangered or endemic to St. John. Plants are eaten, trampled or uprooted by hogs, and their rooting may reduce understory cover, resulting in changes in forest structure and composition. Rooting adjacent to small streams and springs (guts) often results in high rates of soil erosion, which severely affects aquatic habitats. Wild hogs negatively affect the fauna of the USVI through direct predation, habitat alteration, and competition for food. Areas uprooted by hogs undergo notable declines in small mammal and reptile populations (Singer et. al. 1982). Hogs may consume the eggs, chicks and adults of such territorially threatened and endangered species as the Bridled Quail Dove (*Geotrygon mystacea*) and White-cheeked Pintail Duck (*Anas bahamensis*). Wild hogs may also carry infectious and parasitic diseases, such as hog cholera, swine brucellosis, trichinosis, foot and mouth disease, African swine fever, and pseudo-rabies, all of which may be transmitted to livestock.

The **White-tailed Deer**, *Odocoileus virginianus*, ranges from eastern North America southward through Central America to northern South America. They are thought to have been introduced to the USVI from the southern USA in 1790 or possibly earlier. The deer are noted for having a small home range, which has prevented them from becoming exterminated in many places. In the Northern USVI, deer swim among the smaller offshore cays and the main islands of St. Thomas and St. John. They are perfectly at home in the thick woodlands of the USVI, and readily adapt to areas near human habitation and activity.

Deer have no natural predators in the USVI, however, they are sometimes poached by humans (deer hunting is illegal), attacked by dogs, and are occasionally struck by vehicles. They can serve as hosts for ticks that carry cattle fever. Their impact on native vegetation is undetermined. A study was conducted on the feasibility of establishing a hunting program for deer (Swanbeck 1987). Periodic efforts at assessing the distribution and population of the deer in the VI have been attempted but none have been successful, largely because standard survey methods for deer do not work in thick tropical forests. The most recent study was initiated in 2007 by DFW, however staff turnover left this study incomplete.

Goats (*Capra hircus*) are established in free-ranging herds on the main islands and cays. Christopher Columbus brought goats to West Indies in 1493, and the Danes brought goats to St. John in 1718 when they colonized the island (VINP 2004). It is likely that goats were already established on other islands within the USVI because of the practice of early European explorers to leave goats on islands to provide a source of fresh meat during future visits. Local residents also release goats on cays. A conservative estimate of goats within the VINP is between 600-1000 animals (VINP 2004).

Goats are selective browsers, tending to graze small shrubs and grasses close to the ground, although they are capable of denuding large areas of vegetation. The spread of non-native weeds is facilitated by goats, by seed transport and removal of vegetation cover by trampling. Impacts of goats include the reduction of plant cover, increased soil erosion, and sedimentation and nutrient loading of ephemeral streams and salt ponds. Goats can also degrade the scientific value of historical and cultural sites. Goats on cays threaten sea bird colonies by altering vegetation structure and trampling nests (see sections on seabirds and cays). The VINP has initiated a goat reduction plan within the park (VINP 2004), and DFW in conjunction with USDA has been successful at removing goats from cays containing important seabird colonies.

Donkeys (or Burros; *Equus asinus*) were used extensively in the plantation era and beyond for transportation and to operate sugar mills. Although the need for donkeys has declined, they persist in feral populations, especially on St. John where they have become a popular tourist attraction. Efforts to reduce donkey populations have been met with resistance from the community (R. Boulon, pers. comm.). There are also feral populations of **Horses** (*Equus caballus*) on St. Croix. These species present similar impacts to natural ecosystems as goats with their trampling and grazing. The population level of feral donkeys and horses within the USVI is unknown.

2005 Contributors: RJP, FEH, DBM
2017 Contributors: RJP, JV

Banner photo: *Artibeus jamaicensis* by R. Platenberg

2.8 Sea Turtles

Four species of sea turtles forage and nest within the territory, all of which are federally protected. St. Croix hosts one of the most important nesting sites in the United States for the federally endangered Leatherback Turtle (*Dermochelys coriacea*). The federally endangered Hawksbill (*Eretmochelys imbricata*) and the federally threatened Green Turtle (*Chelonia mydas*) forage near and nest on all of the islands. The federally threatened Loggerhead Turtle (*Caretta caretta*) has also been observed nesting around St. Croix, with rare observations of foraging around St. Thomas (J. Cassell, pers. comm., documented in stjohnsource.com 2.20.2017).

Sea turtles spend the majority of their lives in the ocean, with females coming onto land only to nest. The majority of research on sea turtles is focused on nesting ecology, although with advances in tracking technology, we are learning more about in water ecology and the biology of male sea turtles (e.g., Hillbrand 2017). Nests are laid on sandy beaches where eggs incubate for approximately 60 days, depending on species and environmental conditions. During incubation, developing embryos are susceptible to a variety of threats including predation, desiccation, beach erosion, inundation, environmental contaminants and insufficient gas exchange. Like many other reptiles, sea turtles experience temperature sex determination. The temperature during a key period during incubation will determine whether the turtle will be male or female, with higher temperatures producing females and lower temperatures producing males.

Once turtles hatch, they must dig through the sand to the surface and make their way to the ocean. This crawl down the beach to the water generally occurs in the evening or at night to reduce the possibility of predation or desiccation in the hot daytime sun. Hatchlings navigate to the water using the reflection of the moonlight on the water.

Much of what happens to sea turtles from the time they reach the ocean as hatchlings to the time they return to nest as adults is unknown and is often referred to as the “lost years”. Leatherbacks, in particular, are highly pelagic species and are rarely observed in the ocean at any stage other than adulthood. Green turtles and hawksbills can be seen feeding along coastlines as juveniles. It is likely that during these lost years, young turtles focus on feeding to reach reproductive size and there is some thought at they do this while circulating on the large circular ocean currents, often in association with floating mats of sargassum seaweed.

Sea turtle experiences are popular tourist attractions in the Virgin Islands. Snorkel trips or nesting watches that give people the opportunity to see turtles are extremely popular. Indeed, some visitors to the island plan their vacations around this possibility. The value of sea turtles to the VI economy should not be underestimated.

Sea turtles are in decline globally due to threats to both their marine and terrestrial environments. They migrate through many jurisdictional waters, which are subject to different regulations and varying levels of protection. Although sea turtles are protected under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), banning commercial trade between countries, sea turtles are still vulnerable to local threats, including legal harvest, illegal poaching, incidental catch, pollution, depredation by invasive species and habitat destruction. The Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), aims to address these local issues.

Ecological Value

Green turtles maintain seagrass bed diversity through grazing, preventing more competitive species from becoming dominant; constant grazing also increases growth rates of seagrasses. Hawksbills graze on sponges on coral reefs, which hinders coral overgrowth. Leatherbacks feed on jellyfish that feed on larval fish, thus keeping populations of jellyfish in check which in turn reduces predation pressure on fish. Sea turtle nests provide an important allochthonous nutrient input into sand dunes, which supports beach vegetation that help to stabilize shorelines and filter terrigenous runoff.

Threats

Threats to sea turtle populations are many. Nesting beaches are threatened by erosion, erosion control methods, sand mining and beach nourishment, and increased human presence including recreational equipment and beach vehicular impacts. Beaches in the USVI are under the continuous threat of resort development or other threats (e.g., dredging: http://greenervi.org/issues/lindbergh-bay/), which in many cases equates to a complete elimination of the nesting habitat. Threats to nesting females and hatchlings include poaching, dog attacks, beach lighting, beach structures that impede female movement, and compaction of nests by vehicles and livestock. Nests and hatchlings are depredated by mongooses (Nellis and Small 1983, Valiulis and Mackay 2011), as well as by dogs, rats, and pigs.

Lighting along sea turtle nesting beaches from hotels, condominiums, street lights and any other artificial source regularly causes nesting females and emerging hatchlings to become disoriented on their way to the ocean. Turtles use the reflection of the moonlight off of the water to orient themselves to the ocean, but when there is a brighter light, such as that from an artificial source, the turtles may follow that instead. This is a common occurrence throughout St. Croix where lights cause turtles to venture away from the ocean and become trapped in swimming pools, run over by cars in roads, die from heat exposure, dehydration, or predator attack.

In addition to lighting, turtles face other threats on land from large developments such as beach resorts. Turtles can and do get caught in beach furniture, umbrellas are plunged into the sand and through turtle nests, and curious tourists harass turtles with flashlights and photography while the turtles are nesting or hatching. When turtles do successfully nest on resort beaches, known nests are not reported or properly protected. Many beach establishments do not have plans in place for turtle nesting and when it occurs the establishments are unprepared, which can lead to threats from disorientation to trampling of hatchlings from the crowds of people drawn in to observe the event. Guidelines are available (Choi and Eckert 2009) but these are not widely utilized.

One particularly harmful practice is that of beach "nourishment" in which volumes of sand are added to a beach to replace sand that has eroded away. The addition of large volumes of sand can alter important nesting parameters of the beach. For nesting females, beach nourishment can cause beach compaction and alter the geometry of the nest, decreasing the turtle's ability to successfully dig a nest or decrease her ability to properly cover the nest. For embryos and hatchlings, the addition of sand can alter the specific conditions that eggs need to develop, including hydrology, gas exchange, sand compaction, available nutrients, thermal environment and contaminant levels (Crain et al 1995).

Other recreational activities such as driving on the sand, beach fires, trampling by livestock cause harm to incubating turtle nests throughout the islands. Unleased dogs attack nesting females and dig up nests, which are also vulnerable to predation from mongoose and other predators. Egg poaching is still a problem in the USVI.

In the marine environment, threats include incidental catch in fishing gear, ingestion and entanglement of debris, especially plastics, and damage to sheltering and foraging grounds such as coral reefs and seagrass beds. Poor water quality from pollution, including sewage, agricultural and industrial runoff, and oil spills, affect sea turtle health, and any proposed oil and gas exploration and development will increase these impacts. Collisions with boats is a significant cause of mortality in the VI (STAR, unpublished data), and at-sea poaching is still a problem in the USVI, despite legal protection mechanisms. An additional stressor to green sea turtles is the incidence of fibropapilloma, a lethal tumor-causing disease, the causes of which are unknown but likely related to poor water quality (Jones et al. 2016). Leatherback turtles nesting at SPNWR appear to be experiencing increased attacks by sharks, based on the examination of wounds on nesting females (C. Lombard, pers. comm., 2017). This may be the result of decreasing prey base for sharks.

Climate change is likely to have a devastating effect on sea turtle populations worldwide. Sea level rise is already reducing available nesting beaches (Butt et al. 2016), temperature changes are altering sex ratios of developing embryos towards a majority of females (Santidrián Tomillo et al. 2012, Laloë et al. 2016), and changes in storm frequency and other environmental factors are affecting nest persistence and hatch success of turtle nests. Changing ocean currents may alter foraging and migration patterns. Several studies conducted in the USVI have begun to address some of these issues or to at least provide some baseline information that can be used for comparison in the future (Weston 2013, Robinson et al. 2014, Stewart and Dutton 2014, Santidriàn Tomillo et al. 2015, Neeman et al. 2015).

Research and Management

Much of the information on marine turtles in the USVI is derived from nesting activities, especially in St. Croix, where there has been a long history of sea turtle research and conservation. A monitoring program was established by the DFW at the Sandy Point National Wildlife Refuge in 1981, and since then teams of researchers and volunteers have participated in this project (Eckert et al. 1984, Eckert and Eckert 1983, 1985, Basford et al. 1986, 1988, 1990, Brandner et al. 1987, 1989, McDonald et al. 1991, 1993, 1995, 1996, 1997, 1998, 1999,2000, 2001, Dutton et al. 1992, 1994, Alexander et al. 2002, 2003, 2004, Garner et al. 2005, 2006, Garner and Garner 2007, 2008, 2009, 2010, Valiulis and Mackay 2011, and Valiulis 2012, 2013, 2014, 2015).

A major component to the Sandy Point leatherback program involves relocating nests that will likely be washed away by seasonal erosion of the west facing beach. The beach is closed to public access annually during the nesting periods, and during this time the USFWS engages in public education that focuses on school and youth groups in response to the need to limit visitors. The goal of this program is to make the community an integral part of the conservation of the turtles and habitats.

Long-term monitoring of hawksbills on BUIS was initiated in 1988 by the NPS, with beaches checked nightly during nesting season. This program has expanded to include the tracking of individuals' movements during the interesting interval and in-water work to identify near shore habitat preference (Iverson et al. 2016).

TNC also manages a long-term nightly monitoring program for green and hawksbill turtles at East End Bay and Jack's and Isaac's Bays. This program has been challenged by varying levels of funding, but in recent years has been able to provide consistent monitoring and also expand to include satellite tagging of nesting turtles.

In 2004 the Territory in partnership with several Federal agencies began a Sea Turtle Assistance and Rescue (STAR) program involving a network of local biologists and federal agencies that respond to sea turtle emergencies such as injuries, disorientation, and strandings. Although the phone number has remained active with a trained responder on-call at all times, permitting through DFW lagged for several years resulting in minimal activity and reporting. In mid-2016, permitting was reestablished for the STAR network and an initiative is underway to reach out to community members and inform them of the existence and mission of the STAR network.

There is a long history of extensive and in-depth research on sea turtles within the USVI. Recent work has included research on conservation genetics (Stewart and Dutton 2011), inter-nesting habitat and behavior (Casey et al 2010, Perrault et al 2016, Schultz 2016, Hart et al 2017, Hill et al 2017, Asada, Texas A&M dissertation in progress), conservation (Dutton et al 2005), predation (Wetterer and Lombard 2010, Pollock and Hairston 2013), toxicant levels in leatherbacks (Perrault et al 2013), nesting habitat and condition (Lundgren 2009, Garrett et al 2010, Conrad et al. 2011, H. Goodson, unpublished MMES thesis data 2016), foraging in benthic habitat (Pollock 2013) and ecology of juveniles (Hart et al. 2013, Eanes 2016). UVI currently has a project to examine movement of acoustically-tagged green and hawksbill turtles within Brewers Bay, St. Thomas, using an acoustic array (Eanes 2016).

Earlier work on VI sea turtles includes work on nesting activity (Small 1982, Boulon 1994a, Mackay 1994, Mackay and Rebholz 1995), strandings (Boulon 1998), tagging and recoveries (Boulon 1989), and nest predation (Nellis and Small 1983). Studies on leatherbacks include nesting activity (Eckert and Eckert 1983, Boulon et al. 1994, McDonald et al. 1995, Boulon et al. 1996, Freeman et al. 1998) and inter-nesting movements (Eckert et al. 1989). Studies on hawksbills include nesting and related activity (Hillis and Mackay 1989, Hillis 1992, 1994a,b, Mendelson 1993, Hillis and Phillips 1996, Hillis-Starr et al. 1998), growth rates (Boulon 1994b), sex ratios (Geis et al. 2003), activity (Hillis and Phillips 1996), and for green turtles, growth rates (Boulon and Frazer 1990) and foraging (Ogden et al. 1983).

Accomplishments since 2005

Monitoring of nesting beaches through daytime track surveys has increased significantly since 2005. DFW enlisted and trained community volunteers to conduct beach patrol monitoring for sea turtles on St. Thomas from 2009 to 2012 (Platenberg 2012). This effort revealed beach nesting patterns on several northside beaches that were previously unknown. Additional monitoring surveys were conducted in 2016 (H. Goodson, unpublished MMES thesis data 2016). On St. Croix, sea turtle monitoring has been implemented at the Southgate Coastal Reserve (St. Croix Environmental Association), beaches on the East End (Friends of the St. Croix East End Marine Park) and various west end and south shore beaches (DFW). Monitoring on STJ beaches by volunteers has recently been implemented and coordinated by the NPS (S. McKinley, pers. comm. 2016).

Increased and systematic trapping for mongoose at Jack and Isaacs beaches and Sandy Point National Wildlife Refuge has resulted in increased hatch success, in green and hawksbill nests (Valiulis and Mackay 2011, K. Amon Lewis, pers. comm. 2016). In addition, research into the effectiveness of different trap types has enabled managers to adapt limited resources to improve trapping programs (Pollock and Hairston 2013).

Beach profiles and characteristics of nesting sites for hawksbills have been measured on St. Thomas and St. John towards developing models for prioritizing shoreline areas for protection (H. Goodson, unpublished MMES thesis data 2016).

In 2016, DFW hosted a two-day meeting of territorial sea turtle biologists. This meeting was a valuable opportunity for many biologists who normally work in the isolation of their specific programs to share ideas and challenges. Several goals emerged from this meeting including the need to make the meeting an annual event in order to build and maintain collaboration. Other needs that were identified were increased public outreach, a VI sea turtle listserv and in general, more programmatic capacity. Recent improvements in the efficiency and timeliness of permitting at DFW have greatly increased the ability for many of these initiatives to move forward.

A plastic bag ban has recently been implemented in the USVI, and CZM has hired a dedicated Education and Outreach Coordinator that has initiated community outreach events (e.g., Science

Saturday) with a message toward reducing single use plastics that end up in the marine environment.

Conservation Priorities

Although there has been an increase in beaches that are regularly patrolled for sea turtle nesting, there are still large gaps in our knowledge as to which beaches sea turtles are using to nest, especially on St. Thomas and St. John. Protection of nesting beaches is of utmost importance to the conservation of sea turtles. In addition to the constant threat of development, beaches are facing threats from the effects of climate change, in particular, sea level rise.

Sea turtles are protected under local and federal laws yet enforcement of these laws and prosecution are lacking. This problem is not unique to sea turtles as actual enforcement of conservation laws is severely lacking across the board. Outreach to law enforcement officers and decision makers about laws and also the value of these species to the economy of the VI should be ongoing.

Coordination, communication and data sharing between entities involved in turtle work in the Virgin Islands would greatly increase the overall capacity for sea turtle protection and knowledge. In 2016, DPNR held a meeting of these entities in the VI and it was a huge step forward in comprehensively working to protect sea turtles in the Virgin Islands. However, just holding the one meeting one time is not enough. Annual meetings, an online listserv and generally open communication lines are necessary to continue the momentum from the 2016 meeting.

Outreach to the general public and any businesses that interact with turtles (e.g., dive shops, beachfront businesses, boat tours) as to how to properly interact with turtles without harming them is very important. This information has been sporadically distributed in the past, but turnover in staff requires that trainings and outreach be conducted regularly.

Ongoing control of invasive predators, especially mongoose, should be conducted on all high priority nesting beaches. Beaches with hawksbill nesting should be the highest priority for mongoose control.

Post-hurricane needs: Sandy beaches across the Territory were affected by storm surge from the hurricanes in 2017 and again from a unprecedented surge resulting from the March 2018 Nor'easter storm (along the north coasts of the northern USVI). The storms inundated existing nests, damaged vegetation structure, and removed sand to expose roots of coastal vegetation, rendering beaches unsuitable for hawksbill nesting. Access to nesting areas was blocked by storm debris. Salt water intrusion caused a lingering impact that resulted in mortality to coastal vegetation. Ongoing turtle nesting monitoring is necessary for understanding recovery needs, particularly for St. Thomas and St. John.

Species of Greatest Conservation Need

Common Name	Scientific Name	Status
Leatherback Turtle	*Dermochelys coriacea*	High Risk
Hawksbill Turtle	*Eretmochelys imbricata*	High Risk
Loggerhead Turtle	*Caretta caretta*	High Risk
Green Turtle	*Chelonia mydas*	High Risk

Species Accounts

The federally endangered, **Leatherback Turtle** (*Dermochelys coriacea*, family Dermochelyidae) is the largest of the sea turtles, weighing over 600 kg with carapace lengths reaching over 180 cm. It is pan-global and capable of migrating over 4800 km. Leatherbacks nest on tropical and subtropical beaches, but foraging areas extend to cold temperate waters off Canada and northern Europe. The leatherback is only seasonally found around St. Croix, arriving in the late winter months and usually starting to nest in February. Most of the nesting activity occurs on Sandy Point, a 3-km-long expanse of beach on the south west corner of St. Croix. Sandy Point's broad, sandy beaches are located near the shelf edge, thereby allowing the deep-diving leatherbacks to stay in deep water right up to the beach, avoiding potential marine predators. They have been observed nesting on other beaches that are not obstructed by coral reefs such as Ha'Penny/Manchineel and Southgate. Nesting leatherbacks have also been recorded on beaches on St. Thomas, St. John, and associated cays, although these occurrences are rare (NMFS and USFWS 1992, H. Goodson, unpublished MMES thesis data 2016) and in the British Virgin Islands (Freeman et al. 1998). Leatherbacks feed almost exclusively on gelatinous organisms such as jellyfish, and as such are prone to ingesting floating plastic debris. The studies at Sandy Point have shown that in the USVI females nest on average, every 3-4 years, laying an average of 5-6 clutches per season, although they can lay as many as 11 clutches in a season. Adults can dive to depths of at least 1500 m.

The **Hawksbill Turtle** (*Eretmochelys imbricata*, Cheloniidae) is listed as endangered throughout its range (USFWS 1970), and a recovery plan has been prepared (NMFS and USFWS 1993). Decades of intensive harvesting of hawksbills for their "tortoiseshell" and for consumption have led to severe population declines. Hawksbills are relatively small, rarely reaching lengths of 1m, and weighing under 80 kg. They are widely distributed in tropical and sub-tropical waters. In the USVI, hawksbill turtles may nest throughout the year, although the peak nesting season is from July to October. Owing to their small size and relative agility, female hawksbills can negotiate rocks and other obstacles to crawl high up onto beaches. Hawksbills are able to nest in very small pockets of sand and on any beach that has shoreline vegetation. Hawksbills often dig nests under sea grapes or deep within the vegetation beyond the edge of the beach, and several hawksbills have been documented making extensive excursions upland from the beach. Females lay an average of 4-5 clutches per season. Hawksbills are specialized to feed on sponges, making them highly vulnerable to the effects of coral reef degradation.

The **Green Sea Turtle** (*Chelonia mydas*, Cheloniidae) is listed as threatened throughout the Caribbean (USFWS 1978), and is subject to a federal recovery plan (NMFS and USFWS 1991).

Unfortunately, existing regulations have not eliminated poaching and in the Virgin Islands this species is likely the most frequently poached of all the sea turtles. Green turtles can reach lengths of 1 m, and weigh up to 180 kg. They are circum-global, remaining in tropical and sub-tropical waters. Green sea turtles may nest at any time of the year, although the peak nesting season is from August to October. Females generally lay their nests on the edge of the open beach, laying 3-4 clutches per year. Green turtle diet consists mainly of seagrasses and algae, although some gelatinous organisms are also ingested.

The **Loggerhead Turtle** (*Caretta caretta*, Cheloniidae) has also been positively identified in the USVI. Several loggerheads have nested at BUIS in recent years, and a juvenile was found in the waters off of St. Thomas in 2016. Loggerheads are listed as threatened throughout their range (USFWS 1978). They are protected by both Federal and Territorial Laws, and are subject to a recovery plan, which is currently under revision (NMFS and USFWS 2008).

Contributors (2005): RJP, FEH
Contributors (2017): JV, RJP

Banner photo: *Chelonia mydas* by K. Lewis

2.9 Marine Invertebrates

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Invertebrates are a crucial and highly diverse component in the marine ecosystem. The majority of species in the ocean are invertebrates, and the biodiversity of coral reefs is dominated by invertebrates, many of which live in close association with scleractinian corals, relying on corals for food, habitat or settlement cues (Gibson et al. 2011). Many marine invertebrates are planktonic in early larval life stages, remaining in the water column or near the surface until settling out in a specific habitat, thus providing critical food resources for a myriad of pelagic organisms. Many species exhibit ontogenetic shifts in habitat use, requiring not only healthy seagrass, mangrove, and coral habitats, but also the ability to migrate unhindered between these habitats. Coastal zone pollution, eutrophication, red tides, and coastal development have negative impacts on marine invertebrate recruitment (FAO 2006).

Important invertebrates in the USVI include the scleractinians (hard or stony corals) that are key reef-builders, and the commercially harvested Caribbean lobsters (*Panulirus* spp) and Queen Conch (*Strombus (Lobatus) gigas*). Several species of the order Scleractinia are keystone species within the USVI and receive protected status from the ESA including elkhorn coral (*Acropora palmata*), the staghorn coral (*Acropora cervicornis*), the star corals (*Orbicella annularis*, *Orbicella faveolata*, *Orbicella franksi*), the pillar coral (*Dendrogyra cylindrus*) and the rough cactus coral (*Mycetophyllia ferox*) (Smith et al. 2008). Other species of importance include sponges, algae-grazing urchins, crabs, and a myriad of other life forms. This is an incomplete list as there is insufficient data on invertebrate fauna to assess status. It is impossible to discuss each species, guild, or ecosystem service provider, and this section provides an overview of threats, ongoing research and management, and conservation priorities for marine invertebrates, with more targeted information on SGCNs and ecosystem service providers. However, actions that benefit these species will provide benefit to a wide range of other ecosystem inhabitants.

