U. S. Virgin Islands Forest Resources Assessment and Strategies

A comprehensive analysis of forest-related conditions, trends, threats, and strategies

Lignum-vitae (*Guaiacum officinale*)
Photo by: Brian Daley

June 2010

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Abbreviations Used:

BMP	**Best Management Practice**
CDC	**Conservation Data Center**
CSC	**Coastal Services Center**
CWD	**Coarse Woody Debris**
DOC	**Department of Commerce**
DPNR	**Department of Planning and Natural Resources**
DWD	**Downed Woody Debris**
DFW	**Division of Fish and Wildlife, DPNR**
ECC	**Eastern Caribbean Center**
EPA	**Environmental Protection Agency**
ESRI	**Environmental Services Research Institute**
FEMA	**Federal Emergency Management Agency**
FGDC	**Federal Geographic Data Committee**
FIA	**Forest Inventory and Analysis**
IITF	**International Institute of Tropical Forestry**
IPCC	**Intergovernmental Panel on Climate Change**
NASF	**National Association of State Foresters**
NOAA	**National Oceanic and Atmospheric Administration**
NOS	**National Oceanic Services**
NRCS	**Natural Resources Conservation Service**
DBH	**Diameter at Breast Height**
PR-DNER	**Puerto Rico Department of Natural and Environmental Resources**
PW	**Department of Public Works**
REA	**Rapid Environmental Assessment**
SAP	**Spatial Analysis Project**
SGSF	**Southern Group of State Foresters**
SRS	**Southern Research Station**
TPL	**Trust for Public Lands**
TNC	**The Nature Conservancy**
TVIL	**Trust for Virgin Islands Lands**
U&CF	**Urban and Community Forestry**
USACE	**United States Army Corps of Engineers**
USDA	**United States Department of Agriculture**
USFWS	**United States Fish and Wildlife Service**
UVI	**University of the Virgin Islands**
VIDOA	**Virgin Islands Department of Agriculture**
VITEMA	**Virgin Islands Territorial Emergency Management Agency**
WAPA	**Water and Power Authority**
WMA	**Waste Management Authority**

Table of Contents

FIGURES ..... **VI**

TABLES ..... **VII**

EXECUTIVE SUMMARY **1**

INTRODUCTION **5**

FOREST RESOURCE CONDITIONS, BENEFITS AND THREATS **9**

FOREST RESOURCE CONDITIONS 9
Distribution and Abundance of Forest Resources *9*
Forest Types in the US Virgin Islands *21*
Forest Dominance *25*
Forest Ownership *27*
Jobs and Economic Activity *30*
Water Resources *30*
Wildlife and Natural Heritage *32*
Scenic Beauty *34*
Quality of Life *35*
Carbon Sequestration *35*
Summary *36*
THREATS TO FOREST RESOURCES 37
Urbanization *37*
Forest Fragmentation *38*
Biological Threats *40*
Wildfire *41*
Climate Change *42*

PRIORITY ISSUES **45**

ISSUE 1: CONTIGUOUS FOREST LOSS 45
ISSUE 2: LOSS OF TRANSITIONAL FORESTS TO DEVELOPMENT 48
ISSUE 3: URBAN FOREST SUSTAINABILITY 50
ISSUE 4: HAZARD MITIGATION 53
ISSUE 5: WATER MANAGEMENT 54
ISSUE 6: DEGRADATION OF COASTAL FOREST ECOSYSTEMS 57
ISSUE 7: INVASIVE SPECIES 59
ISSUE 8. WILDFIRES 62

STRATEGIES **63**

GOALS & STRATEGIES **64**

GOAL 1: CONTIGUOUS FOREST CONSERVATION AND MANAGEMENT 64
GOAL 2: URBAN FOREST MANAGEMENT 70
GOAL 3: COASTAL FOREST ECOSYSTEMS PROTECTION 75

REFERENCES CITED **79**

APPENDIX A – SURVEY RESULTS **86**

STAKEHOLDERS INVOLVED IN THE DEVELOPMENT OF THE ASSESSMENT AND STRATEGY 87

APPENDIX B – PROGRAM DESCRIPTIONS **89**

FOREST STEWARDSHIP AND FOREST LEGACY 89
URBAN AND COMMUNITY FORESTRY 90
FOREST HEALTH PROTECTION 91
CONSERVATION EDUCATION 92

STATE FIRE ASSISTANCE AND VOLUNTEER FIRE ASSISTANCE 93
VIRGIN ISLANDS FIRE SERVICE 93

APPENDIX C- GIS DATA REFERENCES AND METHODS **94**

MODELING 94
LAYER METRICS 94
DATA AND ANALYSIS NEEDS 94
BASE DATA REFERENCES 95
PRODUCTS DERIVED FROM ANALYSIS AND BASE DATA 97

APPENDIX D- VIRGIN ISLANDS FIRE PLAN **101**

APPENDIX E – FOREST LEGACY ASSESSMENT OF NEED **107**

Figures

Figure 1: Location of the U.S. Virgin Islands 5
Figure 2: St. Croix Forest Cover, U.S. Virgin Islands 10
Figure 3: St. Croix Holdridge Life Zones 12
Figure 4: St. Croix Urban Forest Summary 13
Figure 5: St. Thomas Forest Cover 15
Figure 6: St. Thomas Holdridge Life Zones 16
Figure 7: St. Thomas Urban Forest Summary 17
Figure 8: St. John Forest Cover 18
Figure 9: St. John Holdridge Life Zones 19
Figure 10: St. John Urban Forest Summary 20
Figure 11: St. Croix Forest Types Distribution 22
Figure 12 : St. Thomas Forest Types Distribution 23
Figure 13: St. John Forest Types Distribution 24
Figure 14: Genip Dominated Forest 25
Figure 15: Tan-tan dominated forest 26
Figure 16: St. Croix Forest Ownership 27
Figure 17: St. Thomas Forest Ownership 28
Figure 18: St. John Forest Ownership 29
Figure 19: Concordia Gut 30
Figure 20: Virgin Islands Water Resources 31
Figure 21: Jamaican Fruit Bat in St. Croix Eating Mangoes 32
Figure 22: Lignum Vitae in Bloom 33
Figure 23: Coral Bay View, St. John, U.S. Virgin Islands 34
Figure 24: Saman Tree at a Proposed Development Site 35
Figure 25: Urbanization and Changing Land Use Threats Index 38
Figure 26: Virgin Islands Forest Fragmentation Threat 40
Figure 27: St. Croix Fire Risk 42
Figure 28: Possible Sea Level Rise Scenarios 44
Figure 29: Issue 1 Contiguous Forest Loss 47
Figure 30: Issue 2 Loss of Transitional Forests 49
Figure 31: UVI Urban Forest Inventory 50
Figure 32: Issue 3 Urban Forest Sustainability 52
Figure 33: Hurricane Omar Damage 53
Figure 34 : Issue 5 - Water Management 56
Figure 35: Degradation Coastal Forest Ecosystems 58
Figure 36: Goal 1: Contiguous Forest Conservation and Management 64
Figure 37 : Goal 2 Urban Forest Management 70
Figure 38 : Goal 3. Coastal Forest Ecosystem Protection 75

Tables

Table 1: Percent Forest Cover by Study 9
Table 2: St. Croix Forest Land Use 13
Table 3: St. Croix Summary of Soil Types in Forest 14
Table 4: St. Thomas Summary of Soil Types in Forest 17
Table 5: St. John Forest Land Use 19
Table 6: St. Croix Summary of Soil Types in Forest 20
Table 7: St. Croix Forest Type Summary 22
Table 8: St. Thomas Forest Types Summary 23
Table 9: St. John Forest Types Summary 24
Table 10: Virgin Islands Land Cover Class Patch Metrics 39
Table 11: U&CF Goals and National Themes 50
Table 12: Objective 1.1 Education and Public Outreach about Contiguous Forest Management 66
Table 13: Objective 1.2 Research and Data Acquisition for Contiguous Forest Management 67
Table 14: Objective 1.3 Protecting Existing Contiguous Forest 68
Table 15:Objective 1.4 Managing Existing Contiguous Forest 69
Table 16: Objective 2.1 Education and Public Outreach about Urban Forests 72
Table 17: Objective 2.2 Urban Forest Inventory and Analysis 73
Table 18: Objective 2.3 Managing Existing Urban Forest 74
Table 19 : Objective 3.1 Education and Public Outreach about Coastal Forest Ecosystem Protection 77
Table 20: Objective 3.2 Research and Data Acquisition for Coastal Forest Ecosystem Protections 77
Table 21: Objective 3.3 Protect Coastal Forest Ecosystems 78
Table 22: Objective 3.4 Manage Coastal Forest Ecosystems 78

EXECUTIVE SUMMARY

In 2008 the Congress of the United States of America enacted the Food, Conservation, and Energy Act. This Act included an amendment to the Cooperative Forestry Assistance Act of 1978. The amendment requires each State and Territory to provide a Statewide Assessment of Forest Resources and a Statewide Forest Resources Strategy to the Secretary of Agriculture, USDA, by June 2010. This document is the US Virgin Islands' response to the requirement for a Statewide Assessment of Forest Resources and Strategies (USA, 2008).

The United States Virgin Islands (USVI) consists of three major islands, St. Croix, St. John, and St. Thomas, which includes nearby Water Island and many smaller islands and cays. Each island has its own unique ecological, historical, and cultural heritage reflected in the present state of each island's forest resources. St. Croix is traditionally the agricultural island of the US Virgin Islands; it is the largest island at 84 square miles, with the most flat land. St. Thomas, at 32 square miles, is traditionally the trading center of the U.S. Virgin Islands, as it has a deep water port; tourism is the largest employer on this island. St. John, at 20 square miles, is the eco-tourism island, with nearly two-thirds of St. John's area preserved inside the boundaries of the Virgin Islands National Park.

Many of the issues and challenges facing the USVI are similar to those facing other Caribbean islands and nations. There is an increasing demand for development of seemingly "vacant" land, with a concurrent need for economic growth and creation of jobs (USVI, 2006). Development in the form of hotels, golf courses, condominiums, and other "improvements" puts stress on the remaining forested land. Loss of forested landscapes to development and the stress this places on watersheds is a critical problem on all small islands in the Caribbean, and the USVI is no exception. The forested slopes provide areas for water infiltration and help prevent soil erosion. Development on steep slopes leads to soil erosion, causing damage to the watershed, and to offshore coral reefs and the local fisheries they support, as well as to tourism (Beller et al., 1990).

Significant threats to forests, such as loss of critical forested landscapes to development, point to the need for more progressive strategies for protecting forest resources. With the tightening of federal funds, Congress is demanding additional accountability on how these funds are spent and wants assurance that the funds result in positive benefits to forest resources. In response to these increasing demands, the USDA Forest Service is transforming how it and the states deliver the federally-funded State and Private Forestry (S&PF) programs.

In 2008, the USDA Forest Service implemented a "redesigned" State and Private Forestry Program. It was conceived in response to the combined impacts of increasing pressure on the nation's forests and decreasing state and private forestry resources and funds. The requirements of the USDA Forest Service redesign and of the 2008 Farm Bill will guide the delivery of forestry programs in the US Virgin Islands into the future.

Redesign focuses on three national themes: conserve working forests, protect forests, and enhance benefits from trees and forests. At a minimum, statewide forest resource assessments should:

- Describe forest conditions on all ownerships in the state or territory;
- Identify forest-related benefits and services;
- Identify threats to the forest resources;
- Highlight issues and trends of concern as well as opportunities for action;
- Delineate high priority forest landscapes to be addressed; and
- Be geospatially based and make use of the best existing data.

The US Virgin Islands Statewide Assessment of Forest Resources and Strategies was developed around the issues facing the Territory's forest resources rather than being based on the forest resources themselves. With input from interested stakeholders from all three islands, representing diverse interests of the forest resource, the VI Department of Agriculture's Forestry Division has identified priority issues for the rural and urban forests of the Territory.

A geospatial analysis was conducted to delineate areas in the USVI landscape where future efforts might best be focused. These priority areas were determined using weighted overlay analyses based on currently available data. It is expected that this analysis will be a continuous process as new information becomes available. For the purposes of this document, data layers were utilized to identify priority areas for each issue identified. The sources for these layers can be found in the Appendices.

The following paragraphs summarize the issues that emerged from the analysis of data and input from stakeholders throughout the USVI. Through this process, the areas of highest priority for protection and delivery of forestry programs were identified as: the northwestern corner and eastern end of St. Croix, west end and north shore of St. Thomas, and the east end and south shore of St. John.

Issue 1: Contiguous Forest Loss
Many areas of contiguous forest that contribute to habitat conservation and water quality are under pressure from development. Forested lands are under increasing pressure due to the demand for housing, as a result of continued population growth, and the concurrent demand for economic development, resulting in the planning for and construction of resorts and golf courses. In addition, forested lands are being cleared for agricultural use. Existing zoning laws and environmental regulations are weak and have not been enforced. If existing forested lands are not protected, soon little forested land will be left. This forest conservation priority issue identifies those areas of contiguous forest that are in need of immediate protection and management on the islands of St. Croix, St. John, and St. Thomas.

Issue 2: Loss of Transitional Forests to Development
Transitional forests represent land areas under constant change from one land use type to another. Many of these areas were once forested, then cleared for agricultural uses such as cattle grazing or crop production. As the use of these lands for agriculture diminishes, they will most likely transition to early successional forest or be converted to some type of development, such as housing. At present, more than 1,000 acres of transitional forest in the U.S. Virgin Islands could be lost due to proposed large development schemes. Promoting the establishment of more diverse forests in transitional forest areas would keep some of these areas under forest cover.

Issue 3: Urban Forest Sustainability

Lack of data for urban and community forests has hindered the ability of land managers to measure the value of these abundant resources that provide many natural and cultural benefits to the people of the Virgin Islands. Values attributed to urban forests, especially on a tropical island, include but are not limited to: real estate values; recreation; health benefits; psychological well-being; and cultural and economic attributes. The management of urban and community forests affects the daily lives of Virgin Islanders by providing the aforementioned benefits. Fragmentation of forests on urban edges is especially prevalent near roads and as a result of poor management practices.

Lack of a comprehensive urban forest management plan and lack of trained professionals has contributed to a fragmented urban landscape.

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Issue 4: Hazard Mitigation

Both urban and rural trees in the USVI are subject to the extremes of nature, especially tropical storms and hurricanes. Urban trees are especially susceptible to these storms and tend to be isolated from the forest, and are often located near buildings and along roads. During and after a storm event, many urban trees become hazards as branches break and fall on vehicles or across wires or roads. Rural areas are susceptible to trees falling across roads or clogging drainage. There is a need to monitor the health of trees to prevent them from becoming hazards during and after these storms.

Issue 5: Water Management

Good quality drinking water is one of the biggest concerns in the U.S. Virgin Islands. Most of the potable drinking water in the territory is rainwater collected from rooftops and stored in underground cisterns or water piped from the desalination plants. About 10% of the water used in the US Virgin Islands comes from wells. Ground water recharge affects potable well water resources and surface waters used for agricultural purposes. Water drainage issues cause flooding during rain events that last for prolonged periods of time, and sedimentation in the marine water effects fisheries and tourism alike. Forests have a direct impact on water management issues throughout the Territory.

Issue 6: Degradation of Coastal Forest Ecosystems

Coastal forests including wetlands and mangrove forests are the connective region between the terrestrial and marine environments. Providing habitat for fish nurseries and a wide variety of area fauna and flora, these areas are under threat from a variety of sources, such as climate change and development. Coastal forest resources provide a variety of ecological services such as sediment and nutrient control into the marine environment. A lack of data on coastal forest resources has made it difficult to track how these systems have been affected. According to the last land cover analysis there were approximately 622 acres of mangroves or flooded woodlands, and 600 acres of coastal shrubland in the US Virgin Islands. It is imperative that remaining coastal forest ecosystems be protected.

Issue 7: Invasive Species

Invasive species are identified as the second leading cause of biodiversity loss in the USVI (TNC, 2003). However, little data exist on the effects, threats, or future effects of invasive

species on forests in the Virgin Islands. Limited invasive plant species studies have been conducted through the VI Department of Planning and Natural Resources Division of Fish and Wildlife (DFW) in partnership with the University of the Virgin Islands for the purpose of drafting regulatory legislation. Invasive plant species such as sweet lime (*Triphasia trifolia*) and snake plant (*Sanseveria trifasciata)* can be found in the understory in many of the forests of the USVI. As there is no timber industry in the islands, invasive insect pests are not been identified as being as important as invasive plants, and do not appear to cause much damage to the overall health of the forests. Exotic animals such as deer, donkeys, horses, iguanas, and feral pigs do exist and may alter the forest structure through overgrazing or altered seed dispersal mechanisms. The degree to which these introduced species effect the local forest is unknown.

Issue 8: Wildfire

Global climate change will likely result in changes in wind and rainfall patterns in the Caribbean. An increase in the length or severity of droughts could contribute to an increase in wildfires in the US Virgin Islands. The forests of the US Virgin Islands are not fire-dependent but rather fire-sensitive; they are not ecologically adapted to periodic fires. Wildfires are a relatively minor factor in the forests of the USVI and more often occur in scrubland and grassland on the eastern end of St. Croix where there is limited rainfall year-round. Very few wildfires occur on St. Thomas or St. John. The wildfires that do occur on St. Croix tend to be human-caused and located near roads.

INTRODUCTION

The U.S. Virgin Islands is an organized, unincorporated territory of the United States under the Office of Insular Affairs, Department of the Interior. Geographically, the USVI is part of the West Indies, a chain of islands that extends from Florida to Venezuela and separates the Caribbean Sea from the Atlantic Ocean. These islands are located between 17º40”N – 18º30”N latitude and 64º30”W – 65º10”W longitude, between Puerto Rico and the Leeward Islands **(**Figure 1**)**.

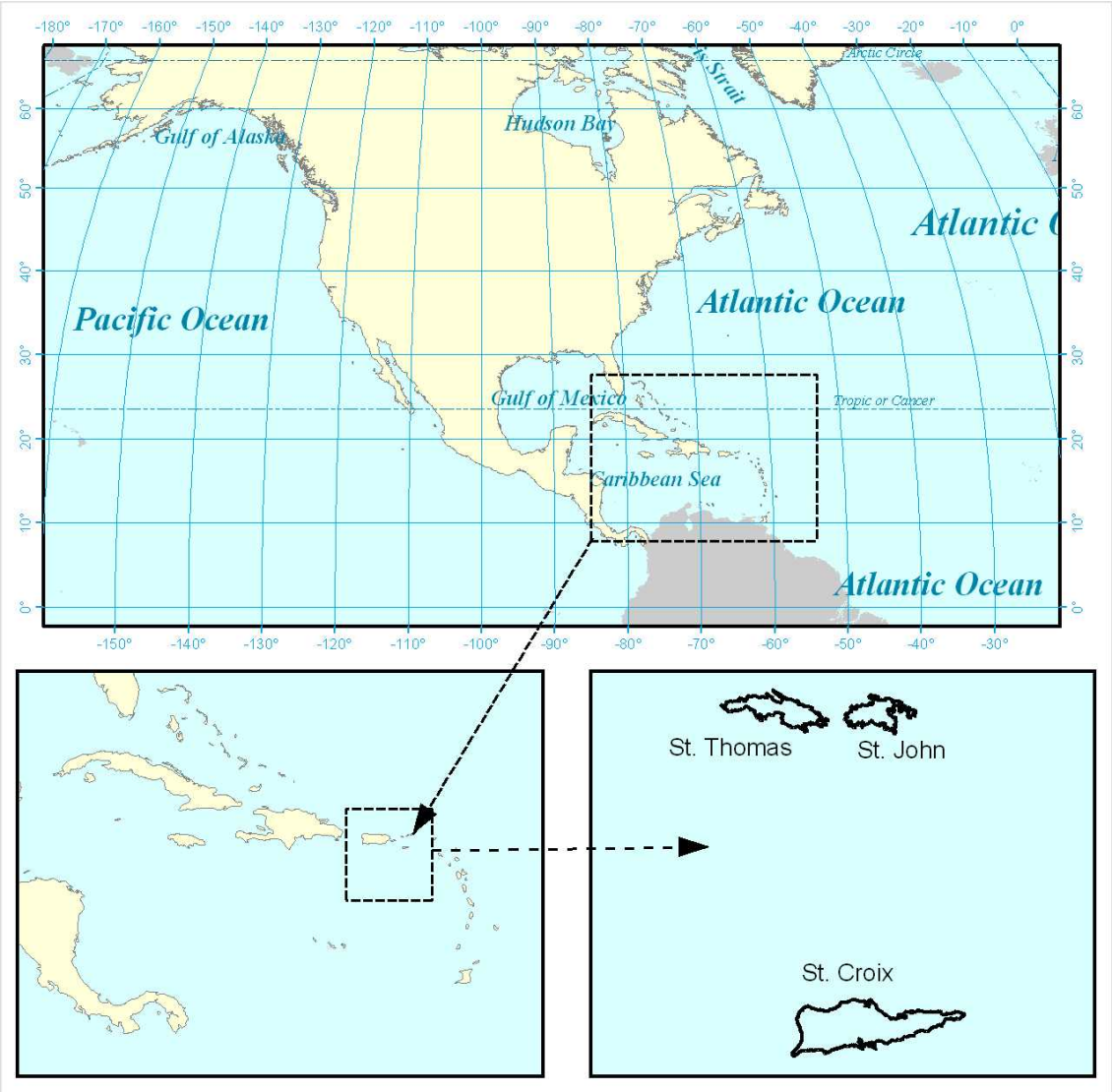


Figure 1: Location of the U.S. Virgin Islands

The USVI is about 1,087 miles southeast of Miami and 40 miles east of Puerto Rico. Comprised of 68 islands and cays, the USVI spans 135 square miles and has approximately 234 miles of shoreline, including the shorelines of the smaller islands and cays (TNC, 2003)

The three main inhabited islands of the USVI are St. Croix, St. John, and St. Thomas. Three miles separate the two smaller islands of St. Thomas (32 square miles) and St. John (20 square miles). Both are distinguished by a rugged mountainous topography with numerous sandy beaches and inlets along the shoreline. The largest island of St. Croix (84 square miles) is located 40 miles to the south of St. Thomas. St. Croix has rolling hills and a broad central plain between the relatively dry east end and the greener, agricultural west end. The capital of the USVI is Charlotte Amalie on St. Thomas (TNC, 2003).

Approximately 110,000 residents (Census, 2009) live year-round in the USVI. The population is comprised of Afro-Caribbean blacks (76.2%), whites (13.1%), mixed race (3.5%), Asian (1.1%), and other (6.1%). The USVI has a population growth rate of 8%. Most Virgin Islanders live in an urban environment (95%); the rate of urbanization is 0.2%. Annually the islands are host to nearly 2.6 million visitors (Census, 1990, Census, 2000).

The USVI has been impacted by colonial exploitation since the 15th century. Only fragments remain of the original forests due to the aggressive clearing and agricultural activities of the past (Weaver, 2006a). Currently, the overwhelming threat to USVI ecosystems is residential development. New housing developments encroach on vital habitats resulting in erosion, sending soil, pollutants and excess nutrients into the sea, impacting coral reefs. The islands' tourism-based economy depends heavily on the high quality of the environment, making conservation essential for local communities (USVI, 2006).

Variances in demography, economy, and landscape are all factors that will influence the pace and manner in which resource protection proceeds. In addressing forest resource protection, it is important to consider the unique characteristics of each of the three main islands.

St. Thomas is about 12 miles east to west by 3 miles north to south, has an extremely irregular coastline and is very hilly with practically no flat land. The highest hills are generally found near the center of the island, with Crown Mountain at 1,565 feet being the highest point. This results in rather steep slopes over the island, so that runoff of rainfall is quite rapid and there are no permanent streams or rivers (Calvesbert, 1970). Little agricultural activity has occurred on St. Thomas in the recent past and it suffers from high development pressure (Wiley and Vilella, 1998).

St. John is about 8 miles long east to west. Like St. Thomas, St. John has an extremely irregular coastline and very hilly topography. It has a number of peaks over 980 feet, topped by Bordeaux Mountain at 1,286 feet in the eastern portion of the island. Slopes are quite steep all over the island, and there are very few areas of flat land. There are no permanent rivers or creeks (Calvesbert, 1970). This island has a relatively small human population compared with St. Thomas and St. Croix (Wiley and Vilella, 1998).

St. Croix is the largest and most southern island of the USVI . Its topography is somewhat different from the other two islands, with a broad expanse of low, relatively flat land running along the southern two-thirds of the island. A range of hills runs along the northern coast, varying in elevation from about 500 to more than 985 feet, topped by Mount Eagle at 1,165 feet. In the eastern end of St. Croix another group of slightly lower hills rise to a maximum elevation

of about 850 feet (Calvesbert, 1970). As a consequence of this relatively low elevation and the forest clearing that has occurred, St. Croix is much drier than most of the Greater Antilles (Wiley and Vilella, 1998).

Although the Virgin Islands are in the tropics (south of the Tropic of Cancer), the seas around the islands keep them cooler than tropical mainland Central America. Additionally, the islands lie directly in the path of the easterly trade winds throughout the year (Calvesbert, 1970). Because the mean annual temperature of the region at sea level is lower than 75°F, the lower limit of the tropical region, these islands are classed as subtropical (Ewel and Whitmore, 1973).

The climate in the USVI is reliably balmy, with daily temperatures averaging between 77ºF in the winter and 82ºF in summer. Easterly trade winds of 15 mph or more keep the humidity relatively low. Rain usually comes in the form of brief tropical showers, and the islands average less than 49 inches of rain per year, with a general increase from east to west. The wettest and hottest months are July to October. Hurricane season comes during these same months, with September being the most likely month for a storm. The USVI has been hit by four major hurricanes in recent years: Hugo (1989), Luis and Marilyn (1995), Lenny (1999) and Omar (2008).

Major Forest Types of U.S. Virgin Islands

There are two primary forest types in the USVI: subtropical moist forest and subtropical dry forest. Each of these can be subdivided into many more specific forest types (see page 21). Although the following descriptions are very broad, they give a clear indication of the differences between these two forest types (Ewel and Whitmore, 1973).

Subtropical Moist Forest

Subtropical moist forests are described as lowland tropical or subtropical seasonal evergreen forest (Gibney et al., 2001). They include upland moist forest, gallery moist forest, basin moist forest and semi-evergreen forest that grades into drier forest types. These ecosystems are evergreen and broadleaf forests, generally receiving over 47 inches rainfall/year when they are located upland, but also having a pronounced dry period lasting from 2-4 months.

When permitted to mature, this forest is usually stratified into three layers. The main canopy reaches about 80 feet, early successional species reach about 50 feet, and the understory is only15-30 feet tall. Shrubs and vines are usually present and epiphytes are more common in upland areas. Roughly 70% of the more than 100 tree species found in this forest are evergreen (Thomas and Devine, 2005).

Common indicator species of a moist tropical forest are the early successional black olive (*Bucida buceras),* sandbox tree (*Hura crepitans),* and silk-cottonwood (*Ceiba pentandra).* Spanish cedar *(Cedrela odorata),* bay rum *(Pimenta racemosa),* royal palm *(Roystonea borinquena),* West Indian locust *(Hymenaea courbaril),* and trumpet tree *(Cecropia schreberiana*) are among the species found in the main canopy. However, tree species' alliances vary significantly from island to island (Somberg, 1976).

Due to colonial land clearing, foraging by domestic and feral animals, present development and recent hurricanes, true examples of this forest type probably no longer exist, but some recovery can be observed in protected areas. However, there are isolated pockets of similar moist forest that are less species rich. On St. Croix, roughly 683 acres of these moist forests are located primarily in the northwest part of the island to the west of Salt River. On St. Thomas there are 525 acres of moist forest, concentrated also in the west-central north shore. St. John contains over 1,300 acres of moist forest, most of which already enjoy protection within the Virgin Islands National Park's borders (Brandeis and Oswalt, 2007, Ewel and Whitmore, 1973, Gibney et al., 2001, TNC, 2003).

Subtropical Dry Forest

Subtropical dry forests are lowland semi-deciduous and lowland drought deciduous forest. Included in this description are: gallery semi-deciduous, semi-deciduous, semi-evergreen and drought-deciduous forests. The dry forest varies widely in structure and is heavily influenced by environmental conditions such as rainfall, slope and aspect, prevailing winds and sea spray (Otto and Zak, 1994). However, dry forests usually have a fairly closed canopy and contain two distinct forest layers. Trees located in or near guts (intermittent streams and creeks) tend to keep their leaves longer or do not lose them at all. A more developed community of shade tolerant epiphytes, shrubs and vines develops beneath the mostly closed canopy. The dry tropical forest designation includes all lowland tropical/subtropical semi-deciduous forests and lowland tropical/subtropical deciduous forests (Ewel and Whitmore, 1973).

Dry forest structure is greatly influenced by wind, salt spray and the presence of fresh water. The maximum height is usually 30-65 feet. It is difficult to distinguish between the four subtypes of dry forest, but many of the typical tree species will demonstrate xeric adaptations such as waxy, pubescent, or folding leaves. Examples of the indicator tree species of the dry forest are gumbo limbo tree (*Bursera simaruba),* Jamaican caper *(Capparis cynophallophora),* orange manjack *(Cordia rickseckeri),* lignum vitae *(Guaiacum officinale),* and frangipani *(Plumeria alba)* (Brandeis and Oswalt, 2007, Ewel and Whitmore, 1973, Gibney et al., 2001).

FOREST RESOURCE CONDITIONS, BENEFITS AND THREATS

Forest Resource Conditions

Distribution and Abundance of Forest Resources

Forest types and structures in the U.S. Virgin Islands are dynamic systems affected by human and climatic influence (Kennaway et al., 2008). Data collection on the distribution, condition, and types of forests is improving, but is generally limited to aerial photo interpretation and satellite imagery. However, in the last several years some newer studies have provided valuable and tested data.

