



Vegetation Map of Virgin Islands National Park, St. John, United States Virgin Islands

Natural Resource Report NPS/SFCN/NRR—2022/2401



ON THE COVER

View of a coastal hedge along Drunk Bay with the peak of Ram Head in the background.
Photograph by: Tiara Thanawastien

Vegetation Map of Virgin Islands National Park, St. John, United States Virgin Islands

Natural Resource Report NPS/SFCN/NRR—2022/2401

Tiara Thanawastien^{1, 2}, Kevin R. T. Whelan¹, Robert B. Shamblin¹, Helena C. Giannini¹, Judd M. Patterson¹, Pablo L. Ruiz¹

¹National Park Service
South Florida / Caribbean Network
18001 Old Cutler Rd., Suite 419
Palmetto Bay, FL 33157

²Florida International University
Southeast Environmental Research Center
University Park Campus
Miami, FL 33199

June 2022

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible and technically accurate.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the [South Florida Caribbean Network website](#) and the [Natural Resource Publications Management website](#). If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Thanawastien, T., K. R. T. Whelan, R. B. Shamblin, H. C. Giannini, J. M. Patterson, and P. L. Ruiz. 2022. Vegetation map of Virgin Islands National Park, St. John, United States Virgin Islands. Natural Resource Report NPS/SFCN/NRR—2022/2401. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/nrr-2293266>.

Contents

	Page
Figures.....	v
Tables.....	vi
Appendices.....	vi
Contributors	vii
Project Summary.....	viii
Acknowledgments.....	ix
Introduction.....	1
Virgin Islands National Park, US Virgin Islands, St. John.....	1
History	3
Natural Resources.....	4
Drivers and Stressors.....	5
Vegetation Inventories.....	7
Methods.....	9
Phase 1: Assessment of the 1994 University of the Virgin Islands' Vegetation Map.....	9
Field Methods & Point Selection	9
Accuracy Assessment Determination.....	11
Phase 2: Virgin Islands (VIIS) National Park Vegetation Map.....	11
Imagery.....	12
Light Detection and Ranging (LiDAR).....	12
Spectral Indices	12
Vegetation Classification System.....	13
Photo-interpretation.....	13
Topology Check	14
Training Points and Accuracy Assessment Points Selection.....	14
Accuracy Assessment.....	14
Results and Discussion	15

Contents (continued)

	Page
Phase I: University of the Virgin Islands' (UVI) Vegetation Map.....	15
Vegetation Map	15
Accuracy Assessment	17
Phase II: South Florida/Caribbean Network (SFCN) Vegetation Map	18
Vegetation Map	18
Accuracy Assessment	21
Comparison of the UVI and SFCN Vegetation Maps	23
Conclusion	28
Literature Cited	29

Figures

	Page
Figure 1. 1994 University of the Virgin Islands vegetation map of St. John, US Virgin Islands.	2
Figure 2. Virgin Islands National Park (VIIS)	3
Figure 3. Path of category 1 or greater hurricanes passing within 30 km of St. John, US Virgin Islands, between 1995 and 2000.....	7
Figure 4. 1994 University of the Virgin Islands vegetation map of Virgin Islands National Park.	9
Figure 5. Field datasheet used to collect vegetation data.....	10
Figure 6. Location of accuracy assessments points visited to verify the accuracy of the 1994 UVI and 2007 SFCN vegetation map for Virgin Islands National Park.....	11
Figure 7. 2007 South Florida Caribbean Network vegetation map of Virgin Islands National Park.	19
Figure 8. Comparison between the 1994 University of Virgin Islands (UVI) vegetation map and 2007 South Florida Caribbean Network (SFCN) vegetation maps of Virgin Islands National Park	25

Tables

	Page
Table 1. Spectral indices used to expand the dimensionality of the aerial imagery used to in the creation of the SFCN vegetation map of Virgin Island National Park.	13
Table 2. Area and percent cover for the thematic classes mapped in the 1994 UVI vegetation map.	15
Table 3. Number of accuracy assessment (AA) points, class accuracy, and percent map area for all the accuracy assessment points visited to assess the accuracy of the 1994 UVI vegetation map.	17
Table 4. Area and percent cover for the thematic classes mapped in the 2007 SFCN vegetation map.	19
Table 5. Number of accuracy assessment (AA) points, class accuracy, and percent map area for all the accuracy assessment points visited to assess the accuracy of the 2007 SFCN vegetation map.	22
Table 6. Difference in number of patches and mean, minimum, and maximum patch size area between the 1994 UVI vegetation map and the 2007 SFCN vegetation map.	23
Table 7. Difference in thematic class area between the 1994 UVI vegetation map and the 2007 SFCN vegetation map.	26

Appendices

	Page
Appendix A. Vegetation Classification System.....	A-1
Appendix B. Photo-interpreter Key	B-1
Appendix C. Confusion (accuracy assessment) matrix for the 1994 UVI vegetation map of Virgin Islands National Park.	C-1
Appendix D. Confusion (accuracy assessment) matrix for the 2007 SFCN vegetation map of Virgin Islands National Park.....	D-1

Contributors

Helena C. Giannini — Biological Science Technician¹

Judd M. Patterson — Data Manager¹

Pablo L. Ruiz — Biologist¹

Robert B. Shamblin — Biological Science Technician¹

Tiara Thanawastien — Resource Management Intern^{1,2}

Kevin R. T. Whelan — Ecologist¹

¹National Park Service, South Florida Caribbean Network, 18001 Old Cutler Rd., Suite 419, Palmetto Bay, FL 33157.

²Florida International University, Southeast Environmental Research Center, University Park Campus, Miami, FL 33199.

Project Summary

In 2009, the National Park Service (NPS) Vegetation Mapping Inventory funded the NPS South Florida Caribbean Network (SFCN) to evaluate the accuracy of a vegetation map produced by the University of the Virgin Islands (UVI) Eastern Caribbean Center, Conservation Data Center for Virgin Island National Park (VIIS). The UVI vegetation map of VIIS was completed in 2001 and was based on aerial imagery from 1994. VIIS park staff felt that the UVI vegetation map was relatively accurate, but recognized that no formal accuracy assessment of the product had occurred at the time of its creation.

The report that follows details the methods used by SFCN to 1) assess the accuracy of the 1994 UVI vegetation map of VIIS, and 2) create a new vegetation map for VIIS using aerial imagery from 2006-07 and Light Detection and Ranging (LiDAR) data. In addition, it contains an analysis of the UVI and SFCN vegetation maps, the accuracy assessment results for both vegetation maps, the vegetation classification key used, and the photo-interpreter key used on the SFCN vegetation map.

Both the UVI and SFCN vegetation maps of VIIS relied on aerial imagery and photo-interpreters to delineate vegetation communities. However, the SFCN vegetation map had the benefit of having LiDAR data available; a technology and data source not readily available when the UVI vegetation map was produced. In addition, the SFCN vegetation map benefited from technological advances in aerial image acquisition that significantly improved the quality and resolution of imagery used; GPS that allowed precise spatial location determination; and GIS science that permitted the viewing, layering, and manipulation of multiple data sources simultaneously. The SFCN vegetation map also benefitted from the use of digital orthophotographs that take into account the surface elevation, topography, of the earth and camera tilt.

The UVI vegetation map has an estimated map accuracy of 45.9% with a lower 90th Percentile Confidence Interval of 38.5% while the SFCN vegetation map accuracy is estimated at 87.9% with a lower 90th Percentile Confidence Interval of 82.0%. The SFCN vegetation map has approximately 2.1 times more detail, in the form of individual patches, than the UVI vegetation map does, 1,430 vs 686 patches, respectively. Mean patch size and maximum patch size are smaller in the SFCN vegetation map than in the UVI vegetation map. This results in the SFCN vegetation map being less homogeneous than the UVI map even though the total number of community types mapped are nearly identical, 27 vs 29.