Ecological Value

The diversity exhibited within the marine invertebrate group provides enormous ecological value. The corals, both hard and soft, are important in building structure within reef systems, providing a wide range of occupiable niche habitats for a range of fish, invertebrates, and marine plants. Crabs, shrimp, lobsters, urchins, and other bottom feeders keep their habitats "clean" by feeding on detritus and algae, while filter feeders such as fan worms and corals remove sediment from the water column. Zooplankton, along with phytoplankton, provide a critical food source for fish, sea turtles, other invertebrates, and whales. All of these roles also contribute towards decomposition and nutrient cycling.

Marine invertebrates also provide valuable ecosystem services that benefit local human communities. Invertebrates form a significant component of the diet of commercially harvested fish (provisioning), while coral reefs protect shorelines by dampening wave action (supporting). The filter feeders maintain water clarity (regulating) so that locals and tourists alike can enjoy the breathtaking color and structure that reef systems provide (cultural).

Threats

Caribbean coral reef systems have undergone significant changes over recent decades, measurable through loss of scleractinian coral cover mainly attributed to global climate change and ocean acidification (Tsounis and Edmonds 2017, and references therein). This has resulted in a shift from high profile scleractinian coral structure offering a multitude of occupiable niches towards low-profile coral rubble, macroalgae, and algal turf, with a resultant loss of habitat for fish and other invertebrates. Declines in herbivorous species such as large parrotfish contribute to an increase in algal cover, thus reducing the density and diversity of coral and sponges that are unable to compete for surface area with the fast-growing macroalgae.

Corals and seagrasses are sensitive to physical damage from boating activities, mainly anchor and prop scarring, and recreational water use. Human interaction through diving, snorkeling, and other water sports can physically damage marine resources through touching, kicking, and standing on, while sunscreens and other skin protectants contain ingredients that are toxic to corals and other marine organisms (Hodgson 1999, Catanzaro et al. 2002).

The condition of marine invertebrates is closely correlated with habitat integrity and water quality, with anthropogenic influences playing a large but potentially manageable role. Physical damage to reefs and seagrass beds can cause mortality and alter habitat structure, while contaminants entering the water column cause degradation through smothering and toxicity. Stormwater runoff consisting of sediment, unmanaged waste, contaminants, and other nonpoint source pollutants is a significant contributor to decreased water quality in the USVI. High sediment levels smother corals and seagrasses, which can result in dead zones with low light transmission and, in extreme cases, toxic water levels (Fabricius 2005). Secondary factors such as coral bleaching and disease are associated with runoff (Sevier 2018).

Increased natural pressures such as hurricanes and climate change have led to elevated surface temperatures and physical damage to coral. These high surface temperatures reduce the likelihood of coral symbionts being effectively used or incorporated into the coral polyp. This contributes to large scale bleaching events that can affect up to half of the shallow reef systems. Bleaching events open the door for secondary effects of disease including the emergence of white pox, white band, black band and other stress associated ailments (Muller et al. 2008, Smith et al. 2008, Brandt and McManus 2009). Weakened corals can act as sites of initiation of some disease whose negative impacts are then multiplied by transmission from colony to colony (Clemens and Brandt 2015). Prevention is best accomplished through mitigation of the causes of coral stress that increases susceptibility to disease.

Rising temperatures also decrease survival, reproduction, food availability, and growth rates for many benthic invertebrates besides coral (Przeslawski et al. 2008). In addition to temperature changes, climate change induced ocean acidification is a significant threat to invertebrates, particularly those with calcified shells or other structure, by affecting fertilization success and growth rates due to the lack of calcium carbonate in the water (see Bryne 2011 for review). Planktonic larvae might also be susceptible to ocean acidification effects (Fangue et al. 2010). Optimum temperatures for spawning may be exceeded, thus affecting the timing and duration of the spawning season for many species.

Research and Management

In the USVI, the Department of the Interior, Department of Commerce and the Virgin Islands territorial government have jurisdiction over the submerged land. At the highest level of management action seven coral species were listed as threatened under the U.S. Endangered Species Act (NOAA 2014). These include the elkhorn coral (*Acropora palmata*), the staghorn coral (*Acropora cervicornis*), the star corals (*Orbicella annularis*, *Orbicella faveolata*, *Orbicella franksi*), the pillar coral (*Dendrogyra cylindrus*) and the rough cactus coral (*Mycetophyllia ferox*). Each of these species is common to hyper-abundant in the USVI. The removal and/or harm of these critical species can result in fines and potential jail sentences. Under the local VI-code Title 12 Chapter 21 section 906 (B7), all corals including black corals are protected and require special permitting to collect. These laws protect coral species individually, however more management has been developed to protect coral reefs as an ecosystem, thereby conferring conservation action on a suite of marine invertebrates. Several commercially-important invertebrates, including lobster and queen conch, have harvest restrictions in place to protect reproductive seasons and output.

In order to better conserve the state of these species and enforce jurisdiction by the federal and state departments, marine protected areas (MPA) and reserves have been established. MPAs limit human based activities to prevent physical destruction and provide a refuge for diversity to reduce potential algal competition (McLeod et al. 2009). Studies comparing abundance of Caribbean commercially important species such as the Spiny Lobster (*Panulirus argus*), Queen conch and Nassau grouper (*Epinephelus striatus*) in an MPA showed significantly larger individuals within the reserve as compared to the other sites (Lipcius et al. 2001). Time-series comparisons of queen conch populations in St. Croix indicate that spatial protection from an MPA has allowed this species to recover and maintain population stability (Doerr and Hill 2018). A study tracking lobster movements off Mexico showed that 15-20% of lobsters residing within MPAs move into fishing areas, indicating that offshore unfished areas provide protection to the majority of the lobster stock in this area while adding to and maintaining fishing yields within the inshore commercial fishery

(Ley-Cooper et al. 2014). These results support the value in MPAs in maintaining ecosystem function while supporting fisheries resources.

There are now over 30 MPAs in the USVI, under a variety of management entities and with a range of objectives that focus on managing human use (Pittman et al. 2014). Protected areas such as the St. Thomas East End Reserves (STEER), St. Croix East End Marine Park (EEMP), Virgin Islands Coral Reef National Monument (VICRNM), Virgin Islands National Park (VINPS), and Buck Island Reef National Monument (BUIS) have shown a reduction in reef degradation, but no significant increase in fish biomass or coral cover (Pitman et al. 2014).

Coral monitoring programs are critical to determining if coral reefs are being impacted and which stressors, particularly those with local management potential, are the most important. The USVI has three major monitoring programs: The National Coral Reef Monitoring Program (NCRMP), the Territorial Coral Reef Monitoring Program (TCRMP), and the National Park Inventory and Monitoring Program (NPS I&M). Researchers in the USVI have collected some of the longest time-series data sets on coral reefs in the Caribbean, which date back decades (Catanzaro et al. 2002, Rothenberger et al. 2008, Jackson et al. 2014; see Habitats sections for more information on these programs). Additionally, research is being done at Hurricane Hole, within the VICRNM to further investigate the remarkable diversity and abundance of corals, sponges, and other invertebrates that grow directly on and near the prop roots of red mangrove trees fringing the shorelines (Rogers 2017).

Accomplishments since 2005

Considerable research at UVI has focused on coral and other marine invertebrates, including coral disease (e.g., Sabine 2013, Clemens 2013, Ennis 2014, Beasley 2015, Brown 2017, Sevier 2018), coral-algae interactions (e.g., Kamman 2013, Olinger 2017, Ramseyer 2017), coral outplanting (Howe 2018), and the role of urchins in ecosystem health (Ramseyer 2017).

In addition to the research and monitoring, there are several programs designed to involve the community in coral reef conservation. TNC established coral nurseries on St. Croix and St. Thomas to regenerate *A. cervicornis* and *A. palmata* for outplanting; the St. Thomas component of this project has been transferred to UVI to achieve outplanting goals. Reef Connect is a project that aims to build resiliency in coral reefs within the USVI through a multifaceted approach of reducing stressors. Bleachwatch is citizen science program that trains community volunteers to recognize and document coral bleaching events.

Conservation Priorities

Many of the marine invertebrates are data deficient, both locally and across the wider Caribbean region. Priority should be placed on conducting surveys to identify local distribution and habitat associations of marine invertebrates, including non-GCN species. An understanding of larval distribution through the use of oceanographic modelling can identify priority areas for establishing or protecting connectivity. Given the spatial and temporal patchiness of queen conch distributions, standardized fishery-independent monitoring surveys should be repeated regularly to provide data sufficient to assess stock conditions and the efficacy of management measures.

As with other marine organisms, ensuring the availability of high quality habitat that marine invertebrates rely on is key for their long term survival. This includes maintaining dispersal opportunities as well as interconnectivity between habitats. Protecting marine environments from land-based sources of pollution, such as trash, chemical contaminants, sediment, and other point and nonpoint sources of pollution is a priority measure towards reducing stressors on systems increasingly affected by climate change. Managing land-based impacts can be accomplished through improvement of best management practices for sediment runoff, improved erosion control through reforestation, and establishing coastal vegetation buffers.

Local marine protected areas have proven effective at protecting marine habitats and have resulted in more resilient ecological communities. Identifying additional areas for protection should be prioritized. Re-establishing native herbivores within coral reef systems will improve habitat conditions to allow invertebrate communities to maintain resilience against climate change impacts. Installing and maintaining moorings in high traffic locations supports habitat protection for reef and seagrass habitats.

Education and engagement of the boating community, fishers, and other stakeholders is valuable for achieving support for conservation actions. Harvested species will benefit from effective adherence to and enforcement of existing regulations, while a widespread understanding of impacts of toxins such as those found in sunscreens may contribute to a reduction in the use of these substances.

Post-hurricane needs: Coral reef structure was severely impacted by the 2017 double hurricanes and the severe ocean swell resulting from the March 2018 Nor'easter storm. While the populations of marine invertebrates likely experienced a short-term decrease due to these impacts, the loss of the reef structure may pose significant long-term influences on recovery. Enhancement of reef structure through the use of coral nurseries and outplantings and installation of artificial reefs, along with subsequent monitoring of the use of these structures by fish and invertebrates, may mitigate these severe disturbances.

Species of Greatest Conservation Need

Common Name	**Scientific Name**	**Status**
Staghorn Coral	*Acropora cervicornis*	High Risk
Elkhorn Coral	*Acropora palmata*	High Risk
Black Coral	*Antipathes spp.*	Data Deficient-At Risk
Lobed Star Coral	*Orbicella annularis*	High Risk
Mountainous Star Coral	*Orbicella faveolata*	High Risk
Boulder Star Coral	*Orbicella franksii*	High Risk
Pillar Coral	*Dendrogyra cylindricus*	High Risk
Rough Cactus Coral	*Mycetophyllia ferox*	High Risk
West Indian Top Knot (Whelk)	*Cittarium pica*	Low Risk
Furry Sea Cucumber	*Astichopus multifidus*	Low Risk
Queen conch	*Strombus gigas*	High Risk
Spiny Lobster	*Panulirus argus*	High Risk
Green Lobster	*Panulirus laevicauda*	High Risk
Long-spined Sea Urchin	*Diadema antillarum*	Low Risk
Mangrove Root Crab	*Goniopsis ruentata*	Low Risk
West Indian Sea Cucumber	*Actinopyga agassizi*	Low Risk

Species Accounts

Order Antipatharia -- Black Corals

Black corals (or wire corals), *Antipathes* spp., are tree-like corals that inhabit deep reef areas, observed to 200 m (Wicksten et al. 2014) but likely occurring to depths of 3000 m. One species has been reported for the USVI, *Antipathes rhipidion*, among six species known to occur within the Caribbean region (Cairns 2017). These corals can form dense aggregations in areas with hard substrates, low light, and strong currents, where zooplankton form the bulk of their diet. Organisms associated with black corals include arthropods, annelids, echinoderms, mollusks, sponges and cnidarians, several of which are adapted to live exclusively on black corals. They reproduce through both sexual and asexual processes, and are generally slow growing and long lived, ranging from decades to millennia (Wagner et al. 2012). Beyond that, little is known about these corals due to the logistical challenges of conducting research at the depths where these occur.

Order Scleractinia--Hard or stony corals

Corals are sessile marine invertebrates in the phylum of Cnidaria that are composed of identical polyps forming a colony system. Scleractinians are species that increase reef structure through the production of a calcium carbonate frame. Reef building species include Elkhorn and Staghorn corals (*Acropora* spp.), Star corals (*Orbicella* spp.), pillar corals (*Dendrogyra cylindrus*), and the rough cactus coral (*Mycetophylllia ferox*). As coral colonies expand, large amounts of calcium are drawn from surrounding water and used to build a calcium carbonate structure that provides protection and structure to the polyps. Colonies of different species tend to grow into a matrix which provides habitat for a variety of marine fish and other invertebrates. An interconnected system allows for easy transport of nutrients and organic materials to each individual polyp (Catanzaro et al. 2002). Corals are both hermaphroditic and gonochronic, which allows them to reproduce sexually and asexually. In order to reproduce at all resources such as nutrients have to be available in large quantities for the production of gametes. Once sexual reproduction in the form of broadcast spawning is initiated, abiotic conditions of water temperature and current can drastically affect survivability and settlement. Settlement of larva benefits from hard substrate with low wave action to allow for formation of the colony.

The order Scleractinia often incorporates symbiotic algae for necessary biological processes, including nutrient acquisition. This symbiotic relationship allows corals to grow and increase biomass in greater quantities than those species that lack the symbiont. Coral communities are often established in coastal shallow waters that have little to no turbidity for these reasons (Catanzaro et al. 2002). Shallow low-nutrient and low-sediment water allows for the symbiont to easily photosynthesize and produce trophic products for the coral. However, due to the intimacy of this relationship, issues within the symbiont may influence the host coral in a negative manner. Surface temperatures that exceed specific ranges of the individual coral species can cause symbionts to inherently cause harm to an individual or entire colony, and to reduce this stress the coral hosts will remove the harmful symbiont in a process known as bleaching, thus exposing the coral to secondary stresses of starvation and disease.

Increasing biotic and abiotic stressors have caused a decline in reef building species, with coral coverage being replaced by filamentous cyanobacteria and macroalgae. This trend, apparent in the USVI, is expected to continue in all areas of the world with the continuation of human based activities and climate stress.

Order Decapoda, Family Palinuridae -- Caribbean Spiny Lobsters

Spiny lobsters are widespread throughout the Caribbean, found up to a depth of 90 m within a range of habitat types, including rocky reefs, coral reefs and seagrass beds (Butler et al. 2011a). They are an important food resource for a range of marine species, including sharks, stingrays, and groupers. Seagrass beds and mangrove areas serve as nursery environments for lobster (Stoner 2003), and in the Eastern Caribbean the peaks of larval recruitment are highest in the spring from February-April (Butler et al. 2009). In the USVI, two species are identified as being of greatest conservation need, the Caribbean Spiny Lobster (*Panulirus argus*) and the Smoothtail Spiny Lobster (*P. laevicaudis*).

Areas around the Virgin Islands and the Caribbean are experiencing a decline in lobsters due habitat loss/degradation, overharvest, illegal take/poaching, disease, and predation (Eggelston et al. 2003). Despite the range-wide exploitation and wide body of literature regarding the commercially important *P. argus* there are still gaps in knowledge relating to fishing efforts and estimations of abundances (Butler et al. 2011a). The IUCN categorized this species as data deficient due to these gaps of information and noted that with further data on catch per unit effort, it is very likely that the species could be uplisted to threatened (Butler et al. 2011a). However, the overall population trend was determined to be declining. Recent assessments on a smaller and more local level throughout the geographic range have suggested that populations are being fully or over-exploited in many places. Based on the best available information, Puerto Rico and the

USVI's *P. argus* status was categorized as fully-exploited or stable with annual landings in live weight being above 100 metric tons (FAO 2006).

One of the biggest threats to the Caribbean spiny lobster is illegal fishing of berried females and undersized individuals (FAO 2006). The capture of juveniles is a biologically inefficient use of the resources and can pose a serious risk to the sustained productive capacity of *P. argus* populations (FAO 2006). With high demand for lobster, there is more incentive for increased fishing effort which has the potential to increase illegal taking of individuals. This has led to traps being left in the water during the closed season, resulting in excessive numbers of traps that may not all be recovered and unnecessary mortality (FAO 2006).

An additional threat specific to *P. argus* populations is a naturally occurring pathogenic virus, PaV1 (Shields and Behringer 2004). The blood thins, loses the ability to clot and once inoculated, animals became moribund in 5-7 days and began dying after 30-80 days post-exposure (Shields and Behringer 2004). Healthy lobsters vacate dens occupied by PaV1-infected lobsters, even when additional shelters were scarce due to sponge die-offs and searching for new dens increased the risk of predation (Butler et al. 2015). This avoidance behavior may serve to control the spread of the disease and limit the negative toll on local population of spiny lobsters.

There is almost no information on the Smoothtail Spiny Lobster *P. laevicaudis* except that it is found in association with *P. argus*. Specific population information on this species is unavailable. There is little FAO data on catches of this species. From information known, this species is most likely over-exploited by legal and illegal harvesting throughout its range and the population will have decreased substantially from its original biomass (Butler et al. 2011b).

Order Littorinimorpha, Family Strombidae--Conch

The queen conch (*Strombus (Lobatus) gigas*) is a marine gastropod mollusk that occurs across the Caribbean, Gulf of Mexico, Florida, and down to the northern coasts of South America. These mollusks live in seagrass beds and sandy substrate where they graze on epibionts of seagrass blades. The queen conch serves as prey for numerous species including sharks and stingrays, crustaceans, and fish. The vacant shell of the queen conch serves as a refuge for small fish and as a home for crustaceans. In addition to the ecological services the queen conch provides, they are bought and sold as an ornamental product and are commercially harvested.

Juvenile queen conch need 5-6 meter deep seagrass bed with a specific set of environmental conditions (Stoner 1997). Adult conch are generally found at greater depths, although this distributional pattern may be attributed to harvest levels (Torres Rosado 1987, Friedlander et al. 1994). The location and abundance of conch populations depend on surface currents carrying juveniles to the same location each year, tidal circulation patterns, depth, and seagrass density (Stoner 1994, 1997). Variation in the size and consistency of a seagrass bed habitat due hurricanes or invasives like the seagrass *Halophila stipulacea* can negatively affect the queen conch population.

In a recent survey of queen conch across the north shore of St. Croix, densities of juvenile queen conch were estimated to be highest in habitats with high levels of patchy seagrass, while adults were found in low seagrass habitats (Doerr and Hill 2018). This study determined that seagrass beds south of Buck Island are functioning as valuable nursery habitat for juvenile conch, and the presence of multiple juvenile cohorts indicates that larval recruitment in the area has been successful in recent years.

The queen conch is one of six species of conch distributed throughout the Caribbean of significant commercial importance (Aranda and Manzano 2017). Conventional stock assessment methods have been ineffective for determining the status of queen conch throughout the Caribbean, mainly due to a lack of available fishery-independent data. Management studies and actions have been implemented in the USVI to better understand declining populations, with local catch limits being an important management tool (NOAA and CFMC 2011). Early estimates of queen conch densities in USVI waters showed a maximum adult density (17.1 adults/ha) in a depth range of 18-24 m (Friedlander et al. 1994). This is in contrast to Puerto Rico, where the maximum adult density occurred at 20-25 m, but the densities at this depth were very low (0.05 conch/ha) (Torres Rosado 1987), with the differences between densities attributed to different fishing practices. More recent surveys along the northeastern coast of St. Croix found an overall density of 302 conch/ha, with densities of juvenile and adult queen conch higher within BUIS boundaries as compared to open fishing areas (Doerr and Hill 2018). Comparisons of data from this and previous studies indicate that the queen conch population in St. Croix is potentially stable under the current management approach and that BUIS is providing the spatial protection required for the population to continue to recover (Doerr and Hill 2018).

Climate change and ocean acidification alter the development of many marine invertebrates including conch (Przeslawski et al. 2008, Kurihara 2008, Fangue et al. 2010). These developmental impacts are thought to significantly affect the calcification process of organisms with calcareous structures, such as mollusks, causing a decrease to populations and disruption of the ecosystem. A recent study, however, found that queen conch egg masses and larvae exposed to a range of increased temperatures over a 30-day period showed increased larval development and settlement at higher temperatures (30 °C) and that the calcification process of *S. gigas* larvae was not affected by the experimental temperatures (Aranda and Manzano 2017).

USVI queen conch population is also affected by unregulated pollution due to runoff and sedimentation from guts (Beets 2005).The ornamental shell trade is a threat to the queen conch population as well, and shells are routinely confiscated from tourists leaving USVI airports.

Other Species of Conservation or Management Importance

Species detailed below were chosen based on their economic and ecological values in the marine ecosystem of the USVI. These species provide invaluable ecosystem services that are connected and ensure the health and balance of coral reefs. Each of these species are being increasingly affected by anthropological and natural factors and are in need of increased management. Because these focal species make up the majority of the marine invertebrate community, they were chosen for better evaluations and management. Each species has distinct, but connected ecosystem services that are in need of management.

The **Long Spine Urchin** (*Diadema antillarum*) is an echinoderm that eats algae, detritus, and sometimes coral (Bak and van Eys 1975). Adults live in groups in coral reefs, mangroves, seagrass beds, sand, and intertidal zones (Randall et al. 1964). Their larvae are planktonic and settle on reefs with high densities of adults (Hunte and Younglao 1988).

Urchins are herbivores that act as a keystone species in Caribbean coral reef communities (Edmunds and Carpenter 2001). By controlling algae cover, *D. antillarum* promotes coral dominance (Hughes et al. 2010) and coral health (Edmunds and Carpenter 2001). This effect was demonstrated after the mass mortality of Caribbean urchins in 1983-4: when *D. antillarum* populations across the Caribbean were decimated, the community became dominated by macroalgae with resultant decline in coral cover (Lessios 1988, Levitan 1988). In addition to providing valuable algal control services, these urchins have many other interactions with coral associated species. They are prey items for larger fish such as the queen triggerfish, *Balistes vetula* (Lessios 1988) and their spines act as shelter for mysid shrimps and juvenile fish (Randall et al. 1964).

Urchins need an adequate supply of food sources (primarily algae) and suitable habitat. While in the planktonic phase, urchins, like many benthic invertebrate larvae, need specific water temperatures, and good water quality (Thorson 1950). Poor food and water temperature cause slow growth and prolonged larval phases, which decrease survival and settlement rates (Thorson 1950). Since urchins make their tests with calcium carbonate from the surrounding water, they need proper water quality to grow (Kurihara 2008). Most importantly, urchins require established populations because their planktonic larvae only settle on corals with a high density of adults.

Before the mass mortality of 1983-4, *D. antillarum* were abundant on shallow reefs throughout the Caribbean, Florida, and Bermuda (Lessios 1988). There have been varied responses of individual populations, but an overall pattern of slow recovery throughout the Caribbean due to speculated decreased reef rugosity, fertilization, and recruitment (Lessios 2016). After recovery in the USVI, populations established a lower population equilibrium (Levitan et al. 2014). These smaller populations bring the species closer to the minimum viable population and make them susceptible to local extinction from stochastic events. Ocean acidification has the potential to severely impact these species that are heavily dependent on calcium carbonate.

The Phylum **Porifera** (sponges) includes sessile, filter-feeding metazoans that have a single layer of flagellated cells driven by water current. Porifera are an ancient and highly successful group with over 10,000 known species (Diaz and Rützler 2001). Sponges are a structural component for reef systems and are important for ecological dynamics. The Demospongiae is the largest class which possesses the greatest number of species and range distribution. Species found in the USVI include but are not limited to *Aphimedon compressa* (erect rope sponge; also known as *Haliclona rubens*), *Chondrilla nucula* (chicken liver sponge), *Cynachirella alloclada*, *Geodia neptuni* (potato sponge), *Haliclona* spp. (finger sponges), *Myriastra* spp., *Niphates digitalis* (pink vase sponge), *N. erecta* (lavender rope sponge), *Spinosella policifera*, *S. vaginalis*, and *Tethya crypta* (Waddell and Clarke 2008).

Sponges provide direct ecological service to local biota by creating hard substrates for recruitment, offering protection for juvenile fish and other organisms, providing food resources for aggregations, and water filtration (Catanzaro et al. 2002). Many sponge species host symbiont communities that assist in nutrient acquisition and digestion, and contribute to carbon uptake through photosynthesis. Due to the large volume of water that sponges filter, they play an important role in nutrient cycling within the reef ecosystems (Colman 2015).

Sponges are associated with hard substrates including rocks, coral, and mangrove roots. Some species develop on soft substrates such as mud and sand to form a hard substrate that facilitates additional organism growth. Certain sponges have adaptations to bore into calcium carbonate structure (Roberts et al. 1998).

