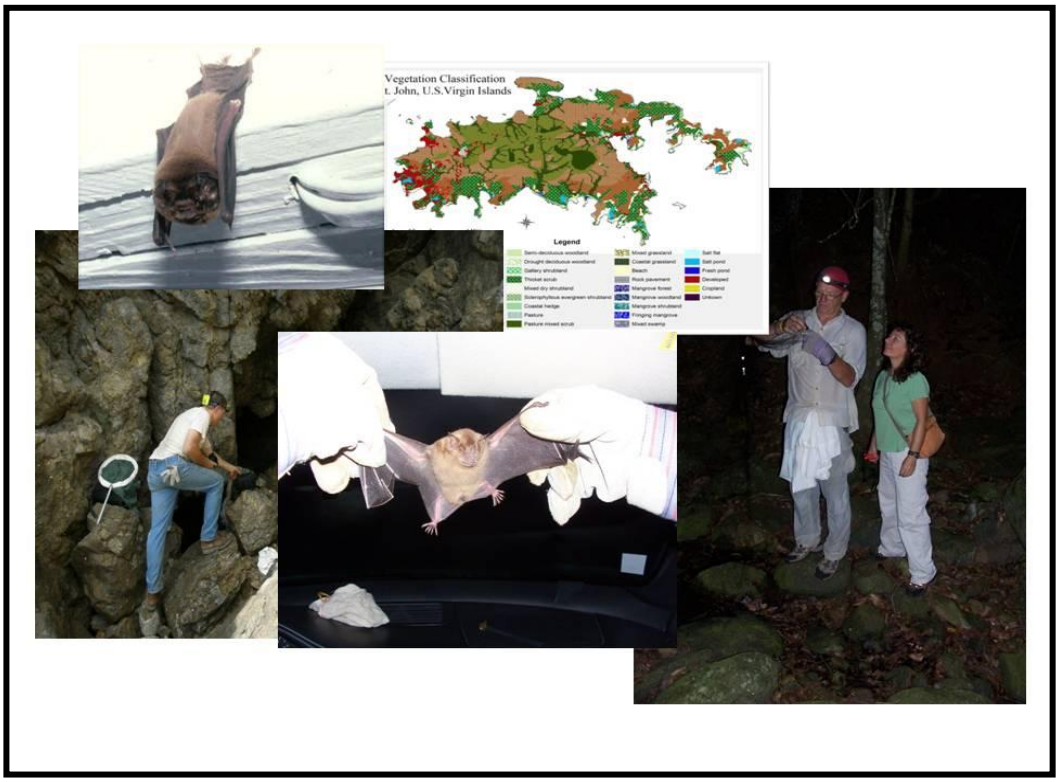
A Bat Conservation and Management Plan for St. Thomas and St. John, U.S. Virgin Islands



SUBMITTED BY:

island resources
FOUNDATION
6292 Estate Nazareth, #100
St. Thomas, VI 00802
Contract No. PC-PNR-101-2006

December 2009

A Bat Conservation and Management Plan for St. Thomas and St. John U.S. Virgin Islands

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SUMMARY

Bats are perhaps the most influential and significant macro-fauna of the Virgin Islands. The verdant green landscape of yesterday and its evolution to what we see today is in fact largely the result of the work of bats. Many of the plants evolved with animals and are dependent on them for pollination and dispersal of their seeds. What would happen if these denizens of the night were gone? What would happen to the protective cover of trees and other plants that insulate us from the desiccating sun and sustains us from day to day?

Islanders know of bats. They hear stories, and some see them darting in the evening skies, or as flutter by on silent wings amongst our fruit trees. But few islanders know the bats. It is very surprising that many people admit that they actually have never even seen a bat despite having lived in the islands most or all of their lives.

Much of what we think we know and almost all of what we have heard over the years is based largely on myths and legends passed down from generation to generation over hundreds of years. Bats are often viewed as omens, harbingers of death and evil, and many women cower in fear because it is believed that bats have a certain curiosity with the hair of human females, and are likely to become entangled in the process.

But we really know so little about bats. Across the world, bat populations are largely on the decline, but researchers know and understand so little about these animals, even as forest ecosystems decline and/or deteriorate. Bats more than birds, control insects, spread plant seeds, and pollinate countless species.

As the landscape of the Virgin Islands becomes more urbanized, forests and other habitats are left fragmented and depauperate, and the limited habitat available is not enough to support viable populations of many of the native species. It is with this backdrop that a management plan for the bats of the Virgin Islands is developed.

The Bat Conservation and Management Plan is unique and first of its kind for the Territory. It brings together the most up-to-date information on each species of bat on St. Thomas, St. John and the offshore cays, and provides a frame-work and strategy for the protection, conservation and management of the six known species to ensure their sustainability.

The Bat Conservation and Management Plan is a direct outcome of the "Survey of Bats of St. Thomas and St. John," a three year effort spanning from 2006 to 2008 (Lindsay et al. 2008).

The primary objectives of the project were to:

– "C*onduct species and distribution surveys of the bats of St. Thomas and St. John and surrounding cays, and update species and habitat information.*"

– "D*etermine ecological parameters and population dynamics, and the threats to the bat species.*"

– "D*evelop and institute education and conservation programs as well as mitigation measures, especially for sensitive and/or threatened bat populations.*"

The study team, under the guidance of the principal scientist and investigator, Dr. Gary Kwiecinski from the University of Scranton, Pennsylvania, undertook field surveys from August 2006 to March 2008. In addition to Dr. Kwiecinski, team members included Kevel Lindsay and Jean-Pierre Bacle (Island Resources Foundation) and Dr. Renata Platenberg (DFW-DPNR).

The team surveyed 39 localities on St. Thomas (which included 3 on Water Island), and 24 localities on St. John. Three offshore cays were examined for potential active bat caves. The sites encompassed riparian habitats, coastal areas, agricultural areas, aquatic habitats, and near-residential areas. The sites ranged from 474 m elevation at Crown Mountain, to sea level.

The Bat Conservation and Management Plan is a five-year program divided into four sections:

Section I provides background information on the project and a summary of the survey results from 2006 to 2008;

Section II provides an account of the species of bats, including descriptions, habitats and habits, and local, national and international conservation status;

Section III deals with conservation and management, including the issues and concerns. The section also provides actions needed to protect and conserve bats, as well as information for homeowners, and;

Section IV deals with homeowners and bats.

The appendices following this section provides information on a number of issues, including the DFW bat flyer, complimentary and supporting initiatives, funding and financial issues, plants that are important to native bats, and legislative issues.

One of the most important steps in the evolution of this plan was to look at the legal framework for bat conservation in the USVI. The development and implementation of effective conservation and management plans for bats of St. Thomas, St. John, and surrounding cays requires a supportive legal framework to give the responsible agencies the needed tools for implementation. As assessed through this project, the bats in the Territory depend on suitable habitat for their survival, including the availability of adequate food and fresh water.

A detailed analysis of the legislative and institutional mechanisms in the Virgin Islands for conservation and management of bats is beyond the scope of this project. Such an analysis, however, is an important supportive next step for effective implementation of any bats conservation and management plan developed pursuant to this project. Appendix V outlines this brief review and provides the framework for future analysis and planning for bats and other biodiversity protection in the USVI.

INTRODUCTION

Although bats are the only native mammals surviving today on St. Thomas and St. John (Philibosian and Yntema 1977), little is documented about them. Critical information, such as species and population size, population estimates, distribution data and threats were mostly unknown.

Bats are an important part of local folk-lore, myth and legend. But local views on bats are mostly negative, and people may go to extra lengths to eradicate bats wherever they are found.

One particular species, *Molossus molossus*, locally called the "roof bat" or "rat bat" on account of its small size, dark color, and its vague resemblance to a mouse, lives under the eaves and metal roofing of houses. At dusk, this species can be seen emerging from their roosts by the hundreds as they zig zag their way across the open skies in search of insects. But people view these creatures with apprehension and dread. The invariable question usually asked is "…*how do I get rid of the bats in my roof*?" People complain that they are noisy, dirty, creepy, dangerous, and are vampires. If bats are to be protected and populations sustained, these attitudes will need to change and bats viewed in more positive tones.

There are six species of bats reported for St. Thomas and St. John (Philibosian and Yntema, 1977; Koopman, 1975; Lazell and Jarecki, 1985; Kwiecinski and Coles, 2007; Bacle, Lindsay, and Kwiecinski, 2008; Lindsay, Kwiecinsky, and Bacle, 2008; Kwiecinsky, et al. 2009). These six species include the Pallas' mastiff bat (*Molossus molossus*), the greater fishing bat (*Noctilio leporinus*), the Jamaican fruit-eating bat (*Artibeus jamaicensis*), the Antillean cave bat (*Brachyphylla cavernarum*), the red fig-eating bat (*Stenoderma rufum*), and the Brazilian free-tailed bat (*Tadarida brasiliensis*). Recent estimates and ultrasonic surveys suggest that there are between six and eight species of bats extant on the islands today (Patterson, 1977; Genoways, pers. Comm., 2005).

Of the six species of bats reported for St. Thomas and St. John, three are listed as locally threatened and/or endangered (Division of Fish and Wildlife, 2005). They are *N. leporinus*, *B. cavernarum*, and *S. rufum*. However, although listed, virtually nothing was known about population numbers, population dynamics, and distributions across islands, and threats to species survival.

In order to effectively manage and protect the bats of St. Thomas and St. John, it had become increasingly evident that species and distribution surveys of the species on both islands and surrounding cays would need to be carried out; thus, the "Survey of the Bats of St. Thomas and St. John" was initiated. Species and habitat information on all bats were up-dated, and specific threats to these species and their habitats determined. With this data in hand, the team has designed what we believe to be appropriate conservation, management and mitigation measures and long-term strategies for the protection of the bats and their habitats.

Designing an appropriate management and conservation plan is no easy and glamorous undertaking. The task involved spring-boarding from a mostly field-based exercise of collecting the raw data, to literally mapping and teasing out often times seemingly abstract values into something more informative and relevant to the specific needs of the citizenry and agencies of these two islands.

Having a Plan is not a recipe for success and it is not expected to solve all of the conservation issues and problems that the bats of these islands face. However, it is a major step to help guide the road to recovery. The first step was undertaking the much needed surveys to update key information. The second step is the design of a management and conservation plan, itself a consensus between the various stakeholders in both islands. The third step would be the implementation of recommendations to their successful end.

COLLABORATING INSTITUTIONS

The institutions collaborating on this survey include:

Island Resources Foundation
www.irf.org

Island Resources Foundation is an independent, non-profit research and education organization with offices in, U.S. Virgin Islands, Tortola, British Virgin Islands, and Washington, D.C. Founded by Dr. Edward Towle in 1972, the Foundation is dedicated to protecting and enhancing the environments of small tropical islands and identifying development options that preserve the special qualities of island life.

Division of Fish and Wildlife, St. Thomas and St. John
www.vifishandwildlife.com

The Virgin Islands Division of Fish and Wildlife (DFW), an agency within the Department of Planning and Natural Resources, is mandated with the conservation and management of marine and wildlife resources within the territory. The division consists of three bureaus: Wildlife, Fisheries, and Environmental Education. The DFW is 100% federally funded through the US Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA). The DFW undertakes the management of the fisheries resources and wildlife management areas and reserves, and conducts research and management on wildlife and their habitats as outlined in the CWCS (Platenberg et al, 2005). Dr. Renata Platenberg, Wildlife Biologist III, is the project's Principal Investigator.

Bat Conservation International (BCI)
www.batcon.org

Bat Conservation International (BCI), based in Austin, Texas, is devoted to conservation, education, and research initiatives involving bats and the ecosystems they serve. It was founded in 1982, as scientists around the world became concerned that bats essential to the balance of nature and human economies were in alarming decline. Under the founding guidance of Dr. Merlin Tuttle, an internationally recognized authority on bats, the organization has

achieved unprecedented progress by emphasizing sustainable uses of natural resources that benefit both bats and people.

BCIs pioneering accomplishments have been featured on all major news networks in the United States, international wildlife documentaries, and in numerous prestigious books, magazines, newspapers, and web sites worldwide, educating millions of people to appreciate bats as invaluable allies.

Bat Conservation provided a small grant to expand the surveys on St. John to include areas within the VINP boundaries.

Virgin Islands National Park, St. John

www.nps.gov/viis

On August 2, 1956, legislation was passed by the U.S. Congress to authorize the establishment of the Virgin Islands National Park. The Park, which covers more than one half of St. John Island and Hassel Island in harbor, includes quiet coves, blue green waters, and white sandy beaches fringed by lush green hills. The Park boundary was expanded in 1962 and again in 1978 and currently encompasses some 14,689 acres (59.44 km^2), including the marine protected areas.

SECTION I: GENERAL BACKGROUND INFORMATION

STUDY AREA

Geography and Politics

The U.S. Virgin Islands are located in the eastern area of the Greater Antillean Chain of islands, about 140km east of Puerto Rico. The Territory consists of four main islands: St. Croix, St. Thomas, St. John, and Water Island, as well as over 50 offshore cays. The island is a mountainous topography with very small steep valleys and narrow coastal plains.

St. Thomas (81 km^2) and St. John (51 km^2), and Water Island (2 km^2) are situated on the Puerto Rican Bank to the east of the Puerto Rican islands of Culebra and Vieques. St. Thomas and St. John are separated by a distance of 3 km. Water Island, the fourth largest is located about 0.8 km southwest of Charlotte Amalie harbor. St. Croix, the largest Island, is located about 100 km south of St. Thomas, and is not part of the Puerto Rican Bank

According to the 2000 census, the population of the Territory is 108,612, with St. Thomas at 51,181, St. John 4,197 and St. Croix 53,234. The population density of each island is relatively high, with St. Thomas having the highest density of 633 people/km^2, St. John 83 people/km^2, and St. Croix 279 people/km^2.

St. Thomas, the main seat of government and commerce, is 21 km long by 6 km wide. St. John is 11 km long by 5 km wide. About two thirds of St. John includes the Virgin Islands National Park (VINP).

Tourism is the primary economic activity for 80% of GDP and employment. The islands hosted 2.6 million visitors in 2005. The main manufacturing sector consists of petroleum refining, textiles, electronics, pharmaceuticals, and watch assembly. One of the world's largest petroleum refineries is located on St. Croix. The agricultural sector is small, with most food being imported.

The U.S. Virgin Islands is part of an archipelago that includes the nearby British Virgin Islands. The British Virgin Islands occupies the east portion of the archipelago and is administered as an overseas territory of the United Kingdom.

The territory comprises four large islands, Anegada, Tortola, Virgin Gorda, and Jost Van Dyke, and also includes over fifty smaller islands

Geology

St. Thomas and St. John, like the rest of the northern US and British Virgin Islands, is a natural appendage of the Puerto Rican bank, and shares many of the same geological, biological and geographic features with these islands.

St. Thomas and St. John were created by volcanic activity during the Cretaceous, and emerged through folding and faulting during the lower Eocene some 35-40 million years ago.

The Virgin Islands are two different geographical areas, with Vieques, Culebra, St. Thomas, St. John, and The British Virgin Islands consisting of the Northern Virgin Islands and St. Croix and its smaller islands as the Southern Virgin Islands. The Northern Virgin Islands (Virgin Island Platform) are on the Puerto Rican Bank, which formed a land extension of Puerto Rico until about 10,000 years ago.

Southeast of the Virgin Island Platform, St. Croix is an emerged part of an east-trending submarine ridge (St. Croix Platform). St. Croix and its associated cays are flanked to its north by the Caribbean Sea and to the southeast by Aves Ridge.

Puerto Rico and the Northern Virgin Islands emerged from the submarine volcanic mountains near the Jurassic-Cretaceous boundary. The Northern Virgin Islands were subsequently separated from each other and Puerto Rico by rising sea levels and tectonic contractions (Heatwole et al. 1981).

Climate

The amount of rain varies monthly and annually, with the general trend of dry-to-wet from east-to-west and south-to-north. Average rainfall data, compiled from several years of records at various stations, can be misleading in that it probably poorly represents that available precipitation at a particular area in any given year. The U.S. Virgin Islands receive an average of 104 cm of rain per year (Bowden, 1970). February and March are normally the driest months, April,

September and October the wettest, with most rainfall coming in the form of localized and brief showers.

Heavy rainfall sometimes occurs during the passage of the easterly tropical waves, which are spurned off the West African coast from June to November of each year. Occasionally, these waves intensify into tropical depressions, tropical storms, or hurricanes.

Temperatures vary little throughout the year, with daytime temperatures falling within the range of 25 -29° C, and usually drops by about 6° C at night. Due to year-round high temperatures and nearly constant winds, the evapo-transpiration rate is generally high.

Flora and Vegetation

The natural landscape of both islands is relatively diverse in its vegetation communities and land uses. The area is also rich ecologically, and includes salt ponds, mangrove forests, well developed riparian systems and a diverse spectrum of flora and fauna.

