United States Virgin Islands Wildlife Action Plan Volume 1: Management Framework

Preprint · January 2018

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Volume 1:
Management Framework

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For:

Division of Fish and Wildlife
Department of Planning and Natural Resources
St. Thomas, U.S. Virgin Islands
September 2018

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This document should be cited as:

Platenberg, R. J. and J. M. Valiulis (Eds). 2018. United States Virgin Islands Wildlife Action Plan, Vol. 1: Management Framework. Final report to the USVI Department of Planning and Natural Resources Division of Fish and Wildlife. University of the Virgin Islands and St. Croix Environmental Association, US Virgin Islands.

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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U.S. Virgin Islands Wildlife Action Plan
Executive Summary

The United States Virgin Islands (USVI) comprises three major islands: St. Thomas, St. John and St. Croix and more than 50 smaller offshore cays with a total land area of about 353 km^2. The USVI is an organized, unincorporated territory of the U.S. with policy relations under the jurisdiction of the Office of Insular Affairs, U.S. Department of the Interior. Tourism, trade, and other services are the primary economic activities, accounting for nearly 60% of the Virgin Island's GDP and about half of total civilian employment.

Caribbean islands, including the USVI, are a recognized global biodiversity hotspot, containing high levels of endemism that has resulted from long periods of geographic isolation with limited dispersal opportunities for terrestrial plants and animals. Most islands have species assemblages that are found nowhere else, not even on a neighboring island. These islands, however, have had a long history of disturbance, leading to the second part of the definition: a biodiversity hotspot is an area that contains a high proportion of the world's unique species that are in decline due to human activities.

Current threats to terrestrial and marine wildlife and habitats of the USVI include ongoing habitat loss and degradation, invasive species, diseases, pollution, and climate impacts. The demands for space by a rapidly growing human population of over 100,000 in the USVI have resulted in ongoing loss and degradation of natural ecosystems, which also affect marine environments. Expanding residential communities and commercial centers, including tourism infrastructure, have replaced or encroached on native forests, while marinas and other coastal development have affected coastal wetlands, while marine activities threaten fragile mangrove swamps, coral reefs, and seagrass beds. Human development has increased pollution and the introduced non-native plant and animal pests. Moreover, the natural ecosystems are subject to the effects of short- and long-term wet and dry climatic cycles, and to periodic disturbances from hurricanes, including the devastating hurricanes Hugo in 1989, Marilyn in 1995, and Irma and Maria in 2017. Cumulative impacts and synergism between these influences leads to ecosystem change, a term that represents anthropomorphic alteration of ecosystems that cannot be reversed. The USVI, as with many places, experiences an additional threat of "inaction", which includes challenges from lack of funding, limited opportunities for training, difficulties in coordination, collaboration, and communication, and economic and social priorities that may conflict with the goals of species and habitat conservation.

In 2005, under the newly formed State Wildlife Grant (SWG) program, the USVI Department of Planning and Natural Resources Division of Fish and Wildlife (DFW) produced a comprehensive wildlife conservation strategy (CWCS) that described the terrestrial habitats and species of the territory. This plan offered a checklist of priority actions towards species management and was a valuable tool for resource managers and those interested in the Territory's wildlife. This strategy was updated from 2016-2017 to become the VI Wildlife Action Plan (VI-WAP). In addition to updating the current knowledge on terrestrial species and habitats, the 2018 VI-WAP also assesses marine habitats and species.

The comprehensive state wildlife action plans (SWAP) are required for each state to receive funding under the SWG program. SWAPs contain information about species and their status and the extent and condition of their habitats and provide a strategy that prioritizes threats and the management and research needs towards addressing those threats. The SWAPS are not just a plan for the fish and wildlife agencies of each state; rather, they identify a suite of conservation strategies and offer a management framework through coordination across entities. In the USVI, the original CWCS was used not only as a planning document

but fulfilled a need for a key guide for natural resources managers and others seeking information on the status of and threats to wildlife in the USVI.

Using stakeholder input from surveys, interviews, and meetings, eight priority goals toward addressing the main issues surrounding species and habitat conservation in the territory were identified with the following themes: 1) habitat and species protection, 2) habitat and species management, 3) capacity, 4) research, 5) education and outreach, 6) adaptive management, 7) adaptation and mitigation, and 8) economics and incentives. Fundamental objectives and actions were developed within these goals toward improving both the status of the wildlife resources and the management capacity for these resources, and priority actions were highlighted toward achieving conservation success directly focused on wildlife and habitats.

Each SWAP is required to have eight elements for approval by USFWS. The following are brief descriptions of the VI-WAP approach to addressing these elements.

1. **Species**: The current status of terrestrial and marine species has been updated through a process comparing species status listed in the IUCN Red List (iucn.redlist.org) and the Puerto Rico SWAP, along with extensive literature reviews. All species of terrestrial herpetofauna, avifauna, and mammals, as well as key marine fish and invertebrates, were evaluated; 138 species were identified as being of Greatest Conservation Need (SGCN) within the USVI: 66 terrestrial species of frogs, reptiles, bats, and birds (and three freshwater species of fish and crabs), and 72 species of marine fish, invertebrates, and mammals. The SGCN status has been categorized according to High Risk, Low Risk, and Data Deficient-At Risk to aid in management prioritization. Information on the distribution and abundance of wildlife species of the USVI are covered in depth in Vol. 2 of this document, while the SGCN list and explanation of process for development is found in Vol. 1, chapter 3. A comprehensive list of terrestrial and marine species along with habitat associations can be found in Appendix 2.1.

2. **Habitats**: The extent and condition of USVI habitats is described in the VI-WAP for terrestrial forests and woodlands, shrublands, grasslands, and coastal area; wetlands, including guts (natural freshwater systems) and freshwater and saline ponds; and marine habitats including mangroves, seagrass beds, and coral reefs. The primary threat to these habitats is decline and degradation from upland development activities, and conservation actions have been identified to address these threats, to include protection, restoration, acquisition, and educational and recreational potential. Post-hurricane condition and needs are also described. Habitat condition, threats, and action priorities are described in Vol. 2 along with sources of information.

3. **Threats**: The VI-WAP provides a thorough assessment of the driving factors of ecosystem change, and how they affect species and habitats. Six primary threats were identified that apply to major taxa groups: habitat loss, invasive species, disease, pollution, climate impacts, and a ubiquitous influence resulting from inaction, which includes shortfalls in management capacity, enforcement, and lack of awareness. These categories were identified through a process involving a risk assessment of a suite of threats, including climate change influences, to each wildlife taxon (see Appendix 1.4 for example of risk assessment), and prioritization through stakeholder input.

4. **Conservation Actions**: Conservation goals, objectives, and actions necessary to conserve USVI species and habitats were identified using threat risk assessments and prioritized using a combination of planning processes. Included in this assessment was an evaluation of the effectiveness of the conservation actions identified in the 2005 CWCS. Stakeholder values and input were aligned with objectives to develop an overarching conservation strategy towards not only reducing threats but also proactively protecting and managing species and their habitats. Priority actions to address specific threats to species and habitats are aligned with goals and indicators, with partners identified for implementation. Although the primary focus of the conservation goals is the SGCN, most conservation action will also benefit species that are not in need of specific protection. There are large

gaps in our knowledge of the status and ecology of many species in the USVI so in some cases, conservation actions include filling in those knowledge gaps.

5. **Monitoring Species and Effectiveness:** Monitoring programs are in place for seabirds, waterbirds, sea turtles, bats, amphibians, some fish species, and corals within the USVI. These programs contribute to long-term datasets that can indicate changes in population trends as a result of management action/inaction. The VI-WAP also contains goals for adaptive management to include identification of useful indicators and the application of decision-making tools to evaluate effectiveness of effort. This revision also evaluated the progress of the 2005 CWCS goals. This document proposes monitoring strategies to better inform future WAPs and to refine Conservation Actions.

6. **Review and Revision:** A full review and update of the VI-WAP, including species status and effectiveness of conservation actions, will be conducted by DFW by 2025 to ensure priority actions and decision making are being conducted using the most recent available science.

7. **Partnerships:** The VI-WAP was developed through a collaborative approach with federal, regional, and local entities to establish joint ownership of the goals. The resource managers from territorial entities were engaged, either through interviews and surveys, or through participation at stakeholder meetings. Subject matter ranged from specific species status, conservation and research work that is occurring, threats to species and habitats, and needs to address those threats. No single entity can accomplish the conservation objectives within the USVI due to extremely limited staffing and resources, emphasizing how necessary it is for all entities to contribute to the WAP and to the fulfillment of the conservation goals. Priority actions identify potential partnership opportunities across a range of entities.

8. **Public Participation:** Broad public participation has been an essential element of developing and implementing the VI-WAP. Public meetings were held to solicit input from the community, and participants were asked to rank threats and identify solutions, which were aligned with VI-WAP goals to develop a broad strategy for addressing wildlife and habitat needs across the territory. Additional input was requested across social media, and the VI-WAP was available for comment during a 30-day review period. Many of the objectives and actions contained within the VI-WAP require community participation in implementation, and a range of community activities, ongoing and proposed, to engage, educate, and enthuse the community towards stewardship of our VI wildlife resources have been proposed.

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The 2018 VI-WAP was produced by Renata Platenberg (UVI) and Jennifer Valiulis (SEA), with the assistance of UVI students and USVI stakeholders, with funding from USFWS SWG program

Chapter One
The U.S. Virgin Islands Context

Prior to 2000, there were few funding opportunities across state fish and wildlife agencies for research and management for species of conservation need that were not harvested or listed under the Endangered Species Act (ESA). Most of the federal funding that was available to state agencies was for ensuring the sustainability of game species and commercial or recreational fish (paired fin species). The U.S. Congress recognized the shortfall while at the same time lamenting the number of species being added to the ESA list, and in 2000 it created a new program, the State Wildlife Grants (SWG) program. SWG has the goal of keeping common species common while focusing effort and funds on those species of greatest conservation need (SGCN).

SWG provides an annual discretionary apportionment to each state and territory, and funds under this program can be used to address a variety of conservation needs, including research, surveys, species and habitat restoration, and monitoring. In order to receive these funds, the state/territory must produce a State Wildlife Action Plan (SWAP), approved by Congress, that identifies the species of greatest conservation need and prioritizes conservation actions. The completion of the first round of plans in 2005 for every state and territory was a major milestone in wildlife conservation across the U.S. Collectively and for the first time, the plans identified a national blueprint for proactive and coordinated conservation of wildlife resources. The collaborative effort between states to develop objectives for shared resources spawned other initiatives, including the Landscape Conservation Cooperatives and the Regional Climate Centers.

In 2005 the USVI Division of Fish and Wildlife produced a Comprehensive Wildlife Conservation Plan (CWCS) for terrestrial resources and a Marine Resources and Fisheries Strategic and Comprehensive Conservation Plan ("Marine Plan"). This 2018 revision (VI-WAP) aims to consolidate both sections while still providing a comprehensive treatment of all the USVI's wildlife and habitats. This VI-WAP contains two parts: 1) a management section that identifies

the mandated components of the SWAPs, status of the SGCN, threats to resources, and introduces strategic and action priorities towards addressing threats and resources needs within the territory with associated appendices; and 2) a comprehensive catalog of the current state of knowledge of habitat and species resources with associated appendices. Appendices provide supplemental information, including a comprehensive list of USVI species, extent of USVI habitats, and individuals who participated in the revision process.

This chapter describes the geographic and management structure of the USVI as relevant toward implementing WAP goals.

Geographic and Demographic Setting

Situated near the eastern terminus of the Greater Antillean chain of islands in the northern Caribbean Sea, the United States Virgin Islands (USVI) comprise three major islands and more than 50 smaller offshore cays with a total land area of about 353 km^2 (Fig. 1.1). St. Thomas (74 km^2) and St. John (50 km^2) are the two major islands to the north, located on the Puerto Rican Bank to the east of Puerto Rico and its offshore islands (Culebra and Vieques), and west of the British Virgin Islands (BVI). The third island, St. Croix (217 km^2), is located about 64 km to the south of St. Thomas and is more isolated than the other Virgin Islands. The offshore cays collectively comprise about 3% of the territory's area (12 km^2; habitat descriptions are provided elsewhere).

The USVI is an organized, unincorporated territory of the U.S. with policy relations under the jurisdiction of the Office of Insular Affairs, U.S. Department of the Interior. Tourism, trade, and other services are the primary economic activities, accounting for nearly 60% of the Virgin Island's GDP and about half of total civilian employment. The islands host nearly 3 million tourists per year, mostly from visiting cruise ships (data from CIA World Factbook 2017).

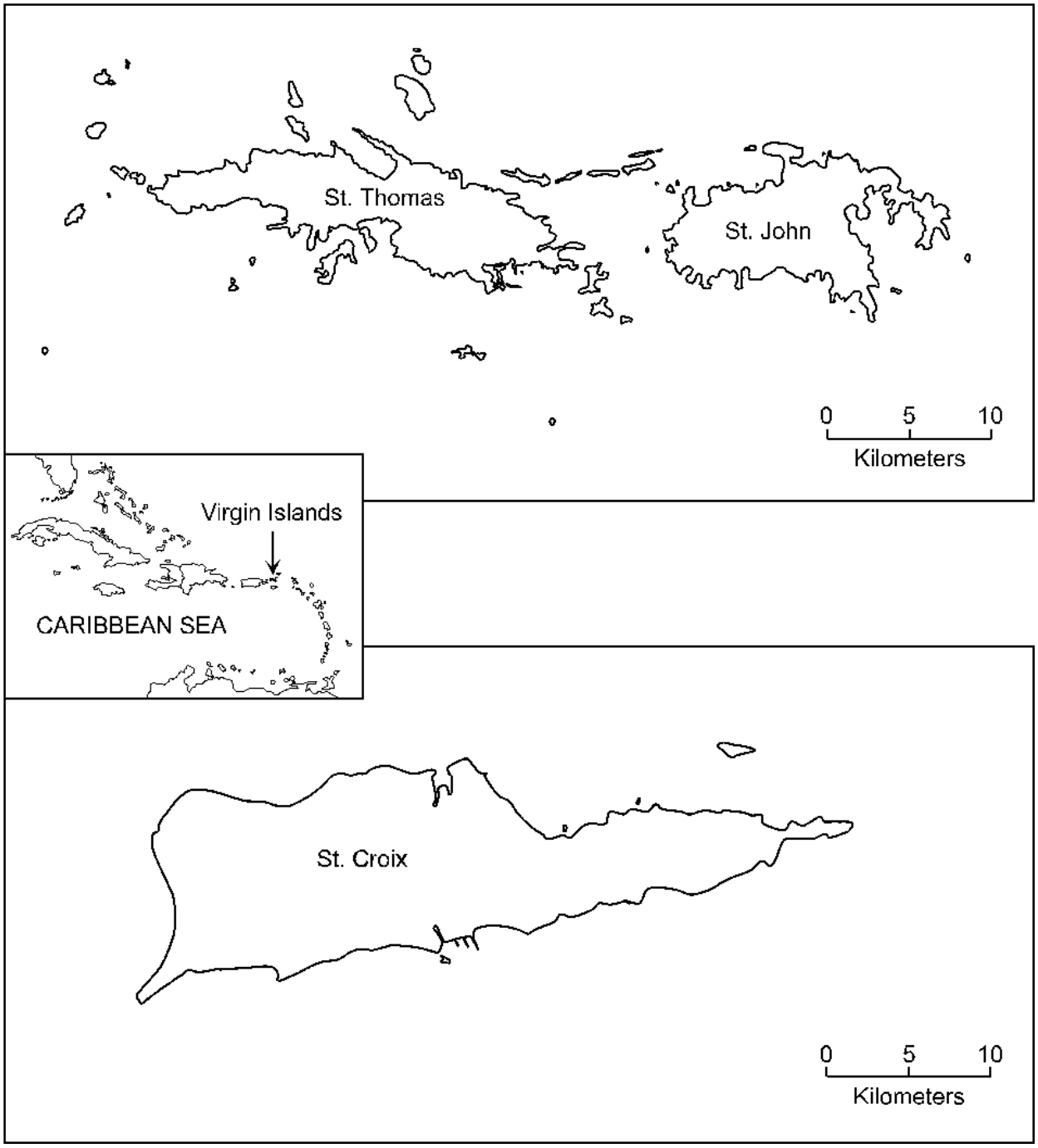
St. Thomas is highly developed, with a human population of over 51,000 (2010 census data). The island has a thriving tourism industry, with marinas, hotels, and shopping areas, and is the headquarters of the VI Government and VI Legislature. While the main industry is tourism-focused, St. Thomas also hosts many U.S. businesses that take advantage of Economic Development Commission benefits while providing economic support to the local community.

St. Croix is almost twice the size of St. Thomas, with less infrastructural development. Agriculture has dominated the landscape of this island, both historically and currently. A refinery on St. Croix, Hovensa, was one of the world's largest and processed 350,000 barrels of crude oil a day until it was shut down in February 2012; its operations are much more limited now, functioning only as an oil storage facility. Two major rum distilleries (Cruzan Rum and Captain Morgan) contribute significantly to the economy, although to a much lesser degree than the Hovensa refinery once did. Ecotourism is an increasing industry on an island that has extensive beaches, trails, and snorkeling opportunities.

St. John is the smallest population of less than 5000. Around 60% of the land area on St. John is contained within the Virgin Islands National Park, and the island is nearly completely surrounded by marine protected areas. Tourism also drives the economy of St. John, although it attracts more

long-stay visitors who rent villas or camp at NPS or private campsites. The areas outside of the NPS boundary are under severe pressure of development, and the island has seen significant changes in development in the past decade. There is continued interest in adding a big marina mid-island.

Figure 1.1. Map of the United States Virgin Islands.



The demands for space by a rapidly growing human population of over 100,000 in the USVI have resulted in extensive loss and degradation of natural ecosystems, especially on densely populated St. Thomas. Expanding residential communities and commercial centers have replaced or fragmented much of the native forest. Hotels, condominiums, and marinas have been constructed on coastal wetlands, and marine recreational activities have damaged fragile mangrove swamps, coral reefs, and seagrass beds. Human development has led to increased pollution and the introduction of exotic plant and animal pests. Moreover, the natural ecosystems are subject to the effects of short- and long-term wet and dry climatic cycles, and to periodic disturbances from hurricanes, including the devastating hurricanes Hugo in 1989, Marilyn in 1995, and Irma and Maria in 2017.

Natural Resources Management Framework

Department of Planning and Natural Resources

Within the USVI, the Department of Planning and Natural Resources (DPNR) is the government agency mandated to protect, maintain, and manage the natural and cultural resources of the Virgin Islands, through the coordination of economic development, in collaboration with local, federal and non-government organizations, ensuring sustainability to enable present and future Virgin Island generations live in harmony with their environment and cultural heritage.

Several divisions within the DPNR are involved in environmental resource management, including the Division of Fish and Wildlife (DFW), Division of Coastal Zone Management (CZM), Division of Environmental Protection (DEP), and Division of Environmental Enforcement (DEE).

Division of Fish and Wildlife

The Division of Fish and Wildlife (DFW) is the agency responsible for the assessment of marine and wildlife resources within the USVI. Initially named the Bureau of Fish and Wildlife, the DFW was first organized in 1969 to qualify for federal funding under Sport Fish and Wildlife Restoration. In 1980 it was reorganized and renamed the DFW.

The mission of the DFW is to manage and improve the fish and wildlife resources of the USVI. The primary responsibilities of the DFW include: conducting research and monitoring studies of marine and wildlife resources; developing and implementing management strategies when studies reveal the need; developing public awareness through environmental education; providing technical guidance to appropriate agencies, groups, and individuals; and coordinating intra- and inter-agency programs relating to marine and wildlife resources.

The operations of DFW are shared between two offices, one in St. Thomas and one in St. Croix. The staff is divided within three bureaus: Bureau of Fisheries, Bureau of Wildlife, and Bureau of Environmental Education, each with a Bureau Chief to manage activities within that unit. The Bureau of Wildlife oversees management of primarily terrestrial species and habitats, The Bureau of Fisheries focuses on commercial and recreational fisheries management as well as marine species and habitats. The Bureau of Environmental Education responsibilities include both fisheries and wildlife issues. DFW does not have any regulatory or enforcement authority, although the division conducts scientific review of CZM and other agency permit applications and prepares

permits for select activities, such as wildlife research and mangrove cutting, which are approved at the departmental level.

Funding for the DFW is derived exclusively from federal grants, which come from two sources: 1) Financial Assistance Program, U.S. Fish and Wildlife Service (USFWS), Department of the Interior; and 2) National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration, Department of Commerce. The DFW's annual budget typically exceeds $3 million with around $700,000 targeted for wildlife. Wildlife activities are funded primarily from Wildlife Restoration (WR) and State Wildlife grants (SWG) under the Wildlife and Sport Fish Restoration Program, and Endangered Species grants (ES) under the Cooperative Endangered Species Conservation Fund program.

DFW's activities are limited by the constraints of the funding mechanisms. The Wildlife Restoration program supports projects that enhance wild birds and mammals and their habitats. WR funded activities also include wildlife-related recreation, hunter education, and generally exclude plants, invertebrates, amphibians, and reptiles, as well as prohibiting funding for law enforcement, licensing, and regulatory functions. SWG funding is directed toward management of species of greatest concern and their habitats that are identified through the SWAP planning process. Conservation action for sea turtles and other listed species is funded through the Cooperative Endangered Species Conservation Fund program.

Division of Coastal Zone Management

The USVI Coastal Zone Management Program was established to manage, enhance, protect, and preserve coastal resources, while reducing conflict between competing land and water uses. It represents a comprehensive approach to minimizing the impacts of activities on coastal resources. The program is strongly committed to the overall management of the coastlines to ensure environmental and economical sustainability for future generations. CZM is charged with permitting within the Coastal Zone, including evaluation of Environment Assessment Reports for major permit applications for development projects within the coastal zone.

CZM is also responsible for the oversight and day-to-day management of a number of other programs. Major programs managed and administered by CZM include but are not limited to: Public Access, Federal Consistency, St. Thomas East End Reserves and St. Croix East End Marine Park, and Public Education and Outreach. The primary goal of the CZM Public Education & Outreach program is to enhance public awareness of the value of protecting the coastal resources for the long-term, sustainable benefits that protection and maintenance can provide to our territory. Initiatives included in this program are the Beach Plastics Recycling Program, Rock City Clean Streets cleanup initiative, VI Clean Coasts environmental certification, and Environmental Education with schools and summer camps.

Division of Environmental Protection

The Division of Environmental Protection (DEP) is a regulatory body within DPNR. In collaboration with other DPNR divisions, the DEP is entrusted with the responsibility for environmental protections and enforcement of USVI environmental laws and regulations and certain national environmental laws, as delegated by the United States Environmental Protection

Agency. This agency is responsible for activities related to water quality management, air pollution control, groundwater, use of pesticides, and solid waste management.

Division of Building Permits

Division of Building Permits' primary responsibility is to enforce and regulate the local and national building codes and regulations, and they also are responsible for the management of nonpoint source pollution and the Earth Change program. The Nonpoint Source Pollution program strives to enhance coastal waters quality by funding various projects, ranging from information and education programs, to demonstrating and monitoring projects, and highly technical applications of nonpoint source control technology. The Earth Change Program implements non-point source pollution controls, including sediment control, erosion mitigation measures, and protection of coastal and ground resources.

Division of Environmental Enforcement

The Division of Environmental Enforcement serves as the compliance arm of DPNR. Its primary function is to enforce all environmental, boating safety and permitting laws of the USVI and to protect, conserve and preserve the natural resources of the Territory. Secondary functions are to support the philosophy of "zero tolerance" toward illegal drugs by assisting federal and local enforcement agencies in initiatives aimed at eradicating illegal drugs and enforcement of Homeland Security duties through land and marine patrols focused at preventing terrorist attacks. DEE is also responsible for the local enforcement of federal fisheries laws.

Other Resource Management Partners

Federal Entities

The U.S. Fish and Wildlife Service (USFWS) has an Ecological Services office in Puerto Rico with oversight for projects in the USVI under the Endangered Species and the Coastal programs as well as two USFWS National Wildlife Refuges (Sandy Point and Buck Island). The U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) has a presence in the USVI with oversight over invasive species. The USDA is also represented by personnel with the Natural Resources Conservation Service (NRCS). There are two U.S. National Park Service (NPS) management units in the USVI: Virgin Islands National Park (including the Virgin Islands Coral Reef National Monument) on St. John, and Buck Island Reef National Monument (including Christiansted National Historic Site and Salt River Bay National Historical Park and Ecological Preserve) on St. Croix.

University of the Virgin Islands

The University of the Virgin Islands is a learner-centered institution dedicated to the success of its students and committed to enhancing the lives of the people of the U.S. Virgin Islands and the wider Caribbean through excellent teaching, innovative research, and responsive community service. It has campuses on both St. Thomas and St. Croix, with an extension facility on St. John.

Within UVI, the Center for Marine and Environmental Studies aims to advance knowledge and learning in marine, coastal and watershed systems through research, education, student training and outreach programs and to disseminate such knowledge to the academic body, scientific community, government agencies and the general public.

Non-Governmental Organizations

The St. Croix Environmental Association was founded in 1986 as a non-profit committed to protecting the natural resources of St. Croix. Much of the focus is on education and outreach to school age students but also to adults through hikes, field trips, snorkel clinics and other activities. SEA also manages the Southgate Coastal Reserve, including conducting regular bird and turtle surveys, and the Barren Spot Bat Tower.

In addition to SEA, there are several non-governmental organizations (NGOs), both non-profit and private, that serve valuable roles toward meeting WAP goals through research, resource and protected area management, and outreach and education. Some of these are the Nature Conservancy (TNC), Coral Bay Community Council (CBCC), Magens Bay Authority (MBA), Virgin Islands Conservation Society (VICS), and Geographic Consulting, LLC.

The 2018 VI-WAP update was a collaborative effort between DFW, UVI, and SEA, with stakeholder input from each of the entities listed.

Banner photo: Charlotte Amalie, St. Thomas by R. Platenberg

Chapter Two
Introduction to the USVI Wildlife Action Plan

Why A WAP?

Prior to the USVI State Wildlife Grant (SWG) program, there were few funding opportunities for research and management for terrestrial species of conservation need that were not listed under the Endangered Species Act (ESA) or for non-harvested marine species. Most of the federal funding that was available to the VI-DFW was for ensuring the sustainability of birds and mammals under the Pittman-Robertson (P-R) Wildlife Restoration program, and commercial or recreational fish under the Dingell-Johnson Sport Fish Restoration program. The U.S. Congress recognized the shortfall and in 2000 it created the SWG program with the goal of reducing the number of species being added to the ESA list. SWG has the goal of keeping common species common while focusing effort and funds on those species of greatest conservation need. SWG funds can be used to address a variety of conservation needs for local species, including research, surveys, habitat restoration, and monitoring.

As an insular U.S. Territory the USVI is highly dependent on federal funds, and the DFW is 100% funded through NOAA and USFWS Wildlife and Sport Fish Restoration programs. Non-federal match requirements are difficult to meet because many resources within the territory are federally-sourced, and unlike state Fish & Wildlife Agencies, the VI-DFW is exempt from the match requirements for eligibility for allocated funding except for competitive grants. The SWG program augments state revenue and competitive funding discrepancies.