Sponges, as with other invertebrates, are sensitive to changes in water quality. Sponge cover, including that of encrusting sponges, has been seen to decrease rapidly after discharge of sewage effluent into areas (Roberts et al. 1998). Sediment and runoff also contribute to the decline in sponge cover. Due to the slow growing nature of sponges, physical damage can reduce cover and increase the effect of secondary stressors due to exposed tissues. While most damage to sponge structure is caused by storms and wave action, fishing and recreational activities can also result in scouring. Physical damage reduces the effectiveness of defense mechanisms against other stressors by redirecting resources towards repair (Catanzaro et al. 2002). Increased surface temperatures in shallow reef systems have caused an increase in the prevalence of disease transmission in sponges (Przeslawski et al. 2008). Sponge diversity and abundance has declined in coral reef communities across the Caribbean (Wulff 2006), and this trend may also be reflective of the sponge populations in the USVI although the status of the marine sponges has not been assessed.

Octocorals comprise around 3,000 species of coral formed of colonial polyps with 8-fold symmetry. This group includes the blue coral, soft corals, sea pens, and gorgonians (sea fans and sea whips). As with all Cnidarians, octocorals have a complex life cycle including a planktonic larval phase and an adult sessile phase. There are 35 species within the USVI (Tsounis et al. 2018).

Octocorals have increased in abundance on a number of Caribbean reefs (Tsounis et al. 2018). Longitudinal surveys indicate that the species composition remains the same, but abundance and cover have increased as these species expand into areas likely made available from loss of scleractinian coral cover. Comparisons between octocorals between sites on St. John with contrasting conditions of wave energy, sedimentation, and water clarity found little difference between community composition, i.e., diversity and evenness, between sites, although habitat structure differed. The octocorals were taller and denser at the site with more modere wave energy and higher water clarity (East Cabritte) than at the more exposed site (Europa Bay) (Tsounis et al. 2018).

Banner photo: Brain Coral by K. Lewis

2.10 Marine Fish

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From the tangled prop roots of red mangroves to the deep ocean trenches, marine fish are largely mobile organisms that can be found in the vast array of marine habitats around the world. In the Caribbean, the most common habitats include, but are not limited to, seagrass beds, coral reefs, algal beds, mangroves, and uncolonized hardbottom. Each support a diversity of species by providing shelter, foraging grounds, migration corridors, and sites for reproduction. Many marine fish species rely on more than one of these habitat types over the course of their life span and move between them during certain life stages. Mangroves and seagrass beds, for example, provide nursery grounds for juvenile fishes that will later move to coral reefs or open water during their adult life stage while coral reefs serve as refuge for fishes that forage in mangrove and seagrass beds (Bohnsack 1992).

Since there is such a high degree of connectivity between nursery and adult habitats for a large number of marine fishes, conservation of multiple habitats will likely make a greater contribution to protecting fish species rather than focusing on isolated or single areas. The movements from juvenile to adult habitats can be on the scale of meters to thousands of kilometers (Gillanders et al. 2003). Therefore, it is critical to have species specific information about these movements in a fish's life cycle in order to better identify areas that warrant protection so that these shifts are not compromised. Coastal development and fishing activities can affect multiple life stages of the same species but are often managed under different regulatory paths or bodies. This makes conservation of healthy marine fish populations challenging because most species rely on the persistence of multiple habitats as well as a healthy land-sea interaction for survival.

Within marine ecosystems, there is a trophic structure in place that maintains the balance of all species. There are generally considered to be six major trophic groups: 1) herbivores (consume detritus, turf algae, and/or macroalgae); 2) invertivores (consume benthic-associated invertebrates); 3) omnivores (diet contains both animal and plant matter); 4) piscivores (prey on living fishes and <10% invertebrates); 5) carnivores (eat both invertebrates and fishes); and 6) planktivores (consume macro and micro zooplankton, including larval fishes) (Paddack et al. 2009). Each trophic group fills niches within a habitat and exerts a biological control on other trophic groups. Consumption of plant matter, invertebrates, and fish by fish can regulate trophic structure and thus influence the stability, resilience, and food web dynamics of an ecosystem (Holmlund and Hammer 1999). Each trophic group is discussed in further detail, including preferred habitat use, in the "Species Accounts" section below.

Ecological Value

Marine fish populations generate ecosystem services, which are fundamental services for maintaining ecosystem functioning and resilience and are often demand-driven services based on human value (Holmlund and Hammer 1999). Estimates of the value of fish populations for human societies have predominantly focused on the monetary values of goods, such as meat for protein, and services such as recreational fishing and ecotourism (Holmlund and Hammer 1999). However, these values are derived from ecosystems with complex interactions, where both economically and non-economically valuable fishes play active roles in the maintenance of these services. Imbalances in the interrelationships among trophic levels of an ecosystem can lead to a degradation of these services. Unfortunately, marine fishes face a myriad of threats, direct and indirect, from anthropogenic influences on marine environments. Contributions of each trophic guild are discussed in the "Species Accounts" section below.

Threats

In the USVI, increased natural and human stressors have caused the decline of marine fishes (Beets and Rogers 2000). In 2016 and 2017, as part of the VI-WAP development process (see Vol. 1, Chapter 2) stakeholder meetings were held to understand the major threats that are currently affecting marine fish species in the US Virgin Islands. The majority of stakeholders concurred that marine species decline in the territory is likely due to habitat degradation from land based sources of pollution and coastal development, overfishing, ocean warming, invasive species, and insufficient enforcement of management regulations.

Habitat degradation/destruction

Losses of marine diversity are high in coastal areas as a result of conflicting uses of coastal habitats. This is also due to the fact that marine biodiversity is higher in coastal areas than open ocean areas as there is a greater range of habitats near the coast (Gray 1997). The complete loss of a habitat is the most severe outcome and if there is a high degree of connectivity to other habitats within a landscape, that loss could be followed by the degradation of the connected habitats. An example would be the loss of a mangrove ecosystem on the coast, which provides shelter for juvenile fishes that will later shift to the coral reef adjacent to the mangrove forest. The coral reef might be considered degraded without the mangrove to support critical early life stages of its eventual residents. Seagrasses and mangroves are under high exploitation pressure from coastal development and land based pollution; 30-60% of these habitats have already been lost (Gray 1997, Valiela et al. 2001, Kimirei et al. 2011), although these habitats receive statutory protection in the USVI.

While the complete loss of a habitat may be the worst outcome, fragmentation of habitats is also a threat, even when those fragments are maintained and monitored (Gray 1997). Breaking a larger habitat apart can result in clusters of species assemblages that are remote and therefore have limited resources such as prey and shelter. Fragmented habitats would not be able to support the same number of marine fishes or the diversity compared to an unfragmented habitat. Inadequate planning and management of coastal land and upland activity has been identified as a primary agent of degradation of reef systems (Gray 1997) and most likely this holds true for seagrass beds and mangrove forests.

Mismanaged upland activities have the potential to alter marine habitats, especially in areas where the coast is bordered by mountainous terrain, as with St. Thomas and St. John. Eutrophication from excess nutrient or sewage runoff can have immediate and long term effects on coastal habitats and this occurrence has been documented in almost every coastal state (Gray 1997) or territory. Coastal coral reefs are increasingly being exposed to growing inputs of nutrients, sediments, and pollutants discharged from land based sources (Fabricius 2005). Immediate effects on habitats can include light reduction from suspended sediment and smothering of corals (Fabricius 2005). If sediment and nutrient enrichment persists, long term effects on reefs include reduced settlement of new corals, tissue damage, reduced growth and survival, and increased severity of coral diseases (Bruno et al. 2003, Fabricius 2005). This compromises many adult stage marine fishes through habitat degradation.

Overexploitation

Overexploitation can be through direct harvest, incidental catch, bycatch or through indirect effects such as trophic disruption and habitat degradation from destructive fishing gear or practices (Kappel 2005). The status of marine fish is heavily influenced by fisheries and many targeted species have become vulnerable due to overharvesting. Exploitation at high levels can ultimately result in local level extinctions (Gray 1997).

Fisheries on coral reefs tend to focus on the larger, more desirable species and progressively shift towards smaller, less desirable ones as time goes on and resources decline. Typically these larger species are apex predators that importantly structure the coral reef fish assemblage and influence ecosystem function (Friedlander and DeMartini 2002). Intensive fishing in reef systems adjacent to highly populated areas has been shown to result in lower biomasses of herbivores and other lower trophic levels, which can affect the entire reef fish assemblage of an ecosystem (Friedlander and DeMartini 2002). An altered community structure may lack the full diversity of species, trophic links, and interrelationships that would prevail without exploitation.

Climate change, ocean warming, and acidification

Climate change has the potential to influence and disrupt many processes that affect marine fish communities. Long term shifts like the Pacific Decadal Oscillation or short-term shifts, like El Niño or La Niña can have global influences on productivity, oceanic currents, water temperature, and other habitat parameters, which can have profound influences on prey availability and distribution. Changes in these parameters may render previously used habitats unsuitable and cause an overall degradation in the ability of coral reefs and other marine habitats to provide essential resources. Copepod distribution has shown signs of shifting in the North Atlantic due to climatic changes (Hays et al. 2005); this is likely to have significant impacts on food availability for fish.

Invasive species

The first Indo-pacific lionfish was detected in the Virgin Islands in 2008 off the northwest shore of St. Croix (Schofield 2009). In the intervening years, lionfish have been found around all three USVI islands in a variety of habitats and depths. Lionfish have devastated reef fish communities in areas where they have been introduced by outcompeting native fish, such as snapper and grouper, and voraciously consuming large numbers of smaller, juvenile prey fish (Morris and Akins 2009, Arias-Gonzalez et. al. 2011). CORE, a non-profit organization, has assumed much of the responsibility for outreach and control of lionfish in the territory.

Another invasive species found within the territory is *Halophila stipulacea,* a seagrass native to the Mediterranean that has since spread to 19 islands since its introduction to the Caribbean in 2002 (Ruiz and Ballantine 2004, Willette et al. 2014). This invasive seagrass has the ability to rapidly recolonize or spread to new areas through fragmentation and may be competing with native seagrass species (Willette and Ambrose 2012, van Tussenbroek et al. 2016). A recent study found reduced family diversity of juvenile fishes in habitats composed of this invasive when compared to native seagrass beds (Olinger et al. 2017). There were also different compositions of trophic levels between native and invasive seagrass beds, suggesting alterations in trophic structure with the persistence of this invasive seagrass, creating habitat for nocturnal carnivores but suboptimal conditions for herbivores and diurnal carnivores (Olinger et al. 2017).

Research and Management

Although marine fish species have traditionally been studied for fisheries purposes in the territory, there has been an increase in ecological research of marine fish in recent years. Biological monitoring of fishes is commonly used to assess environmental degradation since the relative health of a fish community is a sensitive indicator of direct and indirect stresses on an ecosystem (Fausch et al. 1990). In addition, these studies have assisted in the monitoring of marine fish species for management needs. For instance, Nemeth (2005) evaluated the population and habitat utilization of red hind (*Epinephalus guttatus*) at the Red Hind Bank Marine Conservation District located in St. Thomas. This study found an increase in average red hind size, as well as an increase in average density and biomass of spawning red hind since the permanent closure of 1999 at the Red Hind Bank Marine Conservation District (MCD). Similarly, Nemeth and Quandt (2005) found that since the closure of the Red Hind Bank MCD, carnivore (snappers and groupers) and herbivore (parrotfish and surgeonfish) fish species are more abundant within the MCD compared to sites outside the MCD.

Many of the ecologically and commercially important reef fish species such as groupers (Serranidae) and snappers (Lutjanidae) share common life history characteristics that make these species particularly vulnerable to overfishing including slow growth, late sexual maturity, spawning site fidelity, complex sexual patterns (e.g., sex change), and reproductive output restricted to brief periods of time and locations, i.e., spawning aggregations (Luckhurst 2002). In the USVI at least 20 species from eight families (Lutjanidae, Epinephelidae, Carangidae, Balistidae, Kyphosidae, Acanthuridae, Scaridae, Mullidae) are known or suspected to form transient or resident fish spawning aggregations. These aggregations occur at predictable times and locations and often represent the majority of the total annual reproductive output. As such, intense fishing effort targeting these areas can have serious negative consequences for these populations, and there are notable examples of the disappearance of spawning aggregations of Nassau groupers due to high fishing mortality during these spawning periods (Aguilar-Perera 2006). These depleted populations often do not recover (Sadovy and Domeier 2005). To date red hind is the only species that has shown recovery due to direct protection of its spawning aggregation site. Its numbers have increased proportionally at the spawning aggregation site and in commercial catches and is now one of the most numerically abundant species within the fishery. However, this has only been realized for the areas around the MCD that protected a large red hind spawning aggregation site south of St. Thomas. In contrast, the red hind spawning population in St. Croix has shown continuous decline for the past 10 years in terms of size of males and females, sex ratios, population abundance and biomass, even though it has received similar protection.

The Grammanik Bank on the shelf edge south of St. Thomas fish spawning aggregations (FSA) and fish populations are periodically assessed including snapper and grouper, such as yellowfin (*Mycteroperca venenosa*), tiger (*M. tigris*), yellowmouth (*M. interstitialis*) and Nassau (*Epinephelus striatus*) groupers and cubera snapper (*Lutjanus cyanopterus*), or other species such as the Bermuda chub (*Kyphosus sectatrix*). Studies suggest a significant increase in fish abundance and FSA densities of important grouper, snapper and other fish species in the Grammanik Bank since its permanent closure (Kadison et al. 2006, Nemeth et al. 2006a,b, Nemeth et al. 2007, Kadison et al. 2010, Nemeth and Kadison 2013, Bernard et al. 2016). Another example includes the Mutton Snapper Seasonal Closed Area (MSSCA) south of St. Croix, where benthic surveys indicate increased fish abundance since its establishment, including fish species represented by the Acanthuridae, Scaridae, Holocentridae and Lutjanidae families (Kojis and Quinn 2010). Similarly, a study using acoustic telemetry showed that many Caribbean fish species have high site fidelity to MPAs in the USVI territory; however these species also spent time outside MPAs and traveling between MPAs (Pittman et al. 2014). These studies suggest that permanent closures such as the Red Hind Bank MCD, the Grammanik Bank, Buck Island National Park (STX), Lang Bank (STX) or other Marine Protected Areas (MPA) in the USVI have been successful at recovering fish populations, especially fish that are endangered such as groupers or snapper species.

Management regulations include three U.S. federal marine protected areas (Marine Conservation District, Virgin Islands Coral Reef National Monument, Buck Island National Monument), three federal and local seasonal area closures (Mutton Snapper closed area, Grammanik Bank, Lang Bank) and three areas with limited protection (St. Croix East End Marine Park, St. Thomas East End Reserve, Virgin Islands National Park). Additional regulations include no-take for Nassau and goliath grouper (*E. itajara*) and three endangered parrotfish (*Scarus guacamaia, S. coelestinus, S. coeruleus*) and seasonal catch restrictions on groupers (February to April) and snappers (April to June). Species for which management measures have been enacted specifically to protect spawning aggregations include the Nassau grouper (*Epinephalus striatus*), red hind (*Epinephelus guttatus*), yellowfin grouper (*Mycteroperca venenosa*) and mutton snapper (*Lutjanus analus*). Several species which form spawning aggregations at the same time and place have also benefited including tiger grouper (*Mycteroperca tigris)*, yellowmouth grouper *(Mycteroperca interstitialis)*, dog snapper *(Lutjanus jocu)*, schoolmaster snapper (*Lutjanus apodus*), Bermuda chub (*Kyphosus sectatrix*) and probably other species. Species which benefit from seasonal catch restrictions include the red grouper (*Epinephelus morio),* yellow edge grouper *(Epinephelus flavolimbatus),* black grouper *(Mycteroperca bonaci)*, and several species of snappers (*Lutjanus vivanus, Lutjanus buccanella, Apsilus dentatus, Rhomboplites aurorubens, Lutjanus analis, Lutjanus synagris).* Most recently (2013) a seasonal closure for the island of St. Croix has prohibited harvest of all triggerfishes (Balistidae), which are also suspected of forming aggregations, from November 1 to December 31 each year. Finally new size restrictions (minimum 22.9 cm fork length) have been implemented in the USVI for all species of parrotfishes of which several species are known to form aggregations.

Accomplishments since 2005

UVI has been involved in conducting many aspects of marine fish research, in particular, research involving understanding movement patterns using acoustic telemetry. These fish movement studies have shed light on fish behavior and habitat utilization in the territory and are of further aid in fish species management in the USVI. For instance Hitt et al. (2011) studied how seascape patterns affect movement patterns and habitat interactions of *H. sciurus* and *L. apodus*. This study found that both fish preferred coral reef habitats during the day and at night shifted to spaces with lower-complexity soft sediment such as sand, seagrass and scattered coral/rock. Biggs and Nemeth (2016) studied movement patterns of *L. jocu* and *L. cyanopterus* spawning aggregations to determine catchment area, and found high site fidelity although the maximum possible catchment area could cross jurisdictional bounds. Knowledge of this site fidelity may prove effective for management of fisheries. Legare et al. (2015) studied movement patterns of juvenile blacktip sharks (*Carcharhinus limbatus*) and lemon sharks (*Negarion brevirostris*) within Fish Bay and Coral Bay, St. John. The research indicated that both shark species exhibit high site fidelity to both bays, especially in the summer time after birth (Legare et al. 2015). Jossart (2014) studied how much time yellowfin grouper (*Mycteroperca venenosa*) are spending in the Grammanik Bank closure area using passive acoustic telemetry, and found that this species only spends about 24.9% of its time in the Grammanik Bank. Ruffo (2016) studied movements and utilization of spawning aggregation sites of yellowtail parrotfish (*Sparisoma rubripinne*) in Reef Bay, St. John and Hassel Island, St. Thomas. Her study reconfirmed that *S. rubripine* aggregates at various sites of Reef Bay, in particular in an eastern fish spawning aggregation (FSA) site of Reef Bay. Moreover, fish caught within inner Reef Bay would travel and spend more time in the western FSA than the fish captured from the outer Reef Bay. Lastly, the study indicated that decreasing barometric pressure influenced fish absence at spawning sites. Renchen et al (2014) studied the impacts of derelict fish traps in Caribbean waters and showed derelict fish traps affect fish behavior and condition and can lead to fish mortality. Ortiz (2013) studied the social structure of the local fisherman community and its capacity to enhance sustainability of USVI fisheries and found that leaders of the local fishing community may be a good resource for increasing knowledge on fishery sustainability.

Entities within the USVI, including DPNR, DFW, NPS, NOAA, and UVI continue to collaborate in conducting research and monitoring on fish species in the territory. Such research and monitoring projects include fish surveys, assessment of fish status/abundance/distribution, mapping essential fish habitats, tracking fish movement patterns, ciguatera monitoring, fish landing sampling and lionfish population control (Recksiek et al. 2006, Friedlander and Beets 2008, Pittman et al. 2008, Monaco et al. 2011, Pittman and Brown 2011, Friedlander et al. 2013).

Conservation Priorities

Optimizing the amount and quality of the suite of habitats that marine fish rely on is key for their long term survival. This includes maintaining dispersal opportunities as well as interconnectivity between habitats. Protecting marine environments from land-based sources of pollution, such as trash, chemical contaminants, sediment, and other point and nonpoint sources of pollution is a priority measure towards reducing stressors on systems increasingly affected by climate change. Managing land-based impacts can be accomplished through improvement of best management practices for sediment runoff, improved erosion control through reforestation, and establishing coastal vegetation buffers.

Local marine protected areas have proven effective at protecting marine habitats and have resulted in increased fish stocks. Identifying additional areas for protection, at least on a seasonal (breeding/aggregation) basis, should be prioritized. Establishing marine zones that spatially and temporally limit certain types of activities may also prove effective in supporting marine habitats.

Re-establishing native predators and herbivores within coral reef systems will improve habitat conditions to allow fish communities to maintain resilience against climate change impacts. Implementing the Lionfish Response Management Plan (Kilgo 2014) is ongoing, and additional creative methods for reducing populations of these invasives should be identified.

In addition to fisheries management activities, including enforcement of existing fishing regulations and implementation of a recreational fishing license requirement, increased outreach to the general public about fishing regulations and conservation including consumers, tour operators, dive shops and fishermen would be beneficial. The Reef Responsible program has initiated this effort toward establishing a successful outreach and certification program. Education and engagement of all stakeholders is critical to garner public and widespread support for the highlighted issues. Conservation initiatives and policy can be designed and implemented, but without participation from all stakeholder groups, the initiative and policy will be rendered ineffective.

Species of Greatest Conservation Need

Common Name	**Scientific Name**	**Status**
Bonefish	*Albula vulpes*	Data Deficient-At Risk
Gray Triggerfish	*Balistes capriscus*	Data Deficient-At Risk
Queen Triggerfish	*Balistes vetula*	High Risk
Greater Amberjack	*Seriola dumerili*	Data Deficient-At Risk
Porkfish	*Anisotremus virginicus*	Low Risk
Black Grunt	*Haemulon bonariense*	Data Deficient-At Risk
Hogfish	*Lachnolaimus maximus*	Data Deficient-At Risk
Mutton Snapper	*Lutjanus analis*	High Risk

Common Name	**Scientific Name**	**Status**
Cubera Snapper	*Lutjanus cyanopterus*	Data Deficient-At Risk
Lane Snapper	*Lutjanus synagris*	Low Risk
Silk Snapper	*Lutjanus vivanus*	High Risk
Vermillion Snapper	*Rhomboplites aurorubens*	High Risk
Spotted Goatfish	*Pseudupeneus maculatus*	High Risk
Midnight Parrotfish	*Scarus coelestinus*	High Risk
Blue Parrotfish	*Scarus coeruleus*	High Risk
Rainbow Parrotfish	*Scarus guacamaia*	High Risk
Princess Parrotfish	*Scarus taeniopterus*	Low Risk
Queen Parrotfish	*Scarus vetula*	Low Risk
Redtail Parrotfish	*Sparisoma chrysopterum*	Low Risk
Stoplight Parrotfish	*Sparisoma viride*	Low Risk
Graysby	*Cephalopholis cruentata*	High Risk
Coney	*Cephalopholis fulva*	High Risk
Marbled Grouper	*Dermatolepis inermis*	High Risk
Rock Hind	*Epinephelus adscensionis*	High Risk
Red Hind	*Epinephelus guttatus*	Low Risk
Goliath Grouper	*Epinephelus itajara*	High Risk
Red Grouper	*Epinephelus morio*	High Risk
Nassau Grouper	*Epinephelus striatus*	High Risk
Black Grouper	*Mycteroperca bonaci*	High Risk
Longsnout Seahorse	*Hippocampus reidi*	Data Deficient-At Risk
Black Marlin	*Istiompax indica*	Data Deficient-At Risk
Sailfish	*Istiophorus platypterus*	High Risk
White Marlin	*Kajikia albida*	High Risk
Striped Marlin	*Kajikia audax*	High Risk
Blue Marlin	*Makaira nigricans*	High Risk
Shortbill Spearfish	*Tetrapturus angustirostris*	Data Deficient-At Risk
Atlantic Bluefin Tuna	*Thunnus thynnus*	High Risk
Albacore Tuna	*Thunnus alalunga*	High Risk
Yellowfin Tuna	*Thunnus albacares*	High Risk
Bigeye Tuna	*Thunnus obesus*	High Risk
Spotted Eagle Ray	*Aetobatus narinari*	High Risk
Blacktip Shark	*Carcharhinus limbatus*	High Risk
Oceanic Whitetip Shark	*Carcharhinus longimanus*	High Risk
Caribbean Reef Shark	*Carcharhinus perezii*	High Risk
Tiger Shark	*Galeocerdo cuvier*	High Risk
Lemon Shark	*Negaprion brevirostris*	High Risk
Giant Manta Ray	*Manta birostris*	High Risk
Whale Shark	*Rhincodon typus*	High Risk
Scalloped Hammerhead Shark	*Sphyrna lewini*	High Risk

Species Accounts --Trophic Guild Descriptions

Herbivores

The two most important herbivorous fish families on Caribbean reefs in terms of density, biomass, and impact on the aquatic plant community are parrotfish and surgeonfish (TNC 2002). Damselfish are another group of important herbivores that graze on aquatic plants, mainly algae, and coral. Parrotfish in particular are ecologically and economically important for a variety of reasons. First, they are one of the sought after species by local fishermen across the territory. Second, encounters with the often colorful parrotfish, such as queen and stoplight parrotfish, are a focus of many ecotourism dives/snorkels, bringing money into the local economy. Third, parrotfish play an integral role in maintaining the structure of important, shallow-water reef communities (TNC 2002). It has been suggested by many studies that by suppressing the abundance of fast-growing algae, herbivorous fish indirectly facilitate the persistence of coral reefs (TNC 2002). Parrotfish are unique among all reef fishes in their ability to consume fleshy as well as heavily calcified algae (TNC 2002). For these reasons, scientific studies have pointed to their keystone role as important top-down agents, affecting the distribution and abundance of seagrass and macroalgae across flats and coral reef communities (TNC 2002; Rogers et al. 1997).