The vegetation of St. Thomas and St. John is considered sub-tropical, a result of the unique conditions created by climate, soil, wind, elevation and aspect and geographical location. The classification of the islands' plant communities is complex because of the blending of types across environmental gradients, leading to subtle changes in species composition, associations and abundance. Past land use activities and fluctuation in the natural environment contribute to this complexity. The dry tropical climate, geography, geology, and historical land use practices, have helped to determine today's vegetation.

Today, there are 30 vegetation community types to be found on St. Thomas and St. John. Much of this is secondary in nature (Thomas and Devine 2005). The bat survey netted in at least two thirds of these vegetation / habitat types.

St. Thomas is largely urbanized, with a population density of approximately 632 persons per km^2 (wikipedia.org), and much of the landscape and its natural communities remain extremely vulnerable to housing and tourism developments.

The VINP, renowned throughout the world for its breathtaking beauty, covers approximately 60% of St. John. The VINP encompasses 59.4 km^2, including marine protected areas. St. John has a population density of 83 persons per km^2 and most of this is concentrated in Cruz Bay on the west coast, and in Coral Bay on the east coast.

Within park borders lie protected bays of crystal blue-green waters, teaming with coral reef life, white sand beaches, and subtropical forest providing habitat for over 800 species of plants. The area is also rich in biodiversity including salt ponds, mangrove forests, well developed riparian (guts) systems and a diverse spectrum of flora and fauna.

The most recent vegetation classification system for the U.S. Virgin Islands was created using the Rapid Ecological Assessment (REA) vegetation classes developed by the Virgin Islands Conservation Data Center (CDC, which is based within the Eastern Caribbean Center of the University of the Virgin Islands), The Nature Conservancy (TNC) and Island Resources Foundation (IRF) in 1998. For the REA, the site was mapped using aerial photographs at a scale of 1:9,600, and the information verified through extensive field investigations.

SITE SELECTION AND DESCRIPTION

The study team visited a total of 62 sites during the survey period (Figures 1 and 2). A number of factors were used in the site selection process, and are summarized below. Time constraints and accessibility were also key considerations.

Historical reports may include records from previous studies and collected specimens.

Recent sightings and reports refer to information gathered from local residents about where bats have been seen or have been reported in the recent past.

Type of forest refers to forest habitats that were considered to be important for bats. Most of the forests on St. John and St. Thomas are secondary forests, and have been allowed to re-vegetate agricultural and pasture sites and are therefore quite important for watershed protection. Most of these sites are gallery and riparian forest.

The presence of **flowering and/or fruiting trees** is always a good indicator that nectar and fruit bats will visit an area. These sites were selected based on the type of flowering and fruiting trees present and whether they were attractive to bats.

The presence of **open and standing or flowing water** is also another strong indicator of the possible presence of bats. Water may indicate the presence of aquatic fauna such as fish and crustaceans (important for the greater fishing bats), and bats need to drink fresh water regularly. Some of these sites are located in riparian habitats on north shores.

Roost sites were determined from local knowledge (conveyed through personal communications), historical reports, and maps.

The team made a concerted effort to include **representative habitats** in the surveys. This was an important consideration because the team wanted to survey bats across as many habitat types and locations as possible, and be able to compare results across these types.

Finally, the team checked various **maps and aerial photos** for details of natural features that might indicate the presence of caves and/or roost sites. Field visits to these sites were undertaken based on accessibility.

A complete detail on the survey sites, results, discussion, and analysis is provided in the Island Resources Foundation's final report submitted to the Division of Fish and Wildlife, Department of Planning and Natural Resources.

The reported is cited as:

Lindsay, K C., G.G. Kwiecinski, and J.P. Bacle. 2008. Conservation of bats of St. Thomas and St. John, U.S. Virgin Islands. Island Resources Foundation. Report prepared for the Division of Fish and Wildlife, Department of Planning and Natural Resources, St. Thomas, U.S. Virgin Islands. 70pp.

METHODS AND MATERIALS

The materials and information gathered for this Plan were collected and collated from a variety of sources and ideas presented through reports, research, comparison of various conservation and management plans, from discussions with various experts both outside and in the Virgin Islands, and from the data gathered during the three years of field surveys.

During the field survey, for all sites on St. Thomas and St. John, bats were captured by mist netting usually between 18:00 and 24:00 hours. Site areas were pre-selected during the day. At roost sites such as caves, photographs were taken along with counts to determine species and in attempts to estimate roost numbers. Surveys were undertaken during all periods of the year, including the rainy and dry seasons.

Mist nets used were of five different lengths (2.8, 6, 9, 12 and 18 meters wide in length), and their deployment was based on site factors such as available space, obstructions, habitat type, suspected flight paths of bats, sources of freshwater, fruits and flowers, clearings in forests, and suspected roosting areas. Along streams, the nets were strung across the path where vegetation growth provided a tunneling effect to channel bats toward the net. At ponds, the net was set along one end where bats leaving the pond were likely to follow. Near-fruiting and flowering-trees nets were set across suspected fly-paths of bats. For open areas, nets were also set in suspected flight paths.

Mist nets were purchased through www.avinet.com (see Appendix 1 for list of materials). Nets were initially set up around an hour to 45 minutes before dusk. To prevent incidental capture of birds and other non-target species, nets were left "turned down". Following sunset, nets were extended to their full height of 2.6 meters and monitored throughout the period when they are set out.

As specimens stumbled into the nets (Figure 1.), attendants dislodged the animal (usually with the aid of thick gloves to prevent injury to both bat and person), and the specimen was then placed in a cotton bag for processing.

Bats were separated into bags based on species and sometimes sex, health and physical condition. Cotton cloth bags were used because they allowed the bats to breathe and move about relatively comfortably.

Nets were dismantled usually by 11 pm, and then the processing of bats took place. Each specimen was examined and the gender, age and maturity, reproductive condition, health and physical conditions were determined. The reproductive conditions for females (pregnant, lactating, pregnant and lactating), and males (testes descended or not) were documented. The team measured the right forearm and weighed each bat. Each specimen was examined for ectoparasites and general health.

Most specimens were released at the site of the survey, though a proportion (15%) were taken as vouchers for further study according to the terms of collecting permits issued by the Division of Fish and Wildlife /DPNR (Permit No. STT-063-06), and National Park Service (NPS)/USDOI (permit no. VIIS – 2007–SCI – 0020). Voucher specimens were exported primarily to Museum of Texas Tech University (MTTU), though a proportion may temporarily be on loan to the University of Scranton (SU) in Pennsylvania.

Information concerning voucher specimens is available from DFW. For specimens taken within the boundaries of the Virgin Islands National Park, these remain the property of the Federal Government, and are considered on temporary loan to the MTTU and SU. For those taken outside of the Park, these remain the property of the Division of Fish and Wildlife.

G.G. Kwiecinski

Figure 1. Mist-netting activity at Botany Bay, St. Thomas.

SUMMARY OF BAT SURVEY RESULTS

Mist-netting activity occurred during 6 separate trips to St. Thomas and St. John between October 2006 and March of 2008 (Lindsay, Kwiecinski, and Bacle. 2008). Table 1 below provides a summary of bats netted for St. Thomas and St. John.

Table 1. Summary of bats netted (2006 – 2008).

Species	**St. Thomas**	**St. John**	**Total**	**%**
Artibeus jamaicensis	436	402	838	69.6%
Brachyphylla cavernarum	32	55	87	7.2%
Noctilio leporinus	85	16	101	8.3%
Molossus molossus	93	69	162	13.4%
Stenoderma rufum	5	10	15	1.2%
Tadarida brasiliensis	0	1	1	0.08%
Total	651	553	1204	100%

Mist-netting surveys included a total of 212 net nights for St. Thomas, and 142 net-nights for St. John. During this period, 651 bats were captured on St. Thomas giving an average capture rate of 3.2 bats per net per night (BNN), and for 553 bats captured on St. John for an average of 3.7 BNN. As expected the capture rate for St. John exceeded that of St. Thomas given that habitat on that island is significantly less disturbed.

Over the three year period, the team recorded mist net survey results from 39 sites on St. Thomas and 24 sites on St. John with a few of these sites revisited at different seasons. Location of survey sites and percentage of species netted are presented in figures 2 to 5.

Of the 651 bats captured on St. Thomas, 563 were released, and 88 (14%) were kept as voucher specimens. Of the 553 bats captured on St. John, 461 were released, and 92 (17%) were kept as voucher specimens.

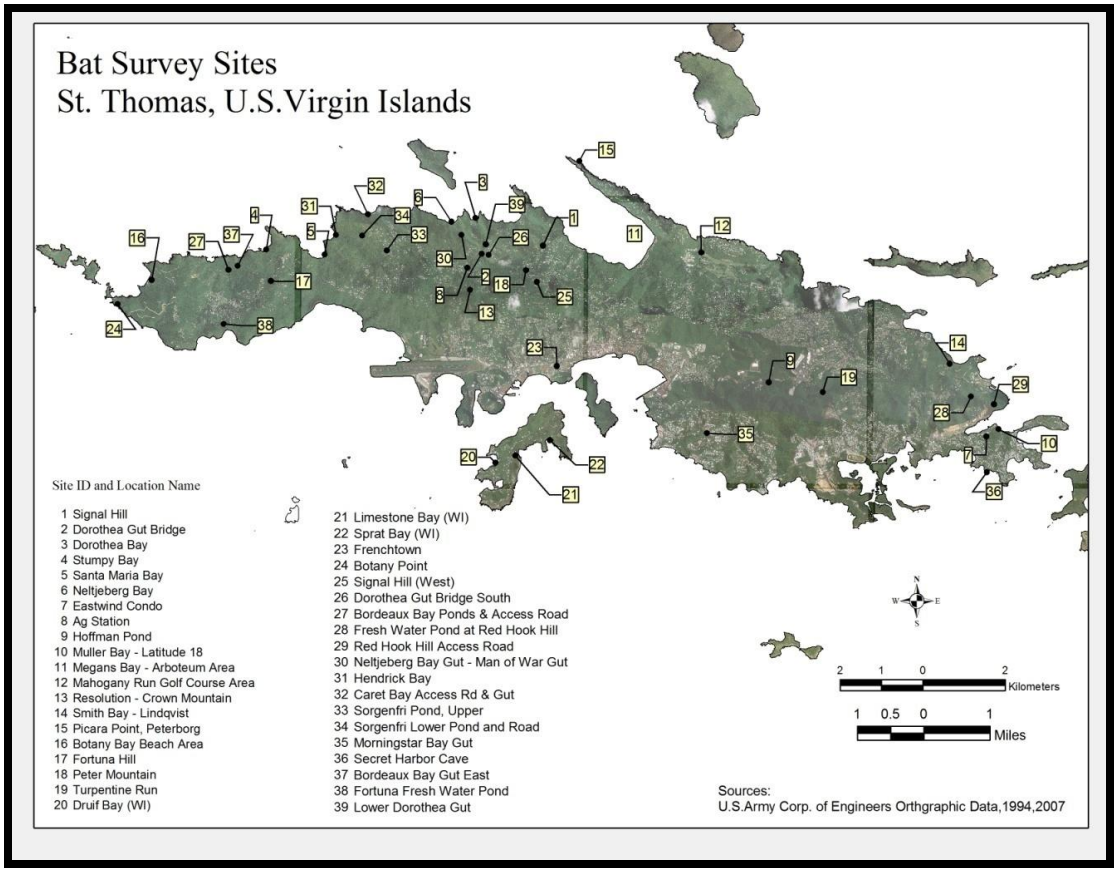

Figure 2. Bat Survey sites, St. Thomas.

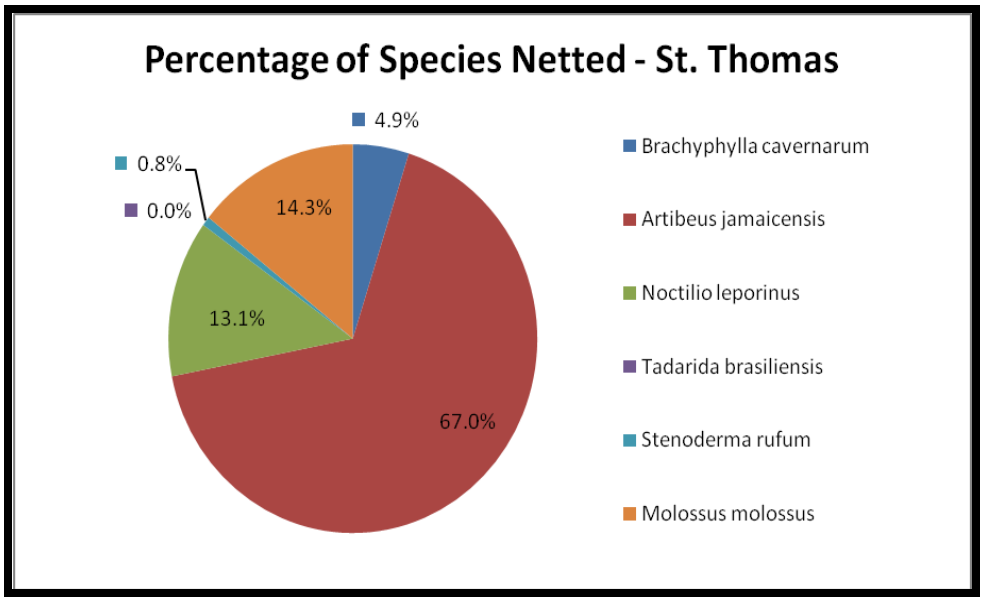

Figure 3. Percentage of species netted (2006 -2008), St. Thomas.

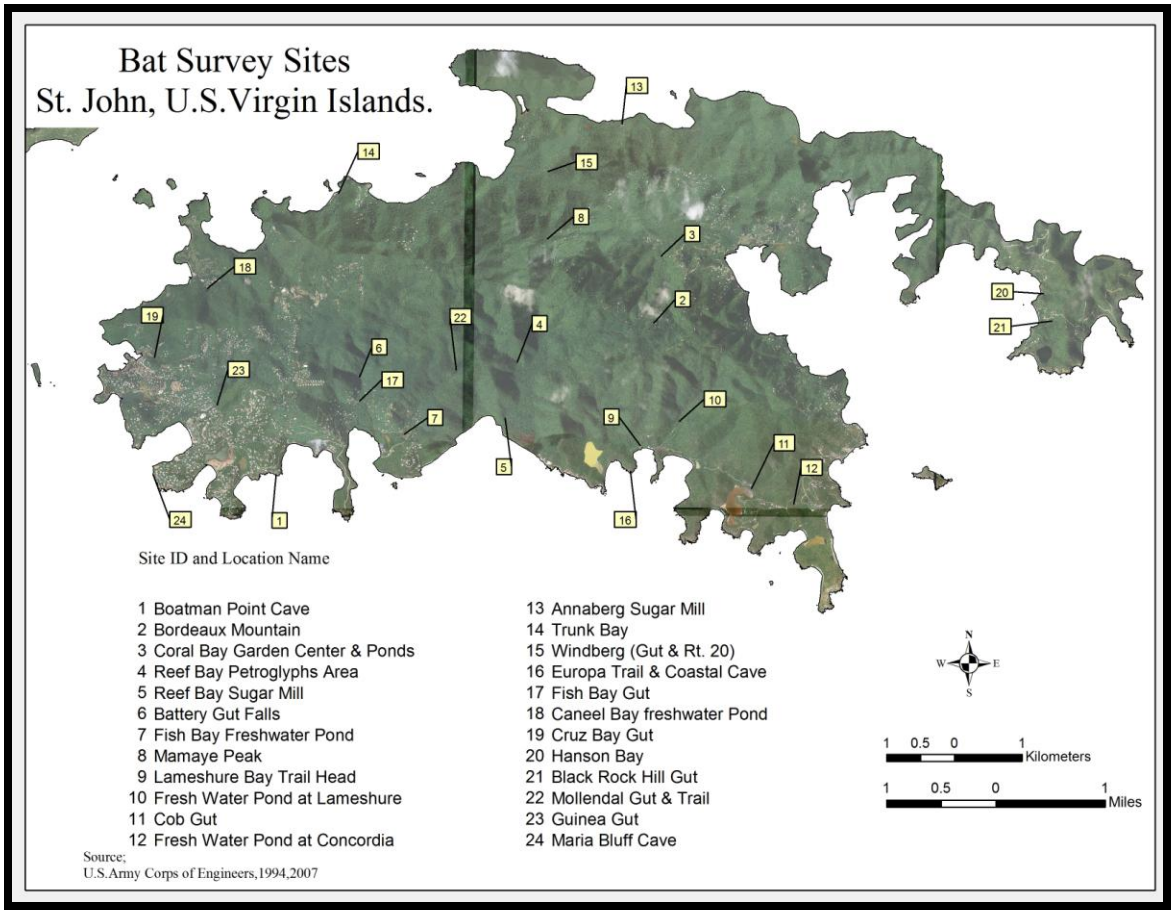

Figure 4. Bat survey sites, St. John.