In order to receive SWG funds, each state/territory must produce a conservation action plan that identifies the species of greatest conservation need and prioritizes conservation action. The first round of plans, released in 2005, were developed collaboratively between federal, state, and local

agencies, and identified a commitment for coordination between partners to achieve the goals identified.

In 2005 the USVI Division of Fish and Wildlife produced two separate plans in-house to meet the SWG requirements: a Comprehensive Wildlife Conservation Plan (CWCS) for terrestrial resources and a Marine Resources and Fisheries Strategic and Comprehensive Conservation Plan ("Marine Plan"). This revision (VI-WAP) aims to consolidate the conservation priorities from both documents while still providing a comprehensive treatment of all the USVI's species and habitats. The information is organized into two volumes, a management section useful for management personnel and others looking for information on species status and conservation goals, and a catalog of local resources that is a valuable resource for anyone interested in learning more about VI habitats and species and ongoing research. To increase access by the community, each species and habitat section can be extracted to create individual webpages on a VI-WAP website.

This chapter describes the mandated components of the VI-WAP, the process for revision, community and stakeholder participation, and review, and implementation successes of the 2005 CWCS.

Eight Required Elements

In order to ensure that the goals of the SWG program are being met and that plans are consistent across states, each plan is mandated to address eight Required Elements (Table 2.1). The elements focus on establishing priorities for conservation action for both species and habitats, and require those priorities to be based on scientific findings. In recognition that no one entity is responsible for meeting all conservation goals, coordination between federal and local agencies and other conservation entities is required both for the development and implementation of conservation objectives. Community participation is also encouraged. Each Required Element is represented within this document, as described herein.

Table 2.1. State Wildlife Action Plan Eight Required Element and Location in the VI-WAP.

Required Element	Description	Where it can be found in VI-WAP
1	**Species** - Information on the distribution and abundance of species of wildlife, including low and declining populations as the state fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the state's wildlife.	Vol. 1, Ch. 3 (status); Vol. 2, Ch. 2: each taxon has a dedicated section
2	**Habitats** - Descriptions of extent and condition of habitats and community types essential to conservation of species identified in (1).	Vol. 2, Ch. 1: each habitat type has a section; extent of habitat listed in App. 2.2
3	**Threats** - Descriptions of problems which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats.	Vol. 1, Ch. 4; App. 1.4; Vol. 2: habitat- and taxon-specific threats are described
4	**Conservation Actions** - Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions.	Vol. 1, Ch. 5; Vol. 2: habitat- and taxon-specific actions are described
5	**Monitoring Species and Effectiveness** - Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions.	Vol. 1, Ch. 5; Vol. 2: habitat- and taxon-specific monitoring are described
6	**Review and Revision** - Descriptions of procedures to review the plan at intervals not to exceed ten years.	Vol. 1, Ch. 2
7	**Partnerships with Land Management Agencies and Tribes** - Plans for coordinating the development, implementation, review, and revision of the plan with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats	Vol. 1, Ch. 5 (Tabs 5.2 & 5.3): identifies partners for implementation; Vol. 1, Ch. 7: details partnership management activities
8	**Public Participation -** Broad public participation is an essential element of developing and implementing these plans, the projects that are carried out while these plans are developed, and the species in greatest need of conservation	Vol. 1, Ch.5: opportunities for public involvement in implementation are identified; App. 1.3 participation in planning described

Species Status (Required Element 1)

The VI-WAP identifies 138 Species of Greatest Conservation Need, comprising 66 terrestrial species and 72 marine species. Rankings are defined as High Risk for species that require management intervention to persist, Low Risk for species that require monitoring and management to improve conservation status, and Data Deficient-At Risk for species that are known or suspected

to be in decline but for which insufficient information is available to determine status. The process used to evaluate the status of USVI species is described in Chapter 3. Thorough descriptions of species' biological requirements, threats, and conservation actions needed are contained in Volume 2, along with sources of information. This document represents the most comprehensive collection of information on USVI terrestrial species, and a synthesis of understanding of marine species.

Habitat Condition (Required Element 2)
The VI-WAP identifies and describes the terrestrial, wetland, and marine wildlife habitats, including forests, shrublands and grasslands, shorelines, guts (natural stormwater drainages), freshwater and saline ponds and salt flats, mangroves, seagrasses, coral reefs, and floating sargassum mats. The primary threat to these habitats is decline and degradation from upland development activities, and conservation actions have been identified to address these threats, to include protection, restoration, acquisition, and educational and recreational potential. Post-hurricane condition and needs are also described. Habitat condition, threats, and action priorities are described in Vol. 2 along with sources of information.

Threats (Required Element 3)
The major threats identified for USVI wildlife species and habitats are summarized as habitat loss, invasive species, disease, pollution, climate impacts, and a ubiquitous influence resulting from inaction, which includes shortfalls in management capacity, enforcement, and lack of awareness. These categories were identified through a process involving a risk assessment of a suite of threats, including climate change influences, to each wildlife taxon (see Appendix 1.4 for example of risk assessment), and prioritization through stakeholder input. A thorough synthesis of threats to USVI species and habitats is provided in Chapter 4, along with a description of the risk assessment process. Action priorities towards understanding and addressing impacts are identified in Chapter 5. Influences on wildlife species and habitats are discussed in Vol. 2.

Conservation Actions (Required Element 4)
Conservation goals, objectives, and actions necessary to conserve VI species and habitats were identified using threat risk assessments and prioritized using a combination of planning processes (TNC 2007, USFWS 2008, NFWPCAP 2012). Included in this assessment was an evaluation of the effectiveness of the conservation actions identified in the 2005 CWCS. Stakeholder values and input were aligned with objectives to develop an overarching conservation strategy to address the major threats across both the territory and within entities (Chapter 5). Priority actions to address specific threats to species and habitats are aligned with goals and indicators, with partners identified for implementation. The strategy and priority actions and how they were developed are contained within Chapter 5.

Monitoring Species and Effectiveness of Conservation Actions (Required Element 5)
Monitoring programs are in place for seabirds, waterbirds, sea turtles, bats, amphibians, some fish species, and corals within the USVI. These programs contribute to long-term datasets that can indicate changes in population trends as a result of management action/inaction. Monitoring species response to management action allows adjustments to activities to optimize effort. Monitoring needs for wildlife resources are outlined for each taxon and habitat in Vol. 2.

The 2005 CWCS offered lists of priority actions for each resource. For this revision, each action was evaluated to determine if implementation had been completed, was ongoing, or had not yet been pursued (Appendix 1.1), and activities conducted towards meeting these goals have been summarized, using published studies, agency reports, and interviews with key personnel, as available (see Volume 2). These priorities were updated based on effectiveness measures for the 2018 VI-WAP (Chapter 5).

Revision of the 2005 CWCS and 2018 WAP (Required Element 6)

Required Element 6 requires plans to be revised at least every 10 years to ensure priority actions are based on the most up-to-date scientific information available. In 2015 states submitted their revisions to the 2005 conservation strategies, now known as the State Wildlife Action Plans (SWAP), that additionally outlined conservation successes of this program. In 2016 DFW established an MOU with UVI to prepare the VI-WAP. The development of the 2018 VI-WAP has been a collaborative effort between DFW, UVI, and SEA that aimed to capture all the wildlife and habitat conservation goals within the Territory, not just those limited to DFW.

The 2005 CWCS presented a comprehensive species list and identified protective and management status for the species that required specific action. Thorough habitat descriptions and species accounts and a comprehensive listing of relevant literature were key components of the document. It has been an invaluable resource for anyone seeking information on local conditions and status of VI species and habitats, and it has been used in several planning exercises and status reviews (e.g., STEER, IUCN Red List status review for Caribbean reptiles). These sections have been revised and updated to include significant findings from research conducted since 2005 for the 2018 VI-WAP.

The next cycle for SWAP revision is 2025 and to bring the VI-WAP back in schedule with the other states, a revision will be completed and approved no later than 2025. The process for this revision will include a full search for published and unpublished (i.e., agency reports) research and management findings, coordination with other agencies that may have implemented VI-WAP priority actions, and stakeholder input. Revisions will update current levels of understanding, including results of research and management undertaken in the interim with particular emphasis on data deficient resources, and will assess the success of conservation actions. A full assessment of species and habitat status must be completed to support a revision of the list of Species of Greatest Conservation Need. DFW will engage in SWAP revision activities and utilize revision guidelines as available. It is recommended that DFW develop a "working document" that is updated annually across all bureaus with accomplishments toward meeting WAP goals. This not only mitigates the review process, but also establishes a framework for tracking outcomes for adaptive management.

Partnerships with Management Agencies (Required Element 7)

Natural resource managers and habitat/species experts were targeted for input on their area of expertise or on the plan in general. Input was solicited through email, one-on-one interviews, group meetings and any other method that elicited a response from individuals with the NPS, USFWS, UVI, TNC, and other entities (see Appendix 1.2 for list of participants, and Appendix 1.3 for VI-WAP development and review process). Groups that are creating related plans, such as the Caribbean Landscape Conservation Cooperative (CLCC), were included to allow the sharing of

planning strategies and input received from community and stakeholders. This approach was taken to identify ongoing management activities to enable coordination of priority needs. Action priorities developed through this process identify potential partners across agencies and other entities.

Public Participation in Review and Implementation of VI-WAP (Required Element 8)
The VI-WAP is a plan for the Territory, not just DFW, and as such, it needed to be developed not only by the resource managers but also with input from the VI community. The joint collaboration between UVI, DFW, and SEA aimed to join research, management, and community interactions into the planning effort.

Prior to submission of the draft document to the SWAP review team, it was available to stakeholders for review, although this limited review was insufficient in scope and intent, and a second 30-day review period (May – June 2018) was deemed necessary. An invitation to review was sent to each participant in any aspect of the VI-WAP development, and was also shared widely across social media and environmentally-focused listservs. We received comments from 22 individuals; themes and our responses are outlined in Appendix 1.3.

Based on public and stakeholder input, there is a strong environmentally-conscious community within the USVI that is interested in participating in meeting SWAP goals. This community can be engaged through public outreach activities, citizen science projects, and by other means (see table 5.2 for community engagement objectives). A community grant program should be implemented to allow individuals and entities, including private and NGOs, to apply for funding to accomplish priority actions listed in tables 5.2 and 5.3 (Chapter 5).

One of the weaknesses of the 2005 CWCS was that it was not widely disseminated. Those that knew about it found it useful as a source of information to guide management activities, but very few entities were aware of its existence and value. It was also difficult to locate for those that were aware of it and wanted to use it. The plan resided on the DFW website as a downloadable pdf document, but eventually became unavailable during website revision. A VI-WAP website or other form of communication should be developed so the community can follow accomplishments and updates.

Meeting the 2005 Goals

The State Wildlife Grant program allowed DFW to initiate several programs that were previously unsupported through other USFWS funding mechanisms. Since 2005, SWG funds have been used to conduct research and management activities for reptiles, amphibians, and invertebrates, which are important taxa in the USVI that had not been previously studied (Table 2.2). SWG funds were also used for habitat management to support species of concern, such as removal of invasives. SWG funds support salary for DFW wildlife biologists as well as contractual services. DFW continues to conduct research and management work on seabirds using Wildlife Restoration (WR) funds.

In addition to research, resource management, and outreach activities, DFW has also expanded relationships with other entities to optimize the agency's ability to accomplish goals.

Collaborations were established with several entities, including TNC, SEA, APHIS, and private consultants. The development of the STEER management plan was a joint effort between TNC, DFW, CZM, UVI, community groups, and stakeholders. Coordination of sea turtle stranding response through the Sea Turtle Assistance and Rescue (STAR) Network opened up discussion and collaboration opportunities between St. Thomas and St. Croix personnel. Staff turnover across entities, however, can reduce the persistence of many of these initiatives.

Many goals identified in the 2005 CWCS have also been met through funding sources other than SWG, and many of these efforts were conducted through collaborations between DFW and other entities. See Appendix 1.1 for the complete list of CWCS goals for species and habitat conservation and how they were addressed within the territory.

Table 2.2. VI-DFW SWG Grants since 2005.

SWG Grant	Program	SWAP Conservation Goal
T1	Reintroduction of Boas Surveys	Species & Habitat Protection/ Management
T2	Preparation of CWCS	Planning
T3	Coordination of SWG Activities	Coordination
T4	Ameiva Conservation and Management	Species & Habitat Management
T5	Herp Conservation	Research, Species & Habitat Management
T6	Exotic Species Control on Offshore Refuges	Species & Habitat Management
T7	Implementation of SWG: Herpetofauna and Land Crabs	Research, Species & Habitat Management
T8	Wildlife Damage Control on Protestant Cay	Species & Habitat Management
T9	Species & Habitats of Concern	Research, Species & Habitat Management, Education & Outreach

What's New in the 2018 VI-WAP?

The following changes have been made from the 2005 CWCS:

- A Strategy table was developed with stakeholder input to address priority threats and conservation needs across the territory (Chapter 5: Table 5.2).
- Key Priority Actions for species conservation are summarized and include indicators for effectiveness measures and potential partners for collaboration (Chapter 5: Table 5.3).
- The Species of Concern list has been revised based on new information. Marine species have been included (Chapter 3: Table 3.3; Appendix 2.1).
- The goals from the 2005 CWCS have been evaluated for accomplishment (Chapter 2: Meeting the 2005 Goals; Appendix 1.1).
- The Threat chapter is new and takes a more holistic view of conservation and management challenges facing USVI species and habitats. (Chapter 4: Threats to USVI Ecosystems; Appendix 1.2).

- A new section on ecosystem services provides a framework towards ecosystem management (Chapter 6: Ecosystem Services), which is illustrated in a description of a multi-agency management effort towards conservation of species and habitats on and around cays (Chapter 7: Ecosystem Management).
- Habitat sections have been expanded to include marine habitats and habitats that were data deficient in 2005, e.g., terrestrial wetlands (Volume 2: USVI Habitats).
- Species sections have been expanded to include taxa that were data deficient in 2005, e.g., bats and freshwater fauna. Some sections have been reorganized into other sections (i.e., "Exotic Species" information is now contained in relevant resource sections (Volume 2: USVI Species) and in Chapter 4 (Threats).

Banner photo: Marine WAP stakeholder meeting by Kitty Edwards

Chapter Three
Status of USVI Species

One hundred thirty eight USVI native species were identified as SGCN under the three categories (Table 3.1). The majority of GCN species are birds (30%) and marine fish (36%). Of the total, 17% are considered to be data deficient sufficient to determine status but are known to be in decline. This chapter describes how the Species of Greatest Concern list and status rankings were evaluated from the 2005 CWCS and updated for the 2018 VI-WAP.

Table 3.1. Status of USVI Species of Greatest Conservation Need by taxon.

Taxa	High Risk	Low Risk	Data Deficient – At Risk	Total
Terrestrial Invertebrates	0	2	2	**4**
Freshwater Fish	1	0	0	**1**
Amphibians	1	1	0	**2**
Reptiles (incl. Sea Turtles)	9	2	1	**12**
Mammals (Bats)	1	4	0	**5**
Birds	18	15	9	**42**
Marine Fish	32	8	9	**49**
Marine Invertebrates (incl. Corals)	10	5	1	**16**
Marine Mammals	0	5	2	**7**
Total	**72**	**42**	**24**	**138**

Revision of Species Lists

A wide range of information was assessed to determine species status. A single, comprehensive list that combines marine, aquatic, and terrestrial species from the 2005 CWCS and Marine Plan was developed for the 2018 VI-WAP. Due to a general lack of information and an incomplete inventory, most terrestrial and many marine invertebrates are not included. This comprehensive species list was evaluated against current IUCN Red List (iucn.redlist.org) status and the SGC list from the Puerto Rico SWAP (PR-DNER 2015). Extensive literature reviews on research and management published or conducted since 2005 on species found in the USVI were conducted to update new information that might be relevant to species status. Resource experts were consulted regarding species distributions and population trends within the USVI, and level of knowledge for each species was assessed. Only the status of the species within the USVI was considered in the ranking process, which in some instances conflicted with global or national status when species that are abundant elsewhere are undergoing distribution or population constrictions locally. Plant species were not ranked.

Using the information gathered, a population status was assigned to each species for which there is adequate information. Species status categories defined by the IUCN (i.e., endangered, threatened, vulnerable, at risk, least concern) (IUCN Standards and Petitions Subcommittee 2016) and used in the PR-WAP SGCN list were too refined to meaningfully rank USVI species based on the available information, therefore these were simplified into three categories of GCN (Table 3.2): 1) **High Risk (HR)**: those species in immediate or ongoing need of management action due to severely restricted populations or distributions, 2) **Low Risk (LR)**: those species in immediate or ongoing need of management action due to declining populations or distributions, and 3) **Data Deficient--At Risk (DDR)**: those species for which insufficient information is available toward assessing population abundances or distributions, but whose populations are believed to be experiencing significant ongoing threat such to put these populations at risk of decline or extinction. We have also assigned status for non-SGCN species based on management need: **Least Concern (LC)**: those species that are widespread and abundant; **Data Deficient--Not At Risk (DD)**: those species for which insufficient information is available and management effort should be focused on collecting biological data; **Introduced (I)**: non-native species that are not in urgent need of management action; and **Introduced-Management Need (IM)**: non-native species in need of management action because their impacts are causing declines in populations or habitat quality.

The comprehensive list with recommended species status updates was sent to experts and circulated at several public and stakeholder meetings for review and comment. We compiled all comments and revised species statuses based on consensus. Where there was no consensus nor published status, a category of “data deficient” was given. This category was divided into two tiers: species that are abundant but for which little data have been collected were considered to be not at risk of decline due to manageable threats (DD), and those species for which insufficient information is available but are known to be at risk due to threats or observed population declines (DDR).

Table 3.2. Definition of species status used in VI-WAP

Category	Category Definition
Status Category--SGCN	
High Risk (HR)	Species faces a risk of extinction in the wild in the near or foreseeable future without management intervention
Low Risk (LR)	A species that is showing population declines that put it at risk of becoming "high risk" without management effort
Data Deficient--At Risk (DDR)	A species for which there is not enough information for an assessment of population status or distribution but is expected to be declining due to known threats
Status Category--non-SGCN	
Least Concern (LC)	A species that is stable or increasing in population abundance and not declining due to manageable threats
Data Deficient--Not At Risk (DD)	A species for which there is not enough information for an assessment of population status or distribution but is not declining due to manageable threats
Introduced (I)	A species that is not-native to the USVI and has no discernable impact to native species
Introduced--Management Need (IM)	A species that is not-native to the USVI and is causing threat to native species

The 2005 CWCS identified 42 species of concern across amphibians, reptiles, bats, and birds; of those 30 were identified as being of Greatest Concern, with 12 being of Concern. Across the same taxa, the 2018 revision identifies 61 SGCNs: 29 as being High Risk (equivalent to Greatest Concern), 22 as Low Risk (equivalent to Concern), and 10 as Data Deficient-At Risk. While the number of SGCN have increased for this group of taxa since 2005, the status definitions better reflect the information and level of effort needed for species conservation.

The terrestrial plant list from the 2005 CWCS was also updated against a priority list of rare plants produced by Lindsay et al. (2015) and T. Thomas (pers. comm. 2016), and marine plants were added. The 2005 and 2018 statuses are listed in the comprehensive species list (Vol. 2, Appendix 2.1).

A goal of the 2005 CWCS was to update the territorial statutory list of Threatened and Endangered Species protected under the VI Code (Title 12, Chapter 2). This updated list required promulgation by the Endangered Species Protection Commission, which was never convened. Therefore, in the 2018 VI-WAP revision, there was no attempt made to revise the proposed statutory list.

Table 3.3. USVI Species of Greatest Conservation Need. Legal protection afforded by USFWS Endangered Species Act: **FE = Federally Endangered**. **FT = Federally Threatened**. See Appendix 2.1 for comprehensive list of USVI species along with status and habitat associations.

FAMILY	SCIENTIFIC NAME	COMMON NAME	2005 STATUS	2017 STATUS
TERRESTRIAL INVERTEBRATES				
CRABS				
Gecarcinidae	*Cardisoma guanhumi*	Blue Land Crab	--	LR
Gecarcinidae	*Gecarcinus ruricola*	Terrestrial Crab	--	DDR
Pseudothelphusidae	*Epilobocera sinuatifrons*	Freshwater Crab	--	DDR
Ocypodidae	*Leptuca leptodactyla*	Thin-fingered Fiddler Crab	--	LR
TERRESTRIAL VERTEBRATES				
FRESHWATER FISH				
Anguillidae	*Anguilla rostrata*	American Eel	--	HR
AMPHIBIANS				
Eleutherodactylidae	*Eleutherodactylus lentus*	Yellow Mottled Coqui	LDD, C	LR
Eleutherodactylidae	*Eleutherodactylus schwartzi*	Virgin Islands Coqui	LE, GC, EX?	HR (EX?)
LIZARDS				
Teiidae	*Ameiva (Pholidoscelis) polops*	St. Croix Ground Lizard	FE/LE, GC	FE, HR
Amphisbaenidae	*Amphisbaena fenestrata*	Virgin Islands Amphisbaena	LDD, GC	HR
Scincidae	*Spondylurus semitaeniatus*	Lesser Virgin Islands Skink	--	HR
Scincidae	*Spondylurus sloanii*	Virgin Islands Bronze Skink	LT, GC	HR
Sphaerodactylidae	*Sphaerodactylus beattyi*	Beatty's Dwarf Gecko	LC	DDR
SNAKES				
Boidae	*Chilabothrus granti*	Virgin Islands Tree Boa	FE/LE, GC	FE, HR
Dipsadidae	*Borikenophis portoricensis*	Puerto Rican Racer	LT, C	LR
Dipsadidae	*Magliophis exiguus*	Ground Snake	LDD, LC	LR
Typhlopidae	*Antillotyphlops richardii*	Blindsnake (Richard's Worm Snake)	LDD, C	HR
TURTLES				
Cheloniidae	*Caretta caretta*	Loggerhead	FT, GC	FT, HR
Cheloniidae	*Chelonia mydas*	Green turtle	FT/LT, GC	FT, HR
Dermochelyidae	*Dermochelys coriacea*	Leatherback	FE/LE, GC	FE, HR
Cheloniidae	*Eretmochelys imbricata*	Hawksbill	FE/LE, GC	FE, HR

BATS				
Phyllostomidae	*Artibeus jamaicensis*	Jamaican Fruit-eating Bat	LC	LR
Phyllostomidae	*Brachyphylla cavernarum*	Antillean Fruit-eating Bat	LDD, GC	LR
Phyllostomidae	*Stenoderma rufum*	Red Fig-eating Bat	LDD, GC	HR
Molossidae	*Molossus molossus*	Pallas's Mastiff Bat	LC	LR
Noctilionidae	*Noctilio leporinus*	Greater Bulldog Bat	LDD, GC	LR
BIRDS				
Anatidae	*Nomonyx dominicus*	Masked Duck		DDR
Anatidae	*Oxyura jamaicensis*	Ruddy Duck	SC	LR
Anatidae	*Dendrocygna arborea*	West Indian Whistling Duck	LE/GC	DDR
Anatidae	*Anas bahamensis*	White-cheeked Pintail	SC	LR
Ardeidae	*Nycticorax nycticorax*	Black-crowned Night Heron	SC	LR
Ardeidae	*Ardea herodias*	Great Blue Heron	LC	LR
Ardeidae	*Ardea alba*	Great Egret	LC	LR
Ardeidae	*Ixobrychus exilis*	Least Bittern	GC/Ex	DDR, EX?
Ardeidae	*Egretta thula*	Snowy Egret	SC	LR
Ardeidae	*Egretta tricolor*	Tricolored Heron	SC	LR
Caprimulgidae	*Chordeiles gundlachii*	Antillean Nighthawk	GC	HR
Charadriidae	*Charadrius vociferus*	Killdeer	LC	DDR
Charadriidae	*Charadrius melodus*	Piping Plover		HR
Charadriidae	*Charadrius nivosus*	Snowy Plover	GC	DDR
Charadriidae	*Charadrius wilsonia*	Wilson’s Plover	SC	HR
Columbidae	*Geotrygon mystacea*	Bridled Quail-Dove	GC	HR
Columbidae	*Patagioenas squamosa*	Scaly-naped Pigeon	LC	LR
Columbidae	*Patagioenas leucocephala*	White-crowned Pigeon	GC	HR
Falconidae	*Falco peregrinus*	Peregrine Falcon	SC	LR
Fregatidae	*Fregata magnificens*	Magnificent Frigatebird	GC	HR
Haematopodidae	*Haematopus palliatus*	American Oystercatcher	GC	HR
Hirundinidae	*Progne dominicensis*	Caribbean Martin	SC	HR
Laridae	*Sternula antillarum*	Least Tern	SC	HR
Laridae	*Sterna dougallii*	Roseate Tern	SC	FT, HR
Laridae	*Thalasseus maxima*	Royal Tern		LR
Laridae	*Thalasseus sandvicensis*	Sandwich Tern		LR
Parulidae	*Setophaga adelaide*	Adelaide's Warbler		DDR
Pelecanidae	*Pelecanus occidentalis*	Brown Pelican	SC	LR
Phaethontidae	*Phaethon aethereus*	Red-billed Tropicbird	SC	HR
Phaethontidae	*Phaethon lepturus*	White-tailed Tropicbird	GC	HR

Podicipedidae	*Tachybaptus dominicus*	Least Grebe	GC	HR
Procellariidae	*Puffinus lherminieri*	Audubon's Shearwater	GC	HR
Rallidae	*Rallus crepitans*	Clapper Rail	GC	HR
Scolopacidae	*Calidris canutus*	Red Knot	GC	FT, DDR
Scolopacidae	*Calidris pusilla*	Semipalmated Sandpiper		LR
Scolopacidae	*Numenius phaeopus*	Whimbrel	GC	LR
Scolopacidae	*Tringa semipalmata*	Willet	GC	LR
Sulidae	*Sula leucogaster*	Brown Booby		HR
Sulidae	*Sula dactylatra*	Masked Booby	GC	HR
Sulidae	*Sula sula*	Red-footed Booby	GC	HR
Trochilidae	*Orthorhyncus cristatus*	Antillean Crested Hummingbird	LC	DDR
Trochilidae	*Anthracothorax dominicus*	Antillean Mango	GC	DDR
MARINE ORGANISMS				
MARINE FISH				
Albulidae	*Albula vulpes*	Bonefish	--	DDR
Balistidae	*Balistes capriscus*	Gray Triggerfish	--	DDR
Balistidae	*Balistes vetula*	Queen Triggerfish	--	HR
Carangidae	*Seriola dumerili*	Greater Amberjack	--	DDR
Haemulidae	*Anisotremus virginicus*	Porkfish	--	LR
Haemulidae	*Haemulon bonariense*	Black Grunt	--	DDR
Labridae	*Lachnolaimus maximus*	Hogfish	--	DDR
Lutjanidae	*Lutjanus analis*	Mutton Snapper	--	HR
Lutjanidae	*Lutjanus cyanopterus*	Cubera Snapper	--	DDR
Lutjanidae	*Lutjanus synagris*	Lane Snapper	--	LR
Lutjanidae	*Lutjanus vivanus*	Silk Snapper	--	HR
Lutjanidae	*Rhomboplites aurorubens*	Vermillion Snapper	--	HR
Mullidae	*Pseudupeneus maculatus*	Spotted Goatfish	--	LR
Scaridae	*Scarus coelestinus*	Midnight Parrotfish	--	HR
Scaridae	*Scarus coeruleus*	Blue Parrotfish	--	HR
Scaridae	*Scarus guacamaia*	Rainbow Parrotfish	--	HR
Scaridae	*Scarus taeniopterus*	Princess Parrotfish	--	LR
Scaridae	*Scarus vetula*	Queen Parrotfish	--	LR
Scaridae	*Sparisoma chrysopterum*	Redtail Parrotfish	--	LR
Scaridae	*Sparisoma viride*	Stoplight Parrotfish	--	LR
Serranidae	*Cephalopholis cruentata*	Graysby	--	HR
Serranidae	*Cephalopholis fulva*	Coney	--	HR