Many herbivorous species can be found during the day foraging on algae over reefs and rubble patches, and even seagrass in nearby flats. These species return to the reef at night for protection from predators. Some species, such as bucktooth and green blotch parrotfish, live almost exclusively in seagrass habitat (TNC 2002). Mangrove communities are also important nursery grounds for many herbivorous marine fish (TNC 2002). A variety of parrotfish have been observed to be diurnally active in mangroves in Puerto Rico, where highly mobile, species-specific foraging groups continuously moved in and out of mangroves (Rooker and Dennis 1991).

Invertivores

Invertivores are fishes that consume benthic-associated invertebrates, although often a small portion of their diet may consist of algae or plant detritus (Paddack et al. 2009). Common marine fishes found in this trophic group include triggerfish, butterflyfish, porcupinefish, grunts, squirrelfish, and goatfish. Select species of wrasses, angelfish, porgies, and pufferfish are also in this group. These varying species groups in this trophic level may have similar diet compositions, but their movements across different habitat types and feeding strategies can differ. This is demonstrated by comparing goatfish and grunts, which are often two of the most common invertivores seen in marine ecosystems in the territory.

Goatfish are diurnal feeders that are quite mobile while foraging over diverse habitat types such as sandy patches, rubble, and within seagrass beds (Sazima et al. 2006). Other fish species benefit from goatfishes' foraging in that they follow the goatfish and capitalize on food items and organic particles exposed when the goatfish chin barbels stir up the bottom substrate in their search for prey (Sazima et al. 2006). One study documented seventeen other fish species associated with the spotted goatfish foraging, including other invertivores but also herbivores, planktivores, and omnivores (Sazima et al. 2006). This suggests that goatfish can have a large impact across multiple trophic groups in coral reef/rubble and seagrass habitats.

Grunts are often considered carnivorous, but only prey on invertebrates, not other fish species. Compared to goatfish, grunts are more nocturnal feeders and migrate during twilight on a daily basis from their daytime habitat to nocturnal feeding grounds (Rooker and Dennis 1991). During the day, they generally form large inactive schools at sheltered, resting sites within a reef, as adults, or within mangrove root structure, as juveniles. Then at dusk, they migrate to seagrass beds and sand flats to forage for invertebrates (Rooker and Dennis 1991). Therefore, grunts likely move between coral reefs, seagrass beds, and mangrove habitats throughout the course of their life cycle and maintain a degree of influence over the benthic invertebrate communities they prey on within each.

There is likely competition between the species in the invertivore trophic group; however, if a certain species group feeds nocturnally while the other exhibits daytime feeding, there may not be a large overlap in their movements. There may be more competition between species that either both feed nocturnally or diurnally.

Omnivores

Omnivorous fishes consume both animal and plant material (Paddack et al. 2009). There is a great deal of overlap with the invertivores, as many of the families in this trophic group have species that consume both invertebrates and plant material. Species of butterflyfish, gobies, trunkfish, and pufferfish are considered omnivorous.

Piscivores/Carnivores

Piscivores are marine fish that prey almost exclusively on living fishes, with less than 10% of their diet consisting of invertebrates. Carnivores are marine fish that prey on both living fishes and invertebrates. There is a great deal of overlap in fish families between these two trophic groups, which are often lumped together as carnivores. Families that include species of both trophic groups include jacks, sharks, tarpon, snappers, moray eels, tunas, groupers, scorpionfish, barracuda, and lizardfish (Paddack et al. 2009). However, more species are carnivores than piscivores, eating both fish and invertebrates. Many of the species in this group are considered to be apex predators, which are well known to exert top-down control across multiple trophic groups through direct consumption (Baum and Worm 2009). Carnivorous fishes are usually at the top of food webs and an ecosystem with high levels of predator diversity can induce indirect interactions with all trophic levels that modify behavior and affect aquatic plant communities by altering herbivore foraging (Bruno and O’Connor 2005).

Two of the most popular, commercially targeted groups of species in this trophic level are snappers and groupers. Both share common life history characteristics, such as larger body sizes, slower growth, late sexual maturity, and the formation of spawning aggregations. These aggregations are events characterized by very predictable locations and timing where the spawning adults come together and represent the primary source of annual reproductive effort. In the USVI, at least 20 species from eight fish families are known or suspected to form transient or resident fish spawning aggregations. Adults migrate large distances to these locations from their home ranges within coral reefs. Red hind in the USVI, for example, were found to migrate up to 30 km to an aggregation area (Nemeth et al. 2007). These large movements by reproductively active fish and the subsequent habitation of the spawning grounds most likely impact the habitats of the migration corridors and spawning sites through competition for space and food. Both snappers and groupers use a broad array of ecosystems across continental shelves (Lindeman et al. 2000). As juveniles, many species use mangroves and seagrass beds as nursery habitats where there is ample shelter due to structural complexity, as well as a high abundance of prey (Kimirei et al. 2011). Either a dietary (ontogenetic) shift or reaching size at maturity can spur the move to adult habitats within coral reefs (de la Morinière et al. 2003). These movements also typically occur from shallow to deeper water habitat gradients (Kimirei et al. 2011).

Within this trophic group, there is a huge diversity of life cycles, life history characteristics, behavior, and movements despite sharing a common type of diet. Certain carnivorous or piscivorous fishes can be much more mobile than others, even crossing international boundaries. Tuna species, for example, are highly migratory, move great vertical lengths in the water column to feed, and are known for trans-oceanic movements (Rooker et al. 2007). Tuna species are also known to shoal, a social grouping where individuals stay and move together. Grouper species such as Nassau or red hind, however, show strong site fidelity to a home range (Beets and Hixon 1994) and may migrate to a spawning site but otherwise do not exhibit regular, long distance movements. Groupers, as well as some snappers, are normally solitary species and the only time large congregations are observed are during spawning aggregations (Sadovy and Eklund 1999). Lizardfish are also solitary and exhibit ontogenetic shifts that correspond to offshore movements but can be found from open ocean habitats to sand/mud flats in estuaries (Cruz-Escalona et al. 2005). Regardless of the differences between these fish families, their predation has a much broader impact on the a food web as they consume not only other trophic levels like herbivores but also other carnivores. This biological control from the top of a food web can have effects all the way down to the primary production of an ecosystem (Bruno and O'Connor 2005).

Planktivores

This trophic group is often also found on the bottom of food webs, similar to herbivores. Planktivores consume macro and micro zooplankton which often includes larval fishes (Paddack et al. 2009). Families within this group are cardinalfishes, scads, herrings, sardines, damselfishes, and certain wrasses. Zooplankton and phytoplankton communities provide a food and energy source for corals and other suspension-feeding reef organisms (Glynn 1973) and can be affected by the feeding selectivity of planktivorous fishes (Lazzaro 1987). Through this predation, these fishes could potentially impact food availability for the benthic community. The consumption of fish larvae could also exert localized influence on fish recruitment to a habitat.

As with many marine fishes, planktivores can be found in mangrove prop-roots seeking shelter or foraging. The two main types of planktivores in prop-roots are demersal and midwater feeders (Rooker and Dennis 1991). Specific species include beaugregory, sergeant majors, and silversides. While these fishes do not show diel changes in abundance, there are significant day-night changes, suggesting that feeding activity is restricted to diurnal hours and individuals seek cover at night (Rooker and Dennis 1991). This trophic group also inhabits coral reef structure, such as wrasse species and cardinalfish. Cardinalfish are nocturnally active and during the day rest within caves and crevices of corals where they can form dense multi-specific aggregations (Barnett et al. 2006).

The interaction between piscivores and planktivores can have a large influence on the microalgae communities of a habitat, such that disruptions to the natural balance could have cascading effects. Planktivores interact with other, higher trophic groups, usually as a source of prey. Piscivores consume the often small- bodied planktivorous fishes, which in turn affects the biomass and abundance of zooplankton. With piscivores, levels of plankton predation from planktivores decrease causing zooplankton and copepod biomass and mean body size to increase. Zooplankton and copepods prey on phytoplankton, which influence the chlorophyll concentrations and primary production of an ecosystem. Therefore, higher zooplankton and copepod numbers causes reduced chlorophyll and primary production (Hambright 1994). When piscivores are less abundant or removed from an ecosystem, the relationship reverses. Planktivores are released from predation pressure and increase in number, leading to higher predation on zooplankton and copepods, which then subsequently releases phytoplankton from predation pressure. In this case, chlorophyll and primary production are enhanced (Hambright 1994).

Banner photo: *Acanthurus coeruleus* by R. Platenberg

2.11 Marine Mammals

The diversity of the underwater habitats in the Caribbean provides feeding and calving grounds for around 30 species of marine mammals, with at least seventeen species reported in or near U.S. waters in the northeastern Caribbean (Mignucci-Giannoni 1998, Mignucci-Giannoni et al. 1999). Most of these are wide-ranging cetaceans, with one sirenian occurring in several localities including Puerto Rico and the island of Vieques.

Some species of marine mammals are resident year-round, including many of the dolphins and the sperm whales, while others, such as the humpback whale, migrate long distances each year. Around the USVI, most cetaceans are observed during the winter and early spring, with an increase in sightings beginning in December, peaking in February, and gradually decreasing in March and April, with few sightings from May through November. Species that do not migrate can be seen throughout the year, utilizing these waters for feeding and reproduction throughout the year (Mignucci-Giannoni 1998). Except for the humpback whale, which occurs in specific areas during winter to breed and calf, abundances and distributions of most marine mammals in the northeastern Caribbean are poorly known (Hayes et al. 2018).

The diet of whales and dolphins is primarily composed of fish, although some species, such as sperm whales supplement with squid, octopus, shrimp, and crabs (NMFS 2009), while Caribbean populations of orca have been observed feeding on sea turtles and other marine mammals (Bolaños-Jiménez et al. 2014). Although feeding groups tend to be small, healthy fish stocks are required to sustain these populations across their ranges. Manatees are primarily herbivorous, feeding on seagrasses and other aquatic plants.

Throughout the 17th-20th centuries whales were valued for their meat, oil, spermaceti, and baleen, and were hunted to near extinction (e.g., Kennedy and Clapham 2017). Many countries, such as Norway, the Faroe Islands, Japan, St Vincent and the Grenadines, and indigenous communities in the U.S. still hunt some species of whales (Hoyt 1999, Hoyt and Hvenegaard 2002). Economic value of marine mammals have shifted toward more social and intrinsic values, and public awareness of these species has been increasing (Alie 2008). People enjoy seeing these animals and marine mammal watching is a growing industry that provides extended benefits to the local economy. There has been a recent shift in the whaling industry away from hunting towards observing, with a world-wide increase in whale watching operations. In Dominica, for example, whale watching is encouraged and promoted by the government, tourism, hotels, and calling cruise ships, producing significant revenue for the country (Hoyt 1999) while St. Vincent and the Grenadines, where whaling is still practiced, the tourism revenue is much lower.

Marine mammals also have very high existence values; people value them, because they are perceived as intelligent and gentle, and as such, people are willing to support programs that aim to conserve and protect them even though the contributors might not themselves derive direct benefit.

ESA-listed species for which the USVI are identified as within distributional range include three baleen whales (blue, fin, and sei), one toothed whale (sperm), and one sirenian (West Indian manatee). Humpback, Pilot, and Sperm whales and a number of dolphins, including Spinner Dolphins and Orca, are occasionally observed in VI waters. Mignucci-Giannoni (1998) reviewed cetacean sighting data from published and unpublished records collected in the insular shelf waters of Puerto Rico, the USVI, and the British Virgin Islands (BVI) through 1998. Humpback whales were most commonly sighted, comprising nearly 80% of sightings records, followed by bottlenose dolphins, shortfin pilot whales, sperm whales, spinner dolphins and Atlantic spotted dolphins. Orca are also infrequently observed in waters around the USVI and Puerto Rico (Bolaños-Jiménez et al. 2014), and there may be an orca population that is resident off Puerto Rico.

Ecological Value

Marine mammals are important in the regulation of fish populations. Cetaceans are apex predators as adults and contribute to the stability of marine ecosystems. They play a major role in the transport of nutrients through excretion, and their carcasses provide an important food source to other animals. Dead whales that sink in deep water habitats contribute nutrients that support pelagic and benthic organisms. The balance between baleen whales and their planktonic prey is delicate and shifts in abundance of either can have significant impacts on oceanic nutrient abundance, which can have indirect effects on water quality and habitat availability.

Threats

Threats to marine mammals in and around USVI waters include collision with boats, entanglement in fishing gear, marine debris, and chemical contaminants (Hayes et al. 2018). Due to dependence on large schools of fish as prey, trends in fish populations as influenced by fisheries operations, habitat degradation, and natural processes affect the size and distribution of cetacean populations locally. Increasing presence of plastic pollution in marine habitats poses a significant threat for mortality from ingestion (Gregory 2009, de Stephanis et al. 2013).

Marine mammals are affected by fisheries interactions, with mortality caused by incidental capture or entanglement in nets. Entanglement seems to be the most significant cause of mortality for marine mammals in local waters (Waring et al. 2012, Hayes el al. 2018), although interactions with long line fisheries have been reported for Bottlenose Dolphins. The extent of these interactions in the Caribbean are unknown (Waring et al. 2012).

The long life span of marine mammals makes them susceptible to bioaccumulation of pollutants, such as organochlorines (OC) and heavy metals from coastal industrial and agricultural activities (UNEP 2008, Waring et al. 2012). OC pesticides and polychlorinated biphenyls (PCBs) have been found in high concentrations in the blubber of several European cetaceans, including Bottlenose Dolphins, despite long-term regulations to restrict these use of these substances (Jepson et al. 2016).

Climate change has the potential to influence and disrupt many processes that affect cetaceans and other marine organisms. Long term shifts like the Pacific Decadal Oscillation or short-term shifts, like El Niño or La Niña can have global influences on productivity, oceanic currents, water temperature, and other habitat parameters, which can have profound influences on prey availability and distribution. Changes in these parameters may render previously used habitats unsuitable, such that site selection for activities such as feeding, breeding, and migration may be altered (NMFS 2011). Surveys have found that copepod distribution has showed signs of shifting in the North Atlantic due to climatic changes (Hays et al. 2005); this is likely to have significant impacts on baleen whales that depend on this food source, although species with large feeding ranges, such as fin whales, are likely to be more resilient to these changes than those with narrower ranges or specialized diets (NMFS 2011).

Research and Management

All marine mammals are protected under the Marine Mammal Protection Act (MMPA), which prohibits “take” of all species of marine mammals, with take defined as hunting, killing, capture, and/or harassment. The act also establishes a moratorium on the import, export or sale of any marine mammal or part within the US (MMPA 1972, found at mmc.gov). The MMPA also requires periodic stock assessments of the geographical range, population and productivity estimates, causes of mortality, and level of fishing interactions. Additionally, sei, fin, and sperm whales and manatees are protected under the Endangered Species Act.

Within U.S. waters, NMFS maintains jurisdiction over marine mammals (except manatees, which are managed by the USFWS), which includes around 160 marine mammal stocks listed under the MMPA. Programs towards marine mammal conservation and management include development and implementation of species-specific management plans, maintenance of the Marine Mammal Health and Stranding Response Program, administration of a national captive display program, issuance of permits, including CITES, and mitigating bycatch within U.S. commercial fisheries (www.nmfs.noaa.gov/pr/species/mammals).

The Marine Mammal Protection Act defines a marine mammal “stock” as a group of individuals of the same species or in a common spatial arrangement that interbreed when mature (i.e., a metapopulation). Stock assessment reports for all marine mammals in U.S. waters are required at least every three years or when new information becomes available. “Strategic” stock, which are populations that may be experiencing unsustainable human impacts, are reviewed annually. . Since that time, all stocks have been reviewed at least every three years or as new information becomes available. Stocks that are designated as "strategic" are reviewed annually. NOAA produces annual stock reports for Puerto Rico and the US Virgin islands for the following species: Sperm Whale, Common Bottlenose Dolphin, Cuvier’s Beaked Whale, Short-finned Pilot Whale, Spinner

Dolphin, and Atlantic Spotted Dolphin; injuries and mortality levels are unknown and have not been updated since 2011 (Hayes et al. 2018).

The International Whaling Commission (IWC) was established in 1946 under the International Convention for the Regulation of Whaling to regulate hunting quotas. Measures under the IWC include catch limits by species and area, designated sanctuaries, and protection for mothers with calves. The IWC also coordinates and funds conservation work, to include an international entanglement response and establishing management plans for species and populations of cetaceans. Conservation actions and key documents can be found at IWC website (https://iwc.int/home).

Observations of marine mammals in USVI waters are rare, and systematic research on marine mammals in the USVI has been limited to physiological parameters of captive animals at the Coral World Ocean Park on St. Thomas (Arencibia 2015). Reports on cetacean strandings are submitted to DFW, the NMFS Marine Mammal Health and Stranding Response Program in Miami, or the USFWS field office in Boquerón, PR. There is also a Manatee Conservation Center in Bayamón, PR that conducts research, offers education and outreach, and provides rescue and rehabilitation services for manatees and other marine wildlife (manatipr.org).

Due to the sporadic nature of cetacean observations, a whale-watching industry has not been developed in the VI or PR, although these types of activities have been shown to increase awareness and promote conservation efforts even when trips do not result in whale observations (Hoyt and Hvenegaard 2002). EAST organizes a series of whale watching day sails with a guest lecturer annually, and although these trips are popular, they have limited availability and reach to the local community. One major goal of these trips that is successfully achieved is to contribute to the operating budget of this non-profit organization. There is a potential and likely market value in expanding educational ecotourism activities to raise awareness and funding towards conservation of cetaceans and other marine organisms. Best practice guidelines have been developed for marine mammal watching activities in the Caribbean that promote tourism, local industry, and marine conservation while ensuring protection of marine mammals (http://www.car-spaw-rac.org/?Whale-Whatching-Guidelines,652; UNEP 2011).

Accomplishments since 2005

The global distribution of the Humpback Whale has been divided into 14 distinct population segments, equating to management units (Bettridge et al. 2015). The Caribbean population has been removed from the ESA, although this population is still under the protective measures of the MMPA.

The Manatee has been downlisted from Endangered to Threatened across its range (USFWS 2017) due to widespread conservation efforts and increases in manatee population numbers. While the species is no longer considered in danger of extinction across its range, it is likely to become so in the foreseeable future without continued protective measures offered by the ESA.

Locally, there have been no conservation or research activities that have focused specifically on wild populations of marine mammals.

Conservation Priorities

A long-term objective for marine mammals identified by the UNEP Specially Protected Areas and Wildlife (SPAW) Protocol for the Wider Caribbean Region (WCR) includes protection of marine mammals and their feeding, breeding, and calving grounds as well as their migration corridors (http://www.cep.unep.org/cartagena-convention/spaw-protocol/overview-of-thespaw-protocol). However, better information is needed towards targeting specific threats (Boisseau et al. 2006). Despite low numbers of marine mammals in USVI waters, local research on impacts from anthropogenic noise from vessels, prevalence of ship strikes, and loss of prey resources from ecosystem change could provide meaningful contributions to an understanding of how these impacts affect these species across their range.

Periodic standardized surveys should be conducted for marine mammals in USVI waters to build an understanding of spatial and temporal habitat use, distribution, and population abundances. A Citizen Science project could be developed to capture opportunistic observations. A local reporting system with a dedicated coordinator for marine mammal strandings should be established, with a widely publicized reporting protocol. In addition, an increase in education and outreach toward marine mammal protections, approach distances, and reporting will benefit local populations and mitigate human threats to marine mammals.

The UN Caribbean Environment Program has produced a useful document for marine mammal conservation that can be found at: http://www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/marine-mammals.

Post-hurricane needs: Because whales and dolphins are able to move quickly and utilize deep waters, it is unlikely that the 2017 hurricanes had a significant impact on them. The potential impact to manatees is high, both due to immediate storm effects as well as long term influences from habitat damage and slow recovery of both habitats and manatee recruitment. While there are no recommended actions to be implemented within the USVI to directly support the Antillean manatee population, establishing a hotline for sightings can provide support to conservation efforts in nearby Vieques and Puerto Rico.

Species of Greatest Conservation Need

Common Name	**Scientific Name**	**Status**
Sei Whale	*Balaenoptera borealis*	Low Risk
Fin Whale	*Balaenoptera physalus*	Low Risk
Humpback Whale	*Megaptera novaeangliae*	Low Risk
Atlantic Spotted Dolphin	*Stenella frontalis*	Data Deficient-At Risk
Bottlenosed Dolphin	*Tursiops truncatus*	Data Deficient-At Risk
Sperm Whale	*Physeter macrocephalus*	Low Risk
West Indian Manatee	*Trichechus manatus*	Low Risk

Species Accounts

Species descriptions and other biological information on marine mammals can be found on the NOAA-NMFS website (www.nmfs.noaa.gov/pr/species/ and www.fisheries.noaa.gov/). Stock assessment reports that provide the most recent population estimations across the species' ranges can also be found at these sites.

Humpback Whales (*Megaptera novaeangliae:* Baelaenopteridae**)** are frequently spotted in USVI waters through the winter to late spring. These large whales (22,000-35,000 kg, up to 18 m in length) spend the summer months in North Atlantic feeding grounds in and around the Gulf of Maine, where they feed on plankton, mostly krill, and small fish that they filter through baleen. In the winter they migrate to subtropical and tropical breeding and calving grounds, which are typically near offshore reef systems or islands, where they congregate and engage in courtship and mating. Females breed every 1-3 years. Humpbacks have around a 50-year lifespan.

There has been a long history of record-keeping for humpback whales (Kennedy and Clapham 2017). The species was listed as endangered in 1970 and considered "depleted" under the MMPA. An ESA status review requires both the identification of taxonomic units (Distinct Population Segments, or DPS) and the risk of extinction for each of these units. A population is considered a DPS if it is discrete from and significant to the remainder of the taxon to which it belongs (Bettridge et al. 2015). A status review team assessed demographic data of humpback whale populations and identified 14 global DPS; the status of each was evaluated separately (Bettridge et al. 2015). The "West Indies DPS" consists of the humpback whales whose breeding range is within the Atlantic margin of the Antilles from Cuba to Venezuela, and whose feeding range includes the North Atlantic from the Gulf of Maine and eastern Canada to western Greenland. The status review determined that the West Indies DPS is not at risk of extinction with a high certainty, and estimations of population sizes are around 10,000 to 12,000 individuals (see Bettridge et al. 2015 for discussion on estimation methods), and slowly increasing. For this reason, the West Indies DPS has been removed from ESA listing.

Threats to this DPS include discharge of run-off and pollutants into marine waters, vessel strikes, and a significant threat from entanglement in fishing gear. Underwater noise can affect behavior, but the extent of these impacts is unknown. While hunting in the 18th – 19th centuries was the major cause of precipitous population declines, this impact has been regulated although there is a still a hunting industry in St. Vincent and the Grenadines, where there is an annual hunt quota of 24 individuals (Bettridge et al. 2015). In the North Atlantic, threats of harmful algal blooms, vessel collisions, and fishing gear entanglements are likely to moderately reduce the population size or growth rate of the West Indies DPS. All other threats are likely to have minor impacts.

Whale watching has become an important industry, particularly in the Dominican Republic, and there is some suggestion that increased boat and cruise ship traffic may be driving the humpbacks away from previously occupied breeding grounds (Bettridge et al. 2015). This impact is unverified and should be evaluated.

The **Fin whale** (***Balaenoptera physalus:*** Baelaenopteridae) is ESA Endangered throughout its range. This species occurs in deep offshore waters of all major oceans. Most migrate from feeding grounds in New England waters, where they feel on krill, small schooling fish, and squid, to calving areas in the mid-Atlantic.

The most recent estimate of the Western North Atlantic populations is 1618 individuals (Hayes et al. 2018), down from around 4000 prior to 2010 (NMFS 2011). Population trends are unknown (but apparently declining). Threats include vessel strikes and entanglement in fishing gear, although no fishing related serious injury and mortality has been reported recently (Hayes et al. 2018). Climate change is likely to have an influence on prey availability through shifting currents. Fin whales may be somewhat resilient to shifts in prey distribution due to a large feeding range (NMFS 2011).

Sei whales (***Balaenoptera borealis:*** Baelaenopteridae**)** are ESA endangered throughout their range. They have a global distribution across the North Atlantic, North Pacific, and Southern Hemisphere, although their population structure is unknown (NMFS 2012). The North Atlantic group is typically found in the summer off the U.S coast and winter in temperate to tropical waters, occasionally in the Gulf of Mexico and Caribbean although they predominantly occur in deep open waters. Females are sexually mature at 6 to 12 years, and breed every 2-3 years (Hayes et al. 2018). Individuals eat about 900 kg of food daily, mostly plankton (copepods and krill), small fish, and cephalopods.