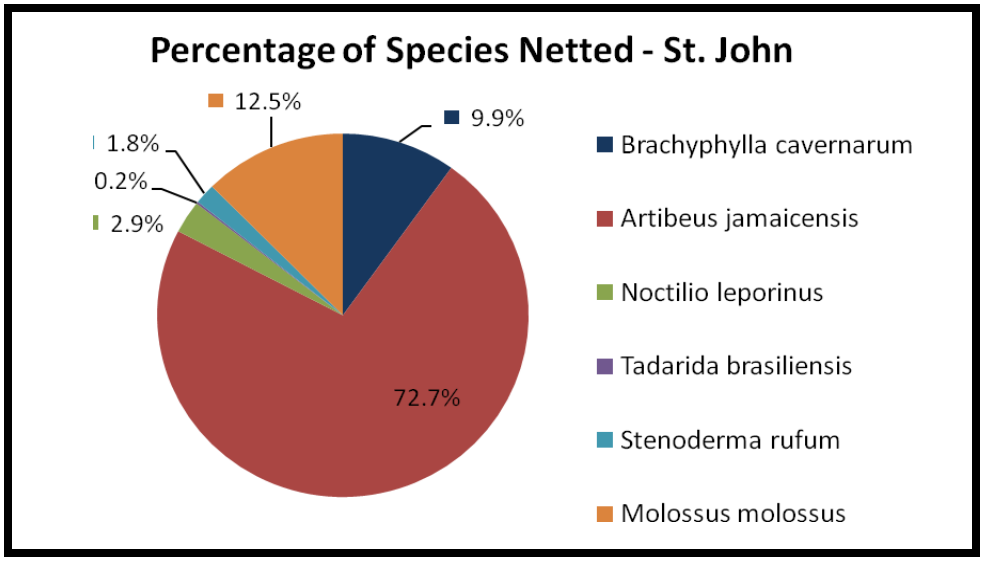

Figure 5. Percentage of species netted, St. John.

SECTION II: BAT SPECIES ACCOUNTS AND DESCRIPTIONS

Officially, there are six species of bats reported for St. Thomas and St. John (Philibosian and Yntema, 1977; Koopman, 1975; Lazell and Jarecki, 1985; and Kwiecinski and Coles, 2007; Bacle, Lindsay and Kwiecinski, 2008). These six species include the Pallas' mastiff bat (*Molossus molossus*), the Greater fishing bat (*Noctilio leporinus*), the Jamaican fruit-eating bat (*Artibeus jamaicensis*), the Antillean cave bat (*Brachyphylla cavernarum*), the red fig-eating bat (*Stenoderma rufum*), and the Brazilian free-tailed bat (*Tadarida brasiliensis*).

Recent estimates and ultrasonic surveys suggest that there are between six and eight species of bats extant on the islands today (Patterson, 1977; Genoways, H. pers. Comm., 2005). These records are based on museum specimens taken from these islands over the last 100 to 150 years.

A more recent source suggests that there may be at least a seventh species This would be the Antillean ghost-faced bat (*Mormoops blainvillii*), known from a 20-year photo (see below) taken at the residence of Rafe Boulon at Trunk Bay, St. John, but no specimens have ever been documented or captured in the Virgin Islands. The Antillean ghost-faced bat described below has not been seen since, and could be considered as vagrant.

Pallas' Mastiff or Velvety Free-tailed Bat (*Molossus molossus*)

G. G. Kwiecinski

Description: Small free-tailed insectivorous bat, wingspan under 30 cm, smooth lips, long tail with uropotagia present (membrane connecting tail and legs).
Habitat: This species often roosts in a wide variety of human-made structures. It has been encountered in woodlands and located in rock fissures along the coast. Also roosts in hollow trees and caves. Can often be seen hawking for insects above residential areas, above canopy, along riparian habitats, and other rural or urban open areas, including Charlotte Amalie, St. Thomas and Cruz Bay, St. John.
Feeding Ecology and Diet: These free-tailed bats feed in open, uncluttered habitats, usually above forest canopy, but are able to fly through dense vegetation to get to fresh water sources (e.g., pools along streams, ponds). They eat only flying insects, including moths, mosquitos and flying ants.
Reproduction: Generally seasonally spermatogenic, with scrotal males found in winter and spring months. Females in Virgin Islands are seasonally monoestrous, but sometimes seasonally polyestrous in more southern parts of their range (Hayssen et al., 1993). In the Virgin Islands, pregnant females are found in spring and summer, with lactating females found in summer.
Distribution: Central and South America, and West Indies.
Conservation Status: Locally common, especially above towns and residential areas. It is less common in natural areas. *M. molossus* may be experiencing slow declines across the islands. The species may be limited by the availability of suitable natural roosting caves/sites. In the islands, roof architecture design has shifted from metal roofing to ceramic, wood, concrete and other materials that

are unsuitable for these small bats. This may be having an impact on overall numbers for this species. *M. molossus* should be closely monitored for further population decline.

Mexican Free-tailed Bat (*Tadarida brasiliensis*)

G. G. Kwiecinski

Description: Small, high flying insectivorous bat, wingspan under 30 cm, wrinkled lips, larger ears than *M. molossus*, long tail with uropotagia present (membrane connecting tail and legs).
Habitat: In other islands such as Puerto Rico and Antigua, this species may often roost close to houses; roosts in hollow trees, rock fissures, under bridges, culverts, abandoned human structures, and caves. However, in the Virgin Islands, no roosts have been located. *Tadarida* is a high flier and is known to go elevations above 3000 meters in search of insects. On St. John, the species is believed to prefer rock cavities and small caves.
Feeding Ecology and Diet: These bats are clearly underrepresented in our survey because they fly high altitudes, above the forest canopy. They fly at high speeds and feed only on insects, mainly moths and beetles.
Reproductive Biology: The few individuals of this species captured on the Virgin Islands have not allowed an analysis of their reproductive biology on the Virgin Islands. The single female captured in October was non-reproductive, which is consistent with a seasonal monoestrous pattern (pregnancy in spring, single young) for Tadarida found elsewhere in the Antilles (Hayssen et al., 1993).
Population: Very rare. Only one specimen was caught during this bat project,

but less than 10 specimens are known from St. John. It is recorded from Guana Island in the BVI.
Distribution: Southern US, Mexico, Central and South America, West Indies.
Conservation Status: Extremely rare in the Virgin Islands. In the entire U.S. Virgin Islands, Hall and Bee (1960) report capturing 14 specimens (no sex, age or reproductive information) and we report the capture of one specimen on St John. During this survey, a single female was caught on St. John. It is not recorded for St. Thomas or most of the British Virgin Islands, except Guana. It is also recorded for Vieques and Culebra. It is listed as a species of Greatest Concern on the Territory's Endangered Species List. The species requires further study and where possible, strong intervention to help boost population numbers.

Jamaican Fruit Bat (*Artibeus jamaicensis*)

G.G. Kwiecinski

Description: Large leaf-nosed bat, wingspan up to 40-45 cm, thick brown fur, sometimes with a mild yellowish tinge, especially around shoulders. Faint eye-stripes may be present.
Habitat: In the Virgin Islands, *Artibeus* are found in a variety of habitats, including dry forest, moist forest, coastal habitats, residential areas, gardens and farms; roosts in caves, tree cavities, ruins, and abandoned buildings, as well as in tall trees. It has not been found in xeric and wind-blown habitats on the northern part of the islands.
Feeding Ecology and Diet: These bats eat a range of wild and cultivated plants, primarily fruit, nectar, pollen, flower parts, and some leaves, and insects are

incidentally consumed.
Reproductive Biology: On the Virgin Islands scrotal males are found at all times of the year. Pregnant and lactating females have been found in January, March, June, July, August, and October. This species experiences a post-partum estrous. Young are typically produced at least twice a year following the bimodal polyestry pattern described by Wilson (1979), with birth peaks in spring and summer, and possibly a third birth (winter) occurring after a period of delayed development (Fleming 1971). *Artibeus jamaicensis* typically bears one young, twins are rare.
Population: The most abundant bat in the Virgin Islands, over 60% of the specimens caught during this three-year survey was of this species. It is caught across almost all habitat types on St. Thomas and St. John.
Distribution: Mexico, Central America, South America, all across West Indies
Conservation Status: Very common, especially around fruiting and flowering trees. The species seems quite adaptable and able to take advantage of a diversity of circumstances.

Antillean Cave Bat (*Brachyphylla cavernarum*)

G.G. Kwiecinski

Description: Large, muscular bat, 6.5-11.8 cm long with 45 cm wingspan, short cone-shaped muzzle with stumpy nose-leaf, yellow to brown fur with whitish undertones.
Habitat: Roosts in caves and rock overhangs.
Feeding Ecology and Diet: Fruit, pollen, nectar, and insects.
Reproductive Biology: *Brachyphylla cavernarum* is seasonally monoestrous with

spermatogenic males found from September to December on St. Croix (Krutzsch and Nellis 2006). Pregnant (single young) females have been captured from February to June and lactating females have been found from April through July (Hayssen et al., 1993) but we captured a lactating female in August on St. Thomas.

Population: Overall, relatively rare throughout the islands. Seemingly more common on St. John than St. Thomas but nowhere abundant.

Distribution: A regional endemic found in Puerto Rico, Virgin Islands, Lesser Antilles.

Conservation Status: Uncommon to rare, more so, on St. Thomas. The species may be limited by a combination of factors, including limited natural cavities and caves for roosting, by the availability of food sources and by habitat destruction. It is listed as a species of Greatest Concern on the Territory's Endangered Species List.

Red Fig-eating Bat (*Stenoderma rufum*)

G.G. Kwiecinski

Description: Medium size fruit bat; two white patches of fur, one on shoulder just below the ear and one at the antebrachial membrane; body length 6.6 cm, forearm 4.6 cm; dark chocolate color on back; nose leaf present.

Habitat: Roosts in trees in lower semi-deciduous to evergreen forests. Not much is known about the habitat preferences of this species in the Virgin Islands.

Feeding Ecology and Diet: Fruits, including that of the Piper species.

Reproductive Biology: This species is asynchronously polyestrous and pregnant females (single young) and spermatogenic males can be found any time of year

(Gannon and Willig 1992).
Population: Quite rare, though more widespread on both islands than previously thought. In the three years of survey, only 15 individuals (1.2%) of the over 1,200 bats captured represented this species.
Distribution: Only in Puerto Rico and Virgin Islands, including Vieques. Unknown from the British Virgin Islands.
Conservation Status: Extremely rare.
Through the efforts of this project, the species is now known to occur from Dorothea to Santa Maria along the north coast of St. Thomas. On St. John, it is known from Lameshur on the south coast and from Coral Bay on the east coast.

Species seems vulnerable to habitat disturbance, fragmentation and shrinking habitats as well as well as human presence. It is listed as a species of Greatest Concern on the Territory's Endangered Species List.

The Virgin Islands population is given the specific name *S. rufum rufum*, endemic to the Virgin Islands.

Greater Fishing Bat (*Noctilio leporinus*)

G.G. Kwiecinski

Description: The largest of the bats measuring 9.8 to13 cm long with wingspan up to 50 cm, pointed muzzle, almost like a bulldog. Color variable depending on age, maturity, breeding season and other environmental factors. It may be from brown to a bright orange color, especially on chest and stomach. It also has a single white stripe along the mid-dorsum.

Habitat: Roosts in hollow trees, caves, fissures and cavities along or near streams, and coastal cliffs.
Feeding Ecology and Diet: Eats fish and aquatic crustaceans that it catches while echo-locating above surface of water. This species will also hawk for insects, and may often be seeing flying low along country lanes and roadways.
Reproductive Biology: Females are seasonally monoestrous and bear a single young. Males are seasonally spermatogenic with mating occurring in autumn and winter (Hood and Jones 1984). Pregnant individuals in the Lesser Antilles are found December to June, with a peak in parturition from April to June (Hood and Jones 1984). A single young is typical.
Population: Relatively widespread throughout both islands, though nowhere common.
Distribution: Mexico, Central America, South America, Greater and Lesser Antilles.
Conservation Status: Locally common and perhaps the most well known bat species in the Virgin Islands since it often observed "fishing" near sea ports, marinas and ponds.

The species is listed as a species of Greatest Concern on the Territory Endangered Islands.

(Vagrant)

Antillean or Blainville's Ghost-faced Bat (*Mormoops blainvillii*)

R. Boulon

Description: Small bat, weighing about 9 grams, forearm length up to 5cm, small rounded ears and reduced eyes, lips highly ornamented with flaps and folds.
Habitat: In Puerto Rico and other islands, this species prefers hot caves for roosting, habitat that may be absent on most of the Virgin Islands. However, very little is known about caves and in fact, the specimen located at the Boulon residence may have come across from the nearby British Virgin Islands or Puerto Rico. Much more research is needed to determine the presence of this species on the Virgin Islands. The survival of this species without hot caves is in question. The individual found by Boulon could have been a transient or incidental finding and may not represent a representative of an established, breeding population on the Virgin Islands.
Feeding Ecology and Diet: By night, feeds on insects caught in the underbrush and from the canopy of trees.
Reproductive Biology: This species is seasonally monoestrous, with pregnancy (typically one young) occurring March to June and lactation extending until September on Cuba (Silva Taboada 1979).
Population: Only known from a 20-year photo of a lone (sex unknown) specimen taken at the home of St. John resident, Rafe Boulon. This specimen may represent an incidental visitor after the passage of a storm after it was blown off course, or an occasional visitor to the Virgin Islands.
Distribution: A regional endemic found on Jamaica, Hispaniola and Puerto Rico.
Conservation Status: A rare and often overlooked species. It has become extinct in the Lesser Antilles but prior to the photographic evidence it was previously unknown in the Virgin Islands. Despite the fact that it may be an incidental visitor the species requires further study to determine its exact status.

M. blainvillii is listed as threatened on the International Union for the Conservation of Nature (IUCN) Red List.

Identification of Species

The Virgin Islands bats are most easily identified in the hand. However, most people only see fleeting glimpses of the species, and usually at quite a distance when they are on the wing. The table below provides some identification features and characteristics that help to distinguish one from the other.

Most species are easily told apart by the external characteristics and habits. However, four local species may prove difficult to discern when encountered. These are *M. molossus* and *T. brasiliensis*, both of which look very similar and are closely related, and *A. jamaicensis* and *B. cavernarum*, which are fruit bats, and are similar in size, color and general habits. Table 2. below summarised some of the key identification features than can be used to identify the bats of the Virgin Islands.

Table 2. Identification summary on the features of the bats of the V Is.

Species Name	Local Name(s)	Identification
Molossus molossus Common names: Pallas' Mastiff Bat/ Velvety Free-tailed bat	Roof bat, rat bat	Small bat, forearm < 50 mm, wingspan < 30 cm, smooth lips, long tail, dark brown and black; roost in roofs and natural rock fissures
Tadarida brasiliensis Common name: Mexican Free-tailed Bat	Rat bat	Small bat, similar to the sp. above, three lower incisors on each side; wingspan < 30 cm, lips wrinkled, long tail, dark brown; roost in roofs, caves and natural rock cavities
Mormoops blainvillii Common name: Antillean Ghost-faced bat	None	Broad rounded short ears, joined across the cranium, eyes small, lips highly ornamented with flaps and folds; back chocolate brown in color
Artibeus jamaicensis Common name: Jamaican Fruit bat	None known	Faint white stripes above and below the eyes; brown fur, sometimes with yellowish tinge, especially on shoulder, distinctive large nose-leaf; wingspan of 40-45 cm
Brachyphylla cavernarum Common name: Antillean Cave Bat	None known	Large fruit bat; similar in size and shape to Artibeus but with short stumpy nose-leaf, brown fur with white undertones; aggressive and often noisy around fruiting trees, and in their roosts
Stenoderma rufum Common name: Red Fig-eating Bat	None known	Medium-size fruit bat, dark chocolate brown on back, with a white patch of fur on shoulder; about 7 cm in body length
Noctilio leporinus Common name: Greater Fishing Bat	Fishing Bat	Largest bat on the island, often found fishing around ports even when people are around; measuring 9.8-13 cm long with wingspan up to 50 cm, pointed muzzle, almost like a bulldog, very large claws for grasping fish; often with a fish and musky odor

SECTION III: CONSERVATION & MANAGEMENT

Bats are the slowest reproducing mammals in the world for their body size, with most species producing only one young annually (Bat Conservation International 2002). Three of the six confirmed species of bats in the Territory are listed as endangered under the Virgin Islands Indigenous and Endangered Species Act. They include *B. cavernarum, N leporinus*, and *S. rufum*. It is anticipated that *T. brasiliensis*, because of its rarity, will be listed during the next revision of the Territorial Act. These four species occur in few habitat types and with restricted geographical ranges.

All bats in the Virgin Islands are faced with different levels of threats to their population and survival. The two main factors include: the destruction and encroachment on their roosting habitats and depletion of foraging opportunities.