The Forest Inventory and Analysis (FIA) program conducted by the USDA Southern Research Station – Forest Service – International Institute of Tropical Forestry (IITF) established permanent forest plots on the four main islands (including Water Island adjacent to St. Thomas) of the USVI and conducted substantial forest inventory data collection (Brandeis and Oswalt, 2007). The latest study released by Todd Kennaway in 2008 by Colorado State University in conjunction with IITF, utilized airborne light detection and ranging (LIDAR) data, aerial photography, LandSat data and ground truthing to create a region-wide land cover classification for the year 2000. Brian Daley conducted a study on forest change on St. Croix from the year 1992 to 2002 (Daley, 2009). This study utilized information from more than 200 individual sites on St. Croix to define forest or non-forest structure and was then tested for on-ground accuracy. The most commonly used land cover classification in the USVI is the Rapid Environmental Assessment (REA) based on 1994 black and white aerial photo interpretation (Gibney et al., 2001) and described in the book, *Island Peak to Coral Reef* (Thomas and Devine, 2005). These data have currently not been tested for accuracy.

In the USVI the FIA reported 61% total forest cover (Brandeis and Oswalt, 2007). A comparable number of 64% total forest cover was found in the IITF 2000 data (Kennaway et al., 2008). Forest cover by island is provided in Table 1.

Table 1: Percent Forest Cover by Study

Study	STJ	STT	STX	Accuracy Assessment
REA 2001	87%	63%	51%	NA
IITF 2000 (Kennaway)	89%	69%	57%	73%
SRS IITF FIA 2004	92%	74%	50%	NA
B. Daley UFL 2009	NA	NA	57%	91%

The forests of each of the three major islands have unique characteristics, largely due to their different histories of land use. Because of this, the current and past forest trends of each island are described individually.

St. Croix

At about 84 square miles, St. Croix is the largest of the U.S. Virgin Islands. It is historically called the agricultural island due to its large areas of flat arable land. The most recent IITF study conducted in 2008 estimates total forest cover in 2001 to be 57% **(Kennaway et al., 2008) (**Figure 2**).** The Rapid Environmental Assessment (REA) conducted in 2001 (ECC, 2000, Gibney et. al., 2001) closely matches the Forest Inventory and Analysis (FIA) with forest covers of 51% and 50% respectively (Brandeis and Oswalt, 2007). The study conducted by Daley (2010) found forest cover to be 57% (approx. 31,000 acres) with a total accuracy assessment of 91%.

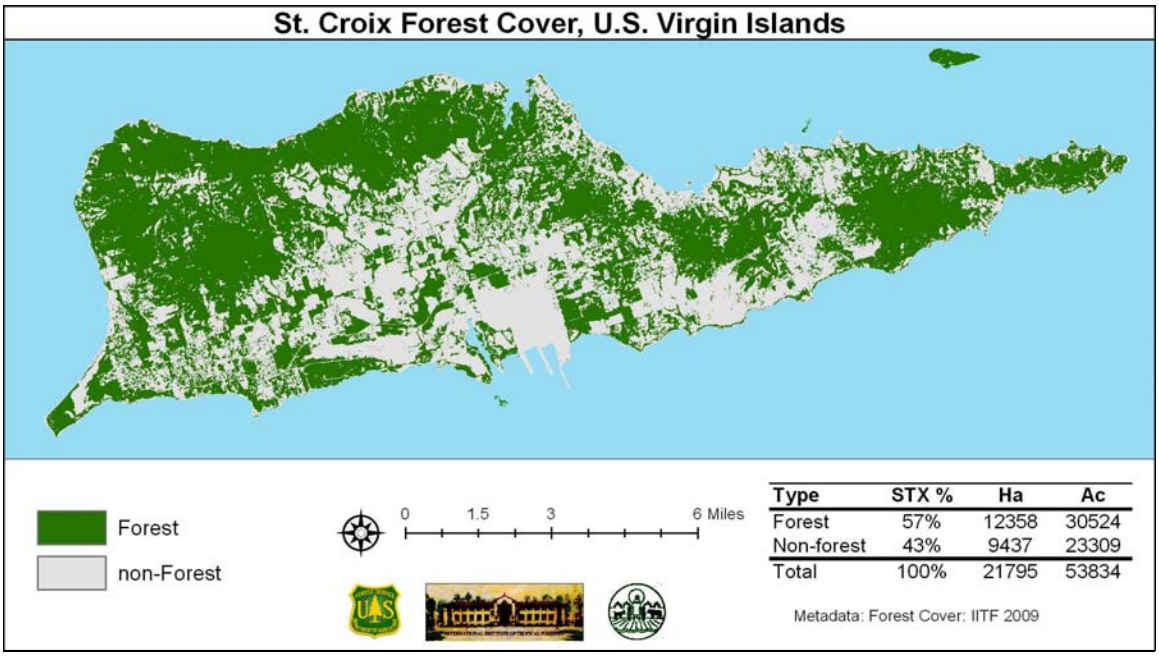


Figure 2: St. Croix Forest Cover, U.S. Virgin Islands

History of Forests on St. Croix

St. Croix's forests were first utilized by the Taino and Carib peoples for boat building, tools, medicines and food (TNC, 2003). Haagensen (1995) as described by Brandeis and Oswalt (2007) suggests that forests covered more than 90% of the island in pre-Columbian times. Christopher Columbus, credited for naming the Virgin Islands, sailed by what is now known as Salt River Bay. He later remarked in his journal on "the great and plentiful forests in the Caribbean" (Nicholls, 2006), suggesting most of the islands were lush with trees, including the USVI.

In 1625 English and Dutch settlers came to St. Croix and by the 1630s started construction of a road system. After 20 years of ownership exchanges between the Spanish, Dutch, French and English, the French established themselves on the island in the 1650s and started planting crops with hired and slave labor from St. Kitts. They planted sugar cane, indigo, and tobacco. After establishing themselves on St. Thomas in 1672, the Danes finally took over St. Croix in 1733 (Weaver, 2006a).

By 1740, 114 cotton plantations were established on the rocky steep slopes. Sugar cane production, at first a distant second to cotton on the island, increased during the subsequent years. Many plantations were established on the lower elevation soils. The Danes, as the new owners of the island, by 1758 harvested much of the still intact forests (Nicholls, 2006 as adapted from Eggers, 1879) and by 1796, half of St. Croix was in sugar cane production. Many of the trees cleared for sugar cane and cotton production were removed and sold as timber (Nicholls, 2006 as adapted from Jones, 1995).
Some reports from the 1800s claimed that income from the sales of timber exceeded the income from subsequent plantation crops (Weaver, 2006a from Lawaetz,1991).

By 1815, with timber resources depleted, sugar cane dominated the agricultural landscape and covered much of the island (Weaver 2006 from Lawaetz 1991). However, by 1900, production had declined in acreage from 8,175 ha (21,000 acres) to 6,600 ha (16,300 acres) and continued to decline until 1916 when only three sugar factories remained (Weaver, 2006a). Today there is no large-scale commercial sugar cane production on the island.

In 1917 the United States purchased the Virgin Islands from Denmark, primarily for military purposes. At that time, an estimated 90% of forests on St. Croix had been cleared for agriculture and timber products (Brandeis 2007 as adapted from Ward & others 2000). With the exception of some cattle and dairy farming, by 1931, fourteen landowners owned 70% of the island and agricultural production continued to plummet. (Weaver 2006 as adapted from O'Neil 1972). Forestry management activities began in the 1930s with the United States Forest Service (USFS) establishing mahogany and teak for traditional timber production in experimental plots scattered around the island of St. Croix (Weaver, 2006a).

St. Croix's population remained low, at somewhere between 13,000 to 15,000 inhabitants, from 1940 to 1960, but began to increase rapidly into the 1970s with an influx of "continentals" (mainland U.S. citizens), tripling to more than 50,000. Industry, including an oil refinery (HESS), alumina plant, and the Virgin Islands Water and Power Authority (WAPA) attracted workers to the island as well. In 1976 Somberg estimated forest cover for all the Virgin Islands at 45.1 percent (Brandeis and Oswalt, 2007). At the same time, the USDA Soil Conservation Service noted a loss of agricultural land to development (Davis, 1998).

Indigenous forests were mostly cleared for agriculture during the Danish period (1733 – 1917). Beginning in 1917, agriculture on the island transitioned from an agricultural to a pastoral system for dairy and beef cattle, sheep, and goats. As livestock operations declined, many of these pastures reverted to secondary forest (Somberg, 1976).

Currently, secondary forests are continuing to emerge on old agricultural lands and account for much of the forest lands that cover St. Croix. However, these secondary forests are being changed again due to development. Overall the Virgin Islands FIA shows a loss of 8% of forests on St. Croix from 1994 to 2004. Of the forested lands, 80% were composed of stands of saplings and seedlings, and 20% were stands of trees with a small diameter at breast height (dbh). Only 3% of forests on St. Croix were considered mature forest (Brandeis and Oswalt, 2007). A slight gain in overall forest cover was found for St. Croix (Daley, 2010). These gains tend to be located

in the transitional pasture and agricultural areas that were previously cleared of forest. These differences and changes suggest a dynamic forest system in transition.

Throughout its history, St. Croix's landscape has changed from minimal use by indigenous people to heavy agricultural use through the cotton and sugar plantation era to the current state of use by industry, agriculture, tourism, and clearing for development.

Forests in Ecological Zones (Holdridge Life Zones 1973)

The Virgin Islands FIA reported ecological zones as sub-tropical dry and subtropical moist forests. Seventy-two percent of the forests on St. Croix were reported to be in the sub-tropical dry forest zone. Twenty-eight percent of the forests are in the subtropical moist forest zone and are located in the northwestern portion of the island **(**Figure 3**)** (Brandeis and Oswalt, 2007, Ewel and Whitmore, 1973).

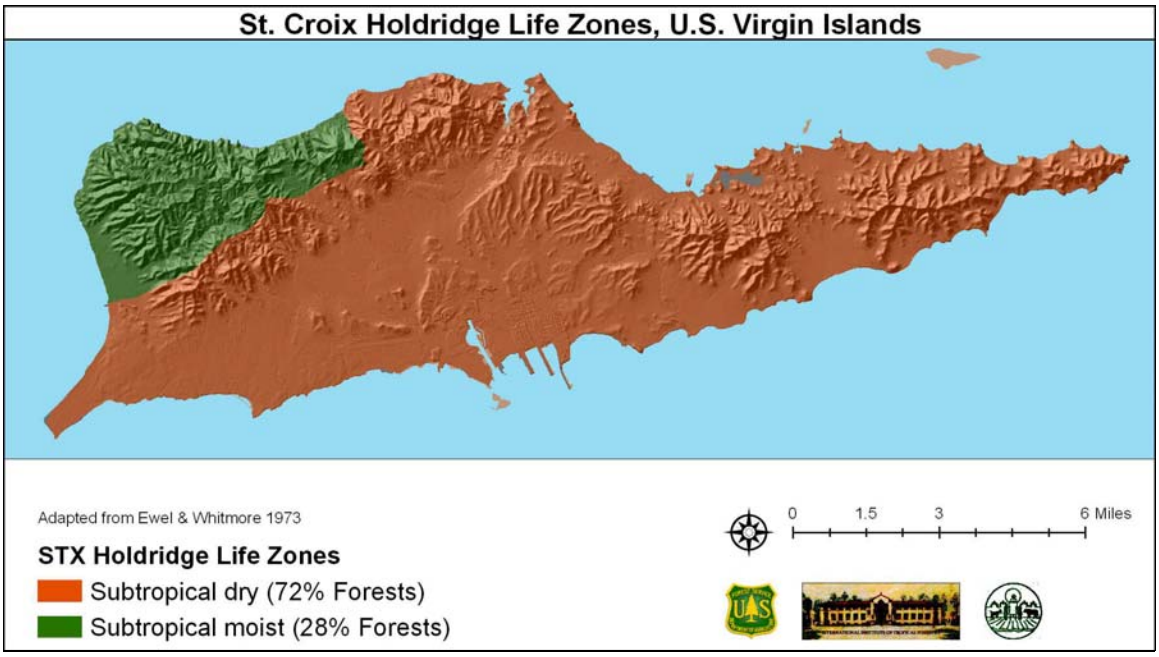


Figure 3: St. Croix Holdridge Life Zones

These two zones are quite broad and do not describe the biodiversity of the forest resources on St. Croix. They do describe the effects of climate on these tropical forest systems.

Urban and Community Forests

St. Croix's population density of approximately one person per acre is considered mostly urban (Census, 2000). Forests in populated areas are considered urban and community forests and represent many of the forested areas of the island. Gallaher defined community forestry as: "The planning, design and management of vegetation on public lands in and around communities to maximize their visual, social, economic, and environmental contributions to the well-being of the community" (Johnson et al., 1990). Although no formal studies have been conducted on urban

and community forests on St. Croix, a rough estimate of forested land use was calculated by summarizing existing forests within future land use zones **(**Table 2**).**

The designation of "urban" is defined by the U.S. Census as a population density of 1.5 persons per acre, with surrounding areas having a population density of 0.78 persons per acre. On St. Croix, summarizing the census blocks with this urban designation resulted in 17% (5186 acres) of the forested lands being identified as urban (Figure 4).

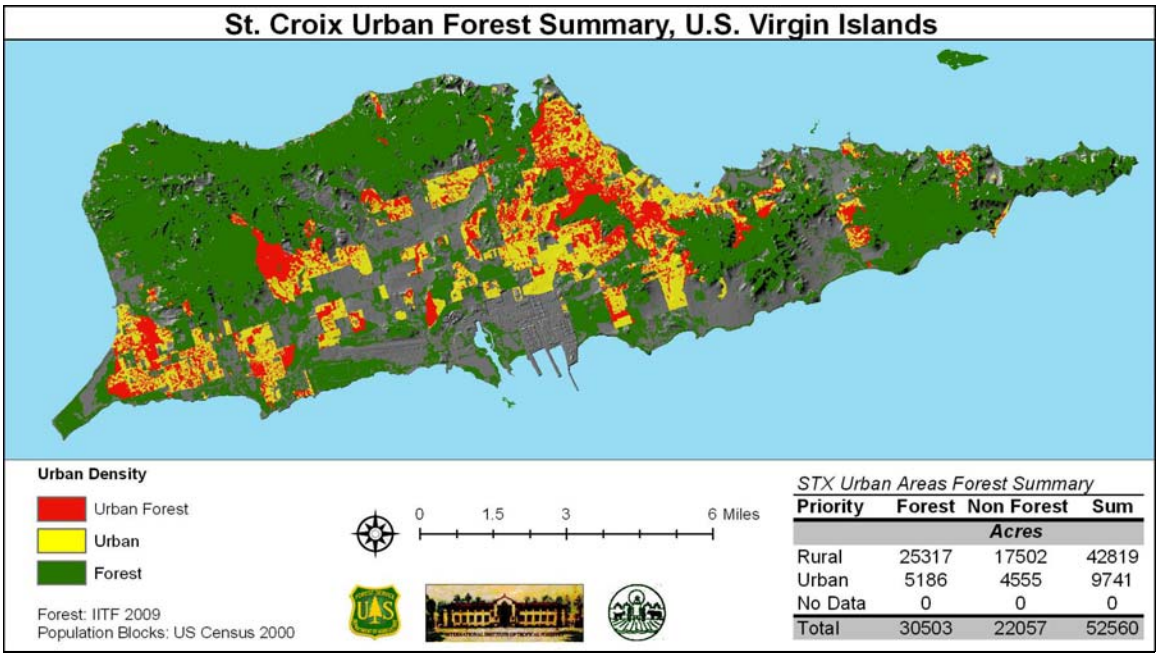


Figure 4: St. Croix Urban Forest Summary

Forests in the USVI lie in many mixed use areas. Another way to add in the zones around heavily urban areas is to look at community forestry as well in the areas that are less populated. Using the 2004 Land Use and Water Plan future zone designations, it was calculated that 48% of the total forested land area of St. Croix falls within the urban and community forestry category (Table 2). These forests are often overlooked in planning and consideration of forestry activities but play a large role in the overall forested area of the island.

Table 2: St. Croix Forest Land Use

Land Use Description	Rural/Urban	Ha	Acres	% Total Forest
Agriculture	Rural	1816.6	4487.0	14.8%
Conservation Zones	Rural	4474.8	11052.8	36.4%
Sparse Developed/Sub-Divided	Urban/Comm	2383.3	5886.8	19.4%
Medium Density Residential	Urban/Comm	1771.9	4376.5	14.4%
Moderate to High Density	Urban/Comm	963.4	2379.6	7.8%
High Intensity Residential/Commercial	Urban/Comm	16.1	39.8	0.1%
Industrial	Urban/Comm	418.9	1034.7	3.4%
Roads	Urban/Comm	418.1	1032.7	3.4%
Total		12263.1	30289.9	100%

Forests and Soils

Forest soils were analyzed using the International Institute of Tropical Forestry's (IITF) land cover data layer from Kennaway (2008) in conjunction with the USDA's Natural Resource Conservation Service's (USDA-NRCS, 2008) Soils Survey. More than half of the forest soils on St. Croix fall into just six categories as described in the NRCS soils manual (**Table 3)**.

Table 3: St. Croix Summary of Soil Types in Forest

Soil	%total	Acres
Victory-Southgate complex on 40-70% slopes	18%	5551
Annaberg-Cramer complex on 60-90% slopes	10%	3059
Annaberg-Cramer complex on 40-60% slopes	9%	2944
Glynn gravelly loam on 2-5% slopes	6%	1948
Cramer-Victory complex on 20-40% slopes	4%	1346
Glynn gravelly loam on 5-12% slopes	4%	1172

Victory-Southgate complex (VsF) on 40-70% slopes and Annaberg-Cramer complex (AcG) on 60-90% slopes are well drained soils with top surface layers of gravelly gray and brown loams. These soils are generally found on steep slopes, and have moderate natural fertility and low available water capacity. The NRCS characterizes these soils as useful mainly for rangeland (Davis, 1998).

St. Croix's forests have changed dramatically since pre-Columbian times. Exactly what forests looked like before Europeans arrived is not easy to discern. It is known that some large canopy trees existed, but the extent of the mature forest cover is not clear. Historical accounts of the forests focus on clearing land for agriculture, with anecdotal reports of timber cut down and sold off the island (Brandeis and Oswalt, 2007).

St. Thomas

At 32 square miles, St. Thomas is the second largest of the U.S. Virgin Islands. It is mostly steep sloped with some agricultural history (Brandeis and Oswalt, 2007). Forest cover is calculated at 69% (Kennaway et al., 2008) **(**Figure 5**)**. The Rapid Environmental Assessment (REA) conducted in 2001 (Gibney et al., 2001) differs from the Forest Inventory and Analysis (FIA) report (Brandeis and Oswalt, 2007) showing forest covers of 63% and 74%, respectively. Water Island, located to the south of St. Thomas, is included with St. Thomas statistics and descriptions.

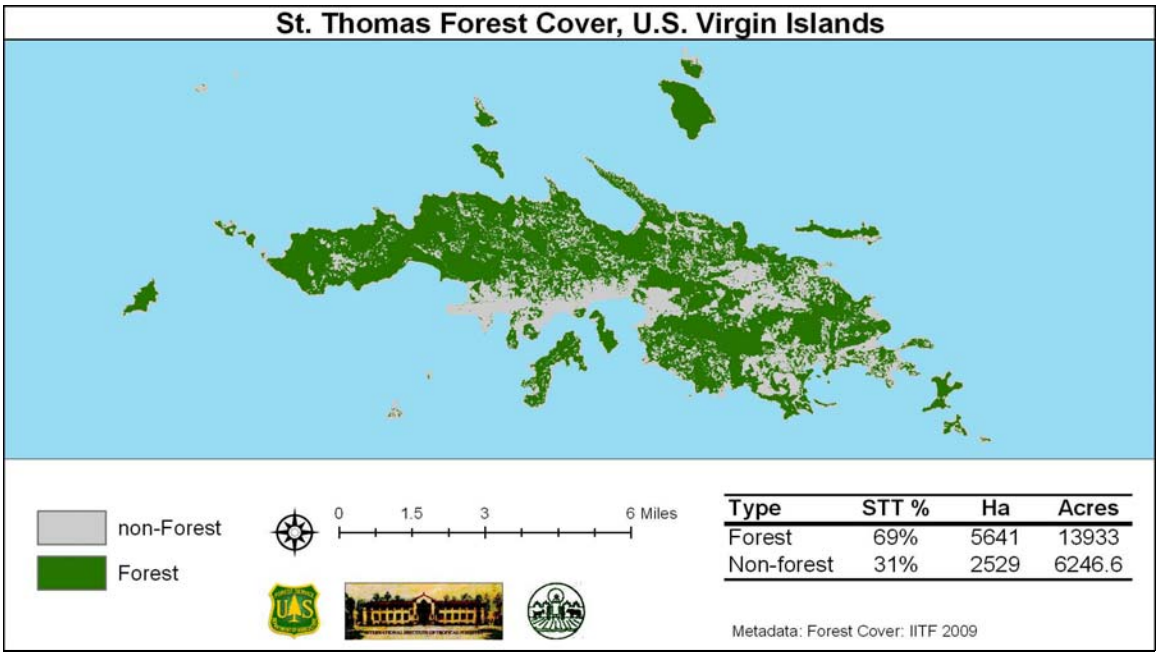


Figure 5: St. Thomas Forest Cover

Forests of St. Thomas

St. Thomas has a pre-Columbian history similar to that of St. Croix. However, its colonial development is somewhat different. St. Thomas was settled by Denmark in 1672, when agricultural production began, but by the mid-1800s agricultural lands were being abandoned due to the crash of the sugar market, loss of slave labor due to emancipation and the difficulty of farming due to steep slopes and the rough terrain of the island (Brandeis and Oswalt, 2007, Weaver, 2006a).

St. Thomas is roughly one-third the size of St. Croix, with approximately the same population (~55,000). St. Thomas is a popular tourist destination for cruise ships between the months of January and April, and may receive as many as nine ships carrying thousands of passengers each day. For this reason, St. Thomas has long been known as the tourist island of the Virgin Islands (USVI-Tourism, 2009).

As on St. Croix, secondary forests have been re-established on St. Thomas (Brandeis and Oswalt, 2007). The USDA FIA found that 8% of the forests on St. Thomas were mature secondary

forests with no establishment of transitional forests. There was a calculated loss of forest at 9.3% from 1994 to 2004 (Brandeis and Oswalt, 2007).

Forests in Ecological Zones (Holdridge Life Zones 1973)

The FIA reported ecological zones in terms of the sub-tropical dry and sub-tropical moist forests (Ewel and Whitmore, 1973). Thirty-three percent of the forests on St. Thomas were reported to be in the sub-tropical dry forest zone and 66% in the sub-tropical moist forest zone **(**Figure 6**)**. Unlike St. Croix, in which the sub-tropical moist forest is concentrated in the northwestern area, sub-tropical moist forest can be found throughout all areas of steep-sloped St. Thomas.

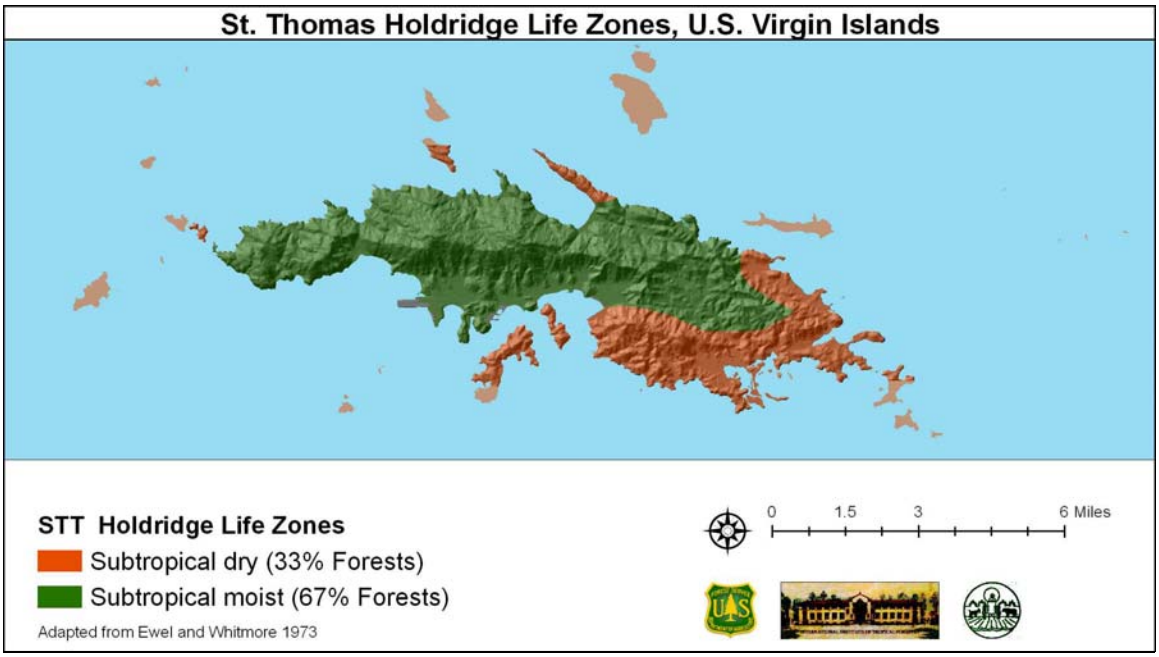


Figure 6: St. Thomas Holdridge Life Zones

Urban and Community Forests

Currently there are no studies or data quantifying the urban and community forests of St. Thomas. With a population density of 2.5 persons per acre, more than twice that of St. Croix, many areas are considered urban (Census, 2000). Based on the same designation for urban areas of a population density of 1.5 persons per acre and 0.78 persons per acre in surrounding areas, on St. Thomas approximately 4,445 acres (30.5%) of forests fall into the urban designation. It is likely that the total percentage of urban forest is greater than 30.5%, but due to the weighted analysis of the census, some data were not displayed due to discrepancies in census block weighted data. As on St. Croix, the forest cover in populated areas of St. Thomas is often overlooked by researchers but plays an important part in total forest cover **(**Figure 7**)**.

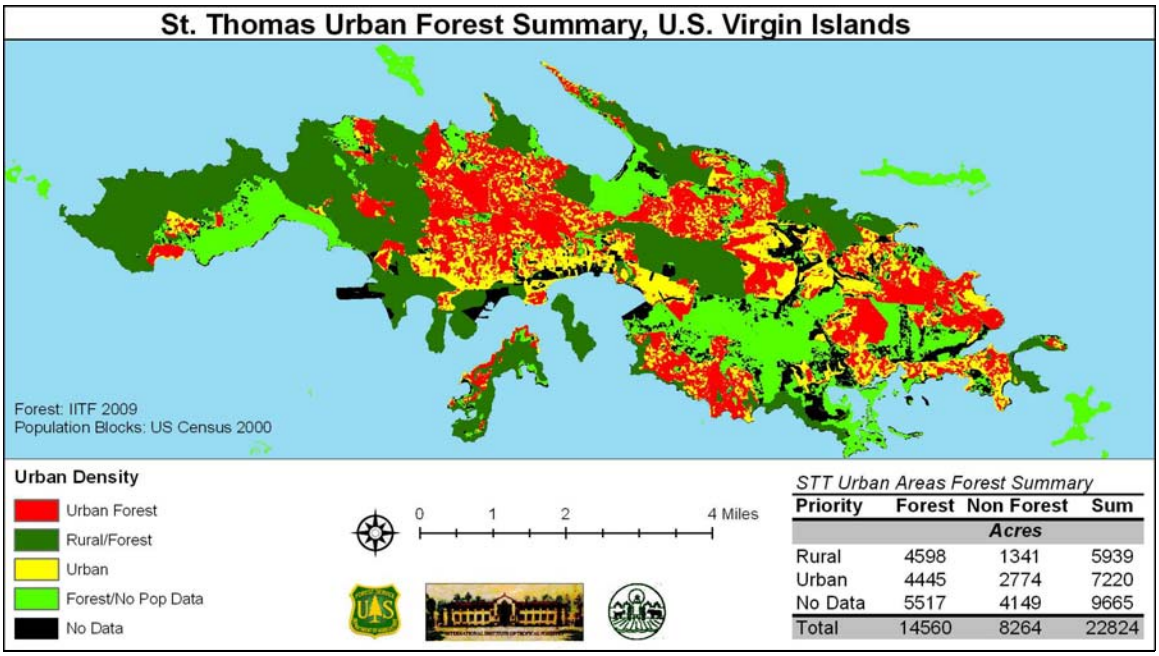


Figure 7: St. Thomas Urban Forest Summary

Forests and Soils

The International Institute of Tropical Forestry's (Kennaway et al., 2008) land cover data layer was analyzed in conjunction with the USDA NRCS 2008 soils layer. This resulted in six soil types accounting for 63% of the forest area on St. Thomas. Fredriksdal soils (FsF) were the dominant soil series in forested lands **(Table 4).** Characteristics of these soils include shallow well-drained soils on steep slopes. The soils are typically a reddish brown clay loam, with a relatively high organic matter and natural fertility. They typically have a very low water-holding capacity and a root zone of 10-20 inches. The soil survey describes these soils to be mainly used as rangeland. Most of these soils are found on steep slopes and are near drainage areas locally known as guts.