Sei whales were targeted by modern commercial whaling practices from the 1950s to 1970s, which significantly depleted populations. They have been ESA listed as Endangered since 1973 and received protection from the International Whaling Commission's moratorium on whaling in 1986 (NMFS 2012). Population estimates from 1978 suggest that the Western North Atlantic stock had between 1400 to 2250 individuals (Waring et al. 1999), while recent estimates of this population are significantly lower at less than 400 (2011 estimate reported in Hayes et al. 2018). Accurate abundance estimates are difficult because they are rarely encountered, and population trends are unknown. Known threats include entanglement in fishing gear, vessel strikes, and ocean noise.

The **Sperm Whale (*Physeter macrocephalus:*** Physeteridae**)** is ESA endangered throughout its range. It is the largest of toothed whales, with the widest global distribution of all the marine mammals. They are found mostly in deep water, with a diet comprised largely of species found in deep water such as squid, sharks, skates, and fish. Their distribution is dependent on food sources and breeding conditions, and tropical populations show no obvious seasonal migration pattern. In local waters they are found from late fall through winter and early spring but rarely from April to September. Sperm whales are sexually mature at around 9 years, and breed every 5 to 7 years. Females form social groups that stay in tropical waters, while males join bachelor schools that migrate polewards.

The best estimate of world-wide abundance is 300,000 – 450,000 individuals. The PR and USVI population is provisionally considered separate stock for management. The population abundance and trend in local waters is unknown due to low sighting numbers. Threats include vessel strikes, entanglement in fishing gear, ocean noise, ingestion of marine debris, and climate change, which affects habitat and food availability. The fishing related serious injury and mortality levels in local waters are unknown (Waring et al. 2012).

Other whales known to occur in PR and USVI waters include **Cuvier's Beaked Whale** (*Ziphius cavirostris:* Ziphiidae) and the **Short-finned Pilot Whale** (***Globicephala macrorhynchus:*** Delphinidae*)*. The status of both of these species is unknown due to insufficient sightings (Waring et al. 2012).

The **Atlantic Spotted Dolphin (*Stenella frontalis:*** Delphinidae**)** is usually found in groups of up to 50, but sometimes travel in groups up to 200. Diet is small fish, invertebrates, and cephalopods. They are sexually mature at 8-15 years, and females reproduce every 1-5 years. World-wide population is unknown, although estimated at least 81,000 in US waters (Waring et al. 2012). Abundance in PR and USVI water is unknown and the status has not been assessed (Waring et al. 2012). Threats include entanglement in fishing gear, ocean noise, and illegal feeding and harassment. They are not ESA protected. **Spinner dolphins (*Stenella longirostris longirostris*)** are also found in PR and USVI waters, although their status here is unknown and has never been assessed (Waring et al. 2012).

Common Bottlenose Dolphins (*Tursiops truncatus:* Delphinidae**)** are frequently observed in USVI waters, where they travel alone or in groups, feeding on fish, squid, crabs, and shrimp. This species is found in temperate and tropical waters across the globe. The Atlantic population ranges along the U.S. east coast from New York to Florida and throughout the Gulf of Mexico and Caribbean. They are sexually mature between 5-15 years, females reproduce every 3-6 years, and individuals can live at least 40 years.

Threats include interactions with fishers and fishing gear, habitat degradation, particularly from chemical contaminants such as PCBs and oil spills, biotoxins, harmful algal blooms, along with illegal feeding and harassment. Bottlenose dolphins continue to be targeted for live-capture fisheries in Cuba, Dominican Republic, Haiti, and Honduras for use in captive displays (Waring 2012). The PR and USVI population abundance is unknown and there is no minimum population estimate or trends. Level of past or current direct human caused mortality in local waters is unknown, although there are reports of mortality to dolphins entangled in fishing gear. They are not ESA protected.

Orca (*Orcinus orca:* Delphinidae**)**, also known as the Killer Whale, is the largest species in the dolphin family. Males range from 20-26 ft (6-8m), females 16-23 ft (5-7m). They have a diverse diet, feeding on fish and marine mammals including sea lions, seals, walruses, and even whales. These dolphins are easily recognizable by their white chest and black back. Generally seen on the outer periphery of the Antilles, the orca has been observed around the Virgin Islands several times in recent years. It is thought they are resident year-round in the region (Bolaños-Jiménez et al. 2014).

The **West Indian Manatee** (***Trichechus manatus:*** Trichechidae**)** occurs around the southern and eastern end of Puerto Rico and around nearby Vieques Island. This species inhabits both marine and freshwater environments, typically found in canals, rivers estuarine habitats, and saltwater bays; habitat selection is tied to food supply and access to fresh water. Primarily herbivorous, their diet consists of aquatic vegetation but they also feed on fish. Manatee recruitment is low; they exhibit delayed maturity, long gestation periods with a single calf, and long parental investment.

Weaning generally occurs between 9 and 24 months, although a calf may remain with its mother for several more years, resulting in a breeding interval of two to five years.
Low reproductive rates combined with habitat specificity renders this species extremely vulnerable to anthropomorphic impacts and stochastic events (Rathbun and Possardt 1986). Historically hunted, manatee numbers declined precipitously prior to their endangered designation in 1966 (USFWS 2017). Other causes of mortality include boat collision, entanglement in fishing gear, and indirect impacts from habitat degradation, including water pollution, algal blooms, and loss of seagrass from coastal development. Recovery efforts for the West Indian Manatee include habitat protection and restoration, as well as increased enforcement of take regulations and outreach efforts aimed at reducing human interactions in Florida. In Puerto Rico, poaching incidences significantly declined after aggressive public education campaigns turned public perception against illegal hunting (USFWS 2017). Despite having a global population estimate of around 5000 across both Florida and Antillean populations, and Caribbean population estimates of under 200 individuals (USFWS 2014), the species was downlisted from Endangered to Threatened in 2017.

Florida populations of manatees migrate and aggregate according to water temperature; these trends in habitat use are not known from the Puerto Rican populations although they do seem to move between PR and nearby Vieques (USFWS 2014). While manatees do not naturally occur in VI waters, there have been occasional sightings, most recently on the northside of St Thomas in 2012 (DFW unpublished data) and on St. Croix near Altona Lagoon in 2014 and around the west end in 2018 (https://stthomassource.com/content/2018/05/25/search-for-displaced-manatees-continues/). Reasons for their presence in the VI is unknown (there is no reliable source of freshwater), and there is a general concern that manatees in VI waters are disoriented. Efforts in the past to help these manatees have ended with the death of the individuals (R Boulon, pers, comm., 2014). All sightings should be reported to the Marine Mammal Stranding Network immediately, and expertise provided by the Sea Turtle Stranding and Rescue (STAR) network may be useful in these cases.

Contributor (2018): RJP

Banner Photo: Dolphins by R. Platenberg

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APPENDICES

Appendix 2.1. Comprehensive Species List

Part 1: Fauna

The following is a comprehensive list of amphibians, reptiles, birds, and mammals that have been recorded within the U.S. Virgin Islands, followed by a list of plant (terrestrial and marine) species of concern. A fully comprehensive list of plant species is not available. The list presents the management status of species for both 2005 and updated for 2018. The federal statutory status (Endangered Species Act listing) is indicated; territorial statutory status as recorded in 2005 has not changed and is not included for 2018. Habitat associations are also listed for each species (habitat descriptions can be found in Volume 2).

2005 Status: Legal protection afforded by USFWS Endangered Species Act or VI Endangered and Indigenous Species Act (status under the existing territorial legislation is shown in parenthesis where different from the proposed revised status). **FE = Federally Endangered**. **FT = Federally Threatened**. LE = Locally Endangered. LT = Locally Threatened. LSC = Local Special Concern. LDD = Locally Data Deficient. LCP = Locally Peripheral. LCT = Locally Controlled. LNP = Locally Not Protected (Exotics). Management Concern = Species requiring management actions within USVI. GC = Species of Greatest Concern; those species requiring significant research, monitoring, and/or restorative effort for populations and/or habitats to recover populations sufficient to ensure long-term sustainability. C = Species of Concern; species requiring research, monitoring, and/or restorative efforts for populations and/or habitats to maintain population levels to ensure long-term sustainability. LC = Species of Lesser Concern; species that would benefit from research, monitoring, or restorative efforts for populations or habitats to maintain current population levels. I = Introduced species; species requiring monitoring to determine impact and distribution spread. IM = Introduced species of management concern; non-native species requiring research, monitoring, and control to reduce impacts on native species. EX = Extirpated; species no longer present within the USVI.

2018 Status: **HR = High Risk**; those species in immediate or ongoing need of management action due to severely restricted populations or distributions (equivalent to GC). **LR = Low Risk**; those species in immediate or ongoing need of management action due to declining populations or distributions (equivalent to C and LC). **DDR = Data Deficient--At Risk**; those populations for which insufficient information is available toward assessing population abundances or distributions, but whose populations are experiencing significant ongoing threat such to put these populations at risk of decline or extinction. **DD = Data Deficient**--Not At Risk; those species for which insufficient information is available and management effort should be focused on collecting biological data. **LC = Least Concern**; those species that are widespread and abundant and not currently in need of targeted conservation action. **IM = Introduced**; non-native species in need of management action because their impacts are causing declines in populations or habitat quality. **EX = Extirpated**; species no longer present within the USVI.

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
INSECTS					
All Species			--	DD	All terrestrial habitats
ARACHNIDS					
All Species			--	DD	All terrestrial habitats
CRABS					
Sesarmidae	*Aratus pisonii*	Mangrove Crab	--	DD	Mangroves
Portunidae	*Callinectes sapidus*	Blue Crab	--	DD	Mangroves, salt ponds

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Gecarcinidae	*Cardisoma guanhumi*	Blue Land Crab	--	LR	Mangroves, guts
Gecarcinidae	*Gecarcinus ruricola*	Terrestrial Crab	--	DDR	Guts
Grapsidae	*Grapsus grapsus*	Sally Lightfoot Crab	--	DD	Rocky shorelines
Grapsidae	*Pachygrapsus sp.*	Shore Crab	--	DD	Shorelines
Coenobitidae	*Coenobita clypeatus*	Soldier Crab	--	LC	Guts, forests
Mithracidae	*Microphrys bicornutus*	Decorator Crab	--	DD	Intertidal, seagrass
Pseudothelphusidae	*Epilobocera sinuatifrons*	Freshwater Crab	--	DDR	Guts
Ocypodidae	*Uca burgersi*	Fiddler Crab	--	LC	Mangroves, salt ponds
Ocypodidae	*Leptuca leptodactyla*	Thin-fingered Fiddler Crab	--	LR	Mangroves, salt ponds
Ocypodidae	*Uca rapax*	Mudflat Fiddler Crab	--	LC	Mangroves, salt ponds
Ocypodidae	*Uca thayeri*	Atlantic Mangrove Fiddler Crab	--	LC	Mangroves, salt ponds
Ocypodidae	*Ocypode quadrata*	Ghost Crab	--	LC	Sandy beaches
FRESHWATER SHRIMP					
Artemiidae	*Artemia franciscana*	Brine Shrimp	--	DD	Salt ponds
Atyidae	*Atya innocous*	Basket Shrimp	--	DD	Guts
Atyidae	*Atya lanipes*	Basket Shrimp	--	DD	Guts
Palaemonidae	*Macrobrachium carcinus*	Bigclaw River Shrimp	--	DD	Guts
Xiphocarididae	*Xiphocaris elongata*	Yellow-nose Shrimp	--	DD	Guts
TERRESTRIAL VERTEBRATES					
FRESHWATER FISH					
Mugilidae	*Agonostomus monticola*	Mountain Mullet	--	DD	Guts
Anguillidae	*Anguilla rostrata*	American Eel	--	HR	Guts, marine
Eleotridae	*Gobiomorus dormitor*	Bigmouth Sleeper	--	DD	Guts
Eleotridae	*Eleotris perniger*	Small Scaled Spinycheek Sleeper	--	DD	Guts
Poeciliidae	*Poecilia reticulata*	Guppy	--	I	Guts
Gobiidae	*Sicydium punctatum*	Spotted Algae-eating Goby	--	DD	Guts
Gobiidae	*Sicydium plumieri*	Sirajo Goby	--	DD	Guts
Cichlidae	*Oreochromis mossambicus*	Mozambique Tilapia	--	I	Guts, freshwater ponds
AMPHIBIANS					
Eleutherodactylidae	*Eleutherodactylus antillensis*	Antillean Frog	LC	LC	All habitats
Eleutherodactylidae	*Eleutherodactylus cochranae*	Whistling Frog	LC	LC	Dry forest

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Eleutherodactylidae	*Eleutherodactylus coqui*	Common Coqui	IM	IM	Moist forests
Eleutherodactylidae	*Eleutherodactylus lentus*	Mute Frog	LDD, C	HR	Moist areas within all habitats
Eleutherodactylidae	*Eleutherodactylus schwartzi*	Virgin Islands Bo-peep	LE, GC, EX?	HR (EX?)	Moist forest, shrublands
Leptodactylidae	*Leptodactylus albilabris*	White-lipped Frog	LC	LC	Guts, wetlands, ditches
Hylidae	*Osteopilus septentrionalis*	Cuban Tree Frog	NP, IM	IM	All habitats
Bufonidae	*Peltophryne lemur*	Puerto Rican Crested Toad	FT/EX	FT (EX) Potential for Reintrod.	
Bufonidae	*Rhinella marina*	Cane Toad	LNP, IM	IM	Freshwater ponds, guts
LIZARDS					
Teiidae	*Ameiva (Pholidoscelis) exsul*	Ground Lizard	LC	LC	All habitats
Teiidae	*Ameiva (Pholidoscelis) exsul*	Ground Lizard	--	IM (STX)	All habitats
Teiidae	*Ameiva (Pholidoscelis) polops*	St. Croix Ground Lizard	FE/LE, GC	FE, HR	Coastal shrubland
Amphisbaenidae	*Amphisbaena fenestrata*	Virgin Islands Amphisbaena	LDD, GC	HR	Forest and woodland with sandy soils
Polychrotidae	*Anolis acutus*	St. Croix Anole	LC	LC	All habitats
Polychrotidae	*Anolis cristatellus*	Crested Anole	LC	LC	All habitats
Polychrotidae	*Anolis pulchellus*	Grass Anole	LDD, LC	LC	Shrubland, forest edge
Polychrotidae	*Anolis stratulus*	Barred Anole	LDD, LC	LC	Forest, woodland
Scincidae	*Capitellum parvicruzae*	Lesser St. Croix Skink	--	EX?	Shrubland
Scincidae	*Spondylurus semitaeniatus*	Lesser Virgin Islands Skink	--	HR	Shrubland
Scincidae	*Spondylurus sloanii*	Virgin Islands Bronze Skink	LT, GC	HR	Shrubland
Scincidae	*Spondylurus spilonotus*	Greater Virgin Islands Skink	--	EX?	Shrubland
Iguanidae	*Cyclura pinguis*	Anegada Rock Iguana	--	Potential for Reintrod.	Karst, shrubland
Iguanidae	*Iguana iguana*	Green Iguana	LC/I?	I, LC	All habitats
Gekkonidae	*Hemidactylus mabouia*	Mediterranean House Gecko	LC/I	I, LC	Residential

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Sphaerodactylidae	*Sphaerodactylus beattyi*	Beatty's Dwarf Gecko	LC	DDR	All habitats
Sphaerodactylidae	*Sphaerodactylus macrolepis*	Dwarf Gecko	LC	LC	Woodland and forest
Phyllodactylidae	*Thecadactylus rapicauda*	Fat-tailed Gecko	LC/I	I, LC	Forests
SNAKES					
Boidae	*Chilabothrus granti*	Virgin Islands Tree Boa	FE/LE, GC	FE, HR	Dry forest, shrubland
Boidae	*Boa constrictor*	Boa Constrictor	--	IM	Dry forest, wetlands
Colubridae	*Pantherophis guttatus*	Corn Snake	--	IM	Dry forest, shrubland, urban
Dipsadidae	*Borikenophis portoricensis*	Puerto Rican Racer	LT, C	LR	Dry forest, shrubland
Dipsadidae	*Borikenophis sanctaecrucis*	St. Croix Racer	Extinct	EX	Forest
Dipsadidae	*Magliophis exiguus*	Ground Snake	LDD, LC	LR	Forest, shrubland
Typhlopidae	*Antillotyphlops richardii*	Blindsnake (Richard's Worm Snake)	LDD, C	HR	Moist to dry forest
Typhlopidae	*Indotyphlops braminus*	Flowerpot Blindsnake	--	I	Residential
TURTLES					
Testudinidae	*Chelonoidis carbonaria*	Red-legged Tortoise	LC	I, LC	Forests, shrublands
Emydidae	*Trachemys scripta*	Red-eared Slider	LNP, IM	IM	Freshwater ponds
Emydidae	*Trachemys stejnegeri*	Puerto Rican Slider	--	DD	Freshwater ponds
Cheloniidae	*Caretta caretta*	Loggerhead	FT, GC	FT, HR	Beaches
Cheloniidae	*Chelonia mydas*	Green turtle	FT/LT, GC	FT, HR	Beaches, seagrass beds
Dermochelyidae	*Dermochelys coriacea*	Leatherback	FE/LE, GC	FE, HR	Beaches, pelagic waters
Cheloniidae	*Eretmochelys imbricata*	Hawksbill	FE/LE, GC	FE, HR	Beaches, coral reefs
BATS					
Phyllostomidae	*Artibeus jamaicensis*	Jamaican Fruit-eating Bat	LC	LR	Forests, guts
Phyllostomidae	*Brachyphylla cavernarum*	Antillean Fruit-eating Bat	LDD, GC	LR	Forests, guts
Phyllostomidae	*Stenoderma rufum*	Red Fig-eating Bat	LDD, GC	HR	Forests, guts
Molossidae	*Molossus molossus*	Pallas's Mastiff Bat	LC	LR	All habitats, residential
Molossidae	*Tadarida brasiliensis*	Brazilian Free-tailed Bat	LDD, GC	*	Forests

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Noctilionidae	*Noctilio leporinus*	Greater Bulldog Bat	LDD, GC	LR	Forests, guts, nearshore waters
LAND MAMMALS					
Canidae	*Canis lupis familiaris*	Dog	--	IM	All habitats, esp. residential
Bovidae	*Bos taurus*	Cow	--	IM	Agricultural habitats
Bovidae	*Capra hircus*	Goat	--	IM	Shrubland, grassland
Equidae	*Equus asinus*	Donkey	IM	IM	Forest edge, shrubland (STJ)
Felidae	*Felis catus*	Cat	--	IM	All habitats, esp. residential
Herpestidae	*Herpestes auropunctatus*	Small Indian Mongoose	--	IM	All habitats
Cervidae	*Odocoileus virginianus*	White-tailed Deer	--	IM	Forest, woodland, shrubland
Muridae	*Mus musculus*	House Mouse	LNP, IM	IM	All habitats
Muridae	*Rattus norvegicus*	Brown Rat	LNP, IM	IM	All habitats
Muridae	*Rattus rattus*	Black Rat	LNP, IM	IM	All habitats
Suidae	*Sus scrofa*	Pig	IM	IM	Agricultural habitats
BIRDS					
Accipitridae	*Circus cyaneus*	Northern Harrier		*	wetlands, coastal areas
Accipitridae	*Pandion haliaetus*	Osprey		LC	wetlands, coastal areas
Accipitridae	*Buteo jamaicensis*	Red-tailed Hawk	LC	LC	All habitats
Alcedinidae	*Megaceryle alcyon*	Belted Kingfisher		LC	Wetlands
Anatidae	*Anas americana*	American Wigeon		LC	Wetlands
Anatidae	*Anas discors*	Blue-winged Teal		LC	Wetlands
Anatidae	*Anas cyanoptera*	Cinnamon Teal		*	Wetlands
Anatidae	*Dendrocygna bicolor*	Fulvous Whistling Duck		LC	Wetlands
Anatidae	*Aythya marila*	Greater Scaup		*	Wetlands
Anatidae	*Anas Crecca*	Green-winged Teal		LC	Wetlands
Anatidae	*Aythya affinis*	Lesser Scaup		LC	Wetlands
Anatidae	*Nomonyx dominicus*	Masked Duck		DDR	Wetlands
Anatidae	*Cairina moschata*	Muscovy Duck		I	Domestic
Anatidae	*Anas acuta*	Northern Pintail		LC	Wetlands
Anatidae	*Anas clypeata*	Northern Shoveler		LC	Wetlands
Anatidae	*Aythya collaris*	Ring-necked Duck		LC	Wetlands
Anatidae	*Oxyura jamaicensis*	Ruddy Duck	SC	LR	Wetlands

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Anatidae	*Dendrocygna arborea*	West Indian Whistling Duck	LE/GC	Potential for reintrod.	Wetlands
Anatidae	*Anas bahamensis*	White-cheeked Pintail	SC	LR	Wetlands
Apodidae	*Cypseloides niger*	Black Swift		LC	All habitats
Apodidae	*Chaetura pelagica*	Chimney Swift		LC	All habitats
Apodidae	*Chaetura brachyura*	Short-tailed Swift		LC	All habitats
Ardeidae	*Botaurus lentiginosus*	American Bittern		*	Wetlands
Ardeidae	*Nycticorax nycticorax*	Black-crowned Night Heron	SC	LR	Wetlands
Ardeidae	*Bubulcus ibis*	Cattle Egret	LC	I	Wetlands and pasture/grasslands
Ardeidae	*Ardea herodias*	Great Blue Heron	LC	LR	Wetlands
Ardeidae	*Ardea alba*	Great Egret	LC	LR	Wetlands
Ardeidae	*Butorides virescens*	Green Heron	LC	LC	Wetlands
Ardeidae	*Ixobrychus exilis*	Least Bittern	GC/Ex	DDR, EX?	Wetlands
Ardeidae	*Egretta caerulea*	Little Blue Heron	LC	LC	Wetlands
Ardeidae	*Egretta thula*	Snowy Egret	SC	LR	Wetlands
Ardeidae	*Egretta tricolor*	Tricolored Heron	SC	LR	Wetlands
Ardeidae	*Nyctanassa violacea*	Yellow-crowned Night Heron	LC	LC	Wetlands and shorelines
Caprimulgidae	*Chordeiles gundlachii*	Antillean Nighthawk	GC	HR	Open areas with minimal vegetation
Caprimulgidae	*Antrostomus carolinensis*	Chuck-will's-widow		*	Woodlands
Caprimulgidae	*Chordeiles minor*	Common Nighthawk		LC	Open areas with minimal vegetation
Cardinalidae	*Passerina caerulea*	Blue Grosbeak		*	Forest edges, woodlands
Cardinalidae	*Passerina cyanea*	Indigo Bunting		LC	Woodlands, Shrubland, Pasture
Cardinalidae	*Pheucticus ludovicianus*	Rose-breasted Grosbeak		*	Forest edges, woodlands, shrubland
Charadriidae	*Pluvialis dominica*	American Golden Plover		LC	Wetlands
Charadriidae	*Pluvialis squatarola*	Black-bellied Plover		LC	Wetlands
Charadriidae	*Charadrius vociferus*	Killdeer	LC	DDR	Open areas with minimal vegetation

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Charadriidae	*Charadrius melodus*	Piping Plover		HR	Wetlands
Charadriidae	*Charadrius semipalmatus*	Semipalmated Plover		*	Wetlands
Charadriidae	*Charadrius nivosus*	Snowy Plover	GC	HR	Wetlands
Charadriidae	*Charadrius wilsonia*	Wilson's Plover	SC	HR	Wetlands
Columbidae	*Geotrygon mystacea*	Bridled Quail-Dove	GC	HR	Moist Forest
Columbidae	*Columbina passerina*	Common Ground Dove	LC	LC	All habitats, except heavily wooded areas
Columbidae	*Streptopelia decaocto*	Eurasian Collared Dove		I	Residential/ Urban
Columbidae	*Streptopelia risoria*	Ringed Turtle Dove		I	Residential/ Urban
Columbidae	*Columba livia*	Rock Dove		I	Urban
Columbidae	*Patagioenas squamosa*	Scaly-naped Pigeon	LC	LR	Forest/Shrubland
Columbidae	*Streptopelia chinensis*	Spotted Dove		I	Open woodland, residential
Columbidae	*Patagioenas leucocephala*	White-crowned Pigeon	GC	HR	Forest/ Mangroves
Columbidae	*Zenaida asiatica*	White-winged Dove	LC	LC	All habitats
Columbidae	*Zenaida aurita*	Zenaida Dove	LC	LC	All habitats
Corvidae	*Corvus leucognaphalus*	White-necked Crow	GC/Ex	EX	forest, woodland, shrub
Cuculidae	*Coccyzus minor*	Mangrove Cuckoo	LC	LC	Forests, woodlands, mangroves
Cuculidae	*Crotophaga ani*	Smooth-billed Ani	LC	LC	All habitats
Cuculidae	*Coccyzus americanus*	Yellow-billed Cuckoo	SC	LC	Dry forest, shrubland
Falconidae	*Falco sparverius*	American Kestrel	LC	LC	Forest edges, woodland
Falconidae	*Falco columbarius*	Merlin		LC	All habitats
Falconidae	*Falco peregrinus*	Peregrine Falcon	SC	LR	wetlands, cays, coastal areas
Fregatidae	*Fregata magnificens*	Magnificent Frigatebird	GC	HR	Coastal areas, wetlands, at sea
Haematopodidae	*Haematopus palliatus*	American Oystercatcher	GC	HR	shorelines
Hirundinidae	*Riparia riparia*	Bank Swallow		LC	Open coastal areas
Hirundinidae	*Hirundo rustica*	Barn Swallow		LC	Open coastal areas