This section outlines many of the issues and the recommended responses and actions that may be required to deal with these issues. The first part of the section deals with conservation and management issues, and highlights six key areas for action. These include:

ROOST SITES;
HABITAT;
FOOD;
FRESHWATER;
REASEARCH & MONITORING; and
EDUCATION & AWARENESS

Each of these issues is discussed below, and a specific set of "actions" are provided for each with the intention to guide future management and conservation initiatives. Following this, the discussion focuses on **BATS and CLIMATE CHANGE**, and on **BATS and WIND TURBINES**, two issues that may negatively impact the already declining populations of native biodiversity, and especially bats and to a lesser extent birds, where wind turbines are concerned.

Though wind generation is not yet a major source of alternative energy for the Territory, it is expected that the government will move ahead with plans to allow local initiatives and programs to use wind as an important source of energy, and

this has implications, both for the natural environment and for human ecosystems.

An important next step for this plan is the design of a "bat conservation strategy," which is necessary for fleshing out many of the actions and for providing a detailed map on how these will be carried out.

ROOST SITES

Most species of bats on St. Thomas and St. John are primarily natural roost users. Two species, *Molossus* and *Tadarida*, will use the space under the roofs of residences as roosts, while *Artibeus* and *Brachyphylla* may use ruins and abandoned buildings. *Noctilio* prefers coastal rock cavities and overhangs, and tree cavities. For *Stenoderma*, much of the information about natural roosting in the Virgin Islands remains elusive.

Despite the fact that most of the species in the Virgin Islands are natural roosters, very little is known about where these bats actually roost, where the natural caves and cavities are located, the micro-climate peculiarities of these sites, the threats to these sites and the conservation and management needs.

There are two categories of roost sites in the islands. These are natural and artificial (Table 3).

Table 3. Roost types.

Natural Roosts	Artificial Roosts
Coastal bedrock fissures, caves	Roofs and walls (human-made structures)
Bedrock overhangs	Abandoned buildings
Large trees (fig palm)	Wells, cisterns
Tree cavities, fissures	Historical sites (ruins, e.g., sugar mills & estates)

Natural roost sites are perhaps one of the most critical limiting factors for bats on these islands. During the surveys, the team located and identified several caves and tree roosts on St. Thomas, St. John and the offshore cays. Most of these are coastal fissures and cavities occupied by Brachyphylla. One cavity was occupied by Artibeus (St. John), and the other by Noctilio (St. Thomas). We located only one tree cavity roost occupied by *N. leporinus* at Dorothea (Figure 6) on St. Thomas.

J.P. Bacle

Figure 6. Tree cavity occupied by roosting *N leporinus*.

The most common artificial roosts are associated with human residences, particularly older roof structures. The most common species to colonize these areas as well as abandoned buildings are *M. molossus*. However, new building design has dramatically reduced the opportunity for roosting, and older buildings are gradually retrofitted to exclude bats.

Historical ruins offer great roosting opportunity for larger colonies of bats, especially if the structure has been restored with a roof. In the Reef Bay watershed (St. John) two sites were investigated; the Great House had a roost population of approximately 700 *A. jamaicensis*, and the roost in the Reef Bay Sugar Mill, had a count of approximately 137 *A. jamaicensis* (Figure 7). The Mollendal ruin was also investigated because it was known to have a roost (Gibney, pers. com), however the roost was abandoned because of a roof collapse due to fallen tree.

J.P. Bacle

Figure 7. Reef Bay's Sugar Mill ruins with galvanized roof.
The roost contains ca. 137 *Artibeus jamaicensis*.

Artificial roosts are also relatively scarce, especially on St. Thomas and Water Island. *Molossus* has successfully learned to colonize human residences.

To help lure fruit bats, it becomes important not only to render old ruins as suitable roosts opportunities, but also to construct additional artificial roosts specially designed to attract fruit bats. Figure 8 is an example that illustrates a design that is cheap to construct, easy to build, and able to withstand the tropical climate and termites. This artificial roost was designed to mimic the characteristics of the large, hollow tree trunks favored by fruit bat species. The design consisted of a single box 2 m tall by 60 cm wide, made of concrete-and-saw dust slabs. Plastic netting on the ceiling provided a roosting surface. This study undertaken by the University of Erlangen (Germany) was partially funded by BCI. This roost type was deployed in a variety of land-use types and landscapes. Results were overall very positive as bats quickly colonized theses artificial roosts within a couple of weeks (source: Bat Conservation Times, 2008).

Figure 8. Artificial roost designed to attract fruit bats.
(source: Bat Conservation Times, 2008)

NEEDS:

- Undertake surveys to learn where the natural roosts are located;
- Undertake surveys to learn where all potential artificial roosts are located;
- Determine micro-climate factors in natural caves to learn more about the roosts needs of each species in the Virgin Islands;
- Conduct intensive and extensive surveys to locate *Tadarida, Stenoderma, Brachyphylla* and *Mormoops*. To learn more about the roosting habits and requirements for these particular species;

ACTIONS:

- Protect natural rock roosts. Any measures should include a policy to protect possible roosts not yet discovered or known, and those on private as well as public lands;
- Protect and restore ruins that currently have roosts or could potentially attract roosts;
- Develop an annual monitoring protocol to census populations in these roosts;
- Work with private landowners to manage and protect roosts;
- Create artificial box roosts for *Molossus* and *Tadarida*, and artificial cave roosts for *Brachyphylla*;
- Undertake cooperative efforts with conservation authorities in the BVI to identify other roost areas, especially those that possibly share bats with the USVI;
- Carry out specific field surveys for *Mormoops* and *Stenoderma* roosts. These surveys should include collaboration with conservation authorities in the BVI to identify potential occurrence of this species on those islands, especially on the smaller offshore cays nearby to St. John, including Great Thatch, Little, the Tobago Cays, Norman Island, etc. These surveys should consider the use of radio tracking devices to help locate the roosts.

HABITAT

St. Thomas and St. John are very different islands. On the one hand, the island of St. Thomas is largely urbanized. An extensive road network dissects the landscape into smaller and smaller fragments, while residential and commercial developments continue to explode across the island. The island has few protected forests, except on offshore cays, and these may offer very limited habitat, given their size and drier climates.

The highest peak in all of The U.S. Virgin Islands is located on St. Thomas, Crown Mountain at 474 m. The habitat on the peak has changed dramatically over the years, but must have approached rainforest conditions prior to its development. This area would have proved important for bats in the past because of the water and moisture that it generated and maintained, the size of the trees, the plant and animal diversity, the cover that it offered, the regular food availability, and it would have provided a corridor for bats moving from one side of the island to the other.

Today, what should be an example of the diversity of the range of habitats found in the Virgin Islands is now mostly a residential area. This is just an example of the destructive result of fragmented development the island has experienced.

The lower slopes of the central ridge of the island are quite variable dependent on the orientation, elevation and rainfall. The northern slopes of the island are wetter and harbor moist forest in many places, while the southern slopes down to the coast are drier and more fragmented developed.

Today, there are few examples of extensive natural forest and woodlands remaining. Some good examples include:

- The Dorothea watershed;
- The upper slopes of Magen's Bay;
- Caret Bay watershed;
- Hull Bay watershed;
- Sorgenfri watershed;
- Santa Maria;
- Perseverance;

- Bonne Esperance;
- Parts of Botany Bay;
- Hoffman area;
- Neltjeberg
- Northeast side of Flag Hill
- Redhook Point

Having continuous tracts of natural forests is critical to the survival of all species of bats on all the islands. Forest habitats are critical for providing food, flyways, freshwater, roosts, cover, and recovery from natural disasters. Though many of the areas listed above are limited in their ability to provide and meet habitat needs of any species, they nevertheless are what St. Thomas has, and are the best option for the conservation and management of the bats.

Two species in particular seem quite vulnerable to decline of forest habitat, these include *Stenoderma* and *Brachyphylla*. The fragmentation and decline of forest seem to be having an adverse effect on the population of these two species.

During the 2006 to 2008 surveys, *Stenoderma* was captured at Santa Maria, Dorothea Gut, Neltjeberg and Sorgenfri. All sites are relatively close to the coast. The most interesting capture was at a small freshwater pond at Sorgenfri, which was about a half mile from the coast. The previous captures of this species were near guts situated in proximity of the coast. The collection of a specimen at the Sorgenfri may suggest that the species will occupy suitable habitats further inland. The fact that most captures were in coastal forest community may be because there remains no suitable habitat further inland, and the further urbanization of the island doesn't bode well for this species.

All of the sites where this species was captured are situated on private property. The habitats are largely intact and connected to adjacent sites by narrow strips of vegetation. Some areas like Dorothea and Sorgenfri have private residences, which would indicate that the species can tolerate some level of human presence, though we do not know anything about its threshold limits.

The largest number of specimens was obtained from Santa Maria, the site where, in 1968, the species was rediscovered as extant on the Puerto Rico Bank, and the first record for this species from the Virgin Islands. The site has been until recently used by locals for beach recreation, camping, hiking and for collecting

mango fruits. However, within the last year, the owners of the property have excluded the public from access to the site.

St. John is much more forested and this is largely due to the presence of the VINP, which includes over half the land area of the island, and historically has had a much lower human population. However, despite the luxuriant appearance of many of the areas on St. John, a closer examination shows that the forests in many of the moister parts are depauperate and/or degraded. These areas include most of the basin moist forests, and many of the guts on both the north and south shores.

There are mature moist forests on the eastern slopes of Bordeaux Mountain, the north side of the Carolina Valley and the steeper uplands of the Fish Bay, Cinnamon Bay, and Maho Bay watersheds. In general, the moister the habitat, the more likely it is to be heavily disturbed, the exception being on steep slopes (where the moisture tends to be compromised by rapid drainage, thin soil and exposure to wind and sun). High quality dry forests, with very few exotics, dominate steeper slopes throughout the island, The vegetation with the most endemic and rare species is low statured dry forest and scrubland, with many of the best examples occurring in the non-National Park section of the south shore from Cruz Bay to Fish Bay. This area has been heavily developed in the past 30 years.

The most important areas outside the National Park:

- The eastern slopes of Bordeaux Mountain above Carolina Valley
- Southern slopes of Bordeaux from Saunder's Gut to Mandahl
- The northern side of East End
- Slopes of Gift Hill above Ditliff Point and western Fish Bay

In the forests of St. John (and this is true for St. Thomas as well) there is a relative rarity or absence of the species of Ficus native to the island, namely *F. citrifolia* and *F. trigonata*. The distribution of these two species is largely aided by bats and some birds. It is perplexing as to why more are not observed. The native Ficus would have been important food sources for bats when the islands were still largely forested. According to Gibney, hazarding an educated guess, continued large-scale grazing has prevented the growth of larger native trees. Ficus are not palatable, even to goats, and their common habit of growing

epiphytically on rocks protected them to a large degree from both manual land-clearing and from the fires that were used to clear land in the past. The commonness of Ficus on certain islands (Virgin Gorda comes to mind immediately) is an entirely artificial situation. Ficus do not compete well in a canopied forest, and in the Virgin Islands they tend to be restricted to coastal rocks and inland rock outcrops with high light levels.

These two trees may just be examples of a much larger issue of seed dispersal and forest health in the Virgin Islands. It is perhaps possible that many of the tree and other plant species are being out-competed for space by the prolific genip (*Melioccus bejugatus*), an exotic introduction from South America, though this is only suggestive at this point.

This species is very prolific, producing thousands of viable seeds, which are dispersed by bats and by humans. According to Eleanor Gibney, genip is overwhelmingly a moisture lover, and dominates on moister areas that were cleared in the last 125 years or so. On St. John that tends to mean former cattle land, as opposed to former sugar land. Even though the genip supposedly came with the Taino, it apparently did not become common until after the mid- 19th century. Genip is a common species on any more than 20% of St. John forests, and that's being liberal.

This is not to say it's not a problem, and it would be a great study to find out if it is expanding into areas that were previously free of it. It certainly isn't diminishing, and there is a lot of conjecture that allelopathy is a factor in the pure stands of genip with very limited species in the understory.

Observations by Gibney on her property have provided some very invaluable insights into the many of the native and naturalized species that bats are consuming. From observations of seeds and seedlings under the roosting palms, the top 9 fruit species are:

Cassine xylocarpa – Nothing nut, false nutmeg, marble tree
Andira inermis – Cabbage tree
Terminalia bijugatus
Eugenia biflora - Rodwood
Maytenus elliptica
Randia aculeate – Inkberry, Christmas tree, five finger, fishing rod

Mycianthes fragrans
Coccothrinax alta – Broom palm
Spondias Lutea – Hog plum

At least another dozen species appear pretty regularly under her coconuts, and there are approximately another 100 native trees and woody shrubs with fruits that are presumably palatable to bats. Several species have white or light colored fruits or seed coats that appear designed for visibility.

At least once a month, she finds ripped shreds of papaya leaf in the morning, on her porch or under the trees in the yard. This suggests that bats are chewing on papaya leaves. *Artibeus* are known to eat Solanacea and Tamarindus leaves.

NEEDS:

- Protection and management of remaining forest habitat;
- Increasing available habitat;
- Increasing fruit trees and food sources in forests;
- Connecting fragmented habitat by creating forest corridors;
- Replanting ficus.

ACTIONS:

- Where possible, the local and federal government should purchase and acquire private land for forest reserves and wildlife management areas, including properties listed in areas above. These lands should then be placed into a Territorial protected areas system;
- Work with urban forestry programs and initiatives to undertake reforestation programs. Though urban forestry programs focus mainly on trees and other plants in towns, the focus in the Virgin Islands should be widened to include all of the landscapes since so much of the islands are largely urbanized;
- Develop a local easement program with private landowners as part of a local wildlife management and option;
- Use bats as keystone species for local wildlife conservation;

- Develop wildlife management zones for St. Thomas and St. John. The island is zoned according to areas of conservation priority and management options are developed based on various factors, including wildlife needs, available options, size of area, species, habitat, landownership, etc.;
- The VINP and the DFW should collaborate with the U.S. Department of Agriculture (USDA) and the International Institute of Tropical Forestry (IITF) in Puerto Rico to develop a Virgin Islands Forest Management Plan to help protect remaining forest, develop effective forests on small properties, and improve the forest environments;
- Undertake forest enrichment planting using native and some naturalized plant species with a view toward providing habitat and food sources for bats and other wildlife, e.g., ficus. A list of plants used by bats is provided in Appendix IV;
- Create forest corridors between forest fragments, especially along guts, and in areas provided in the list above.

FOOD

As natural forests and woodlands decline, as local agriculture makes less and less contribution to the local culture and economy, and as residents choose not to plant local fruits and other preferred food plant species, bats have fewer and fewer choices for food, especially fruit bats.

Insect bats like *Molossus* and *Tadarida* are dependent on the forest for the diversity and numbers of flying insects. As forest cover declines, so do the number of insect species.

Even in backyard gardens, people seem to be planting less and less of the local fruits and other plants. Fruit bats seem to depend on the mangoes, almond, guava, marmy, sappodilla, bananas, palms and many others for survival. As fewer and fewer people cultivate these species then the bats have few food options available.

Similarly, farming is on a sharp decline in the Virgin Islands. Many of the remaining fruit trees are relics from old farms and homesteads and as residential development expands then these trees are removed.

It is during the drier months that the bats most need these fruiting trees. There are two dry periods in the islands. The most important runs from the end of December to March/April. From June to early August, there is a minor dry period, although this is much less stressful than the former.

If the bats of the Virgin Islands are to survive then they are going to need flowering and fruiting species of plants.

NEEDS:

- Increasing the number and types of fruit and food plants on the islands by;
- Maintaining existing fruit trees both on private and public land;
- Protecting agricultural areas from urban and commercial development.

ACTIONS:

- Encourage enrichment planting of food plants in natural areas, on farms, and on private and on public land. This should include both native and non-invasive naturalized species. A list of species used by bats is provided in Appendix IV;
- Use Arbor Day to celebrate tree planting and spread the word to sensitize residents about the need for planting more trees;
- Work with government properties to plant food plants on those sites;
- Undertake annual surveys of forest habitats, private and public land to assess the availability of food sources for bats.

FRESHWATER

Freshwater is very limited on St. Thomas and St. John as there are no remaining perennial streams (locally named as guts). Fortunately, rainy periods replenish temporary pools along guts, and these pools may persist for most of the year. Also, as artificial ponds are developed for irrigation, these provide additional sources of water. However, guts, pools, and natural springs are vulnerable to habitat fragmentation, urbanization, pollution and other abuse.

NEEDS:

- Save remaining natural pools, springs and artificial ponds on St. Thomas and St. John;
- Increase the freshwater source for bats;
- Reduce pollution from solid and other waste;
- Reduce sedimentation and erosion that can reduce the capacity of ponds;
- Reduce deforestation which has a negative impact on natural hydrological cycles.