Table 4: St. Thomas Summary of Soil Types in Forest

Soil	Acres Forest	% Attrib Forest
Fredriksdal-Susannaberg complex on 40-60% slopes	1985	13%
Fredriksdal-Susannaberg complex on 60-90% slopes	1805	12%
Southgate-Rock outcrop complex on 40-60% slopes	1559	11%
Dorothea-Susannaberg complex on 40-60% slopes	1521	10%
Fredriksdal-Susannaberg complex on 20-40% slopes	1403	9%
Dorothea-Susannaberg complex on 60-90% slopes	1203	8%

St. John

St. John is the smallest island of the U.S. Virgin Islands and covers about 20 square miles. The steep slopes and beautiful views have resulted in much of the island being designated as the largest dry forest preserve in the Lesser Antilles. Total forest cover was calculated at 89% **(**Figure 8**)** (Kennaway et al., 2008)**.** The Rapid Environmental Assessment (REA) (Gibney et al., 2001) and the Forest Inventory and Analysis (FIA) (Brandeis and Oswalt, 2007) reported forest covers of 87% and 92% respectively

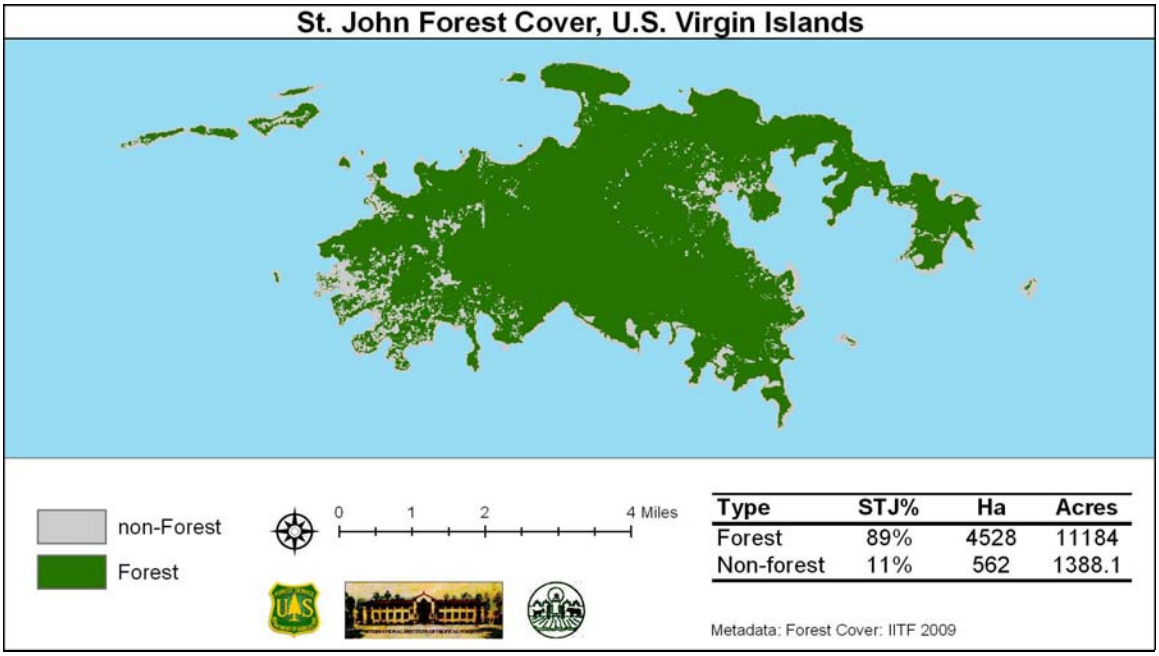


Figure 8: St. John Forest Cover

Forests of St. John

St. John, like the other Virgin Islands, was most likely dominated by forests before colonization. Denmark's colonization of St. John in 1718 marked the beginning of land clearing for agriculture. However, agricultural practices were abandoned on the island starting in 1848 due to the decline of the sugar cane industry and the steep slopes and rugged terrain of the island (Brandeis and Oswalt, 2007, Weaver, 2006b). St. John retained over 50% of its native forests and/or shrub land at any one time, contributing to the greater regeneration of native forests in formerly disturbed areas (Gibney, 2004). Change in ownership in 1917 to the United States eventually led to the formation of the Virgin Islands National Park in 1956 (Eisenhower, 1956).

Most of the areas within the park preserve have established forests which allow continual uninterrupted forest succession (Gibney, 2004). The FIA did show a loss of 3% of forests on St. John between 1994 and 2004, most likely occurring outside the designated park boundaries due to development (Brandeis and Oswalt, 2007).

Forests in Ecological Zones (Holdridge Life Zones 1973)

The FIA reported ecological zones in terms of the sub-tropical dry and sub-tropical moist forests. Sixty-one percent of the forests on St. John are in the sub-tropical dry forest zone and 39% are in the sub-tropical moist forest zone, located on the southeast to northwest portions of the island **(**Figure 9**)**

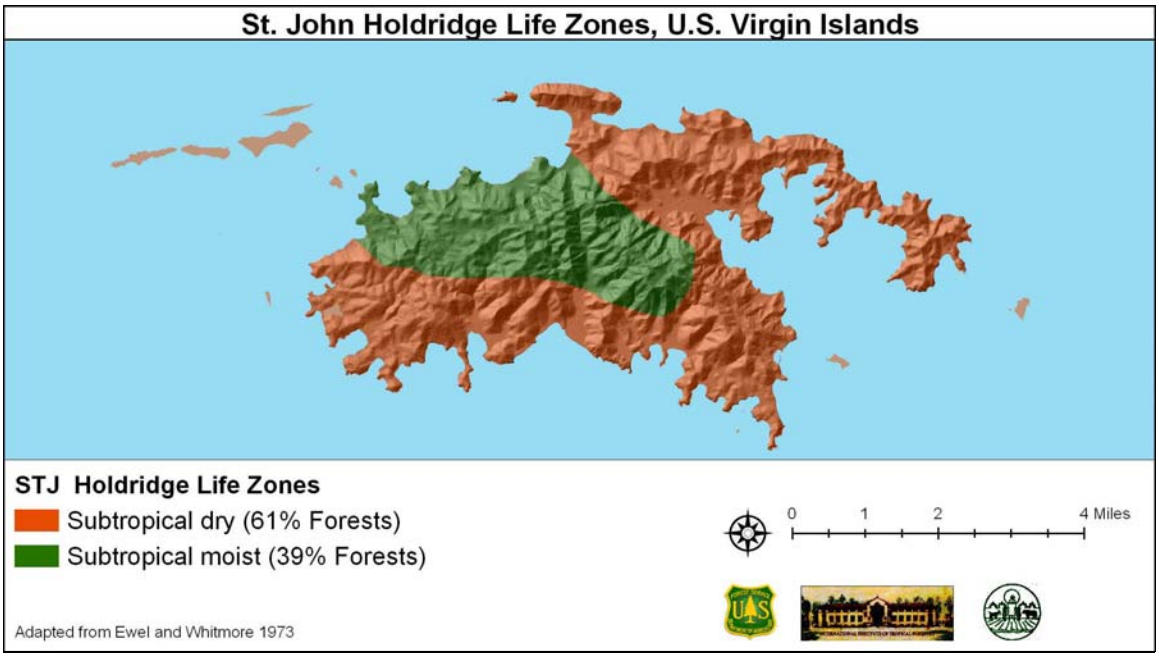


Figure 9: St. John Holdridge Life Zones

Urban and Community Forests

Although no formal studies have been conducted on urban and community forests on St. John, a rough estimate of forests in different planning schemes was calculated (**Table 5)**. The Virgin Islands National Park encompasses 74% of all the forested lands on St. John.

Table 5: St. John Forest Land Use

Land Use Description	Urban/Rural	Ha	Acres	% Forest
Conservation Zones	Rural	3726.7	9204.9	81%
Sparse Development/Sub-Divisions	Rural	485.6	1199.3	11%
Medium Density/ Residential	Urban/Comm	98.9	244.2	2%
Moderate to High Density	Urban/Comm	70.6	174.4	2%
High Intensity/ Residential/Commercial	Urban/Comm	0.0	0.1	1%
Roads	Urban/Comm	132.5	327.3	3%
Total		4514.3	11150.2	**100%**

On St. John, only 14 acres (1%) of forest fell into the urban category of a population density of 1.5 persons per acre and 0.78 persons per acre in surrounding areas. Census block data showed no areas with densities of 1.5 persons per acre. In our analysis, areas with population densities of greater than 0.78 people per acre were considered as “urbanizing”. A greater amount could be considered urban but due to the weighted analysis of the census blocks, some data were not

displayed. The focus on forests on St. John resides with the Virgin Islands National Park area (Figure 10)

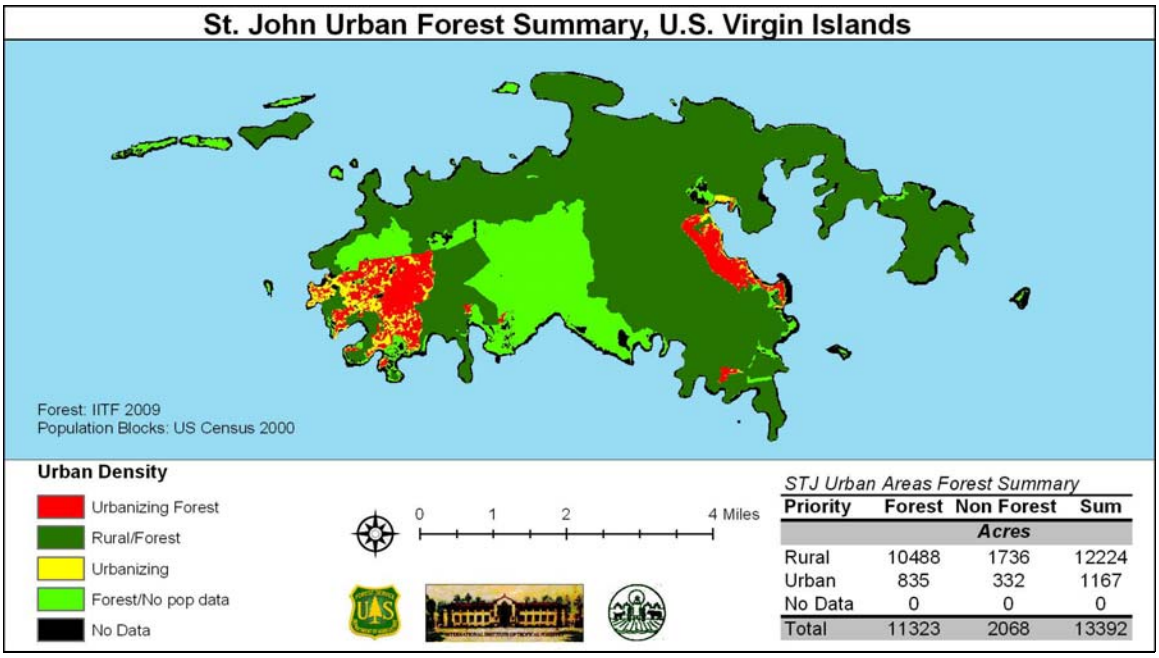


Figure 10: St. John Urban Forest Summary

Forests and Soils

Analyzing the IITF land cover layer with the NRCS soils layer by soil type resulted in six soil types of the 32 soils in the NRCS soils manual accounting for 60% of the forested area on St. John **(Table 6)**.

Table 6: St. Croix Summary of Soil Types in Forest

Soil Type	Forest (Acres)	% Forest/SoilType
Victory-Southgate complex on 40-70% slopes	1855	15%
Fredriksdal-Susannaberg complex on 40-60% slopes	1458	12%
Southgate Rock outcrop complex 40-60% slopes	1046	9%
Fredriksdal-Susannaberg complex on 20-40% slopes	987	8%
Annaberg-Maho complex 60-90% slopes	925	8%
Southgate Rock outcrop complex on 20-40% slopes	858	7%

Soils of the Victory-Southgate complex (VsF), Annaberg-Cramer complex and Fredriksdal-Susannaberg (FsF) complex are shallow well drained soils on steep slopes. Soil texture is a reddish brown clay loam. These soils have a relatively high organic matter and natural fertility and very low water capacity with a root zone of 10-20 inches. The soil survey finds these soils to be mainly used as rangeland. Most of the forested land with these soils consists of steep slopes near drainage areas (Davis, 1998).

Forest Types in the U.S. Virgin Islands

Descriptions of forest types in the US Virgin Islands in this assessment are based on the International Institute of Tropical Forestry's (IITF) land cover project (Kennaway et al., 2008). These forest types relate to the FIA's utilization of the Holdridge life zones of subtropical dry and subtropical moist forest, Federal Geographic Data Committee (FGDC, 2008) National Vegetation Classification (FGDC, 2008), and Woody Vegetation Classification (Areces-Mallea et al., 1999). The repeatable method and accuracy assessment of these systems make this information more rigorous as more data are collected and tested. The following is a list of forest types found in the Virgin Islands (adapted from Table 1 in Kennaway, 2008).

Forest, forest/shrub, woodland and shrubland (dry and moist)

- Drought Deciduous Woodland – 25-60% woody canopy cover with understory of grasses and forbs affected by grazing
- Drought Deciduous Young Forest and Forest Shrub – Young drought deciduous secondary forest with *Leucaena leucocephala* and *Acacia muricata* common
- Drought Deciduous Xeric Coastal Shrubland – Very dry drought deciduous shrubland dominated by succulents and exposed soil and rock
- Deciduous, Evergreen Mixed Forest and Shrubland with Succulents – Deciduous, drought deciduous evergreen forest and shrub species (succulents common)
- Evergreen Coastal Shrubland – Shrubland with > 75% evergreen species including hemi-sclerophyllous and sclerophyllous species
- Semi-deciduous Forest and Forest Shrub (Includes Semi-Evergreen Forest) – Stands with 25-75% deciduous woody canopy species
- Semi-deciduous Gallery Forest – Stands with 25-75% deciduous woody canopy species located in drainages
- Seasonal Evergreen Forest and Forest Shrub – Stands with greater than 75% evergreen woody canopy species (may drop leaves during drought)
- Seasonal Evergreen Young Forest and Forest Shrub – Young seasonal evergreen secondary forest
- Seasonal Evergreen Gallery Forest - Stands with greater than 75% evergreen woody canopy species, located in drainages
- Seasonal Evergreen Forest with Coconut Palm - Stands with greater than 75% evergreen woody canopy species dominated by coconut palm

Forested Wetlands

- Mangrove – Mangrove forest
- Seasonally Flooded Woodland – Disturbed forested wetland with 25-60% woody canopy cover and seasonal flooding or soil saturation

St. Croix

Dominant forest types on St. Croix are Deciduous, Evergreen Mixed Forest and Shrubland with succulents (49.8%), Drought Deciduous Young Forest and Forest Shrub (24.1%) and Semi-deciduous Forest and Forest Shrub (14.3%) **(**Table 7**)**.

Table 7: St. Croix Forest Type Summary

Forest Classifications (St. Croix)	ha	Acres	% Forest
Deciduous, Evergreen Mixed Forest and Shrubland, with Succulents	6153	15198	49.8%
Drought Deciduous Young Forest and Forest Shrub	2974	7346	24.1%
Semi-Deciduous Forest and Forest Shrub	1770	4372	14.3%
Semi-Deciduous Gallery Forest	528	1304	4.3%
Drought Deciduous Woodland	409	1010	3.3%
Drought Deciduous Xeric Coastal Shrubland with Succulents	93	230	0.8%
Evergreen Coastal Shrubland	117	289	0.9%
Seasonal Evergreen Gallery Forest	128	316	1.0%
Mangrove	185	457	1.5%
Total	12358	30524	100%

Forests in riparian areas represent 5.3% of forested areas. The young forests and shrubs are indicative of a changing landscape dominated by tan-tan (*Leucaena leucocephala)* and casha (*Acacia macracantha*) where agricultural lands are reverting back and forth between forest and non-forest uses **(**Figure 11**)**.

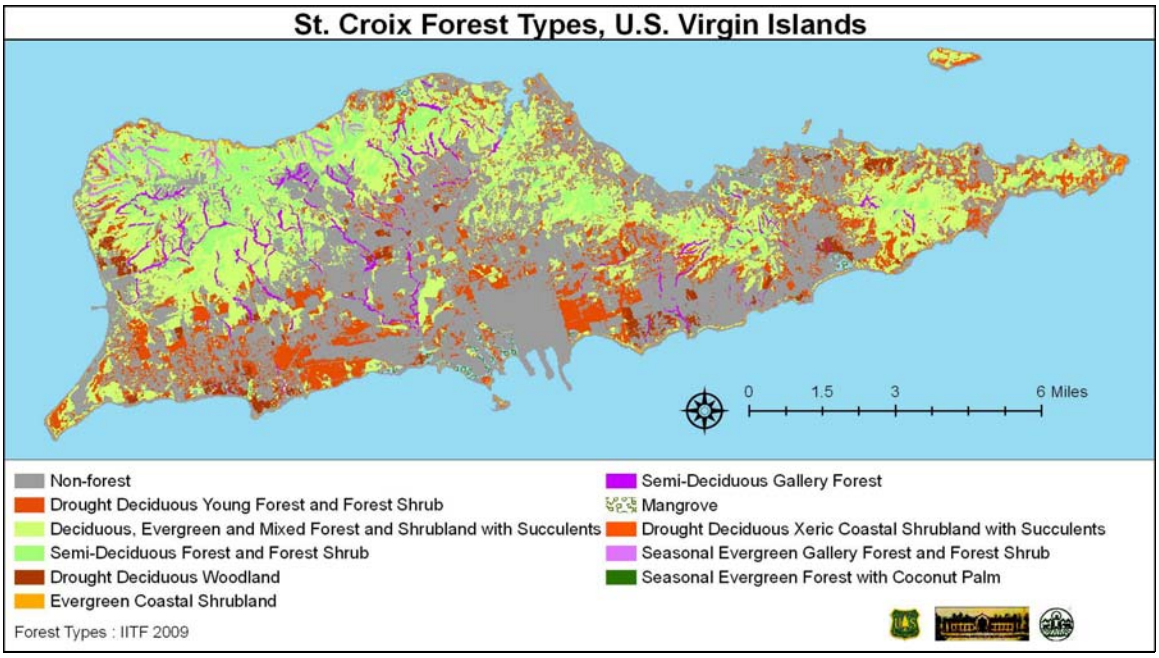


Figure 11: St. Croix Forest Types Distribution

St. Thomas

The dominant forest types on St. Thomas are Semi-deciduous Forest and Forest Shrub (45.9%), Deciduous, Evergreen Mixed Forest and Shrubland (31.8%), and Seasonal Evergreen Forest (8%). Unlike St. Croix, young forest and forest shrub on St. Thomas only account for 4% of the analyzed forest types **(**Table 8**)** (Kennaway et al., 2008).

Table 8: St. Thomas Forest Types Summary

Forest Classifications (St. Thomas)	ha	Acres	% Forest
Semi-Deciduous Forest and Forest Shrub	2587	6389.89	45.9%
Deciduous, Evergreen Mixed Forest and Shrubland, with Succulents	1794	4431.18	31.8%
Seasonal Evergreen Forest	453	1118.91	8.0%
Drought Deciduous Young Forest and Forest Shrub	211	521.17	3.7%
Drought Deciduous Xeric Coastal Shrubland with Succulents	160	395.2	2.8%
Seasonal Evergreen Gallery Forest	147	363.09	2.6%
Evergreen Coastal Shrubland	101	249.47	1.8%
Mangrove	105	259.35	1.9%
Semi-Deciduous Gallery Forest	64	158.08	1.1%
Drought Deciduous Woodland	1	2.47	0.0%
Seasonal Evergreen Young Forest and Forest Shrub	6	14.82	0.1%
Seasonal Evergreen Forest with Coconut Palm	8	19.76	0.1%
Seasonally Flooded Woodland	4	9.88	0.1%
Total	5641	13933.27	100%

St. Thomas forest types **(**Figure 12**)** include abandoned agricultural lands that have grown up into tan-tan. With little agricultural activity on the island, the main disturbance of forested areas is human activity in the form of development.

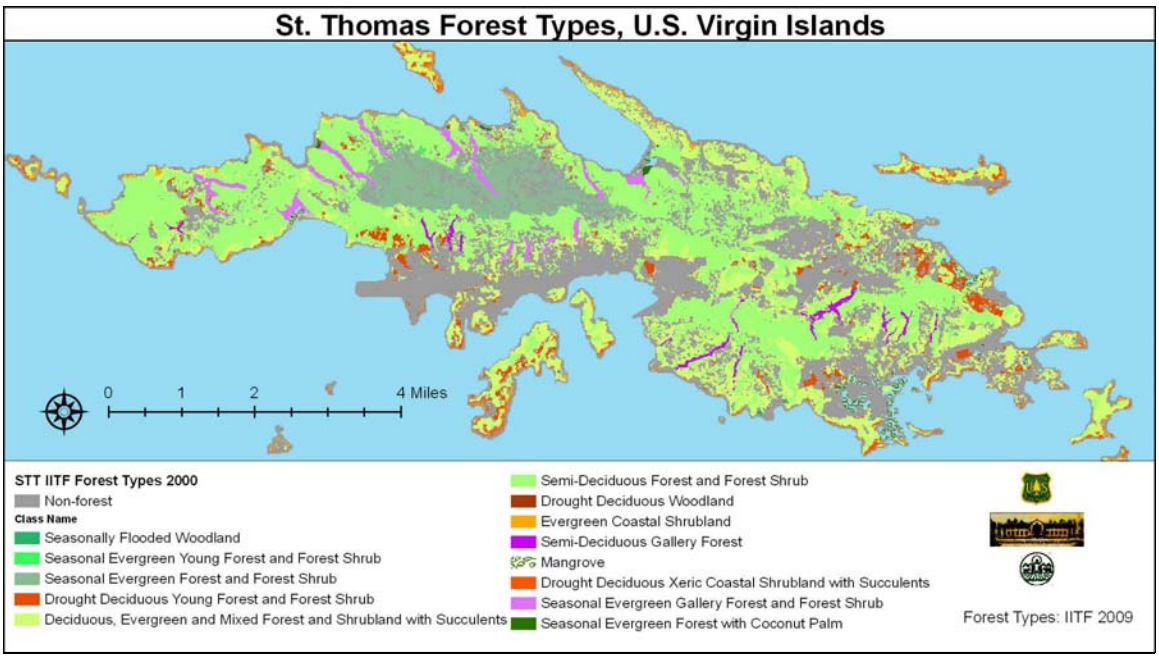


Figure 12 : St. Thomas Forest Types Distribution

St. John

The dominant forest types on St. John are Semi-deciduous Forest and Forest Shrub (35%), Deciduous, Evergreen Mixed Forest and Shrubland with Succulents (34.4%), and Seasonal Evergreen Forest (17.3%) **(**Table 9**)**

Table 9: St. John Forest Types Summary

Forest Classifications (St. John)	ha	Acres	% Forest
Semi-Deciduous Forest and Forest Shrub	1584	3912.48	35.0%
Deciduous, Evergreen Mixed Forest and Shrubland, with Succulents	1558	3848.26	34.4%
Seasonal Evergreen Forest	783	1934.01	17.3%
Drought Deciduous Young Forest and Forest Shrub	190	469.3	4.2%
Seasonal Evergreen Gallery Forest	175	432.25	3.9%
Drought Deciduous Xeric Coastal Shrubland with Succulents	85	209.95	1.9%
Evergreen Coastal Shrubland	44	108.68	1.0%
Semi-Deciduous Gallery Forest	41	101.27	0.9%
Mangrove	48	118.56	1.1%
Seasonal Evergreen Young Forest and Forest Shrub	1	2.47	0.0%
Seasonal Evergreen Forest with Coconut Palm	11	27.17	0.2%
Seasonally Flooded Woodland	8	19.76	0.2%
Total	4528	11184	100%

St. John **(**Figure 13**)** is the most widely studied island in terms of forest structure, type and succession. More than half the island is under conservation management by the National Park Service as the Virgin Islands National Park.

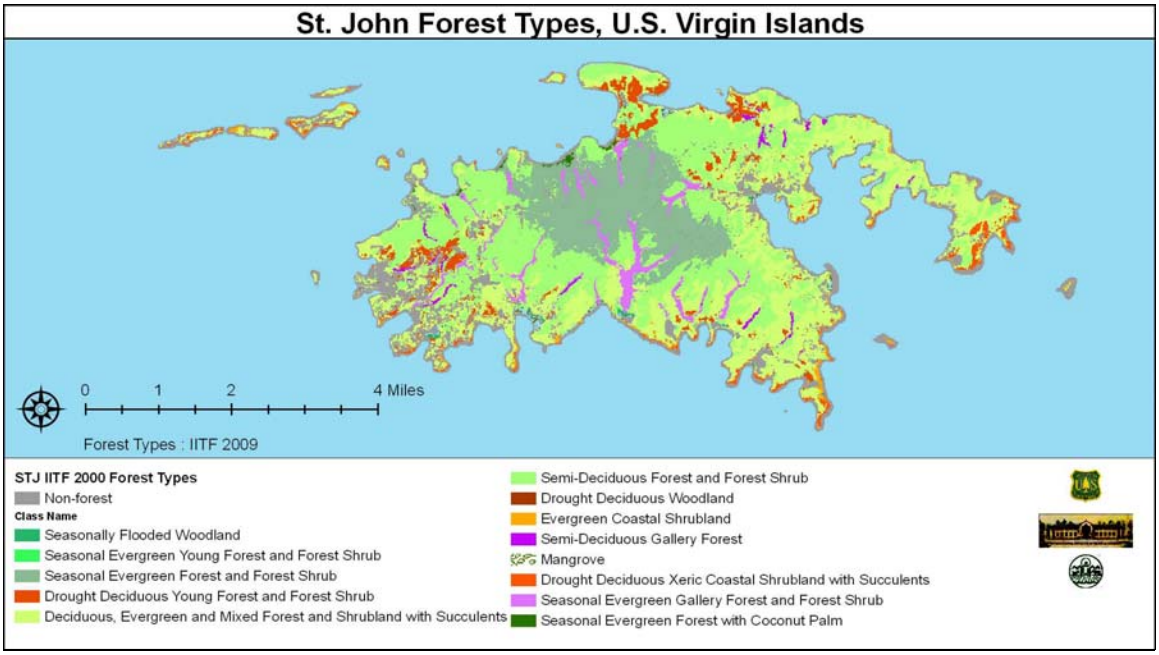


Figure 13: St. John Forest Types Distribution

Forest Dominance

The 2004 Forest Inventory Analysis (FIA) reports that two species of native trees (black mampoo and gumbo limbo), and one non-native species (genip), with a diameter at breast height (dbh) of 12 cm or greater dominate the USVI forests. Black mampoo (*Gaupira fragrans*) and gumbo limbo (*Bursera simaruba*) are found at relative dominance of 17.45% and 10.74%, respectively. Genip (*Melicoccus bijugatus*), a favorite fruit of local island inhabitants during the months of June-August, was second on the list of relative dominance at 11.33%. Although not a native tree species, genip fruit is eaten for the tart flesh surrounding the seed and the wood is used for charcoal production by many locals because it grows quickly **(**Figure 14**)**. Pigeon berry (*Bourreria succulenta*) was the next most commonly noted species (Brandeis and Oswalt, 2007).

Figure 14: Genip Dominated Forest (Photo by Dr. Gary Ray)

Tan-tan (*Leucaena leucocephala*) dominates **(**Figure 15**)** the pool of both seedlings and saplings, at 18.61% and 10.94%, respectively. Much of what is considered newly forested land on St. Croix is, in fact, abandoned pastures covered in a single age-class of tan-tan (Daley, 2009).

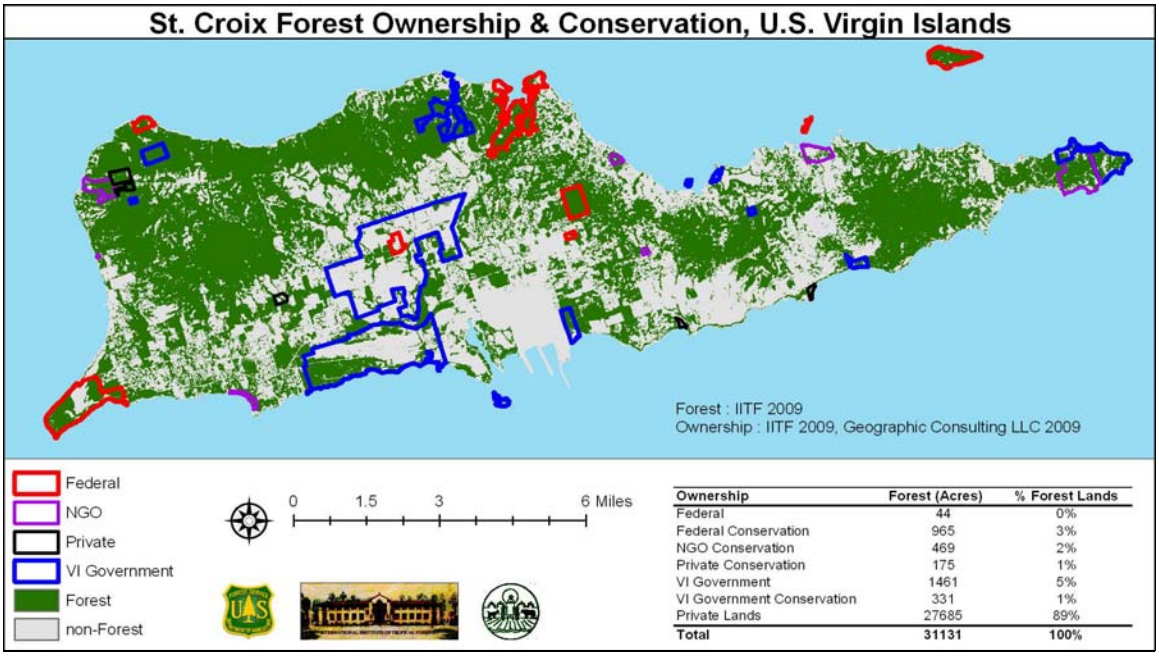
Figure 15: Tan-tan dominated forest (Photo by Geographic Consulting, LLC)

Forest Ownership

With the exception of St. John, most of the forest types in the USVI are found on private lands. With no official comprehensive land and water use plan, it is difficult to track changes in land use and ownership.

St. Croix

St. Croix has the most diverse ownership pattern of the Virgin Islands **(**Figure 16**)**. Federal conservation lands make up 3% of forested lands. Non-governmental organizations manage approximately 2% of forested lands. Private conservation lands and VI government conservation lands make up 1% each of forested lands. By far the majority of forested land is privately owned (89%) and most is not managed for forest activities, with the exception of properties in the Forest Stewardship Program of the VI Department of Agriculture. This means more than 85% of forested lands on St. Croix are probably not managed specifically for forests. These data do not include private holdings within the Forest Stewardship Program that account for approximately 1,050 acres.