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Hirundinidae	*Progne dominicensis*	Caribbean Martin	SC	HR	Open areas with minimal vegetation
Hirundinidae	*Petrochelidon fulva*	Cave Swallow		DD	Open areas and wetlands
Hirundinidae	*Petrochelidon pyrrhonota*	Cliff Swallow		LC	Open coastal areas
Hirundinidae	*Stelgidopteryx serripennis*	Northern Rough-winged Swallow		*	Open areas and wetlands
Hirundinidae	*Progne subis*	Purple Martin		LC	Open areas with minimal vegetation
Hirundinidae	*Tachycineta bicolor*	Tree Swallow		*	Wetlands
Hydrobatidae	*Oceanodroma leucorhoa*	Leach's Storm Petrel		*	At sea
Hydrobatidae	*Oceanites oceanicus*	Wilson's Storm Petrel		*	At sea
Icteridae	*Icterus galbula*	Baltimore Oriole		LC	Forest edges, woodlands, shrubland
Icteridae	*Dolichonyx oryzivorus*	Bobolink		*	Grasslands, pasture
Icteridae	*Molothrus bonariensis*	Shiny Cowbird		*	Open areas
Icteridae	*Icterus icterus*	Venezuelan Troupial		*	Shrublands
Laridae	*Sterna paradisaea*	Arctic Tern		LC	Coastal areas including beaches and wetlands
Laridae	*Onuchoprion anaethetus*	Bridled Tern		LC	Coastal areas including beaches and wetlands
Laridae	*Anous stolidus*	Brown Noddy		LC	Coastal areas including beaches and wetlands
Laridae	*Hydroprogne caspia*	Caspian Tern		LC	Coastal areas including beaches and wetlands
Laridae	*Thalasseus sandvicensis eurygnatha*	Cayenne Tern		LC	Coastal areas including beaches and wetlands
Laridae	*Sterna hirundo*	Common Tern		LC	Coastal areas including

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
					beaches and wetlands
Laridae	*Sterna forsteri*	Forster's Tern		LC	Coastal areas including beaches and wetlands
Laridae	*Gelochelidon nilotica*	Gull-billed Tern	SC	DD	Coastal areas including beaches and wetlands
Laridae	*Larus argentatus*	Herring Gull		LC	Coastal Waters
Laridae	*Leucophaeus atricilla*	Laughing Gull		LC	Coastal Waters
Laridae	*Sternula antillarum*	Least Tern	SC	HR	Coastal areas including beaches and wetlands
Laridae	*Larus fuscus*	Lesser Black-backed Gull		LC	Coastal Waters
Laridae	*Stercorarius pomarinus*	Pomarine Jaeger		*	At sea
Laridae	*Larus delawarensis*	Ring-billed Gull		LC	Coastal waters
Laridae	*Sterna dougallii*	Roseate Tern	SC	FT, HR	Coastal areas including beaches and wetlands
Laridae	*Thalasseus maxima*	Royal Tern		LR	Coastal areas including beaches and wetlands
Laridae	*Thalasseus sandvicensis*	Sandwich Tern		LR	Coastal areas including beaches and wetlands
Laridae	*Onychoprion fuscata*	Sooty Tern		LC	Coastal areas including beaches and wetlands
Laridae	*Chlidonias leucopterus*	White-winged Tern		LC	Coastal areas including beaches and wetlands
Mimidae	*Mimus polyglottos*	Northern Mockingbird	LC	LC	Woodland, shrubland, open areas
Mimidae	*Margarops fuscatus*	Pearly-eyed Thrasher	LC	LC	All habitats

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Parulidae	*Setophaga adelaide*	Adelaide's Warbler		DDR	Forests, woodlands, shrublands
Parulidae	*Setophaga ruticilla*	American Redstart		LC	Forests, woodlands, shrublands
Parulidae	*Setophaga castanea*	Bay-breasted Warbler		*	Forest edges, woodlands
Parulidae	*Mniotilta varia*	Black-and-White Warbler		LC	Forests, woodlands
Parulidae	*Setophaga fusca*	Blackburnian Warbler		*	Forests
Parulidae	*Setophaga striata*	Blackpoll Warbler		LC	Woodlands, shrubland, wetlands
Parulidae	*Setophaga caerulescens*	Black-throated Blue Warbler		LC	Forests, woodlands
Parulidae	*Setophaga virens*	Black-throated Green Warbler		LC	Forests, woodlands
Parulidae	*Vermivora cyanoptera*	Blue-winged Warbler		LC	Forests
Parulidae	*Cardellina canadensis*	Canada Warbler		*	shrublands near wetlands
Parulidae	*Setophaga tigrina*	Cape May Warbler		LC	Forests, woodlands, mangroves
Parulidae	*Setophaga pensylvanica*	Chestnut-sided Warbler		LC	Woodlands
Parulidae	*Geothlypis trichas*	Common Yellowthroat	SC	LC	Grasslands, wetlands
Parulidae	*Oporornis agilis*	Connecticut Warbler		*	Woodland
Parulidae	*Vermivora chrysoptera*	Golden-winged Warbler		*	Forests, woodlands
Parulidae	*Setophaga citrina*	Hooded Warbler	SC	LC	Forests, wetlands
Parulidae	*Geothlypis formosus*	Kentucky Warbler	SC	LC	Forests
Parulidae	*Parkesia motacilla*	Louisiana Waterthrush	SC	LC	Wetlands
Parulidae	*Setophaga magnolia*	Magnolia Warbler		LC	Woodlands, wetlands
Parulidae	*Setophaga americana*	Northern Parula		LC	Forests, woodlands, shrublands
Parulidae	*Parkesia noveboracensis*	Northern Waterthrush		LC	Wetlands
Parulidae	*Seiurus aurocapilla*	Ovenbird		LC	Forests, woodlands
Parulidae	*Setophaga palmarum*	Palm Warbler	SC	LC	Shrubland, pasture

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Parulidae	*Setophaga discolor*	Prairie Warbler		LC	All habitats
Parulidae	*Protonotaria citrea*	Prothonotary Warbler	SC	LC	Wetlands
Parulidae	*Limnothlypis swainsonii*	Swainson's Warbler		*	Forests, woodlands
Parulidae	*Oreothlypis peregrina*	Tennessee Warbler		LC	Woodlands
Parulidae	*Helmitheros vermivorum*	Worm-eating Warbler	SC	LC	Forests
Parulidae	*Setophaga petechia*	Yellow Warbler	LC	LC	Mangroves and coastal forest
Parulidae	*Setophaga coronata*	Yellow-rumped Warbler	SC	LC	Woodlands, wetlands
Parulidae	*Setophaga dominica*	Yellow-throated Warbler	SC	*	Forests, residential/urban
Passeridae	*Passer domesticus*	House Sparrow		I	Urban
Pelecanidae	*Pelecanus occidentalis*	Brown Pelican	SC	LR	Coastal areas, wetlands, at sea
Phaethontidae	*Phaethon aethereus*	Red-billed Tropicbird	SC	HR	At sea, nesting colony on cays
Phaethontidae	*Phaethon lepturus*	White-tailed Tropicbird	GC	HR	At sea, nesting colony on cays
Phalacrocoracidae	*Phalacrocorax auritus*	Double-crested Cormorant		*	At sea
Phasianidae	*Numida meleagris*	Helmeted Guineafowl		IM	Pasture, shrubland
Phoenicopteridae	*Phoenicopterus ruber*	American Flamingo	GC	EX	Wetlands
Picidae	*Sphyrapicus varius*	Yellow-bellied Sapsucker	SC	LC	Forests, woodlands
Ploceidae	*Euplectes franciscanus*	Orange Bishop		*	Pasture, grassland
Podicipedidae	*Tachybaptus dominicus*	Least Grebe	GC	HR	Wetlands
Podicipedidae	*Podilymbus podiceps*	Pied-billed Grebe		LC	Wetlands
Procellariidae	*Puffinus lherminieri*	Audubon's Shearwater	GC	HR	At sea, nesting colony on cays
Psittacidae	*Eupsittula pertinax*	Brown-throated Parakeet		I	forests, woodlands
Rallidae	*Fulica americana*	American Coot	GC	LC	Wetlands
Rallidae	*Rallus crepitans*	Clapper Rail	GC	HR	Wetlands
Rallidae	*Gallinula galeata*	Common Gallinule	LC	LC	Wetlands
Rallidae	*Porphyrio martinicus*	Purple Gallinule		*	Wetlands
Rallidae	*Porzana carolina*	Sora		LC	Wetlands
Recurvirostridae	*Recurvirostra americana*	American Avocet		*	Wetlands

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Recurvirostridae	*Himantopus mexicanus*	Black-necked Stilt	LC	LC	Wetlands
Scolopacidae	*Calidris bairdii*	Baird's Sandpiper		*	Wetlands and shorelines
Scolopacidae	*Limosa lapponica*	Bar-tailed Godwit		*	Wetlands and shorelines
Scolopacidae	*Calidris subruficollis*	Buff-breasted Sandpiper		*	Wetlands and shorelines
Scolopacidae	*Calidris alpina*	Dunlin		*	Wetlands and shorelines
Scolopacidae	*Tringa melanoleuca*	Greater Yellowlegs		LC	Wetlands and shorelines
Scolopacidae	*Limosa haemastica*	Hudsonian Godwit		*	Wetlands and shorelines
Scolopacidae	*Calidris minutilla*	Least Sandpiper	SC	LC	Wetlands and shorelines
Scolopacidae	*Tringa flavipes*	Lesser Yellowlegs		LC	Wetlands and shorelines
Scolopacidae	*Limnodromus scolopaceus*	Long-billed Dowitcher		*	Wetlands and shorelines
Scolopacidae	*Limosa fedoa*	Marbled Godwit		*	Wetlands and shorelines
Scolopacidae	*Calidris melanotos*	Pectoral Sandpiper		LC	Wetlands and shorelines
Scolopacidae	*Calidris canutus*	Red Knot	GC	FT, DDR	Wetlands and shorelines
Scolopacidae	*Arenaria interpres*	Ruddy Turnstone		LC	Wetlands and shorelines
Scolopacidae	*Calidris pugnax*	Ruff		*	Wetlands and shorelines
Scolopacidae	*Calidris alba*	Sanderling		LC	Wetlands and shorelines
Scolopacidae	*Calidris pusilla*	Semipalmated Sandpiper		LR	Wetlands and shorelines
Scolopacidae	*Limnodromus griseus*	Short-billed Dowitcher	SC	LC	Wetlands and shorelines
Scolopacidae	*Tringa solitaria*	Solitary Sandpiper		LC	Wetlands and shorelines
Scolopacidae	*Actitis macularius*	Spotted Sandpiper		LC	Wetlands and shorelines
Scolopacidae	*Calidris himantopus*	Stilt Sandpiper		LC	Wetlands and shorelines
Scolopacidae	*Bartramia longicauda*	Upland Sandpiper		LC	Grasslands
Scolopacidae	*Calidris mauri*	Western Sandpiper		LC	Wetlands and shorelines
Scolopacidae	*Numenius phaeopus*	Whimbrel	GC	LR	Wetlands and shorelines

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Scolopacidae	*Calidris fuscicollis*	White-rumped Sandpiper		--	Wetlands and shorelines
Scolopacidae	*Tringa semipalmata*	Willet	GC	LR	Wetlands and shorelines
Scolopacidae	*Phalaropus tricolor*	Wilson's Phalarope		--	Wetlands and shorelines
Scolopacidae	*Gallinago delicata*	Wilson's Snipe		--	Wetlands and shorelines
Strigidae	*Megascops nudipes*	Puerto Rican Screech Owl	GC/Ex	EX	Forests, woodlands
Strigidae	*Asio flammeus*	Short-eared Owl		*	Woodlands, shrublands
Sturnidae	*Sturnus vulgaris*	European Starling		I	Pastures, urban, residential
Sulidae	*Sula leucogaster*	Brown Booby		HR	At sea, nesting colony on cays
Sulidae	*Sula dactylatra*	Masked Booby	GC	HR	At sea, nesting colony on cays
Sulidae	*Sula sula*	Red-footed Booby	GC	HR	At sea, nesting colony on cays
Thraupidae	*Coereba flaveola*	Bananaquit	LC	LC	All habitats
Thraupidae	*Tiaris bicolor*	Black-faced Grassquit	LC	LC	Open woodland and shrubland, forest edges
Thraupidae	*Loxigilla noctis*	Lesser Antillean Bullfinch	SC	LC	Forest, woodlands
Thraupidae	*Piranga olivacea*	Scarlet Tanager		*	Forest edges, woodland
Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis		*	Wetlands
Trochilidae	*Orthorhyncus cristatus*	Antillean Crested Hummingbird	LC	DDR	All habitats
Trochilidae	*Anthracothorax dominicus*	Antillean Mango	GC	DDR	All habitats
Trochilidae	*Eulampis holosericeus*	Green-throated Carib	LC	LC	All habitats
Tyrannidae	*Elaenia martinica*	Caribbean Elaenia	LC	LC	Forest, woodland, shrub
Tyrannidae	*Tyrannus dominicensis*	Gray Kingbird	LC	LC	All habitats
Tyrannidae	*Myiarchus antillarum*	Puerto Rican Flycatcher	GC	LC	Forest, woodland, mangrove edges
Vireonidae	*Vireo altiloquus*	Black-whiskered Vireo	LC	LC	Forests
Vireonidae	*Vireo griseus*	White-eyed Vireo		LC	Woodland, shrubland, coastal thickets
Vireonidae	*Vireo flavifrons*	Yellow-throated Vireo		LC	All habitats

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
MARINE ORGANISMS					
MARINE FISH--not comprehensive					
Acanthuridae	*Acanthurus bahianus*	Ocean Surgeonfish	--	LC	Reefs
Acanthuridae	*Acanthurus chirurgus*	Doctorfish	--	LC	Reefs
Albulidae	*Albula vulpes*	Bonefish	--	DDR	Shallow waters
Balistidae	*Balistes capriscus*	Gray Triggerfish	--	DDR	Reefs, hard bottom
Balistidae	*Balistes vetula*	Queen Triggerfish	--	HR	Reefs, rocky bottoms, seagrasses
Carangidae	*Caranx crysos*	Blue Runner	--	LC	Reefs, brackish waters
Carangidae	*Caranx hippos*	Crevalle Jack	--	DD	Reefs, estuaries, brackish waters
Carangidae	*Caranx latus*	Horse Eye Jack	--	DD	Reefs, estuaries, brackish waters
Carangidae	*Caranx ruber*	Bar Jack	--	DD	Reefs, shallow waters
Carangidae	*Seriola dumerili*	Greater Amberjack	--	DDR	Reefs
Carangidae	*Trachinotus falcatus*	Permit	--	LC	Reefs, seagrasses, shallow waters
Carangidae	*Trachinotus goodei*	Palometa	--	LC	Reefs
Centropomidae	*Centropomus mexicanus*	Mexican Snook	--	DD	Brackish to marine waters
Centropomidae	*Centropomus pectinatus*	Tarpon Snook	--	DD	Lagoons, bays, estuaries
Centropomidae	*Centropomus undecimalis*	Common Snook	--	DD	Mangroves
Chaetodontidae	*Chaetodon capistratus*	Foureye Butterflyfish	--	DD	Reefs, shallow waters
Chaetodontidae	*Chaetodon striatus*	Banded Butterflyfish	--	DD	Reefs, shallow waters
Chaetodontidae	*Prognathodes aculeatus*	Longsnout Butterflyfish	--	DD	Reefs, shallow waters
Haemulidae	*Anisotremus virginicus*	Porkfish	--	LR	Reefs
Haemulidae	*Conodon nobilis*	Barred Grunt	--	DD	Sandy shores, shallow waters
Haemulidae	*Haemulon aurolineatum*	Tomtate	--	DD	Reefs
Haemulidae	*Haemulon bonariense*	Black Grunt	--	DDR	reefs, seagrasses, mangroves
Haemulidae	*Haemulon chrysargyreum*	Smallmouth Grunt	--	DD	Reefs

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Haemulidae	*Haemulon flavolineatum*	French Grunt	--	LC	Reefs
Haemulidae	*Haemulon plumierii*	White Grunt	--	LC	Reefs, seagrasses
Haemulidae	*Haemulon sciurus*	Bluestriped Grunt	--	LC	Reefs
Labridae	*Lachnolaimus maximus*	Hogfish	--	DDR	Reefs
Lutjanidae	*Apsilus dentatus*	Black Snapper	--	DD	Reefs
Lutjanidae	*Lutjanus analis*	Mutton Snapper	--	HR	Seagrass
Lutjanidae	*Lutjanus apodus*	Schoolmaster Snapper	--	LC	Reefs, pelagic
Lutjanidae	*Lutjanus buccanella*	Blackfin Snapper	--	DD	Pelagic
Lutjanidae	*Lutjanus cyanopterus*	Cubera Snapper	--	DDR	Reefs, brackish waters
Lutjanidae	*Lutjanus griseus*	Gray Snapper	--	DD	Reefs
Lutjanidae	*Lutjanus jocu*	Dog Snapper	--	DD	Reefs, deep water
Lutjanidae	*Lutjanus synagris*	Lane Snapper	--	LR	Reefs
Lutjanidae	*Lutjanus vivanus*	Silk Snapper	--	HR	Reefs
Lutjanidae	*Ocyurus chrysurus*	Yellowtail Snapper	--	DD	Reefs
Lutjanidae	*Rhomboplites aurorubens*	Vermillion Snapper	--	HR	Reefs
Megalopidae	*Megalops atlanticus*	Tarpon	--	LC	Reefs, pelagic
Mullidae	*Mulloidichthys martinicus*	Yellow Goatfish	--	DD	Seagrass (juv), reefs (ad)
Mullidae	*Pseudupeneus maculatus*	Spotted Goatfish	--	LR	Shallow coastal waters, sandy bottoms near reefs
Ostraciidae	*Lactophrys trigonus*	Trunkfish	--	DD	Reefs, seagrass
Scaridae	*Scarus coelestinus*	Midnight Parrotfish	--	HR	Reefs
Scaridae	*Scarus coeruleus*	Blue Parrotfish	--	HR	Reefs
Scaridae	*Scarus guacamaia*	Rainbow Parrotfish	--	HR	Reefs
Scaridae	*Scarus taeniopterus*	Princess Parrotfish	--	LR	Reefs
Scaridae	*Scarus vetula*	Queen Parrotfish	--	LR	Reefs
Scaridae	*Sparisoma chrysopterum*	Redtail Parrotfish	--	LR	Reefs
Scaridae	*Sparisoma viride*	Stoplight Parrotfish	--	LR	Reefs
Sciaenidae	*Odontoscion dentex*	Reef Croaker	--	DD	Shallow reefs
Scombridae	*Scomberomorus regalis*	Cero Mackerel	--	DD	Reefs
Serranidae	*Cephalopholis cruentata*	Graysby	--	HR	Reefs
Serranidae	*Cephalopholis fulva*	Coney	--	HR	Reefs
Serranidae	*Dermatolepis inermis*	Marbled Grouper	--	HR	Reefs

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Serranidae	*Epinephelus adscensionis*	Rock Hind	--	HR	Reefs
Serranidae	*Epinephelus guttatus*	Red Hind	--	LR	Reefs, mangroves, lagoons, seagrass
Serranidae	*Epinephelus itajara*	Goliath Grouper	--	HR	Reefs, mangroves, seagrass, estuarine
Serranidae	*Epinephelus morio*	Red Grouper	--	HR	Reefs
Serranidae	*Epinephelus striatus*	Nassau Grouper	--	FT, HR	Reefs
Serranidae	*Mycteroperca bonaci*	Black Grouper	--	HR	Shallow water, pelagic
Sparidae	*Calamus bajonado*	Jolthead Porgy	--	DD	Reefs, seagrass
Sphyraenidae	*Sphyraena barracuda*	Great Barracuda	--	LC	Reefs, pelagic
Syngnathidae	*Hippocampus reidi*	Longsnout Seahorse	--	DDR	Reefs, brackish water
Scorpaenidae	*Pterois volitans*	Red Lionfish	--	IM	Reefs
Scorpaenidae	*Pterois miles*	Devil Firefish	--	IM	Reefs
BILLFISH					
Belonidae	*Strongylura marina*	Atlantic Needlefish	--	LC	Reefs, mangroves
Istiophoridae	*Istiompax indica*	Black Marlin	--	DDR	Pelagic
Istiophoridae	*Istiophorus platypterus*	Sailfish	--	HR	Shallow waters
Istiophoridae	*Kajikia albida*	White Marlin	--	HR	Pelagic
Istiophoridae	*Kajikia audax*	Striped Marlin	--	HR	Pelagic
Istiophoridae	*Makaira nigricans*	Blue Marlin	--	HR	Pelagic
Istiophoridae	*Tetrapturus angustirostris*	Shortbill Spearfish	--	DDR	Pelagic
Istiophoridae	*Tetrapturus georgii*	Roundscale Spearfish	--	DD	Pelagic
Istiophoridae	*Tetrapturus pfluegeri*	Longbill Spearfish	--	LC	Pelagic
TUNA					
Scombridae	*Thunnus thynnus*	Atlantic Bluefin Tuna	--	HR	Pelagic
Scombridae	*Allothunnus fallai*	Slender Tuna	--	LC	Pelagic
Scombridae	*Auxis rochei*	Bullet Tuna	--	LC	Pelagic
Scombridae	*Auxis thazard*	Frigate Tuna	--	LC	Pelagic
Scombridae	*Euthynnus alletteratus*	Little Tunny	--	LC	Pelagic
Scombridae	*Gymnosarda unicolor*	Dogtooth Tuna	--	LC	Pelagic
Scombridae	*Katsuwonus pelamis*	Skipjack Tuna	--	LC	Pelagic
Scombridae	*Thunnus alalunga*	Albacore Tuna	--	HR	Pelagic
Scombridae	*Thunnus albacares*	Yellowfin Tuna	--	HR	Pelagic
Scombridae	*Thunnus atlanticus*	Blackfin Tuna	--	LC	Pelagic

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Scombridae	*Thunnus maccoyii*	Southern Bluefin Tuna	--	LC	Pelagic
Scombridae	*Thunnus obesus*	Bigeye Tuna	--	HR	Pelagic
SHARKS AND RAYS					
Aetobatidae	*Aetobatus narinari*	Spotted Eagle Ray		HR	Estuaries, seagrasses
Carcharhinidae	*Carcharhinus limbatus*	Blacktip Shark	--	HR	Pelagic
Carcharhinidae	*Carcharhinus longimanus*	Oceanic Whitetip Shark		FT, HR	Pelagic
Carcharhinidae	*Carcharhinus perezii*	Caribbean Reef Shark	--	HR	Reefs
Carcharhinidae	*Galeocerdo cuvier*	Tiger Shark	--	HR	Seagrasses, lagoons, reefs
Carcharhinidae	*Negaprion brevirostris*	Lemon Shark	--	HR	Mangroves, reefs, coastal waters
Dasyatidae	*Hypanus americanus*	Southern Stingray	--	DD	Seagrasses, reefs, estuaries
Ginglymostomatidae	*Ginglymostoma cirratum*	Nurse Shark	--	DD	Reefs
Mobulidae	*Manta birostris*	Giant Manta Ray	--	FT, HR	Pelagic, coastal waters
Rhincodontidae	*Rhincodon typus*	Whale Shark	--	HR	Pelagic
Sphyrnidae	*Sphyrna lewini*	Scalloped Hammerhead Shark	--	FT, HR	Pelagic
MARINE INVERTEBRATES					
CORALS					
Acroporidae	*Acropora cervicornis*	Staghorn Coral	--	FE, HR	Reefs
Acroporidae	*Acropora palmata*	Elkhorn Coral	--	FE, HR	Reefs
Acroporidae	*Acropora prolifera*	Fused-staghorn Coral	--	DD	Reefs
Agariciidae	*Agaricia agaricites*	Lettuce Coral	--	DD	Reefs
Agariciidae	*Agaricia fragilis*	Fragile Saucer Coral	--	DD	Reefs
Agariciidae	*Agaricia grahamae*	Dimpled Sheet Coral	--	DD	Reefs
Agariciidae	*Agaricia humilis*	Low Relief Lettuce Coral	--	DD	Reefs
Agariciidae	*Agaricia lamarcki*	Whitestar Sheet Coral	--	DD	Reefs
Agariciidae	*Agaricia tenuifolia*	Thin Leaf Lettuce Coral	--	DD	Reefs
Agariciidae	*Agaricia undata*	Scroll Coral	--	DD	Reefs
Agariciidae	*Helioceris cucullata*	Sunray Lettuce Coral	--	DD	Reefs
Antipathidae	*Antipathes* spp.	Black Coral	--	DDR	Reefs
Astrocoeniidae	*Stephanocoenia intersepta*	Blushing Star Coral	--	DD	Reefs