Acknowledgments

We wish to acknowledge the National Park Service's National Vegetation Mapping Inventory Program for the funding of this project. We gratefully acknowledge Eleanor Gibney with the St. John Historical Society, Kermit Lewis with 3001 International, and Rudy O'Reilly with the United States Department of Agriculture. We would like to thank former Virgin Islands National Park employees Rafe Boulon and Christy McManus. We express our appreciation to Dr. James Fourqurean of Florida International University for providing the Resource Management Intern for this project. This report is a deliverable under task agreement #J2117072808. Finally, this project was greatly assisted by the efforts of Joaquin Alonso, Andrea Atkinson, Andrew Davis, Jose Luciani, Jeff Miller, Rachel Vargas, and Brian Witcher of the National Park Service South Florida Caribbean Network. Technical editing, document formatting, and 508 compliance provided by Lise Grace, Alyssa McGinnity, and Fagan Johnson from the National Park Service.

Introduction

The National Park Service (NPS) Vegetation Mapping Inventory Program (VMI) is a national program designed to classify, describe, and map the vegetation communities within all U.S. national park units except Alaska¹. The objective of the NPS VMI program is to provide vegetation inventory data for regional and national level management decisions while addressing the local management needs of each park unit. This program sets guidelines by which all NPS vegetation mapping products must adhere to. This ensures consistency throughout all park units and that all VMI mapping projects meet Federal Geographic Data Committee standards on vegetation classification system, metadata, minimum mapping unit, spatial accuracy, and minimum acceptable map accuracy (Owens 1999; Studd *et al.* 2013).

The NPS Biological Resource Management Division located in Fort Collins, Colorado manages the VMI and maintains a collaborative partnership with the United States Geological Survey Center for Biological Informatics, which provides scientific and technical oversight (Owens 1999). Since its inception in 1992, the NPS VMI has overseen 185 NPS VMI mapping inventory projects. All NPS VMI mapping products are expected to be completed by 2022. For more information regarding the NPS VMI program, please visit <http://science.nature.nps.gov/im/inventory/veg/>

In 2009, the NPS VMI funded the NPS South Florida Caribbean Network² (SFCN) to evaluate the accuracy of a vegetation map produced by the University of the Virgin Islands (UVI) Eastern Caribbean Center, Conservation Data Center for Virgin Island National Park (VIIS). This vegetation map hereinafter referred as the UVI vegetation map (Figure 1) was completed in 2001 and was based on aerial imagery from 1994 (Thomas and Devine 2005). VIIS park staff felt that the UVI vegetation map was accurate but recognized that it lacked a formal accuracy assessment.

The report that follows details the methods used by SFCN to assess the accuracy of the 1994 UVI vegetation map and the steps taken to create a new vegetation map for VIIS using aerial imagery from 2006-07 and Light Detection and Ranging (LiDAR) data.

Virgin Islands National Park, US Virgin Islands, St. John

Virgin Islands National Park (VIIS) was established on St. John in 1956. The park has an area of 6,182 hectares (15,276 acres) of which 2,383 hectares are on the island of St. John (Patterson *et al.* 2008)—one of two other islands, St. Thomas and St. Croix, that make up the United States Virgin Islands (USVI) archipelago. VIIS also includes about 2,286 hectares of submerged lands and most of Hassel Island located in St. Thomas's Charlotte Amalie Harbor (Figure 2).

¹ National parks in Alaska are being mapped by the Alaska Landcover Inventory Program (<https://www.nps.gov/subjects/aknatureandscience/aklandcover.htm>)

² SFCN is one of 32 inventory and monitoring networks established across the nation by the National Park Service.

Virgin Islands National Park

1994 University of the Virgin Islands Vegetation Map of Saint John, US Virgin Islands

National Park Service
U.S. Department of the Interior



Legend

Dry Forest

- Drought Deciduous Forest
- Gallery Semi-Deciduous Forest
- Semi-Deciduous Forest
- Semi-Evergreen Forest

Moist Forest

- Basin Moist Forest
- Gallery Moist Forest
- Upland Moist Forest
- Mixed Swamp

Woodlands

- Evergreen Woodland
- Semi-Deciduous Woodland

Mangroves

- Fringing Mangrove
- Mangrove Forest
- Mangrove Woodland
- Mangrove Shrubland

Shrubland

- Coastal Hedge
- Gallery Shrubland
- Mixed Dry Shrubland
- Sclerophyllous Evergreen Shrubland
- Thicket/Scrub

Grasslands

- Coastal Grassland
- Mixed Dry Grassland
- Pasture

Sparse Vegetation

- Beach
- Freshwater Ponds and Wetlands
- Salt Pond
- Salt Flat
- Rock Pavement

Anthropogenic

- Developed

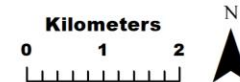
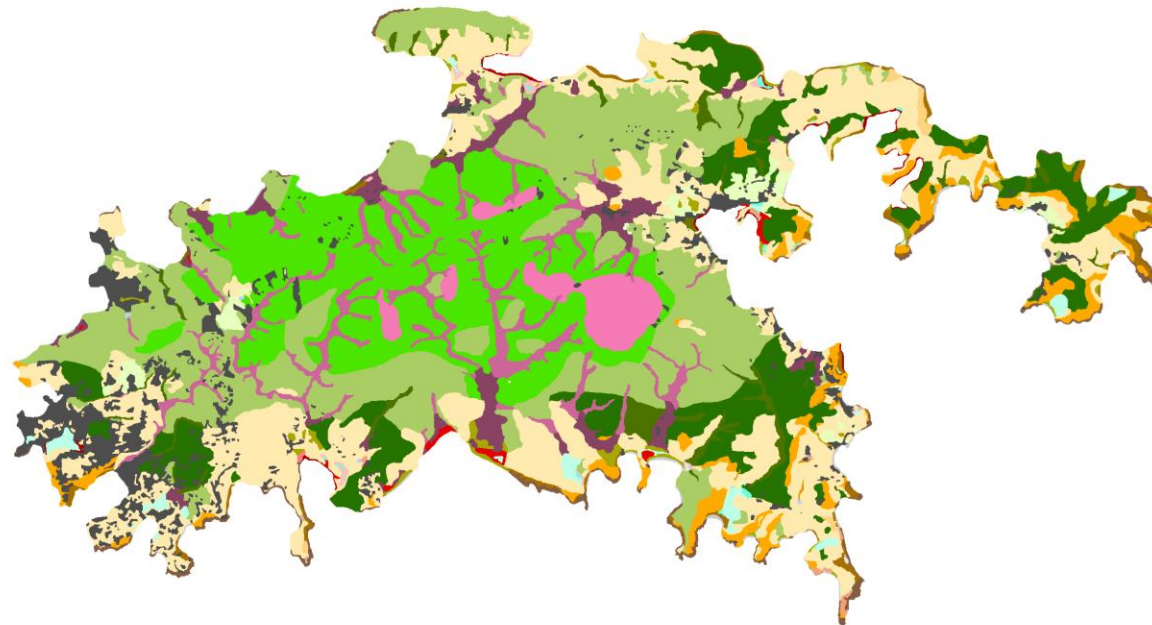


Figure 1. 1994 University of the Virgin Islands vegetation map of St. John, US Virgin Islands.