Ownership	Forest (Acres)	% Forest Lands
Federal	44	0%
Federal Conservation	965	3%
NGO Conservation	469	2%
Private Conservation	175	1%
VI Government	1461	5%
VI Government Conservation	331	1%
Private Lands	27685	89%
Total	**31131**	**100%**

Figure 16: St. Croix Forest Ownership

St. Thomas

St. Thomas forests are also dominated by private land holdings (Figure 17) (94%). Five percent of forested lands are protected under the Virgin Islands government, with most being located on the surrounding cays and large area of the Magens Bay Authority. The other 1% is the federally-protected Hassel Island, U.S. Navy Land on Crown Mountain Peak and the Smith Bay Territorial Park.

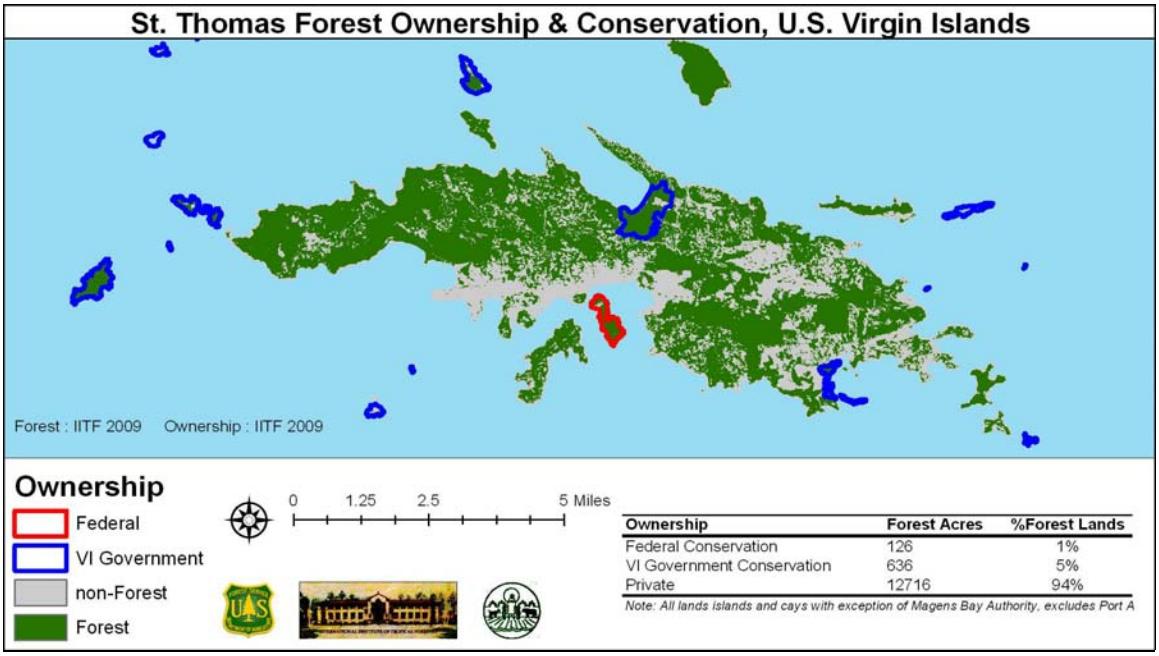


Figure 17: St. Thomas Forest Ownership

St. John

Seventy-four percent of St. John's forests are protected within the Virgin Islands National Park (Figure 18). Twenty-five percent of forested lands are privately owned with the other one percent under local government control.

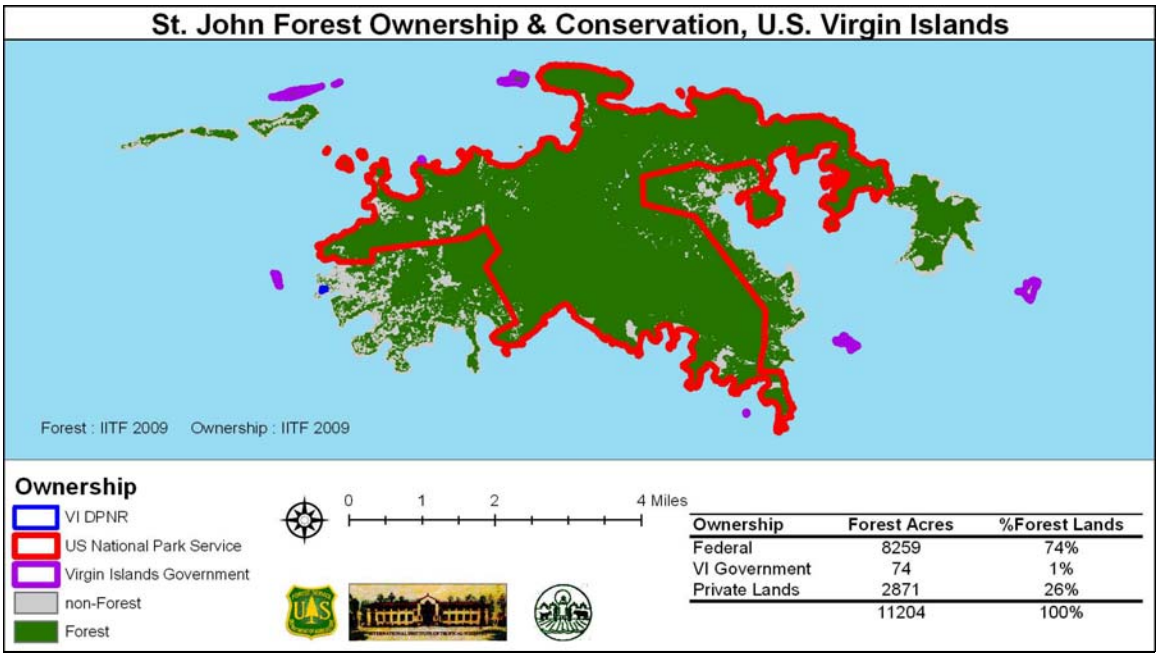


Figure 18: St. John Forest Ownership

Summary

The U.S. Virgin Islands are forested with subtropical dry and moist forests consisting of secondary growth and shrubland. All of the islands have heavy past anthropogenic effects from agricultural practices from the production of sugar cane and cotton. These practices were largely replaced by livestock production, especially on the island of St. Croix. Due to the limited land resources of the islands, forest lands are slowly being developed into other land uses such as residential housing or resorts. One such proposed project on St. Croix would remove approximately 600 acres of forest land, or 2% of the total forest land. With the exception of the Virgin Islands National Park on St. John most of the forest lands are privately owned. With little incentive to keep lands in forest or knowledge of the services these forests provide, there is a true danger of losing these diverse and unique forest ecosystems.

Public Benefits from Forest Resources

U.S. Virgin Islands forests provide many cultural and ecological services such as rainwater infiltration, wildlife habitat, soil stabilization and production of oxygen, as well the more economic values of shade, artisanal crafts and jobs. Forests also provide us with benefits less easily quantified, such as beautiful vistas and a sense of well being. Some of the public benefits of forest resources in the US Virgin Islands are summarized below.

Jobs and Economic Activity

Forest products from woody species on the islands are used to make craft items. Mahogany (*Swietenia* spp.) and tibet (*Albizia lebbeck*) are used for building materials and artisanal work. The Virgin Islands Bureau of Labor and Statistics does not include a category for natural resources or forest related activities, but forest activities do provide employment to state and federal employees in the region. Federal grants are further disseminated to the public for forestry projects and educational opportunities. Environmental educators from various state, federal and non-profit groups spend some of their billable time conducting outreach and education about forests (VINE, 2009).

Current data is not available on income produced from forestry related activities. The last reported data from 1997 indicated a gross income of $600,000 from forest products. (Brandeis, 2006 adapted from Pierce and Hultgren, 1997). Although there are no specific numbers to report, St. John's intact forests serve as an example of the value of forested land for eco-tourism. More than one million people visit the island annually (Weaver, 2006b).

Water Resources

There are few natural lakes or ponds in the Virgin Islands, and no permanent rivers (CIA, 2010). Most households collect rainwater from their rooftops and funnel this water into cisterns, barrels, drums, or tanks. The Virgin Islands Water and Power Authority (WAPA) runs desalination plants on St. Croix and St. Thomas that provide piped water to certain neighborhoods and office buildings.

St. Croix is the only island with a working aquifer system underlied by unconsolidated sediment. The Kingshill aquifer provides about 10% of the water in the form of wells, but the water is generally of poor quality. St. Thomas and St. John have systems that have cracks and joints in their geologic formations, allowing some infiltration and water access. However, the importance of these limited aquifer systems (Figure 20) is that they provide

Figure 19: Concordia Gut (Photo by Russell Slatton)

an alternate source of water and provide ecological services (Davis, 1998, Wiley and Vilella, 1998, Ramos-Scharrón and MacDonald, 2007, MacDonald et al., 1997, Sammarco, 1996)..

Guts act as the veins of the island, transporting water through the terrestrial habitats to the marine ecosystems. They provide moist areas for forests and wildlife. Forested guts with a diversity of vegetation filter and slow the water flowing through them, allowing the water to infiltrate through the soil into the groundwater and preventing soil erosion and nutrient overload in the marine systems (Ramos-Scharrón and MacDonald, 2007, MacDonald et al., 1997, Sammarco, 1996).

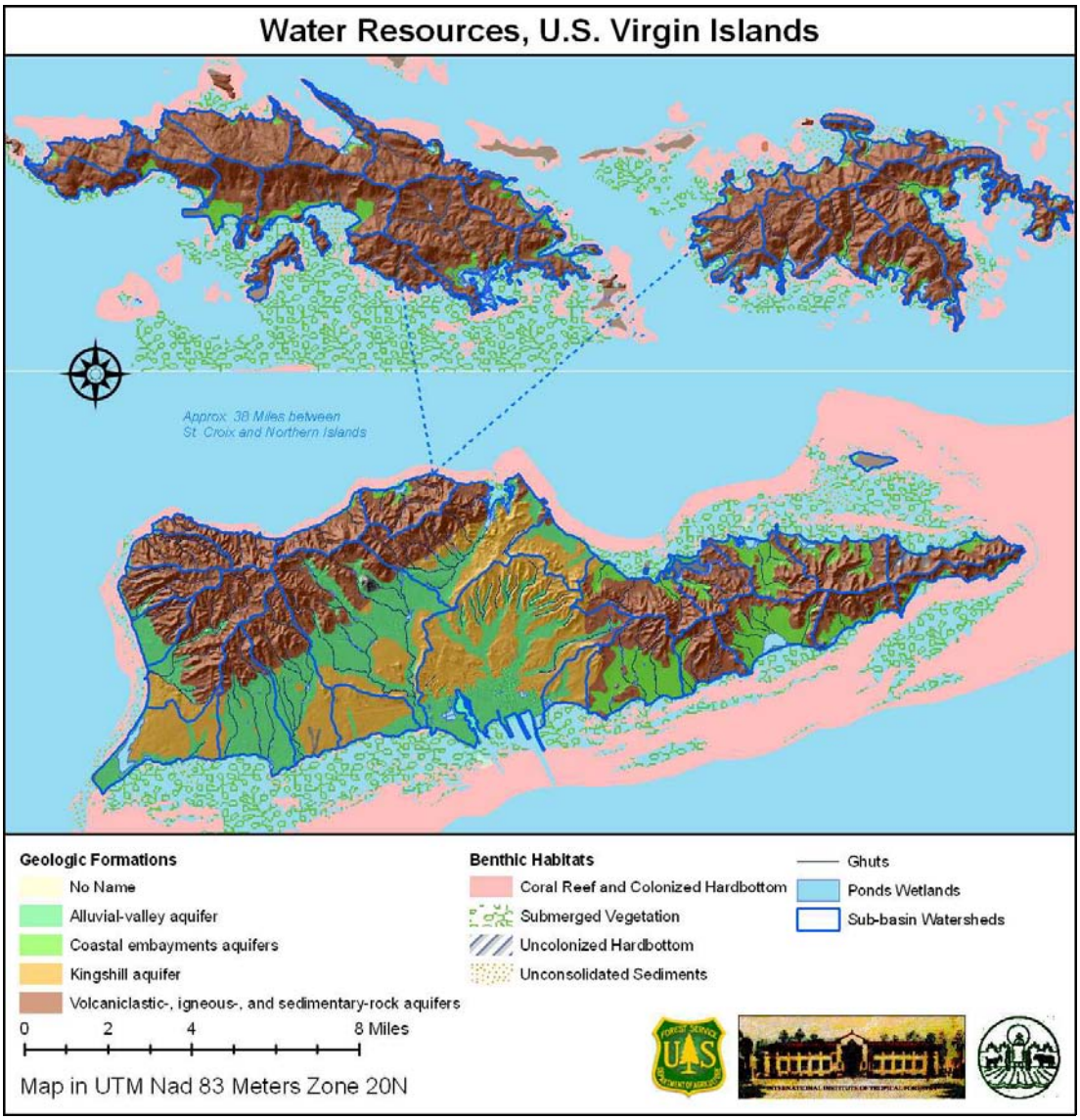


Figure 20: Virgin Islands Water Resources

Wildlife and Natural Heritage

The Division of Fish and Wildlife under the Virgin Islands Department of Planning and Natural Resources (DPNR) has identified forests as an important resource for wildlife and recreation. Despite the fact that a variety of wildlife species rely on forest habitat, little research has been conducted on the specific usage of forest by wildlife. It is known that a number of species of birds and reptiles use the forest for food and shelter, including several endemic lizards. Bats roost in a variety of niches including trees, caves, and man-made structures, and provide important services to certain plants by pollinating flowers and distributing seeds from fruits **(**Figure 21**)** (Platenberg et al., 2005). Six bat species, the USVI's only native mammals, including the red fig-eating bat (*Stenoderma rufum*), greater bulldog bat (*Noctilio leporinus*), Antillean fruit-eating bat (*Brachyphylla cavernarum*), Brazilian free-tailed bat (*Tadarida brasiliensis*), Jamaican fruit-eating bat (*Artibeus jamaicensis*), and the velvety free-tailed bat (*Molossus molossus*) rely on forest habitats.

Figure 21: Jamaican Fruit Bat in St. Croix Eating Mangoes (Photo by Russell Slatton)

The bridled quail dove (*Geotrygon mystacea*), a locally endangered species, lives almost exclusively in the forests of northwestern St. Croix (Valiulis and VI-FWS, 2009, Platenberg et al., 2005). This species' population was dramatically decreased by Hurricane Hugo in 1989 as a result of forest loss. The white crowned pigeon (*Columba leucocephala*) probably feeds in areas of urban and community forests; it is also locally endangered and in serious decline throughout the Caribbean (Platenberg et al., 2005, 2009). The natural habitat for most reptiles is tropical forest. The federally endangered VI tree boa, (*Epicrates granti),* for example, relies entirely on

the forests of the east end of St. Thomas (Valiulis and VI-FWS, 2009). The St. Croix ground lizard (*Ameiva polops*), also listed as federally endangered, is now limited to the coastal forests of the offshore cays of St. Croix. The St. Croix anole (*Anolis acutus)* lives on the trunks and branches of trees and the tiny dwarf gecko (*Sphaerodactylus sp.)* lives in the leaf litter of the forest floor. Local frogs are found in high numbers in the forests, and the smaller tree frogs breed in the tiny puddles of water that accumulate in the tree canopy and in the bromeliads that grow on forest trees.

DFW has recognized the need to focus more of its limited resources on forests, both in terms of monitoring and conservation (Platenberg et al., 2005). The first proposed step was to inventory the remaining forest of the VI, particularly the large patches. This objective has been completed in this document. Other DFW program goals with regards to forests include conducting more complete surveys for wildlife in forests and mapping distribution of forest wildlife, including bird nesting on the more than 60 cays surrounding the islands which act as nesting and breeding grounds for many migratory species of birds (Damman and Nellis, 1992). This information will allow for better prioritization for conservation. There has been very little coordination between DFW and the Division of Forestry in the VI, largely due to lack of awareness of each division's respective programs and limited staffing and other resources.

Timber Products

The Virgin Islands was once known for its hard tropical woods, such as lignum vitae (*Guaiacum officinale*). Lignum vitae **(Figure 22)** was used to make posts for houses by the Taino people, and as a testament to its durability, an 18-inch remnant of an 800-year old post of lignum vitae was found on the site of the Tutu Park Mall in St. Thomas (Nicholls, 2006). Lignum vitae was one of the most important tropical woods in the 18th and 19th centuries, used in everything from clock-making to ship-parts, because the wood is extremely hard and it secretes its own lubricating oil.

Figure 22: Lignum Vitae in Bloom (Russell Slatton)

The first useful chronometers (devices for measuring longitude for ships at sea) incorporated lignum vitae for the interior moving parts. Englishman John Harrison's first three chronometers, H1, H2, and H3, all built between 1722 and 1752, are still running today as they need no additional oil other than the oil exuded by the lignum vitae clockworks (Sobel, 1995).

The last published material reported by TNC (2003) conducted by Pierce and Hultgren in 1997 found timber production to be at 188,500 board feet per year. This harvested timber is used almost exclusively on-island, mainly for custom house building. Secondary forest products, also known as non-timber forest products (NTFPs) such as wooden arts and crafts, and medicinal and cultural uses, add to the value of the

forest. Furniture and artwork carved from local wood is sold to residents and tourists alike; however, like timber products, there is no export market for medicines derived from trees.

Local use of medicines derived from trees can be seen on island (Honeychurch, 1986, Woodbury and Weaver, 1987, Thomas, 1997). However, exporters from commercial herb companies, drug companies, and off-island academic researchers have expressed interest in exporting currently known medicinal plants as well as medicinal and cytotoxic natural products that have yet to be identified in VI forests (Thomas, 2009). Seed collection and export of seeds of tropical hardwoods, specifically mahogany, has recently been conducted on St. Croix (Chakroff, 2010).

Scenic Beauty

Figure 23: Coral Bay View, St. John, U.S. Virgin Islands (Photo by Russell Slatton)

What the Virgin Islands lacks in timber production it more than makes up for in scenic beauty. When one thinks of the Caribbean today, beautiful beaches are what most often come to mind and the Virgin Islands has no shortage of those. However, these tiny islands also house an amazing scenic beauty beyond the beaches in the form of large open vistas of land and sea and large tracts of forests that house many species of trees not often encountered by visitors from the U.S. mainland.

Large tree species can be found in the Virgin Islands, including the silk cotton tree locally known as kapok (*Ceiba pentandra*) that can reach heights of 80 feet and a diameter of 9 feet above its buttresses. A drive on the west end of St. Croix, scattered parts of St. Thomas, and most of St. John affords one the opportunity to drive under magnificent big trees, some of which are hundreds of years old, complete with lianas reaching to grasp your vehicle and shade so prolific one considers putting on the headlamps.

Both native species such as the sandbox tree (*Hura crepitans*) and introduced species such as saman (*Samanea saman)* grow to astounding sizes in the USVI. Photos dating back to colonial times portray people gathered in buttresses of giant fig trees, straining to hug saman (*Samanea saman*) and huge mahogany trees (*Swietenia spp*.), and thinking twice about climbing the prickly bark of the tall sandbox tree. The scenes in these photos are repeated every day on the islands, where the landscape is still dotted with these giants of the sub-tropics.

The USVI relies on its scenic beauty for the tourist industry, and the forests of the island rival the beaches in this beauty. The recent rise in ecotourism activities has brought new life to the possibilities of the Virgin Islands' forests. It is hoped that this surge of eco-minded tourists will

warrant the protection of the trees that remain on the islands and encourage the planting of new trees to continue the legacy of scenic beauty for future generations.

Figure 24: Saman Tree at a Proposed Development Site (Photo by Russell Slatton)

Quality of Life

Our trees and forests improve the quality of life for humans by providing oxygen, shade, food, lumber and a number of other resources. In recent years, scientists have discovered further benefits of trees such as their effect on our climate and carbon sequestration. Still other scientists have begun to try to quantify the psychological benefits of trees, learning that the presence of trees makes humans happier and better-adjusted. Studies in urban areas particularly show that the presence of trees and green space leads to reduction in crimes against both property and people (Kuo and Sullivan, 2001).

In the Virgin Islands, trees provide these same benefits. They provide much needed shade and their presence often encourages drifting clouds to produce rain for these tiny islands. There is no doubt that the trees and forests of the VI improve the quality of life for residents and visitors alike.

Carbon Sequestration

With a possible agreement for a cap and trade system for global warming, carbon sequestration may emerge as a way for the Virgin Islands to receive additional funding for forestry programs (Krugman, 2009). There are industries on the islands, such as WAPA and HOVENSA, that may

be required to cap their emissions. Trade for reforestation and mitigation could be a viable economic use of forested lands. Eighty-two percent of carbon sequestered in the Virgin Islands is found in live trees while fine woody debris and the forest floor account for 16% of carbon sequestered (Brandeis and Oswalt, 2007).

Summary

Forest resources provide a great many benefits to the Virgin Islands. These benefits are irreplaceable. It is imperative to understand the ecology and character of these small Caribbean islands in order to identify how changes in forest cover affect these benefits. Understanding existing forest conditions from a past and present perspective allows us to predict the effects of particular kinds of changes in forested lands. The threats to forest resources must be understood in order to manage the forests in a more effective manner.

Threats to Forest Resources

Urbanization

In 2008-2009, the VI Department of Planning and Natural Resources, with the assistance of The Nature Conservancy, updated the conservation portion of a previously developed comprehensive land and water use plan for the Virgin Islands (Margles and TNC, 2009). However, the plan has not been published as yet. The VI Code has multiple regulations regarding forested lands around waterways (guts) that are contradictory. Procedures and policies regarding the pruning of native trees are regulated under the Indigenous and Endangered Species Act of 1990 and enforced by the Division of Fish and Wildlife, DPNR. However, what constitutes a native tree species is not always clear in existing legislation. All of this leads to general confusion as to what laws are being applied, and which agency has the legal authority over trees in the territory (Platenberg et al., 2005).

Industry is another development poorly checked. Quarries expand at unknown rates taking forest lands around them. Wetland and coastal forest ecosystems may be affected by the stockpiling of tailings from the past processing of bauxite (USVI, 1999), air pollution from the processing of petroleum at HOVENSA, and from the oil-fueled WAPA power plants. Bauxite and petroleum are not mined in the Virgin Islands, but the processing of each no doubt has had effects on natural resources of the islands, including forest resources. Currently there is no published literature on the effects to Virgin Islands forest lands from mineral development, and little on direct effects of the processing of minerals and petroleum as listed above.

Information on land use change has been poorly documented for the Virgin Islands. For this document, a spatial weighted analysis was conducted using the best available data layers and information to show threats and areas of influence. In this analysis, an edge of development layer of 0-20% (weighted at10% in analysis) and future zoning (weighted at 5%) represent the outer layers of core developed areas that could develop more fully in the future. Core developed areas and their full area of influence represent approximately 30% in this weighted analysis. Land use change from undeveloped areas,1989-1999 (weighted at 20%) and population change from 1990-2000 (weighted at 10%) represent changing land use trends. Urban populations by block (weighted at 15%) and developed areas greater than 1 acre (weighted at 20%) are also represented in this land use change analysis.

High and medium zones **(**Figure 25**)** on all of the islands tend to be concentrated around the main population centers and extend outward. In one study, the loss of the forest lands to development on St. Croix occurred as lands transitioned from large scale cattle pasture areas to new forest (Daley, 2009).

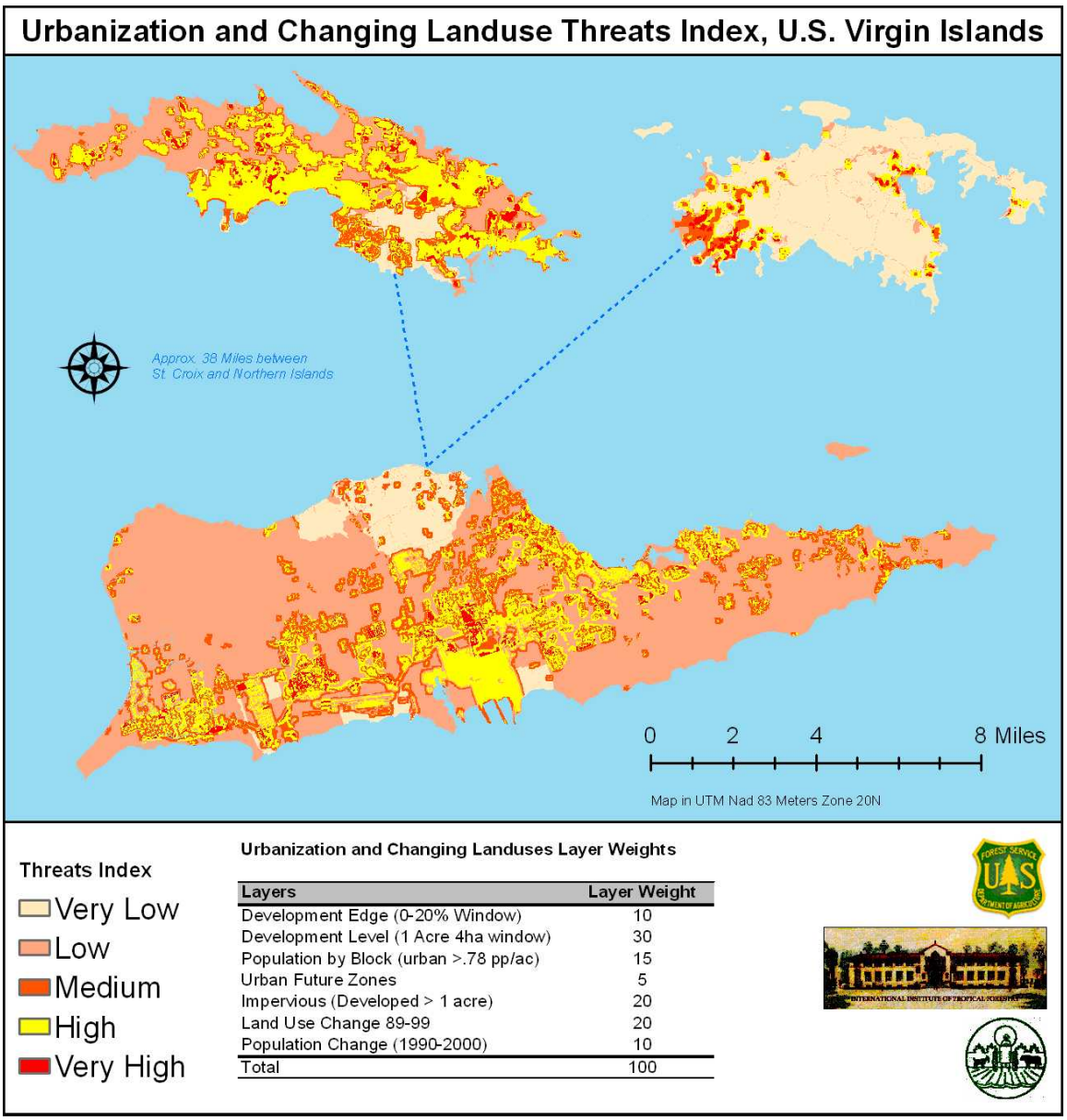


Figure 25: Urbanization and Changing Land Use Threats Index

Forest Fragmentation

Forest fragmentation seriously degrades the quality of forests by creating more edge habitat. The constantly changing nature of edge habitat, the different climatic conditions such as increased light penetration and the proximity to roads and other corridors of development make edge habitat less than ideal for many forest species. Edge habitat is also where many invasive plants and animals become established. Roads and population growth contribute greatly to fragmentation of forests and forest types (Daley, 2009, Meddens et al., 2008, Riiters et al., 2004).

St. Croix's classified areas of change from 1994-2004 were found to have an average patch size of 1.7 acres while other more stable areas had a range of average values from 19-33 acres (Daley, 2010a). Land use change has been inadequately measured over the years, leading to poor

planning decisions. Forest change over time has been detected by the FIA (Brandeis and Oswalt, 2007) and Daley (2010). Drivers of this change on St. Croix have been attributed to distance to roads and the change from agricultural land use.

Analysis for fragmentation of the IITF land cover forest classes calculated average patch sizes for individual land use classes and varies by island. This matrix does not show variable differences between the classes because of large standard deviations. However it does indicate each island still has a large contiguous patch of varying forest types represented by the area difference. St. Croix has 26,313 acres of contiguous forest (41 sq. miles), St. Thomas has 11,371 acres (17.8 sq. miles) and St. John, not surprisingly, with 10,916 acres (17 sq. miles). These tracts of forest account for half of each island or more (Table 10).

Table 10: Virgin Islands Land Cover Class Patch Metrics

St. Croix (ha)					
TYPE	**#Patches**	**Mean Area**	**Median area**	**Area Diff**	**Stdev. Area**
Forest	3849	7.95	0.11	26313.26	424.17
Developed	5021	1.62	0.22	2285.36	34.66
Non Forest	7421	2.03	0.00	0.00	47.62

St. Thomas (ha)					
TYPE	**#Patches**	**Mean Area**	**Median area**	**Area Diff**	**Stdev. Area**
Forest	822	16.87	0.11	11371.26	396.98
Developed	2097	2.25	0.17	1330.19	35.31
Non Forest	2625	0.59	0.11	54.07	2.43

St. John (ha)					
TYPE	**#Patches**	**Mean Area**	**Median area**	**Area Diff**	**Stdev. Area**
Forest	196	57.38	0.11	10916.60	777.69
Developed	925	0.81	0.17	184.29	6.37
Non Forest	908	0.75	0.11	29.23	2.40

A threats analysis was conducted utilizing three weighted layers for St. Thomas and St. John, and four layers for St. Croix. For St. Thomas and St. John, development level (weighted at 30%), future urban zoning (weighted at 40%) and impervious surface layers (weighted at 30%) represent those areas of development including roads that fragment existing forest areas. The St. Croix analysis utilized forest change areas from 1992-2002 to represent possible development in transitional forest types (Daley, 2010a). Areas with possible effects from threats are identified (Figure 26). Areas are centered on existing developed infrastructure.