Serranidae	*Dermatolepis inermis*	Marbled Grouper	--	HR
Serranidae	*Epinephelus adscensionis*	Rock Hind	--	HR
Serranidae	*Epinephelus guttatus*	Red Hind	--	LR
Serranidae	*Epinephelus itajara*	Goliath Grouper	--	HR
Serranidae	*Epinephelus morio*	Red Grouper	--	HR
Serranidae	*Epinephelus striatus*	Nassau Grouper	--	FT, HR
Serranidae	*Mycteroperca bonaci*	Black Grouper	--	HR
Syngnathidae	*Hippocampus reidi*	Longsnout Seahorse	--	DDR
Istiophoridae	*Istiompax indica*	Black Marlin	--	DDR
Istiophoridae	*Istiophorus platypterus*	Sailfish	--	HR
Istiophoridae	*Kajikia albida*	White Marlin	--	HR
Istiophoridae	*Kajikia audax*	Striped Marlin	--	HR
Istiophoridae	*Makaira nigricans*	Blue Marlin	--	HR
Istiophoridae	*Tetrapturus angustirostris*	Shortbill Spearfish	--	DDR
Scombridae	*Thunnus thynnus*	Atlantic Bluefin Tuna	--	HR
Scombridae	*Thunnus alalunga*	Albacore Tuna	--	HR
Scombridae	*Thunnus albacares*	Yellowfin Tuna	--	HR
Scombridae	*Thunnus obesus*	Bigeye Tuna	--	HR
Aetobatidae	*Aetobatus narinari*	Spotted Eagle Ray		HR
Carcharhinidae	*Carcharhinus limbatus*	Blacktip Shark	--	HR
Carcharhinidae	*Carcharhinus longimanus*	Oceanic Whitetip Shark		FT, HR
Carcharhinidae	*Carcharhinus perezii*	Caribbean Reef Shark	--	HR
Carcharhinidae	*Galeocerdo cuvier*	Tiger Shark	--	HR
Carcharhinidae	*Negaprion brevirostris*	Lemon Shark	--	HR
Mobulidae	*Manta birostris*	Giant Manta Ray	--	FT, HR
Rhincodontidae	*Rhincodon typus*	Whale Shark	--	HR
Sphyrnidae	*Sphyrna lewini*	Scalloped Hammerhead Shark	--	FT, HR
CORALS				
Acroporidae	*Acropora cervicornis*	Staghorn Coral	--	FE, HR
Acroporidae	*Acropora palmata*	Elkhorn Coral	--	FE, HR
Antipathidae	*Antipathes* spp.	Black Coral	--	DDR
Faviidae	*Orbicella annularis*	Lobed Star Coral	--	FT, HR
Faviidae	*Orbicella faveolata*	Mountainous Star Coral	--	FT, HR
Faviidae	*Orbicella franksii*	Boulder Star Coral	--	FT, HR
Meandrinidae	*Dendrogyra cylindricus*	Pillar Coral	--	FT, HR
Mussidae	*Mycetophyllia ferox*	Rough Cactus Coral	--	FT, HR

OTHER MARINE INVERTEBRATES				
Tegulidae	*Cittarium pica*	West Indian Top Knot/Whelk	--	LR
Stichopodidae	*Astichopus multifidus*	Furry Sea Cucumber	--	LR
Strombidae	*Strombus gigas*	Queen Conch	--	HR
Palinuridae	*Panulirus argus*	Spiny Lobster	--	HR
Palinuridae	*Panulirus laevicauda*	Green Lobster	--	HR
Diadematidae	*Diadema antillarum*	Long-spined Sea Urchin	--	LR
Grapsidae	*Goniopsis ruentata*	Mangrove Root Crab	--	LR
Holothuriidae	*Actinopyga agassizi*	West Indian Sea Cucumber	--	LR
MARINE MAMMALS				
Balaenopteridae	*Balaenoptera borealis*	Sei Whale	--	FE, LR
Balaenopteridae	*Balaenoptera physalus*	Fin Whale	--	FE, LR
Balaenopteridae	*Megaptera novaeangliae*	Humpback Whale	--	LR
Delphinidae	*Stenella frontalis*	Atlantic Spotted Dolphin	--	DDR
Delphinidae	*Tursiops truncatus*	Bottlenosed Dolphin	--	DDR
Physeteridae	*Physeter macrocephalus*	Sperm Whale	--	FE, LR
Trichechidae	*Trichechus manatus*	West Indian Manatee	--	FT, LR

2005 Status: 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.

Banner photo: *Eretmochelys imbricata* by R. Platenberg

Chapter Four
Threats Overview:
What is impacting local resources?

Caribbean islands are a recognized global biodiversity hotspot, containing high levels of endemism that has resulted from long periods of geographic isolation with limited dispersal opportunities for terrestrial plants and animals. Most islands have species assemblages that are found nowhere else, not even on a neighboring island. These islands, however, have had a long history of disturbance, leading to the second part of the definition: a biodiversity hotspot is an area that contains a high proportion of the world's unique species that are in decline due to human activities (Myers et al. 2000).

Early colonizers arriving in small boats from South and Central America brought with them plants and animals from the mainland or from other islands, thereby introducing new species. European arrival altered the landscape by clearing forests for plantations and introducing domestic animals, pests and diseases, and hitch-hikers, such as rats. Later island inhabitants introduced other animals (e.g., mongoose) to control pests introduced earlier (e.g., rats). Cane toads were introduced in the late 1800s and early 1900s to control an introduced insect pest in plantations of introduced crops.

The USVI historically experienced near complete deforestation from agriculture, introduction of invasives of multiple taxa, and persecution of some native wildlife, such as bats and snakes, due to misguided fears. Current threats to wildlife and habitats of the USVI include ongoing habitat loss and fragmentation from development, and impacts from invasive species, diseases, pollution, and climate change. Cumulative impacts and synergism between these influences leads to ecosystem change, a term that represents anthropomorphic alteration of ecosystems that cannot be reversed. The USVI, as with many places, experiences an additional threat of "inaction", which

corresponds to challenges faced by small administrations divided between islands and jurisdictions. Inaction includes lack of funding, limited opportunities for training, difficulties in coordination, collaboration, and communication, and economic and social priorities that may conflict with the goals of species and habitat conservation.

Each of these threats is discussed in the following section, along with impacts to local ecosystems. Management recommendation are included in the resources sections as well as the Priority Actions and Strategy tables (Tables 5.2 and 5.3) in the next chapter.

Habitat Loss

Nearly all natural habitats in the Virgin Islands have been reduced, degraded or fragmented. The prevailing belief is that if land is cleared or wetlands filled, the wildlife will move elsewhere. On small islands such as those in the VI, the opportunities to relocate to other appropriate sites after habitat disturbance are limited, and the pathways to do so may be blocked by roads or other barriers. For each new land use change proposal, the opportunities for birds, lizards, bats, and other native species to move to another location decrease because previous land use has already reduced available alternative locations to a minimum.

The IUCN Red List identifies that habitat loss is the reason for decline for 85% of the species listed as imperiled. In the VI, habitat loss has already caused the extinction or extirpation of several birds (Puerto Rican Screech Owl *Megascops nudipes*, Puerto Rican Lizard Cuckoo *Coccyzus vieilloti*, and the White-necked Crow *Corvus leucognaphalus*) and is contributing to the decline of the Virgin Islands Tree Boa (*Chilabothrus granti*), a snake that is critically endangered, largely due to loss of its St. Thomas East End habitat to development (Platenberg and Harvey 2010).

Habitat loss in the VI dates back to the era of sugarcane plantations in the Virgin Islands (approx. 1733-1917). Historical records indicate that the Pre-Columbian Virgin Islands were 90% forested. By 1917, when the U.S. purchased the Virgin Islands from Denmark, only 10% of the forested areas remained on St. Croix (Chakroff 2010). Although large-scale sugarcane plantations no longer exist on the islands, only some of the forest is recovering. With a high density of human population on the islands and expansive resorts and commercial centers, development has prevented the recovery of much of this previously forested land. Encroaching residential communities have replaced or fragmented remaining or recovering forests. Forests in the process of succession are often viewed as sub-optimal and therefore less valuable habitat, although if given the opportunity, the forests will eventually recover. As of 2007, only 3% of the VI's forests were considered fully mature forest (Brandeis and Oswalt 2007). The majority of the remaining forest is secondary, transitional forest.

The loss of forest cover has affected wildlife from nearly every taxonomic group, including marine organisms. Changes in composition, complexity and extent of forest will have devastating effects on the wildlife that rely on healthy forests, such as bats, frogs, birds and reptiles. Changes in forest structure that allows for more light penetration alters the microhabitats and microclimates of the forest floor, thereby rendering smaller reptiles such as *Sphaerodactylus* and habitat specialists such as amphisbaenids and blind snakes vulnerable to desiccation. Without the large trees that bats prefer for roost sites, many populations have taken to opportunistically roosting in artificial refugia such as abandoned buildings and historical ruins. The loss of forest has also resulted in increased erosion especially along the steep slopes that are found throughout St. Thomas, St. John, and

northwest St. Croix. Increased erosion results in deposition of sediment on to coral reefs and seagrass beds.

The Virgin Islands Tree Boa is on the verge of extinction in its natural range due to severe habitat loss. Unlike some of the other major losses from a single large development, like Krause Lagoon on St. Croix, this has been a slow erosion of habitat, parcel by parcel, adding up to the loss of the majority of the boa's habitat and the fragmentation of what is remaining. This severe fragmentation means that boas are isolated in small habitat islands and when they attempt to disperse they are forced to cross roads or through human development, with resulting mortality. Had there been a comprehensive plan in place for habitat protection and development, the boa might be able to persist within a forest preserve or connected patches of habitat.

Wetlands have also faced dramatic reductions, which unlike the loss of forest, has happened primarily over the last century. Hotels, condominiums, and marinas have been constructed on coastal wetlands, and marine recreational activities have damaged fragile mangrove swamps, coral reefs, and seagrass beds. 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. The Krause Lagoon on St. Croix was once the largest mangrove wetland in the Virgin Islands (over 240 ha); in the 1960s it was filled in for the construction of a large oil refinery.

Other large wetlands that have been lost include Lindbergh Bay lagoon (once known as Mosquito Lagoon) on St. Thomas (IRF 1977) and the Southgate Pond on St. Croix has been reduced to a fraction of its former size by the construction of the Green Cay Marina (Coast and Harbor Institute 2004).

Habitat loss is typically attributed to development of land or other land use change for human use, but it can also be the result of other threats. For example, sea level rise will result in the loss of sandy beaches. Habitat compromised by disturbances such as hurricanes can offer opportunities for invasion of non-native species. Rapidly spreading invasive shrubland species can decrease native forest cover. Marine habitats are also being lost through degradation of healthy marine conditions.

Invasive Species

The spread of invasive species is a global concern from both an ecological and economic standpoint, and the introduction of non-native species has been widely accepted as one of the leading drivers of recent extinctions (Gurevitch and Padilla 2004). It is estimated that as many as two thirds of extinctions globally may involve interactions between native and invasive species (Kairo et al. 2003). Threats to island ecosystems are magnified by factors such as high levels of endemism, relatively small areas, isolation, and exposure to storms that increase the vulnerability of native species to disturbances (Platenberg and Boulon 2006).

Of the many species that are introduced, most are unsuccessful at becoming established in a new area, and do not become invasive (Kairo et al. 2003). A species is considered invasive once it gains a foothold within a system and succeeds to a point where other species, habitats, or ecosystems are negatively affected, or when there is risk of harm to human health. It is estimated that in the United

States, $120 billion dollars annually is attributed to expenses associated with invasive species, both in control costs and in the economic damage that they cause (Pimentel et al. 2005).

Invasive species cause damage through the endangerment of native species, degradation of environments (both aquatic and terrestrial) and even alteration of biogeochemical cycles (Mooney and Hobbs 2000). Additionally, invasive species can contribute to social and economic hardship by creating limitations on economic growth, sustainable development and conservation efforts. After initial introduction, other anthropogenic threats such as habitat destruction, species removal and increased pollution can magnify the effects of the invasive species (Theoharides and Dukes 2007).

The USVI has a long history of human-mediated species introductions, dating back to the arrival of the first human colonizers who brought plants and animals up the Antillean island chain from South America. These introductions have increased with the intensification of travel and trade. The pathways of introduction vary depending on the species; many species are intentionally imported for agriculture, domestic use, or for horticulture, posing the risk of potential release or escape (Lovell et al. 2006, Daley et al. 2012, Platenberg 2016). Many important agriculture species fall into this category, such as Papaya (*Carica papaya*) and Genip (*Meliccoccus bijugatus*), as well as deer, donkeys, goats, and pigs. Houseplants and ornamentals can be culprits, such as the Snake Plant (*Sanseveria* spp.). Significant threats to wildlife populations are posed by escaped housepets that become feral, such as cats, dogs, and more recently *Boa constrictors* on St. Croix.

Some species are accidentally introduced as hitchhikers through the importation of materials, e.g., rats (*Rattus* spp.), the Pacific Lionfish (*Pterois* spp.), Cuban Treefrogs (*Osteopilus septentrionalis*), and Puerto Rican Coquis (*Eleutherodactylus coqui*). Others are introduced intentionally as biocontrol for species that were unintentionally introduced, thereby compounding the problem. Two key examples in the USVI of these are the Small Indian Mongoose (*Herpestes auropunctatus*) that was deliberately introduced to control rats, and Cane Toads (*Rhinella marina*) that were released as a biocontrol for white grub (beetle larvae) agricultural pests.

Virtually all of the habitats in the U.S. Virgin Islands are affected either directly, or indirectly by invasive species. Non-native plants can alter habitat and prevent recruitment of native forest species. Problematic species include Mother-in-law Tongue (*Sanseveria trifasciata*), Tan-tan (*Leucaena leucocephala*), Chinaberry (*Melia azedarach*), and Sweetlime (*Triphasia trifolia*). Water Hyacinth (*Eichhornia crassipes*) is a problem in wetlands and waterways where it chokes up the water surface and consumes nutrient resources.

Feral cats, rats, mongoose, and to a lesser extent stray dogs, have a tremendous negative impact on native species through direct predation. Nesting success of seabirds and sea turtles can be severely reduced by rats in seabird colonies and mongoose on turtle nesting beaches. Cats are well known for their strong prey response and will capture and kill anything they encounter, including birds and the endangered VI Tree Boa. The impacts of these species are compounded by an r-selected ecological strategy that includes generalist habitat and diet requirements and high fecundity, which also makes control and eradication difficult and resource expensive. Feral cats (also dogs, goats, deer, donkeys, and other charismatic species) have the added challenge of emotional attachment by the community that is often not supportive of control efforts. Many

colonies of feral cats are maintained through cat cafe feeding stations and trap-neuter-return programs.

The Puerto Rican coqui (*Eleutherodactylus coqui*) is a fairly recent invader that has a different and less obvious impact, primarily on native frogs and their prey. These frogs occupy the same ecological niche as the native frogs, but are better competitors for niche resources, such as invertebrate prey and sheltering and breeding sites, and are slowly displacing native frog species. The impact of *Boa constrictors*, believed to be recently established on St. Croix, is unknown, as are its current abundance and distribution.

Other problematic terrestrial vertebrates include White-tailed Deer (*Odocoileus virginianus*), goats (*Capra hircus*), hogs (*Sus scrofa*), and donkeys (*Equus asinus*) that destroy native vegetation through eating, trampling, or excavating, thus changing habitat structure. Feral chickens (*Gallus gallus domesticus*) can change forest structure by removing seeds and seedlings. Cane Toads (*Rhinella marina*) and the Common Ground lizard (*Ameiva exsul*; native to STT/STJ, but introduced to STX) consume native species of frogs, lizards and invertebrates (Treglia et al. 2013).

Less understood are the invertebrate pests, many of which arrive with landscaping or horticulture material. Fire ants (*Solenopsis* spp) are a significant threat to ground nesting birds and small terrestrial reptiles, as these can quickly overwhelm and consume pipping eggs, chicks, and lizards. The Agave Weevil produced near complete mortality of one of the endemic Century Plants (*Agave missionum*), and Tiger Mosquitos (*Aedes aegypti*) are responsible for transmitting viral diseases to humans, such as dengue fever, chikungunya, and zika.

The marine environment is similarly affected by invasive species. The invasive seagrass, *Halophila stipulacea*, has rapidly altered seagrass bed structure thus limiting shelter and forage for seagrass inhabitants, including Nassau Grouper and Green Sea Turtles. The Indo-Pacific Lionfish (*Pterois* spp) poses a great threat to fish stocks in the USVI due to its ability to consume large portions of food relative to its body weight and reproduce rapidly and in great numbers.

Diseases

Disease is a threat that has generally stayed under the radar of many resource managers in the VI. Knowledge of the extent that diseases affect local flora and fauna is limited. Yet, disease has the potential to rapidly affect whole populations, particularly species already under stress from other impacts.

Birds in the VI face periodic outbreaks of Avian Botulism that can be severe for susceptible species. Avian Botulism is caused by ingestion of a toxin produced by the bacterium *Clostridium botulinum*, which is widespread in soil. Specific conditions are required for the bacteria to thrive including warm temperatures, a protein source and anaerobic conditions (USGS 2016). Avian Botulism primarily affects waterbirds and has been especially frequently seen in waterfowl, laughing gulls and pelicans in the VI (J. Valiulis and R. Platenberg, pers. obs., 2017). Outbreaks generally are the result of changes in hydrology, such as rapid decreases or increases in water level that result in fish or invertebrate die offs causing anaerobic conditions. Laughing gulls are more susceptible due to their habit of scavenging for food scraps at the landfill, where maggots are the

likely carriers of the bacteria. When encountered early and with the right facilities, botulism can be treated and cured.

Fibropapillomatosis is a disease found in sea turtles that causes numerous internal and external tumors. Although benign, the tumors can interfere with swimming, eyesight, feeding and buoyancy. Fibropapillomatosis has only been seen rarely in the VI turtles and generally on turtles that have been found as the result of strandings or injury. Healthy nesting turtles or even turtles observed in the water rarely exhibit signs of the disease. However, STAR (Sea Turtle Assistance and Rescue) does keep records of all turtles that are reported with the disease so if incidences increase, resource managers will be able to react to the outbreak. While the cause of fibropapillomatosis is unknown, it is associated with impaired water quality, and may be exacerbated by a combination of factors, including pollution, stress, parasites or changing water temperature.

Chytrid fungus has emerged as one the primary contributors to amphibian decline globally. It has caused devastating population declines in some amphibian populations and has even resulted in species extinctions. Although the USVI is outside of the expected range for this fungus, due to thermal conditions that are not conducive for fungal survival, frogs were sampled for it in 2011. Results found chytrid in three out of 63 samples, associated with *Eleutherodactylus coqui* and/or *E. antillensis* (R. Platenberg, unpublished data). Further study and sampling is necessary to determine the extent of the presence of chytrid throughout all islands of the USVI and to better understand the conditions in which it thrives.

In the marine environment, various coral species are threatened by mortality-inducing bacteria-induced diseases, which have caused a massive decline of major reef-building corals in the Caribbean (Muller et al. 2008). In fact, the Caribbean waters have been declared a 'disease hot-spot', due to the high virulence of coral reef diseases (Weil and Gil-Agudelo 2006). Coral diseases are primarily caused by bacteria; for example, white plague is caused by the bacterium *Aurantimonas,* white-pox is caused by the bacterium *Serratia marcescens,* and white-band disease is caused by the bacterium *Vibrio* (Weil and Gil-Agudelo 2006). Atypically high water temperatures increase the abundance and virulence of coral pathogens and increase the corals susceptibility (Muller et al. 2008), although disease outbreaks are highly correlated with sediment-transporting precipitation (M. Brandt, pers. comm., 2017). The USVI has experienced significant loss of corals; in 2005, an especially warm year, 60% of coral cover was lost on USVI reefs due to bleaching and subsequent disease (Miller et al. 2009). With the increasing temperatures associated with climate change, coral disease will likely become more widespread.

There are other pathogens that are or may be present in the USVI, but about which little is known, such as *Oncicola venezuelensis*, a parasite that infects cats, lizards, termites and birds (Nickol et al. 2006), and malaria in *Anolis* lizards. Lizards that have been infected with malaria may have reduced body condition, altered behavior, and changes in reproductive success (Schall and Pearson 2000). Plants diseases may affect habitats; insects such as soft scale (*Philephedra tuberculosa*) feed on local trees and can cause serious damage to infested trees (Williamson 2008).

The isolation of the Virgin Islands has thus far protected it from some diseases that are commonly found elsewhere, such as rabies. Rabies is found as close by as Puerto Rico (CDC), where it persists

in uncontrolled mongoose populations. Rabies is a viral disease that is spread through saliva from animal bites. Bats are maligned as being carriers of rabies, but in fact bats are susceptible to the disease and become infected and die from it (unlike carriers that are unaffected), and studies have shown that where present, less than 1% of the bat population is infected by rabies. However, rabid bats are able to transmit rabies to humans, who are more likely to encounter a sick bat than a healthy one. Tests on bats and other animals in the USVI have not been positive for rabies (CDC, pers. comm. 2016). The likelihood of a bat in the VI being infected with rabies is slim, because VI bats are resident, and are not migrating to areas where rabies is prevalent. Bats infected with rabies are sick, and unlikely to migrate to the VI. In Puerto Rico, work is currently being conducted to test an oral vaccination for mongoose to reduce the number of mongoose carrying rabies.

The tropical climate has also prevented White Nose Syndrome, a disease that is devastating bat populations in the United States. This disease works by interrupting hibernation by bats in the cold months of the year, so is unlikely to become a problem in the VI.

In addition to diseases that affect wildlife and their habitat, wildlife itself can serve as a disease vector for zoonotic diseases, potentially affecting management of the species. Perhaps the most obvious example is that of the various mosquito borne illnesses such as dengue, chikungunya and zika. The mosquito that carries these diseases, *Aedes aegypti,* is an introduced species. Mosquito-borne illness has been on the rise and this threat is likely to increase with climate change (Staples and Fischer 2014, Pastula et al. 2016). Measures to reduce human infection by these mosquito-borne diseases often involve fogging or large scale application of pesticides. These pesticides can be harmful to other wildlife and invertebrates that are harmless and are important parts of the food chain. Cats and mongoose are carriers of toxoplasmosis, another reason to keep feral populations under control.

The heartwater and Ehrlichea diseases transmitted by the tropical bont tick has the potential to threaten our commercial livestock. Tick borne diseases such as cattle fever and heartwater pose risks to domestic cattle that reside mainly on St. Croix (Corn et al. 2009, Beati et al. 2012). Transmission of the bont tick has been linked to Cattle Egrets.

Pollution

There are many sources of pollution in the VI, originating from both land and marine activities. Pollutants include trash that is not disposed of properly, sediment from upland erosion, contaminants from road surface runoff and boats (sewage, bottom paint, oil), sunscreen, thermal pollution (WAPA discharge of RO effluents), pesticides, larger oil spills/leakage from tankers, oil leakage from marine gas stations, and so on.

The effects of pesticides on vital pollinators such as bees has been well documented (Desneaux 2007, Henry et al. 2012). Without good information on the identification, population and distribution of the invertebrates in the VI, it is difficult to assess the effects of pesticides on the invertebrate community as a whole. Wildlife such as birds, bats, frogs, and lizards that consume insects are also likely to be affected by pesticides. Bioaccumulation (the accumulation of a substance, such as pesticide in an organism) and biomagnification (the tendency of a pollutant to concentrate as it moves from one trophic level to the next) have major impacts on organisms higher in the food chain, including humans.

Much of the land-based pollution in the VI can be lumped into one of two categories: Point Source pollution, where the pollution comes from a known source, and Non-Point Source, where pollution originates from an unspecified source and accumulates through movement of stormwater. While great efforts have been put into reducing point sources (an exception being perhaps the dumpster sites in the USVI), land based sources of pollution are difficult to identify and control.

Nonpoint source pollution results from rain water flowing over and through the ground, picking up pollutants (soil, oil, grease, bacteria, pathogens, heavy metals, nutrients, pesticides and other contaminants), carrying them away and depositing them into guts, wetlands, salt ponds, beaches, coastal waters and groundwater. Runoff is a problem for any wildlife that relies on water including frogs, birds (especially waterbirds), bats, and gut fauna (fish, shrimp).

Although all habitats are affected by pollution, marine habitats are disproportionately affected simply because they are downstream. Every Virgin Islander is familiar with the sediment plumes in the ocean during torrential rains and the warnings to not swim in the ocean after rains due to contamination from pollutants washing into the water. Coral infection rates increase in correlation with rainfall events that carry stormwater with high sediment loads.

The capacity for disposal of trash is already overwhelming the infrastructure. The landfills on both St. Croix and St. Thomas are at capacity and have been scheduled for closure for years. Despite beach clean ups, shorelines are persistently littered with garbage from littering or illegal dumping, or transported via wind or water. Trash is often tossed to the side of the road, leaving it to wash down the guts and into the ocean. Larger garbage such as tires and appliances are frequently dumped in the bush. To a large degree, this is the result of carelessness, but it can be challenging to properly dispose of larger items. Transfer stations do exist, but they have limited hours and will periodically stop accepting certain types of waste without warning so people are left without an easy option for disposal. Single use plastic, such as shopping bags, straws, and water bottles, along with Styrofoam containers are a staple of the food and beverage industry in the Virgin Islands. Although convenient, especially for beachside bars, they produce an extraordinary amount of trash, only a percentage of which makes it into trash cans to be disposed of at the overfilled landfill.

The subject of trash in the ocean, collectively called “Marine Debris” has started to receive a lot of attention as a significant cause of mortality in marine organisms. In addition to trash washed down from the land, fishing nets, lines, traps and other gear is often abandoned once it ceases to be useful. Sea turtles and marine mammals can become entangled and drown in nets if they are not able to reach the surface for air. Seabirds, whales, turtles, and just about every other marine organism eats plastic causing blockages in their digestive system and sometimes poisoning from chemicals contained in the trash. Improperly discarded monofilament fishing line can be a death trap for both water and land birds which become entangled in it. Microplastics, very small pieces of plastic resulting from the breakdown of larger pieces of plastic trash, are now found ubiquitously in the ocean and in marine organisms as they make their way into and through the food chain, even in the USVI (Lasseigne 2018).