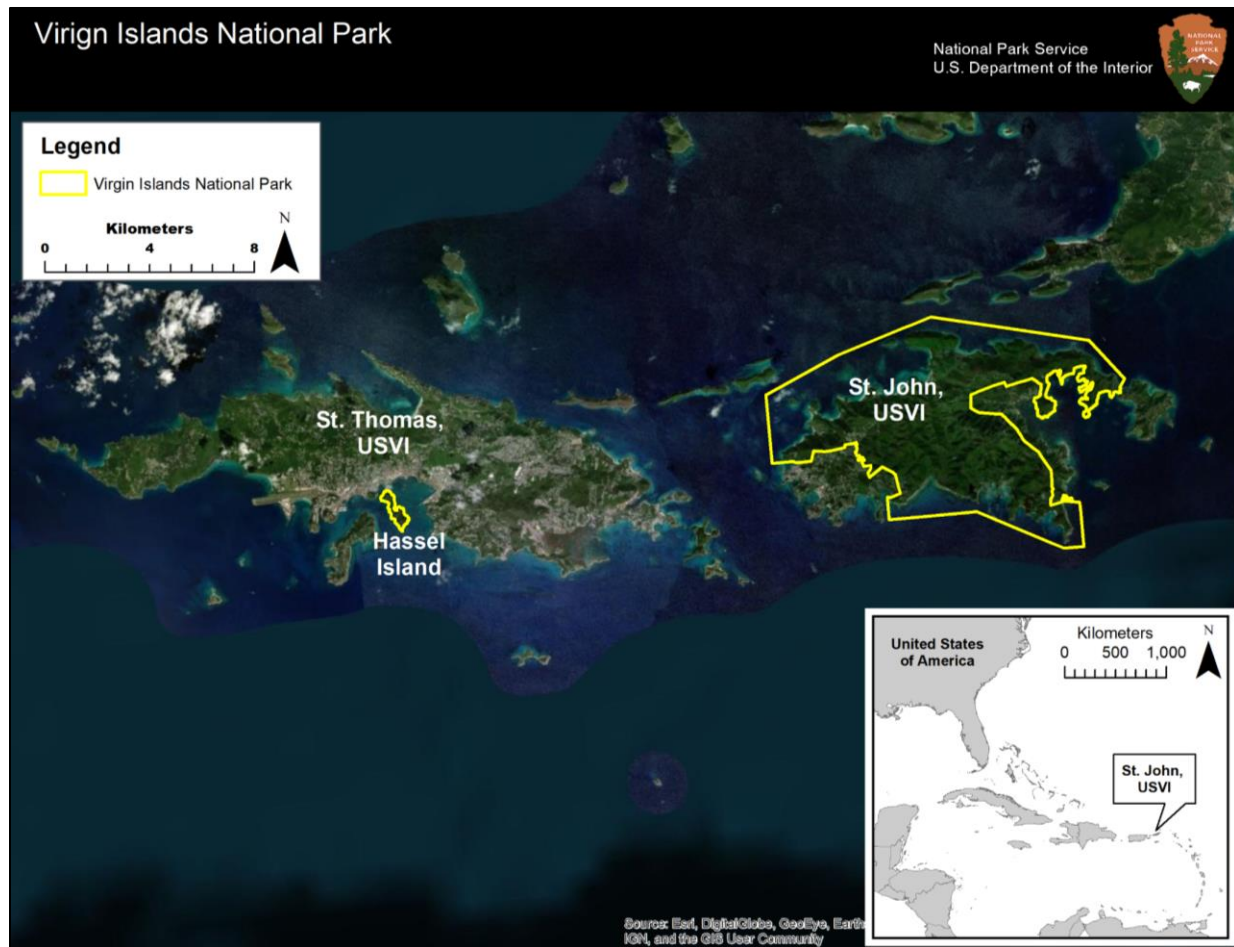


Figure 2. Virgin Islands National Park (VIIS). Park is outlined in yellow, including Hassel Island on the island of St. Thomas.

Approximately 60% of the land area in St. John is protected as part of VIIS. In 1976, the United Nations Educational Scientific and Cultural Organization, through its Man and the Biosphere program, designated the park a Biosphere Reserve (Patterson *et al.* 2008).

History

The USVI boasts a rich cultural history. The first people arrived in the Virgin Islands circa 2,000 BC, and migrations continued through 200 AD (Thomas and Devine 2005). The Saladoid people traveled from the interior of South America to the mouth of the Orinoco River and then island-hopped their way north to the Virgin Islands starting in 500 BC. Small villages popped up throughout the Virgin Islands between 200 BC and 600 AD. Between 600–1200 AD the Virgin Islands experienced large-scale agriculture, rapid population expansion, and a major cultural shift where pre-ceramic and ceramic groups eventually coalesced into the peaceful, Arawak-speaking Taíno group (Thomas and Devine 2005). Around 1,000 AD the Carib people, after whom the Caribbean is named, migrated from South America to the Virgin Islands.

In 1493, Christopher Columbus came upon the cluster of mountainous islands he claimed on behalf of the Spanish empire, naming them “Las Vírgenes,” and thus the islands are known today as the Virgin Islands (Knight 2001). Denmark set up a mercantile colony on St. Thomas in 1672 (Knight 2001). In 1718, the governor of the Danish West Indies, Eric Bredal, claimed St. John on behalf of Denmark (Knight 2010). Thousands of Africans enslaved by the Danish West India Company were imported to farm coffee, tobacco, cotton, and a great number of sugar plantations. A slave revolt in 1733 was foiled by French troops and was followed by a golden age of sugar and cotton production, as well as booming maritime commerce. In the early 1800s, during the Napoleonic War, St. John was occupied by the British.

The emancipation of slavery in 1848 ended sugar and cotton production in St. John, giving way to pastures, livestock and dairy production, subsistence farming, bay rum, and charcoal production (Weaver 2006). In 1917, fearing the possibility of a German naval presence in the Virgin Islands, the United States purchased St. John, St. Thomas, and St. Croix from Denmark. An American naval base was promptly established on Hassel Island, which remained in operation through World War II (Wild 2011).

Tourism in the USVI date back to the early 1920’s. By the 1950s tourism had become the island’s major industry (Wild 2011) and has been growing exponentially to over 2.3 million annual visitors by 2003 (Weaver 2006). A notable early visitor to St. John was Laurance S. Rockefeller. He was an influential figure in the American conservation movement, like his father John D. Rockefeller, Jr. before him (Winks 1997). Laurance Rockefeller was inspired by his visit and a 1930s NPS report and moved Rockefeller to purchase 2,023 hectares (5,000 acres) on the island (Wild 2011). This area was then donated to the federal government, and Virgin Islands National Park was born in 1956 when President Eisenhower signed public law 85-925. Congress approved new legislation to extend the park’s boundaries over 2,286 hectares (5,650 acres) of submerged land in 1962, and to include 55 hectares (136 acres) on Hassel Island in 1978. Through enabling legislation and further acquisitions, VIIS now totals 6,182 hectares (15,276 acres, Patterson *et al.* 2008). The adjacent Virgin Islands Coral Reef National Monument was established in 2001, protecting an additional 5,142 hectares (12,706 acres) of submerged land.

Today, the U.S. Virgin Islands are undergoing rapid urbanization and are under heavy developmental pressure. Rapid urbanization on St. John is fragmenting and reducing habitat outside and within (inholdings) the park. This increases related stressors such as construction impacts, hydraulic loading on septic systems, solid waste, invasive species, contaminants in island streams, and possibly increased freshwater runoff from lawns into dry natural areas which alter plant and invertebrate communities (Patterson *et al.* 2008).

Natural Resources

The U.S. Virgin Islands sits atop the submerged platform known as the Puerto Rico Bank (Rogers and Teytaud 1988). Rocks found on St. John and the rest of the archipelago include cretaceous basalt, andesite, keratophyre, their volcanoclastic and hypabyssal intrusive equivalents, and minor calcareous rocks and chert. This means that there is little soil development with most soil production related to the erosion of the base rocks.

St. John contains a number of tropical terrestrial, coastal and marine ecosystems. These include various types of moist and dry forests, salt ponds, beaches, mangroves, seagrass beds, coral reefs and algal plains. It has ephemeral freshwater streams (locally referred to as ghuts) and pools along with estuarine channels which support fish and aquatic invertebrates (Loftus 2003). Most of the vegetation on the island was cleared in the late 1700s and early 1800s, making the present forest mostly secondary growth (Rankin 2002). The dominant vegetation on St. John is dry tropical forest. Cacti, thorny legumes, grasses, and short trees with flattened crowns are common on wind-swept portions of the island (Patterson *et al.* 2008).

Some of the most diverse tropical dry forest left in the Caribbean are found on St. John (Gibney 2004). Of the 748 native or naturalized plants found on St. John, 643 species are indigenous and pre-date the arrival of humans on the island (Gibney 2004). St. John is a significant wintering habitat for neo tropical migratory birds (Askins *et al.* 1989). Marine environment consists of 34% coral reef and colonized hard-bottom, 20% submerged aquatic vegetation, 17% sand, and 28% unknown (areas deeper than 20 m, NOAA 2001). Sixteen federally listed endangered and threatened species have been observed at VIIS, including six species of marine mammals, three birds, three reptiles (all sea turtles), two marine invertebrates and two plants. Other faunal species include bats (9), birds (170), reptiles (14), insects (1000s), fish (300+) and numerous marine invertebrates (Patterson *et al.* 2008).