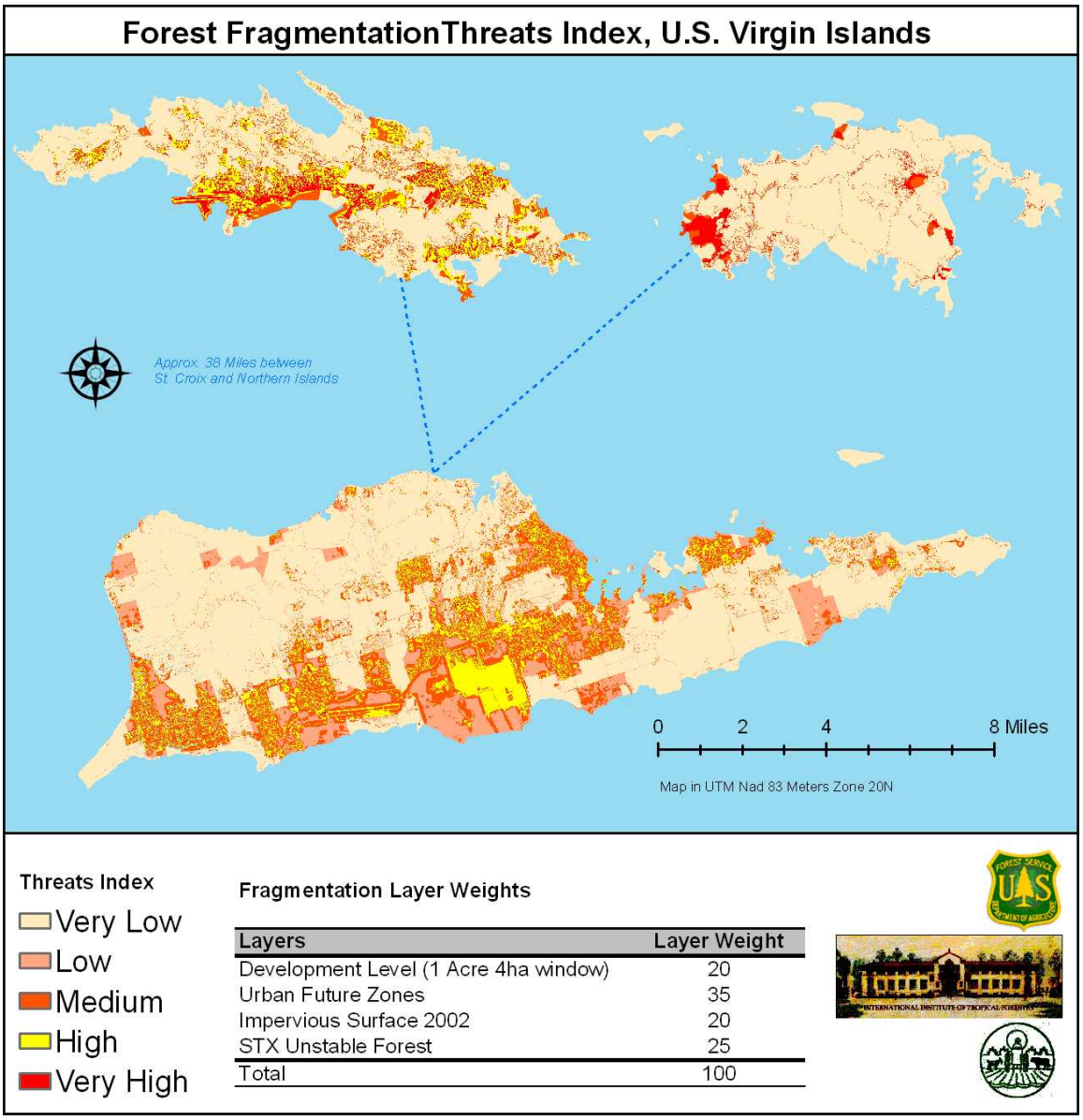


Figure 26: Virgin Islands Forest Fragmentation Threat

Some of the very high zones are part of the industrial areas of the islands. These areas include the tailing stockpiles from the past processing of bauxite (St. Croix Alumina, LLC)(USVI, 1999), and areas downwind from HOVENSA and from the oil-fueled WAPA power plants. These facilities also discharge water used in processing that affect wetlands and coastal forest areas.

Biological Threats

Invasive species mapping and monitoring has been done effectively on a global and regional scale. Maps are frequently created using models with environmental inputs, such as temperature or altitude, rather than physically mapping the presence of the organism on concern. The potential spread of fire ants, for example, has been mapped on a regional scale based on rainfall

and temperatures (Morrison et al., 2004). This type of 'habitat suitability' mapping likely has limited potential in the US Virgin Islands because of the islands' relative uniformity in habitat type (Ewel and Whitmore, 1973b) and small size.

The most comprehensive, forest inventory of the US Virgin Islands indicated that the single most common tree in the territory is the exotic tan-tan (*Leucaena leucocephala*) which is found at all elevations and in almost all forest types (Brandeis and Oswalt, 2007). The FIA provides detailed information on the species composition of sample sites, but was not designed to generate detailed forest maps or species distribution maps. Other inventories of individual properties in St. John (Ray and Brown, 1995) and St. Croix (Adam and Ryan, 2003, Daley, 2010b) and several other informal inventories provide detailed species composition and density data appropriate for finer spatial scales.

Non-native plant species compete with native species for sunlight, nutrients and water, and can be very aggressive. Little data have been collected on pathogens in the USVI. Most programs focus on rodent eradication. Brandeis and Oswalt (2007) reported that only 3.8% of live trees in their small sample size had some form of damage or disease. The most common form of disease was fungal root infection. The other symptoms of pathogens were terminal leader mortality, cankers and galls and resinosis. As the USVI has no timber industry per se, there appears to be little threat to the forests from diseases.

The threat of invasion for these non-natives that come from many other places mainly stems from a poor system for tracking plant species that come in and out of the territory and no official comprehensive lists of organisms that are allowed and not allowed.

Wildfire

In the USVI, wildfires usually occur on changing pasture areas that have some woody growth, such as stink casha *(Acacia macracantha*) and tan-tan (*Leucaena leucocephala*). According to Fire Service officials, most of these wildfires appear to be caused by humans, either by accident or intentionally, because most of these fires originate close to roads. Fire hotspots were identified by the Fire Chief for St. Croix and the number of fires was reported by location **(**Figure 27). According to Fire Service data, there are very few wildland fires on either St. Thomas or St. John; in 2008 there were a total of four fires on these two islands combined (Torres and Chief, 2009). The discrepancy between the areas identified as hotspots and the number of fires by estate is largely the result of inadequate geographically referenced data.

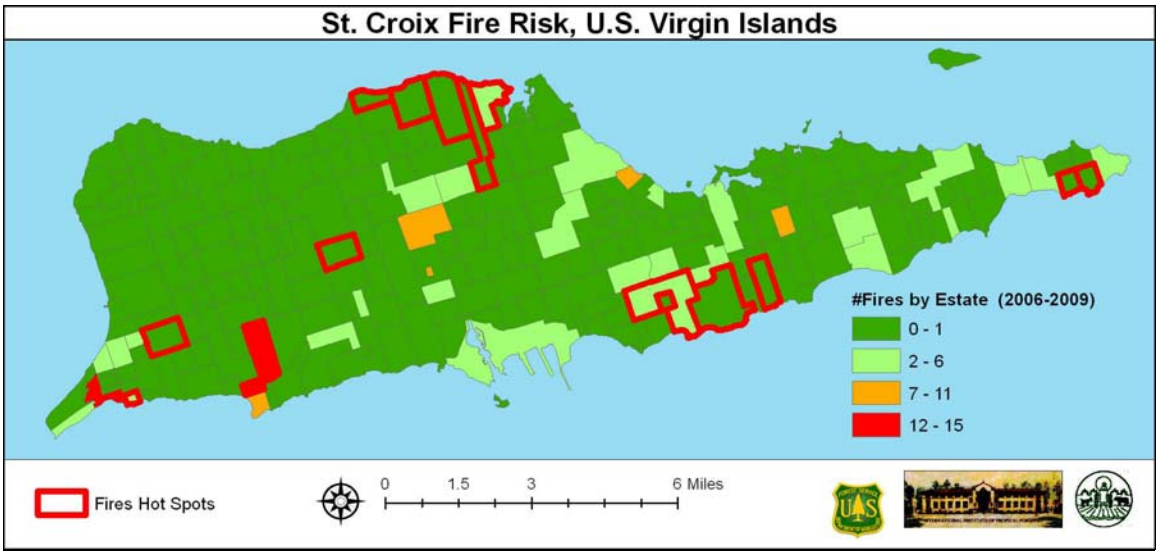


Figure 27: St. Croix Fire Risk

The FIA has included a fuel-hour class indexed by downed woody debris (DWD) diameter class. The mean fuel hour class was 10.81 hours with a standard error of 1.16 hours. This represents a medium fine woody debris understory structure excluding live material (Brandeis and Oswalt, 2007).

Climate Change

The effects of climate change have the potential to be devastating in the USVI and throughout the world. A recent study of forests in the USVI and Puerto Rico found that climate is the overarching influence on forest species composition when recovering from deforestation; all other factors are secondary to the influence of climate (Brandeis et al 2009). Although perhaps not surprising, it indicates that changes in climate can change the forests more than other highly managed factors such as land use. The predicted intensity of change and the time frame over which change will occur in the USVI depends on the model, however most models agree that climate change will result in a number of changes that will affect the forests of the USVI, especially along the coastlines. A summary of these effects was presented in the report "Climate Change in the Caribbean and the Challenge of Adaptation" by the United Nations Environmental Program (UNEP 2008):

- Deteriorating coastal conditions, e.g. through beach erosion and coral bleaching, are expected to adversely affect local resources, fisheries for example, and reduce their value as tourist destinations.

- Floods, storm surge, erosion and other coastal hazards, exacerbated by sea-level rise and that threaten vital infrastructure, settlements and facilities that support the livelihood of island communities.

- Reduction in freshwater resources by mid-century, to the point where

they cannot meet demand during low rainfall periods.

- Increased invasion by non-native species as a result of higher temperatures is also expected, particularly on middle and high-latitude islands.
- Economic losses from reduced agricultural yields. For example, shortening of the growing season, drought.
- Loss of mangrove forests and coral reefs due to sea level rise.
- Bleaching and acidification of the ocean.
- Damage to terrestrial forest caused by extreme events.
- Reduction in the size of freshwater lenses and of general water resource availability due to decreased rainfall and saltwater intrusion.
- Inundation of coastal settlements and arable land on the coast.
- Reduction in tourism due to increased frequency and severity of extreme weather.

The USVI is in the direct path of strong hurricanes and tropical winds from Africa. The expected increase in extreme weather such as hurricanes will result in more storms like Hurricane Hugo that devastated the Virgin Islands in 1989, removing most of the foliage and causing tree mortality (Lugo, 2001). Hurricanes and tropical storms uproot even large tropical trees, causing them to fall onto power lines, houses, vehicles, and roads. A strong forest structure can mitigate the effects of lone urban trees standing before the winds. In 2008 Hurricane Omar produced an estimated 200 tons of vegetation debris on St. Croix that had to be removed from streets and yards and then disposed of in a timely and economically efficient manner (Osinski, 2009). Winds from tropical storms can reach more than 170 miles per hour and can devastate the landscape (Reilly, 1991).

The expected sea level rise (Figure 28) is another issue that will significantly affect the forests of the USVI. A rise in sea level of just one foot could have a detrimental effect on coastal forest areas. Coastal forests consist primarily of endangered mangroves that act as nurseries for fish, habitat for other wildlife and sediment filters for runoff. Research suggests that under current conditions sea level could rise from 48 cm (1.3') (Pfeffer and O'Neel, 2008) to as much as 880 cm (27.7') (Carlson et al., 2008) over the next hundred years. The more conservative numbers from IPCC estimate 40-102 cm over the next 100 years. Sea level rise could affect FEMA flood zones, pushing development back into the central parts of the islands, further impacting forest composition.

Climate change is likely to enhance many of the existing threats to forest ecosystems. Climatic warming and drying and the increase in invasive species will make forests more vulnerable to

wildfires. Evidence of this is already being seen in Puerto Rico where wildfires are increasing in frequency and occurring in areas where such fires have never been recorded before (Robbins et al., 2009).

In addition, the Sahara dust carried into the region by prevailing winds from Africa has been increasing either because of cyclical changes or climate change. The effects of exposure to Sahara dust on the USVI vegetation needs to be studied further (Pett-Ridge, 2009).

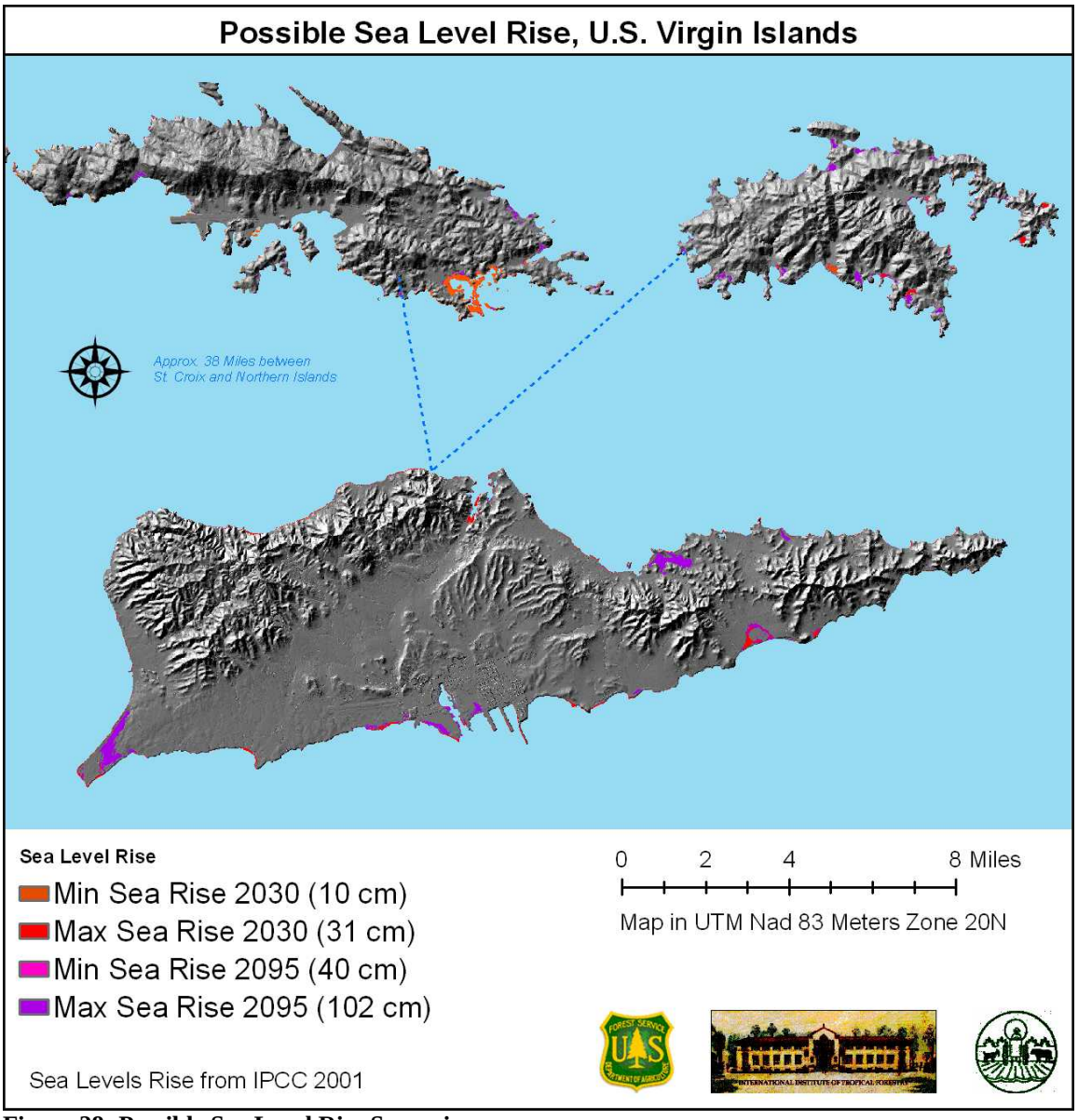


Figure 28: Possible Sea Level Rise Scenarios

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Priority Issues

Issue 1: Contiguous Forest Loss

In the U.S. Virgin Islands, contiguous forest areas are necessary for many reasons, including watershed protection, increased infiltration rates, and surface temperature reduction (Thomas and Devine, 2005). These areas also provide beneficial habitat for local species, such as several species of bats, the only native mammals (Platenberg et al., 2005). Contiguous or mostly contiguous forest cover provides the connection for these beneficial ecological functions to take place. However, these important forested areas are under increasing pressure due to population increase, creating a demand for housing, and the need for economic development, including the construction of resorts and golf courses and the unmanaged clearing of forested land for agricultural use or development.

Lack of enforcement for existing zoning codes and weak environmental regulations have led to zoning variances being issued, even though they are not based on the clear language of the law. This could be due to some of the existing laws being unclear or conflicting in nature, such as rules pertaining to the clearing of trees in riparian areas. At present, there are three laws in the VI code pertaining to the width of land to be preserved when clearing near a riparian area; these laws have conflicting standards (USVI, 1965, USVI, 1960). The agency charged with enforcing environmental laws in the islands has little to no authority and its policies are often ignored by landowners. The staff simply does not have the capacity to enforce these regulations, and has not been given proper authority or clear mandates to do so.

One strategy for protecting and conserving forests in the USVI is acquisition under private land trusts or government ownership. Examples exist today on all of the islands of this strategy, and it has worked as a way to preserve forested land. St. Thomas, St. John and St. Croix have public lands and private landholders such as The Nature Conservancy and the St. Croix Environmental Association. One third of the respondents to our questionnaire stated that conservation of forest resources was important. One third also stated that purchasing land for conservation was a top opportunity for forest protection.

There are several key players and institutions involved in the conservation and protection of forested land in the USVI. The Virgin Islands Department of Planning and Natural Resources (DPNR), the Virgin Islands Lt. Governor's Tax Assessors Office, The Nature Conservancy (TNC), and the Governor's Office are crucial to revising existing zoning laws as well as implementing a comprehensive land and water use plan. The Virgin Islands Department of Agriculture (VIDOA), through its Division of Forestry, promotes and delivers forestry programs in the territory, through funding from the USDA – Forest Service – International Institute of Tropical Forestry. Other key stakeholders include the Trust for Virgin Islands Lands (TVIL) and the Trust for Public Land (TPL), as well as other land trusts that can purchase land. Recently, an analysis of existing zoning codes was conducted and findings included unclear and conflicting zoning laws (Meck, 2009). One of the recommendations was to rewrite the zoning laws completely in an organized fashion that allows the laws to be more easily followed. Included in the zoning maps are conservation designation areas that could alleviate development pressure in

the identified areas. This new zoning code could also be easily enforced, alleviating the current issue of lack of enforcement.

Identified priority areas **(**Figure 29**)** for St. Croix lie on the eastern end and the northwest section, representing the subtropical moist forests and following the higher elevation ridge east across the island to the dry forest regions. Many of these forests lie on steep slopes. The northwest section also has cultural and historical significance as an area where enslaved people were able to escape servitude and hide. Niels Nielson (2008) utilized historical maps to show that the landscape hid the escaped slaves and their fires. This area also contains many small caves that were used by escaped slaves. The areas on the map represent very low areas of interest to very high areas of interest, according to the weighted overlay.

On St. Thomas the highest priority forests are located on the less populated west end and the north shore and also scattered throughout the island.

On St. John, the current Virgin Islands National Park area is already well protected and encompasses most of the medium priority areas. The high priority areas on St. John represent the large forest edges near developed areas, specifically the east end and south shore.

Issue 1 - Contiguous Forest Loss Priority Areas, U.S. Virgin Islands

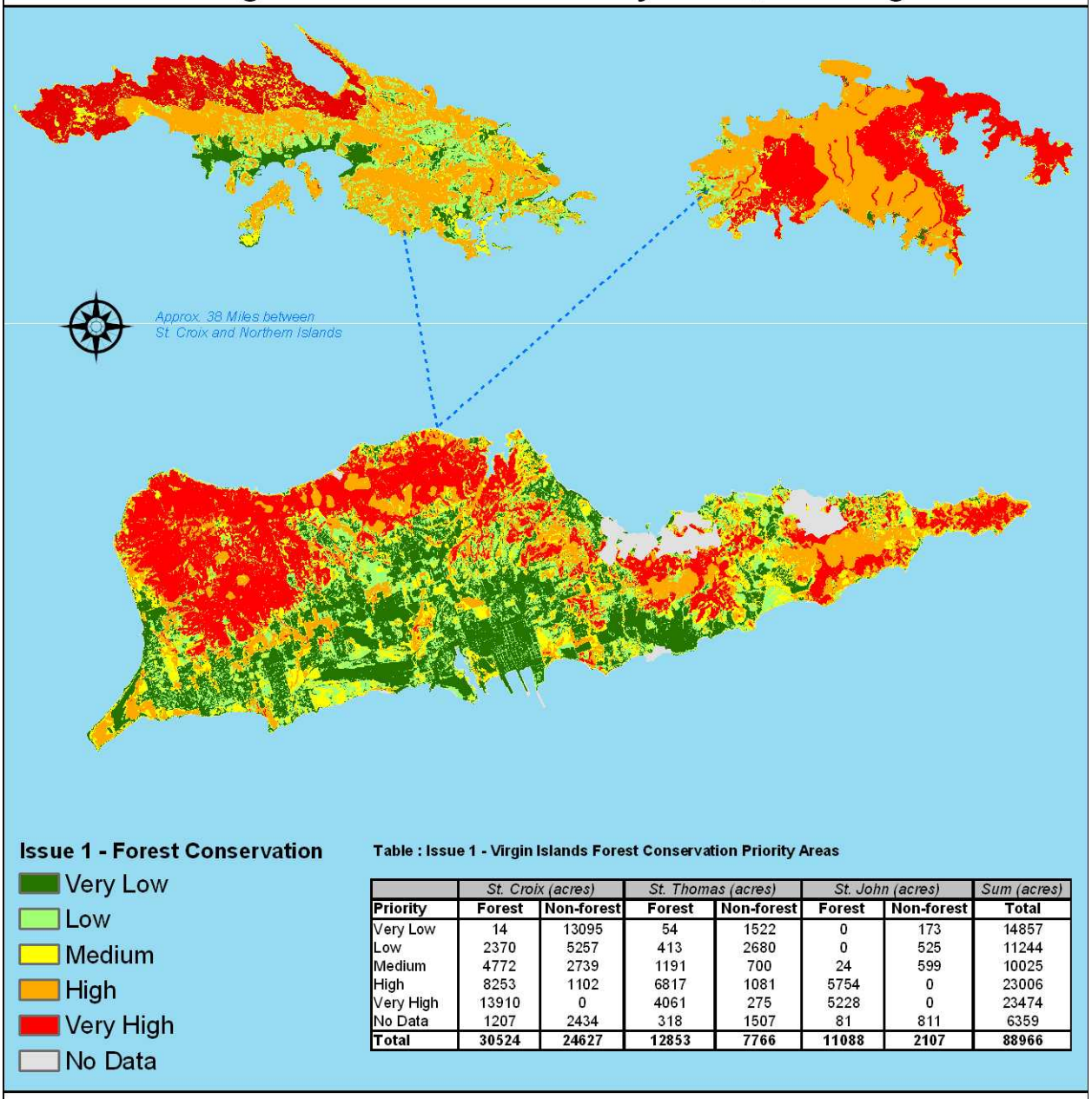


Table : Issue 1 - Virgin Islands Forest Conservation Priority Areas

	St. Croix (acres)		St. Thomas (acres)		St. John (acres)		Sum (acres)
Priority	**Forest**	**Non-forest**	**Forest**	**Non-forest**	**Forest**	**Non-forest**	**Total**
Very Low	14	13095	54	1522	0	173	14857
Low	2370	5257	413	2680	0	525	11244
Medium	4772	2739	1191	700	24	599	10025
High	8253	1102	6817	1081	5754	0	23006
Very High	13910	0	4061	275	5228	0	23474
No Data	1207	2434	318	1507	81	811	6359
Total	**30524**	**24627**	**12853**	**7766**	**11088**	**2107**	**88966**

0 1.5 3 6 Miles

Map in UTM Nad 83 Meters Zone 20N

Layers	Layer Weight
Forest	40
Slope (>20%)	20
Forest Patch (>100 acre)	15
Watershed Risk Level	10
Population Change (1990-2000)	5
Riparian Areas	5
Wetlands/Ponds	5
Total	100

Figure 29: Issue 1 Contiguous Forest Loss

Issue 2: Loss of Transitional Forests to Development

Forests in transition are changing from and to forest lands. Usually transitional forests are found in agricultural land, such as pasture, or areas that were once cleared for development that have been left undeveloped (Daley, 2009). The secondary forests that establish themselves in these areas provide habitat for wildlife and an opportunity for native forest flora to reestablish itself. Much of St. John's intact secondary forests are intact because of the ability of forests around these cleared areas to reseed and recover (Gibney, 2004).

One of the direct threats to transitional forests is the conversion of these lands to development. Once buildings or some form of impermeable surface is put in place, the ability to reestablish forest in the area is lost. The decline of agriculture, especially of cattle and dairy farming, has left these areas susceptible to conversion for other land uses. With little incentive to leave land dormant or allow it to convert to transitional forest types, land is being developed for housing or resorts. As an example 300 acres on the east end of St. Thomas has been converted to developed land (Slatton, 2009). At present, more than 1000 acres of transitional forests in the U.S. Virgin Islands could be lost due to proposed large development schemes. Zoning variances are readily given to allow these lands to be subdivided (Meck, 2009), especially if they are no longer used for agriculture.

There is a great need for more data collection and analysis of forest conversions. Although there are some data available regarding changes of parcel types, there is currently little or no tracking available. The Cadastral and Tax Assessors' Office under the Lt. Governor processes land ownership changes and parcels, while the Department of Planning and Natural Resources (DPNR) provides zoning regulation, permitting, and enforcement. Utilizing strategies identified by both agencies as well as other parties such as the VI Department of Agriculture, The Nature Conservancy, the St. Croix Environmental Association and other local groups, strategies can be further identified to enable land owners to transition to forested lands.

Transitional forest priority areas were identified using a weighted analysis of best available layers. The layers identified included forest fragments layers representing 5-40 acres (weighted at 40%) showing most likely forest transitional types, and unstable forests (weighted at 20%) representing forests changing back and forth between pasture, cleared, and developed land. Layers interacting with these transitional forest types included riparian areas (weighted at 5%), and wetland areas (weighted at 5%). Threat layers included development edges (weighted at 20%), population change by U.S. census tracts (weighted at 5%) and future growth areas by possible future zoning (weighted at 5%). The St. Croix analysis also used forest change areas identified in Daley (2010).

As reported by Brandeis and Oswalt (2007), most of these transitional forests are located on St. Croix at lower elevations. There has been some activity in the northwestern portion of St. Croix which was found in the analysis. The very few high priority areas on St. Thomas are located on the south near highly developed areas. In a recent update to the St. Thomas REA, 300 acres were converted to some form of development within the last 10 years. St. John's priority areas are located near the town centers **(**Figure 30**)**.