The busy boating and shipping industry in the VI, especially around St. Thomas, results in added pressure from pollutants. Daily visits by cruise ships carrying thousands of people leave behind oil, trash, and emissions and churn up bottom sediment. A study in the northern VI found that chemicals that indicate contamination by an antifouling agent were ubiquitous in molluscs, including the popularly consumed whelk (Strand et al. 2009).

The VI lacks adequate pump out facilities for boaters and some are forced to release waste into the ocean. Regulations require vessels to go three miles from shore to do this, but there are boats that don't fully comply. There are a significant number of live aboard boats that no longer run and function as floating apartments attached to mooring balls or anchors. Some of these permanently placed boats release waste directly into the ocean.

Pollutants can render organisms, such as coral, more susceptible to disease. Studies on coral found that even a moderate increase in nutrients (such as from fertilizer) causes a significant increase in severity of coral disease (Bruno et al. 2003). A study in the northern VI found that nearshore corals were more susceptible to impairment, either through disease or mortality, than coral farther from shore. Sedimentation is believed to be one of the primary drivers of the nearshore coral degradation (Smith et al. 2012).

In recent years, oxybenzone, a key component in most popular sunscreens has been found to be one of the contributing factors to coral decline. Areas that are popular with beach goers and snorkelers show impairment from corals smothered in sunscreen slime (C. Rogers, pers. comm.). There are currently no regulations in the USVI to limit the sale of sunscreens with this damaging contaminant.

Generally, air pollution in the Virgin Islands is less of a problem than in many other parts of the world. The Hovensa oil refinery was likely the largest single source of air pollution in the VI until it shut down in 2012. Plans are in place to reopen the facility, which will likely result in the overall degradation of air quality. African dust carries pesticides and microorganisms, some of which are pathogens, to the Virgin Islands. Although it is difficult to mitigate air pollution from African dust, it underscores the need to maintain healthy local ecosystems that can better resist threats from beyond the borders of the Virgin Islands.

Climate Change

All of the current conservation measures in place could be for nought if climate change continues on its current path. Globally, climate change is negatively affecting both marine and terrestrial environments and their associated species and microhabitats (Walther et al. 2002). These effects are potentially more apparent in tropical and island ecosystems, including the USVI, due to low lying and remote locations, small size, proximity to the ocean, and concentration of infrastructure and populations along coasts (McCarthy 2001). Endemic species and diverse environments of island ecosystems such as coral reefs, mangrove forests, and seagrass beds are vulnerable to climate change (Whittaker et al. 1999, McCarthy 2001). Climate change threats such as sea level rise, ocean acidification, rising temperatures, increased precipitation, and increased storm frequency/severity impact the local populations and diverse ecosystems of the U.S. Virgin Islands.

Both air and water temperatures are expected to increase with climate change. Increased temperatures will affect the timing of seasonal activities of both animals and plants. Many species rely on temperature cues for mating, spawning, and migration. Changes in the timing of reproduction of birds, insects, amphibians, reptiles, and plants are likely to be seen in the USVI. Changes in the arrival time of migrating birds, for example, may result in a lack of food for refueling if the food source is not able to survive or even alter its own timing. Fruit eating bats may be more resilient to these shifts, but are still affected if drought fails to produce fruiting across

one or more seasons. The sex of sea turtles is determined by the temperature during a key time period in incubation. Increased temperatures will affect sex ratios of sea turtles.

Changes in temperature also cause changes in species range shifts, meaning as temperature increases in a particular location, species will move to cooler areas to adapt. It has already been documented that terrestrial species are moving to higher elevations to escape areas with warming conditions (Chen et al. 2011). Species that live on islands and that cannot disperse to other locations within their temperature tolerance, will likely die out. Microhabitats may become less favorable, particularly as deforestation and an increase in "new forests" alters forest structure and microclimate.

Climate change will impact local weather phenomena such as altered winds and precipitation patterns (EPA 2015). A recent study found that the hatch success of leatherback turtles at SPNWR in St. Croix has decreased as a result of decreased precipitation resulting from climate change (Santidriàn et al. 2015). Predictions for the effects of climate change on hurricane frequency and intensity differ. A complex mix of factors (sea water temperature, ocean currents, moisture in the air) cause the formation and sustainment of a hurricane and the path that it takes; many of these factors will be altered in some way by climate change. Nonetheless, changes in patterns of these storms will affect the island flora and fauna.

It is well documented that hurricanes and severe storms occurring in tropical locations can change the community compositions of species. On Puerto Rico, studies have shown that there are shifts in animal and plant composition in the El Yunque Rainforest after extreme hurricanes (Jennings et al. 2014). Changes in composition, complexity and extent of forest will have devastating effects on the wildlife that rely on healthy forests such as bats, frogs, birds and reptiles. Smaller reptiles such as *Sphaerodactylus* species and habitat specialists such as amphisbaenids and blind snakes will face desiccation. Although some species will be able to adapt and move, others such as the critically endangered Virgin Islands Tree Boa, are blocked by roads and development. The hurricanes in 2017 had severe impacts on fruit and seed eating species, although these were not fully documented.

Coral reefs and rainforests have been shown to recover after storm events at an intermediate level of disturbance (Lugo et al. 2000). With changes in precipitation, storm intensity, and wind speed tied with the frequency of these events, habitats and species could have insufficient time to recover and cause further degradation to both marine and terrestrial environments.

Rising water temperatures will affect marine organisms. Commercially important fish species will move to areas with cooler water temperatures thus depleting a vital food source in the U.S. Virgin Islands. Outbreaks of coral bleaching have become frequent in the VI and have been tied to increases in water temperature. Although coral can recover from short term bleaching, long term, regular bleaching will result in the death of coral and thus, the many species that rely on healthy coral reefs. There is some evidence that coral may be going through a rapid evolutionary event, resulting in the increased resistance to bleaching (T. Smith, pers. comm., 2017)

Sea level rise is the result of warming oceans and melting ice caps (UNEP 2008). As global temperatures increase, glaciers and ice caps melt and oceans naturally absorb heat which causes

water to expand, contributing to the rise in sea level. The NOAA modeled future sea level rise projections for all three islands of the USVI at 6ft above the mean higher high water (MHHW) mark (Figures 4.1 – 4.3). Low lying areas, such as shorelines and coastal wetlands are expected to be inundated. The huge diversity of wildlife, especially birds, that rely on salt ponds will likely be displaced as the ponds become too deep and ultimately become part of the nearshore ocean waters. In some cases, coastal habitats such as mangroves may be able to adjust their ranges inward, but only if there is available land to inhabit. They will not be able to move into or across developed land so it is important to consider creating habitat corridors in land use planning. Forest habitat will be diminished as coastlines move inward. The many wildlife species that already face a squeeze on available habitat due to forest loss will face further loss of habitat. Species that rely on beaches for survival will also face displacement, for example, sea turtles that will see a reduction in available nesting beach habitats.

Marine organisms, such as coral and seagrasses that have specific light and depth requirements will find themselves in deeper waters and if they cannot move to shallower waters, and will not survive. Loss of these two habitats will affect nearly every nearshore marine species.

Ocean acidification caused by climate change will severely affect marine habitats and their associated species (Hoegh et al. 2007, UNEP 2008). Studies have shown that calcifying organisms such as coccolithophores, corals, foraminifera, echinoderms, crustaceans and molluscs will be most affected by ocean acidification as acidic conditions degrade calcium carbonate structures (Mora et al. 2013). Ocean acidification could result in the entire loss of coral reefs and their associated species. Ocean acidification and warming ocean temperatures will both have negative impacts on seagrass meadows disrupting changes in photosynthesis, seed germination, and growth to name a few (Short and Neckles 1999).

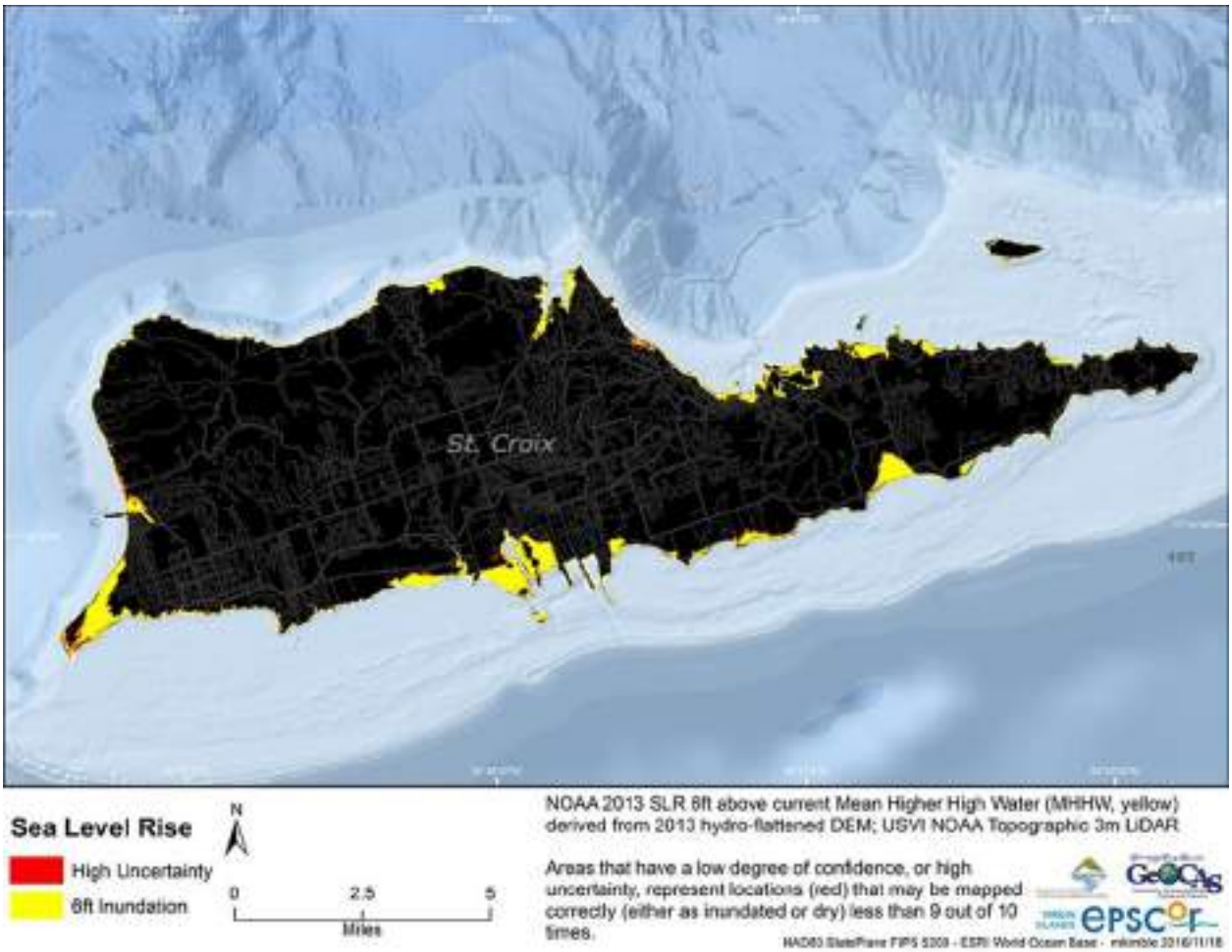


Figure 4.1. Projected sea level rise for St. Croix. Map produced by M. Kimble, UVI GeoCAS, 2016.

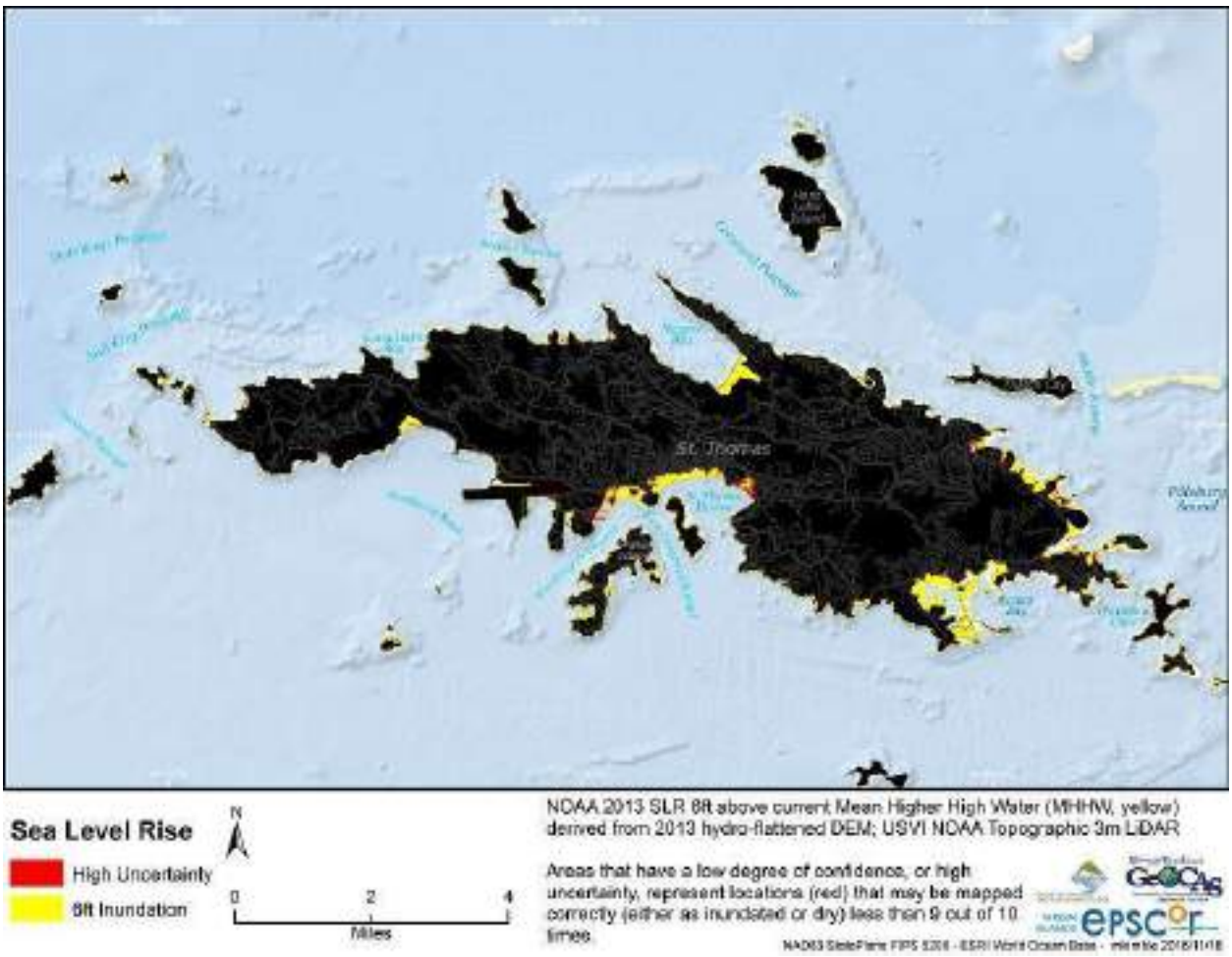


Figure 4.2. Projected sea level rise for St. Thomas. Map produced by M. Kimble, UVI GeoCAS, 2016.

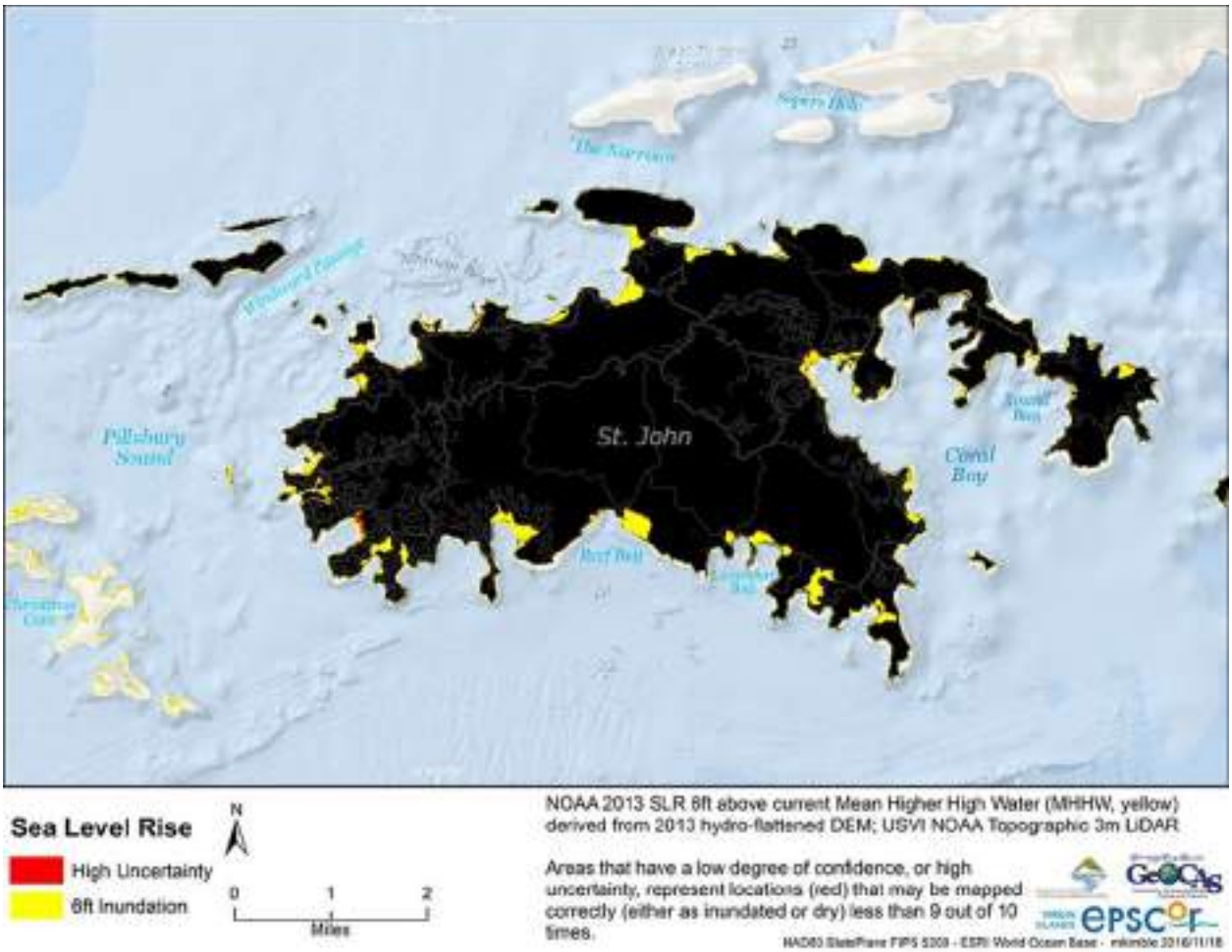


Figure 4.3. Projected sea level rise for St. John. Map produced by M. Kimble, UVI GeoCAS, 2016.

Inaction

While the previously discussed threats all have a specific cause and measurable impact, there are additional stressors on the USVI natural environment that are more difficult to identify and quantify. Yet these stressors were frequently identified in stakeholder discussion as being related in some way to a lack of awareness or ability to take action. We have grouped these stressors into a threat category that we have called "Inaction". Inaction can relate to lack of policy, poor enforcement of an existing policy (Johnstone et al. 2008), or to a variety of forms on the social level including lack of awareness or knowledge about the issue, lack of information sharing, lack of regulations, lack of enforcement of regulations, or lack of funding to mitigate the issue. In the USVI, inaction stems from all these causes.

Much of the environmental degradation in the VI can be attributed to a lack of awareness both of the value of environmental resources and to the consequences of actions. Actions are not always connected to consequences. For example, the person tossing a bag of trash into the bush may not

be cognizant that that trash will eventually wash into the sea and to be consumed by a fish that that person later eats. There are many examples of threats caused by lack of awareness such as beach bonfires that can cook turtle eggs, driving on beaches can destroy least tern and sea turtle nests, the use of guts for tire disposal, etc. These are all damaging practices that are very often carried out without awareness of the consequences. It is likely that with increased awareness, to some degree, these negative practices can be minimized.

There is a lack of knowledge about existing regulations among residents (Stakeholder Input, 2017), and residents don't know where to find information about policy or the responsibility of regulatory agencies. Enforcement officers also may not fully understand the regulations, nor do they have the expertise to identify all environmental violations, particularly in cases where species identification is critical. Judges and prosecutors appear to have a poor understanding of the value of some local resources and how they are regulated (Page et al. 2012).

While there are laws requiring the installation of sediment fences during construction projects to reduce sediment runoff, there are no laws requiring the maintenance of the fences (Horsley Witten Group 2013). These fences are not particularly effective for sediment control on steep slopes with poor soils, and the fences degrade quickly. A shortage of enforcement officers means that these sediment control mechanisms go uninspected as they fail and allow sediment to wash off sites during construction. A more pervasive problem, however, is the unregulated land clearing activities that do not require sediment control, such as vegetation removal not associated with construction. There is currently no program for detecting and preventing improper disposal of regulated hazardous wastes, nor are there laws limiting the amount of impervious cover (land that does not allow water to soak in) created by development (Horsley Witten Group 2013). It is unclear whether this lack of regulation stems from a lack of awareness about the issue, a lack of concern, or a lack of funding.

The lack of communication and coordination between resource management entities hampers the ability to successfully achieve conservation goals. Many local environmental issues have scientific data to support them, but the data is not always shared between agencies or converted into regulations or actions (Page et al. 2012). Many of the local entities have a high personnel turnover rate, making communication more difficult, and reducing, even eliminating, institutional memory, continuity of agreements, and collaborative relationships. There is little communication between islands and travel expense and logistics between islands is challenging. Additionally, many of the representatives from federal agencies are based in Puerto Rico making it difficult for them to be aware of the on-the-ground issues facing the VI. Finally, the responsibility for managing or regulating different environmental issues is not always clear to the community, and sometimes even the entities involved in management and regulation.

Many researchers have collected data over the years that have not been published and shared with the VI community and beyond. Lack of time and access to resources such as statistical analysis tools or scientific information have prevented these data form being analyzed or published.

Lack of funding is pervasive in all aspects of resource management in the VI. Positions go unfilled or are eliminated due to lack of funds, and many people end up doing the work of several people and often work outside their area of expertise. This greatly limits the effectiveness of resource management and also contributes to high turnover rates in personnel.

How to Respond to These Threats

Human activities have a significant influence on this land-sea relationship. Poor land use practices have resulted in the removal of forest cover, leaving land and marine communities exposed to the damaging effects of unfiltered stormwater. Other nonpoint source pollutants, including household chemical products and trash, are washed along with sediment down these conduits into the coastal wetlands or directly into the sea. Lack of awareness or concern leads to violations of regulations and increased degradation of the physical environment. The inability to respond to these degradations, through lack of personnel, training, funding, or other causes results in impairments that are not easily corrected.

While each of these identified threats can potentially be managed or mitigated, combined they synergistically result in a steady erosion of habitat quality and a decline in species abundance and degradation of community and ecosystem integrity. Rather than focusing on single threats or causes of species declines, resource managers would be better served by thinking about ecosystems as a whole and what critical components are needed to allow ecosystem function. Healthy, or functioning, forests provide habitat for a range of terrestrial species, and deliver important ecosystem services such as soil retention, nutrient cycling, and climate regulation. In order to maintain function, forests require pollinators, seed dispersers, soil, and clean water. By thinking holistically, small actions, such as ensuring the forests are buffered from encroachment and water contaminants are minimized, can provide support for ecosystem integrity, which will then support wildlife species.

When faced with irreversibly changing ecosystems, resource managers are increasingly being called upon to develop adaptation mechanisms to allow species the opportunity to survive under changing conditions. Commonly applied adaptation mechanisms include establishing migration corridors, which in the USVI can be achieved by protecting forested corridors and riparian gut systems that connect habitat patches. Buffering wetlands and mangroves with woodland habitat allows for upland migration, while planting seagrape trees behind beach dunes can protect from upland erosion, and allows for dune migration. Protecting species from controllable stressors allow organisms to better cope with uncontrollable stressors, for example controlling sediment will allow corals to expend critical energy towards surviving sea temperatures, thus reducing synergistic effects.

All of these threats are bad enough on their own, but combined, they lead us down a trail of ecosystem change, to the point of no return. The next chapter details specific actions towards addressing these threats

This section was researched and drafted by Carolyn Courtien, Kristen Ewan, Katharine Egan, Lora Johansen, Akacia Halliday, Elizabeth Smith, Vernita Smith, Amelie Jensen, and Alex Gutting, University of the Virgin Islands Master in Marine and Environmental Science Natural Resource Management 2016 Cohort, with additional material and editorial oversight by JV and RJP.

Banner photo: Habitat fragmentation on St. Thomas by R. Platenberg

Chapter Five
The VI-WAP Conservation Strategy

Conservation Goals for VI Resources

The VI-WAP Conservation Management Strategy consists of three key parts: overarching goals for successful fish and wildlife conservation and management in the territory (Table 5.1), the strategies for achieving those goals at the ecosystem and social infrastructure level (Table 5.2), and the specific wildlife-related action items that DFW and partners can implement to achieve these large scale goals (Table 5.3).

A combination of planning processes were used to develop the conservation goals. We used the Conservation Action Planning (CAP) process devised by The Nature Conservancy (TNC 2007) to identify targets (conservation status of resources) and key ecological attributes of the resources and targets, and to identify and rank threats to those attributes. We also used a Structured Decision Making approach, as developed by USFWS (USFWS 2008), to evaluate stakeholder values and develop objective hierarchies. We drew upon resources contained within in the national guidance for climate change adaptation for fish, wildlife, and plants (NFWPCAP 2012). For more specifics on the planning process, see Appendix 1.3.

The revised VI-WAP takes a territorial and ecosystem management approach to conservation management of species and habitats. Through interviews with stakeholders and public meetings, eight overarching goals were identified that address the main concerns that were cited by stakeholders across resources. These goals fall into the following action categories: habitat and species protection, habitat and species management, capacity, research, education and outreach, adaptive management, adaptation and mitigation, and economics/incentives (Table 5.1). Although these goals are by necessity very broad, they are organizing goals that give context to specific

individual projects and also identify areas that may be receiving less focus and resources yet are key to overall conservation of VI natural resources.

Table 5.1. VI-Wildlife Action Plan goals for habitat and species management in the USVI.