ACTIONS:

- Protect all remaining ponds, springs and pools on St. Thomas and St. John, especially at sites listed above and at Coral Bay, St. John. The recently completed study by Nemeth and Platenberg (2007) can help inform management options for bats, and support efforts to protect these areas;
- In some of these areas, it should be possible to restore pools along guts, especially on the south and southwest of St. Thomas, and on the north side of St. John;
- Reduce solid waste, sewerage and other forms of pollution in guts, especially at Hull Bay, Neltjeberg and Santa Maria on St. Thomas;
- Reduce unnecessary road cuts, unpaved roads, poor road construction and erosion that can reduce the capacity of ponds, clog pools, cause pollution and reduce the flow of natural springs.

RESEARCH & MONITORING

NEEDS:

- To learn more about the ecology and the conservation needs of the bats of the Virgin Islands;

- Undertake active regular monitoring to help in the formulation, planning and execution of conservation and management options;
- Learn more about rare bat species, including *Stenoderma*, *Brachyphylla*, *Tadarida* and *Mormoops*;
- Gauge the effectiveness of conservation and management efforts;
- Provide needed training of DFW and other DPNR personnel;
- Create opportunities for research for local, national and international students and researchers;
- Publish findings in reputable journals and other publications;

ACTIONS:

- Set up a monitoring protocol for roosts, including any artificial roosts that are established;
- Conduct further research on *Stenoderma*, *Brachyphylla*, *Tadarida* and *Mormoops* to determine ecological needs and habits, find additional roost sites and to confirm the presence of *Mormoops* in the Virgin Islands;
- Continue to train professional staff at DFW to survey and monitor bats;
- Include expert review of monitoring, research and conservation programs by reputable bat scientists.

EDUCATION & AWARENESS

Bats can and should be used as a vehicle for increasing and improving awareness about biodiversity and other environmental and sustainable development issues in the Virgin Islands. But it is important to highlight here that bats are not the most popular symbols for positive messages. The public views on bats have long been negative, and therefore, their use will be an uphill battle. Nevertheless, the Virgin Islands are losing a great deal of its natural heritage and bats can provide a viable option for helping to improve conservation on the ground.

Use the bat houses as an educational tool to reach the public. Formalize the program to improve its capacity to meet the demand for alternative roosting homes for roof and plant visiting bats while setting an artificial limit to that supply capacity so that the DFW won't be overwhelmed by request for artificial houses from the public.

Also set up boxes on government properties and at prominent public places where they can be visible enough to remind the public of their importance, but being secure from potential harassment and from being vandalized. Options for public bat houses include the Park office compounds, and the properties of prominent residents.

Bat houses could be set up on school compounds and it could be proposed that science and biology students help monitor them.

NEEDS:

- Increasing awareness and education about local bats.

ACTIONS:

- Setting up displays and information kiosks at local festivals such agricultural fairs;
- Improving the existing DFW bat handout and making it more widely available, even as a bookmark and other similar products;

- Publish a local guide and information booklet, and make it widely available to schools and the general public;
- Further develop the DFW bat information flyer into a homeowners guide to bats;
- Use Arbor Day as a way to reach people and encourage residents to plant fruit and native species on their property as way to provide habitat for wildlife. This initiative should be backed up by information on "Best Management Practices (BMPs) for planting trees, beautifying the landscape, soil and water conservation and community development;
- The DFW could set up a public display "board" or mural on its property that is widely visible to the public, especially to pedestrians, and have monthly conservation themes that will include species as well as information on issues affecting nature and people of the Virgin Islands;
- Set up a website on the bats of the Virgin Islands. This website could include a wider regional bat conservation initiative that includes the Spanish Virgins, Puerto Rico and the BVI;
- Use the bats as a focus in conservation biology – work with the University of the Virgin Islands to develop a semester course on bats and conservation of native species, and sustainable development;

BATS AND CLIMATE CHANGE

Islands are more vulnerable to the effects of global warming and climate change than continents because of their size, vulnerability to rising sea levels, the dramatic changes in weather patterns, increasing temperatures, isolation, among other things.

It is difficult to predict what effects global warming and climate change will have on any species and/or ecosystem in the Virgin Islands, including bats. The effect on biodiversity is not yet understood, and much of the discussion on what is possible is mostly speculative and/or hypothetical. Nevertheless, recent events such as the death of 6% of the flying fox population in New South Wales Australia in 2002 due to dramatically high temperatures, which reached 42º C, illustrate the seriousness of the threats to animals, plants and ecosystems.

No one yet knows how dramatic the shift in local Virgin Islands weather and climate will be. In fact, there are no local initiatives or projects monitoring changes in the local weather and climate, and much of the predictions for the region are based on climate models originating from North America, Europe and Australia.

Understanding the impacts on bats is a difficult task because so little is known about our bats in the first place. Despite the fact that bats are so important to our economies, and to sustaining a local biodiversity, relatively little is known about the lives of bats under normal conditions, making it difficult to predict what shifting environmental conditions may cause.

In recent years, a series of events such as the one in Australia described above, and a number of ground-breaking studies are trying to grapple with the potential adverse impacts of changes in the climate on bats. In one study, researchers from Westminister College, Pennsylvania are looking at the "Impacts of climate change on Vampire Bats" by investigating how climate change will shift the distribution of the vampire bat extending its range north from Mexico into the southern United States.

It is possible to infer from studies of other species and from the effects on some ecosystems just what some of the possible impacts may be. Dramatic and erratic temperature shifts seems to be of major concern for some bat species, especially

in temperate climates, but increasing temperatures could also affect local bats. For example, two species are known to roost in large trees and shrubs. These are *A. jamaicensis*, which sometimes roosts in trees, small palms and shrubs, and *S. rufum*, which roosts in large trees, including palms. Because they roost in more exposed conditions, this makes these species very vulnerable to high or low temperatures, and to dramatic weather events, especially frequent hurricanes and cold front from the north, which often result in the toppling of large old trees and the death of many species of plants.

Sea level rise poses serious risks not only for coastal homes, properties, commerce, tourism facilities and infrastructure, but most of the caves in the Virgin Island are small coastal fissures and cavities and these are extremely vulnerable to increasing storm surges, rising sea levels, to harassment and development. Most of the species of bats in the Virgin Islands roosts in coastal caves and are therefore vulnerable to sea level rise and to human activities.

Despite the seriousness of climate change and its impacts on native biodiversity, bats have been on the decline for many years, and the loss of suitable habitat is the main cause. Some species of bats are known to live up to 30 years, though we do not yet know how long Virgin Islands bats may live, and they have relatively very low birth rates, most producing only one pup a year, making them vulnerable to increased mortality or depressed birth rates. Humans are increasingly impacting bats on multiple levels. They are killed outright, they lose habitats to increasing urbanization, there is a decline in food, in shelter and roosts and in available freshwater.

Along with existing human impacts, climate change will only compound the effects on native biodiversity, and will undoubtedly have adverse long-term consequences for bats. There is a serious need for a monitoring and response program to look at the impacts of changing climate on local biodiversity, and this should inform Territorial policies and programs, and the way development and conservation takes place in the Virgin Islands.

BATS AND WIND TURBINES

In recent years, the wind turbine seems to have become the poster child for large-scale alternative energy generation. Wind power is abundant and a safe source of generating energy for present and future economies, and with increasing attention on dependence on petroleum, increasing CO_2 emissions from this fuel, and to the need for increasing and tightening national security by reducing the dependence on foreign oil, alternative energy sources have been touted as the best option.

Though wind turbines may in fact have far less environmental and social impacts than petroleum, turbines have been shown to have a serious impact on birds, bats, natural aesthetic, and human wellbeing than was originally anticipated. Commercial wind turbines are usually large, obvious, and noisy. They also take up quite a bit of space, and they kill wildlife. This is an unintentional consequence of a drive to meet our energy needs without fully understanding the long-term impacts on nature and human quality of life.

In recent months, researchers have concluded that the spinning blades attract bat and literally caused the lungs of bats to explode. Under sensational headlines in national and international press like "*Wind turbines make bat lungs explode*" the nation learned of the potential dangers that these turbines pose to bats. What researchers have learned is that at some sites, wind turbines may cause as many as two thirds more deaths in bats than birds, accounting for up to 60% of the winged animals killed, according to one study (US National Research Council, 2007). At one site, about 90% of the bats showed signs of internal hemorrhaging consistent with the trauma caused by a sudden drop in air pressure. About half showed signs of collision with the turbines, perhaps also as a result of becoming paralyzed and disabled by the trauma. In fact, some researchers believe that fatalities are underestimated because we only see bats dead at the wind farm sites and many more may have serious trauma and die further away or in returning to their roosts.

Through the use of their echolocation, bats avoid collisions with man-made-objects. However, wind turbines "attract" bats for unknown reasons. Spinning blades cause a drop in the localized air pressure around the blades and this is reported to make them undetectable to the bats, a serious hazard to animals.

Birds are less susceptible to this "barotrauma" thus resulting in fewer collisions and fatalities.

The impacts of wind turbines on bats have been shown to be adverse to bats on land and at offshore wind farms.

As bat populations continue to decline, wind turbines may add to the already long list of adverse impacts on the populations, pushing some species even closer to extinction.

As the eyes of Virgin Islanders turn to wind turbines as a "safer" and more convenient form of alternative energy technology, it is prudent for the state to take stock and to recognize the potential biodiversity and human impacts that this may have. Utility companies, developers, governments and residents must work with bat experts to develop appropriate wind turbines that have little or no impact on the islands' native biodiversity, while at the same time provide residents with the energy they need. Before the rush begins, policies and guidelines on alternative energy should be developed as a foundation for the proper development and provision of a sound energy policy and supply for the Virgin Islands.

SECTION IV: HOMEOWNERS and BATS

This section provides homeowners, farmers, educators, conservationists and members of the general public with important information on how to control bats in the home, handling errant bats, the value of bats to our lives and to the Virgin Islands, protecting crops and ways to help the bats of the islands.

THE VALUE OF BATS

Bats are very valuable component of the natural landscape of the Virgin Islands. They play a significant role in nature, pollinating many species of plants, and they help to control insect pests such as mosquitoes, flies, moths and beetles. A single bat can consume as many as 500 insects in just one hour, or nearly 3,000 insects every night.

In the Virgin Islands, fruit bats help to pollinate mango trees (*Mangifera indica*), locust (*Hymanea courbaril*), calabash (*Crescentia cujete*), cashew (*Anacardium occidentale*), breadfruit (*Artocarpus altilis*), bananas (*Ananas* spp.), the agave or century plant (*Agave missonium*), silk cotton (*Ceiba pentandra*) and the columnar or dildo cactus (*Philosocereus royeni*). They also help to spread the seeds of countless species of forest and garden plants. Without bats, some species of plants would severely decline or even disappear. Some of these, such as the cactus, agave, locust and silk cotton, depend largely or completely on bats for pollination.

Like us, bats have a love for sweet juicy fruits. Many farmers and homeowners can attest to bats that eat their sugar apples, papayas, tamarinds, mangoes, guavas, West Indian almonds, and other fruits.

Bats also feed on the nectar of various plants, including the silk cotton, the locust tree, bananas, the calabash, and many species of cacti.

For most crop farmers, bats may go unnoticed as they swoop above the plots feasting on insect pests that infest the crops, while for others who have ponds and dams near their farms, bats can often be seen swooping down to the water's surface to drink or glean insects from the water surface. All species of bats in the

Virgin Islands must drink frequently, and local freshwater sources are extremely important to their survival.

Though the farmer and homeowner may begrudge the bat for damaging fruits on the tree, their damage is often minimal, especially if the crops are harvested before they are ripe, since bats eat only ripe or over ripe fruit. However, farmers and homeowners can be accommodating to bats by allowing for a certain amount of small loss of crops to the bats since they provide a very important and irreplaceable service to the islands' economy and ecology.

Farmers and homeowners should plant fruit and nectar producing trees to provide food sources for bats. Also, bat houses can be placed on the property to encourage healthy insect-eating bat populations around to help reduce insect pests.

A list of the species of plants preferred by fruit bats is provided in Appendix IV, and property owners should contact the Division of Fish and Wildlife for other tips and advice on other things that can be done to help bats.

BATS IN THE HOME

Of the six species of bats known from the Virgin Islands, only two are common roof roosters: *Molossus molossus* and *Tadarida brasiliensis*, while *Artibeus jamaicensis* may use overhangs and eaves for temporary evening roosts, or may occasionally use abandoned structures and large cavities as permanent roosts.

Most homeowners with bats in their roof are often unaware of their presence or tolerate them because they cause few problems, and avoid human interactions, and emerge at dusk so are seldom seen.

However, there are a few homeowners who have a bat "problem" as their numbers, noisy habits, droppings and urine may cause an annoyance. Some owners are terrified of bats and their presence unnerves them.

The roof bats of the Virgin Islands find the underside of roofing an invaluable and attractive place to roost, and for *M. molossus*, this may in fact be the primary

site of roosting for this species. However, over the last 20 years or so, new home designs have improved ways to exclude bats from these structures.

Many older homes, however, have gaps between the roofing materials and the frame, and also may have vents to allow the ceiling cavity to "breathe". These homes may hosts dozens to even hundreds of individual bats. In a few cases, the droppings from these bats can build up and increase the weight of the upper parts of the structure, and may also become unsightly, filtering through cracks and cavities to fall onto the occupants and property below.

Though bats may be a nuisance, they pose little or no threat to the occupants. For evicting bats from the structure, the following information is important to know, and steps and process outlined below is recommended:

First, contact the Division of Fish and Wildlife and get them to come out and inspect the property and provide assistance. It is important to know that repellent devices are not effective. In fact, when ultrasonic devices were tested by bat experts some of them actually attracted bats.

If You Have Bats in Your Roof

Most homeowners in the Virgin Islands are aware that they have bats in their roofs by the squeaking, scurrying and scratching noises that the bats make during the day and as they leave at dusk to feed. During the day, bats will likely be roosting in narrow crevices in the attic walls, between the rafters, or tucked into the space between the rafters and roofing material.

Your may also look for the presence of bats by inspecting for their droppings or urine stains on walls (siding) at site of entry. The dry, black droppings are about the size of a grain of rice, and accumulate in piles below areas where the bats roost. (Mouse droppings look similar, but you would find them scattered in small amounts throughout the attic).

Sometimes, when homeowners understand the important role that bats play in controlling insects, they decide to allow the colony to remain in the roof. In this case, the homeowner must seal all openings that would give bats access into the

living spaces. This safety measure is particularly important for families with small children and pets.

If you have a bat colony and you want to remove it, you must use the proper methods to do so. Do not use chemical poisons or repellents to eliminate a bat colony. Poisons are exposed to all occupants of the building often unintended, but nonetheless are detrimental to humans exposed, as well as scattering dead, dying, or disoriented bats throughout the house and neighborhood, which increases the risk of children or pets coming into contact with sick bats. Repellents, such as moth balls or flakes (naphthalene), sulfur candles, or electromagnetic or ultrasonic sound devices do not permanently remove bats from a home. Unless their entrances are sealed, the bats will return as soon as the chemical repellents wear off.

The best way to safely and permanently evict a maternity colony is to physically exclude, i.e., seal all of the colony's entrances. This inexpensive procedure, called bat-proofing, is described below. However, before sealing any entrances, it is important to make sure that all bats have vacated the premises. Exclusion activity should be avoided during the season where pups are likely to inhabit the roost (between May and November).

Bat Proofing

Bat-proofing a building involves sealing the bats' entrance holes and then providing the colony with an alternate roost, or bat box. Bat-proofing a building is usually a simple procedure that does not require the skills of a professional or any expensive materials. To bat-proof your home: (1) stage a "bat watch" to identify bat entrances, (2) seal the holes to prevent their entry, (3) provide an alternative roost, or bat box, for the colony to occupy.

Identifying Entrances

The first step in bat-proofing is to locate the holes that bats use to enter and exit the roof. Bats commonly enter at points where joined materials have warped, shrunk, or pulled away from one another, or just below the roofing material.

Some common points of access occur at louvered vents with loose screening, at the roof peak.

To identify which of these areas are providing access, look for tell-tale bat droppings on the side of the house below a suspicious crack or crevice, or look for urine stains since bats empty their bladders immediately before the entrance or immediately after exiting. Also, entrances that have been used for a long time may have a slight brown discoloration at the edges from bodily secretions. Inspecting inside ceiling cavities can also reveal openings that need to be sealed. Inside, bat droppings often accumulate below bat entrances and exits.

Staging a "bat watch" can also help you locate the bats' entrances. At dusk, station a person on each side of the building and watch as the bats exit the building. Once the first bats are seen leaving, focus on that area of the building and watch for other exiting bats until you have pinpointed their exit(s). Dawn is another good time to identify their entrances, because the returning bats will swarm around their entrances a few times before actually entering the building.