A significant amount of the vegetation on St. John is in a successional stage from historic land uses such as agricultural and residential uses. Even the earliest human inhabitants in the Virgin Islands practiced horticulture, and archaeologists estimate large scale agriculture may date back to sometime around 600 AD (Thomas and Devine 2005). The most notable impacts to St. John's vegetation occurred between 1730 and 1780, during the peak of sugar and cotton production, when most of the island was cleared for agriculture. After this Plantation Era, secondary forest began to re-colonize abandoned plantations (Woodbury and Weaver 1987). Drier and windier areas on St. John, such as the East End and the southern shore, were not as favorable for large-scale agriculture and so were not as heavily used. These areas have retained considerable diversity. Since the island was never entirely cleared at once, there was always a neighboring seed source from which native plants were able to re-colonize (Gibney 2004).

Drivers and Stressors

Topography is a major driver of St. John's vegetation communities. St. John has a mountainous terrain with steep slopes surrounded by small coastal plains. Half of the island is covered by slopes of 25% to 35% (Thomas and Devine 2005) with most of the slopes (80%) being greater than 30% (CH2M Hill 1979). Given this topography, location becomes a major driver of vegetation, as plants must adapt to different conditions in different places (Thomas and Devine 2005).

Climate, including rainfall, wind, and hurricanes, are the principal driver affecting the natural communities of the Virgin Islands. Despite their tropical latitude, cooling surrounding waters result in a subtropical climate, and seasonal variation in rainfall (Thomas and Devine 2005). Annual precipitation averages 890–1,400 mm and most of it falls between August and November (Woodbury and Weaver 1987). The dry season spans January to April and is followed by a short raining season during the month of May. Temperatures range from lows of 23°C in the winter and 25°C in the

summer, and highs from 29 °C to 32°C (Patterson *et al.* 2008). Easterly trade winds shape weather in St. John as they constantly blow west across the landscape, especially in the winter. Air quality is periodically impacted by clouds of African dust carried over the Atlantic Ocean.

The most common source of precipitation on the island is convection caused by the physical obstruction of the trade winds by the mountains (Woodbury and Weaver 1987). Higher elevations entail a moister and cooler microclimate, steep slopes are subject to rapid storm water runoff and erosion, hillsides are subject to low moisture, and lowlands are subject to flooding. Aspect, or the direction that a slope faces, influences vegetation in that it dictates how exposed a vegetation community is to elements like sun and wind. Prevailing winds carry away most of the moisture from south and east facing slopes which get more sun exposure and become drier. North and west facing slopes get more rain and moisture (Thomas and Devine 2005).

The U.S. Virgin Islands have an active Hurricane season that spans June to November. Hurricanes can physically damage vegetation, create canopy gaps, expose forests to potential stress, and reset succession processes. Direct hits on St. John are infrequent with only six category 1 or greater hurricanes approaching within 30 kilometers of St. John between 1995 and 2000 (Figure 3). Typical hurricane impacts include heavy rainfall, strong winds, powerful waves, high tides, flooding, and erosion. Hurricane impacts, like those from Hurricane Irma, with 155 kt winds, can be catastrophic (Cangialosi *et al.*, 2018).

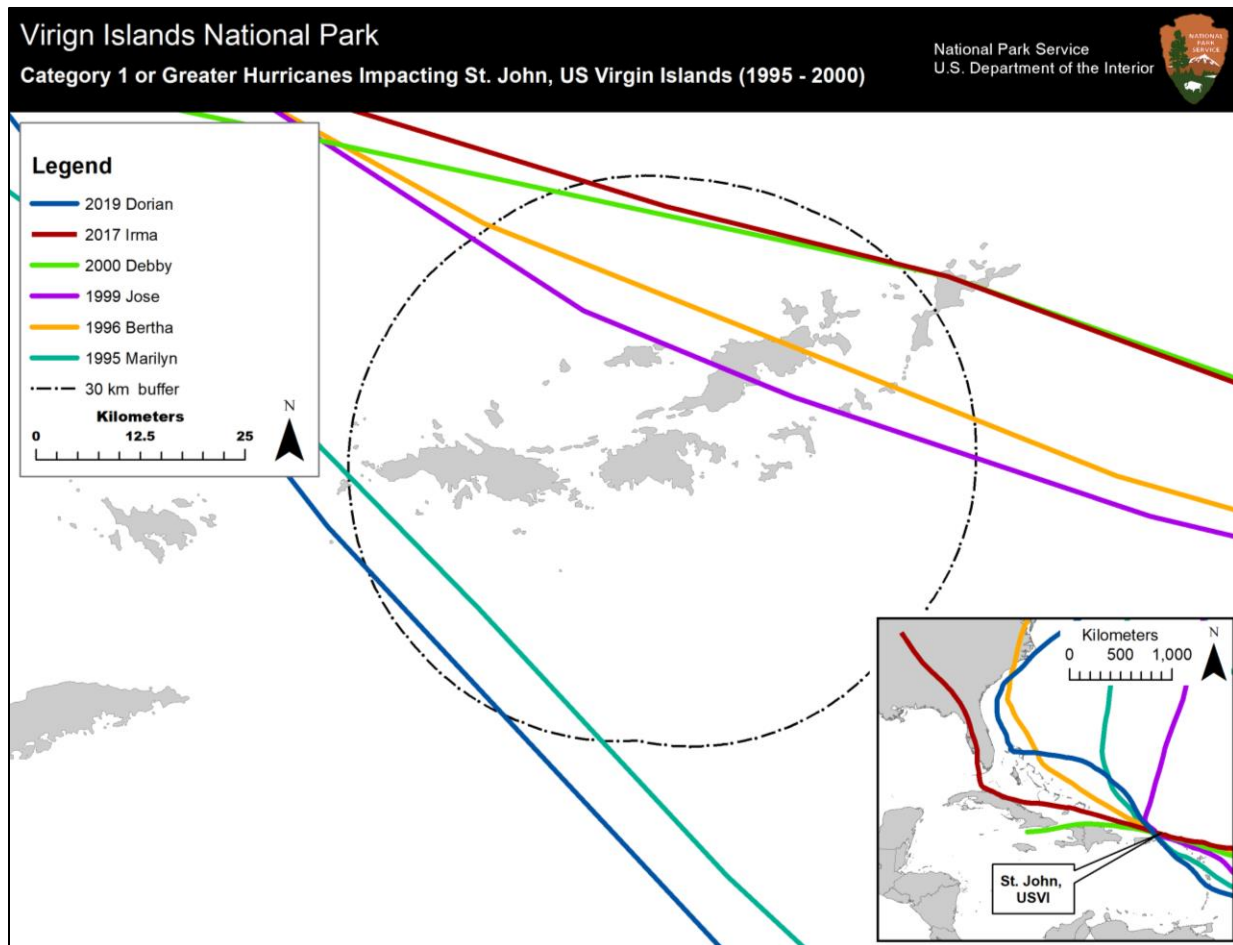


Figure 3. Path of category 1 or greater hurricanes passing within 30 km of St. John, US Virgin Islands, between 1995 and 2000 (data available from <https://coast.noaa.gov/hurricanes/>).

Vegetation Inventories

Botanists believe St. John was once almost completely covered by dense forests. Historical accounts give us a general understanding of the spatial and temporal scales of the anthropogenic effects on St. John's vegetation communities. Weaver (2006) outlines some of these major events, as follows. By 1725 the island of St. John has no large mature trees in its landscape. The most notable impacts to vegetation, however, occur between 1730 and 1780 during the peak of sugar and cotton production. A 1780s topographic land use map shows 40% of the vegetation on St. John has been cleared (Weaver 2006). By the end of the century, 60% of St. John was under sugar cultivation, with the remaining area largely devoted to cotton, tobacco, and coffee (Acevedo-Rodríguez *et al.* 1996).