Goals	Objective	Problem Statement
Goal 1: Protect habitat to support healthy fish and wildlife populations and ecosystem function	**Habitat and species protection**: to maximize the extent of protected and managed areas to support a wide range of species and ecosystem services	Although there is substantial area within the USVI terrestrial and marine environments that is under statutory protection, not all areas receive equivalent management, and not all vulnerable species and habitats are adequately protected. Few protected areas are connected to allow migration, and adding new areas can be challenging due to ownership and land values. There is a need for a creative and coordinated approach to increasing the amount and value of protected lands.
Goal 2: Manage species and habitats to protect ecosystem function and resiliency	**Habitat and species management**: to minimize reduction in population abundances and distributions of species of concern or ecosystem function by optimizing the ability of species & habitats to adjust to directional ecosystem changes	The protection of VI species and habitats varies across CZM Tiers and according to the type of activity proposed, rather than on species/habitats threats and conservation needs. There is a need for a more coordinated approach towards managing species and habitats to avoid degradation of ecosystem function and services.
Goal 3: Enhance capacity and regulatory mechanisms for effective management of species and habitats	**Capacity**: to optimize access to resources (training, funding, expertise, information) across jurisdictions through coordinated collaborations and effective policy frameworks	Coordination and communication across agencies and organizations within the USVI is limited, which can restrict opportunities to effectively accomplish shared goals. The availability of funds for new personnel, research, and access to technology is limited. There is a need to identify opportunities for collaboration, accessing funds, increasing personnel, and streamlining policies such that they can be effectively applied.
Goal 4: Increase knowledge and information on species and habitats and their responses to impacts	**Research**: to maximize understanding of ecological processes of species and habitats	There are many deficiencies in the scientific understanding of species and habitats, and particularly their response to realized or predicted ecosystem change. There is a need to increase the ability of researchers, resource managers, and the community to collect and share data and to interpret the results

Goals	Objective	Problem Statement
Goal 5: Increase awareness and motivate action to safeguard fish & wildlife populations and ecosystem function	**Education and outreach**: to maximize community awareness of species and habitats and their ecosystem services, the impact of human actions on these resources, and the policies for ensuring protection of these resources	The level of general understanding and appreciation of terrestrial and marine species and habitats within the USVI is poor, leading to erosion of habitat quality and species persecution due to carelessness. There is a need to raise environmental awareness and appreciation within the community to foster stewardship of resources
Goal 6: Support adaptive management through integrated monitoring and use of decision support tools	**Adaptive Management**: to optimize ecosystem management to allow adjustments based on ecosystem response	Resource management personnel do not always know what to do with data collected or how to use it to better structure management activities. There is a need for a coordinated approach towards decision making based on analysis of outcomes of previous action
Goal 7: Reduce stressors to help fish, wildlife and ecosystems adapt to changing environmental conditions	**Adaptation and Mitigation**: to optimize the ability of species and habitats to adjust to directional ecosystem changes	Environmental conditions are changing in ways that cannot be reversed, such as habitat loss to development, establishment of invasive competitors/predators, and climate change. Vulnerable species and habitats are not able to persist under these conditions without targeted management and threat reduction. While it might not be possible to reverse these impacts, there is a need to reduce other stressors to provide support for ecosystem adaptation
Goal 8: Support sustainable cultural, subsistence, recreational, and commercial use of species and habitats	**Economics/Incentives**: to maximize stewardship and sustainable use of resources through the use of economic incentives	The political emphasis within the USVI community is geared toward economic growth, with goals that are often in conflict with the protection and appropriate use of natural resources. There is a need to increase the perceived value of ecosystem services within the community by providing realized economic benefit

2018 VI-WAP Strategies

Once these goals were identified and agreed upon, stakeholder and expert input accompanied by extensive review of reports and research into management approaches was used to identify a comprehensive range of strategies (Table 5.2) to address the goals. We opted to focus the strategies around ecosystem change, rather than at species level because many resources in the USVI are experiencing directional and irreversible changes, e.g., habitat loss due to residential and infrastructural development, establishment of invasives, and climate change. We also did not want to limit the scope of the strategies to what one entity could accomplish. It is expected that the strategies presented in the WAP will be used by multiple agencies and can be a starting point for conversations about collaboration and coordination of effort within the USVI and beyond to regional entities.

After the broad scale strategies were developed, we aligned them to the SGCN and habitats by developing Priority Actions (Table 5.3) that identify specific needs for resources along with measurable indicators and potential partners for implementation. By working towards these measurable indicators, successes and shortfalls can be specifically identified for planning and for the 2025 WAP update. The SGCN and habitats are described in detail within Volume Two.

Implementation of the VI-WAP Strategy and Action Priorities

Although the VI-WAP is managed by the DFW, the conservation goals cannot be achieved by this agency alone. Indeed, many of these actions are outside the scope of DFW's mission. Table 5.3 specifies partners that would enable success for specific strategies, including filling in gaps in capacity. These goals and priority actions address the need to fill capacity gaps through shared resources, including funding, expertise, and data and describe partnership opportunities.

The priority actions table identifies specific actions and measurable indicators that can be incorporated into SWG funded projects for DFW. Progress towards these actions in particular is expected to be evaluated in the 2025 update of the WAP. However these specific actions should always be conducted with the broader goals and strategies in mind as the ultimate avenue to success in conservation.

In implementation, it would be beneficial for entities such as UVI to enter into standing contractual agreements with DFW for collaboration, e.g., by establishing a paid student internship program towards accomplishing research needs within the division. DFW may also establish a community grant program with SWG funding to increase local participation in activities towards accomplishing WI-WAP goals. Such a program would meet the Required Element 8 for public participation in SWAP implementation. A VI-WAP implementation website can provide results of ongoing studies such that information can be accessible by the community and can be used for decision-making by other entities.

Banner photo: Coastal Field Day at The Southgate Coastal Reserve by J. Valiulis

Table 5.2. VI-WAP conservation strategies aligned with goals

Goal	Description	Possible Action Themes
1	**Protect habitat to support healthy fish and wildlife populations and ecosystem function**	
1.1	**Identify and secure areas for inclusion in an ecologically-connected protected-areas network of terrestrial, freshwater, coastal, and marine habitats to support a broad range of species and increase resilience to ecosystem change**	
1.1.1	Identify and prioritize areas for protecting	Conduct inventory, mapping, and decision making; prioritize survey effort for data deficient and vulnerable species
1.1.2	Secure areas for inclusion into protected areas network	Establish acquisitions of priority areas, using mechanisms such as purchasing and easements, Territorial Park System
1.1.3	Establish protection measures on private lands	Promote landowner agreements using mechanisms such as landowner agreements: HCPs, easements, Forest Stewardship, and other incentive programs (USFWS, USFS)
1.2	Conserve, restore, and establish new ecological connections among conservation areas to facilitate species migrations, range shifts, and other transitions.	
1.2.1	Identify migration corridors	Conduct mapping and modeling (essential habitat, habitat change, retreat models, vulnerability assessments)
1.2.2	Secure and/or recover habitat	Conduct habitat restoration, easements, use of green infrastructure, constrain development constraint to allow migration and buffers, adjust shoreline boundaries to accommodate sea level rise
2	**Manage species and habitats to protect ecosystem function and resiliency**	
2.1	**Update current or develop new species, habitat, and land and water management plans, programs and practices to support adaptation and responses to threats**	
2.1.1	Identify gaps in knowledge and management needs as priorities for management action	Conduct inventory, species and habitat studies, data sharing, ecosystem change predictions & scenario planning
2.1.2	Align existing management plans (Invasive spp, Climate Change, ESA Recovery Plans, Regional plans) to reduce conflicting objectives and build partnerships	Promote management decision making with other agencies and stakeholders, co-management agreements
2.1.3	Develop best management practices guidelines	Establish data collection and monitoring protocols, ecosystem management approach, use of vulnerability assessments and scenario planning to design management action, zoning and mooring plans
2.2	**Develop and apply species/habitat-specific management approaches to address critical threats**	
2.2.1	Focus management effort towards species and habitats of concern and ecosystem service providers	Conduct actions to maintain habitat integrity of coastal marine habitats and wetlands, and ecosystem support for herbivorous marine fish, migratory birds, sea turtles, bats, frogs
2.2.2	Promote appropriate use and implementation of management actions	Develop methods and protocols for consistent application of management action and permitting, effectiveness measures and accountability, monitoring and adaptive capacity.
2.2.3	Establish effectiveness measures	Conduct assessment of effectiveness of actions, monitoring and follow-through, accountability for project budgets and timelines.
2.3	**Actively manage species and habitats to maintain biodiversity, ecosystem function, connectivity, and resiliency**	
2.3.1	Minimize reduction in population abundances of species of concern and ecosystem service providers	Conduct habitat restoration, threat reduction, translocation, captive breeding, disease management

2.3.2	Restore native communities	Activate removal and replacement of invasive plants and animals, use of locally sourced spp in landscaping, guidelines on native plant propagation
2.3.3	Build resiliency by maintaining redundancy of diverse habitats	Promote protection of connected habitat patches through policy and guidelines
2.4	**Conserve genetic diversity by protecting diverse populations and genetic material across full range**	
2.4.1	Conduct genetic inventory of species to reveal management units, population structure, and metapopulation dynamics	Survey and collect genetic samples from species of concern, terrestrial spp on cays & across islands, spp with marine dispersal, species with limited dispersal ability
2.4.2	Appropriately manage genetically isolated populations and management units	Establish connectivity between populations through corridors or translocation; maintain isolation as appropriate for population structure
3	**Enhance capacity and regulatory mechanisms for effective management of species and habitats**	
3.1	**Increase the awareness and capacity of natural resource managers towards species, habitats, and stressors**	
3.1.1	Optimize training and further education opportunities to resource managers and regulatory personnel	Create online training and certification programs, online guidelines, training for law enforcement and other regulatory agency personnel, development of planning and management guidelines, support for regional management conferences, support for further education of existing personnel; topics: invasive species response, soil conservation, native plant nurseries, restoration practices
3.1.2	Maximize access to technology and research	Improve access to technology and ability to use technology, access and training in GIS, access to published research, research and data clearinghouse
3.1.3	Increase redundancy in personnel knowledge and skills	Hire qualified personnel, require training to increase competence of existing personnel, increase staffing of regulatory agencies, create new jobs in ecosystem management (including invasive spp response), establish "train the trainer" programs to increase local redundancy (more people have access)
3.2	**Facilitate a coordinated response to fish, wildlife, and habitat conservation at landscape, regional, national, and international scales across state, federal, and tribal natural resource agencies and private conservation organizations.**	
3.2.1	Optimize participation and coordination of effort with regional entities	Engage in interagency partnerships using agreement mechanisms (DPNR, USDA, UVI, CLCC, USFWS, NPS, NGOs), enhance capability for data sharing and communication framework (online, F2F, conferences), provide financial and logistic support for non-profits, establish MOUs for shared resources (including personnel, expertise, funding and data).
3.2.2	Maximize environmental enforcement capability	Improve efficiency of permitting processes, hotline for reporting violations, improved response from enforcement personnel, training in identification of protected resources and interpretation of regulations, active participation in conservation action
3.2.3	Foster interactions with landowners, NGOs, local experts, and federal agencies to identify opportunities for conservation action that might not be available to small landowners	Improve guidelines for land clearance and sediment control, provide access to information on available information and funding resources, build landowner cooperatives to access resources available only for large areas (e.g., Forest Stewardship)
3.3	**Review existing regulatory and policy frameworks for conservation of fish, wildlife, and habitats to identify opportunities to improve their usefulness to address impacts were appropriate.**	
3.3.1	Create USVI Land and Water Use Plan	Identify areas with conservation value, establish single-tier system, update zoning maps to reflect locations of conservation resources, establish mooring plan, update flood plain/sea level rise zones
3.3.2	Update and revise natural resource policy in VI Code & VI Rules and Regulations	Revise VI Endangered and Indigenous Species Act, incorporate ecosystem service protections, build adaptability into policy to allow rapid updating, promulgate list of locally protected species,

		simplify and clarify language of VIC, provide online access to and interpretation of rules & regulations. Increase awareness of rules & regs in community.
3.3.3	Develop and implement new policies to counter impacts from ecosystem change	Develop climate change adaptation policy, invasive species biosecurity policy, limit sunscreen and other reef toxins, reduce marine debris through limits on single-use plastics, protection for essential habitat (habitat delineations used like wetland delineations), habit
3.4	**Optimize use of existing fish, wildlife, and plant conservation funding sources to design, deliver, and evaluate ecosystem adaptation programs.**	
3.4.1	Maximize shared and leveraged funding opportunities between agencies.	Establish streamlined MOU framework with reduced overhead requirements for partnerships and resource-sharing between agencies, UVI, and NGOs, training for grant-writing and grant management; revenue-raising permits/licenses for hunting & fishing with money tied in with conservation.
3.4.2	Increase awareness of funding opportunities available to support ecosystem management	Establish web-based clearinghouse for funding resources; establish public SWG fund
4	**Increase knowledge and information on species and habitats and their responses to impacts**	
4.1	**Identify knowledge gaps and define research priorities via a collaborative process among federal, state, tribal, private conservation organizations, and academic resource managers, and research scientists.**	
4.1.1	Increase coordination and communication between resource managers and scientists to ensure research is connected to management needs	Seek opportunities to establish MOUs for research (UVI, NGOs, consultants, fed agencies) to support management (CZM, DFW); increase participation in research seminars/meetings
4.1.2	Bring managers and scientists together at local and regional levels to prioritize research needs and share relevant findings	Develop research-management conferences; joint DPNR-UVI meetings, newsletters & list-serve, online resource library for dissemination of research publications
4.1.3	Prioritize research on based on imminent conservation needs	Seek opportunities to conduct research on near-term risk environments (cays, beaches); quantify ecosystem service valuations
4.2	**Conduct research into ecological aspects of species and habitats, including likely impacts and the adaptive capacity of species, communities and ecosystems, and their associated ecosystem services, working through existing partnerships or new collaborations as needed (e.g., USGCRP, NCA, CSCs, RISAs, and others).**	
4.2.1	Support basic research on life histories and food web dynamics to better understand and predict responses to threats and adaptive capacity	Conduct research on data deficient spp., inventories, ecological parameters, impacts of fragmentation, spp distributions and changes with climate change, habitat resiliency. Indicator species. Population genetics. Migrations. Engage community and schools in research participation
4.2.2	Support research on adaptation management implications	Develop monitoring protocols, lessons learned & examples, experimental studies on system response
4.2.3	Accelerate research on ecosystem services valuations	Conduct research on quantifying ecosystem services; engage in stakeholder ecosystem valuation exercises
4.3	**Advance understanding of threat impacts and species and ecosystem responses through modeling.**	
4.3.1	Define suite of ecological parameters needed to build predictive models of response to ecosystem change	Conduct species & habitat studies, incorporate research findings from other regions where threat has been impacting for longer
4.3.2	Develop modeling of responses of vulnerable species to impacts, including projected future distributions and viability assessment	Establish GIS and modelling capacity; predictions and scenario planning for habitat loss, invasives (arrival pathways, impacts), sea level rise, precipitation changes (drought monitoring program)
4.3.3	Conduct modeling of distribution and impact scenarios of increasing threat risks of climate change, disease, pollution, and invasive species	Create invasion/climate change/disease scenarios based on responses of these threats in similar systems

4.3.4	Provide access to current climate data and threat models and ensure alignment with data management and decision making tools	Establish web-based clearinghouse for data and data synthesis
5	**Increase awareness and motivate action to safeguard fish & wildlife populations and ecosystem function**	
5.1	**Increase public awareness and understanding of local impacts to natural resources and ecosystem services at regionally and culturally-appropriate scales.**	
5.1.1	Develop focused outreach efforts and materials aimed at local authorities, regulatory and enforcement officials, policy decision makers, and politicians on ecosystem services, climate impacts, the impacts of local stressors, and the value of supporting adaptation measures	Educate senators; update Waves of Change and encourage use; informational products for upper level management
5.1.2	Develop outreach efforts to other key audiences, such as community and cultural leaders, tourism, and private landowners	Use social media, PSAs; engage Tourism, Education, Waste Management, churches, businesses; address "fear of wildlife" and cultural values, creative venues for advertising key methods
5.1.3	Partner with key stakeholder groups (environmental organizations, dive shops and tour operators) to help develop and distribute messages tailored to interest groups and broader public.	Evaluate effectiveness and provide guidance on messaging; reduce mixed/conflicting messaging,
5.1.4	Incorporate the importance of climate change and other drivers of ecosystem change impacts to ecosystem services in education curricula	Promote early education; engage Dept of Ed and teachers, update environmental curricula
5.2	**Engage the public through targeted education and outreach efforts and stewardship opportunities**	
5.2.1	Develop new and enhance existing programs to motivate action and engage citizens in monitoring impacts of ecosystem change	Establish Citizen Science programs: Christmas Bird Count, Backyard Bird Count, Great VI Frog Count, snorkel clinics, beach cleanups
5.2.2	Make research and monitoring information widely available and easily understood	Create web-based Citizen Science reporting site; PSAs and mini-documentaries on social media
5.2.3	Develop K-12 classroom educational materials and activities and provide training to teachers in their use	Identify gaps in teaching capacity for delivery of environmental education, pollution/climate change/spp & habitats science fairs, UVI STEM outreach
5.2.4	Develop core messaging strategies and assessment of effectiveness for use within the culturally diverse USVI community	Identify creative outreach methods; align messaging
5.3	**Coordinate communication efforts across jurisdictions**	
5.3.1	Increase communication pathways between federal and local agencies, NGOs, and community	Optimize coordination of messaging, centralized non-profit to help prioritize & focus environmental message
5.3.2	Engage non-environmental management personnel from government agencies	Promote events and activities that include admin and support staff, newsletters, weekly update emails, social media
5.3.3	Provide access to tools to enhance communication and collaboration	Establish online sharepoint for research articles, data, maps; web-based communication, guidelines for the use of social media
6	**Support adaptive management through integrated monitoring and use of decision support tools**	

6.1	**Support, coordinate, and where necessary develop integrated inventory, monitoring, observation, and information systems at multiple scales to detect and describe ecosystem change impacts on species, habitats, and ecosystems**	
6.1.1	Synthesize existing observations, monitoring, assessment, and decision support data to conduct a status review and gaps in knowledge analysis of existing monitoring networks	Evaluate what's been done and lessons learned; CLCC or GEOcas as clearinghouse for monitoring data
6.1.2	Identify, develop, and disseminate "lessons learned" based on monitoring results	"Learning by Doing", share results, build adaptability into plans; develop decision trees for resource management
6.1.3	Identify informative and measureable indicators of ecosystem change for a range of resources and develop monitoring protocols	Identify indicators for temperature, drought, OA, sea level rise, invasives, disease (eg chytrid)
6.1.4	Support and develop coordinated long-term monitoring programs using indicators to monitor the response of species and habitat to ecosystem change and effectiveness of conservation actions	Develop and share monitoring protocols, agree on informative indicators, co-management agreements; adaptation & effectiveness monitoring: mitigated lands, restoration.
6.1.5	Support a collaborative approach to acquire, process, archive, and disseminate data	Establish data sharing agreements
6.2	**Identify, develop, and employ decision support tools for managing under uncertainty (e.g., vulnerability and risk assessments, scenario planning, strategic habitat conservation approaches, forecasting, and adaptive management evaluation systems) via dialogue with scientists, managers (of natural resources and other sectors), economists, and stakeholders.**	
6.2.1	Develop predictive models of ecosystem change downscaled to VI to conduct vulnerability risk assessments of species, habitats, and ecosystems	Work with CLCC, Southeastern Region Climate Center, USVI Climate Task Force; develop predictive models and scenario mapping for OA, SST, SLR, distributions of invasives and diseases
6.2.2	Engage scientists, managers, planners, permitting agencies, economists, and stakeholders in ecosystem change adaptation planning	Promote interagency/inter-regional cooperation & collaboration. Partner with NGOS (education). CLCC. Partnerships to help with capacity deficiencies. Co-management, shared positions.
6.2.3	Ensure availability and guidance on the use of decision support tools	Establish online clearing house for data
6.2.4	Use observation and monitoring systems in an adaptive management framework to evaluate the effectiveness of specific management actions and adapt management approaches accordingly	Build adaptation into plans. Put plans online, allow for rapid revision
7	**Reduce stressors to help fish, wildlife and ecosystems adapt to changing environmental conditions**	
7.1	**Slow and reverse habitat loss and fragmentation.**	
7.1.1	Work with land use planners, permitting agencies and others to identify shared goals and potential conflicts in reducing/reversing habitat fragmentation and loss through planning, permitting, and zoning processes	Implement Land and Water use plan. Mooring plans. Simplify and make transparent permitting process. Identify essential habitat for vulnerable species. Train personnel in use of GIS
7.1.2	Provide landowners with incentives for conservation and restoration of key wildlife habitat	Increase awareness of resources on private lands, information on federal stewardship projects available, establish coalitions of landowners to increase benefit from stewardship programs.

7.1.3	Establish a dedicated mitigation banking program to compensate for unavoidable impacts to promote strategic habitat restoration and protection	Promote no net loss of habitats, money goes towards restoration or acquisition projects
7.1.4	Minimize impacts of necessary infrastructure by siting on existing disturbed or degraded areas	Establish no new habitat loss for alternative energy projects.
7.2	**Slow, mitigate, and reverse where feasible ecosystem degradation from anthropogenic sources through land/ocean- use planning, water resource planning, pollution abatement, and the implementation of best management practices.**	
7.2.1	Reduce existing non-point source pollution, sediment, and solid waste input into marine environment through regulatory frameworks and best management practices	Establish better BMPs & enforcement on sediment control; reduce land based sources of pollution, sediment runoff, nonpoint source pollution. Clean up guts (avoid input)
7.2.2	Develop watershed management plans to identify local sources and solutions for marine pollution input and wetland degradation	Promote or regulate reduction or restriction on impervious surfaces, establish a watershed planning approach rather than parcel by parcel decision-making
7.2.3	Increase riparian buffers	Restore woodland habitat along guts, restore shoreline mangroves, water greenbelts
7.3	**Use, evaluate, and as necessary, improve existing programs to prevent, control, and eradicate invasive species and manage pathogens.**	
7.3.1	Using predictive models and data from other vulnerable regions, develop and disseminate lists of species, pests, and diseases that are likely to become invasive in the VI	Develop and circulate lists of spp to look out for and to restrict permitted entry
7.3.2	Establish a biosecurity protocol by employing a multiple barrier approach for detecting and containing incoming and established invasive species	Develop lists and ID guides & training in spp recognition for enforcement, border, and customs officials, signage; training on how to respond
7.3.3	Establish a detection & rapid response program to contain, control, or eradicate invasive species	Obtain funding for equipment, training for response, increase "boots on the ground"; share invasive response equipment, training, and personnel across agencies
7.3.4	Establish a widely accessible reporting mechanism for collecting invasive species data	Establish online data storage and access, dedicated data and response coordinator
7.3.5	Develop and apply integrated pest management protocols for development in vulnerable areas, such as cays.	Adapt biosecurity protocols for use in VI, strict regulations and permitting for cay development
7.4	**Reduce destructive capture practices (e.g., fisheries bycatch, destructive fishing gear), over-harvesting and illegal trade to help increase fish, wildlife, and plant adaptation.**	
7.4.1	Reduce bycatch of non-target species	Reduce discarded monofilament line, ghost traps; increase education on appropriate response to capture of non-targeted species; better trap design
7.4.2	Reduce negative impacts of capture practices and gear on wildlife and habitats	Reduce discarded monofilament line, ghost traps, ghost nets
7.4.3	Using stakeholder input and relevant data, determine sustainable harvest levels and threshold levels under ecosystem change scenarios	Target Fishing Associations and tournaments to work within community to understand harvest needs, levels, sustainable practices
8	**Support sustainable cultural, subsistence, recreational, and commercial use of species and habitats**	
8.1	**Increase environmental economic opportunities**	
8.1.1	Create new career paths in ecosystem stewardship	Provide retraining (species ID & ecology, messaging, entrepreneurship), provide tax incentives for new environmental stewardship businesses

8.1.2	Promote sustainable use of species and habitats while reducing threats from unsustainable practices	Provide education on sustainable practices with permits and licenses, monitoring and enforcement of unsustainable activities
8.2	**Develop incentive programs for sustainability**	
8.2.1	Expand financial incentive programs to promote ecosystem protection	Provide landowners and stakeholder with incentive for conservation and restoration of key habitats and habitat features: tax relief through easements, grant-based stewardship programs. Blue Carbon markets, ecosystem service valuations
8.2.2	Develop indirect incentives through recognizing use of best management practices	Establish Green Certifications, "Green Ratings"

Table 5.3. SGCN Priority Actions, listed by taxa. This table identifies actions that benefit SGCN along with indicators and potential partners for implementation.