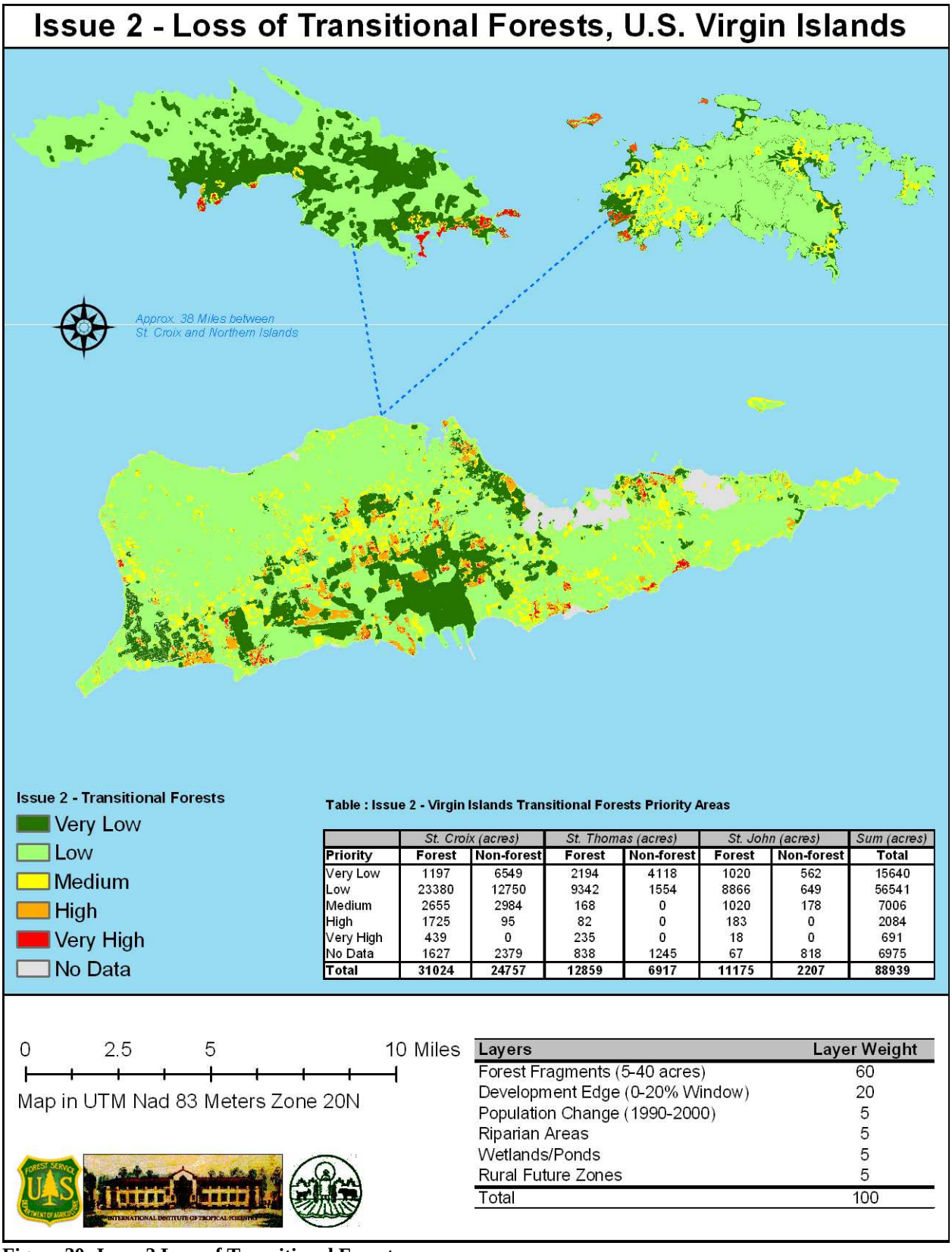


Table : Issue 2 - Virgin Islands Transitional Forests Priority Areas

	St. Croix (acres)		*St. Thomas (acres)*		*St. John (acres)*		*Sum (acres)*
Priority	**Forest**	**Non-forest**	**Forest**	**Non-forest**	**Forest**	**Non-forest**	**Total**
Very Low	1197	6549	2194	4118	1020	562	15640
Low	23380	12750	9342	1554	8866	649	56541
Medium	2655	2984	168	0	1020	178	7006
High	1725	95	82	0	183	0	2084
Very High	439	0	235	0	18	0	691
No Data	1627	2379	838	1245	67	818	6975
Total	**31024**	**24757**	**12859**	**6917**	**11175**	**2207**	**88939**

Layers	Layer Weight
Forest Fragments (5-40 acres)	60
Development Edge (0-20% Window)	20
Population Change (1990-2000)	5
Riparian Areas	5
Wetlands/Ponds	5
Rural Future Zones	5
Total	100

Figure 30: Issue 2 Loss of Transitional Forests

Issue 3: Urban Forest Sustainability

Figure 31: UVI Urban Forest Inventory (Photo by Russell Slatton)

Urban and community forests are estimated to account for 48% of St. Croix's forests, 60% of St. Thomas forests and 7% of St. John's forests (according to different allowable building densities). Lack of data for urban and community forests have hindered the ability of land managers to measure the value of these abundant resources that provide many natural and cultural benefits to the people of the Virgin Islands. Values attributed to urban forests, especially on a tropical island, include but are not limited to real estate values, recreation, health benefits, cleaner air, psychological well-being, and cultural and economic attributes. The management of urban and community forests affects the daily lives of Virgin Islanders by providing the aforementioned benefits but also as identified by the Urban and Community Forestry Goals and National Themes (**Table 11**).

Table 11: U&CF Goals and National Themes

Urban and Community Forestry (U&CF)	National Themes
1. Reduce the impacts of urbanization on forested landscapes	Conserve Working Forests
2. Moderate the impacts of catastrophic events	Protect Forest From Harm
3. Protect and improve air and water quality	Enhance Public Benefits
4. Mitigate climate change	Enhance Public Benefits
5. Conserve energy	Enhance Public Benefits

The USVI has well defined zoning and land use maps, but for the most part actual development has not followed those plans due to the high rate of non-enforcement, non-compliance and easily given variances. Thus encroachment along the urban interface leads to fragmentation and parcelization of forest lands. Fragmentation of forests on urban edges is especially prevalent near roads.

The average parcel size for the USVI is 9.88 acres (4 ha); the average residential lot is 1 acre. This type of development is not unlike rural habitation in the mainland United States or the suburban areas outside of the city centers. Continual development of large lots leads to encroachment on the existing contiguous forests leading to a less concentrated effort towards urban forestry in the urban zones. In the Virgin Islands, where there is limited available land, good development involving positive urban forestry can achieve the goals and national themes mentioned.

Priority areas **(**Figure 32**)** were identified by a weighted layer analysis. The weights were assigned as follows: using development level (1 acre developed areas) (weighted at 40%), existing forest areas (weighted at 20%), forest patches greater than 100 acres to capture any large tracts of forest in or on edges of urban areas (weighted at 20%), protected areas (weighted at 10%) and future urban zones representing potential urban zoning (weighted at 10%). These

layers represent existing development layers with zoning potential and existing forest resources to help identify priority areas for urban forest management.

All of the islands had large areas of medium potential due to many networks of housing and development. Without an approved land use and water plan, zoning laws with conflicting rules, and government entities lacking the funding or professional staff to act appropriately, there is little actual management of urban forests. This is particularly evident in looking at the management of roadside trees, that is, public trees located on rights of way. The high and very high potential areas for immediate management were concentrated around the many road networks found on each island. DPNR and Public Works are directly in charge of zoning and development in the Virgin Islands and revision of existing codes.

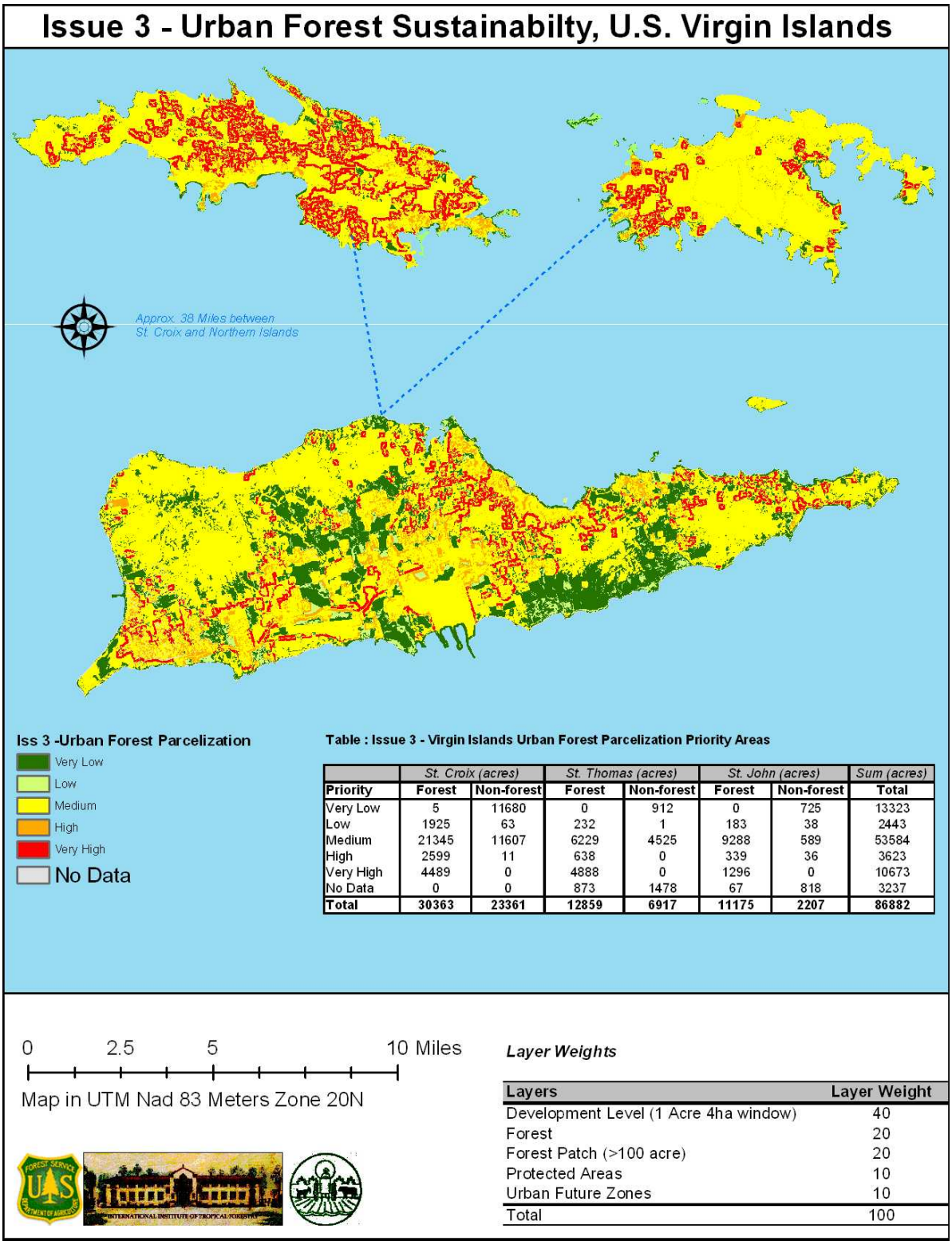


Table : Issue 3 - Virgin Islands Urban Forest Parcelization Priority Areas

	St. Croix (acres)		*St. Thomas (acres)*		*St. John (acres)*		*Sum (acres)*
Priority	**Forest**	**Non-forest**	**Forest**	**Non-forest**	**Forest**	**Non-forest**	**Total**
Very Low	5	11680	0	912	0	725	13323
Low	1925	63	232	1	183	38	2443
Medium	21345	11607	6229	4525	9288	589	53584
High	2599	11	638	0	339	36	3623
Very High	4489	0	4888	0	1296	0	10673
No Data	0	0	873	1478	67	818	3237
Total	**30363**	**23361**	**12859**	**6917**	**11175**	**2207**	**86882**

Layer Weights

Layers	Layer Weight
Development Level (1 Acre 4ha window)	40
Forest	20
Forest Patch (>100 acre)	20
Protected Areas	10
Urban Future Zones	10
Total	100

Figure 32: Issue 3 Urban Forest Sustainability

Issue 4: Hazard Mitigation

All trees and forests are subject to the extreme forces of nature. Urban trees may be more vulnerable to damage from wind as they often stand alone in the landscape. Urban trees also are usually near buildings and other infrastructure. When urban trees are damaged during storms there may be an immediate impact on public safety. Trees and heavy branches can bring down utility lines, and fall onto buildings and roadways, blocking emergency response vehicles and preventing evacuation. The removal of downed trees following a storm event can become a financial burden as well. Following Hurricane Omar in 2008, 20 tons of woody debris were removed from roadways on St. Croix (Osinski, 2009)

Figure 33: Hurricane Omar Damage (Photo from Shanty Vibes.com)

While natural events such as hurricanes are not preventable, good forestry management practices can help prepare urban trees and rural forests for such storms. Selecting tree species for planting that are less susceptible to breakage, using pruning practices that result in stronger trunks and branches, and promoting cultural practices that encourage strong root systems are all ways to grow a storm-resistant forest. Trees that are monitored and pruned when needed are less likely to become hazard trees during and after a storm event. The USVI emergency response plan needs to incorporate a plan for managing the woody debris that results from such storms (Potter, 1995). Such a plan is critical to managing a storm event and receiving federal aid when warranted.

The most damage from hazard trees occurs during hurricanes, although improper pruning practices exacerbate this damage. Hurricane Hugo devastated the islands in 1989 and some of its effects are still apparent. Currently there is no public tree management plan. The VI Waste Management Authority (VIWMA) is in charge of debris disposal after a storm. The Water and Power Authority (WAPA) is in charge of utility lines (most are overhead). The Department of Public Works (PW) is in charge of rights of way and road clearance. The VI Territorial Emergency Management Agency (VITEMA) is charged with emergency planning. The local Coast Guard also plays a role during disasters. After Hurricane Omar in 2008, many parts of St. Croix lacked power for up to three or four weeks as a result of trees falling across utility lines. Many of these trees were uprooted as a result of ground saturated with water, strong winds, poor placement and poor management practices. An active urban tree management plan is needed to address this issue that impacts the daily lives of Virgin Islands residents.

Issue 5: Water Management

Forests have the potential to affect the water quality of the USVI. Most potable water is supplied by desalination plants (WAPA) or rain water catchment systems with only about 10% coming from wells. Agriculture relies on rain water, cisterns, WAPA water and wells. Water quality also affects wetlands and coastal resources, including the marine environment where it affects coral reefs, sea grass beds, and fisheries.

Components controlling rainwater in the USVI depend on climate, geology and land cover. Climate is changing (IPCC, 2007). Geologically speaking the USVI has one aquifer that acts as a source of groundwater: the Kingshill aquifer on St. Croix. Although the water quality is considered poor, it is of great importance due to its availability as an alternative source of water. Other aquifer types of the USVI, including alluvial valley and volcaniclastic aquifers, hold little water. The fractures in the volcaniclastic rock aquifers act as deposition areas of water in the highly fractured and shattered transition zone (Veve and Taggart, 1994, Renke et al., 2002, USGS, 1999).

Forests directly affect infiltration into USVI aquifers. Leaves and branches intercept and hold rain droplets, reducing volume and delaying peak flows. Air spaces in the soil around tree roots increase infiltration rates. Tree canopies reduce the impact of raindrops on barren soil, thus reducing erosion. Transpiration by leaves moves water from the soil back to the atmosphere, reducing the amount of water entering surface water bodies. A majority of the soils on St. Thomas and St. John have an overlying regolith zone that must be saturated to allow permeability. These major soil types of Cramer-Isaac and Dorothea-Victory-Magens, once fully saturated, can hold up to three inches of water per foot of depth (Veve, 1994).

Land cover and land use are other components affecting water systems in the USVI. Forest cover affects water infiltration rates and storm runoff once the soils are too saturated and shed water. The interaction of forested lands and water systems in the USVI are poorly documented and much of the literature focuses on geologic and climatic processes. However, people can manage lands at the landscape and planning level (Veve and Taggart, 1994, Renke et al., 2002, USGS, 1999, Vargas et al., 2007).

Areas in contiguous native forest cover are documented as facilitating infiltration and slowing water down; this helps to reduce flooding and runoff. Forest buffers along the mostly now intermittent streams (guts) also control for sedimentation, infiltration and surface runoff (Ramos-Scharrón and MacDonald, 2007). Trees and forests provide these valuable services, including filtering chemicals such as nitrogen and phosphorus from fertilizers out of subsurface flows through the soil (Sammarco, 1996, Carbery et al., 2006). Forest soils also serve as sponges that hold significant amounts of storm water, allowing it to infiltrate slowly, thus reducing peak runoff and flash flooding. As mentioned previously, USVI soils tend to have less water holding capacity than temperate soils and therefore the preservation of trees on these riparian soils is of even greater importance on the islands (Davis, 1998, Mac, 1998, Wiley and Vilella, 1998). Coral reefs and sea grass beds are directly affected by the large amounts of soils and pollutants entering the marine environment through guts after a heavy rain, which is a concern to fishermen and tourism-based businesses. When rain falls on impervious surfaces it picks up debris,

chemicals, sediment, and other pollutants and delivers them directly to that marine environment (Wiley and Vilella, 1998). Development that includes unpaved and paved roads and impermeable surfaces impacts the water resources of the USVI and need to be better understood.

Agencies responsible for the regulation and management of the water systems include the Division of Environmental Protection, Division of Planning and Division of Fish and Wildlife, all of which are part of DPNR, and the VI Waste Management Authority. These agencies are responsible for storm water runoff and watershed protection. Federal government agencies include the USGS and NOAA who fund and facilitate these state agencies. Without a comprehensive plan and adequate enforcement, water management issues will continue to be problematic. However, with the use of tools such as GIS and outreach we can identify immediate areas of concern and focus on those regions. Prior analysis has been conducted of the Forest Legacy Program in the form of the Assessment of Need that identified priority areas as watersheds.

In this analysis water quality issues were analyzed with the following weighted priorities: watersheds at risk (20%) as identified by The Nature Conservancy (2003); existing forests (15%) and riparian areas (20%); impervious layer as represented by development greater than 1 acre (25%) and developed areas not allowing water flow and infiltration (20%). Most of the high priority areas for impaired water quality were concentrated around the existing forest structure.

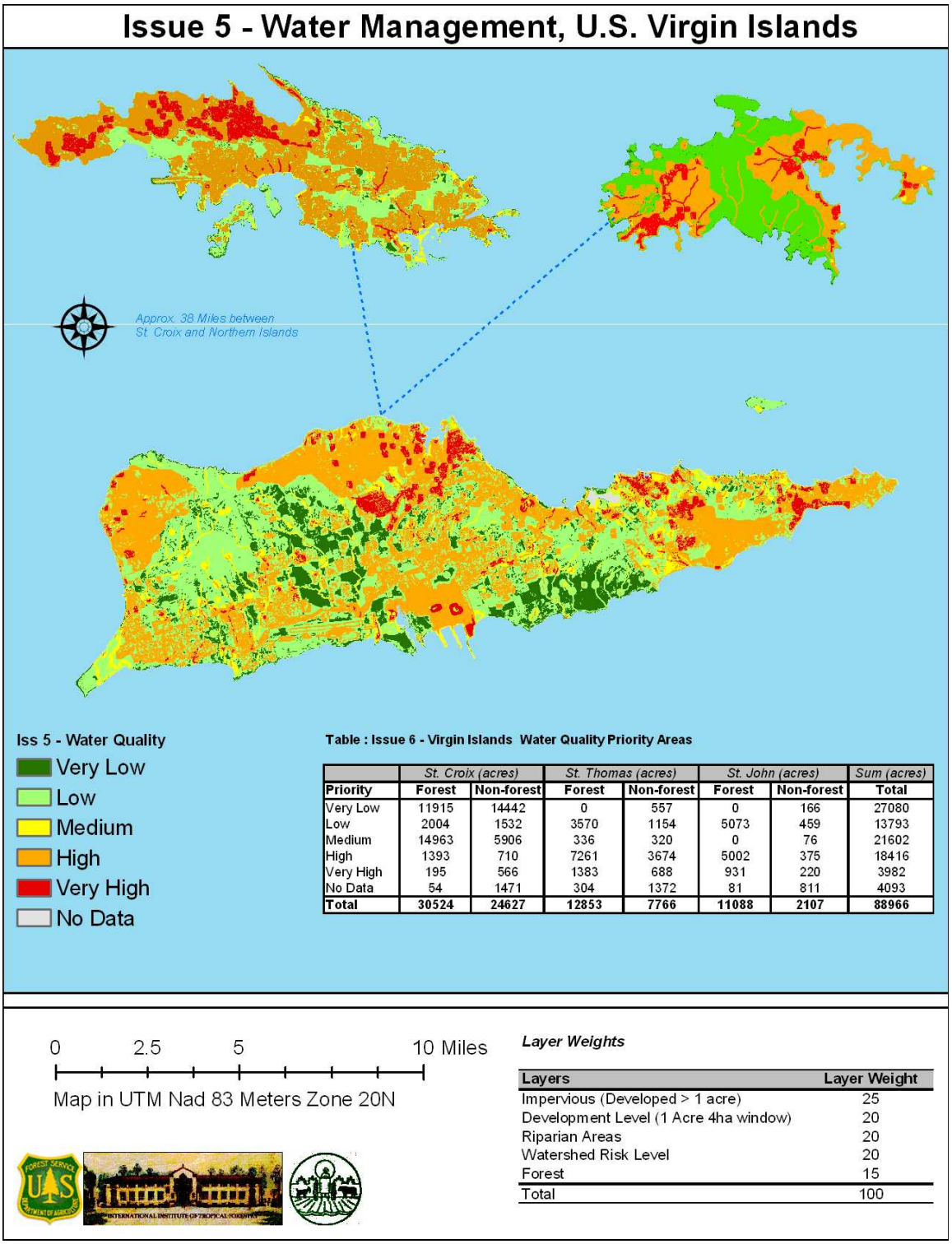


Figure 34 : Issue 5 - Water Management

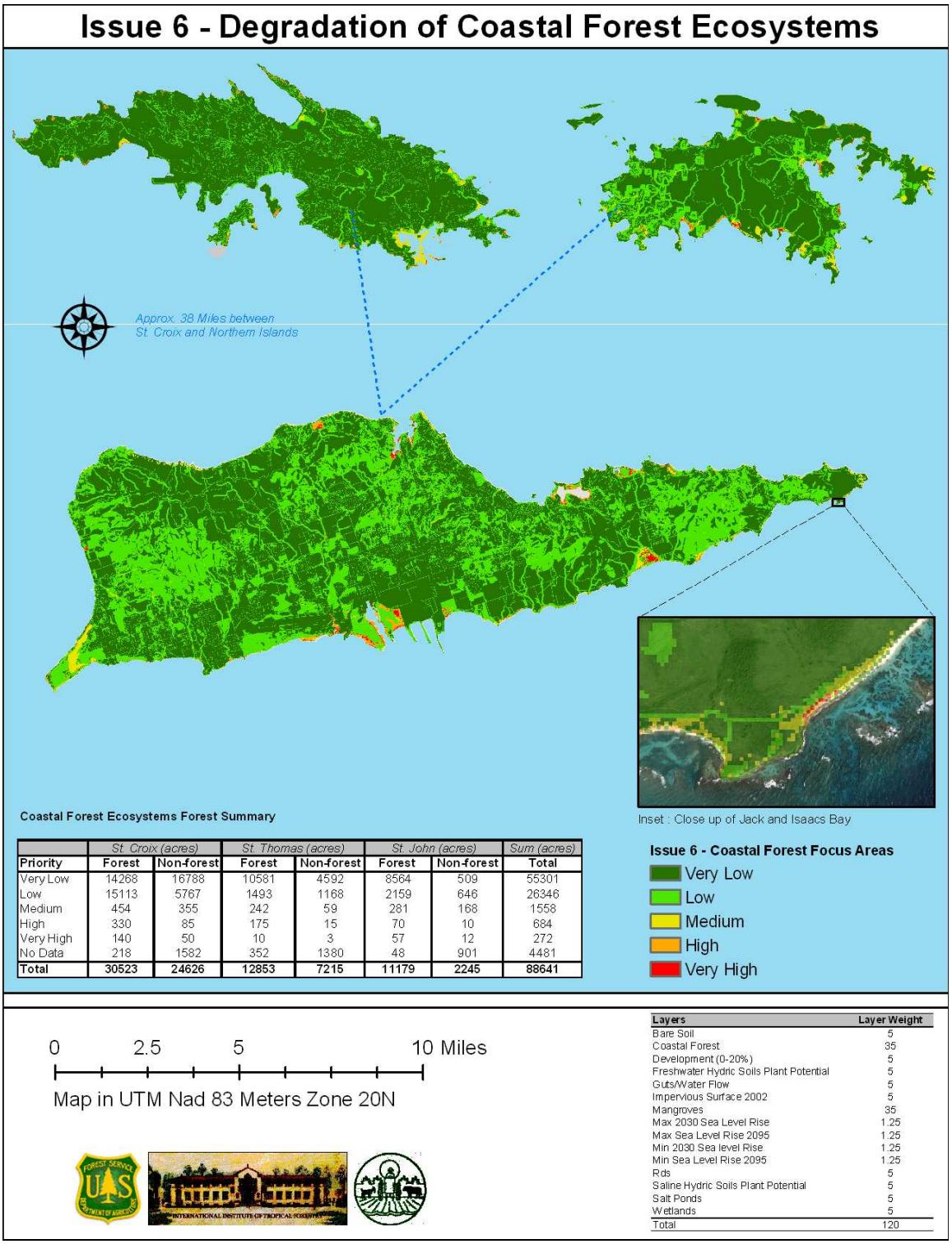
Issue 6: Degradation of Coastal Forest Ecosystems

Coastal forest resources are the integral zone between the terrestrial and marine lands. Coastal dry scrub includes rare and endemic species of wetland regions including the federally endangered mangroves. Mangrove studies show high rates of biodiversity (Nagelkerken et al., 2000) and include benefits for many wildlife species (Platenberg, 2005), including waste assimilation and nurseries for fisheries (Hopkinson et al., 2008). Other services include buffering from wind and flooding from storm events such as hurricanes.

A lack of data availability has made it difficult to track how these systems have been affected. According to the last land cover analysis by IITF (2007) there were approximately 622 acres of mangroves or flooded woodlands and approximately 600 acres of xeric and evergreen coastal shrubland in the USVI (Kennaway et al., 2008). There are many threats to these fragile systems including but not limited to land development, sedimentation from upland runoff, sea level changes, wind and flooding (Platenberg, 2005).
Currently the EPA, CZM, Lt. Governor's Office, VI DPNR, NOAA and the U.S. Army Corps of Engineers are the regulating authorities. The main program that regulates coastal areas is the Coastal Zone Management Act in the Tier I areas of the USVI.

In an attempt to capture coastal forest ecosystems, a variety of data sources were used to represent opportunities for working with existing coastal forest ecosystems in a variety of states. Representing existing resources since 2001 were the layers for mangroves (weight 35) and coastal scrub (weight 15). Potential resources areas were represented as saline (weighted 5) and freshwater (weighted 5), wetland plant soil suitabilities, wetlands (weighted 5) and salt ponds (weighted 5). The buffered gut layer (weighted 5) shows where there might be inland flow into the marine resources. These layers represent existing and potential coastal forest resources.

In the second part of the analysis we identified existing threat layers to further add to potential focus areas, including bare soil (weighted 5), development edge (weighted 5), impervious surfaces (weighted 5) and roads (weighted 5). These threats are currently described and interact with coastal forest ecosystems. A second large threat is climate change. Existing expected numbers of sea level rise (IPCC, 2007) were used to categorize the sea level rise into four distinct categories. Minimum and maximum sea level rise for 2030 and maximum and minimum sea level rise for 2095, all weighted at 1.25 each respectively, were identified.



	St. Croix (acres)		St. Thomas (acres)		St. John (acres)		Sum (acres)
Priority	Forest	Non-forest	Forest	Non-forest	Forest	Non-forest	Total
Very Low	14268	16788	10581	4592	8564	509	55301
Low	15113	5767	1493	1168	2159	646	26346
Medium	454	355	242	59	281	168	1558
High	330	85	175	15	70	10	684
Very High	140	50	10	3	57	12	272
No Data	218	1582	352	1380	48	901	4481
Total	**30523**	**24626**	**12853**	**7215**	**11179**	**2245**	**88641**

Layers	Layer Weight
Bare Soil	5
Coastal Forest	35
Development (0-20%)	5
Freshwater Hydric Soils Plant Potential	5
Guts/Water Flow	5
Impervious Surface 2002	5
Mangroves	35
Max 2030 Sea Level Rise	1.25
Max Sea Level Rise 2095	1.25
Min 2030 Sea level Rise	1.25
Min Sea Level Rise 2095	1.25
Rds	5
Saline Hydric Soils Plant Potential	5
Salt Ponds	5
Wetlands	5
Total	120

Figure 35: Degradation Coastal Forest Ecosystems

Issue 7: Invasive Species

Today humans exert influence over natural habitats in virtually every habitat on Earth. The two greatest threats to global biodiversity are habitat loss resulting from human conversion of natural systems and the influence of exotic invasive species (Vitousek et al., 1997). A recent comprehensive analysis of emerging issues affecting global biological diversity indicated that biological invasions by invasive exotic species and related management issues will remain at the forefront of environmental concern for years to come (Sutherland et al., 2010).

Humans have introduced countless new species to almost every habitat on earth. The organisms are introduced both intentionally, (as in the case of attractive, ornamental flowering plants to a landscape or fast-growing leguminous plants to improve a pasture) and accidentally, such as marine organisms that are transported around the world in ballast water of super tankers or weed seeds that hitch a ride in the wheel wells of automobiles. It would be impossible to calculate actual numbers of introductions. In the vast majority of cases the newly introduced plant or animal simply dies without anyone noticing. In rare instances the organism survives and thrives well enough to actually reproduce itself naturally and its offspring establish themselves as part of the new community.

Definition of Terms

These terms are commonly used when discussing exotic and invasive plant species. Not all professionals agree on the exact terms and definitions, but the following list is generally considered helpful.

- Native – Organisms found within what is considered their natural range.
- Endemic – Similar to native but usually refers to a more specific geographic range.

EXOTICS – Exotic species are any organism taken from its natural range and transported to a new area. This only pertains to organisms moved by humans, such as in cargo ships or planes. It does not include natural migrations like birds or fish that travel great distances.

- Naturalized – An organism that is able to reproduce itself unassisted in its new habitat is considered naturalized.
- Invasive – An organism that grows or spreads aggressively in its new environment.

There are many "naturalized" species in the US Virgin Islands including the flamboyant tree (Madagascar), the tibit tree (India), and the neem tree (India). In extremely rare instances, the newly introduced species behaves differently than it does in its native habitat and grows, reproduces and spreads very aggressively. When this aggressive behavior becomes harmful to the environment or the local economy the species can be designated as invasive.

An invasive species is *"a non-native species whose introduction does, or is likely to cause, economic or environmental harm or harm to human, animal, or plant health" (Executive Order 13112, 1999).*

Natural habitats around the world have been invaded by exotic species, from tropical forests to temperate mountains and marine systems. The diversity of the plants and animals that invade these habitats is so great that it is difficult to describe what they have in common. However, many share a few characteristics such as: rapid growth, reproducing at a young age, producing a large number of off-spring, and rapid spread. Invasive plants tend to prefer areas of disturbance, such as land cleared by fire, and thrive in high sunlight conditions and tolerate harsh climatic conditions. They frequently alter disturbance regimes, like making an area more prone to fire, and also prevent other species from becoming established.

One complicated aspect of predicting whether an exotic species will become invasive is that they are usually not invasive within their native range and only cause problems when they are brought to new areas. In the US Virgin Islands, tan-tan (*Leucaena leucocephala*) trees grow very quickly, produce copious amounts of seeds and re-sprout after they are cut. Tan tan has become the most common woody plant in the territory (Brandeis and Oswalt, 2007) and one of the most problematic noxious weeds, yet in its native Central America, it behaves just like any other tree. One explanation for why this happens is the competitive release hypothesis which states that populations are kept under control by predators. When they are brought to a new region where there are no natural enemies, the population explodes.

Another method utilized in the effort to understand how invasive exotics affect habitats is to classify habitats by their invasability. Invasive species mapping and monitoring has been done effectively on a global and regional scale. Maps are frequently created using models with environmental inputs, such as temperature or altitude, rather than physically mapping the presence of the organism of concern. The potential spread of fire ants, for example, has been mapped on a regional scale based on rainfall and temperatures (Morrison et al., 2004). This type of 'habitat suitability' mapping likely has limited potential in the US Virgin Islands due to the islands' relative uniformity in habitat type (Ewel and Whitmore, 1973b) and small size.