The oldest records of botanical exploration on St. John date back to 1767 and are attributed to Oldendorp (1777) who described natural history and plant uses. Based on literature reviews and herbarium records, Acevedo-Rodríguez *et al.* (1996) profile fourteen botanists from the 1800s that collected plant specimens on St. John. These botanists deposited their specimens in museums and herbaria throughout the world. The first few publications on the flora of the Virgin Islands are attributed to West (1793), Schlechtendal (1828–1831), and Krebs (1847) (described by Acevedo-

Rodríguez *et al.* 1996). With the downfall of the plantation system in the mid-1800s, significant agricultural areas were abandoned, and vegetation communities began to slowly recover. The most significant botanical work from this time was “The Flora of St. Croix and the Virgin Islands,” an extensive catalog published by Eggers in 1879. He reported on historic land uses and described St. John as the most forested of all the Virgin Islands. He was also the first to study the plant communities in the Virgin Islands and described vegetation formations, such as littoral, scrubland, forest, and cultivated areas (Acevedo-Rodríguez *et al.* 1996).

This laid the groundwork for twentieth century vegetation work in the Virgin Islands. Acevedo-Rodríguez *et al.* (1996) profile seven botanists from the 1900s that collected on St. John. Publications by Millspaugh (1902), Urban (1902), Britton (1918), and Britton and Wilson (1923–1926) furthered the library of Virgin Islands and Puerto Rico floristic inventories. After a visit to St. John in 1913 Britton lamented that “there [was] but little natural forest remaining” and how it was confined to hilltops. He described rainfall quickly washing down hillsides and noted how little soil remained because of vegetation clearing and subsequent erosion (Britton 1918).

The first comprehensive vegetation map of St. John, and the first study to focus on the vegetation of VIIS and Hassel Island, was completed by Woodbury and Weaver (1987). They surveyed flora using a modification of Beard’s system (1944, 1949, 1955), in order to account for secondary vegetation and different moist forest types (Woodbury and Weaver 1987). They recognized two life zones (moist and dry) and ten formations (vegetation types). Their vegetation types are characterized by the physiognomy of the vegetation and are highly influenced by humidity (Acevedo-Rodríguez *et al.* 1996). Gibney *et al.* (2000) developed a comprehensive classification system for the USVI archipelago. This classification system was then used by UVI Eastern Caribbean Center, Conservation Data Center in a rapid ecological assessment of the USVI. In 2001, using this data and aerial imagery from 1994, UVI produced a vegetation map for USVI and VIIS (Thomas and Devine 2005).

Methods

The vegetation inventory for VIIS was accomplished in two Phases: Phase 1 – Assessment of the 1994 University of the Virgin Islands' vegetation map of VIIS National Park; and Phase 2 – the creation of a new, updated, vegetation map for VIIS National Park by SFCN.

Phase 1: Assessment of the 1994 University of the Virgin Islands' Vegetation Map

Field Methods & Point Selection

Two field expeditions, May 2009 and October 2009, were conducted to collect accuracy assessment plot data necessary to verify the accuracy of the UVI vegetation map for VIIS National Park (Figure 4). All vegetation plots (133) were sampled on foot, often traversing steep slopes and rugged terrain. Exception being a few sites located on steep coastal cliffs and cays where observation were made from a boat via binoculars.

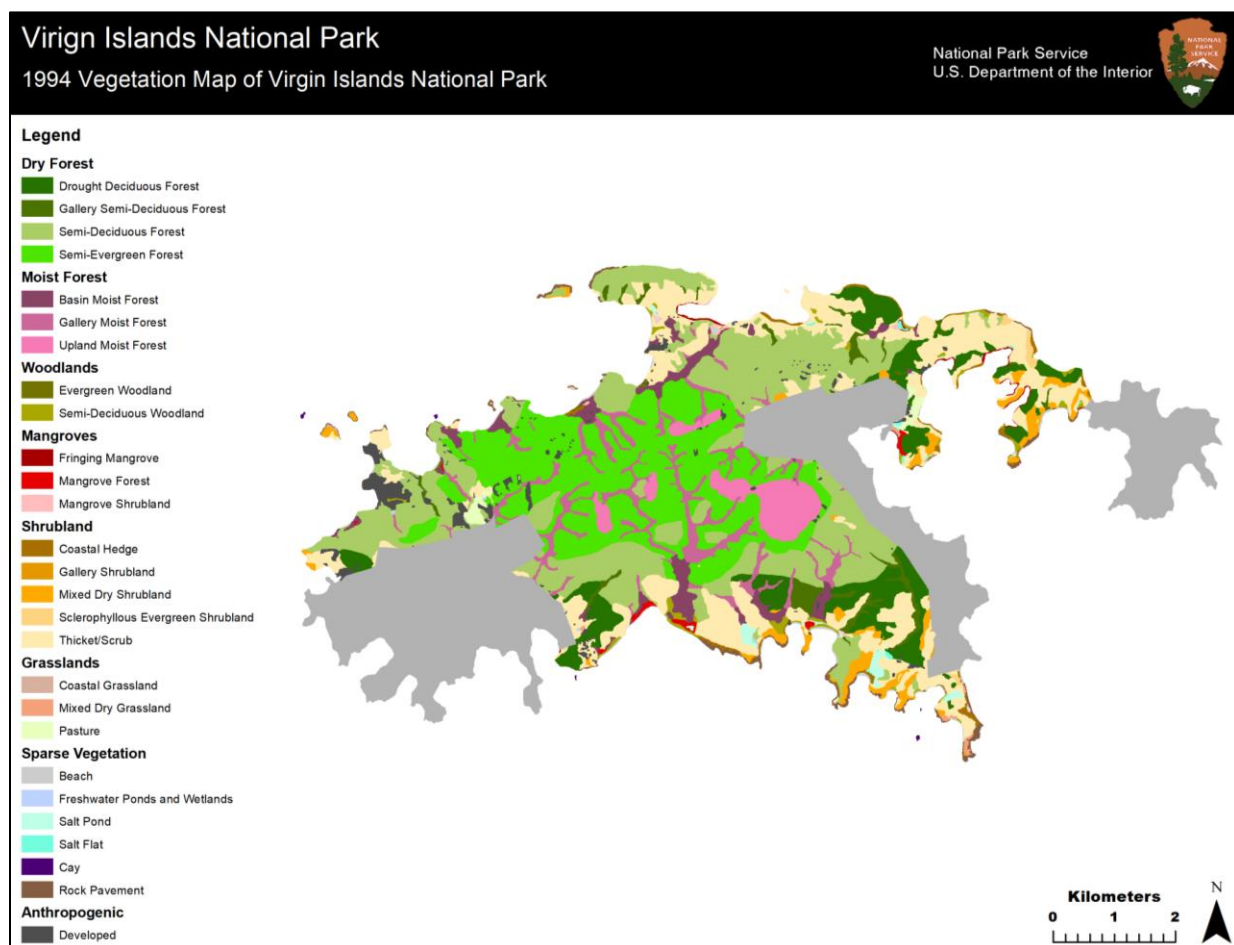


Figure 4. 1994 University of the Virgin Islands vegetation map of Virgin Islands National Park.

The accuracy assessment data consisted of two types of accuracy assessment (AA) points: preselected and non-preselected plots. Preselected plots were selected using a randomized stratified

sampling design (by vegetation type) in ESRI ArcMap prior to field work to ensure the proper sampling of each vegetation class being assessed. This sampling designed follows the methods outline in Lea (2010).

A Garmin GPSMap 60CSx GPS unit was used to navigate to these preselected field plots. Upon arrival at the plot center, a GPS coordinate was recorded after allowing for a 120 second collection period by the GPS. Standing at the center of the plot, the primary observer evaluated a circular 10-meter radius, 314.2 m² area, plot and populated the point datasheet (Figure 5). The data collected included: the structural and compositional data for the plot as well as the date and the observes present. Unknown plant species were bagged and tagged and keyed out later using the *Flora of St. John, U.S. Virgin Islands* (Acevedo-Rodríguez 1996). Field plot photos were also taken to preserve a visual representation of the plot at the time of visit. A total of 110 preselected points where collected.

Non-preselected plots were collected to replace preselected points while in the field or for unique vegetation community types encountered. These plots were used when the preselected point was not assessable due to steep slopes or cliffs or if a vegetation type found on the way to a preselected point was determined to be clearly different and unique. These non-preselected plots were treated in the same manner as preselected plots. A total of 23 non-preselected points where collected.