Priority Action	Goal	Indicators	Benefits to	Partners
Multiple Species				
Conserve large forested tracts with connectivity	Goal 1: Habitat & species protection	Extent and connectivity of native forest communities is ≥ current	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	Wetland and riparian buffer are ≥ regulated minimum setback	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	Number of restoration projects for protected areas ≥ current	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	Reduction in number of data deficient species	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	Increase in research addressing ecosystem change factors	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	Implementation of ecosystem approach to permitting	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	Implementation of effective sediment control	Freshwater fauna, bats, amphibians,	DPNR, WMA

Priority Action	Goal	Indicators	Benefits to	Partners
	regulatory mechanisms		waterbirds, marine species	
Provide training to entities in acoustic methods for biodiversity monitoring.	Goal 3: Enhance capacity and regulatory mechanisms	# of workshops held and increase in use of bioacoustics	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	MOUs across entities for data sharing; increase in joint funding proposals	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	Number of training sessions ≥ current	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	Curriculum in use, # of teachers trained, development of material	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	# of Citizen Science projects & participation ≥ current	Amphibians, birds, coastal resources	DFW, UVI, VIDOEd, EcoSchools, NGOs
Improve vigilance and response towards potential invasive species introductions	Goal 7: Reduce stressors	# non-native species detected, reporting & response time	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	Extent of mapped habitat ≥ current; increase in use of mapping products in decision-making	All species	DFW, UVI, NGOs, CZM, NPS, USFWS, VIDOA (Forestry)

Priority Action	Goal	Indicators	Benefits to	Partners
	monitoring and support tools			
Develop protocols to address range of management actions needed in response to monitoring outcomes	Goal 6: Adaptive management with monitoring and support tools	All projects include monitoring and decision models	All resources	DFW, UVI, NGOs
Freshwater Fauna				
Initiate studies on basic ecology and life histories, including reproductive cycles and migration requirements.	Goal 4: Increase knowledge	Decrease in data deficient species	All freshwater species	DFW, UVI, NGOs
Identify monitoring methods for wetlands and wetland fauna.	Goal 6: Adaptive management with monitoring and support tools	Increase in species with monitoring parameters	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	Anthropogenic debris on wetlands < current	All freshwater species	WMA
Restore water flow into and through guts to ensure connectivity with marine environment.	Goal 2. Manage species and habitats	Water flow in guts > current	All freshwater species	DPW, DFW, NGOs
Amphibians				
Conduct research on amphibian response to environmental change.	Goal 4: Increase knowledge	Increase in projects related to impacts	All amphibians	DFW, UVI, NGOs
Monitor phenology of seasonal calling activity.	Goal 4: Increase knowledge	Establishment and use of database on phenology	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; Goal 6: Adaptive management with monitoring and support tools	Research focused on *E. lentus*	*Eleutherodactylus lentus*	DFW, UVI, NGOs
Explore reintroduction potential of *P. lemur* within its former range.	Goal 2. Manage species and habitats	Surveys for *P. lemur* habitat	*Peltophryne lemur*	DFW, UVI, NGOs, USFWS
Conduct annual monitoring of activity and distribution.	Goal 6: Adaptive management with	Establishment and use of monitoring	All amphibians	DFW, UVI, NGOs

Priority Action	Goal	Indicators	Benefits to	Partners
	monitoring and support tools	protocol and decision tools		
Assess exposure to pesticide residue and other contaminants.	Goal 7: Reduce stressors	Research on exposure	All amphibians	DFW, UVI, DPNR
Terrestrial Reptiles				
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	Sightings of subterranean spp > current	*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	Extent and connectivity of native forest communities is ≥ current	*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	Distributional range maps; # genetic samples collected	*Chilabothrus granti* and *Spondylurus* spp.	DFW, UVI, NGOs, USFWS
Control feral cat populations.	Goal 7: Reduce stressors	Feral cat populations << current	All reptiles	USDA-APHIS
Control or eradicate invasive *Pholidoscelis exsul* populations on St. Croix	Goal 7: Reduce stressors	*P. exsul* populations << current	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	# educational outreach products and events; curriculum in use	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	# areas identified; purchase agreements	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	Use of ebird> current	All land and waterbirds	DFW, UVI, USFWS, NGOs, NPS

Priority Action	Goal	Indicators	Benefits to	Partners
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; Goal 6: Adaptive management with monitoring and support tools	# bird surveys across all islands > current	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	# of wetlands with protection > current	All waterbirds	DFW, UVI, USFWS, NGOs, NPS
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	Establishment of invasive program for data collection and response	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	Use of ebird for wetland birds > current	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	Identifiable stressors < current	*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	Bird tours and tourism info > current	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	Human disturbance to breeding colonies < current	All nesting seabirds	DFW, DEE

Priority Action	Goal	Indicators	Benefits to	Partners
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	# colonies monitored > current	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	Reduction in these items in annual CoastWeeks cleanups	Birds, marine species, sea turtles	WMA, DFW
Support local fish stocks by working with local fishers.	Goal 8: Support sustainable uses	# fishers involved in management > current	All seabirds	DFW, UVI
Control or eradicate invasive species such as goats and rats from cays with sensitive nesting colonies.	Goal 7: Reduce stressors	Rats and goats on cays << current	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	Education/outreach > current; bird entanglements < current	All seabirds	DFW, UVI
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	Development of monitoring & decision models	*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	# birds tracked > current; monitoring & decision trees > current	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	Focused outreach > current	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	Extent of mapped habitat ≥ current; use of mapping products in decision-making	All seabirds	DFW, UVI, USFWS, NGOs, NPS
Bats				
Protect maternity roost sites from visitation and disturbance	Goal 1: Habitat & species protection	# roosts located > current; human disturbance < current	*Brachyphylla cavernarum,*	DFW, UVI, NGOs

Priority Action	Goal	Indicators	Benefits to	Partners
			Artibeus jamaicensis	
Conduct surveys to determine basic information such as locations of roost sites and key habitat features.	Goal 4: Increase knowledge: Goal 6: Adaptive management with monitoring and support tools	# known roosts/habitat features > current	All bats; *Stenoderma rufum*	DFW, UVI, NGOs
Assess impacts of power-generating wind turbines on mortality to bats and birds.	Goal 4: Increase knowledge	Data on mortality > current	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	# areas monitoring with bioacoustics > current	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	# pest control personnel trained > current	*Molossus molossus*	DFW, UVI, DPNR
Conduct studies on exposure to pesticides and other contaminants.	Goal 4: Increase knowledge	Data on exposure	All bats; *Noctilio leporinus*	DFW, UVI, DPNR
Conduct genetic studies to evaluate population structure and metapopulation dynamics	Goal 4: Increase knowledge	# research projects on metapopulations > current	All bats; *Stenoderma rufum*, all other spp	DFW, UVI, NGOs
Conduct nonlethal sampling for the presence of lyssavirus and other pathogens	Goal 7: Reduce stressors	Establishment of monitoring program	*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	# nest sites protected > current	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	# beaches surveyed annually > current	All sea turtle species, especially *Chelonia mydas*	DFW, UVI, NGOs, NPS, USFWS

Priority Action	Goal	Indicators	Benefits to	Partners
			and *Eretmochelys imbricata*	
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	Reduction in these items in annual CoastWeeks cleanups	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	Increase in information/outreach; harassment reports < current	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	Increase in information/outreach; disorientation reports < current	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	Implementation of effective sediment control	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	Shoreline buffers are ≥ regulated minimum setback	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; Goal 6: Adaptive management with monitoring and support tools	# Data Deficient spp < current	Marine Invertebrates	UVI, DFW, NOAA
Expand research on fish breeding aggregations to protect important breeding areas	Goal 1: Habitat & species protection	# essential breeding habitat protected > current	Aggregate breeders	UVI, DFW, NOAA
Conduct studies of larval distribution through oceanographic modelling to identify priority areas for connectivity	Goal 4: Increase knowledge	Research conducted on larval distributions	All marine fish and invertebrates	UVI, DFW, NOAA

Priority Action	Goal	Indicators	Benefits to	Partners
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	Establishment of fisheries-independent monitoring program; decision tools	Priority fisheries species	DFW, NOAA, UVI
Identify additional areas for inclusion into Marine Protected Areas	Goal 1: Habitat & species protection	List of potential MPAs developed	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	# herbivores > current	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	# predators > current; spp richness > current	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	# moorings > current	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	Availability of these products locally << current	Coral and associated reef species	DPNR, NGOs
Marine Mammals				
Promote ecotourism and whale-watching enterprises	Goal 5: Increase awareness	# tours offered > current	Primarily whale species	NGOs, VIDOT
Establish “hotline” for sightings and strandings	Goal 3: Enhance capacity and regulatory mechanisms	Establishment and use of hotline	All marine mammal species	DFW, USFWS, NPS
Increase education of boaters and tour operators of marine mammal encounter guidelines	Goal 3: Enhance capacity and regulatory mechanisms	Increase in information/outreach; harassment reports < current	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

Chapter Six
Ecosystem Services

Peter Freeman
Northside Resource Economics

The USVI ecosystems provide a range of benefits to the territorial population, and the provision of such *ecosystem services* stem from the myriad functions performed by the species and habitats reviewed in the VI-WAP. Ecosystem services have been defined many ways different for analytical purposes (Costanza et al. 1997, Daily 1997, de Groot et al. 2002, Wallace 2007, 2008), most generally as "the benefits people obtain from ecosystems" (Alcamo 2003).

Presented in this chapter are institutional, ecological, and economic frameworks for implementing an ecosystem service approach in the USVI. Included is a discussion of how ecosystem services can be used to coordinate and add value to single-species wildlife management and planning in the territory and the benefits of doing so, a guide to federal programs and statutes that can help the align an ecosystem service approach in the territory with ongoing initiatives, and a discussion from both an ecological and economic perspective of ecosystem services provided by the species and habitats reviewed in the VI-WAP, as well as opportunities to move forward with ecosystem service research in the territory.

Institutional Framework

An ecosystem services approach can be applied to add value to single-species management in the territory by systematically characterizing interactions between ecological resources, and between resources and human activities, resulting from local environmental changes and management actions. Incorporating ecosystem services into wildlife planning and management can help balance outcomes, both ecological and socioeconomic, within department objectives, mandates, and regulatory constraints. It does not replace existing objectives or priorities, but rather provides

additional information about how to best meet them. Ecosystem service evaluations can add value to a range of decision contexts, including area-based planning, regulatory decision analysis, environmental damage assessment, environmental management, and development of conservation instruments (see Preston and Raudsepp-Hearne (2017) for a detailed guide for each context, and NESP (2014) for U.S. case studies). Specifically, it can help reveal tradeoffs, prioritize actions, estimate costs and benefits, identify unintended ecological and social consequences, demonstrate win-win solutions, identify potential partners and funding sources, leverage actions and develop strategies to address large-scale threats and issues. Characterization of ecosystem service provision can also identify co-benefits relevant to other efforts, which can in turn help shift program funding and engage external beneficiaries (e.g., businesses, territorial and federal agencies, regional governments and organizations) in cost-sharing programs or partnerships to improve ecosystem services provision. Such outcomes would ultimately optimize and jointly enhance the state and the delivery of ecosystem services, and therefore the value of the local ecosystem (Slocombe 1998) to residents and visitors alike.

Ecosystem services is a component of and can be used as an aid in implementing other systematic planning frameworks, such as ecosystem-based management (McLeod et al. 2005, Curtin and Prellezo 2010, Granek et al. 2010), marine spatial planning (White House CEQ 2010), terrestrial spatial planning (Polasky et al. 2008), systematic land planning (Margules and Pressey 2000), multi-species management (Pikitch et al. 2004), integrated natural resource management (Frost et al. 2006, Bryan and Crossman 2008), and coordinated management (White et al. 2012). An ecosystem service approach can therefore help the territory align with similar management approaches at federal agencies. While implementation of ecosystem services planning is not mandated at the federal level, it is authorized and encouraged through various rules and guidance documents, including the 2012 USFS Land Management Planning Rule (US Forest Service 2012), the 2011 President's Council of Advisors on Science and Technology report Sustaining Environmental Capital (Executive Office of the President 2011), and the 2013 White House Council on Environmental Quality's Principles and Requirements for Federal Investments in Water Resources (White House CEQ 2013). It is also commonly incorporated into assessments under the National Environmental Policy Act (see Bear (2014) for guidance). Systematic planning with an ecosystem service component is central to federal programs like USDA's "all-lands" approach to resource management (Tidwell 2010), the Caribbean Landscape Conservation Cooperative at the Department of the Interior and U.S. Forest Service (CLCC 2017), the U.S. Army Corps' watershed informed budgeting, NOAA's Integrated Ecosystem Assessment and Habitat Blueprint programs (www.integratedecosystemassessment.noaa.gov), USDA's Office of Environmental Markets (https://www.oem.usda.gov/), wetland and stream mitigation rules applied by the U.S. Army Corps and EPA, and White House guidance on coastal green infrastructure (Executive Office of the President of the United States 2015). See National Ecosystem Services Partnership (2014) for a comprehensive review of guidance documents, as well as a framework for application of the ecosystem service approach to federal natural resource planning and management.

Ecological Framework

From an ecological perspective, ecosystem services are defined as "the conditions and processes through which natural ecosystems and the species that make them up, sustain and fulfill human life" (Chee 2004, p. 1). This definition is analogous to ecological functions. As such, an ecosystem

service approach draws from functional ecology to describe and quantify the dynamics underlying service provision, and the value of an ecosystem service can be thought of as its functional value to the system (see the "Ecological Value" sections of the species and habitats chapters in the VI-WAP for detailed analysis). Estimating functional value within the VI-WAP would involve both understanding the functions that wildlife species have in the local ecosystems that contributes to service provision, as well as understanding the many service values generated by the habitat needed to sustain target species, including species of concern. The multi-species focus of an ecosystem service approach could improve the ability of management actions to sustain additional target species populations, shared habitats, and the services flowing from both. Such actions could produce co-benefits in the form of additional services, which might in turn provide additional support for regulations and recovery plans. Overall, an ecosystem service approach holds the potential to identify management alternatives that provide the greatest benefit to multiple species while also optimizing the delivery of ecosystem services.

A prominent approach to describing the services provided by species and their habitats is called the *service provider* concept, developed in Luck et al. (2009). The service provider approach is an explicit framework for "delineating and quantifying the contribution of organisms and ecological systems to service provision…whether these are populations, functional groups, or ecological communities" (p. 223), and can be applied across ecological organizational levels (Noss 1990), including communities, habitat types, or landscapes. See Table 6.1 for a list of example ecosystem services, and the service providers and functional units that provide them. Operationally, the service provider approach characterizes ecosystem services (or ecological functions) by the component populations, species, functional groups or guilds, or habitat types that collectively produce them. These are usually measured as a quantity (abundance, distribution, quality, or variability), and the rate at which they provide services is indicated by their functional efficiency (Kremen 2005). Finally, it also characterizes species interactions, such as competition, commensalism, mutualism, and predatory interactions (e.g., carnivory and parasitism), as well as functional relationships on service provision (called effect traits), and response to environmental changes (called response traits) (Larsen et al. 2005, Bennett et al. 2009).
Service Providing Units

Populations within a single species

Many ecosystem services are provided at the unit of a single species, sometimes called "key service providers, analogous to the concept of keystone species" (Luck et al. 2009, p. 228). Species populations contribute most to ecosystem services like biological control or seed dispersal, rather than environmental regulating services (though Holmlund et al. (1999) describe various regulating services provided by fish populations). Service provision is often achieved at a threshold population level set by demand, and could be managed with an approach comparable to the concept minimum viable populations (Lacava and Hughes 1973, Shaffer 1981). Services providers, however, could correspond to any metric of population diversity (i.e., density, size, distribution, or genetic variance) (Luck et al. 2003). The important thing is that management considers the population metric(s) that corresponds with the service. For example, in the USVI, numerous bat, bird, insect, and lizard species provide pollination and seed dispersal functions. This service would be disrupted when the population size falls below a certain level (Potts et al. 2010), but also as population density changes (Kearns et al. 1998, Kremen et al. 2007), and as the distance between pollinator and plant change (Ricketts et al. 2008).

Multi-species functional groups

Many ecosystem services are provided at the unit of functional groups comprised of multiple species with shared functional traits (see Table 6.1). Functional traits are species traits that interact with the surrounding environment, like body size, dispersal distance (effect trait), and response to disturbance (response trait) (Elmqvist et al. 2003). The analytical focus at this unit is understanding how service provision is connected to species characteristics manifested at the functional-group level (group composition, or guild). Like populations, multi-species functional groups usually contribute most to ecosystem services like biological control or seed dispersal, rather than environmental regulating services. Additionally, provision of these services have been found to rely more on populations of individual species than the diversity of populations with shared ecological function (e.g., transport of pollen and seeds) (Jordano et al. 2007).

Communities

Many ecosystem services are provided at the unit of communities of organisms (see Table 6.1). The analytic focus at this unit should be the role that species and functional diversity play in modulating ecosystem processes such as primary production, nitrogen retention, decomposition, and stability (Tilman 1996, Loreau and de Mazancourt 2013), as well as ecosystem productivity (Paquette and Messier 2011) and resilience (Oliver et al. 2015). These processes and functions have complex links to ecosystem service provision (Balvanera et al. 2001, 2006), and are usually assessed at aggregate levels (Worm et al. 2006) because of simultaneous and joint production of multiple services.

Habitat

Habitat types usually provide supporting services, or regulating ecosystem services like flood mitigation, water regulation, and carbon storage (see Table 6.1). The analytical focus at this unit should be the habitat characteristic (e.g., area, geographic distribution, connectivity, condition) required by target service providers. These characteristics can be expressed along a gradient or other continuum of variation in order to inform different management strategies. For example, Yee et al. (2014) estimated ecosystem service across a biological condition gradient, comprised reef attributes that reflect different classes of ecological integrity along a stressor gradient, in St. Croix, USVI. A habitat-based management approach is not only relatively widely used in conservation planning, but also has the potential to provide numerous co-benefits by supporting various service providers (Chan et al. 2006).

Table 6.1. Example ecosystem services, service providers, and functional units at which service provision should be analyzed. Adapted from (Kremen 2005). Where possible, service providers are listed according to the species family used in the VI-WAP.

Service	Service Providers (Family)	Functional Unit
Seed dispersal	Birds, bats, lizards, land mammals	Populations, species, functional groups
Pollination	Terrestrial invertebrates (insects), birds, bats, lizards	Populations, species, functional groups
Carbon storage	Trees, mangroves, seagrass, corals	Populations, species
Pest control	Terrestrial and aquatic invertebrate and vertebrate parasitoids and predators	Populations, species, functional groups
Disease control	Vertebrate host species	Populations, species, functional groups
Invasion resistance	Herbaceous community	Populations, species
Water purification	Vegetation, soil micro-organisms, aquatic micro-organisms, aquatic invertebrates	Populations, species, functional groups, communities, habitats
Water flow regulation	Trees, vegetation	Communities, habitats
Flood mitigation	Mangroves, corals, vegetation	Communities, habitats
Drought mitigation	Vegetation	Communities, habitats
Climate stability	Vegetation	Communities, habitats
Soil generation and fertility	Soil invertebrates, nitrogen fixing plants, plant and animal production of waste products	Populations, species, functional groups
Primary productivity	Terrestrial and aquatic herbaceous community	Communities
Bioturbation	Benthic marine and freshwater invertebrates, freshwater and marine fish	Populations, species, functional groups
Detoxification and decomposition of wastes	Soil invertebrates, soil micro-organisms, aquatic invertebrates, aquatic micro-organisms	Populations, species, functional groups, communities, habitats
Leaf litter decomposition	Freshwater invertebrates	Populations, species, functional groups
Ecosystem goods	Diverse species	Populations, species, communities, ecosystems
Aesthetic, cultural	All biodiversity	Populations, species, communities, ecosystems

Economic Framework

An economic framework for an ecosystem service approach describes the process of defining and identifying ecosystem services for use in economic valuation and decision-making. This process moves beyond measures in the ecological framework, which are not *explicitly* linked to human benefits, in order to integrate the ecosystem services outcomes that are valued by people. Within this framework, ecosystem services must first be defined by beneficiaries' demand for those services. Their underlying production is then modeled using the approach described in the ecological framework.

Final and Intermediate Ecosystem Services

An economic framework for an ecosystem service approach uses a systems-based approach that separates services into those that are directly utilized to provide a benefit, and those that indirectly contribute to benefits delivery. The former are called *final ecosystem services*; the latter are called *intermediate ecosystem services* (Chee 2004, Heal et al. 2005, Brown et al. 2007, Wallace 2007, Boyd and Krupnick 2009, EPA Science Advisory Board 2009,). Final ecosystem services can be defined as: "the end-products of nature…directly enjoyed, consumed, or used to yield human well-being" (Boyd and Banzhaf 2007), and must include four properties described in Johnston and Russell (2011). Intermediate ecosystem services can be defined as ecosystem organization, operation, functions, and outflows that contribute to the provision of final ecosystem services but are not directly utilized to produce a benefit (Fisher et al. 2008, 2009), and therefore are not directly valued (Limburg et al. 2002, Barkmann et al. 2008, Kontogianni et al. 2010). See Table 6.2 for examples of connections between example final and intermediate ecosystem services provisioned from coral reefs.

Beneficiaries and the ecologically-derived benefits they value thus set the parameters for the set of final ecosystem services, and the associated intermediate ecosystem services, that are evaluated. As stated by Landers and Nahlik (2013), "[in] order for ecologists to measure final ecosystem services, they have to know what to measure; and what to measure depends on the beneficiary and what they directly utilize, consume, or enjoy from the environment" (p. 16). This quality is called benefit relevance, and is thoroughly described by Olander et al. (2015).

Table 6.2. Examples of coral reef final and intermediate ecosystem services. Adapted from Principe et al. (2012).

Ecosystem Services	
Final	**Intermediate**
Recreational fishing opportunity	Habitat; primary and secondary production of benthic and aquatic prey species
Recreational diving, snorkeling and underwater photography opportunity	Coral reef formation; primary and secondary production; habitat; biological integrity; reef structure; water filtration
Harvesting opportunity for seafood products (fish, shellfish, and algae)	Habitat; primary and secondary production of benthic and aquatic prey species; biological integrity
Protection from shoreline erosion; protection from coastal inundation during extreme events	Wave energy attenuation

Valuation

Ecosystem service valuation is the practice of quantifying human benefits derived from the environment, provided directly by final ecosystem services. The value metrics quantified can be expressed in dollars or non-monetary units like preference weights. When human and social welfare are a policy goal, values of any metric are necessary for comparing costs and benefits, as well as making explicit tradeoffs. Ecosystem service valuation has been applied in the USVI and greater Caribbean for a range of management purposes (Waite et al. 2014), and can provide a guide for the types and scale of value estimates that could be characterized for species and habitats included in the VI-WAP:

- **Estimating the "Total Economic Value" of a resource**. For example, the value of six ecosystem services (recreation, coastal protection, fisheries, tourism, research and education, and amenity value to real estate) provided by coral reefs in the USVI was calculated to be $202 million annually (van Beukering et al. 2011). Burke et al. (2008) estimated the annual value of coral reefs to tourism and recreation as $101-130 million in Tobago, and $160-194 million in St. Lucia, respectively; the annual value of coral reefs to fisheries as $0.8-1.3 million in Tobago, and $0.5-0.8 million in St. Lucia, respectively; and the annual value of coral reefs to shoreline protection as $18-33 million in Tobago, and $28-50 million in St. Lucia, respectively. Cooper et al. (2008) estimated the combined annual value to Belize of coral reefs and mangroves for reef-associated tourism as $150-196 million to tourism, $14-16 million to fisheries, and $231-347 to shoreline protection.
- **Financing protected area management**. For example, visitors to the St. Thomas East End Reserve were found to be willing to pay (WTP) between $15,000-150,000 to fund the conservation area (McKenzie 2013). Estimates of WTP value of recreational game fishing opportunity in the British Virgin Islands is $4.6 million per season (Gillet et al. 2007).
- **Economic impact analysis of protected areas**. For example, visitors to the Virgin Islands National Park were found to spend an annual total of $92 million (Israel 2004), and the park overall was estimated to have a 11:1 benefit/cost ratio to the territorial economy (IRF 1981). Analysis of reef condition and ecosystem service provision under different water quality standards was conducted for St. Croix (Yee et al. 2012).

Natural resource economics provides a range of methods to quantify the value of changes in ecosystem goods and services (see Table 6.3). Techniques of valuing nonmarket ecosystem services (i.e., services that are not traded in formal markets, like amphibian population size) are categorized generally as either stated preference or revealed preference. The choice between these two nonmarket valuation techniques depends on targeted types of value (Bockstael et al. 2000, Freeman 2003, EPA 2009). Market non-monetary estimates of ecosystem service values can also be achieved using a suite of analytical methods that develop a ranking or rating of alternatives based on their contributions to stakeholder preferences for ecosystem services. These multi-metric approaches are collectively referred to as multi-criteria decision analysis (MCDA) (Kiker et al.

2005, Hajkowicz 2007) and commonly advocated for ecosystem service valuation (Gatto and De Leo 2000, Chee 2004, Norton and Noonan 2007, Spash 2008ab, Chan et al. 2012). MCDA methods are oriented to the multi-dimensional character of many natural resource management problems (Chee 2004). See (Freeman et al. 2013) for an MCDA approach using a tradeoff exercise using ecological indicators of final ecosystem service provision. This approach is based on the service provider concept used in the ecological framework section above and tailored to be applied locally.

Species and Habitat Services

Studies on final ecosystem services in the USVI and wider Caribbean region have largely focused on coastal habitats, in particular coral reefs, mangroves, and seagrasses (Waite et al. 2014). An opportunity exists, therefore, for researchers in the territory to evaluate the contribution of species to other commonly studied final ecosystem services. The EPA's Final Ecosystem Goods and Services Classification System (Landers and Nahlik 2013) identifies a number of final ecosystem services provided by wildlife that would serve as good starting points for evaluating species identified in the VI-WAP:

- Pollinators that provide opportunity to grow crops
- Depredators and pest predators that provide opportunity to grow crops
- Organisms that are viewed recreationally (e.g., fish, birds, sharks)
- Organisms or products associated with organisms used in medicine

In particular, many bat, bird, amphibian and reptile, and invertebrate species in the territory are providers of pollination and pest control final services. The dynamics underlying this service, including the effects of land use change on supporting habitat, has been well studied (Kremen et al. 2002, Larsen et al. 2005, Kremen et al. 2007, Ricketts et al. 2008) and provide numerous conceptual and quantitative measures that could be applied to the territorial ecosystem. For example, values could be attributed to individual species using agricultural production values, or prioritize habitat within a certain distance to agricultural beneficiaries.

Given that aggregate values have been estimated for habitats in the region, an opportunity also exists for researchers in the territory to apply these values to the service providers reviewed in the VI-WAP that they support, including coral and mangrove associated species, their populations, functional groups and guilds, and community dynamics. Ecological production functions have been quantified for coral reef ecosystem services in the USVI (Yee et al. 2012, Yee et al. 2014), but additional functions could be characterized for species habitat associations. Also, an opportunity exists to leverage the values already estimated for USVI habitats as co-benefits of management actions that further enhance or protect coral and mangrove habitat and the species that depend on them. Lastly, additional coral reef and other ecosystem service values could be estimated using service providers in the VI-WAP. A review of coral reef ecosystem values in the United States (Brander and van Beukering 2013) shows that values for diving, snorkeling, other tourism and recreation, and recreational fishing have not been estimated for the USVI.

Finally, an opportunity exists for researchers in the territory to better characterize the local population of beneficiaries, the environmental benefits they value, and the nature of their value

functions. This type of work would prioritize and provide more locally specific descriptions of the ecosystem services that are valued most in the territory, as well as contribute most to the health and wellbeing of its residents and visitors. See Freeman et al. (2013) for a community-based approach based on the service provider concept used in the ecological framework section of this chapter.

Banner photo by Sipke Stapert, www.birdscaribbean.org

Table 6.3. Economic valuation methods applied to ecosystem services. Adapted from (NESP 2016) and (Waite et al. 2014).

Valuation Method		Description	Final Ecosystem Services Valued
Market Valuation	Market Analysis	Derives value from households' or firms' inverse demand function based on observations of use.	Fisheries Mangrove timber Other marketed raw goods Tourism
	Production Function	Derives value based on the contribution of an ecosystem to the production of marketed goods.	Crop production (from pollination, natural pest control, etc.) Fish production (from habitat, water conditions, etc.)
Revealed Preference	Hedonic Price	Derives an implicit value for an ecosystem service from market prices of complementary goods.	Shoreline protection Recreation Noise and light pollution
	Recreation Demand Models (e.g., travel cost)	Derives an implicit value of an on-site activity based on observed travel behavior.	Recreation value (from water quality, fish and wildlife communities and population levels, etc.)
Defensive and Damage Costs Avoided	Damage Costs Avoided	Value is inferred from the direct and indirect expenses incurred as a result of damage to the built environment or people.	Flood protection from reefs and mangroves (cost of rebuilding homes and buildings, etc.) Health and safety (treatment costs, etc.)
	Averting/ Defensive Behavior	Value is inferred from costs and expenditures incurred in mitigating or avoiding damages.	
	Replacement/ Restoration Costs	Value is inferred from potential expenditures from replacing or restoring an ecosystem service.	Shoreline protection from reefs and mangroves Water filtration by wetlands and forests Fire management
Stated Preference	Contingent Valuation	Value is derived by creating a hypothetical market by asking respondents to state their willingness-to-pay/accept for an outcome (open ended), or whether they would choose actions or policies with given outcomes and costs (discrete choice).	Nonuse values (species, ecosystem protection, etc.) Recreation Aesthetics
	Choice Modeling	Value is derived by creating a hypothetical market by asking survey respondents to choose among multi-attribute bundles of services with associated costs.	
Benefit Transfer	Benefit transfer	Value is estimated based on transferring estimates or value functions from other locations.	Any ecosystem service
	Meta Analysis	Synthesize results from multiple existing valuation studies, using statistical regression to estimate a value function.	

Chapter Seven
Ecosystem Management—Cays

More than 50 small islands, collectively referred to as "cays," dot the USVI (Figures 7.1 and 7.2; Table 7.1) and comprise about 3% of the territory's total area; all but four of these islets surround St. Thomas and St. John. The archipelago of cays fall under a range of management jurisdictions, including the VI government (DFW), NPS, USFWS, private owners, as well as entities within the BVI. Yet they offer critical habitat for a range of species that are not typically found on the larger islands, and represent a significant portion of endemic biodiversity richness. Additionally, the variation in habitats provides an ecosystem mosaic that allows for metapopulation dynamics, particularly for birds that nest on different islands across seasons.