The most comprehensive forest inventory of the US Virgin Islands indicated that the single most common tree in the territory is the exotic tan-tan (*Leucaena leucocephala*) which is found at all elevations and in almost all forest types (Brandeis and Oswalt, 2007). The FIA provides detailed information on the species composition of sample sites, but was not designed to generate detailed forest maps or species distributions maps. Other inventories of individual properties in St. John (Ray and Brown, 1995) and St. Croix (Adam and Ryan, 2003, Daley, 2010b) and several other informal inventories provide detailed species composition and density data appropriate for finer spatial scales.

Most invasive species work in the US Virgin Islands has been by agencies aiming to document the presence of certain target species and remove or control them from individual properties. The majority of these projects have been conducted by agencies that own and maintain property for the protection of natural resources. The St. Croix Environmental Association, for example, has removed problematic exotic plants from the wetlands at their Southgate Wildlife Preserve and planted native tree seedlings to foster native forest succession. Similarly, the US Fish and Wildlife Service has trapped exotic, carnivorous mongoose at the Sandy Point Wildlife Preserve and the Green Cay Wildlife Preserve in order to reduce predation pressure on native species of concern on those properties. Although the issue is widely recognized by natural resources

professionals in the territory, there is no formal council of invasive species in the Virgin Islands, and there is no territory-wide list of invasive species of concern.

An example of a successful planned invasive species control in the US Virgin Islands was done by the National Park Service on Buck Island off of St. Croix. The small island is isolated from St. Croix and provides a unique opportunity to extirpate targeted organisms. Mongoose removal began in earnest in the early 1980s and was complete by 1987. Rats were eradicated by 2001 and monitoring for both is on-going. Starting in 2003 the three most invasive plants (*Leucaena leucocephala*, *Tecoma stans* and *Panicum maximum*) were targeted in an island-wide eradication project, during which other non-natives were also removed. Complete eradication was not the goal, but the current measure of 85% control of these species has been deemed successful (Lundgren, 2010). The National Park Service project at Buck Island National Monument could be used as a model project for the rest of the territory because it 1) identified target species through a plant and animal inventory and analysis, 2) set measurable and achievable goals for each species (complete eradication or control), and 3) utilizes regular monitoring in order to measure the success of the management activity.

Exotic species impact the US Virgin Islands natural environment and the people living there. The financial impacts include increases in roadside maintenance to control tan-tan, farmer inputs to control introduced exotic pests such as pink mealy bug, store-owner costs to clean up after exotic pigeons and prevent them from roosting, and home-owners who have to control rats, guinea grass and tan-tan. If the lionfish becomes established in the coral reefs of the US Virgin Islands the impacts on the SCUBA industry and other aspects of tourism could be enormous.

Issue 8. Wildfires

In the Caribbean, unintended fires are thought to be a major source of deforestation (Robbins et al., 2009). The Virgin Islands' forests are not fire-dependent but rather fire-sensitive, meaning they are not ecologically adapted to periodic fires (Schulte et al., 2004). This is not surprising as fires rarely occur naturally in the USVI; instead the majority are a result of human activity. Burning for agricultural clearing, campfires, cigarettes, arson and trash burning are likely the primary anthropogenic causes of wildfires in the USVI. Fortunately forest fires are relatively rare in the USVI. Most recorded wildfires on St. Croix appear to have occurred in coastal areas of dry grass and shrubland, however this is based primarily on anecdotal information rather than systematic data collection (Torres and Chief, 2009). No reliable information on wildfires on St. Thomas and St. John was available.

Although fires did not originally play a large role in shaping the natural ecosystems of the USVI, past land use that has converted forests to grasslands and shrublands has increased the fire risk. In fire-sensitive areas such as the USVI, wildfires can have severe impacts to the natural ecosystem. After fires are extinguished, the first plants to become established tend to be invasive species that are well-adapted to frequent burning, such as guinea grass. This results in the conversion of forest to grassland. Grasslands tend to burn more frequently and when they are adjacent to forests, regular burning can result in steady loss of forest land.

There is great potential for forests to become increasingly vulnerable to fire due to climate change. Forest fires in the Caribbean have occurred almost exclusively in dry forest and not moist forest (Robbins et al., 2009). Even slight changes in temperature and rainfall have the potential to increase fire frequency. In Puerto Rico, historical and paleoecological data suggest that fire frequency is increasing and moving into humid areas that have not burned before (Burney et al., 1994).

The USVI Fire Service has complete responsibility for all fires on all the islands except for fires that occur at the HOVENSA oil refinery. However, the Department of Agriculture is responsible for soil stabilization and rehabilitation after fires have been suppressed (Schulte et al., 2004). The Division of Forestry has had little to no involvement in fire issues in the USVI.

Lack of consistent data collection and analysis has hindered the study of forest fires in the U.S. Virgin Islands and throughout the Caribbean. Currently, very little information is collected from wildfires in the USVI. Minimal data collection such as location, extent of fire, cause and surrounding land use could assist greatly in determining impacts of fire on the landscape and areas that are especially vulnerable to damage from wildfire.

STRATEGIES

In 2008 the Congress of the United States of America enacted the Food, Conservation, and Energy Act. This Act included an amendment to the Cooperative Forestry Assistance Act of 1978. The amendment requires each State and Territory to provide a Statewide Assessment of Forest Resources and a Statewide Forest Resources Strategy to the Secretary of Agriculture, USDA, by June 2010. This document fulfills the requirement for the Statewide Forest Resources Strategy (USA, 2008).The Statewide Assessment of Forest Resources identified three broad goals for the Virgin Islands Department of Agriculture's Division of Forestry:

1. Contiguous Forest Conservation and Management
2. Urban Forest Management
3. Coastal Forest Ecosystem Protection

Within each of these goals are a number of issues to be addressed .The issues were identified in the forest resources assessment document and are as follows:

Issue 1: Contiguous Forest Loss

Issue 2: Loss of Transitional Forests to Development

Issue 3: Urban Forest Sustainability

Issue 4: Hazard Mitigation

Issue 5: Water Management

Issue 6: Degradation of Coast Forest Ecosystems Resources

Issue 7: Invasive Species

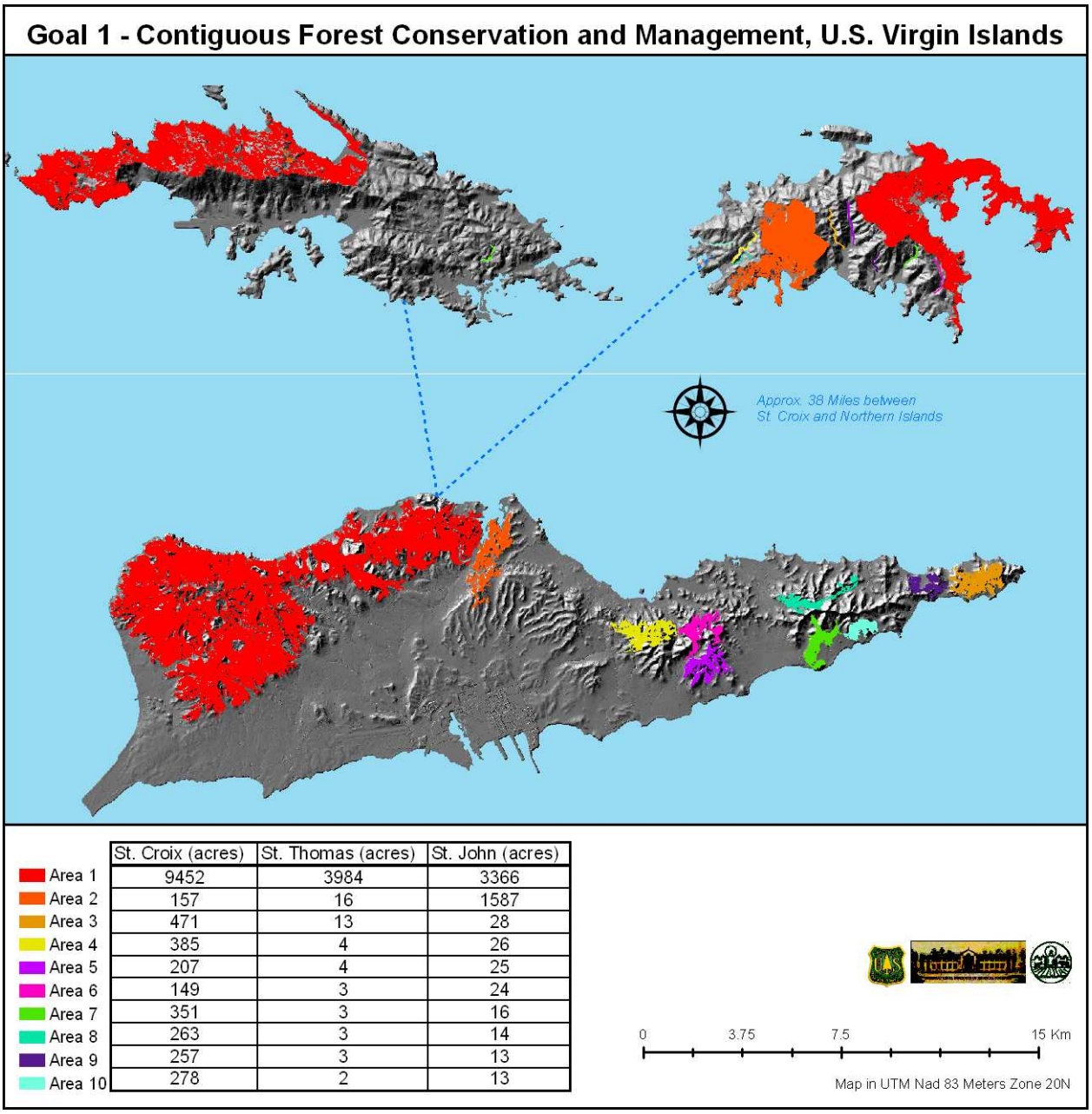
Issue 8: Wildfire

Addressing these issues to achieve the aforementioned goals can be daunting. This document addresses the issues by creating a preliminary set of strategies to address each goal, and providing guidelines as to how that goal contributes to the management of the issues. For each goal a matrix of strategies has been provided that address the issues. These strategies are meant as guides to the process of managing our U.S. Virgin Islands forest resources into the future.

GOALS & STRATEGIES

Goal 1: Contiguous Forest Conservation and Management

The largest tracts of contiguous forest areas in the US Virgin Islands have been identified **(Figure 36)** as areas of focus for the goal of contiguous forest management.



	St. Croix (acres)	St. Thomas (acres)	St. John (acres)
Area 1	9452	3984	3366
Area 2	157	16	1587
Area 3	471	13	28
Area 4	385	4	26
Area 5	207	4	25
Area 6	149	3	24
Area 7	351	3	16
Area 8	263	3	14
Area 9	257	3	13
Area 10	278	2	13

Figure 36: Goal 1: Contiguous Forest Conservation and Management

However, the areas of contiguous forest indicated do not always represent stands of uninterrupted forest. Instead, contiguous forests in the USVI tend to be large patches of forest that are close, but not always adjacent, to other forest patches. Management of these large patches of forest consists of conservation of the existing forest and the protection of areas that provide access to these patches.

Increases in the human population of the Virgin Islands and a push for the conversion of forested land into developed areas as a strategy for economic recovery threatens the existing contiguous forest patches. Many people perceive forests as "empty" land rather than important ecosystems that both wildlife and humans rely upon. Increased knowledge of the importance of contiguous forest ecosystems through research and public outreach to pass on this knowledge is an essential component of managing the contiguous forest patches. It is also necessary to educate existing governmental agencies on the importance of these forests and collaborate with them for protection of existing forest patches.

Forest contiguity is essential in preserving an intact forest ecosystem. Much of the wildlife that resides in forests is adapted to survival in large tracts of contiguous forest. In studies outside of the Virgin Islands, forest birds have been found to rely on large areas of contiguous forest for survival and experience decreases in nesting success and available food when forests become fragmented (Collinge, 1996, Laurance et al., 2000, Pattanavibool and Dearden, 2002, Steadman et al., 2009, Barlow et al., 2006). Similar studies are necessary in the Virgin Islands to determine wildlife usage of forests and dependence on forest contiguity.

Gaps and edges are conduits for the introduction and establishment of invasive species. Invasive plant species can significantly alter the structure and ecosystem function of a forest, causing increased vulnerability to natural disasters such as hurricanes and altered habitat for invasive wildlife. With the introduction of non-native wildlife comes an exponential increase in invasive plants. Oftentimes the invasive wildlife is not able to provide the pollination and seed dispersal activities necessary for continued upkeep of a healthy native forest.

Forest cover is important to the protection of marine ecosystems as well. Roads and gaps in the forest can significantly contribute to soil erosion and runoff into marine ecosystems, causing degradation of the fisheries. Many of the contiguous forest areas contain gallery forests that are found mainly along riparian zones of guts. These guts are the pathways from these contiguous forest areas to the marine environment (Larsen and Webb, 2009, Ramos-Scharrón and MacDonald, 2007, Edmunds, 2002, Veve and Taggart, 1994).

As a result of their island status, the US Virgin Islands do not have geographically adjacent jurisdictions. However, the issues that are being addressed in these strategies are often the same as those found on other islands, whether in the Caribbean or the South Pacific. The preservation of contiguous forest for the purposes of biodiversity conservation, especially for migratory birds and bats, is an area in which collaborative efforts with other islands mav prove beneficial. Collaborative redesign projects with other islands, especially in the Caribbean, may be pursued in the future to provide funding for implementing these strategies. Following is a matrix of strategies that will be used to address contiguous forest conservation management in the US Virgin Islands.

Table 12: Objective 1.1 Education and Public Outreach about Contiguous Forest Management

Strategy 1.1.1. Increase Awareness of the Forest Stewardship Program						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
All	Forest Stewardship Program, Forest Legacy Program, U&CF Program; USFWS Partners in Wildlife, Conservation Education	Private landowners, Federal lands, Non-profit groups, watershed areas	Forest Stewardship Program, U&CF Program, RC&D, Hikers associations; USFWS materials	Specific outreach program	Increase in #'s of inquiries about Forest Stewardship; increased #'s of approved FSP plans on all islands	3.6
Strategy 1.1.2. Develop educational materials and activities for teachers to use to teach the value of all types of forests						
All	Conservation Education	VI Dept. of Education, SEA, EAST, UVI, DPNR, VINE	Forest Stewardship Program, U&CF Program; conservation education materials	Outreach and education funds	Increase in #'s of students receiving information about the value of forests	3.6

Table 13: Objective 1.2 Research and Data Acquisition for Contiguous Forest Management

Strategy 1.2.1. Collect data to determine wildlife usage of contiguous forest and corridors between forest patches						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
All	N/A	DFW, USFWS, TNC, SEA, UVI, NPS, other government agencies	DFW, USFWS, SEA	expertise, dedicated funding	#'s and kinds of wildlife using contiguous forest and forest corridors	3.5
Strategy 1.2.2. Collect data on location and extent of Wildlfires						
3,4,5,6,8	VI Fire Service, Conservation Education	VI Fire Service, VI DPNR, NPS, SEA, Private Landowners	VI Fire	Establish database on fires, training in GPS, coordinate program activities with Fire Service	Record number, extent, location, and cause of wildfires territory-wide	2.1,2.2,3.3
Strategy 1.2.3 Protect existing forests in important aquifers/watersheds						
1,2,4,5,6	Forest Legacy Program, Forest Stewardship Program	DPNR, SEA	NOAA, USGS, UVI	Funding, Interagency cooperation and organization	% of protected forest cover in priority watershed areas; collect information on water flow paths in aquifers	3.1

Table 14: Objective 1.3 Protecting Existing Contiguous Forest

Strategy 1.3.1. Number of parcels enrolled in conservation easements						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
1,2,5	Forest Legacy Program, Forest Stewardship Program	Lt. Governor's office, Private landowners, Neighborhood associations, DPNR	Tax Assessor's Office Documents	Revised AON, Parcel IDs, contact info for property owners	Increase in # of parcels protected with conservation easements	1.1, 3.5
Strategy 1.3.2. Number of permits approved for development of forested lands						
All	Forest Legacy Program, Forest Stewardship Program	DPNR, Developers,Non-profit Organiza-tions	DPNR Staff	Program Cooperation	Decrease in # of permits approved for removing trees for development	1.1,1.2,2.2, 3.5
Strategy 1.3.3 Number of key forested areas protected through fee simple acquisition						
1,2,6	Forest Legacy Program, , TNC	DPNR, TNC, NPS, TPL, TVIL, Lt. Governor's office	TNC, TVIL, other trust organizations	Results of Strategy 1.3.1	Increase in # of parcels acquired by various agencies for protection/ conservation	1.1,3.5

Table 15:Objective 1.4 Managing Existing Contiguous Forest

Strategy 1.4.1. Increase numbers of trees planted through tree planting programs						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
1,2,3,4,5,6,7	U&CF Program, Forest Stewardship, Conservation Education	SEA, EAST, USFS, USFWS, NPS, other NGOs and gvt. Agencies	U&CF Program, Forest Stewardship, UVI Extension, SEA, RC&D	Identification of Priority Planting Areas, Funding, Organization	#'s of trees planted, #'s of acres converted/planted	1.2,3.6,3.7, 3.2
Strategy 1.4.2. Increase acreage under monitoring/control for Invasive Species						
1,2,5,6	U&CF Program	DPNR, NPS, USFWS, USFS, Fishermen, UVI Extension	Forest Health initiatives, IITF	Funding, Studies Delineating the Problem	% of Decrease in acreage of invasive species dominated forests	2.2, 3.5
Strategy 1.4.3 Reduce Area Burned by Wildland Fires						
3,4,5,6,8	U&CF Program, Forest Stewardship, Conservation Education	VI Fire, VI DPNR, SEA , NPS, Private Landowners	Conservation Education, State Fire Assistance, Volunteer Fire		Reduction of numbers and extent of wildfires	2.1, 2.2, 2.3

Goal 2: Urban Forest Management

Urban and community forests account for a large percentage of the US Virgin Islands' forests. Urban forests play a unique role in the health and well being of humans in the urban environment by absorbing pollutants, cooling the air, dampening noise pollution and reducing erosion. Urban forests also provide an opportunity for people living in an urban environment to form connections with and an appreciation of nature, an essential component for any conservation program. As such, urban forests provide great opportunities to teach about the value of trees.

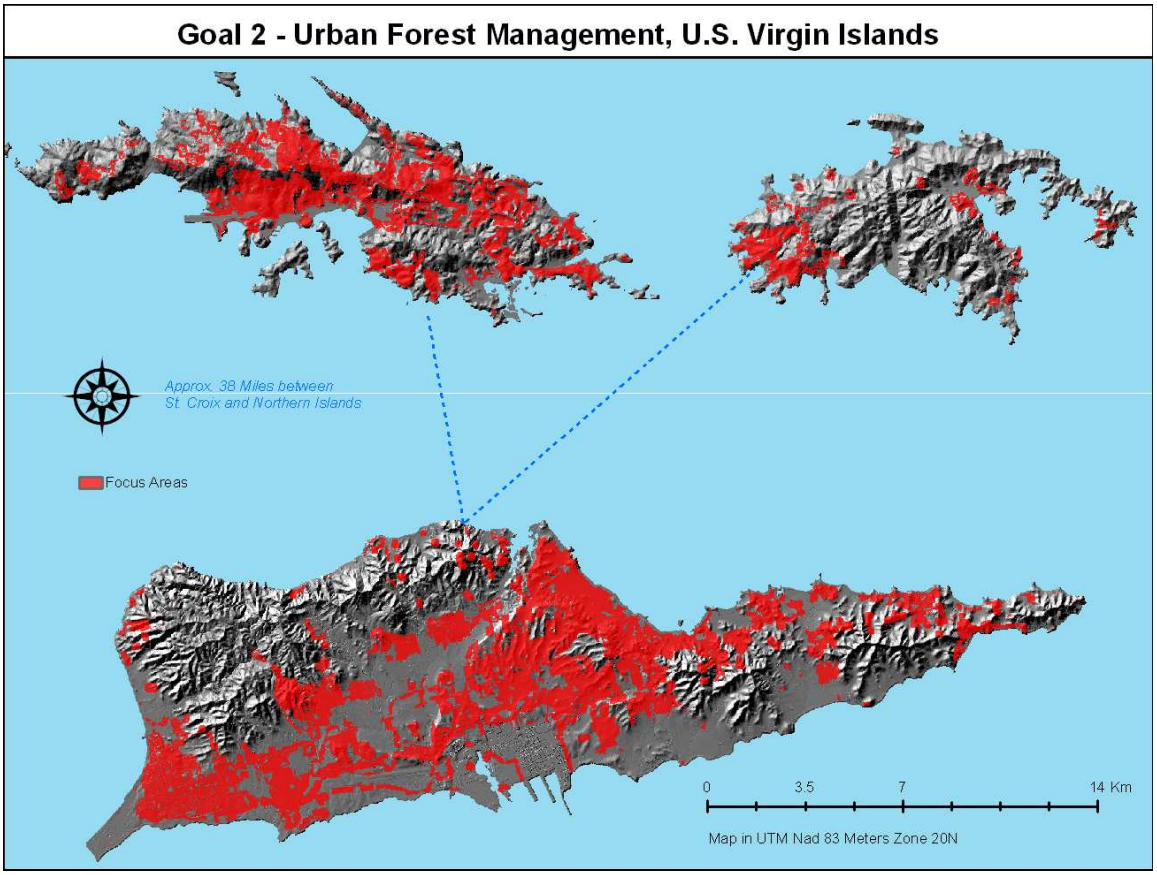


Figure 37 : Goal 2 Urban Forest Management

Little is known about the importance of urban forests to wildlife. Urban forests may provide corridors or small refuges to some animals. Some wildlife species can thrive in urban forest areas, particularly species that are generalists in the habitat and food they prefer.

Urban forests do require a higher level of maintenance and management than most "natural" forests. Trees must be maintained so as not to become hazards to the surrounding infrastructure and residents. Lack of proper maintenance becomes a threat to urban forests as trees that are not well maintained will often be removed and not replaced. In the US Virgin Islands, there is no one agency charged with maintaining the health of urban trees. Often they do not receive any care until and unless the trees become hazards. There is a common perception among residents and the police department as well that urban trees promote crime, serving as meeting spots for drug dealers and providing hiding spots for criminals. In fact, studies have shown the opposite is true:

urban areas with trees and green spaces have reduced numbers of crimes against people and property (Kuo and Sullivan, 2001). This again highlights a need for education about the importance and benefits of trees in the urban landscape.

Table 16: Objective 2.1 Education and Public Outreach about Urban Forests

Strategy 2.1.1. Number of Stakeholders Aware of the Urban and Community Forestry Program						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resource Needed**	**Measure(s) of Success**	**Supports National Objective**
3	U&CF Program, Conservation Education	Public Works, WAPA, Business Owners, Private Households, Tourism	U&CF, RC&D, VINE, NRCS, SEA, VICS	Funding; additional resources	Increase in #'s of community groups involved in U&CF Program projects	3.6
Strategy 2.1.2. Protect and Publicize Remarkable/Heritage Trees						
3	U&CF Program, Conservation Education	VI Public Works, Department of Tourism	UVI, U&CF, TVIL, SEA, State Office of Historic Preservation, DPNR	Funding, Programs	Increase in the #'s of remarkable/ heritage trees protected and promoted	3.6
Strategy 2.1.3. Reduce Risk to Forest Health from Invasive Species						
All	VIDOA,DPNR, Tourism, Conservation Education	Local Community Nuseries	DPNR, Tourism	Funding	Increae % nursery stock	3.6

Table 17: Objective 2.2 Urban Forest Inventory and Analysis

Strategy 2.2.1. Collect data to determine wildlife usage of urban forests as corridors and habitat						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
2,3,4,5,6,7, 8	U&CF Program	DFW, USFWS, TNC, SEA, UVI, NPS VITEMA, VI Fire, Lt. Govemors Office, NOAA	DFW, RC&D ARRA Hazard Tree Assessment	expertise, dedicated funding Funding, agency cooperation	Record numbers and kinds of wildlife using urban forests	All
Strategy 2.2.2. Identify and Manage Hazard Trees						
3	U&CF Program	WAPA, VI Public Works	ARRA Fund (RC&D)	Hazard tree assessment and mapping	Inventory street trees on all islands and plan for continued maintenance	All

Table 18: Objective 2.3 Managing Existing Urban Forest

Issues Addressed	Contributing Program Areas	Key Stakeholders	Available Resources for Implementation	Resources Needed	Measure(s) of Success	Supports National Objective
Strategy 2.3.1. Increase number of trees planted through an urban tree planting program						
1,2,3	U&CF Program, Forest Stewardship Program, Conservation Education	SEA, EAST, USFS, USFWS, NPS, other NGOs and govt. agencies	VIDOA Native Tree Nursery	Funding, Cooperation	#s of trees planted, #s of acres converted/planted	1.2,3.6,3.7, 3.2
Strategy 2.3.2. Develop and implement management plans for developed areas						
ALL	U&CF Program, Conservation Education	DPNR, developers, owners of appropriate businesses	RC&D, SEA, VICS, DPNR-CZM, Army Corps	Funding, Land Use and Water Plan, Support, Reliable Regulations	LUWP, Handbook of Correct Development Options	1.2,3.1,3.5,3.6,3.7
Strategy 2.3.3. Development of certified arborists as a source of reliable technical expertise						
All	U&CF Program, Conservation Education		Geographic Consulting, UVI Extension, VIDOA, SEA, RC&D	Funding, Cooperation, On island ISA Proctor, Consistent Trainings	# of new and renewed certified arborists	2.1,2.2
Strategy 2.3.4. Write and Enact a VI Tree Law						
All	U&CF Program, Forest Stewardship Program, Conservation Education	RC&D, SEA, WAPA, Public Works, Legislature. Public at large	UVI's CES, established Tree Law committees, VI Legislature	Funding, legal write up, organization and lobby support	Enactment of a viable, positive tree law	2.1,2.2

Goal 3: Coastal Forest Ecosystems Protection

Tropical islands rely on coastal forest ecosystems for many important ecosystem services. Mangroves are the backbone of coastal forest ecosystems and their contributions are well studied. They provide essential habitat for a wide range of wildlife, including nursery habitat for economically important juvenile fish. Many birds nest in the branches of the mangroves and rely on the fish and invertebrates in the surrounding water for food (Ogden and Gladfelter, 1984, Nagelkerken et al., 2000, UNEP, 2008, Lugo, 2001). Unfortunately, coastal areas are also most likely to be the focus of development activities, potentially damaging these important forests. Key coastal forest areas in the US Virgin Islands that are or could be threatened in the future are shown in Figure 3.

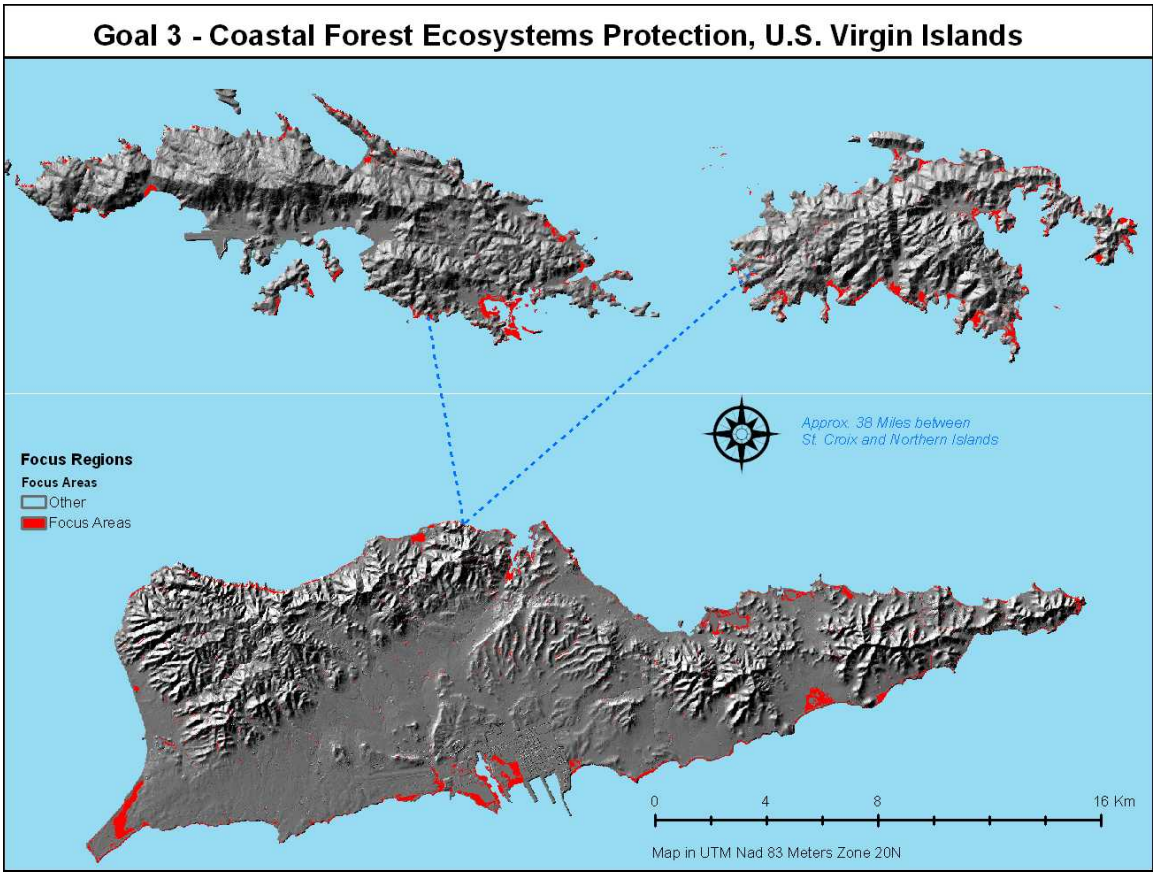


Figure 38 : Goal 3. Coastal Forest Ecosystem Protection

Coastal forests provide buffer areas between terrestrial and marine ecosystems. Marine ecosystems rely on coastal forests to reduce and filter sediment from runoff and to stabilize shorelines by reducing erosion. The deposition of sediment onto coral reefs greatly reduces survival of both the reef and the organisms that rely on the reefs. Without the healthy coastal forest ecosystem in place, the amount of sediment deposited on the reefs would greatly increase (Ramos-Scharron and MacDonald, 2007, UNEP, 2008).