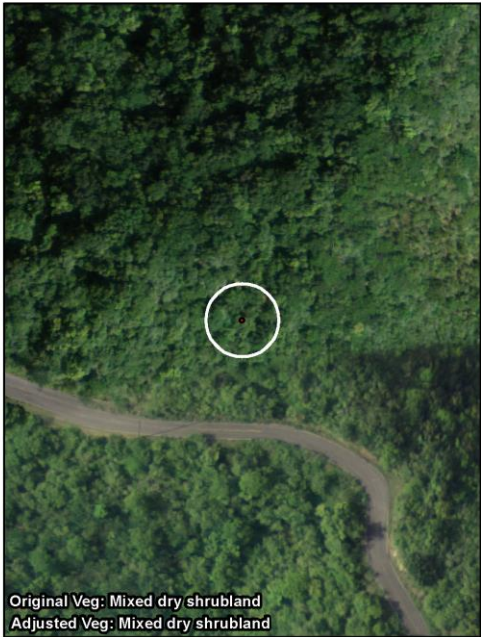
The AA data points (preselected and non-preselected) collected were entered into a Microsoft Office Access database and verified to ensure accuracy.

Point: AA2046

Photo #: _____
Mark #: _____ Unit: _____

Observers: _____ Date/Time: _____
Moved Point?: Y / N Why: _____

General Description of Cell and Veg. Type + Comments
(Structures, aspect, water cover, soil cover, etc.)



Original Veg: Mixed dry shrubland
Adjusted Veg: Mixed dry shrubland

0 10 20 40 Meters

Background Imagery: 2007 Army Corps

Slope: None Slight Moderate Steep

Corrected Veg Type: _____

Dominant Vegetation Type in Cell

Overall Canopy Cover (if present) _____%

Canopy Height (if present) _____m

Note: D = Dominant species % cover only estimated for dominant

Relative Cover of Dominant Species in Tallest Stratum (generally should add to ca. 100%)

Tree _____ % cover	Tree _____ % cover
1) _____	4) _____
2) _____	5) _____
3) _____	6) _____
Shrub _____ % cover	Shrub _____ % cover
1) _____	4) _____
2) _____	5) _____
3) _____	6) _____
Herb _____ % cover	Herb _____ % cover
1) _____	4) _____
2) _____	5) _____
3) _____	6) _____

Canopy (m) Tree: _____ Shrub: _____ Herb: _____

Figure 5. Field datasheet used to collect vegetation data.

Accuracy Assessment Determination

The thematic accuracy of the UVI vegetation map was evaluated using all the preselected and non-preselected AA points surveyed (Figure 6). Map accuracy was calculated as the total number of AA points considered acceptable divided by the total number of AA points collected (133 of which 110 were preselected and 23 were non-preselected, opportunistic, points). In addition, to determine whether the overall map accuracy was equal to or greater than 80% with 90% confidence as required by the NPS VMI, a 1-tailed 90% confidence level test was calculated using Zar (1999, p. 527).

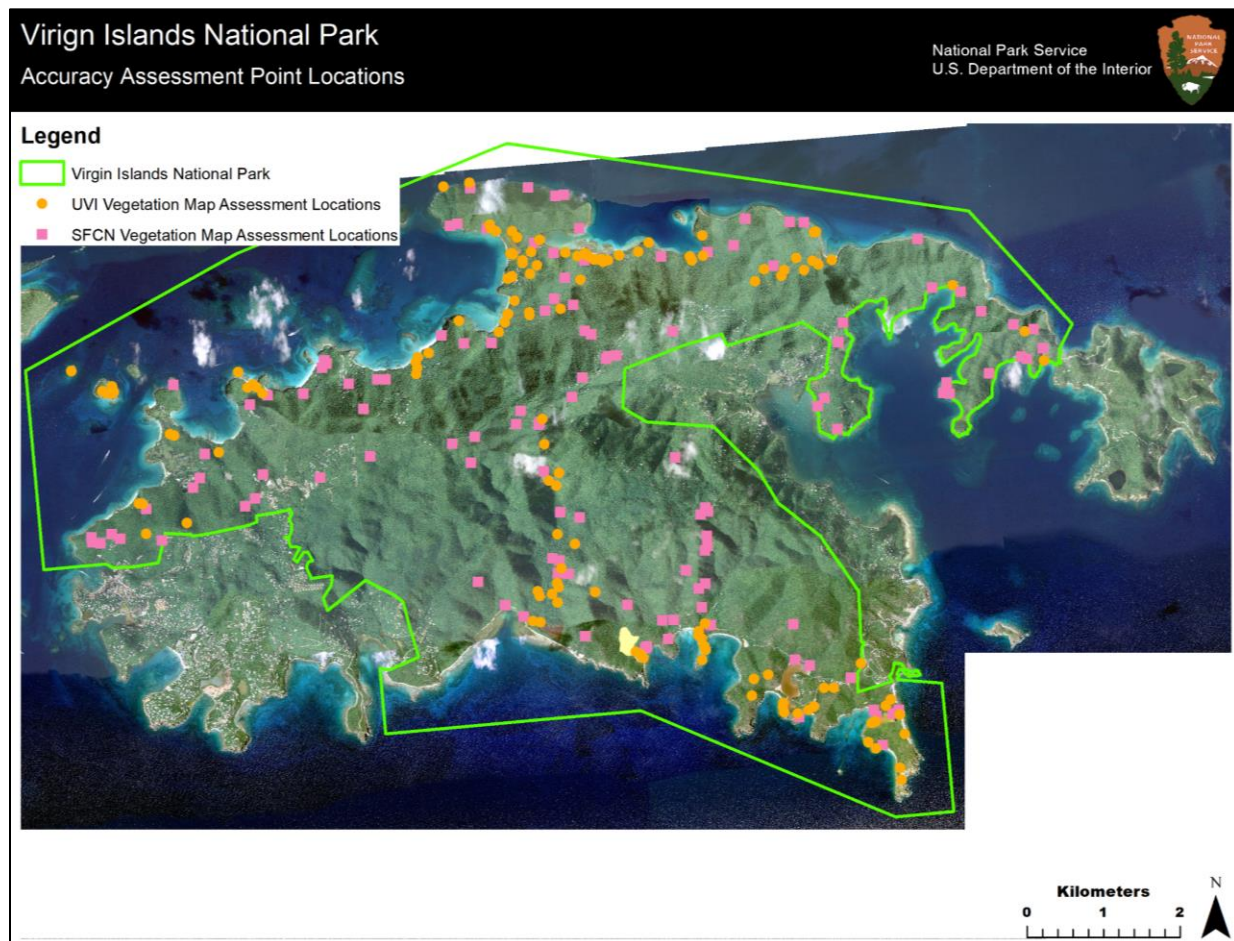


Figure 6. Location of accuracy assessments points visited to verify the accuracy of the 1994 UVI and 2007 SFCN vegetation map for Virgin Islands National Park.

Acceptable polygons included those for which the AA points had a one-to-one match between the vegetation class on the map and the field collected AA point data. Polygon thematic classes were accepted or rejected based on a thorough review of the AA data and the photos collected.

Phase 2: Virgin Islands (VIIS) National Park Vegetation Map

Following the accuracy assessment of the UVI vegetation map a new, updated vegetation map for VIIS was created. This map, the SFCN vegetation map, was created using aerial imagery and LiDAR from 2007

Imagery

The imagery used on the Phase 2 SFCN vegetation map consists of 1-foot (30.5 cm) ground sample distance 3-band natural color (Red, Green, Blue) orthophotos collected by the U.S. Army Corps of Engineers (USACE) in 2007. The raw imagery was collected using an ADS40 pushbroom scanner at a mean flight height of 8,650 feet (2,636.5 meters) above ground level. The imagery was flown with a 30% side lap between adjacent flight lines. The final post-process 8-bit radiometric resolution geotiffs were referenced to State Plane Puerto Rico / U.S. Virgin Islands (Zone 5200), NAD 83, GRS 80, Units Meters.

NPS verified the horizontal accuracy of the imagery by analyzing eight photo-identifiable control point locations. The control points were considered suitable if they were clearly and distinctly visible in the orthoimage and if they had a well-defined corner (e.g., dock or corner of building). In areas of the park without structures, the centroid of distinct rocks or shrubs were used if they were easily identifiable in the photo. Field crews visited each photo-identifiable location control point with a Garmin 60CSx handheld GPS unit. At each control points, field crews collected a single GPS point by averaging 120 positions estimates. The results of the horizontal accuracy test indicated that the position of the eight photo-identifiable control points had a horizontal root mean square error of ± 2.2 meters.