Each cay is completely different from the next; differences in species assemblages are due to island biogeographical influences such as size, distance from nearest land, topography, ocean currents, and prevailing winds. The varied vegetation communities include subtropical dry forest, shrublands, and grasslands, as well as sparsely vegetated geological formations (e.g., cliffs, rock outcrops, and beaches). Some cays support salt ponds and associated mangrove systems. Each cay is illustrated and described by Dammann and Nellis (1992).

Management Framework

A significant challenge to providing a comprehensive management framework for cays is the variety of jurisdictional entities. These areas are managed on a cay-by-cay basis, with little consideration of a network of cays. As a single management unit, the network of cays offers habitat complexity that can support metapopulation dynamics for seabirds, migratory landbirds, and marine species. A good example is the Roseate Tern that nests on different islands each year depending on some unknown favorable condition; the different nesting cays fall under the

jurisdiction of DFW, NPS, and the BVI. The value of these insular systems, both terrestrial and marine components, has been recognized, and the CLCC has assembled a Cays Conservation Action Team (Cays-CAT) to develop a framework for the management of cays across Puerto Rico and the USVI, regardless of management jurisdiction.

In 2016 the USFWS allocated funds from the Coastal Program to support a project with the Applied Coastal Research Laboratory of Georgia Southern University to refine previous modeling results using the biological field data (both terrestrial and marine) being collected with USFWS collaborators, as well as NOAA Coral Reef Conservation Program-funded data such as the benthic habitat maps, National Coral Reef Monitoring Program data, and bathymetry. These data will be used in models for assessing species and habitat vulnerability and to determine the impacts to coastal and marine habitats and resources, including ESA-listed species and their habitats, and fishery habitat around these cays. Using model results, collaborations between regional partners will work toward potential management strategies to protect vulnerable areas. This will feed into Cays-CAT initiative to develop a multi-stakeholder landscape conservation design for the network of cays within the U.S. Caribbean.

Ecological Value

In comparison with the larger islands in the USVI archipelago, the terrestrial species richness of the cays is low. Amphibians and many landbirds are absent from most of these islands because of reduced habitat complexity and the absence of forested habitat. However, because of their relative inaccessibility and lack of predators, the cays provide sanctuary for a variety of wildlife species, particularly reptiles, that are unable to co-exist with human activities. Several species are only found in remnant populations on uninhabited cays, including the Virgin Islands skinks (*Spondylurus* spp.), Puerto Rican Racer (*Borikenophis portoricensis*), and the federally endangered St. Croix Ground Lizard (*Pholidoscelis polops*). Others, such as the VI Blind Snake (*Antillotyphlops richardii*) and the federally endangered VI Tree Boa (*Chilabothrus granti*) are vulnerable to stressors on the larger islands but maintain relatively protected populations on the cays (although the tree boa has been introduced; Tolson 2005). Sea turtles also nest on the beaches of several cays such as Hans Lollick and Inner Brass near St. Thomas and Buck Island off St. Croix.

Coastal wetlands on cays provide habitat for a variety of invertebrates, shorebirds, and indigenous waterbirds. Numerous species of waterbirds visit the cays, especially during migration, and several indigenous species such as the White-cheeked Pintail (*Anas bahamensis*) may nest on some of them (e.g., Saba Island, Shark Island, and Buck Island off St. Croix) where offspring are possibly less vulnerable to predation than on the major islands. Landbird fauna include Zenaida Doves (*Zenaida aurita*) and the territorially listed White-crowned Pigeon (*Patagionas leucocephala*) which nests on all four cays off St. Croix (McNair and Lombard 2006).

Seabird communities inhabit a diverse constituent of cays and adjacent marine ecosystems, making these sites Important Bird Areas (Corven 2008). The major seabird nesting areas in the USVI are found on about 25 of the most remote or rugged cays off St. Thomas and St. John, where their eggs and offspring are less vulnerable to predators than on the major islands (Pierce 1996). The species composition of breeding seabirds varies among the cays depending upon the availability of nest

sites. For example, Flat Cay and Saba Island harbor active rookeries of gulls and terns, Cockroach Cay and Dutchcap Cay host colonies of boobies and tropicbirds, and Congo Cay, Dutchcap Cay, Buck Island (St. Croix), and Green Cay (St. Croix) support nesting pelicans. Except for some terns, most seabirds nest at the same colony year after year, and rarely form new colonies. A variety of techniques have been used on some of the islands to augment suitable nesting habitat for seabirds. These include removal of non-native invasives (e.g., rats and goats), thinning vegetation on Saba Island and Cockroach Cay for Sooty Terns (*Onychoprion fuscata*) and Masked Boobies (*Sula dactylatra*), planting native trees on Saba Island to replace those lost to storms, and repairing nest cavities for tropicbirds at Capella Island, Cas Cay and Cockroach Cay.
Several larger cays off the north shore of St. Thomas have cliff caves and fissures that are occupied by the Antillean Fruit-eating Bat (*Brachyphylla cavernarum*), and the Jamaican Fruit-eating Bat (*Artibeus jamaicensis*) has been recorded on Lovango Cay off St. John (Koopman 1975), but the extent to which bats use cays has not been assessed. White-tailed Deer (*Odocoileus virginianus*) have been observed swimming from cay to cay east of St. Thomas.

The waters around the offshore cays have shallow shelves that are colonized by coral reef communities. These reef systems are protected from stressors associated with inhabited islands, such as runoff and sedimentation, although erosion from goats can be a problem.

Threats

Despite their beauty and charm which lure human visitors, the cays can be treacherous. Some are inaccessible at certain times due to high winds and sea swells, and the more rugged cays require swimming from anchored boats and confident climbing skills. These hindrances tend to buffer the less accessible cays from the adverse effects of human encroachment, yet many cays are readily accessible and several have succumbed to extensive habitat degradation. In addition to marine activities such as fishing and diving, many cays are frequently visited by humans for hiking and picnicking. Seabird egg poaching and dove hunting were once popular activities that have declined greatly in recent decades. Goats have been introduced to the cays by local farmers. During the 1940s, the United States military used several cays for naval artillery and bombing practice. Some cays have been degraded through development for residences or commercial use.

The threat of establishment of non-native plants and animals to the cays is ever present. Boats may run aground during storms, potentially introducing rats (*Rattus* spp.) which are already present on several of the cays. Rats eat native vegetation and prey upon wildlife, including the eggs and nestlings of seabirds, and seabirds have abandoned some of these islands. Because rats prey directly upon the food, offspring, or adults of most, if not all, native animal species, their eradication from small cays is essential to enhance and ultimately restore the habitat of native species. Rats also eat the new shoots of vegetation, further degrading necessary wildlife habitat.

Goats (*Capra hircus*) are present on many of the cays, where they selectively forage on native vegetation resulting in large areas comprising monocultures of unpalatable *Croton flavens*. Their removal and trampling of native vegetation causes significant erosion of shallow soils, leading to sedimentation of reef systems. Goats also trample seabird nests and remove valuable nest site cover. Goats and rats were removed in 2004 from Dutchcap Cay, site of an important seabird colony in the USVI, although they still remain on Thatch, and many other privately owned cays.

The removal of goats from cays can be an unpopular exercise, as there are still cultural values attached to maintaining these insular populations for hunting.

The Small Indian Mongoose (*Herpestes auropunctatus*) was established on Buck Island (off St. Croix), but has been eradicated after much effort (Witmer et al. 1998, Fitzgerald et al. 2015). They have also been reported from Bovoni Cay and Cas Cay in the Mangrove Lagoon on the eastern side of St. Thomas, although these sightings are unverified. Even the domesticated chicken (*Gallus gallus*) was once temporarily common on Saba Island where they no longer exist (J. LaPlace pers. comm.), and are also present on Hans Lollik and Inner Brass (R. Platenberg, pers. obs.)

The impact of non-native plants on native flora and associated fauna is poorly known, although invasiveness can have a major influence on species composition and habitat structure. African guinea grass (*Urochloa maxima*) was introduced on several cays after 1890 (Saba Island, Henley Cay, Flanagan Cay) for use by grazing animals and was burned periodically to improve forage. More recent efforts have been implemented to document and control invasive plants on NPS islands, particularly Buck Island (STX; Clark 2005, Z. Hillis-Starr, pers. comm.). Natural impacts such as periodic hurricanes and tropical storms may damage or destroy trees on cays, including nest sites for seabirds, and increase erosion, yet they otherwise perform a useful service for many species that prefer open environments by scaling back succession.

Privately owned cays are subject to development pressure and several of these have been extensively altered, including Hassel Island (joint private and federal ownership), Little St. James Island (private), and Protestant Cay (VI government ownership); Table 5.2 identifies cay ownership. Development has been repeatedly proposed on Hans Lollick Island, the fifth largest island in the USVI, but no viable projects have emerged. As yet, there is no policy in place for guiding development on cays, such as pest management, shoreline protection, and insular habitat protection to limit impact of development threats.

Climate change is likely to have a disproportionate impact on cays through sea level rise and changes in precipitation patterns. Drought is especially harsh on cays with only shrub cover that offers limited water storage capacity. Extended drought periods are likely to result in reduced fitness for reptiles and seabirds and changes in vegetation communities. Brush fires could pose potential serious threats to seabirds that nest during hot dry summer seasons.

Research, Management, and Monitoring on the Cays

The DFW maintains sanctuary signs on the important seabird cays to limit foot traffic into the seabird colonies and to inform the public of the conservation restrictions, including required permits for visitation beyond the beach. The Commissioner of DPNR is charged with the lead governmental responsibility of protecting and managing these cays.

In a partnership between DFW and USDA/APHIS-Wildlife Services, rat and goat eradication has been conducted on several cays important for seabird nesting. NPS has removed rats from Buck Island (St. Croix). USFWS has made several attempts to eliminate rats from Green Cay (STX) , and Congo Cay (STT), but have so far been unsuccessful. The DFW monitors the effectiveness of the rat eradication by periodically trapping the islands for rats and monitoring the recovery of plant

and animal species. NPS has been monitoring nesting of Hawksbill (and more recently Loggerhead) sea turtles on Buck Island (St. Croix). DFW, NPS, and USFWS have collaboratively conducted management activities toward the recovery of the St. Croix Ground Lizard, in partnership with several universities and their students. Seabird nesting has been the focus of DFW activities on cays for decades.

A coastal vulnerability analysis was conducted for 20 cays around Puerto Rico and the USVI between 2010 and 2013 that assessed historic shoreline change using aerial photographs, satellite imagery, and LiDAR, and projected future change using current sea-level rise data (Bush et al. 2014). This provides valuable baseline and projected data for measuring and monitoring shoreline impacts and targeting vulnerable sites for management. Since 2014, the USFWS has been allocating funds from the Coastal Program to collect ecological information at landscape and seascape levels for at least 16 cays around Puerto Rico and the USVI to develop vulnerability models that can be linked to existing and widely used geophysical models. This information will be used to assess species' vulnerability to coastal hazards, climate change effects, needs for habitat restoration and/or enhancements, and to identify and implement best management strategies. This project is expected to be completed by the end of 2017 and will provide the basis for developing assessment methods that are widely applicable to many coastal settings along the Southeastern U.S. Region and the entire Caribbean (I. Llerandi-Román, pers. comm. 2017).

The cays of the USVI offer a unique opportunity for research and management of wildlife resources, especially seabirds. Early studies of the cays provided some documentation of their herpetofauna (Maclean et al. 1977) and avifauna (Danforth 1935, Nichols 1943, Leopold 1963). More recent studies have focused on: descriptions of the cays and summaries of the flora and fauna (Dewey and Nellis 1980, Dammann and Nellis 1992); St. Croix Ground Lizard (McNair 2003, McNair and Coles 2003, McNair and Lombard 2004, McNair and Mackay 2005); seabirds (e.g., Dewey and Nellis 1980, Pierce 1996; see Seabirds chapter for more references); and the effect of exotic rats on bird diversity (Campbell 1991).

Many of the cays are under statutory protection. In 1973, the territorial government set aside several cays as wildlife reserves, affording some protection from detrimental activities, such as seabird egg poaching and habitat degradation, and since then all territorial-owned cays, including several that were donated to the territorial government, have been designated as wildlife refuges. The USVI government owns 34 cays (two are owned in part; Protestant Cay is leased to a hotel; see table 5.2 for list of ownership). The federal government owns nine cays and part of two others; all federally owned cays are protected within Virgin Islands National Park, Hassel Island National Monument, Buck Island Coral Reef National Monument, or as National Wildlife Refuges.

Conservation Actions Implemented Since 2005

Due to their critical value to vulnerable and endangered wildlife, the cays have received considerable management and conservation attention since the 2005 CWCS prioritized their protection through invasive species control.

Eradication of Invasives
In partnership with USDA/APHIS, eradication of rats on Congo, Dutchcap, and Saba cays was completed in 2004, with rats also removed from Buck and Capella islands off St. Thomas. APHIS also removed goats from Dutchcap. The rat eradication on Congo was unsuccessful, although it is uncertain if that was due to recolonization from nearby cays or from a remnant surviving population (Savidge et al. 2012).

Periodic efforts to eradicate rats from Ruth Island have yet to be successful, but these efforts have only included the use of snap traps and not rodenticide due to concerns of the effects of poison on the endangered St. Croix Ground Lizard. However, with the recent attempt at rat eradication on Green Cay (STX) using rodenticide and without obvious effects on the lizard, it may be possible to eliminate rats from Ruth Island in the future. Rats are an ongoing problem on Protestant Cay.

Endangered Species Management and Recovery
The St. Croix Ground Lizard survives only in remnant populations on cays around St. Croix (see Reptiles chapter for more information). Efforts to expand the population from Green and Protestant cays resulted in the establishment of a translocated population on Ruth Island in the 1970s. Using lessons learned from that project, the NPS, USFWS, and DFW collaborated with Texas A&M University to introduce ground lizards to Buck Island in 2008 (Fitzgerald et al. 2015). Monitoring of the population and distribution status of the St. Croix Ground Lizard has occurred periodically on all four St. Croix cays, with special attention to the successfully established Buck Island population to evaluate the success of the recovery effort.

Several efforts have been made to work with the management of the Hotel on the Cay (Protestant Cay, STX) to manage and minimize the effect of the hotel's activities on the population of the St. Croix Ground Lizard on the island. Ground maintenance by the hotel reduced cover for the lizards, and increased their risk of predation from cattle egrets nesting in large trees. DFW contracted Geographic Consulting to produce a user-friendly management plan for ground lizard habitat on the cay (Valiulis 2011). A variety of native trees were planted to increase habitat, but many were subsequently bulldozed or left unmaintained by hotel staff. Frequent changes in hotel management has made the implementation of long term habitat improvement measures difficult. In 2010, DFW contracted USDA-Wildlife Services to implement measures to harass the cattle egrets; while these measures were successful in the short term, it was not until the large trees were removed that the cattle egrets ceased to be a significant threat to the lizards.

In-water studies of sea turtle use of near-shore habitat around Buck Island (St. Croix) have been conducted and several turtles that were satellite tagged have revealed long-distance migration patterns. UVI students have been involved in several thesis projects that have contributed to the knowledge of these turtles.

Resource Surveys
Ruth Island was the focus of an in-depth mapping project in which areas of interest, such as the extent of invasion by tan-tan and hurricane grass, were delineated. Surveys for nesting birds, especially Least Terns and White-crowned Pigeons, were also conducted on this island. Initial efforts were made to improve habitat for the St. Croix ground Lizard by removing invasive

vegetation. Surveys of herpetofauna on cays around St. Thomas were conducted between 2004 – 2008. Several genetic samples were collected although these have yet to be processed.

Priorities for Conservation Actions

Restoration Actions: Removal of non-native predators and herbivores is an effective restorative measure. While rats have been eradicated from most cays that support important seabird breeding colonies, many other cays with valuable wildlife resources have not received this treatment.

Protection Actions: Better permitting and policy regarding development on cays is critical to protect fragile habitats and vulnerable species on private lands. Guidelines for sustainable development and management of construction impacts should be developed to prevent introduction of non-natives (including pets), erosion, and pollution.

Acquisition Actions: Several private islands have been under considerable development threat in recent years; acquisition of cays to bring them into the wildlife refuge system would safeguard those resources and metapopulation opportunities. Priority islands for acquisition are Hans Lollik, Great St. James, and Thatch.

Education/Recreation Actions: Cays around St. Croix already offer recreational activities, with a hiking trail on Buck Island and a popular beach on Protestant Cay. Although most cays around St. Thomas/St. John are difficult to access, several have the potential to offer recreational opportunities, such as Cas Cay and Buck Island (USFWS Wildlife Refuge). Tours and signage can increase the educational value of these experiences.

***Post-hurricane Needs*:** Because of their limited extent, terrestrial resources on the cays were disproportionately affected by the 2017 hurricanes. Mapping and monitoring of vegetation and habitat mosaics including marine environments is important towards understanding resilience to these disturbances. Vigilance and response towards new invaders is an important priority.

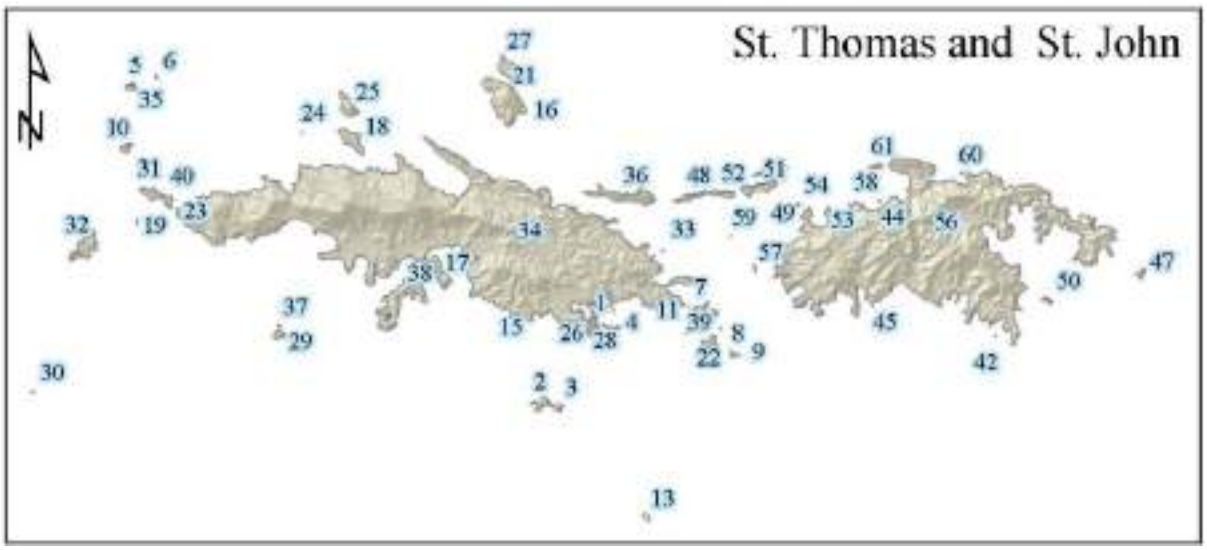


Figure 7.1. St. Thomas and St. John and surrounding cays. Refer to Table 5.2 for island names.

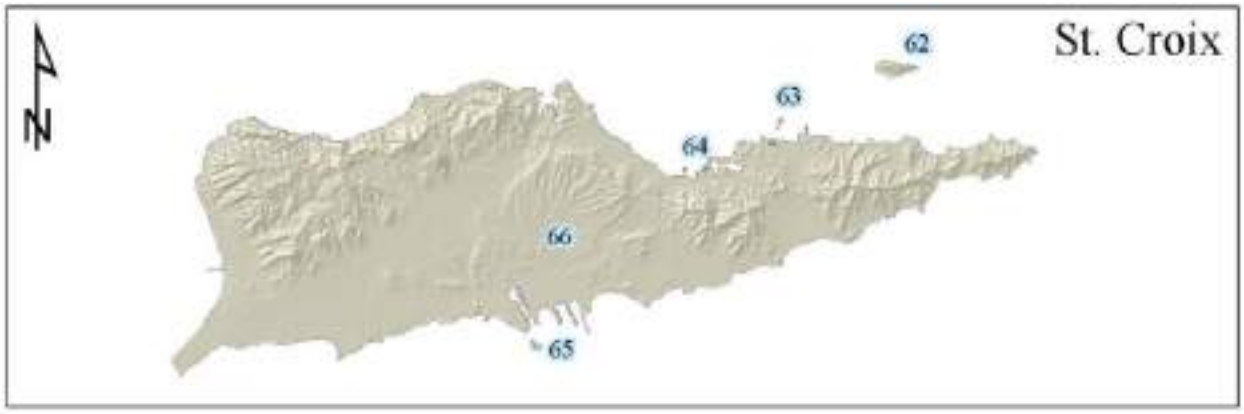


Figure 7.2. St. Croix and surrounding cays. Refer to Table 5.2 for island names. Figures adapted from Gould et al. 2013.

Table 7.1. Islands, cays and rocks names of the U.S. Virgin Islands.

Island	#	Island	#	Island	#	Island	#
Bovoni Cay	1	Inner Brass Island	18	Sula Cay	35	Mingo Cay	52
Buck Island (STT)	2	Kalkun Cay	19	Thatch Cay	36	Perkins Cay	53
Capella Island	3	Little Flat	20	Turtledove Cay	37	Ramgoat Cay	54
Cas Cay	4	Little Hans Lollik Island	21	Water Island	38	Rata Cay	55
Cockroach Cay	5	Little St James Island	22	Welk Rocks	39	St. John	56
Cricket Rock	6	Little St Thomas Island	23	West Cay	40	Steven Cay	57
Current Rock	7	Lizard Rocks	24	Blunder Rock	41	Trunk Cay	58
Dog Island	8	Outer Brass Island	25	Booby Rock	42	Two Brothers	59
Dog Rocks	9	Patricia Cay	26	Carval Rock	43	Waterlemon	60
Dutchcap Cay	10	Pelican Cay	27	Cinnamon Cay	44	Whistling Cay	61
Fish Cay	11	Rotto Cay	28	Cocoloba Cay	45	Buck Island (STX)	62
Flat Cay	12	Saba Island	29	Congo Cay	46	Green Cay (STX)	63
Frenchcap Cay	13	Sail Rock	30	Flanagan Island	47	Protestant Cay	64
Great St. James	14	Salt Cay	31	Grass Cay	48	Ruth Cay	65
Green Cay (STT)	15	Savana Island	32	Henley Cay	49	St Croix	66
Hans Lollik Island	16	Shark Island	33	Leduck Island	50		
Hassel Island	17	St. Thomas	34	Lovango Cay	51		

Table 7.2. Ownership of islands and cays of the U.S. Virgin Islands.

Island Ownership		
Territorial Government	Federal Government	Private
Bovoni Cay Capella Island Carval Rock Cas Cay Cockroach Cay Congo Cay Cricket Rock Dog Island Dutchcap Cay Flanagan Island Flat Cay and Little Flat Cay Frenchcap Cay Grass Cay Hassel Island (partial) Kalkun Cay Leduck Island Outer Brass Island Perkins Cay Protestant Cay Ruth Cay Saba Island Sail Rock Salt Cay Savana Island Shark Island Steven Cay Sula Cay Turtledove Cay Water Island (partial) West Cay Whistling Cay	<u>National Park Service</u> Buck Island (St. Croix) Booby Rock Cocoloba Cay Hassel Island (partial) Henley Cay Ramgoat Cay Rata Cay Trunk Cay Waterlemon Cay <u>USFWS - NWR</u> Buck Island (St. Thomas) Green Cay (St. Croix) <u>U.S. Dept. of Interior</u> Water Island (partial) <u>Unknown</u> Two Brothers Green Cay (St. Thomas)	Cinnamon Cay Current Rock Fish Cay Great St. James Island Hans Lollick Island Hassel Island (partial) Inner Brass Island Little Hans Lollick Island Little St. James Island Lovango Cay Mingo Cay Patricia Cay Pelican Cay Rotto Cay Thatch Cay Water Island (partial)

Source: Dammann and Nellis (1992), with corrections by Judy Pierce.

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

Banner photo: Dutchcap Cay by R. Platenberg

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APPENDICES

Appendix 1.1. Progress toward the 2005 CWCS Priority Action Goals

The following tables provide the priority actions for species and habitats from the 2005 VI-CWCS and identify how the goals were met by DFW, including grant programs and publications, and by other entities.