Inland terrestrial ecosystems rely on the protection that coastal forests provide from the harsh marine environment. Perhaps the most dramatic examples of this protection are the protection

from tsunamis, strong hurricane winds and storm surges along the coastline. Areas with intact coastal forests have suffered far less damage from these natural events than areas in which the forests have been cleared for development (UNEP, 2008, Lugo, 2001, Angeles et al., 2007, Mac, 1998, IPCC, 2007).

Coastal forests face strong threats from developers eager to sell land to be developed into high value resorts or expensive homes. An ocean view or easy access to the ocean can raise the price of a property significantly and can discourage property owners from participating in long-term protection through conservation easements or other devices.

As with the preservation of contiguous forest, conservation of riparian and coastal forests to protect the health of aquatic resources is a strategy that should be considered a regional need for islands of the Caribbean. Conservation of coastal forests is a challenging task that should be addressed through collaborative efforts of island territories and nations region-wide. Redesign projects with other Caribbean islands may be pursued in the future to provide funding for implementing the following strategies.

Table 19 : Objective 3.1 Education and Public Outreach about Coastal Forest Ecosystem Protection

Strategy 3.1.1 Develop Programs to teach importance of coastal forest ecosystems						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
6	Conservation Education	Virgin Islands Community, Fishermen, Tourists	Existing education programs from such organizations as SEA or the EEMP	Funding and Education	#'s of participants in education programs about the importance of coastal ecosystems	3.6

Table 20: Objective 3.2 Research and Data Acquisition for Coastal Forest Ecosystem Protections

Strategy 3.2.1. Collect data on and monitor the effects of climate change						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
6	Conservation Education	NOAA, DPNR, UVI		GIS layers for analysis, field work	List the data needs met with current data/identify new data needed	2.2,3.5,3.7

Table 21: Objective 3.3 Protect Coastal Forest Ecosystems

Strategy 3.3.1. Maximize Forest Cover to Prevent Erosion and Sedimentation						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
All	Conservation Education	DPNR, CZM developers	DPNR	Time, MOU	Increased consideration of coastal forests in land use planning/establish riparian forest buffer zones	1.1,1.2,2.2, 3.5

Table 22: Objective 3.4 Manage Coastal Forest Ecosystems

Strategy 3.4.1. Invasive Species Control						
Issues Addressed	**Contributing Program Areas**	**Key Stakeholders**	**Available Resources for Implementation**	**Resources Needed**	**Measure(s) of Success**	**Supports National Objective**
1,2,7	Forest Health initiatives, Conservation Education	DPNR, NPS, USFWS, USFS, UVI Extension	USDA – Forest Service – IITF forest health initiatives	Funding, resources	Decrease in acreage of invasive species dominated forests	2.2, 3.5

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Appendix A – Survey Results

In order to collect public input and opinion as to the state of the Virgin Islands' forests, a survey was developed and distributed to members of the natural resource community (stakeholders) on all three islands. The survey received a 36% response rate, with 28% of the respondents from the island of St. Croix. Forty-one percent of the respondents identified themselves as natural resource managers, and therefore were aware of forestry issues on their island.

The results indicated that there is an overall sense of a need to conserve and protect our forests (32.2% of respondents mentioned this when they think about forestry). When asked to list the three most important forestry related issues in the territory, the top three responses were: (1) the improper maintenance practices associated with urban trees, (2) unsustainable development practices, and (3) apathy or lack of understanding of forests by the public along with a need for preservation of the forests of the Virgin Islands. Unsustainable development practices could be considered the biggest issue, as issues related to development also scored high – such as deforestation, land clearing, forest fragmentation and a need for government regulations regarding removal of trees.

Surprisingly, many of the respondents, when asked what programs are currently in place in the VI to protect our forests, stated that there are no such programs (24.1%). However, others mentioned the Forest Legacy Program, the Forest Stewardship Program and the Urban and Community Forestry Program. The respondents stated that the top three biggest opportunities for forestry in the VI in the next five years were: (1) the purchase of land for conservation and preservation (30.8%), (2) increasing awareness and education about forests in the VI (23.1%), and (3) the shift in focus of the Obama Administration to green policies on the federal government level (11.5%).

Key areas of forests were identified by respondents as in need of protecting and the top areas were: the northwest quadrant of St. Croix (46.7%), riparian areas throughout the islands (20.0%), and mangrove forests (13.3%). On St. Thomas, respondents were especially concerned about the western areas and Smith Bay, and on St. John the Carolina Valley was listed as in need of protection.

When asked about threats to our forest resources, the overwhelming response was that unsustainable development and issues associated with it are the biggest threats. In fact, development was listed in 100% of the responses as one of the three biggest threats. Other threats that ranked high included human apathy towards the forest (42%), and introduced and invasive species (27%).

STAKEHOLDERS INVOLVED IN THE DEVELOPMENT OF THE ASSESSMENT AND STRATEGY

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Christie Bartle, St. George Village Botanical Garden
Ivan Butcher, U&CF Council Public Relations Officer
Errol Chichester, Deputy Commissioner of Agriculture
Olasee Davis, U&CF Council Vice President, UVI-CES
Pedro Encarnacion, St. Croix Administrator
Mario A. Francis, U&CF Council President
Eleanor Gibney, botanist
Cordell Jacobs, Sr., VIWMA
Rudy O'Reilly, USDA - NRCS
Barbara Petersen, U&CF Council Secretary, St. Thomas/Water Island Administrator
Dr. Louis E. Petersen, Jr., Commissioner of Agriculture
Leona Smith, St. John Administrator
Keith Webster, U&CF Council Treasurer, DPW
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Gregory Willocks, WAPA
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Forest Stewardship Coordinating Committee (FSCC):
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Carol Cramer-Burke, SEA
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Stakeholders Receiving Final Draft of Assessment February 2010:
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Appendix B – Program Descriptions

Forest Stewardship and Forest Legacy

Introduction

The US Virgin Islands Department of Agriculture (VIDOA) Forest Stewardship Program has provided technical assistance to Territory forest landowners since 1998. By providing natural resource management plans and technical assistance to landowners, the program promotes wise use and active management of forest resources in the United States Virgin Islands. Guided by practical information about their properties, landowners are encouraged to implement practices that promote economic, social, and ecological benefits on their forested land. The program offers alternative management incentives for landowners to manage their forest resources for the long term. Landowners who actively manage their properties according to the Forest Stewardship Program management plan are offered a reduction in property taxes, as the government of the Virgin Islands recognizes the benefits of forested land and responsible resource use.

In 2000, the program organized the US Virgin Islands Forest Stewardship Coordinating Committee (FSCC). This body of influential Territorial natural resource professionals meets quarterly to approve forest management plans and guide the work of the Forest Stewardship Program. Since 1998, several Forest Stewardship Program Coordinators have developed the program in the Territory and are responsible for more than 1,000 acres of stewardship forests on St. Croix, St. Thomas, and St. John.

In addition to Forest Stewardship, the Forest Stewardship Coordinating Committee works with the Forest Legacy Program in the Territory. The Forest Legacy Program seeks to identify and preserve land in a forested state, either by outright purchase or by purchase of easements or deed restrictions that limit development on the land. By identifying landowners in priority areas who are willing to sell their property (or development rights), the program plans to preserve ecologically, historically, and culturally important forested land. Priority tracts of land were identified by the FSCC after public meetings and discussions with natural resource professionals through an Assessment of Need (AON) process. In 2009 the FSCC members reviewed the AON and determined that it needed just minor editing to be useful for an additional five years. The Forest Legacy Assessment of Need (AON) (Revised 2010) is attached to this document as Appendix E. Priority areas identified through the Statewide Assessment of Forest Resources will be targeted for future Forest Legacy proposals. As always, approval from the President and Congress is required to purchase land under this program. Upon approval, the VI Department of Agriculture is authorized to perform all the duties necessary to purchase land and/or easements according to guidelines from USDA. The Department will then hold title to and manage the land for maximum public benefit. These lands will be considered 'working' forests, and will be managed as such.

In January 2003, the Territory's first Assessment of Need (AON) for Forest Legacy was completed. This document identified six priority areas for conservation under the Forest Legacy Program in the US Virgin Islands: on St. Croix, the northwestern corner and east end; on St. Thomas, the north shore and the west end; on St. John, the east end and the south shore. The northwestern comer of St. Croix was chosen as the number one priority tract for Forest Legacy for the whole US Virgin Islands.

The FSCC chose the Annaly Bay/Hermitage Valley tracts, located in the northwest corner of St. Croix, as the lands to be submitted to the USDA Forest Service for the first funding under the Forest Legacy Program. Annaly Bay is one of the few undeveloped watersheds on St. Croix. Unfortunately, the original 2000 acres were rezoned for hotel and residential areas, and about 1,600 acres were sold for such purposes. As this first identified tract of land in the northwestern comer of St. Croix was longer available,

the FSCC identified other adjacent tracts of land that could be purchased for Forest Legacy. Funding has been provided by the Forest Service for two tracts of land in northwestern St. Croix to date. The owners of one tract removed the property from consideration for sale; instead, the owners plan to provide a 100% donation of a conservation easement on 30 acres of that property. This easement (the Armstrong easement) may serve as a local match for the second property (the Yusef property), once it meets the guidelines of the Forest Legacy Program. Title searches and surveys have been completed for both properties, and a "Yellow Book" appraisal has been completed on the Yusef property; it is now under review by the US Forest Service. It is hoped that the first land purchase under Forest Legacy will occur in FY2010. In addition, a property on St. John was proposed for Forest Legacy funding in October 2009. Although this property was not chosen for funding this year, it will be resubmitted in October 2010.

Federal funding is the key to the Forest Legacy Program in the US Virgin Islands. The VI government has no funds available for this program, and without federal funding, the VI Department of Agriculture would have no forestry programs at all. However, public opinion is in favor of protecting land in the northwest comer of St. Croix as this area has historical, cultural, and ecological significance to the people of the USVI. With the help of the USDA Forest Service, the Forestry Division of the VI Department of Agriculture hopes to eventually spur the development and operation of a territorial park in the Forest Legacy area on St. Croix. The VI Government already owns several parcels in the northwestern comer of St. Croix; the plan is to purchase one parcel of land that will connect those already owned to create a corridor of protection for wildlife and plants as well as protect soil and water resources.

Urban and Community Forestry

Introduction

The U.S. Virgin Islands are part of the Antillean Island of the Caribbean Sea and are comprised of the four main islands of St, Croix, St. John, and St. Thomas and Water Island and roughly 50 smaller, mostly uninhabited islands and cays. The ecosystem of the Virgin Islands can best be described as sub-tropical dry forest, but each individual island retains a unique combination of flora and associated fauna due to weather patterns, size, and topography. As tourism is the main economy of the Virgin Islands and there is no timber industry to speak of, forest resources serve the community through their aesthetic qualities - providing the distinctly "tropical" look that visitors to the islands seek. The Virgin Islands forests also provide precious shade for the community and often play a large role in food production as many tropical trees provide edible fruit. Often not considered by many island residents, the urban forest of the Virgin Islands plays a very important role in their lives. Besides providing shade, urban trees significantly reduce pollution from vehicles by absorbing exhaust, absorbing heat from concrete areas, controlling and subduing noise, increasing property values, and cutting air conditioning costs. New research has shown that urban areas that have trees have lower crime rates, providing improved physical and mental health of residents. The urban forest is vital to the communities of the US Virgin Islands, and the islands need significant management strategies to maintain and improve their forests for the benefit of visitors and residents alike.

The Urban and Community Forestry Program of the Virgin Islands offers opportunities to provide and enhance the islands' urban forests. The main focus of the program for its eleven years of operation has been the provision of small grants to organizations interested in projects that improve the VI urban forest, through tree planting, tree preservation, educational workshops, and skills trainings. While funding these projects is an essential component of the Program, there is much potential for work in other areas, such as direct outreach and education, organization of tree planting efforts in communities, and working on a tree ordinance for the territory. As there are no municipal government entities on the islands, the Urban and Community Forestry Program Coordinator serves much more at a local level with many communities

than other state coordinators. There is a great need to update resources for members of the community and provide education about the importance of urban trees, which is a new goal for the Program that is reflected in the FY2010 budget for this program.

According to the recent analysis performed for the 2010 US Virgin Islands Forest Resource Assessment, the urban forest of the Virgin Islands covers a significant amount of land on the islands; 48% of St. Croix's forest cover is urban forest, while 30% of St. Thomas's forests are in urban areas. St. John has much less at 1% (due mainly to the fact that the VI National Park covers the majority of the island) and there is no data for Water Island. Most residents of the Virgin Islands (95%) live in an urban environment. Urban forest land cover can mean a wide variety of vegetation, including large landscape trees but also including many woody scrubland patches in the urban environments of the islands. One of the goals of Urban Forestry throughout the US is to increase canopy cover, and that is true also for the Virgin Islands. A project funded by the US Forest Service and directed by the Virgin Islands Resource and Development Council will provide the territory with a full inventory of street trees on St. Croix in 2011. This tree inventory will assist with the Urban & Community Forestry Program's goals to determine areas where improvements can be made in the urban forest vegetation structure, increasing canopy and creating aesthetically pleasing areas where currently patchy scrub exists. The continued funding of the Urban and Community Forestry Program will aid in this goal.

Forest Health Protection

Introduction

The mission of Forest Health Protection is to protect and improve the health of America's rural, wildland, and urban forests. The US Forest Service Forest Health Protection staff includes specialists in forest entomology, forest pathology, invasive species, pesticide use, survey and monitoring, suppression and control, technology development, and other forest health-related services. Staff is located in the national headquarters, in all regional offices, and in the International Institute of Tropical Forestry in Puerto Rico.

Forest Health Protection provides technical assistance on forest health-related matters, particularly those related to disturbance agents such as native and non-native insects, pathogens, and invasive plants. Staff provides forest insect, disease and invasive plant survey and monitoring information, and technical and financial assistance to prevent, suppress, and control outbreaks threatening forest resources. This program helps to maintain, enhance, and restore healthy forest conditions and look for links between changing climate and pest conditions.

There are several programs available under Forest Health Protection. Forest Health Management programs and services direct and implement measures to prevent, slow, or suppress unwanted native and non-native insects, pathogens, and plants affecting trees and forests. Technical assistance is available on technologies available to maintain healthy forests. The Forest Health Monitoring program studies the forests of the US to identify detrimental changes or improvements in forest health occurring over time, and provides annual reports of such monitoring. The Pesticide Use Management program provides technical information, advice, and training in managing and coordinating the use of pesticides in forest integrated pest management programs. It also maintains records of pesticide use on National Forest system lands and prepares human health and ecological risk assessments for a variety of chemical and biological pest management tools. The Technology Development program develops leading edge technologies that help carry out forest health protection work with more accuracy and cost efficiency. All of these programs work closely with USDA Animal and Plant Health Inspection Service to detect

introductions of new forest pests into the States and eradication of introductions that pose significant threats to forest resources.

The U.S. Virgin Islands does not have a timber industry per se, and there are no timber plantations in the islands. Various inventories and monitoring studies in the past have noted few significant threats to forest health in the US Virgin Islands. The VI Department of Agriculture currently has a small grant for forest health in which the most significant invasive species in the islands that are detrimental to forest health are being identified. Although forest health does not appear to be at risk at present, climate change could alter this situation dramatically. In future, the VI Department of Agriculture may wish to include forest health monitoring and other forest health protection measures as strategies to improve forest resources in the US Virgin Islands. At present, the US Virgin Islands are not even listed under the Forest Health Monitoring program on the Forest Service website.

Conservation Education

Introduction

The Conservation Education program helps people of all ages understand and appreciate our country's natural resources, and learn how to conserve those resources for future generations. Through structured educational experiences and activities targeted to varying age groups and populations, conservation education enables people to realize how natural resources and ecosystems affect each other and how resources can be used wisely. Conservation education can help people develop the critical thinking skills they need to understand the complexities of ecological problems. Conservation Education also encourages people to act on their own to conserve natural resources and use them in a responsible manner by making informed resource decisions.

Education about climate change is a major goal of the US Forest Service's Conservation Education program. Climate change is significantly impacting the lands managed by the US Forest Service. These lands are managed to sustain their diversity and productivity, in order to provide for both the needs of today's and future generations. The Forest Service has developed materials to help communicate the effect that climate change will have on forest resources and the impacts of climate change and air pollutants on forests and grasslands. This research already identifies trends and subsequent effects to ecosystems across the United States.
The Forest Service strategy for dealing with climate change is based on years of targeted research and a century of science and management experience on public and private forest land. As a result, the Agency has highly skilled and experienced land managers, internationally recognized climate scientists, and a body of peer-reviewed scientific information for developing responses to climate change.

Although the Conservation Education Program does not have its own funding mechanism, education is a goal of all State and Private Forestry programs identified in this Appendix. The Forest Service provides specific educational programs and links to other programs on the Forest Service website. Technical assistance in both the Forest Stewardship Program and the Urban and Community Forestry Program often includes conservation education for participants and the public at large. In the next five years, when possible, conservation education will be incorporated into the delivery of all forestry programs in the US Virgin Islands. As regards climate change, education programs will need to address these effects on forest resources on all islands, including the US Virgin Islands. It is hoped that other island territories will join the US Virgin Islands to promote education on the effects of climate change on islands.

State Fire Assistance and Volunteer fire Assistance

Introduction

The purpose of the State Fire Assistance Program is to provide financial, technical and related assistance to State Foresters or equivalent State officials and through them to other agencies and individuals. Funding provided through State Fire Assistance should be focused to address critical preparedness needs and hazard mitigation. Critical preparedness needs include firefighter safety, fire planning, firefighter training, increased initial attack capability, and mobilization readiness for the efficient suppression and prevention of wildfires on non-Federal forestlands and other non-Federal lands. Hazard mitigation activities should focus on hazard fuels reduction, Community Wildfire Protection Plans (CWPPs), prevention and mitigation education, Firewise programming and community hazard mitigation. State Fire Assistance funding promotes sustainable economic development, both traditional and non-traditional partnerships and service excellence.

The purpose of Volunteer Fire Assistance is to provide financial, technical and related assistance to State Foresters for organizing, training and equipping rural fire departments. State Foresters pass this funding through to local fire departments and fire training academies. This program authorizes expenditure of federal funding to prevent and suppress rural fires and enhance protection capabilities by assisting rural communities with training, equipment, and organization of the fire service. Fire departments in communities with populations of 10,000 or less are eligible for these grants. Distribution of available VFA funds should be given out with an emphasis on the most needy. Funding provided through Volunteer Fire Assistance should be focused to address wildland-urban interface issues and needs for communities at risk in the wildland-urban interface. Issues and needs include firefighter safety and training, enhancing community water supply and delivery capabilities, communications, and equipping.

Virgin Islands Fire Service

In the US Virgin Islands, the Fire Service is not part of the primary forestry organization, but rather is an independent entity under the Office of the Governor. Unlike other fire services that work on forest fires (wildfires) only, the VI Fire Service is also responsible for structural fire in the territory. There are several fire stations in rural areas in the US Virgin Islands that are responsible for both wildland fires and structural fires in their communities. The VI Fire Service is in need of additional funding for training, equipment, and capacity building in the next five years.

The Virgin Islands Fire Service is a governmental agency which responds to all types of fire outbreaks in the territory. Most of its responses are for structural and other urban incidents, but during the dry season the Service has to respond to what is locally termed "brush fires." Brush fires do affect forested areas as they move from grasslands on the flatter areas up through the forested hills. The Virgin Islands Fire Service receives financial assistance from the US Cooperative Fire Program for equipment/apparatus and training of personnel to respond to these wildland fires.

The VI Fire Service personnel, with proper training, can play a role in the conservation of the existing forests. Trained personnel could help decrease incidents of brush fires through educational programs which Fire Service personnel can do as outreach. Outreach can be geared to property owners in the areas most prone to brush fires, as well as to the general public through public service announcements or other forms of educational media. Stakeholders in preserving local forests from wildland fires include local property owners, the volunteer rescue group on Water Island and the VI Fire Service on the other three islands.

Appendix C- GIS Data References and Methods

Modeling

Weighted layers were combined to identify priority issues for each issue. Each weighted layer was transformed into 15m, 15m cell UTM Nad83 m Zone 20N raster grid. This size was based on the IITF land cover classification by Todd Kennaway (2008). Each raster was matched to the IITF land cover raster and coded a 1 for the analyzed attribute or 0 for non-analyzed attributes. Each layer was given a weighted value in percent and then added to the other values resulting in values from 0-1 unless there were data discrepancies. The product was then categorized from very low to very high priority threats or areas by Jenks natural breaks. Each issue product raster was reclassified into values of one to five (1-5) from very low to very high.

Layer metrics

Fragstats 3.3 was used to assess class and patch statistics for the IITF forest and developed layers. Hawth's tool was used to analyze forest and non-forest found in the priority areas.

Data and Analysis Needs

Forest assessment and analysis especially regarding trends and change over time have been poorly tracked and studied in the U.S. Virgin Islands. There continues to be a lack of baseline data collection, lack of data sharing, and a lack of trained staff with appropriate knowledge about forest analysis in the Virgin Islands. During the process of this forest assessment, data needs have been identified and ranked as follows:

1. Cadastral parcel layer tracking land use change and variances issued
2. Defined census block data or sub-block data to defined populations. Existing layers are missing for St. Thomas and St. John
3. Tree Canopy Layer from LIDAR
4. Corrected water drainage
5. Infiltration rates correlated to forest cover (ground tests)
6. Roads classified and corrected for paved and unpaved
7. Wind Models
8. Rain Models

Base Data References

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USACE 1994b Black and White Aerial Photos of the U.S. Virgin Islands. *Survey #93-366 STX, #93-367 STJ, #93-368 STT*.

USACE 1994c Elevation Models of the U.S. Virgin Islands. *Survey #93-366 STX, #93-367 STJ, #93-368 STT*.

USACE 1994d Major Roads of the U.S. Virgin Islands. *Survey #93-366 STX, #93-367 STJ, #93-368 STT*.

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Products Derived from Analysis and Base Data

1. **Development Edge (0-20%) window**. 2009.Raster Geographic Consulting. From (USDA-IITF and Kennaway, 2009) Reclassified image to represent devloped (1) non-developed 999, passed average parcel size of 4 ha window in fragstats 3.3 over image to create percentage of landscape from 0-100 %, reclassified 0-20% as (1) to represent edge of influence of developed areas

2. **Development Level 2009**. Raster. Geographic Consulting. From (USDA-IITF and Kennaway, 2009). Added a value from 0-6 for each soil type and land use suitability classes of (Cultivated Crops, Pasture Hay, Urban Use, Recreational Value, Wildlife Habitat) and calculated ration of wildlife value to sum to classify Low, Med, High wildlife, forest suitability

3. **Elevation Model Shading**. 2009. Raster. Geographic Consulting. From (USACE 1994. TIN)

4. **FEMA Flood Hazard**. 2007. FEMA (FEMA Case 00-0200005. Vector)

5. **Fire Hotspots**. 2009.Vector Geographic Consulting. From (VIDOA et al., 2009a). Verbal and tabular hotspots by Estate identified by Lt. Fire Chief

6. **Fires by Estate**. 2009. Vector Geographic Consulting. From (VIDOA et al., 2009b). Verbal and tabular hotspots by Estate identified by Lt. Fire Chief

7. **Forest Fragments (5-40 acres)**.2009. Raster. Geographic Consulting. From (Todd Kennaway 2008. IITF Caribbean Landcover Classification. Raster. 2001) Transformed land class to vector retaining raster squares and added attribute of developed, forest and non-forest. Extracted forest patches between 5 and 40 acres, transformed to raster and reclassified to 1, 0

8. **Forest Ownership**. 2009. Raster. Geographic Consulting. From (IITF 2009. Conservation Lands. Vector. 2009) Represented public and non-profit properties on conservation and non-conservation management strategies

9. **Forest Patch >100acre**. 2009. Raster. Geographic Consulting. From (Todd Kennaway 2008. IITF Caribbean Landcover Classification Raster 2001) Transformed land class to vector retaining raster squares and added attribute of developed, forest and non-forest. Extracted forest patches greater than 100, transformed to raster and re-classed to 1, 0.

10. **Forest Suitability**. 2009. Raster. Geographic Consulting From (NRCS 2008. VI Soil Census. Vector. 2008) Added a value from 0-6 for each soil type and land use suitability classes of (Cultivated Crops, Pasture Hay, Urban Use, Recreational Value, Wildlife Habitat) and calculated ration of wildlife value to sum to classify Low, Med, High wildlife, forest suitability

11. **Forest Types**.Todd Kennaway Raster. 2008. IITF Caribbean Landover Classification 2001

12. **Guts (USGS et al., 2008)**.Vector. 2008. NHDFlowline (National Hydrographic Dataset)

13. **Holdridge Life Zones**. 2009. Vector. Geographic Consulting (Adapted from Brandeis 2007).

14. **Impervious (dev>1acre)** 2009. Raster. Geographic Consulting. From (Todd Kennaway 2008. IITF Caribbean Landover Classification Raster 2001). Transformed land class to vector retaining raster squares and added attribute of developed, forest and non-forest. Extracted developed patches greater than 1 acre, transformed to raster and reclassified to 1, 0.

15. **Impervious Surface** STJ 2005.Raster. NOAA (LiDAR Data)

16. **Impervious Surface** STX, STT 2002. Raster. NOAA (LiDAR data)

17. **Lack forest cover (0-20%)**.2009. Raster. Geographic Consulting. From (Todd Kennaway 2008. IITF Caribbean Landover Classification Raster 2001). Re-classed image to represent forested (1) non-forest 999, passed average parcel size of 4 ha window in fragstats 3.3 over image to create percentage of landscape from 0-100 %, re-classed 0-20% as (1) to represent edge of influence of forested areas.

18. **Land use change 89-99**. 2009. Raster. Geographic Consulting. From (UVI-ECC-CDC, 2003). Land use change organized into change from undeveloped. to other land uses, transformed to raster and re-classed to developed (1).

19. **Population Change** (1990-2000). 2009. Raster. Geographic Consulting. From (US Census 1990 and 2000, vector, tabular 2008) Utilized Census tracts from 2000 and data from 1990 to create comparison and change by tract area, transfomed to raster and created increase areas (1) other (0)

20. **Protected Areas**. (Goiuld et al. 2010) 2009. Raster. Geographic Consulting. From (IITF Conservation Lands. 2009 vector). Transformed protected areas to raster and gave value of 1

21. **Rapid Environmental Assessment (REA)**. Vector. 2000. UVI Conservation Data Center, Gibney et. al.. 2001, 1994-2000

22. **Riparian Zones (100' buf)** . 2009. Raster. Geographic Consulting. From (NHDFlowline 2008.National Hydrographic Dataset). Buffered NHDselected water flow lines at 100' each side, transformed to raster and re-classed to riparian 91) and not (0). 100' based on Title 30.chp3.subchp.II subsec 67. “No tree or other vegetation shall be cut or otherwise destroyed within 100’ on either side of a water course or any ravine “gut” or spring”.

23. **Rural Future Zones**. 2009. Raster. Geographic Consulting. From (CLWUP PDF Maps 2004 CDC) Transformed PDF to .tif and Geo-referenced image to 2007 aerial photos and digitized zones based on intensity districts, transformed to raster then re-classed on the proposed urban definition intensity districts of D-1 and D-2

24. **Sea Level Rise**. 2009. Raster. Geographic Consulting. From (USACE, 1994) Transformed Elevation Tin to arcgrid and re-classed to represent cm and result in sea level change

25. **Slope >20%**. 2009. Raster. Geographic Consulting. From (TIN 1994. USACE) Calculated in 3D analyst slope by percent and re-classed for (0-20%) 0 and >20% (1)

26. **St.Croix Forest Change**.2009. Raster. Brian Daley. 1992-2002

27. **STX Stable Forest**. 2009. Raster. Brian Daley. 1992-2002

28. **STX Unstable Forest**. 2009. Raster. Brian Daley. 1992-2002

29. **Urban Future Zones**. 2009. Raster. Geographic Consulting. From (CLWUP PDF Maps 2004 CDC) Transformed PDF to tif and Geo-referenced image to 2007 aerial photos and digitized zones based on intensity districts, transformed to raster then re-classed on the proposed urban definition intensity districts of D-3 and D-6.

30. **Urban Populations**. 2009. Raster. Geographic Consulting. From (US Census 2000, vector, tabular) Prioritized to represent census blocks of population densities greater than .78 persons per acre. Note block values based on weighted 10% 2008 analysis.

31. **Virgin Islands Estates**, IRF, CDC 2000. USACE 20002

32. **Virgin Islands Forest Cover**. Raster. 2009. Geographic Consulting. From (Todd Kennaway 2008. IITF Caribbean Landcover Classification Raster 2001) Reclassified all forest types to one (Forest).

33. **Waterbody**. Vector. 2008. NHDWater (National Hydrographic Dataset)

34. **Watershed Risk Level**. 2009. Raster. Geographic Consulting. From (TNC, 2003) and (DPNR, 2000)

35. **Watersheds sub-basin**. IRF, CDC 2003

36. **Wells.** 2002. USGS and EPA well testing sites from 1956-2002

37. **Wetlands/Ponds** (150' buffer). Raster. 2009. Geographic Consulting. From ( ) Buffered NHD Waterbodies at 150' outside, combined with water bodies, transformed to raster and

re-classed to water (1) and not (0). 150' based on Subchapter IV section 261 of the proposed land use and water plan.