Sealing Entrances

Once the bat entrances have been located, the next step in bat-proofing is to seal these openings. Use window screening or hardware cloth to cover louvered vents or large gaps and cracks in the building. To fill in smaller cracks, use expanding foam insulation or caulking compound. After hardening, these can be trimmed or painted as needed. Unlike mice, bats will not gnaw new holes in the building, so sealing the existing holes will keep them out. Most bat-proofing materials can be obtained in local hardware or building supply stores. A listing of suppliers of bat exclusion products is included below.

Timing of Bat Proofing

One important aspect to consider before bat-proofing your building is the timing of the procedure. *Because pups remain confined in the roost until they are old enough to fly, bat-proofing should never be completed while they are flightless.* Bat-proofing during these months would result in potential health risks and obvious odor problems as the young bats die and decay inside the building. Also, the pups

may enter human living areas in search of a way out, and females may frantically attempt to reenter the building, even during daylight hours, to rejoin their young.

Occasionally, a homeowner may encounter the difficult situation of bat-proofing while the pups are still confined to the attic. This happens when a roofing contractor discovers bats at the worksite but cannot stop the project. In this case, the contractor should complete the project, but allow one of the bats' access points to remain open, so that nursing females can enter and exit the attic. Then, after the pups are able to fly, a one-way door can be installed to evict the bats. Once all of the bats have left the roof, the remaining bat entrance can be sealed.

One-way Doors

One-way doors are pieces of mesh or screening placed over a bat entrance to form a long sleeve or tent. These doors allow bats to exit at night but prevent their reentry at dawn. One-way doors work because bats use their sense of smell, rather than their vision, to locate their entrances. The bats will exit at the bottom, but when they return, they will land on the mesh near their entrance hole. They will smell their entrance through the mesh, and will crawl around in the vicinity of the entrance, trying to find a way inside. The smell of the entrance focuses their attention on that portion of the mesh, and the bats will not move to the opening at the bottom of the door to gain entrance.

Installing One-way Doors

- Choose 0.62 to 1.25 cm wire screening or heavy plastic mesh to cover the bats' points of entry. Cut the screening so that it covers the width of the hole and extends approximately three feet below the hole. The screening should project three-to-five inches clear of the hole, so that the bats can crawl between the screen and the building and exit at the bottom.
- Secure the mesh at the top and sides with duct tape or staples and leave the bottom open.
- Leave the door in place for at least three to four days, or until you are sure that all bats have left the building, then remove the one-way door and permanently seal the opening.

– Again, never use a one-way door while young bats inside, are flightless.

PROVIDING AN ALTERNATIVE ROOST

Bat-proofing has two potential drawbacks. One is that exclusion can be very stressful for a colony. When prevented from using their traditional roost, the bats may move into a nearby building, where they may be expelled again, or even exterminated. Also, displaced colonies will not relocate into buildings and roosts that already house other colonies. In other words, an excluded colony cannot just move down the road into a barn or church that already has bats. If a displaced colony cannot find a new roost, it may leave the area. In fact, evicting bat colonies can contribute to serious declines in local bat populations.

The second drawback is that homeowners may find it difficult to completely bat-proof their home. Bats can crawl through a crack as small as 0.62 by 1.25 cm inches, so persistent bats may find a way to reenter their traditional roost.

Bat boxes may solve both of these problems because they provide alternative roosting sites for colonies. When constructed properly, bat boxes can serve as suitable places for females to raise their pups. With bat boxes, the bats get a safe roosting site outside the home, while homeowners still benefit from the bats' control of insects.

Bat Box Design

Size, interior construction, and temperature control are the three most important design elements of bat boxes. Homeowners should consult with the Division of Fish and Wildlife on obtaining or constructing their own bat houses as well as locating them in the most appropriate places.

A bat box must be large enough to adequately house a colony. Boxes should be at least 18 cm deep, 61 cm wide, and either 30.5 or 61 cm tall (depending on the size of the colony). Boxes 30.5 cm in height will house up to 100 bats, and boxes 61 cm in height will house as many as 200 bats. To house even larger colonies, you can join two boxes side-by-side, or you can install one large box that measures 36 to 53 cm from front to back.

The interior construction of a bat box is important because bats have particular requirements for their roosting chambers. Baffles should be used to divide the interior space into multiple roosting crevices. The crevices should measure from 2 cm up to 3.8 cm in depth, with the majority in the 2 cm to 2.5 cm range. In addition, all of the baffles, interior surfaces, and the landing board below the box should be roughened with saw cuts to provide footholds for bats.

Finally, the boxes must provide high incubation temperatures for the pregnant females and growing pups. Staining the bat boxes dark brown or black enhances a box's ability to absorb sunlight. The boxes must also have cooler areas for the bats to move into, in case temperatures rise too high. Tacking black roofing paper to the upper portions of the box and cutting ventilation slits into the lower sides and front will help to control interior temperature ranges.

Bat Box Placement

Because of the importance of optimal temperatures in the roost, the amount of sunlight a bat box receives may be the most important factor to consider.

A bat box intended to house a displaced colony should be placed on or very near the building in which the bats roosted. Place the box on a pole within 3 m to 6 m of the building. If placed on the building, the box should have at least 1 m of open space under it, so that bats can enter and exit from the bottom. Do not place a bat box in an area that is heavily trafficked by people, or anywhere that droppings from the box will pose a problem. Whether on a building or pole, bat boxes should always be placed at least 3 to 4.5 m above the ground.

Once the bats move into the box and establish it as their roost, the box can gradually be moved farther away from the building. Moving the box more than 18 m per year is not recommended.

Timing of Installation

Ideally, bats should be allowed to familiarize themselves with the bat box before being expelled from their traditional roost. This timing of events makes the task

of bat-proofing easier for the homeowner, because the bats should be less persistent in trying to reenter the house.

If you cannot allow the bats to remain in the building for a period of time (e.g., several weeks) to allow them to familiarize themselves with the alternative houses, then install the bat box and bat-proof the house. The bats may not move into the unfamiliar box right away, but this option is still preferable to expelling a colony without providing an alternative roost.

Colonies identify their roosts, in part, by their smell, so it may help to scent the box with the colony's droppings before installation. Gather a cup of droppings from the attic, mix them with water to make a slurry, and pour this mixture into the bat box. Allow the slurry to soak into the bat box before installing it. If scenting the box is not feasible, new boxes should at least be stored outside prior to installation, so the scent of new materials weathers out of them.

If a bat wanders into the home, do not kill it. It is likely that it came in accidentally and is looking for a way out. First, it is important to assess where the bat came in. Then do the following:

– Shut all doors leading into other rooms to confine the bat to as small an area as possible.
– Open all windows and doors leading outside to give the bat a chance to escape (Don't worry about other bats flying in from the outside, as this is highly unlikely).

  - Remove pets from the room, leave the lights on, stand quietly against a wall or door, and watch the bat until it leaves.
  - Do not try to herd the bat toward a window. Just allow it to calmly get its bearings, and don't worry about it swooping at you.

– Within ten to fifteen minutes the bat should settle down, locate the open door or window, and fly out of the room.

If the bat tires and comes to rest on a curtain or wall, you can easily remove it without directly touching it. Follow the steps below, and remember to never handle a bat, or any other wild animal, with your bare hands.

- Put on a pair of leather gardening or work gloves,

- Place it in a container, such as a large plastic bowl, or empty coffee can over the bat, slide a piece of cardboard under the can trapping the bat inside, and bring the can outside and release it.

This allows you to easily remove a bat from a room without directly touching it.

Information above from:
Williams, L.M., and M.C. Brittingham. 2006. A homeowner's guide to northeastern bats and bat problems. Pennsylvania State University College of Agricultural Sciences, Agricultural Research and Cooperative Extension.

BATS AND PUBLIC HEALTH

Bats are wild animals, and people should not handle bats because they will bite in defense, and may also scratch. This is especially important for children and pets. If you do have to handle bats, use a pair of leather gloves and be very gentle with the bat since they have very delicate bones and wings, and injuring them may mean certain death to the animal.

Histoplasmosis is one of the diseases that is sometimes associated with soil material associated with the droppings of bats and birds such as pigeons. The disease is caused when a person inhales spores of the soil fungus *Histoplasma capsulatum*, which naturally occurs in soils. There is no evidence that the disease can be transmitted from bats to humans. The disease causes flu-like symptoms, but in most instances, the individual may not show any physical symptoms of the disease and the occurrence of Histoplasmosis in the Virgin Islands is extremely rare and virtually unheard of.

Another disease often associated with bats and other wild animals in the United States is rabies. However, there is no recorded case of this disease in the Virgin Islands in humans or in animals. Though people should avoid handling bats at all times, people should not fear getting this disease if bitten.

Needless to say, if dying and or sick bats are observed or suspected, homeowners should immediately call the Division of Fish and Wildlife and report the case, and request that they come out to inspect and collect any evidence.

SOME FACTS ABOUT BATS

- Bats are the only true-flying mammals.
- They make up about a quarter of all the mammals on earth.
- There are over 1100 species of bats found all parts of the world, excluding the Arctic and Antarctic.
- Bats are not flying mice or rats as local names suggests.
- Bats are placed in a group all of their own called Chiroptera.
- A single bat can consume as many as 500 insects in just one hour.
- They come in many types of colors, sizes, some with six foot wing spans and some less than an inch.
- The great diversity of bats means that different species eat different things, with some species eating insects, some fruits, pollen and nectar, while others eat fish and other animals.
- Only three species consume blood, and these are called vampire bats. They are found only in Central and South America.
- Of the bats, 70% eat insects, 20% eat fruits, nectar, pollen and plant matter, and the rest eat animals of one type or another, including frogs.
- Bats have some of the largest congregations of any mammalian species on earth. Bracken Cave in Texas has about 20 million bats.
- Bat populations are declining. Half the bats in the US are listed as rare, threatened or endangered.
- Bats are not blind or deaf, and depend on sonar or echolocation and vision to navigate around objects, map their environment, find food, learn about their surroundings, and avoid danger, including predators.
- Bats do not try to become entangled in women's (or men's) hair.
- Bats locate flying insects primarily by using a radar system known as "echolocation." Bats emits high-pitched sound waves that bounce back to the bat when they strike a flying insect or other object.
- Bats often capture insects when flying by scooping them into their tail or wing membranes, and then putting the insects into their mouth. This results in the erratic flight most people are familiar with when they observe bats feeding in the evening.
- Some individual bats have been known to live for over 43 years.
- Some roosting colonies have been in existence for thousands of years.

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LITERATURE CITED

Bacle, J.-P., K.C. Lindsay, and G.G. Kwiecinski. 2008. Bats of St. Thomas and St. John, U. S. Virgin Islands: Priority conservation measures for species of greatest concern. Island Resources Foundation, Occasional Paper 60:1-13.

Bat Conservation International. 2002. Climate change threatens bats. Bat Conservation Times. Http://www.batcon.org/news2/scripts/article.asp?articleID=223&newsletterID=41.

Bogan, M. A. 2003. Potential effects of global change on bats. United States Geological Survey. Http://geochange.er.usgs.gov/sw/impacts/biology/bats/.

Division of Fish and Wildlife. 2005. Endangered and threatened plants and animals of the United States Virgin Islands. Department of Planning and Natural Resources, St. Thomas. Government of the Virgin Islands.

Fleming, T. H. 1971. *Artibeus jamaicensis:* Delayed embryonic development in a neotropical bat. Science 171.

Gannon, M. R., and M. R. Willig. 1992. Bat reproduction in the Loquillo Experimental Forest of Puerto Rico. Southwestern Naturalist. No 37.

Hall, E. R., and J. W. Bee. 1960. The red fig-eating bat *Stenoderma rufum* Desmarest found alive in the West Indies. Mammalia, 9: 67-75.

Hayssen, V., and A. Van Tienhoven. 1993. Asdell's Patterns of Mammalian Reproduction. Cornell University Press, Ithaca, NY.

Heatwole, H., Levins, R., Byer, M. D. 1981. Biogeography of the Puerto Rican Bank. Atoll Res. Bul. No. 251.

Hood, G. S., and J. K. Jones, Jr. 1984. *Noctilio leporinus*. Mammalian Species.

Koopman, K. F. 1975. Bats of the Virgin Islands in relation to those of the Greater and Lesser Antilles. American Museum Novitates, 2581: 1-7.

Krutzsch, P. H., and D. W. Nellis. 2006. Reproductive anatomy and cyclicity of the male bat *Brachyphylla cavernarum (Chiroptera: Phyllostomidae)*. Acta Chiropterologica, 8.

Kwiecinski, G.G., J.-P. Bacle, K. C. Lindsay, and H. H. Genoways. 2009. New records of bats from the British Virgin Islands. Draft report.

Kwiecinski, G.G., and W.C. Coles. 2007. Presence of *Stenoderma rufum* beyond the Puerto Rican Bank. Occasional Papers of the Museum of Texas Tech University, Number 266: 1-9.

Lazell, J. D., Jr. 2005. Island: fact and theory in nature. Berkeley: University of California Press, xx + 382 pp.

Lazell, J. D., Jr., and L. Jarecki. 1985. Bats of Guana, British Virgin Islands. American Museum Novitates, 2819: 1-7.

Lindsay, K., G.G. Kwiencinski, and J.-P. Bacle. 2008. Conservation of bats of St. Thomas and St. John, U. S. Virgin Islands. Island Resources Foundation. Report prepared for the Division of Fish and Wildlife, Department of Planning and Natural Resources, St. Thomas, U. S. Virgin Islands. 73pp.

Nemeth, D., and R. J. Platenberg. 2007. Diversity of freshwater fish and crustaceans of St. Thomas watersheds and its relationship to water quality as affected by residential and commercial development. Virgin Islands Water Resources Research Institute, University of the Virgin Islands. 28 pp.

Philibosian, R., and J. A. Yntema. 1977. Annotated checklist of birds, mammals, reptiles, and amphibians of the Virgin Islands and Puerto Rico. Information Services, St. Croix.

Platenberg, R. J. 2008. *Bats* (flyer). Division of Fish and Wildlife, Department of Planning and Natural Resources, St. Thomas, U.S. Virgin Islands.

Platenberg, R. J. *et al*. 2005. A comprehensive wildlife strategy for the U.S. Virgin Islands. Division of Fish and Wildlife, Department of Planning and Natural Resources, St. Thomas, U.S. Virgin Islands.

Silva Taboada, G. 1979. Los Murciélagas des Cuba. Editorial Academia, Havana, Cuba.

Thomas, T., and B. Devine. 2005. Island peak to coral reef: A field guide to the plant and marine communities of the Virgin Islands. University of the Virgin Islands. 214pp.

Williams, L. M., and M. C. Brittingham. 2006. A homeowner's guide to northeastern bats and bat problems. Pennsylvania State University College of Agricultural Sciences, Agricultural Research and Cooperative Extension.

Wilson, D. E. 1979. Reproductive patterns Pp 317-378 in Biology of Bats of the New World Phyllostomidae, Part III (R. J. Baker, J. K. Jone, jr., & D. c. Carter, eds). Special publications of the Museum, Texas Tech University 16.

APPENDIX I

The flyer below is a product of Dr. Renata Platenberg for the Division of Fish and Wildlife, St. Thomas. The flyer is made available to the residents the U.S. Virgin Islands to increase public awareness about the value of the native bats. The flyer is an important local source of information and an important first step in the future potential for the types of education and awareness products that can be developed for various sectors of the local communities.

BATS !

Bats are mammals that can fly! They have fur, give birth to live babies, and suckle young on milk. The bats in the Virgin Islands eat only fruit, insects, or fish. Bats roost during the day and fly at night, and most bats use echolocation, a kind of radar system, to navigate in the dark. Bats are important in seed dispersal, insect control, and pollination. Threats to bats include roost destruction and deforestation.

These bats live in the USVI year-round:

Jamaican Fruit-eating Bat
Artibeus jamaicensis

Description: Large leaf-nosed bat with pointed ears, wingspan up to 40-45 cm (16-18 in), thick brown fur
Habitat: Dry forest and rainforest; roosts in caves and tree holes, and sometimes makes tents by biting the center vein of leaves; groups of females roost with a single adult male
Diet: Eats mostly fruit, also nectar, pollen, flower parts, and insects
Distribution: Mexico, Central America, South America, all across West Indies

Red Fig-eating Bat
Stenoderma rufum

Description: Leaf-nosed bat with reddish tan to dark brown fur
Habitat: Subtropical forests; roosts in trees in rainforests
Diet: Fruit, nectar, pollen, flowers, and insects
Distribution: Only in Puerto Rico and Virgin Islands

Antillean Fruit-eating (or Cave) Bat
Brachyphylla cavernarum

Description: Large, muscular bat, 6.5-11.8 cm (2.5-4.5 in) long with 45 cm (18 in) wingspan, short cone-shaped muzzle with stumpy nose-leaf, yellow to brown fur
Habitat: Tropical forests; roosts in caves and rock overhangs
Diet: Fruit, pollen, nectar, and insects
Distribution: Puerto Rico, Virgin Islands, Lesser Antilles

Pallas' Mastiff (or Velvety Free-tailed) Bat
Molossus molossus

Description: Small bat, wingspan under 30 cm (12 in), smooth lips, long tail
Habitat: Tropical and subtropical forests and urban areas; roosts in hollow trees, caves, and houses; uses bat houses
Diet: Insects, mainly mosquitoes, moths, and flying ants
Distribution: Central and South America, West Indies

Greater Bulldog (or Fisherman) Bat
Noctilio leporinus

Description: Large, 96-132 mm (4-5 in) long with wingspan up to 50 cm (20 in), pointed muzzle, orangey color
Habitat: Tropical and subtropical forests; roosts in caves, rocky crevices and hollow trees near streams and coastal marine habitats
Diet: Eats fish that it catches while echo-locating above surface of water
Distribution: Mexico, Central America, South America, Greater and Lesser Antilles

To report any of these bats or for more information contact the Division of Fish and Wildlife 775-6762, vi.wildlife@gmail.com

APPENDIX II

Complimentary Supporting Initiatives and Programs in the U.S. Virgin Islands

There are several ongoing programs and initiatives that may have a long-term impact and implications for the conservation and management of bats in the U.S. Virgin Islands. These initiatives involve various key sectors and divisions across the islands, and also pull relevant information and data from many sources, including the three-year bat survey effort.