Light Detection and Ranging (LiDAR)

Light Detection and Ranging (LiDAR) data was collected at the same time the 2007 aerial imagery was acquired. The LiDAR data was flown under the supervision of a professional mapper/surveyor and at a density that meet Federal Emergency Management Agency guidelines and specifications. The LiDAR data is referenced to State Plane Puerto Rico / U.S. Virgin Islands (Zone 5200), NAD 83, GRS 80, Units Meters.

The LiDAR data was processed in ESRI ArcGIS to derive two separate spatial products: Slope – the steepness of the terrain; and Vegetation Wedge – the difference between the first return (typically the top of the canopy) and the last return (typically the ground) of the LiDAR data. Vegetation wedge is a good estimate of canopy height and forest structure.

Spectral Indices

The dimensionality of the spectral data (2007 orthophotos) was expanded by calculating several spectral indices in ESRI ArcGIS (Table 1). RGB-Reflectance and the Green-Red Vegetation Index were the most consistent spectral indices at distinguishing community types (Appendix B).

Table 1. Spectral indices used to expand the dimensionality of the aerial imagery used to in the creation of the SFCN vegetation map of Virgin Island National Park.

Index	Equation	Reference
RGB-Reflectance	Red + Green + Blue	–
Mean RGB Reflectance	$(\text{Red} + \text{Green} + \text{Blue}) / 3$	Ruiz et al. (2012)
Green-Red Vegetation Index (GRVI)	$\text{Green} - \text{Red} / \text{Green} + \text{Red}$	Gitelson et al. (2002)
Plant Pigment Ratio (PPR)	$\text{Green} / \text{Blue}$	Warren & Metternicht (2005)
Photosynthetic Vigor Ratio (PVR)	$\text{Green} / \text{Red}$	Warren & Metternicht (2005)
Red-Green Simple Ratio	$\text{Red} / \text{Green}$	Gamon & Surfus (1999)
Blue-Green Simple Ratio	$\text{Blue} / \text{Green}$	–

Vegetation Classification System

The vegetation classification system and community descriptions were derived from the original USVI plant community descriptions of Gibney *et al.* (2000), the Thomas and Devine (2005) field guide for USVI plant and marine communities, and the field data collected as part of this project. The vegetation classification system used on this project can be found in Appendix A.

Photo-interpretation

The photo-interpretation of the SFCN vegetation map was completed by overlaying the UVI vegetation map polygons over the 2007 USACE aerial imagery in ESRI ArcGIS. Each polygon on the UVI vegetation map was checked to ensure that it represented the correct thematic class and that its topology matched the 2007 imagery. Polygons that differed were edited through cutting and merging and attributed to the correct thematic class, as needed. The LiDAR data and spectral indices were used as separate layers to help differentiate community types and edges of communities based on vegetation wedge value, slope, and/or spectral characteristic (Appendix B).

A spreadsheet was used to track all changes to the SFCN vegetation map. It documented whether a polygon was modified, left alone, or created new; which layers (aerial imagery, vegetation wedge, slope, spectral indices) were used in the decision-making process; and if the thematic class of the polygon was modified. In addition, it served as a daily log of work completed and which polygons in the map still needed review.

Once the draft map was completed, 331 randomly selected polygons were checked by three separate photo-interpreters not involved in the original photo-interpretation of the map. These photo-interpreters verified that shape of the polygon and whether the thematic class used was correct for each of the selected polygon. In addition, they verified that there were no discrepancies between the training data and the polygon it represented. Out of the 331 polygons selected (22.7% of the total polygons), only 12 (3.6%) were found to have thematic class discrepancies and 28 (8.5%) had polygon linework errors. These errors were discussed with the original photo-interpreter and were corrected.

The final SFCN vegetation map is referenced to the Universal Transverse Mercator (UTM) Zone 20N, North American Datum of 1983 (NAD83). It has a minimum mapping unit of 200 m². However, inholding smaller than 200 m² were mapped.

Topology Check

The process of editing polygons, through cutting and merging, can result in the introduction of topological errors – overlaps and/or slivers (gaps) between adjacent polygons. These kinds of errors must be corrected to avoid incomplete features and to ensure data integrity. As a result, the topology of the SFCN vegetation map was verified in ESRI ArcGIS. All errors identified were checked and corrected to ensure that there were no topological errors in the map.

Training Points and Accuracy Assessment Points Selection

The AA data collected in Phase I of this project was repurposed to serve as photo-interpreter training points. This reduce the cost on the project since no additional field work was needed for the collection of photo-interpreter training data. However, a new draw of 200 AA points was needed for the accuracy assessment of the SFCN vegetation map.

The AA data points for Phase 2 of the project were selected by first removing a 50-meter buffer around all road, trails, and shorelines from the SFCN vegetation map. This was done to avoid edge effects and skewing the accuracy assessment results. Once these areas were buffered out, 120 AA points (60%) were place in polygons that had been changed during the update process. The remaining 80 AA points were distributed among unchanged polygons.

The two sets of AA points were distributed using the “Random Points in Polygons” tool. The “NEAR” tool was then run on the 200 random points to calculate the distance to the nearest AA point previously visited during the Phase I accuracy assessment of the UVI vegetation map. Any new random points within 50 meters of an already visited AA point from Phase I was dropped from the AA point pool. This resulted in the removal of 11 points. An additional 82 points were dropped for safety issues, i.e., not accessible because of terrain or other hazards, or because they did not represent a vegetation class. This left 107 AA points available for use as AA points on the SFCN vegetation map (Figure 6).

A 10-meter buffer was then added to each of the 107 remaining AA points to represent the area being sampled in the field on the map. A total of 48 points ended up too close to polygon edges and were moved to ensure that the 10-meter point buffer, sampling area, did not overlap with an adjacent polygon (community type). Data collection on the final 107 AA points followed the methodology previously described in Phase I of this report. There were an additional 17 AA points that were gained from US Forest Service Forest Inventory Analysis (FIA) program plots on the island. These plots were characterized to the appropriate vegetation classification type. The final accuracy assessment of the SFCN vegetation map consisted of 124 AA points.

Accuracy Assessment

The accuracy assessment of the SFCN vegetation map followed the same methodology used in determining the accuracy of the UVI vegetation map in Phase I of this report.

Results and Discussion

Phase I: University of the Virgin Islands' (UVI) Vegetation Map

Vegetation Map

The UVI vegetation map of VIIS National Park covers a total land area of 3,594.3 ha (8,881.7 acres, Table 2) and consists of 686 polygons, each assigned to one of 27 thematic classes (Figure 4). The majority classes, 16 of out of 27 (59%) thematic classes on the map, account for about 5.0% of the total area (Table 2). The most common thematic classes found on the map are Semi-Deciduous Forest (26.2%), Semi-Evergreen Forest (22.0%), and Thicket/Scrub (17.5%). These three classes account for nearly two-thirds (65.5%) of the total area mapped (Table 2).

Table 2. Area and percent cover for the thematic classes mapped in the 1994 UVI vegetation map.