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Caryophyllidae	*Eusmilia fastigiata*	Smooth Flower Coral	--	DD	Reefs
Dendrophylliidae	*Tubastraea coccinea*	Orange Cup Coral	--	DD	Reefs
Faviidae	*Colpophyllia natans*	Boulder Brain Coral	--	DD	Reefs
Faviidae	*Diploria labyrinthiformis*	Grooved Brain Coral	--	DD	Reefs
Faviidae	*Favia fragum*	Golfball Coral	--	DD	Reefs
Faviidae	*Manicina areolata*	Rose Coral	--	DD	Reefs
Faviidae	*Montastraea cavernosa*	Great Star Coral	--	DD	Reefs
Faviidae	*Orbicella annularis*	Lobed Star Coral	--	FT, HR	Reefs
Faviidae	*Orbicella faveolata*	Mountainous Star Coral	--	FT, HR	Reefs
Faviidae	*Orbicella franksii*	Boulder Star Coral	--	FT, HR	Reefs
Faviidae	*Pseudodiploria clivosa*	Knobby Brain Coral	--	DD	Reefs
Faviidae	*Pseudodiploria strigosa*	Symmetrical Brain Coral	--	DD	Reefs
Faviidae	*Solenastrea bournoni*	Smooth Star Coral	--	DD	Reefs
Faviidae	*Solenastrea hyades*	Knobby Star Coral	--	DD	Reefs
Meandrinidae	*Dendrogyra cylindricus*	Pillar Coral	--	FT, HR	Reefs
Meandrinidae	*Dichocoenia stokesii*	Elliptical Star Coral	--	DD	Reefs
Meandrinidae	*Meandrina meandrites*	Maze Coral	--	DD	Reefs
Milleporidae	*Millepora alcicornis*	Branching Fire Coral	--	DD	Reefs
Milleporidae	*Millepora complanata*	Blade Fire Coral	--	DD	Reefs
Milleporidae	*Millepora squarrosa*	Box Fire Coral	--	DD	Reefs
Mussidae	*Isophyllia rigida*	Rough Star Coral	--	DD	Reefs
Mussidae	*Isophyllia sinuosa*	Sinuous Cactus Coral	--	DD	Reefs
Mussidae	*Mycetophyllia ferox*	Rough Cactus Coral	--	FT, HR	Reefs
Mussidae	*Mycetophyllia lamarckiana*	Ridged Cactus Coral	--	DD	Reefs
Mussidae	*Scolymia cubensis*	Artichoke Coral	--	DD	Reefs
Mussidae	*Scolymia lacera*	Atlantic Mushroom Coral	--	DD	Reefs
Oculinidae	*Oculina diffusa*	Diffuse Ivory Bush Coral	--	DD	Reefs
Pocilloporidae	*Madracis auretenra*	Yellow Pencil Coral	--	DD	Reefs
Pocilloporidae	*Madracis decactis*	Ten-ray Star Coral	--	DD	Reefs
Pocilloporidae	*Madracis formosa*	Eight-ray Finger Coral	--	DD	Reefs
Pocilloporidae	*Madracis pharensis*	Star Coral	--	DD	Reefs
Poritidae	*Porites astreoides*	Mustard Hill Coral	--	DD	Reefs
Poritidae	*Porites branneri*	Blue Crust Coral	--	DD	Reefs
Poritidae	*Porites colonensis*	Honeycomb Plate Coral	--	DD	Reefs

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS	HABITAT
Poritidae	*Porites divaricata*	Thin Finger Coral	--	DD	Reefs
Poritidae	*Porites furcata*	Branched Finger Coral	--	DD	Reefs
Poritidae	*Porites porites*	Finger Coral	--	DD	Reefs
Siderastreidae	*Siderastrea radians*	Lesser Starlet Coral	--	DD	Reefs
Siderastreidae	*Siderastrea siderea*	Massive Starlet Coral	--	DD	Reefs
OTHER MARINE INVERTEBRATES					
Chitonidae	*Ceratozona squalid*	Eastern Surf Chiton	--	DD	Rocky intertidal
Chitonidae	*Acanthopleura granulata*	Mossy Chiton	--	DD	Rocky intertidal
Chitonidae	*Chiton tuberculatus*	Common West Indian Chiton	--	DD	Rocky intertidal
Lottiidae	*Acmaea antillarum*	True Limpets	--	DD	Rocky intertidal
Fissurellidae	*Fissurella* sp.	Keyhole Limpets	--	DD	Rocky intertidal
Littorinidae	*Nodilittorina ziczac*	Zebra Periwinkle	--	DD	Rocky intertidal
Littorinidae	*Littorina angulifera*	Mangrove Periwinkle	--	DD	Mangroves
Littorinidae	*Littorina mespillum*	Brown Periwinkle	--	DD	Intertidal
Neritidae	*Nerita peloronta*	Bleeding Tooth Nerite	--	DD	Intertidal
Neritidae	*Nerita tesselleta*	Checkered Nerite	--	DD	Intertidal
Neritidae	*Nerita versicolor*	Four-tooth Nerite	--	DD	Intertidal
Tegulidae	*Cittarium pica*	West Indian Top Knot/Whelk	--	LR	Rocky intertidal
Muricidae	*Thais deltoidea*	Deltoid rock shell	--	DD	Shallow reefs
Chthamalidae	*Chthamalus fragilis*	Fragile star barnacle	--	DD	Rocky intertidal
Stichopodidae	*Astichopus multifidus*	Furry Sea Cucumber	--	LR	Seagrass, mud and sand
Stichopodidae	*Isostichopus badionotus*	Three-rowed Sea Cucumber	--	DD	Shallow water, seagrass, mud and sand
Strombidae	*Strombus gigas*	Queen conch	--	HR	Seagrass
Sabellidae	*Bispira brunnea*	Social Feather Duster	--	DD	Reefs
Sabellidae	*Sabellastarte magnifica*	Magnificent Feather Duster	--	DD	Reefs
Serpulidae	*Spirobranchus giganteus*	Christmas Tree Worm	--	DD	Reefs
Palinuridae	*Panulirus argus*	Spiny lobster	--	HR	Reefs, seagrass, deep water
Palinuridae	*Panulirus laevicauda*	Green Lobster	--	HR	Reefs, seagrass
Penaeidae	*Penaeus spp.*	Shrimp	--	DD	Reefs, pelagic
Octopodidae	*Octopus spp.*	Octopus	--	DD	Reefs, mangroves
Diadematidae	*Diadema antillarum*	Long-spined Sea Urchin	--	LR	Reefs, rocky intertidal

FAMILY	**SCIENTIFIC NAME**	**COMMON NAME**	**2005 STATUS**	**2017 STATUS**	**HABITAT**
Echinometridae	*Echinonometra lucunter*	Rock Boring Urchin		DD	Reefs
Grapsidae	*Goniopsis ruentata*	Mangrove Root Crab	--	LR	Mangroves
Holothuriidae	*Actinopyga agassizi*	West Indian Sea Cucumber	--	LR	Deep water
MARINE MAMMALS					
Balaenopteridae	*Balaenoptera borealis*	Sei Whale	--	FE, LR	Pelagic
Balaenopteridae	*Balaenoptera physalus*	Fin Whale	--	FE, LR	Pelagic
Balaenopteridae	*Megaptera novaeangliae*	Humpback Whale	--	LR	Pelagic
Delphinidae	*Stenella frontalis*	Atlantic Spotted Dolphin	--	DDR	Pelagic
Delphinidae	*Tursiops truncatus*	Bottlenosed Dolphin	--	DDR	Pelagic
Physeteridae	*Physeter macrocephalus*	Sperm Whale	--	FE, LR	Pelagic
Trichechidae	*Trichechus manatus*	West Indian Manatee	--	FT, LR	Estuaries, seagrasses, lagoons

Part 2: Flora

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS
TERRESTRIAL PLANTS				
Aizoaceae	*Cypselea humifusa*	Panal		
Amaryllidaceae	*Hymenocallis speciosa*	Green-tinge Spiderfly		
Anacardiaceae	*Spondias mombin*	Hogplum		
Annonaceae	*Annona glabra*	Pond Apple		
Apocynaceae	*Rauvolfia biauriculata*	Boit Lait de Montagne		
Aquifoliaceae	*Ilex urbaniana*	Urban's Holly		
Araceae	*Dieffenbachia seguine*	Dumbcane		
Araceae	*Lemna aequinoctialis*	Lesser Duckweed		
Araceae	*Philodendron giganteum*	Giant Philodendron		
Araceae	*Philodendron hederaceum*	Vilevine		
Araliaceae	*Schefflera morototoni*	Matchwood		
Arecaceae	*Roystonea borinquena*	Puerto Rico Royal Palm		
Arecaceae	*Sabal causiarum*	Puerto Rico Palmetto		
Asparagaceae	*Agave eggersiana*	Egger's Century Plant		HR – Federally Endangered
Asparagaceae	*Agave missionum*	Corita		

Asteraceae	*Gnaphalium domingense*	Dominican Cudweed		
Bignoniaceae	*Amphitecna latifolia*	Black Calabash		
Bignoniaceae	*Arrabidaea chica*	Cricketvine		
Bignoniaceae	*Crescentia cujete*	Common Calabash Tree		
Bignoniaceae	*Crescentia linearifolia*	Higuerito		
Bromeliaceae	*Tillandsia lineatispica*	Pinon		
Buxaceae	*Buxus vahlii*	Vahl's Boxwood		HR – Federally Endangered
Cactaceae	*Consolea macracantha*	Tuna de Cruz	--	
Cactaceae	*Consolea rubescens*			
Cactaceae	*Hylocereus triangularis*			
Cactaceae	*Hylocereus undatus*	Nightblooming Cactus		
Cactaceae	*Leptocereus grantianus*	Sebucan		
Cactaceae	*Mammillaria nivosa*	Woolly Nipple Cactus		
Cactaceae	*Melocactus intortus ssp. intortus*			
Cactaceae	*Miqueliopuntia miquelii*	Tunilla	--	Low Risk
Cactaceae	*Opuntia ficus-indica*	Tuna Cactus	--	Low Risk
Cactaceae	*Opuntia repens*	Roving Pricklypear		
Cactaceae	*Opuntia triacantha*	Spanish Lady		
Cactaceae	*Opuntia X cubensis*	Bullsuckers		
Cactaceae	*Pereskia aculeata*	Barbados Shrub		
Cactaceae	*Rhipsalis baccifera*	Mistletoe Cactus		
Cactaceae	*Selenicereus grandiflorus*	Queen of the Night		
Cactaceae	*Stenocereus fimbriatus*	Spanish Stenocereus		
Campanulaceae	*Hippobroma longiflora*	Madamfate		
Cannabaceae	*Celtis trinervia*	Almex		
Cannaceae	*Canna indica*	Indian Shot		
Celastraceae	*Maytenus cymosa*	Caribbean Mayten		
Chrysobalanaceae	*Chrysobalanus icaco*	Coco Plum		
Cleomaceae	*Tarenaya spinosa*	Spiny Spiderflower		
Combretaceae	*Buchenavia tetraphylla*	Fourleaf Buchenavia		
Combretaceae	*Terminalia buceras*	Gregorywood		
Convolvulaceae	*Cuscuta umbellata*	Flatglobe Dodder		
Convolvulaceae	*Evolvulus filipes*	Maryland Dwarf Morning-glory		
Convolvulaceae	*Ipomoea setifera*			
Convolvulaceae	*Jacquemontia solanifolia*			
Cordiaceae	*Cordia alliodora*	Spanish Elm		

Cucurbitaceae	*Melothria pendula*	Drooping Melonnettle		
Cyatheaceae	*Cyathea arborea*	West Indian Treefern		
Cyperaceae	*Bulbostylis pauciflora*	Fewflower Hairsedge		
Cyperaceae	*Cyperus elegans*	Sticky Flatsedge		
Cyperaceae	*Cyperus flexuosus*	Vahl's Flatsedge		
Cyperaceae	*Cyperus nanus*	Indian Flatsedge		
Cyperaceae	*Eleocharis geniculata*	Canada Spikesedge		
Cyperaceae	*Rhynchospora nervosa*	Yerba de Estrella		
Dioscoreaceae	*Dioscorea pilosiuscula*	Bulbous Yam		
Dioscoreaceae	*Rajania cordata var. cordata*	Himber		
Ericaceae	*Lyonia rubiginosa*	St. Thomas Staggerbush		
Ericaceae	*Lyonia stahlii var. stahlii*	Stahl's Staggerbush		
Euphorbiaceae	*Croton fishlockii*	Fishlock's Croton		
Euphorbiaceae	*Euphorbia heterophylla*	Mexican Fireplant		
Euphorbiaceae	*Sapium glandulosum*	Gumtree		
Fabaceae	*Calliandra haematomma*	Red Powderpuff		
Fabaceae	*Canavalia nitida*	Bahama Baybean		
Fabaceae	*Dalea carthagenensis*	Cartagena Prairie Clover		
Fabaceae	*Erythrina eggersii*	Cock's Spur		
Fabaceae	*Galactia eggersii*	Eggers' Milkpea		
Fabaceae	*Machaerium lunatum*			
Fabaceae	*Stahlia monosperma*	Cobana Negra		
Fabaceae	*Vachellia tortuosa*	Poponax		
Fabaceae	*Zapoteca portoricensis ssp. portoricensis*			
Fabaceae	*Zephyranthes puertoricensis*	White Stickpea		
Fabaceae	*Zygia latifolia var. latifolia*			
Goodeniaceae	*Scaevola plumieri*	Gullfeed		
Heliotropiaceae	*Tournefortia filiflora*	Cold Withe		
Heliotropiaceae	*Tournefortia gnaphalodes*	Sea Rosemary		
Hypoxidaceae	*Hypoxis hirsuta*	Common Goldstar		
Lamiaceae	*Callicarpa ampla*	Capa Rosa		
Lamiaceae	*Ocimum campechianum*	Least Basil		
Lamiaceae	*Salvia micrantha*	Yucatan Sage		

Lamiaceae	*Salvia occidentalis*	West Indian Sage		
Lamiaceae	*Salvia serotina*	Littlewoman		
Lamiaceae	*Vitex divaricata*	Higuerillo		
Lauraceae	*Cinnamomum elongatum*	Laurel Avispillo		
Lauraceae	*Licaria parvifolia*	Puerto Rico Cinnamon		
Lauraceae	*Licaria triandra*	Pepperleaf Sweetwood		
Lauraceae	*Nectandra coriacea*	Lancewood		
Lauraceae	*Nectandra patens*	Capberry		
Lauraceae	*Ocotea floribunda*			
Lauraceae	*Ocotea leucoxylon*	Loblolly Sweetwood		
Lythraceae	*Ginoria rohrii*	Bastard Gregre		
Malpighiaceae	*Byrsonima lucida*	Key Byrsonima		
Malpighiaceae	*Byrsonima spicata*	Doncella		
Malpighiaceae	*Malpighia coccigera*	Singapore Holly		
Malpighiaceae	*Malpighia emarginata*	Barbados Cherry		
Malpighiaceae	*Malpighia linearis*	Bastard Cherry		
Malpighiaceae	*Malpighia woodburyana*	Woodbury's Stingingbush		
Malpighiaceae	*Stigmaphyllon floribundum*	Woolly Amazonvine		
Malvaceae	*Bastardiopsis eggersii*	Jost Van Dyke's Indian Mallow		
Malvaceae	*Ceiba pentandra*	White Silk-cotton Tree		
Malvaceae	*Quararibea turbinata*	Swizzlestick Tree		
Malvaceae	*Wissadula amplissima*	Big Yellow Velvetleaf		
Malvaceae	*Wissadula hernandioides*			
Malvaceae	*Wissadula periplocifolia*	White Velvetleaf		
Melastomataceae	*Miconia spp.*	Johnnyberry		
Melastomataceae	*Tetrazygia elaeagnoides*	Krekre		
Menispermaceae	*Hyperbaena domingensis*	Forest Snakevine		
Moraceae	*Ficus spp.*	Fig		
Myrtaceae	*Calyptranthes thomasiana*	Thomas' Lidflower		Endangered
Myrtaceae	*Eugenia cordata var. sintenisii*	Lathberry		
Myrtaceae	*Eugenia earhartii*	Earhart's Stopper		
Myrtaceae	*Mosiera xerophytica*	Aridland Stopper		
Myrtaceae	*Psidium amplexicaule*	Mountain Guava		

Nyctaginaceae	*Neea buxifolia*	Saltwood		
Ochnaceae	*Ouratea littoralis*	Abey Amarillo		
Orchidaceae	*Brassavola cucullata*	Daddy Longlegs Orchid		
Orchidaceae	*Cranichis muscosa*	Cypress-knee Helmet Orchid		
Orchidaceae	*Cyclopogon cranichoides*	Cranichis-like Ladies'-tresses		
Orchidaceae	*Cyclopogon elatus*	Tall Ladies'-tresses		
Orchidaceae	*Epidendrum anceps*	Brown-flower Butterfly Orchid		
Orchidaceae	*Epidendrum ciliare*	Fringed Star Orchid		
Orchidaceae	*Habenaria alata*	Winged Bog Orchid		
Orchidaceae	*Habenaria monorrhiza*	Tropical Bog Orchid		
Orchidaceae	*Ionopsis utricularioides*	Delicate Violet Orchid		
Orchidaceae	*Liparis nervosa*	Pantropical Widelip Orchid		
Orchidaceae	*Oncidium altissimum*	Wydler's Dancing-lady Orchid		
Orchidaceae	*Polystachya concreta*	Greater Yellowspike Orchid		
Orchidaceae	*Ponthieva racemosa*	Hairy Shadow Witch		
Orchidaceae	*Prescottia oligantha*	Small Prescott Orchid		
Orchidaceae	*Prescottia stachyodes*	Mountain Prescott Orchid		
Orchidaceae	*Prosthechea cochleata*	Clamshell Orchid		
Orchidaceae	*Psychilis macconnelliae*	Island Peacock Orchid		
Orchidaceae	*Sacoila lanceolata*			
Orchidaceae	*Spiranthes torta*	Southern Lady's Tresses		
Orchidaceae	*TetramiCra canaliculata*	Serpentine Wallflower Orchid		
Orchidaceae	*TetramiCra canaliculata alba*			
Orchidaceae	*Tolumnia prionochila*	Tropical Dancing-lady Orchid		
Orchidaceae	*Tolumnia variegata*	Harlequin Dancing-lady Orchid		
Orchidaceae	*Vanilla barbellata*	Wormvine Orchid		
Orchidaceae	*Vanilla claviculata*	Green Withe		
Orchidaceae	*Vanilla mexicana*	Mexican Vanilla		
Orchidaceae	*Vanilla planifolia*	Vanilla		
Pentaphylacaceae	*Ternstroemia peduncularis*	Copey Vera		
Phyllanthaceae	*Flueggea acidoton*	Simpleleaf Bushweed		

Phyllanthaceae	*Margaritaria nobilis*	Bastard Hogberry		
Piperaceae	*Peperomia wheeleri*	Wheeler's Peperomia		
Poaceae	*Andropogon bicornis*	West Indian Foxtail		
Poaceae	*Anthephora hermaphrodita*	Oldfield Grass		
Poaceae	*Aristida adscensionis*	Sixweeks Threeawn		
Poaceae	*Aristida cognata*	Spreading Threeawn		
Poaceae	*Arthrostylidium farctum*	Old Man's Beard		
Poaceae	*Axonopus compressus*	Broadleaf Carpetgrass		
Poaceae	*Digitaria hitchcockii*	Shortleaf Crabgrass		
Poaceae	*Digitaria horizontalis*	Jamaican Crabgrass		
Poaceae	*Digitaria insularis*			
Poaceae	*Echinochloa colona*	Watergrass		
Poaceae	*Eragrostis ciliaris*	Gophertail Lovegrass		
Poaceae	*Eragrostis pectinacea var. pectinacea*	Tufted Lovegrass		
Poaceae	*Eriochloa punctata*	Louisiana Cupgrass		
Poaceae	*Heteropogon contortus*	Tanglehead		
Poaceae	*Lasiacis divaricata*	Smallcane		
Poaceae	*Lasiacis ligulata*	Thicket Tribisee		
Poaceae	*Lasiacis sorghoidea*	Woodland Tribisee		
Poaceae	*Leptochloa virgata*	Judd's Grass		
Poaceae	*Melinis repens*	Rose Natal Grass		
Poaceae	*Olyra latifolia*			
Poaceae	*Oplismenus hirtellus ssp. hirtellus*			
Poaceae	*Panicum diffusum*	West Indian Panicgrass		
Poaceae	*Paspalidium geminatum*	Egyptian Panicgrass		
Poaceae	*Paspalum conjugatum*	Herbe Creole		
Poaceae	*Paspalum distichum*	Knotgrass		
Poaceae	*Paspalum fimbriatum*	Panama Crowngrass		
Poaceae	*Paspalum laxum*	Coconut Paspalum		
Poaceae	*Paspalum molle*	Soft Paspalum		
Poaceae	*Paspalum notatum var. notatum*	Bahiagrass		
Poaceae	*Pharus lappulaceus*	Cape Francais Stalkgrass		
Poaceae	*Schizachyrium sanguineum*	Crimson Bluestem		

Poaceae	*Setaria setosa*	West Indian Bristlegrass		
Poaceae	*Setaria utowanaea*	Caribbean Bristlegrass		
Poaceae	*Spartina patens*	Saltmeadow Cordgrass		
Poaceae	*Sporobolus indicus*	Smut Grass		
Poaceae	*Sporobolus tenuissimus*	Tropical Dropseed		
Poaceae	*Sporobolus virginicus*	Seashore Dropseed		
Poaceae	*Tragus berteronianus*	Spiked Burr Grass		
Poaceae	*Uniola virgata*			
Poaceae	*Urochloa adspersa*	Dominican Signalgrass		
Poaceae	*Urochloa fusca*			
Poaceae	*Urochloa reptans*	Sprawling Signalgrass		
Polygonaceae	*Coccoloba diversifolia*	Pigeon Plum		
Polygonaceae	*Coccoloba krugii*	Whitewood		
Polygonaceae	*Coccoloba krugii x uvifera*			
Polygonaceae	*Coccoloba microstachya*	Puckhout		
Polygonaceae	*Coccoloba pyrifolia*	Uvera		
Polygonaceae	*Coccoloba rugosa*	Ortegon		
Portulacaceae	*Portulaca rubricaulis*	Redstem Purslane		
Putranjivaceae	*Drypetes alba*	Cafeillo		
Rhamnaceae	*Colubrina elliptica*	Soldierwood		
Rhamnaceae	*Reynosia guama*	Guama		
Rosaceae	*Prunus pleuradenia*	Antilles Cherry		
Rubiaceae	*Catesbaea melanocarpa*	Tropical Lilythorn		HR - Federally Endangered
Rubiaceae	*Erithalis fruticosa*	Blacktorch		
Rubiaceae	*Genipa americana*	Jagua		
Rubiaceae	*Geophila repens*			
Rubiaceae	*Machaonia woodburyana*			
Ruppiaceae	*Ruppia maritima*	Widgeongrass		
Rutaceae	*Amyris diatrypa*	Harry Torchwood		
Rutaceae	*Pilocarpus racemosus ssp. racemosus*			
Rutaceae	*Zanthoxylum flavum*	West Indian Satinwood		
Rutaceae	*Zanthoxylum thomasianum*	Prickly-ash		Endangered
Salicaceae	*Casearia sylvestris*	Crackopen		
Salicaceae	*Prockia Crucis*	Guasimilla		

Salicaceae	*Xylosma buxifolia*	Mucha-gente		
Sapindaceae	*Cupania triquetra*	Guara Blanca		
Sapindaceae	*Exothea paniculata*	Inkwood		
Sapotaceae	*Chrysophyllum pauciflorum*			
Sapotaceae	*Manilkara bidentata*	Bulletwood		
Sapotaceae	*Manilkara bidentata ssp. surinamensis*	Surinam Bulletwood		
Sapotaceae	*Sideroxylon foetidissimum*	False Mastic		
Sapotaceae	*Sideroxylon salicifolium*	White Bully		
Schoepfiaceae	*Schoepfia obovata*	White Beefwood		
Simaroubaceae	*Picrasma excelsa*	Bitter-ash		
Simaroubaceae	*Quassia amara*	Quassia-wood		
Solanaceae	*Solanum conocarpum*	Marron Bacoba		
Urticaceae	*Pilea richardii*	Richard's Clearweed		
Verbenaceae	*Lantana camara*	Largeleaf Lantana		
Verbenaceae	*Nashia inaguensis*			
Vitaceae	*Cissus verticillata*	Seasonvine		
Vitaceae	*Vitis tiliifolia*	West Indian Grape		
Ximeniaceae	*Ximenia americana*	Tallow Wood		
Zygophyllaceae	*Guaiacum officinale*	Lignum Vitae		Vulnerable
SEAGRASSES				
Cymodoceaceae	*Halodule wrightii*	Shoal Grass	--	Low Risk
Cymodoceaceae	*Syringodium filiforme*	Manatee Grass	--	Low Risk
Hydrocharitaceae	*Halophila stipulacea*	Invasive Halophila	--	Introduced
Hydrocharitaceae	*Thalassia testudinum*	Turtle Grass	--	Low Risk
MANGROVES				
Acanthaceae	*Avicennia germinans*	Black Mangrove	--	Low Risk
Combretaceae	*Conocarpus erectus*	Buttonwood	--	Low Risk
Combretaceae	*Laguncularia racemosa*	White Mangrove	--	Low Risk
Rhizophoraceae	*Rhizophora mangle*	Red Mangrove	--	Low Risk
BROWN ALGAE				
Dictyotaceae	*Canistrocarpus cervicornis*			
Dictyotaceae	*Dictyopteris delicatula*			
Dictyotaceae	*Dictyota caribaea*			
Dictyotaceae	*Dictyota ciliolata*			
Dictyotaceae	*Dictyota Crenulata*			
Dictyotaceae	*Dictyota dichotoma var. menstrualis*			
Dictyotaceae	*Dictyota pinnatifida*			
Dictyotaceae	*Dictyota pulchella*			
Dictyotaceae	*Lobophora variegata*			

Dictyotaceae	*Padina pavonica*			
Sargassaceae	*Sargassum hystrix var. buxifolium*			
Sargassaceae	*Sargassum natans*			
Sargassaceae	*Sargassum polyceratium var. ovatum*			
Sargassaceae	*Turbinaria turbinata*			
GREEN ALGAE				
Bryopsidaceae	*Bryopsis plumosa*			
Caulerpaceae	*Caulerpa prolifera*			
Caulerpaceae	*Caulerpa racemosa*			
Caulerpaceae	*Caulerpa racemosa var. lamourouxii*			
Caulerpaceae	*Caulerpa sertularioides var. farlowii*			
Cladophoraceae	*Chaetomorpha antennina*			
Cladophoraceae	*Chaetomorpha gracilis*			
Cladophoraceae	*Chaetomorpha linum*			
Cladophoraceae	*Cladophora spp.*			
Pithophoraceae	*Dictyosphaeria cavernosa*			
Ulvaceae	*Enteromorpha intestinalis*			
Halimedaceae	*Halimeda monile*			
Halimedaceae	*Halimeda opuntia*			
Halimedaceae	*Halimeda opuntia f. triloba*			
Udoteaceae	*Penicillus dumetosus*			
Udoteaceae	*Udotea cyathiformis* f. *infundibulum*			
Udoteaceae	*Udotea spp.*			
Ulvaceae	*Ulva lactuca*			
Anadyomenaceae	*Ventricaria ventricosa*			
RED ALGAE				
Galaxauraceae	*Galaxaura rugosa*			
Corallinaceae	*Jania adhaerens*			
Corallinaceae	*Jania capillacea*			
Rhodomelaceae	*Laurencia filiformis*			
Rhodomelaceae	*Laurencia papillosa*			

Appendix 2.2 Extent of Habitat

Areal extent (in hectares) of habitat types for each island. Data from 2013 GAP land cover (Gould et al. 2013).