However, this section does not identify programs and projects taking place in the BVI, the Spanish Virgins (Culebra and Vieques) and in Puerto Rico. Nevertheless, programs that reach across borders and boundaries will have far reaching and long-term effects for the conservation of bats in the Virgin Islands and the rest of the Puerto Rico Bank.

The initiatives below could be closely tied together to help in the design of a predictive model for bats and/or for other wildlife and natural resources management options. The work that these programs are doing certainly provide the framework and basis for such a model, and one that would prove very useful for the Virgin Islands, and could act as a model approach for other islands in the Caribbean region.

These supporting initiatives include:-

The Nature Conservation (TNC): Conservation planning process for the Territory's ecological systems and natural resources. Initiated through the VI Department of Natural Resources (DPNR), TNC will facilitate conservation planning in the USVI.

In June 2008, the Department of Natural Resources (DPNR) hosted a key Expert Consensus Workshop. The goal was to objectively identify specific targets of conservation, and threats to them. This information is being be utilized to help map relative conservation priority areas across the entire USVI. The participants

comprised a broad spectrum of VI residents with known expertise on USVI ecology and natural resources.

Participants in this workshop worked to map the resources and produce priority natural resource area maps. These maps don't identify specific resources, but prioritize areas on the islands according to value to natural resources. The maps completed by TNC will go to DPNR, will be available to all divisions, and will constitute a major part of an updated land and water use plan.

This process is part of a larger Comprehensive Planning Initiative. The plan that will be developed as a result of this process shall be integrated in the larger Comprehensive Planning Initiative along with several other components.

The benefit to bats is that areas that are of high value to wildlife in general (under developed) might be better protected from development.

The VI Gap Analysis: This initiative involves the mapping of each and every individual resource, and will identify priority areas that contain many resources but have little protection, so that protective measures can be applied. Though this information is not available on a website for the Virgin Islands, the information for the Puerto Rico Gap exercise is provided below. The Puerto Rico work is nearly completed. The Virgin Islands Gap Analysis is being carried out by the same people doing the Puerto Rico Gap analysis.

Information on the Puerto Rico Gap Analysis can be found at:

http://www.tropicalforestry.net/Members/msolorzano/puerto-rico-gap-analysis
http://muskox.com/powerpoint/NCSU2001/ppframe.htm

The benefit to bats is that each species will have its own map and information page, and the information can be used to better apply habitat protection measures.

The Landowner Incentive Program (LIP): This initiative is currently mapping critical resources according to privately-owned lands in the territory.

This will identify areas for habitat restoration, corridor creation for linkages, and habitat easements.

The benefit to bats is by addressing habitat restoration and protection on a single parcel level.

The VI-DFW Bat House Project: This program aims to provide artificial refugia for in order to increase roosting opportunities to bats. A major part of the program is to raise awareness in the community of the plight of bats and about the project. Roof bat exclusions are being conducted in conjunction with installation of bat houses. The focus at this point is mainly on bat houses for insectivorous bats.

The benefit of bats is two-fold: providing roosting sites and making people love them.

Other programs and initiatives

Though there are no other current programs, projects and initiatives in the USVI of concern to bats, there may be more projects in future, based on priorities identified in the Comprehensive Wildlife Conservation Strategy (CWCS). These include climate change impact studies, which might also address bats.

Wind turbines and communications towers: While there is no program currently that addresses the potential impacts of these devices, DFW is reviewing the placement and technical aspects to ensure minimal threat to bats and migratory birds. The DFW is proposing to collect and necropsy any incidentally-killed animals. This is going to be a big deal coming up, with the Energy Office offering rebates on wind generators and the WAPA prices out the roof.

APPENDIX III

FUNDING AND FINANCING

The Plan cannot move ahead if there isn't the financial resources and political will to carry it beyond the report stage. Funding is perhaps the most limiting and the hardest aspect of this effort. Currently, the DFW receives most, if not all, of its funding from the federal sources.

DFW has funds allocated from the U.S. Fish and Wildlife Service to conduct studies and management activities on USVI wildlife. There are two mechanisms, these are the Pittman-Robertson Wildlife Restoration, and the State Wildlife Grants. These funds are divided among all the projects conducted by DFW (sea birds, invasive species, herps, crabs, deer, bats, cay management, waterbirds). The Division applies for how it wants to spend the funds each year. The USFWS reserves the right to agree with the decision or not. Funds allocated for a specific project one year may not be available for the same project the following year. The total amount available is around $750,000, which also pays all the salaries of wildlife and supporting staff, plus indirect administration costs.

The DFW in its current capacity is limited by both financial and human resources to carry out the extraordinary types of initiatives and programs that would prove very beneficial to the long-term conservation of bats. For this plan, and for any outcomes to be successful, it would be necessary to develop and source other funding mechanisms and support that would allow the DFW and its partners to fully and effectively advance the some of the ideas coming out of the plan.

Though we do not provide any supporting mechanisms or new initiatives as part of the plan, the next step in gaining access to financial support would be to put together a strategy for the plan, which would include funding and political mechanisms. This in and of itself would require some start up monies, and this could be the basis for establishing a regional bat working group that would include the BVI, USVI, Spanish Virgins and Puerto Rico, which would help to strengthen efforts bat conservation across the region, and to gain greater access to financial and human resources.

The DFW would need to develop partnerships with NGOs, the private sector, federal agencies and other local institutions to source initial and long-term funding to move the plan further ahead after it has been reviewed by stakeholders and finally completed.

APPENDIX IV

The table below lists some of the plants used by bats as food and shelter. Not all the species are listed and some species are suspected as being important to the bats based on field observations and evidence from other reports, including local anecdotal information.

List of Plants Species Used by Bats	Origin/ Status	Common Name(s)	Uses/Value of Plants to Bats	Comments
Arecaceae/Palmae				
Cocos nucifera	I	Coconut	Mainly as a shelter, roost or temporary roost, especially for Aj	
Cocothrinax barbadensis	N	Thatch palm	Fruits and as a shelter, especially the leaves	
Sabal spp.	N		Fruits and as a shelter, especially the leaves	
Roystonea spp.	N (some spp. introduced)	Royal palm	Fruits and for roosting by *A. jamaicensus*	
Agavaceae				
Agave spp.	N (some spp. introduced)	Century plant, agave	Nectar from flowers by fruit bats	several species are used by bats
Musaceae				
Musa spp.	I	Bananas, plantains	Nectar and fruits	
Piperaceae				
Piper aduncum	N	Piper	Fruits	
Piper amalago	N	Piper	Fruits	
Piper dilatatum	N	Piper	Fruits	
Polygonaceae				
Coccoloba spp.	N		Fruits	several species are used by bats
Nyctaginaceae				
Guapira fragrans	N	Black loblolly	Fruits	The juicy dark purple fruits are suspected to be eaten based on

				observations of bat ativity around fruiting trees.
Nyctaginaceae				
Trichostigma octandrum	N		Fruits	Suspected to be used by not proven
Lauraceae				
Persea americana	I	Avocado pear, pear	Fruits	
Annonaceae				
Chrysobalanaceae				
Chrysobalanus icaco	N	Coco plum	Fruits	
Leguminosae-Mimosoideae				
Acacia farnesiana		Casha. Cusha	Fruits	
Albizzia lebbek	I	Albizzia	Pollen and fruits	The seeds of the green fruits are suspected as a source of food for some bats
Andira inermis	N	Andira	Pollen and fruits	The seeds of the green fruits are suspected as a source of food for some bats
Inga laurina	N	Inga, Spanish oak	Fruits	The seeds and sugary pulp of the green fruits are suspected as a source of food for some bats
Leucaena leucocephala	I	Tan tan, leucaena	Pollen and fruits	The seeds of the green fruits are suspected as a source of food for some bats
Hymenaea courbaril	N	Locust	Nectar	
Tamarindus indica	I	Tamarind	Flowers and fruits	
Rutaceae				
Citrus spp.	I		Fruits	
Moraceae				
Cecropia schreberiana	N	Cecropia	Fruits	
Ficus altissima		Ficus	Fruits	
Ficus americana		Ficus	Fruits	
Ficus benjamina	I	Ficus	Fruits	
Ficus citrifolia	N	Ficus	Fruits	

Ficus elastica	I	Ficus	Fruits	
Ficus microcarpa		Ficus	Fruits	
Ficus nymphaeifolia	N	Ficus	Fruits	
Ficus obtusifolia	N	Ficus	Fruits	
Ficus religiosa		Ficus	Fruits	
Ficus trigonata	N	Ficus	Fruits	
Nyctaginaceae				
Guapira fragrans	Black loblolly		Fruits	
Annonaceae				
Annona glabra	N	Gut apple	Fruits	
Annona montana	I?	Wild soursop	Fruits	
Annona muricata	I?	Soursop	Fruits	
Annona reticulata	I	Custard apple	Fruits	
Annona squamosa	I?	Sugar apple	Fruits	
Capparaceae				
Capparis baducca			Leaves and possibly fruits	
Capparis cynophallophora	N		Leaves and possibly fruits	
Capparis flexuosa	N		Leaves and possibly fruits	
Capparis hastata	N		Leaves and possibly fruits	
Capparis indica	N		Leaves and possibly fruits	
Anacardiaceae				
Anacardium occidentale	I	Cashew	Fleshy parts (will consume when available)	
Mangifera indica	I	Mango	Fruits	
Spondias cytherea	I	Yellow plum	Fruits	
Spondias mombin	N	Hog plum	Fruits: this seeds of this species are largely dispersed by bats	
Spondias purpurea	I	Red plum	Fruits	
Celastraceae				
Cassine xylocarpa	N	Nothing nut	Fruits: especially important for bats during dry periods	

Sapindaceae				
Melicoccus bijugatus	I	Genip	Fruits	
Rhamnaceae				
Colubrina arborescens	N	Mauby	Fruits	
Krugiodendron ferreum	N		Fruits	
Bombacaceae/Malvaceae				
Ceiba pentandra	N	Silk cotton	Flowers and pollen: this species is largely pollinated by bats	
Clusiaceae				
Calophyllum calaba	N?		Fruits	
Clusia rosea	N	Clusia, bastard fig	Fruits	
Mammea americana	I		Fruits	
Caricaeae		Mammea		
Carica papaya	I?	Papaya	Fruits	
Passifloraceae				
Passiflora laurifolia	N		Nectar and Fruits	
Cactaceae				
Acanthocereus tetragonus	I		Nectar, pollen and fruits	
Cereus hexagonus	I		Nectar, pollen and fruits	
Hylocereus trigonus	N		Nectar, pollen and fruits	
Hylocereus undatus	I		Nectar, pollen and fruits	
Opuntia rubescens	N		Nectar, pollen and fruits	Not yet confirmed, but suspected to be a food source
Pilosocereus royeni	N		Nectar, pollen and fruits	
Selenicereus grandiflorus	I		Nectar, pollen and fruits	
Combretaceae				
Terminalia catappa	I	Almond	Fruits	
Myrtaceae				
Eugenia spp.	N		Fruits	
Psidium guajava	I?	Guava	Fruits	

Sapotaceae				
Chrysophyllum cainito	I	Caimit	Fruits	
Manilkara zapota	I	Sapodilla	Fruits	
Sideroxylon foetidissimum	N	Barbados mastic	Fruits	
Solanaceae				
Solanum torvum	I?		Fruits	
Bignoniaceae			Fruits	
Kigelia Africana	I	Sausage tree	Fruits	

APPENDIX V
LEGISLATION & PROTECTION OPTIONS

Prepared by: Dr. Barbara Lausche

Preliminary Observation on USVI Legal Framework for Bat Conservation

The development and implementation of effective conservation and management plans for bats of St. Thomas, St. John, and surrounding cays requires a supportive legal framework to give the responsible agencies the needed tools for implementation. As assessed through this project, the bats in the Territory depend on suitable habitat for their survival, including the availability of adequate food and fresh water. Typically, legislation protecting endangered or threatened species falls into two complementary areas: l) laws directed at wildlife conservation, and 2) laws for protected areas. In addition, important supportive elements need to be integrated into land/water use plans and general development control laws. Today, the globally-accepted umbrella concept within which these species protections are framed is known as 'biodiversity conservation' (biodiversity comprising species, ecosystems, and genetic resources).

A detailed analysis of the legislative and institutional mechanisms in the Virgin Islands for conservation and management of bats is beyond the scope of this project. Such an analysis, however, is an important supportive next step for effective implementation of any bats conservation and management plan developed pursuant to this project.

For present purposes, this section sets out preliminary observations based upon a desk study, without a field visit, of the existing legal framework in the U.S. Virgin Islands for wildlife and habitat protection, within which management of the resident bat populations would fall.

From this preliminary review, it would appear that the current legal framework for biodiversity conservation, whether for bats or other resident endangered or threatened species in the Virgin Islands, would benefit from significant updating in many respects and, in some areas, development of entirely new legislation to meet modern needs.

I. An Overview of Existing Legislation

In this preliminary review of the U.S. Virgin Islands Code and selected recent Federal and Territorial government reports, the following main legal instruments and issues were identified of relevance in two respects: l) to protecting endangered and threatened species and 2) to protecting their habitats. The discussion below takes each of these in turn.

A. Endangered and Threatened Species

The principle law protecting Federal and resident endangered and threatened species is the Protection of Indigenous, Endangered and Threatened Fish, Wildlife and Plants Act enacted in 1990 (Act No. 5665) (Virgin Islands Code, Title 12, Chapter 2). This Act appears to serve as the main Territorial instrument for listing and protecting local endangered and threatened species as well as implementing the Federal Endangered Species Act and related obligations under the Convention on International Trade in Endangered Species (CITES).

Government already has recognized that some aspects of this law need updating. The 2005 USVI Comprehensive Wildlife Conservation Strategy identifies the need to update the list of endangered and threatened species, expand the categories of species protected to be more in line with the States, and add definitions (Strategy, Appendix III). Among other things, the Strategy urges continued work of the Endangered Species Commission established under the Act toward expanding the two existing species protection categories (endangered and threatened species) to seven separately-defined categories: Endangered, Threatened, Special Concern, Peripheral, Controlled, and Unprotected Species.

This work in progress is an important step toward strengthening the Act. This also may be an opportune time, when the Act is be reviewed for amendments, for the Endangered Species Commission to examine additional areas for strengthening to build a modern and fully-supportive framework for current and emerging needs. For example, new global concerns that will face the Virgin Islands as well as the States in efforts to protect native wildlife relate to introduction of alien invasive species, bio-prospecting and bio-safety. Moreover, there is need for authority to designate critical habitat for listed endangered and

threatened species to support their recovery, with corresponding decision-making tools (e.g., development permit conditions on design and location, environmental impact assessment, mitigation measures, and land/water use planning safeguards). Authority to develop management plans for the most endangered species, the process for plan approval and the legal status of such plans once approved also need attention. Enforcement powers and penalties need updating not only for illegal taking, trade, or disturbance, but also regarding degradation of designated critical habitats.

The Cooperative Agreement Between the United States Department of the Interior, Fish and Wildlife Serve and the Department of Planning and Natural Resources, Territory of the U.S. Virgin Islands, originally concluded in 1996 and renewed annually, lays out a framework of commitments by the Virgin Islands government to implement the endangered and threatened fish, wildlife, and plant species conservation program and by the Federal government to provide financial assistance to help develop and maintain the program so long as it meets national and international standards. This Agreement provides an important policy base and financial incentive for continued commitment to building a responsive legal framework with respect both to protection of such species and to conservation of the ecosystems and critical habitats upon which they depend.

B. Protecting and Restoring Critical Habitat

Commonly, critical habitat is protected in legal systems through three main approaches: protected areas legislation, resource/ecosystem-specific legislation, and development control legislation that integrates environmental concerns.