Goals towards Species Conservation

Resource	CWCS Priority	Progress	Reference
Terrestrial and Freshwater Invertebrates	Species Inventory, including distribution and reference collection	Not completed for terrestrial invertebrates	
		Surveys of freshwater invertebrates	Nemeth & Platenberg, 2007; Tennant unpublished data
		Populations surveys of the Great Land Crabs were conducted on St. Thomas, St. John, and St. Croix (S. Gordon)	T-7 (SWG) 2008-2011
	Determine Species of Concern	Not completed	
	Evaluate crab harvest of crabs to establish regulations	Completed (S. Gordon)	T-7 (SWG) 2008
Amphibians	Distribution and abundance surveys	Ongoing; Population monitoring of reptiles and amphibians.	T-05 (SWG) T-07 (SWG) 2006-2011
		Ecological parameters of native herpetofauna.	T-5 (SWG) 2006
		Population surveys and climate change impact baseline data for St. Thomas.	T-9-R-1 (SWG) 2011-2012
		Dissemination of conservation status	Platenberg & Boulon 2006
	Habitat Protection	Not completed; protection measures initiated as opportunities arise	T-5 (SWG) 2006
	Impacts of non-natives	Completed; Study of invasive amphibians	T-07 (SWG) 2007-2011
	Public education	Do One Thing for Wildlife	T-09 (SWG) 2009-2012
	Establish monitoring protocol	Completed for amphibians (R Platenberg)	T-7 & T-9 (SWG)
		Distribution maps of native and non-native herpetofauna in the USVI (R Platenberg)	T5 (SWG)
Terrestrial Reptiles	Distribution and abundance surveys	Ongoing	T-05-2 (SWG), T-05-3 (SWG) E-7-HM-2 (2012) Reynolds et al. 2015, Barker et al. 2011
		Survey of terrestrial reptiles and amphibians within the northern US Virgin Islands.	T-05 (SWG)

Resource	CWCS Priority	Progress	Reference
	Ecological studies	Completed: habitat models for Tree Boas	Harvey & Platenberg 2009 T-1 (SWG) and E-3 (ES) 2005-2006
		Behavioral surveys of the St. Croix Ground Lizard were conducted on Green Cay.	T-4-2 (SWG) 2005
	Habitat protection	Completed: Boa habitat delineation protocol	Platenberg & Harvey 2010 T5-3 (SWG) 2006
		Restored and monitored St. Croix ground lizard habitat on Protestant Cay.	E-7-HM-2(ES) 2012
	Conservation measures for endangered reptiles	Completed: habitat restoration plan for Protestant Cay	Valiulis 2011 E-7-HM-1 (ES) 2011
		Habitat restoration Protestant Cay began	E-7-HM-1 (ES) 2011
		Completed: draft recovery plan revision for VI Boa	Platenberg 2011 E-5-R-2 (ES) 2011
	Impacts of non-natives	Not completed	
	Assess feasibility of translocation	Completed: *Ameiva polops* introduction to Buck Island; monitoring protocol established	R-1- 3 (ES) 2006
	Public education	Do One Thing for Wildlife; Boa outreach project	T-9 (SWG)
Sea Turtles	Habitat protection	Not completed	
	Conservation measures for sea turtles	STAR established to help stranded sea turtles on STT and STX.	E-6-R-3 (ES) 2011
	Impacts of non-natives	Reduction of mammalian predators in turtle nesting areas	E-6-R-3 (ES) 2011
	Extend nesting beach monitoring	STT & STJ beach patrols	E-6-R-3 (ES) 2011-2012
Seabirds	Distribution and abundance surveys	Protected bird population surveys on Ruth Cay	W-23-1, Amendment 1 (WR) 2009
		Roseate Tern surveys on St. Thomas, St. John, and surrounding cays.	Nellis et al., 2016
		Nesting site surveys for Least Terns on St. Croix were.	W18 (WR) 2005
	Reduce disturbance to breeding colonies	Signs posted at all colonies	
		Predator management of Least Tern colonies.	W-18- 2 (WR) 2005
	Public education	Seabird flyers produced	
	Habitat protection & restoration	Trails established to monitor Masked Boobies populations on Cockroach Cay.	W- 23-HM- 3-(WR) 2010
		GIS habitat and monitoring maps were created for Ruth Cay.	W-23-1 (WR) 2009
	Assess seabird bycatch	Fishermen surveys of bycatch	W-23 (WR) 2010
	Regional conservation measures for seabirds	Satellite tracking of Frigatebirds	Zaluski (JVDPS) 2015
	Impacts of non-natives	Rat & goat eradication from cays	W-23-1 (WR) 2009
	Information dissemination	Leaflets produced	
	Population monitoring	Least Tern population and nesting	W18-2 (WR) 2005

Resource	CWCS Priority	Progress	Reference
		activity were surveyed on STX.	
		Cays monitored for seabird nesting and presence of non-natives	W-23-1, Amendment 1 (WR) 2009
Waterfowl, Marshbirds, and Shorebirds	Distribution and abundance surveys	Population and distribution surveys of waterbirds were conducted on STX.	W-20- 1 (WR) 2009. Valiulis, 2009
	Breeding site monitoring	Monitored /surveyed to determine breeding productivity and nesting survival.	W-12-9 (WR) 2006
	Population monitoring	Population and distribution surveys of waterbirds were conducted on STX.	W-20- 1 (WR) 2009
	Conservation measures for extirpated species	Not completed	
	Control of cattle egrets	Dissuasion and removal of roost trees on Protestant Cay	
		Population surveys of and depredation measures were taken to control the cattle egret population and removed large mahogany trees on Protestant Cay.	T-8-R- 1 (SWG) and T-8-R-2 (SWG) 2010-2011
	Regional conservation measures	Participation in Caribbean Waterbird surveys	
	Assess nuisance birds	Technical guidance to hotels about ducks	
Landbirds	Distribution and abundance surveys	Pop surveys of nesting Columbids were conducted on STX.	W-12-8 (WR) 2005-2006
	Ecological studies	Compared pre- and post-hurricane bird species composition and abundance 13 years after Hurricane Hugo.	W-19- 1(WR) 2006
	Population assessment and monitoring	Not completed	
	Conservation measures for species of concern	White-crowned pigeon surveys	W-23 (WR) 2009, Santiago-Rios
	Impacts of stochastic events	Not completed	
	Impacts of harvest on hunted species	Not completed	
	Evaluate threats to migrants	Not completed	
	Assess nuisance birds	Kestrel nest box program	DFW Special Projects
Terrestrial Mammals: Bats	Inventory & population assessment	Completed; population and habitat surveys	IRF 2009; W-22 (WR) W-24-R-4 (WR) 2011
	Identify habitat use	Bat houses were deployed and monitored on St. Thomas, St. John, and St. Croix.	W-24-R-2-4 (WR) 2010-2012
Terrestrial Mammals: non-natives	Survey distribution	Not completed	
	Reduce non-natives in sensitive habitats	Rat & goat eradication from cays, mongoose control in turtle nesting	W-23-1 (WR) 2009

Resource	CWCS Priority	Progress	Reference
		areas	
Exotic Species	Impose more stringent importation restrictions	Not completed	
	Increase availability of funding for response	Not completed	
	Increase training for inspection	Not completed	
	Evaluate impact on natives	Conducted distribution and population surveys to locate non-native species of reptiles and amphibians to look at impacts on native herpetofauna populations	T-07- 1(SWG) 2008
	Eradicate new arrivals		
	Prioritize target areas for response		
	Eradicate rats & goats from cays	Completed; monitoring ongoing	W- 23-HM- 3 (WR) 2011
		Post rat-eradication monitoring was conducted on offshore cays (Ramgoat Cay, Buck Island (STT), Cas Cay, and Protestant Cay.	W-23- HM-4 (WR) and T-6 (SWG) 2006-2010
	Identify pathways of invasion	Not Completed	
	Monitor populations	White-tailed Deer Monitoring on STX.	W-23- 1,(WR) 2009-2011
		Took 163 rat tail clippings from offshore cays.	W-23-1 (WR) 2009

Goals toward Habitat Conservation

Resource	CWCS Priority	Progress	Reference
Beaches & Rocky Shorelines	Habitat protection		
	Reduce threats from runoff, erosion, and trash	CoastWeeks Beach Clean-ups	
	Monitor wildlife use	Sea turtle beach patrols	E-6-R-3 (ES) 2011
	Monitor detrimental impacts	Not completed	
Wetlands'	Habitat conservation measures	Wetland Conservation Plans for St. Thomas/St. John	Platenberg 2006, McNair publications
		Final draft of STEER management plan was completed.	W-25-P-2 (WR) 2012
	Monitor & assess wildlife use	Breeding bird surveys, St. Croix	McNair publications W-12-9 (WR) 2006
	Habitat protection	Land acquisition, St. John; Golden Pond	Coral Bay Community Association
		Identified species of concern and their habitats.	DFW CWCS, T-9 (SWG) 2010-2012
	Monitor development and encroachment	Enhanced GIS capability	
Shrublands & Grasslands	Inventory distribution & extent	Not completed	
	Monitor wildlife use	Not completed	
	Habitat conservation measures	Not completed	
	Monitor development and encroachment	Not completed	
Forests	Inventory distribution & extent Monitor wildlife use Habitat protection & restoration	Forest surveys Habitat surveys for bats, other wildlife	USFS, USDA DFW T-9 (SWG) 2010-2012, W-24 (WR) 2012
	Establish monitoring protocol	WRRI watershed project	Platenberg, 2017

Resource	CWCS Priority	Progress	Reference
Cays	Habitat protection	Increased enforcement of cay visitation regulations	
	Habitat conservation measures	Invasive plant removal	DFW W-23 (WR) 2009
	Land acquisition	Not completed	
	Wildlife protection & conservation	Ongoing; Signage, public education, eradication of non-natives	DFW W-23 (WR) 2009
		Base map of 10 cays.	DFW W-23 (WR) 2009
		Ruth Cay habitat maps	DFW W-23 (WR) 2009
	Monitor wildlife use	Ongoing; Seabird population surveys, herpetofauna surveys	DFW T-7, T-9 (SWG) 2010-2012 W-23 (WR) 2009
	Monitor habitat threats	Ongoing; identifying and managing threats	W-23 (WR) 2011

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Appendix 1.2. Participants in the VI-WAP Development and Review

The following is a list of the professional and community stakeholders that participating in WAP planning meetings. "MWAP" was a Marine Resources meeting held at Bolongo Beach Resort, St. Thomas, on 1 February, 2017; "STT" was a joint CLCC / VI-WAP meeting held at UVI, St. Thomas, on 17 February 2017, and "STX" was a joint CLCC / VI-WAP meeting held at TNC, St. Croix, on 2 March 2017.

Name	Affiliation	Meeting attended
Sarah-Ann Charles	Fish & Wildlife (DFW)	MWAP 1 Feb 17
Amy Kelley	Red Hook Dive Center	MWAP 1 Feb 17
Rob Tutton	Vital Freediving, CORE	MWAP 1 Feb 17
Karen Hauer	Canines, Cats & Critters	MWAP 1 Feb 17
Julianne Lilholt	Ritz-Carlton	MWAP 1 Feb 17
Jason Quetel	CORE	MWAP 1 Feb 17
Tarrant Dunford	Diver	MWAP 1 Feb 17
Akacia Halliday	UVI	MWAP 1 Feb 17
Lora Johansen	UVI	MWAP 1 Feb 17
Kristen Ewan	UVI	MWAP 1 Feb 17
Mareike Duffing	UVI	MWAP 1 Feb 17
Chrystal Okamoto	unaffiliated	MWAP 1 Feb 17
Miles Brill	unaffiliated	MWAP 1 Feb 17
Brenda Sylvia	Silver Raven Studios	MWAP 1 Feb 17
Marilyn Brandt	UVI	MWAP 1 Feb 17
Tyler Smith	UVI	MWAP 1 Feb 17
Kitty Edwards	CZM	MWAP 1 Feb 17
Renata Platenberg	UVI	MWAP 1 Feb 17
Haley Goodson	UVI	MWAP 1 Feb 17
Danielle Lasseigne	UVI	MWAP 1 Feb 17
John Osoinach	UVI	MWAP 1 Feb 17
Steve Matthews	unaffiliated	MWAP 1 Feb 17
Leslie Henderson	CZM	MWAP 1 Feb 17
Valerie Peters	Blue Flag	MWAP 1 Feb 17
Alex Silva	VIMSIA Montessori	MWAP 1 Feb 17
Tom O'Brien	unaffiliated	MWAP 1 Feb 17
Katharine Egan	UVI	MWAP 1 Feb 17
Sydney Nick	UVI	MWAP 1 Feb 17
Amelie Jensen	UVI	MWAP 1 Feb 17
Carolyn Courtien	UVI	MWAP 1 Feb 17
Allie Durdall	UVI	MWAP 1 Feb 17
Rick Manseau	Aqua Action	MWAP 1 Feb 17
Alex Gutting	UVI	MWAP 1 Feb 17

Name	Affiliation	Meeting attended
Vernita Smith	UVI	MWAP 1 Feb 17
Elizabeth Smith	UVI	MWAP 1 Feb 17
Paul Anderson	UVI	MWAP 1 Feb 17
Karl Callwood	Camp Umoja & Environmental Rangers	MWAP 1 Feb 17
Kitty Edwards	DPNR CZM Outreach	STT 17 Feb 17
James Yrigoyen	USFWS STT office	STT 17 Feb 17
Valerie Peters	VICS (Blue Flag, Coral World)	STT 17 Feb 17
Kristin Grimes	UVI, UVI WRRI	STT 17 Feb 17
Teresa Turner	UVI	STT 17 Feb 17
Haley Goodson	UVI	STT 17 Feb 17
Vanessa McKague	UVI	STT 17 Feb 17
Patsy Breunlin	Phantasia Tropical Botanical Garden	STT 17 Feb 17
Stevie Henry	UVI	STT 17 Feb 17
Brent Murry	USFWS CLCC	STT 17 Feb 17
Peter Freeman	Northside Resource Economics	STT 17 Feb 17
Mareike Duffing	WAP UVI	STT 17 Feb 17
Miguel Garcia	CLCC	STT 17 Feb 17
Dave Worthington	VI National Park	STT 17 Feb 17
Benita Martin	WE Grow Food VI	STT 17 Feb 17
Jose Cruz	USFWS	STT 17 Feb 17
Alan Shane McKinkley	USDA-APHIS	STT 17 Feb 17
Caroline Rogers	USGS	STT 17 Feb 17
Paul Jobsis	UVI CMES	STT 17 Feb 17
Renata Platenberg	UVI	STT 17 Feb 17
Susan Zaluski	BVI JVD Preservation	STT 17 Feb 17
Pedro Nieves	DPNR-CZM	STT 17 Feb 17
Jonathan Brown	DPNR Fish & Wildlife	STT 17 Feb 17
Margaret (Magoo) Boller	Save Salt River Bay Coalition	STX 2 Mar 17
Nathaniel Hanna Halloway	NPS	STX 2 Mar 17
Renata Platenberg	UVI	STX 2 Mar 17
Ivan Butcher II	STX Hiking/SEA/VIUCFC	STX 2 Mar 17
Bernard Cstillo II	UVI	STX 2 Mar 17
Marlon Hibbert	NOAA. OCM	STX 2 Mar 17
Claudia Lombard	USFWS	STX 2 Mar 17
Caroline Pott	DPNR-CZM	STX 2 Mar 17
Devon Bracy	DPNR	STX 2 Mar 17
Lisa Yntema	unaffiliated	STX 2 Mar 17
Luis Villanueva	USFWS	STX 2 Mar 17
Brent Murry	USFWS CLCC	STX 2 Mar 17
Kavita Balkaran	DPNR Fish & Wildlife	STX 2 Mar 17

Name	Affiliation	Meeting attended
Jennifer Olah	Cruzan Cowgirls	STX 2 Mar 17
Julio M Santiago Rios	DPNR Fish & Wildlife	STX 2 Mar 17
Kemit-Amon Lewis	TNC	STX 2 Mar 17
Aaron Hutchins	unaffiliated	STX 2 Mar 17
Jennifer Valiulis	SEA	STX 2 Mar 17

The following individuals submitted comments on review of the 2017 VI-WAP.

Name	Affiliation
Ivan Llerandi-Roman	USFWS
Jan Zegarra	USFWS
James Yrigoyen	USFWS
Brent Murry	CLCC
Miguel Garcia-Bermudez	CLCC
William Coles	DPNR-DFW
Daniel Nellis	DPNR-DFW
Sarah-Ann Charles	DPNR-DFW
Eric Wooden	DPNR-DFW
Matt Kamman	DPNR-DFW
Alexis Sabine	DPNR-DFW
Caroline Pott	DPNR-EEMP
Sharon Coldren	CBCC
Rachel McKinley	CBCC
Olassee Davis	UVI
Toni Thomas	UVI
Michael Evans	USFWS
Jason Budsan	EAST
Karl Callwood	Save Mandahl Bay
Nicole Angeli	unaffiliated
Robert Powell	unaffiliated
Margaret Boller	unaffiliated

Appendix 1.3. Stakeholder and Public Participation in the VI-WAP Development and Revision

The VI-WAP is a plan for the Territory and needed to be developed with input from resource managers across entities and the VI community. The joint collaboration between UVI, DFW, and SEA aimed to join research, management, and community interactions into the planning effort. In updating the plan, we put considerable effort into taking a collaborative approach by reaching out to stakeholders; we felt that if people participated in drafting the plan that they would be interested in seeing and using it on completion.

Information Mining

Our first step was to distribute an online survey to resource managers that asked two simple (but loaded) questions: 1) what are your main concerns about the resources you manage or are interested in, and 2) what are the top five actions that might be taken to address those concerns. We used this initial feedback (from 14 individuals) to structure our subsequent conversations.

Natural resource managers and habitat/species experts were targeted for additional specific input on their area of expertise or on the plan in general. Input was solicited through email, one-on-one interviews, group meetings and any other method that elicited a response from individuals with the NPS, USFWS, UVI, DPNR, TNC, and others. We also worked with groups that are creating related plans, such as the Caribbean Landscape Conservation Cooperative (CLCC), to share planning strategies and input received from community and stakeholders.

We reached out to participants in related workshops and meetings for input and review of the WAP. DFW hosted a VI Sea Turtle Workshop in June 2016, during which one of the authors presented on the VI-WAP, and an Invasive Species Workshop in September 2016. These opportunities elicited discussion on broader conservation challenges that were integrated into the plan.

In addition to gathering information from experts and through extensive searches of literature, existing management plans and other relevant documents, we solicited input from the community through a variety of means, including social media and public meetings.

Threat Assessment

Using stakeholder and expert input, personal experience with resources, and information mined from reports and published accounts, we used the IUCN threat classification scheme (IUCN 2016) to evaluate each species/habitat. We ranked realized and potential threats according to scope and severity of threat to each resource, and assigned a rank (high, medium, low) based on scope and severity of threat to the resource (see Appendix 1.4 for an example for selected terrestrial species; we did the rankings across all terrestrial species and for marine habitats and organisms).

Using these rankings, we identified the priority threats for each resource and across resources. The threats that ranked the highest across terrestrial resources were habitat loss, pollution (both trash and sediment/sewage input to aquatic systems ranked high), human disturbance, and invasive species. Climate change was identified as posing a threat across resources but was much more difficult to rank due to unknown influences. The major climate change threats across marine

resources were increased temperature, ocean acidification, and changes to habitat structure and species distribution.

Development of Conservation Goals, Strategies, and Actions

Focusing on major threats to habitats, we conducted stakeholder meetings on St. Croix and St. Thomas to prioritize strategies and actions on threats. These day-long meetings brought university researchers, NGOs, government agencies, tour operators, and other interested parties together for an intensive planning effort, with participation from all three islands. We also conducted a marine resources community meeting to gain insight on threats and solutions from marine stakeholders. At these meetings, participants were asked to rank threat categories according to the strength of impact on habitats, and then identify and rank solutions to counter the threats. For a list of experts that contributed input to this document, see Appendix 1.2.

We also compiled priority actions from the 2005 CWCS and categorized them according to theme (e.g., inventory, species/habitat studies, education, capacity, etc.). We used these categories to classify objectives and actions into broad goals for conservation action.

We then compiled the stakeholder input into broad "solutions" to develop an overarching strategy for wildlife resources within the USVI and regionally. We aligned the solutions with fundamental objectives, and aligned threats, threat rankings, and resource needs to conservation action (solution) categories and developed goals, strategies, and actions based on resource needs and priority ranking from stakeholder input. Using the input from the surveys, interviews, and meetings, we identified eight priority goals toward addressing the main issues surrounding species and habitat conservation in the territory with the following themes: 1) habitat and species protection, 2) habitat and species management, 3) capacity, 4) research, 5) education and outreach, 6) adaptive management, 7) adaptation and mitigation, and 8) economics and incentives. We adapted the goals and strategies from the National Fish, Wildlife and Plants Climate Adaptation Strategy (wildlifeadaptationstrategy.gov) as a framework and translated the goals and strategies to match USVI needs.

The main concerns of most of the participants of each public input session were more societal: lack of enforcement and lack of knowledge/concern about the resources within the community. Community members focused on single-use plastics as being both a physical threat (plastic debris in the environment) and a societal problem (absence of concern). We categorized these influences on species and habitat condition as "ubiquitous threats", being those impacts that are associated with multiple resources and/or the conservation management of these resources. These include challenges such as data sharing capability, poorly defined and enforced regulations, and shortfalls in personnel and funding. This observation clearly emphasizes that wildlife and species conservation cannot be relegated as a task for DFW alone, but is a multi-agency endeavor that must include community participation.

Stakeholder and Public Review

The draft VI WAP was made available to stakeholders for review in March 2017 prior to submission to the SWAP Review Team. Comments were received from several USFWS partners. This was deemed insufficient and a second review period was opened up for five weeks from May to June 2018 upon recommendation from the SWAP review team. A Google website was created

that allowed open access to each section contained within a separate page to allow for ease of access and navigation. A comment form was also provided at this site to collect reviewer feedback; reviewers were also able to download sections for a more thorough evaluation.

In total, comments were received from 22 individuals (listed in Appendix 1.2). The most common comment referred to the impractical format, i.e., that the document was too large to be useable. Our response was to break the document into two sections that separated the management/compliance requirements from the natural history component. We also streamlined the text by moving cited literature into bibliographies for each section. While we received comments that the document contained too much detail, particularly for certain taxa (i.e., amphibians, reptiles, and bats), we also received comments, primarily from non-technical sources, that praised the depth, detail, and content of the document. Several individuals felt that this is a useful document towards addressing conservation challenges in the USVI. We felt that the value of the 2005 CWCS was contained within the collection of information on natural history that is not published elsewhere and made the decision to retain the detail. We recommend that the document sections be formatted into individual webpages within a VI-WAP website for ease of access.

Reviewers also struggled to locate specific conservation actions. The overarching strategy (Table 5.2) was difficult to interpret and also contained objectives that indirectly aided in wildlife and habitat conservation. We created a new Priority Action table (Table 5.3) to provide specific direct action steps that identified indicators, resources (particularly SGCN) expected to benefit from actions, and potential partners in accomplishing each action. Other comments provided or directed us to additional information that we made every effort to incorporate into the document.

The draft document was completed prior to the 2017 twin hurricanes Irma and Maria, and many reviewers felt that a significant component had been omitted, i.e., the impacts of the storms, ecosystem response, and recovery and resiliency management needs. While we were unable to fully address these during the limited revision period, we included a brief section of post-hurricane needs for each resource.

We acknowledge several deficiencies in our approach to updating this plan. We did not thoroughly communicate with some key entities such as the Waste Management Authority, Department of Education, Department of Agriculture, Department of Tourism, and even divisions within the Department of Planning and Natural Resources. Most of our community input came from people that were willing and able to come to public meetings about conservation; this is not necessarily a representative cross section of the entire community. We acknowledge these deficiencies for the purpose of identifying and ensuring the need to include these entities in implementation of the WAP strategy within the action steps and subsequent revisions.

Appendix 1.4. Threat Rankings

The tables on the following pages were used to identify and prioritize threats for USVI terrestrial species, including SGCN, terrestrial habitats, and marine habitats and organisms (invertebrates, fish, and sea turtles). Each threat (from IUCN threat categories; iucnredlist.org) was ranked according to severity (how bad it is) and scope (how widespread it is, i.e., how many populations are affected) for each resource. Where specific threats were known, these were identified. The threat prioritizations were then used to develop potential solutions which were aligned with goals and fundamental objectives (Chapter 5).

The accompanying tables are for example only, the full assessment is not included within this document.

Table 1. Ranking of threat risk to resources. H (high risk) = significant/widespread impact, affects a large proportion of populations; M (medium risk) = risk that poses moderate impact or exposure; L (low risk) = risk limited in extent or scope

Threat Categories (from IUCN)			Gut Fauna (shrimp & fish)	Frogs	Bats	Stenoderma
Residential & commercial development					M	H
1.1	Housing & urban areas			H		
1.2	Commercial & industrial areas (marinas)			M		
1.3	Tourism & recreational areas			M		
Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops					
	2.1.2	small-holder farming		L	L	M
	2.1.3	Agro-industry farming				
2.2	Wood & pulp plantations					
	2.2.1	small-holder plantations				
2.3	Livestock farming & ranching					
	2.3.1	Nomadic grazing	L	M		
	2.3.2	small-holder grazing, ranching or farming				
2.4	Marine & freshwater aquaculture					
	2.4.1	Subsistence / artisinal aquaculture	U	M		
Energy production & mining						
3.1	Oil & gas (drilling)					
3.2	Mining & quarrying		L	M	L	L
3.3	Renewable energy			L	H	H
Transportation & service corridors						
4.1	Roads		H	M	L	M
4.2	Utility & service lines				U	U
4.3	Shipping lanes					
	cruise ships/cargo ships					
4.4	Flight paths					
Biological resource use						
5.1	Hunting & collecting terrestrial animals		U			
	5.1.1	Intentional use (species is target)				
	5.1.2	Unintentional use (species is not the target)				
	5.1.3	Persecution/control		L	M	L
	5.1.4	Motivation unknown/unrecorded				
5.2	Gathering terrestrial plants					
	5.2.1	Intentional use (species is target)				
	5.2.2	Unintentional use (species is not the target)			L	L
	5.2.3	Persecution/control				
	5.2.4	Motivation unknown/unrecorded				
5.3	Logging & wood harvesting				M	M
	5.3.1	Intentional use (species is target): subsistence/small scale				
	5.3.2	Intentional use (species is target): large scale				
	5.3.3	Unintentional effects (species is not the target): subsistence/small scale				
	5.3.4	Unintentional effects (species is not the target): large scale				
	5.3.5	Motivation unknown/unrecorded				

Threat Categories (from IUCN)			Gut Fauna (shrimp & fish)	Frogs	Bats	Stenoderma
5.4	Fishing & harvesting aquatic resources		U			
	5.4.1	Intentional use (species is target): subsistence/small scale				
	5.4.2	Intentional use (species is target): large scale				
	5.4.3	Unintentional effects (species is not the target): subsistence/small scale				
	5.4.4	Unintentional effects (species is not the target): large scale				
	5.4.5	Persectution/control				
	5.4.6	Motivation unknown/unrecorded				
Human intrusions & disturbance						
6.1	Recreational activities			L	M	U
	boating					
6.2	War, civil unrest & military exercises					
6.3	Work & other activities			L	M	U
Natural system modifications						
7.1	Fire & fire supression					
	7.1.1	Increase in fire frequency/intensity				
	7.1.2	Suppression in fire frequency/intensity				
	7.1.3	Trend unknown/unrecorded				
7.2	Dams & water management/use					
	7.2.1	Abstraction of surface water (domestic us	H	M	M	M
	7.2.5	Abstraction of ground water (domestic us	H	L		
	7.2.9	Small dams	H	M		
7.3	Other ecosystem modifications			H	H	H
Invasive & other problematic species, genes & diseases						
8.1	Invasive non-native/alien species/disease			H	L	U
	8.1.1	Unspecified species				
	8.1.2	Named species	M			
8.2	Problematic native species/disease					
	8.2.1	Unspecified species				
	8.2.2	Named species				
8.3	Introduced genetic material			UKNOWN		
8.4	Problematic species/disease of unknown origin					
	8.4.1	Unspecified species				
	8.4.2	Named species				
8.5	Viral/prion-induced diseases					
	8.5.1	Unspecified species (disease)				
	8.5.2	Named species (disease)				
8.6	Diseases of unknown cause					
Pollution						
9.1	Domestic & urban waste water					
	9.1.1	Sewage	M	M	M	M
	9.1.2	Run-off	H	L	H	H
9.2	Industrial & military effluents					
	9.2.1	Oil spills				
	9.2.2	Seepage from mining		L	L	L
	9.2.3	Type unknown/unrecorded				

Threat Categories (from IUCN)			Gut Fauna (shrimp & fish)	Frogs	Bats	Stenoderma
9.3	Agriculture & forestry effluents					
	9.3.1	Nutrient loads	M	M	M	M
	9.3.2	Soil erosion, sedimentation	M		H	H
	9.3.3	Herbicides and pesticides	M	L	H	L
	9.3.4	Type unknown/unrecorded				
9.4	Garbage & solid waste		H	L	M	M
9.5	Air-borne pollutants			M		
	9.5.1	Acid rain				
	9.5.2	Sahara dust			U	U
	9.5.3	Ozone				
	9.5.4	Type unknown/unrecorded				
9.6	Excess energy					
	9.6.1	Light pollution			U	U
	9.6.2	Thermal pollution	L		U	U
	9.6.3	Noise pollution				
	9.6.4	Type unknown/unrecorded				
Geological events						
10.1	Volcanoes					
10.2	Earthquakes/tsunamis					
10.3	Avalanches/landslides/soil erosion				L	L
Climate change & severe weather						
11.1	Habitat shifting & alteration			H	M	M
11.2	Droughts		M	H	H	H
11.3	Temperature extremes		L	H	U	U
11.4	Storms & flooding			L	L	M
11.5	Other impacts				U	U
Other options						
12.1	Other threat					
	threats outside region					