St. John

Habitat Type	Area (ha)	Percent of total
Dry Forest	**2594.3**	**50.6**
Semideciduous dry forest	1912.5	37.3
Dry Woodland	681.8	13.3
Moist forest	**814.0**	**15.9**
Basin Moist Forest	217.8	4.2
Gallery Moist Forest (Riparian)	588.1	11.5
Moist Woodland	8.2	<1
Shrubland	**1062.2**	**20.7**
Mixed Dry Grassland	**36.2**	**<1**
Pasture	**54.4**	**1**
Wetland	**220.7**	**4.3**
Freshwater Pond	0.7	<1
Guts	0.3	<1
Mixed Swamp	115.2	2.2
Mangrove Forest and Shrubland	51.6	1
Salt Ponds and Salt Flats	53.0	1
Shoreline	**122.05**	**2.4**
Beach	36.7	<1
Rocky Shoreline and Rip Rap	85.4	1.7
Urban Development	**224.9**	**4.4**
High Density	24.0	<1
Medium Density	135.8	2.6
Low Density	65.1	1.3

St. Thomas

Habitat Type	Area (ha)	Percent of total
Dry Forest	**3227.5**	**39.3**
Semideciduous dry forest	1897.7	23.1
Dry Woodland	1329.8	16.2
Moist forest	**712.6**	**8.7**
Basin Moist Forest	188.9	2.3
Gallery Moist Forest (Riparian)	429.9	5.2
Moist Woodland	93.9	1.1
Shrubland	**1702.6**	**20.7**
Mixed Dry Grassland	**118.8**	**1.4**
Pasture	**410.8**	**5.0**
Wetland	**235.2**	**2.9**
Freshwater Pond	10.6	<1
Guts	0.1	<1
Mixed Swamp	104.4	1.3
Mangrove Forest and Shrubland	99.8	1.2
Salt Ponds and Salt Flats	24.3	<1
Shoreline	**300.7**	**3.7**
Beach	52.0	<1
Rocky Shoreline and Rip Rap	248.7	3.0
Urban Development	**1504.8**	**18.3**
High Density	456.4	5.6
Medium Density	865.2	10.5
Low Density	183.3	2.2

St. Croix

Habitat Type	Area (ha)	Percent of total
Dry Forest	**2767.3**	**12.7**
Semideciduous dry forest	490.4	2.2
Dry Woodland	2277.0	10.4
Moist forest	**1040.8**	**4.8**
Basin Moist Forest	8.1	<1
Gallery Moist Forest (Riparian)	1015.2	4.7
Moist Woodland	17.6	<1
Shrubland	**9031.7**	**41.4**
Mixed Dry Grassland	**2287.8**	**10.5**
Pasture/agriculture	**3233.6**	**14.8**
Wetland	**962.3**	**4.4**
Freshwater Pond	40.2	<1
Guts	4.1	<1
Mixed Swamp	226.0	1
Mangrove Forest and Shrubland	341.9	1.6
Salt Ponds and Salt Flats	350.1	1.6
Shoreline	**133.0**	**<1**
Beach	80.9	<1
Rocky Shoreline and Rip Rap	52.1	<1
Urban Development	**2363.7**	**1.8**
High Density	654.5	3.0
Medium Density	1115.7	5.1
Low Density	593.5	2.7

Gould W. A., M. C. Solórzano, G. S. Potts, M. Quiñones, J. Castro-Prieto, L. D. Yntema. 2013. U.S. Virgin Islands Gap Analysis Project – Final Report. USGS, Moscow ID and the USDA FS International Institute of Tropical Forestry, Río Piedras, PR.

Appendix 2.3. SGCN Priority Actions

Priority Action	Goal	Benefits to	Partners
Multiple Species			
Conserve large forested tracts with connectivity	Goal 1: Habitat & species protection	Terrestrial Species; Stenoderma rufum, Brachyphylla cavernarum	DFW, CZM, CCZP, NPS, NGOs
Replant native forest and riparian trees to restore, enhance, and maintain ecosystem function, buffer the habitat from encroachment, maintain connectivity between forested areas, and mitigate negative effects of climate change.	Goal 2. Manage species and habitats	Freshwater fauna, amphibians, birds, bats, all terrestrial species; Pollinators; Stenoderma rufum	DFW, VIDOA, USDA-NRCS, USFS, NPS, NGOs
Improve habitat through reforestation in areas that are protected but habitat has been degraded, such as the Southgate Coastal Reserve and Jack and Isaac Bay on St. Croix. Identify areas for potential habitat improvement on St. Thomas.	Goal 2. Manage species and habitats	Bats, landbirds, amphibians, invertebrates, reptiles	DFW, VIDOA, USDA-NRCS, area managers
Address data gap needs for data deficient species to develop conservation actions	Goal 4: Increase knowledge	All data deficient species: freshwater fauna, terrestrial invertebrates, reptiles, birds, marine species	DFW, NPS, UVI, NGOs
Conduct research on species response to ecosystem change	Goal 4: Increase knowledge	Amphibians, bats, land/water/sea birds, reptiles, sea turtles, marine species	DFW, UVI, NPS, NGOs
Revise land use planning and permitting to protect habitat surrounding proposed development, with an emphasis on forest communities rather than single large trees.	Goal 3: Enhance capacity and regulatory mechanisms	All terrestrial species; erosion control	DPNR
Develop best management practices to reduce trash, sediment, and other point and nonpoint source contaminants into wetlands and streams.	Goal 3: Enhance capacity and regulatory mechanisms	Freshwater fauna, bats, amphibians, waterbirds, marine species	DPNR, WMA

Priority Action	**Goal**	**Benefits to**	**Partners**
Provide training to entities in acoustic methods for biodiversity monitoring.	Goal 3: Enhance capacity and regulatory mechanisms	Bats, birds, amphibians, insects	DFW, UVI
Establish agreements for coordination, communication and data sharing between entities committed to common goals (e.g., annual meetings, online listservs, data sharing platforms, etc)	Goal 3: Enhance capacity and regulatory mechanisms; Goal 6: Adaptive management with monitoring and support tools	All species	DFW, UVI, NPS, NGOs
Conduct outreach to law enforcement officers and decision makers about laws and the value of wildlife and protected species to the economy of the VI.	Goal 5: Increase awareness	All species, especially species of special concern	DPNR, DFW, DEE, VIPD, CBP, LEGVI
Develop education programs within the community towards the value of wildlife and their ecosystem services with a goal of dispelling fears	Goal 5: Increase awareness	Bats, terrestrial reptiles, amphibians, snakes; Chilabothrus granti	DFW, UVI, VIDOEd, EcoSchools, NGOs
Engage schools and local community in citizen science efforts	Goal 5: Increase awareness	Amphibians, birds, coastal resources	DFW, UVI, VIDOEd, EcoSchools, NGOs
Improve vigilance and response towards potential invasive species introductions	Goal 7: Reduce stressors	All species; Chilabothrus granti, sea turtles	DFW, DEE, CBP, VIDOA, USDA-APHIS
Map habitats to enable monitoring of changes in vegetation structure to trigger habitat management action.	Goal 1: Habitat & species protection; Goal 6: Adaptive management with monitoring and support tools	All species	DFW, UVI, NGOs, CZM, NPS, USFWS, VIDOA (Forestry)
Develop protocols to address range of management actions needed in response to monitoring outcomes	Goal 6: Adaptive management with	All resources	DFW, UVI, NGOs

Priority Action	Goal	Benefits to	Partners
	monitoring and support tools		
Freshwater Fauna			
Initiate studies on basic ecology and life histories, including reproductive cycles and migration requirements.	Goal 4: Increase knowledge	All freshwater species	DFW, UVI, NGOs
Identify monitoring methods for wetlands and wetland fauna.	Goal 6: Adaptive management with monitoring and support tools	All freshwater species	DFW, UVI, NGOs
Reduce contaminants in guts by removing dumpster sites from roads or install measures to prevent trash and contaminants from entering watercourses from dumpsters.	Goal 7: Reduce Stressors	All freshwater species	WMA
Restore water flow into and through guts to ensure connectivity with marine environment.	Goal 2. Manage species and habitats	All freshwater species	DPW, DFW, NGOs
Amphibians			
Conduct research on amphibian response to environmental change.	Goal 4: Increase knowledge	All amphibians	DFW, UVI, NGOs
Monitor phenology of seasonal calling activity.	Goal 4: Increase knowledge	All amphibians with possible exception of E. lentus	DFW, UVI, NGOs
Develop and implement protocols for determining status and distribution of E. lentus.	Goal 4: Increase knowledge	Eleutherodactylus lentus	DFW, UVI, NGOs
Explore reintroduction potential of P. lemur within its former range.	Goal 2. Manage species and habitats	Peltophryne lemur	DFW, UVI, NGOs, USFWS
Conduct annual monitoring of activity and distribution.	Goal 6: Adaptive management with monitoring and support tools	All amphibians	DFW, UVI, NGOs
Assess exposure to pesticide residue and other contaminants.	Goal 7: Reduce stressors	All amphibians	DFW, UVI, DPNR
Terrestrial Reptiles			

Priority Action	**Goal**	**Benefits to**	**Partners**
Protect and manage forest cover and soils to provide support for subterranean Antillotyphlops and Amphisbaena that are likely to experience disproportionate impacts from long-term climate changes that include longer periods of drought.	Goal 1: Habitat & species protection	Antillotyphlops richardii, Amphisbaena fenestrata	DFW, UVI, NGOs
Restore habitat to establish connectivity between forested areas on St. Thomas' east end to improve migration potential for tree boas.	Goal 1: Habitat & species protection	Chilabothrus granti	DFW
Increase distributional surveys that include population genetic analysis with priority given to locating and evaluating populations of Chilabothrus and Spondylurus.	Goal 4: Increase knowledge	Chilabothrus granti and Spondylurus spp.	DFW, UVI, NGOs, USFWS
Control feral cat populations.	Goal 7: Reduce stressors	All reptiles	USDA-APHIS
Control or eradicate invasive Pholidoscelis exsul populations on St. Croix	Goal 7: Reduce stressors	All native lizard species on STX; Pholidoscelis polops	DFW, USDA-APHIS
Increase public education targeted at dispelling fears and promoting the value of ecosystem services.	Goal 5: Increase awareness	All reptiles	DFW, UVI, NGOs, VIDOEd, EcoSchools
Land and Waterbirds			
Identify opportunities for acquisition and protection of Important Bird Areas (e.g., Perseverance Bay)	Goal 1: Habitat & species protection	All land and waterbirds	DFW, USFWS, NGOs
Establish and maintain regular standardized monitoring of bird breeding sites, wetlands, and forested areas across all three islands and including cays. The online bird survey data reporting site, ebird Caribbean (http://ebird.org/content/caribbean/) should be used to record and share bird observations.	Goal 6: Adaptive management with monitoring and support tools	All land and waterbirds	DFW, UVI, USFWS, NGOs, NPS
Expand bird banding beyond SPNWR to include multiple sites and habitats on St. Croix, St. Thomas and St. John to reveal movements between islands.	Goal 4: Increase knowledge	All landbirds	DFW, UVI, USFWS, NGOs, NPS
Prioritize suitable wetland habitats for preservation and restoration as refueling areas for migratory shorebirds.	Goal 1: Habitat & species protection	All waterbirds	DFW, UVI, USFWS, NGOs, NPS

Priority Action	**Goal**	**Benefits to**	**Partners**
Evaluate the effects of the introduction and establishment of the red-tailed boa to St. Croix. Stomach content analysis of boas and periodic bird surveys in areas of high snake density should be initiated.	Goal 4: Increase knowledge	Primarily Landbirds, potentially waterbirds and seabirds	DFW, USFWS
Participate in Caribbean wide efforts, such as the Caribbean Waterbird Census, to help regional conservation efforts.	Goal 6: Adaptive management with monitoring and support tools	All bird species	DFW, UVI, USFWS, NGOs, NPS
Colonies of ground nesting waterbirds should be identified and managed to limit negative impacts from invasive predators, human disturbance and any other threats.	Goal 2. Manage species and habitats	Charadrius wilsonia, Sturnula antillarum, Haematopus palliatus, and other ground nesting birds	DFW, UVI, USFWS, NGOs, NPS
Improve ecotourism and bird watching enterprises that focus on habitat conservation. Coordinate with BirdsCaribbean to extend the Caribbean Bird Trail to the USVI and train bird guides	Goal 5: Increase awareness; Goal 8: Support sustainable uses	All bird species	UVI, NGOs, NPS, VIDOT
Seabirds			
Enhance community awareness of sensitive breeding areas on cays and in wetlands, along with increased enforcement, to limit visitation to these important areas during the breeding season.	Goal 5: Increase awareness	All nesting seabirds	DFW, DEE
Conduct research to estimate age-specific survival and connectivity between sites. Population structure and habitat use of colonies should continue to be monitored. (Metapopulation dynamics)	Goal 4: Increase knowledge	All nesting seabirds	DFW, UVI, USFWS, NGOs, NPS
Develop actions to reduce the use of single-use plastics in the community and better solid waste management is needed to protect sea birds from ingesting or become entangled in plastic debris.	Goal 7: Reduce stressors	Birds, marine species, sea turtles	WMA, DFW
Support local fish stocks by working with local fishers.	Goal 8: Support sustainable uses	All seabirds	DFW, UVI
Control or eradicate invasive species such as goats and rats from cays with sensitive nesting colonies.	Goal 7: Reduce stressors	All nesting seabirds	DFW, USDA-APHIS
Work with the fishing community to reduce broken and cut monofilament lines to reduce impacts to birds accidentally hooked that then become entangled.	Goal 5: Increase awareness	All seabirds	DFW, UVI

Priority Action	Goal	Benefits to	Partners
Explore the feasibility and the likelihood of success of reintroducing seabird species that no longer nest in the VI, such as the Red Footed Booby.	Goal 2. Manage species and habitats	Sula sula, possibly Fregata magnificens	DFW, UVI, USFWS, NGOs, NPS
Establish satellite tracking of migratory species to reveal foraging areas and migration pathways. This information can be used to develop spatial analyses of breeding populations to enhance a metapopulation approach to management that is also cross-jurisdictional.	Goal 4: Increase knowledge	All seabirds	DFW, UVI, USFWS, NGOs, NPS
Identify key locations for targeting outreach efforts to reduce hunting, bycatch, and egg poaching threats.	Goal 7: Reduce stressors	All seabirds	DFW, NGOs
Habitat mapping and monitoring changes in vegetation structure can be used to trigger habitat management action.	Goal 1: Habitat & species protection	All seabirds	DFW, UVI, USFWS, NGOs, NPS
Bats			
Protect maternity roost sites from visitation and disturbance	Goal 1: Habitat & species protection	Brachyphylla cavernarum, Artibeus jamaicensis	DFW, UVI, NGOs
Conduct surveys to determine basic information such as locations of roost sites and key habitat features.	Goal 4: Increase knowledge	All bats; Stenoderma rufum	DFW, UVI, NGOs
Assess impacts of power-generating wind turbines on mortality to bats and birds.	Goal 4: Increase knowledge	All bats; Stenoderma rufum	DFW, UVI, NGOs, VIDOEn
Establish acoustic and video monitoring of roost sites and resource-rich areas	Goal 6: Adaptive management with monitoring and support tools	All bats; Stenoderma rufum	DFW, UVI, NGOs
Develop training program for pest control services to reduce inhumane destruction of bat roosts associated with human habitations, as well as reduction in pesticide use overall.	Goal 5: Increase awareness	Molossus molossus	DFW, UVI, DPNR
Conduct studies on exposure to pesticides and other contaminants.	Goal 4: Increase knowledge	All bats; Noctilio leporinus	DFW, UVI, DPNR
Conduct genetic studies to evaluate population structure and metapopulation dynamics	Goal 4: Increase knowledge	All bats; Stenoderma rufum, all other spp	DFW, UVI, NGOs

Priority Action	Goal	Benefits to	Partners
Conduct nonlethal sampling for the presence of lyssavirus and other pathogens	Goal 7: Reduce stressors	Molossus molossus, Artibeus jamaicensis	CDC, VIDOH, VIDOA, DFW, UVI, NGOs
Sea Turtles			
Control/eradicate mammalian predators from sea turtle nesting areas	Goal 7: Reduce stressors	All sea turtle species, especially Chelonia mydas and Eretmochelys imbricata	USDA-APHIS, DFW, USFWS, NPS, NGOs
Expand the number of beaches that are monitored for turtle nesting activity, especially on St. Thomas and St. John.	Goal 6: Adaptive management with monitoring and support tools	All sea turtle species, especially Chelonia mydas and Eretmochelys imbricata	DFW, UVI, NGOs, NPS, USFWS
Develop actions to reduce the use of single-use plastics in the community and better solid waste management is needed to protect sea turtles from ingesting or become entangled in plastic debris.	Goal 7: Reduce stressors	All sea turtle species	VIWMA, CZM, DFW
Conduct outreach to the general public and businesses that interact with turtles (e.g., dive shops, beachfront businesses, boat tours) as to how to properly interact with turtles without harming them	Goal 5: Increase awareness	All sea turtle species	DFW, UVI, NGOs, NPS, USFWS, CZM
Increase awareness of disorientation of sea turtles due to improper lighting. Develop funding sources to assist private landowners in updating lighting with "turtle friendly" lighting.	Goal 5: Increase awareness	All sea turtle species	DFW, UVI, NGOs, NPS, USFWS, CZM
Marine Fish and Invertebrates			
Develop best management practices to reduce trash, sediment, and other point and nonpoint source contaminants into the marine environment	Goal 3: Enhance capacity and regulatory mechanisms; Goal 7: Reduce stressors	All marine fish and invertebrates	DPNR, WMA, UVI
Establish coastal vegetation buffers to stabilize shorelines and filter land-based sources of contamination	Goal 1: Habitat & species protection; Goal 7: Reduce stressors	All marine fish and invertebrates, but especially those in nearshore habitats	DFW, UVI, NGOs, NPS, NOAA, CZM
Conduct surveys to identify local distribution and habitat associations of marine invertebrates	Goal 4: Increase knowledge	Marine Invertebrates	UVI, DFW, NOAA

Priority Action	**Goal**	**Benefits to**	**Partners**
Expand research on fish breeding aggregations to protect important breeding areas	Goal 1: Habitat & species protection	Aggregate breeders	UVI, DFW, NOAA
Conduct studies of larval distribution through oceanographic modelling to identify priority areas for connectivity	Goal 4: Increase knowledge	All marine fish and invertebrates	UVI, DFW, NOAA
Conduct standardized fishery-independent monitoring surveys to assess stock conditions and the efficacy of management measures.	Goal 6: Adaptive management with monitoring and support tools	Priority fisheries species	DFW, NOAA, UVI
Identify additional areas for inclusion into Marine Protected Areas	Goal 1: Habitat & species protection	All marine fish and invertebrates	UVI, DFW, CZM, NOAA, NPS, NGOs
Re-establish and support native herbivores within coral reef systems to reduce algal cover	Goal 2. Manage species and habitats	Coral reefs and associated species	UVI, DFW, CZM, NOAA, NPS, NGOs
Re-establish and support native predators (incl. sharks) to improve ecosystem function across trophic levels	Goal 2. Manage species and habitats	Sharks and other predatory species	UVI, DFW, CZM, NOAA, NPS, NGOs
Install and maintain moorings in high traffic locations to protect reef and seagrass habitats	Goal 1: Habitat & species protection; Goal 2. Manage species and habitats	Coral reefs and seagrass beds and associated species	DPNR, NOAA, NPS
Establish and enforce a ban on harmful sunscreen products; increase awareness within the local and tourism community of the damage caused by these products	Goal 3: Enhance capacity and regulatory mechanisms; Goal 5: Increase awareness	Coral and associated reef species	DPNR, NGOs
Marine Mammals			
Promote ecotourism and whale-watching enterprises	Goal 5: Increase awareness	Primarily whale species	NGOs, VIDOT
Establish “hotline” for sightings and strandings	Goal 3: Enhance capacity and regulatory mechanisms	All marine mammal species	DFW, USFWS, NPS

Priority Action	Goal	Benefits to	Partners
Increase education of boaters and tour operators of marine mammal encounter guidelines	Goal 3: Enhance capacity and regulatory mechanisms	All marine mammal species	DFW, NPS, VIDOT, NGOs, Boating community

Partner acronyms listed in table

Territorial Government

DPNR	Department of Planning and Natural Resources
CCZP	Coastal and Comprehensive Zone Planning
CZM	Coastal Zone Management
DEE	Division of Environmental Enforcement
DFW	Division of Fish and Wildlife
DPW	Department of Public Works
LEGVI	VI Legislature
VIDOA	VI Dept. of Agriculture
VIDOEd	VI Dept. of Education
VIDOEn	VI Dept. of Energy
VIDOH	VI Dept. of Health
VIDOT	VI Dept. of Tourism
VIPD	VI Police Department
WMA	Waste Management Authority

Federal Government

CBP	Customs and Border Control
CDC	Center for Disease Control
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
USDA	US Dept. Agriculture
APHIS	Animal and Plant Health Inspection Service
NRCS	Natural Resource Conservation Service
USFS	US Forest Service
USFWS	US Fish and Wildlife Service

Other Local Entities

UVI	University of the Virgin Islands
NGOs	Non-governmental Organizations (e.g., St. Croix Environmental Association, Coral Bay Community Council)
	EcoSchools
	Boating Community
	Area Managers