1. Protected Areas Legislation

The Virgin Islands Wildlife Act, from the late 1950s and still in force (Virgin Islands Code, Title 12, Chapter 1) appears to be the legislative instrument providing authority to designate Territorial protected areas (Federal protected areas being authorized under Federal national parks legislation with separate rules and regulations).

Three types of protected areas are authorized: *game preserves* associated with hunting (§91), *wildlife sanctuaries* and *marine sanctuaries,* both for propagating, feeding and protecting birds, fish and other wildlife (§97, a 1987 amendment). The responsible Department is authorized to designate game preserves and wildlife sanctuaries on offshore islands and cays owned by the Government.

There is no guidance on such matters as the process of establishment, management plans, buffer zones, corridors, or stakeholder participation – key elements in modern protected areas legislation. Also notably absent is the wide range of protected areas categories now recognized by international law and countries worldwide tied to conservation objectives, best illustrated through IUCN's six protected areas management categories ranging from strict protection to habitat management to natural resource multiple use.

In 2003, the Wildlife Act was amended with the addition of a modern section creating the St. Croix East End Marine Park and authorizing the establishment of a Territorial system of marine parks (§98). There does not appear to be a parallel provision authorizing creation of a Territorial system of terrestrial protected areas which would be an important tool for ensuring effective management of the Virgin Islands terrestrial endangered species such as the bats.

The Wildlife Act also provides for wildlife restoration (§81), but the extent and focus of its use could not be determined through this review. That provision is in response to the 1937 Federal Aid in Wildlife Restoration Act which provides Federal aid to the States and Territories for management and restoration of wildlife with funds from an excise tax on sporting arms and ammunition. The provision gives no specifics on priorities for restoration, nor the powers, duties, incentives or obligations associated therewith.

The remaining provisions of the Wildlife Act, which is the bulk of the original Act, deals with hunting licenses, hunting seasons, and bag limits – all areas which probably should be reviewed for relevancy in today's environment.

It is worth noting that the Virgin Islands legislature passed a new law in 2006 to begin to provide for conservation initiatives on private lands. The Uniform Conservation Easement Act (Virgin Islands Code, Title 12, Chapter 15) provides that a conservation easement may be created, conveyed, recorded, assigned, released, modified, terminated or otherwise altered or affected in the same manner as other easements. 'Conservation easement' is defined as a non-possessory interest of a holder in real property imposing limitations or affirmative obligations the purposes of which include retaining or protecting natural, scenic, or open-space values of real property, assuring its availability for agricultural, forest, recreational, or open-space use, protecting natural resources, maintaining or enhancing air or water quality, or preserving the historical, architectural, archaeological, or cultural aspects of real property. The 'holder' of

such an easement may be a government body so empowered or a charitable corporation, charitable association, or charitable trust which has purposes related to the purposes of the conservation easement. While it does not yet appear to have been used, the Act provides an important tool for supplementing a terrestrial system of public protected areas and underscores the importance of developing strengthened principal legislation for protected areas as the foundation. This new tool should be explored with owners of property having critical habitat for bats.

2. Special resource/ecosystem management legislation.

Currently, there appear to be two main ecosystem issues receiving attention in Virgin Islands legislation: l) watersheds and 2) the coastal zone with attention primarily to the narrow strip of coastline adjacent to the sea.

a. Watersheds

The Trees and Vegetation Adjacent to Watercourses Act (Virgin Islands Code, Title 12, Chapter 3), also originating in the late 1950s, is comprised of two substantive sections. The first prohibits cutting or injuring by a landowner of any tree or vegetation within 30 feet of the center of any natural watercourse or within 25 feet of the edge of such watercourse, whichever is greater (§123). The second authorizes such activity pursuant to a written permit issued by the responsible authority where it appears the proposed cutting or injuring is necessary for purposes of access to or development of the property (§124).

The Environmental Protection Act (Virgin Islands Code, Title 12, Chapter 13), enacted in 1971, aims to protect watersheds from improper development. The Act's declared policy is that the "lands and waters comprising the watersheds of the United States Virgin Islands are great natural assets and resources; and that improper development of land results in changed watershed conditions such as erosion and sediment deposition on lower-lying land and in the tidal waters, increased flooding, gut and drainage filling and alternation, pollution, and other harmful environmental changes to such a degree that fish, marine life, and recreational and other private and public uses of lands and waters are being adversely affected" (§531).

In response, the Act establishes an Environmental Protection Program which is defined as "rules and regulations to prevent improper development of land and harmful environmental changes and in accordance with the [Stated policy, including] comprehensive erosion and sediment control measures applicable to both public and private developments including the construction and maintenance of streets and roads" (§532). The Act requires that a plan be submitted and approved by DPNR prior to any proposed earth changes (clearing, grading, filling, or otherwise disturbing for any purpose or use any real property, e.g., for erection of any building or structure, quarrying of stone or construction of roads and streets) and if approved, issuance of a permit by DPNR authorizing such changes (§§533-534). A coastal zone permit issued under the VI Coastal Zone Management Act (see below) satisfies this permit requirement.

It was not possible during this survey to identify rules or regulations that may have been issued under either Act. However, from the language of the Acts themselves, they do not appear to include guidance on environmental factors that might be sufficient triggers to either deny or condition permits. The Environmental Protection Act, the most recent of the two, still was enacted prior to emergence of most of the modern environmental legislation in the United States. Key modern day elements for such legislation normally would include the requirement of an environmental impact assessment, mitigation measures, conditions upon which DNPR may deny a permit, or impose specific environmental design or other safeguards it deems needed to fulfill the Act's policy. Moreover, the Environmental Protection Act arguably does not cover endangered terrestrial wildlife habitat affected by development with its stated policy focused on minimizing harmful environmental effects on fish and marine life.

b) Forests

As noted in the body of this report, forest habitat is critical for survival and maintenance of several resident bat populations. It appears that the U.S. Virgin Islands does not have distinct forestry legislation. It is unclear what authority exists for protection of valuable forest areas through conservation or sustainable use management regimes, including creating forest reserves for specific management needs.

c) The Coastal Zone

By Federal definition, the Virgin Islands 'coastal zone' is the entire Territory. This means it includes all the islands and Territorial waters extending towards the outer limits of the Territorial sea. This includes open waters, tidal flats, estuaries, bays, inlets, wetlands, lagoons, beaches, dunes, and bluffs, as well as upland areas.

The Federal Coastal Zone Management Act of 1972 (CZMA) is the main Federal legislation guiding activities of States and Territories with respect to management and development of their 'coastal zones'. That Act aims to protect coastal resources through encouraging responsible coastal management at the State and Territorial levels. It is administered by the National Oceanic and Atmosphere Administration (NOAA). Federal technical and financial assistance is available to coastal States and Territories which development and implement NOAA-approved coastal management programs and prepare plans and assessments in accordance with the Act's requirements. Individual State and Territorial plans are required to include discussion of a number of different coastal elements including permissible land uses, designation of areas of particular concern (APCs), prioritization of use types, and provisions for addressing coastal and beach erosion (CZMA, §308).

The Federal CZMA encourages but does not require that States and Territories engage in coastal planning efforts. However, for States and Territories that do comply, the Act not only provides attractive financial incentives, it allows State/Territorial review of all Federal and Federally sponsored activities that occur within their boundaries – a right known as 'consistency' reviews. The approved coastal management programs and consistency reviews are how the CZMA is operationalized on a day-to-day basis.

The Virgin Islands participates in the Federal Coastal Zone Management Program. It does this through the Virgin Islands Coastal Zone Management Act (CZM) (Virgin Islands Code, Title 12, Chapter 21) which provides for development of the Coastal Zone Management Program and creates a Coastal Zone Management Commission charged with implementing the program pursuant to the CZMA (§§902, 904). The Territory's first Coastal Management Program was approved by NOAA in 1979. The lead agency is the Department of Planning and Natural Resources (DPNR), within which the Commission resides.

Because the coastal zone is all of the USVI, which the Virgin Islands CZM recognizes, the entire Territory is covered by the Act and is to be managed by the Act. However, for purposes of coastal resource management and development, the Act gives attention mostly to coastline development. It divides the Territory into two tiers (§902), the first tier being a relatively narrow strip of land along the coast where development requires a CZM permit from the DPNR, thus triggering environmental analysis and conditions where needed. The second tier covers all remaining upland areas including watersheds and adjacent land areas. In this second tier CZM requirements do not appear to apply, but only those related to zoning, subdivisions, and earth moving controls under the Planning and Development Act administered by the Department of Public Works. From this desk study, it was not possible to determine the degree of administrative coordination between the Commission and this Department.

Since the Virgin Islands Coastal Zone Management Act was enacted, development pressures throughout the Territory have grown significantly. Scientific understanding also has advanced about the interconnected nature of upland, coastal and marine systems and the need for an integrated ecosystem-based management approach. Moreover, as America's coasts continued under threat, the Federal Coastal Zone Management Act was amended in 1990 to create a new initiative, the Coastal Zone Enhancement Program, which among other things introduced 'special area management plans' as a more specific management tool to be used to protect significant coastal natural resources.

In light of these developments, strengthening the Virgin Island coastal zone legislation already has been identified as part of NOAA's periodic review of the program. The latest evaluation by NOAA of the Virgin Islands Coastal Zone Management Program identified specific issues where the program (and corresponding Act) could be strengthened (NOAA, 2005). Covering the period March 1998 to April 2003, and issued in 2005, this NOAA evaluation identified the need to consider a single tier permitting structure to be applied island-wide with procedures and enforcement being approached in a similar manner under the Coastal Zone Management Act (p. 9). The evaluation also found CZM program enforcement to be an area for strengthening and called for a strategy to develop enforceable management plans for 'areas of particular concern' and also to enhance efforts to address erosion and sediment control. These findings underscore the need for strengthened legislation to be responsive to Federal

requirements for continued funding and to provide responsible local agencies with the modern tools they need to effectively implement the program.

These issues are worth further attention. Moreover, strengthening the coastal legislation would be a timely initiative in light of new emphasis on performance and outcomes in the Federal Coastal Zone Management Program Strategic Plan for FY2007-2012 (NOAA, 2007). This plan highlights, among other things, the Federal intention to develop a performance measurement system to track indicators of effectiveness of the CZM at the national level. National effectiveness depends on CZMP implementation on a day-to-day basis at State and Territorial levels through their Federally approved programs

A few elements of this NOAA Coastal Zone Management Strategy are worth noting here, especially keeping in mind that the entire Territory of the Virgin Islands is a 'coastal zone' for Federal CZMA purposes. Goal No. 1 of the Strategy has two main objectives for coastal zone programs: 1) acquiring coastal habitats important for conserving natural resources of national and State/Territorial concern, and 2) restoring and creating key coastal habitats where essential for fish and wildlife in order to lead to the re-establishment of healthy natural communities. Among the strategies for meeting these objectives is supporting State/Territorial actions "protect, restore, and create key coastal habitats through comprehensive planning, habitat identification, technical assistance, education and outreach, and funding, [and to] require habitat mitigation for permitted activities that disturb habitat, to offset unavoidable habitat loss" (NOAA, 2007, p.

These are harbingers of the future on the kinds of implementation tools and performance measures that will be used to monitor and evaluate State and Territorial coastal zone management programs and corresponding legislation in the coming years. Furthermore, when the new administration takes office, NOAA anticipates giving priority to a full-scale review of the Federal Coastal Zone Management Act with a view to amendments that strengthen its provisions on requirements for protecting the nation's coastal resources, especially in the face of new challenges posed by climate change, including sea level rise and storm surge.

3. Land Use Planning and Development Control

In most States, the coastal resource management programs are reinforced by land use and development legislation that is harmonized with and integrates coastal resource program goals and requirements. In the Virgin Islands, the Coastal Zone Management Act requires a Comprehensive Land/Water Use Plan. However, the 2005 NOAA evaluation noted above found that Plan to be outdated and in need of updating especially with respect to erosion and sedimentation control (NOAA, 2005, p. 9). The Virgin Islands also has general public planning and development legislation (Title 29) which deals with zoning, subdivision, and other development permitting issues. This land use legislation requires a General Development Plan but does not appear to require environmental analysis as an element of conditions for a development permit. There was insufficient time for this review to obtain a copy of either the Land/Water Use Plan or General Development Plan, but these documents would be important components of any in-depth legal review, particularly with respect to consideration of endangered wildlife and habitat issues.

II. Strengthening the Virgin Islands Legal Framework

This brief legal survey highlights a number of weaknesses and gaps in the existing legislative framework for biodiversity conservation, particularly for terrestrial species and critical habitat. The legislation is outdated by several decades in some cases. Because of the weakness of the legal framework, institutions charged with wildlife management and conservation in the Territory face major challenges in advancing their missions. Not only is implementation of management plans and other Federal and Territorial wildlife and environmental protection mandates complicated by these deficiencies, effective enforcement is hampered, and jurisdictional roles may be uncertain.

In recent decades, as suggested above, legislative and institutional advances have been significant with respect to biodiversity conservation generally and, for purposes here, particularly with respect to endangered species management, ecosystem maintenance (including coastal zones), and integrated land and water use planning and development. It is important for the future economic viability of the Virgin Islands and natural and human system resilience, particularly in the face of new global challenges such as sea level rise and extreme weather events, that the Virgin Islands develop a strategy to update its legal framework for biodiversity conservation and associated legal tools for sustainable development.

The first step – and a recommended next phase for this project – is a full legal technical analysis of the existing legislation (laws and regulations) and corresponding institutional capacities and jurisdictions. The purpose should be to identify areas for strengthening and options to achieve those, either through amendments of existing laws or the development of new (and in some cases consolidated) legislation. This analytical step normally would include consultation with all involved or concerned government agencies as well as stakeholder groups and the community at large.

This legal technical analysis should take into account developments in the fields of environmental and biodiversity law at national level, particularly as exemplified by states with similar challenges, and international laws and policies to which the United States is committed. This should include the guidance and mandates flowing from the Convention on Biological Diversity where US ratification is expected to receive renewed attention by the new administration. Even now, the US participates in CBD meetings and the numerous decisions on specific programs of work with island biodiversity and protected areas are important guides for future planning.

US obligations under other relevant treaties to which it is a party also need to be inventoried and assessed for obligations that may not be self-executing but need explicit incorporation in local legislation (e.g., Ramsar, Law of the Sea, InterAmerican Convention for the Protection and Conservation of Sea Turtles, the Cartagena Convention and its associated Protocols especially that on Specially Protected Areas and Wildlife (SPAW)).

In addition, a number of globally-accepted principles are important to incorporate in modern legislation for wildlife and habitat conservation. These include the need for science-based decision-making, ecosystem-based management, adaptive management, stakeholder participation, public access to information, government accountability, co-management, the precautionary principle, conservation agreements and private/public partnerships for voluntary conservation, environmental education and outreach on terrestrial as well as marine environmental matters.

As noted above, the Endangered Species Commission already has critically important work underway to expand the list of endangered and threatened species and populations and the categories for species protection (including

migratory species). This may be an opportune time to review the entire wildlife legal framework for areas needing attention, including the authority and framework for a Territorial system of protected areas using IUCN guidelines on protected areas categories and management requirements especially for terrestrial protected areas. Related habitat issues worth consideration include possible inclusion of measures for sustainable forest operations and management, conservation of freshwater systems, protection of wetlands and estuaries, environmental impact assessments, strengthened enforcement powers and updated penalties, and financing provisions to ensure that revenues and fines associated with wildlife conservation are devoted to wildlife and ecosystem restoration, recovery, education, and community outreach.

References:

"Cooperative Agreement Between the United States Department of the Interior, Fish and Wildlife Serve and the Department of Planning and Natural Resources, Territory of the U.S. Virgin Islands – ENDANGERED AND THREATENED FISH AND WILDLIFE, ENDANGERED AND THREATENED PLANT SPECIES" (1996 and renewed annually) (available from the FWS Regional Office, Atlanta, Georgia).

Department of Planning and Natural Resources (DPNR), Comprehensive Wildlife Conservation Strategy for the U.S. Virgin Islands, Division of Fish and Wildlife, Government of the U.S. Virgin Islands, (2005).

NOAA, "Coastal Zone Management Program Strategic Plan: Improving Management of the Nation's Coastal Areas, FY 2007-2012", Office of Ocean and Coastal Resource Management (2007) (online at: < http://coastalmanagement.noaa.gov/programs/czm.html>, PDF doc. link).

NOAA, "Virgin Islands Coastal Zone Management Program – Final 312 Evaluation Findings, March 1998 to April 2003", Office of Ocean and Coastal Resource Management, National Ocean Service, National Oceanic and Atmospheric Administration, (2005) (online at < http://coastalmanagement.noaa.gov/myState/virgin_islands.html>, PDF doc. link).

U.S. Code: Title 48, Chapter 12, "Revised Organic Act of the Virgin Islands".

Virgin Islands Code, Title Twelve: "Conservation", and Title Twenty-Nine: "Public Planning and Development."