Formation Class	Formation Subclass	Alliance (Thematic Class)	Area (Ha)	Map Area (%)
Forests	Dry Forest	Drought Deciduous Forest	301.5	8.4%
	Dry Forest	Gallery Semi-Deciduous Forest	75.7	2.1%
	Dry Forest	Semi-Deciduous Forest	941.7	26.2%
	Dry Forest	Semi-Evergreen Forest	789.5	22.0%
	Dry Forest	Dry Forest Total (all)	2,108.5	58.7%
	Moist Forest	Basin Moist Forest	113.1	3.1%
	Moist Forest	Gallery Moist Forest	212.4	5.9%
	Moist Forest	Upland Moist Forest	126.3	3.5%
	Moist Forest	Moist Forest Total (all)	451.7	12.6%
	Wetland Forest	Fringing Mangrove	9.7	0.3%
	Wetland Forest	Mangrove Forest	12.5	0.3%
	Wetland Forest	Wetland Forest Total (all)	22.2	0.6%
	Forests Total (all)	–	2,582.3	71.8%
Woodlands	Upland Woodland	Evergreen Woodland	3.0	0.1%
	Upland Woodland	Semi-Deciduous Woodland	33.0	0.9%
	Upland Woodland	Upland Woodland Total (all)	36.0	1.0%
	Woodland Total (all)	–	36.0	1.0%
Shrublands	Upland Shrubland	Coastal Hedge	29.0	0.8%
	Upland Shrubland	Gallery Shrubland	0.8	0.02%
	Upland Shrubland	Mixed Dry Shrubland	100.5	2.8%
	Upland Shrubland	Sclerophyllous Evergreen Shrubland	10.1	0.3%
	Upland Shrubland	Thicket Scrub	628.4	17.5%
	Upland Shrubland	Upland Shrubland Total (all)	768.8	21.4%
	Wetland Shrubland	Mangrove Shrubland	7.6	0.2%
	Wetland Shrubland	Wetland Shrubland Total (all)	7.6	0.2%
	Shrublands Total (all)	–	776.5	21.6%

Table 2 (continued). Area and percent cover for the thematic classes mapped in the 1994 UVI vegetation map.

Formation Class	Formation Subclass	Alliance (Thematic Class)	Area (Ha)	Map Area (%)
Grasslands	Grassland	Coastal Grassland	0.9	0.03%
	Grassland	Mixed Dry Grassland	5.7	0.2%
	Grassland	Pasture	20.6	0.6%
	Grassland	Grassland Total (all)	27.1	0.8%
	Grasslands Total (all)	–	27.1	0.8%
Other	Anthropogenic	Developed	84.2	2.3%
	Anthropogenic	Anthropogenic Total (all)	84.2	2.3%
	Sparse Vegetation	Beach	16.6	0.5%
	Sparse Vegetation	Cay	1.5	0.04%
	Sparse Vegetation	Freshwater Ponds	1.2	0.03%
	Sparse Vegetation	Rock Pavement	40.6	1.1%
	Sparse Vegetation	Salt Flat	6.1	0.2%
	Sparse Vegetation	Salt Pond	22.3	0.6%
	Sparse Vegetation	Sparse Vegetation Total (all)	86.7	2.4%
	Other Total (all)	–	170.9	4.8%
Total (all)	–	–	3594.3	100.0%

Forests are by far the most dominant community type. Forested communities account for 72% of the entire map area with the Dry Forest (58.7%) being the most common followed by Moist Forest (12.6%), and then Mangroves (0.6%; Table 2). Semi-Deciduous and Semi-Evergreen Dry Forests are the most common forest types present (Table 2).

Woodlands account for approximately 1% of the total area mapped (Table 2) and consist of Evergreen Woodland and Semi-Deciduous Woodland.

Shrublands are the second most common community types represented in the UVI vegetation map (Table 2). Shrublands account for approximately 22% of the total area mapped (776 ha). It consists of five upland community types: Coastal Hedge, Gallery Shrubland, Mixed Dry Shrubland, Sclerophyllous Evergreen Shrubland, and Thicket/Scrub; and one mangrove class.

Grasslands are a minor component of the UVI vegetation map. Grasslands account for < 1.0% of the total area mapped (Table 2) and consist of three types: Coastal Grasslands, Mixed Dry Grassland, and Pasture. Pasture is the most common of the three types mapped.

Anthropogenic and sparsely vegetated areas account for about 5% of the total area mapped (Table 2). This ground includes Developed lands, Beaches, Freshwater Ponds and Wetlands, Rock Pavement, Salt Flats, Salt Ponds, and Cays. Of these, the Developed thematic classes, which includes inholding

within VIIS National Park, account for about 2.3% of the total area mapped. The rest of the thematic classes, in this group, account for about 1% or less, each, of the total area mapped (Table 2).

Accuracy Assessment

An exact one-to-one match (complete agreement) between the Accuracy Assessment (AA) points and the thematic class on the UVI vegetation map occurred for 61 of the 133 AA points sampled (Appendix C). Based on the total number of AA points (61) accepted, the accuracy of the UVI vegetation map is estimated at 45.9% with a lower 90th Percentile Confidence Interval of 38.5% (Appendix C).

Out of the 27 thematic classes used on the UVI vegetation map, 21 (77.8%) were assessed with at least one AA point (Table 3). These 21 classes accounted for approximately 92% of the area mapped. The six classes that were not assessed included four non-vegetative classes: Beach, Developed, Freshwater Ponds, and Rock Pavement; one agricultural land use class, Pasture; and a vegetative class, Upland Moist Forest, that was not accessible due to lack of accessible roads and steep terrain.

Table 3. Number of accuracy assessment (AA) points, class accuracy, and percent map area for all the accuracy assessment points visited to assess the accuracy of the 1994 UVI vegetation map.

Thematic Class	Number of AA Points	User Accuracy (Commission Error, %)	Map Area (%)
Coastal Grassland	1	100.0%	0.03%
Sclerophyllous Evergreen Shrubland	1	100.0%	0.28%
Cay	2	100.0%	0.04%
Drought Deciduous Forest	2	100.0%	8.39%
Fringing Mangrove	3	66.7%	0.27%
Gallery Semi-Deciduous Forest	3	66.7%	2.11%
Mixed Dry Grassland	3	66.7%	0.16%
Mixed Dry Shrubland	15	66.7%	2.80%
Semi-Evergreen Forest	5	60.0%	21.97%
Semi-Deciduous Forest	16	56.3%	26.20%
Salt Flat	4	50.0%	0.17%
Evergreen Woodland	6	50.0%	0.08%
Basin Moist Forest	18	50.0%	3.15%
Thicket Scrub	21	42.9%	17.48%
Coastal Hedge	6	33.3%	0.81%
Gallery Moist Forest	5	20.0%	5.91%
Semi-Deciduous Woodland	9	11.1%	0.92%
Gallery Shrubland	1	0.0%	0.02%
Mangrove Forest	2	0.0%	0.35%
Salt Pond	2	0.0%	0.62%
Mangrove Shrubland	8	0.0%	0.21%

Table 3 (continued). Number of accuracy assessment (AA) points, class accuracy, and percent map area for all the accuracy assessment points visited to assess the accuracy of the 1994 UVI vegetation map.

Thematic Class	Number of AA Points	User Accuracy (Commission Error, %)	Map Area (%)
Beach	0	—	0.46%
Developed	0	—	2.34%
Freshwater Ponds and Wetlands	0	—	0.03%
Pasture	0	—	0.57%
Rock Pavement	0	—	1.13%
Upland Moist Forest	0	—	3.51%

User map accuracy (commission errors) for the assessed classes ranged from 0% to 100% (Table 3). Four thematic classes (Coastal Grassland, Sclerophyllous Evergreen Shrubland, Cay, Drought Deciduous Forest) were estimated to have a user map accuracy of 100%. These four classes account for 8.7% of the map and were assessed with two or fewer AA points (Table 3). The majority of classes, nine, have an estimated user map accuracy between 50% and 67% (Table 3). These nine classes accounted for 56.9% of the map area and are mostly forested community types (Table 3). Ten classes had five or more assessment points; these classes varied in map accuracy from 0% to 66% with an average map accuracy of 39%. User map accuracy below 50% included four classes (Thicket with user map accuracies between 11% and 43% and four thematic classes with user map accuracy of 0% (Table 3). These latter classes, except for one, Mangrove Shrubland, were assessed with two or fewer AA points and do not contribute significantly (1.2%) to the overall map area (Table 3). A detailed breakdown of user (commission) and producer (omission) errors for the UVI vegetation map is found in Appendix C.

Phase II: South Florida/Caribbean Network (SFCN) Vegetation Map

Vegetation Map

The SFCN National Park vegetation map covers a total area of 3,585.2 ha (8,858.7 acres) and contains 1,458 polygons, each assigned to one of 29 thematic classes (Figure 7). Most classes, 16 out of 29 (55%), account for less than 1%, each, of the total area mapped (Table 4). The most common thematic class is Sem-Deciduous Forest (26%) followed by Semi-Evergreen Forest (16.3%), Thicket Scrub (13.7%), and Semi-Deciduous Woodland (11.6%). These four classes account for over two-thirds (68%) of the total area mapped (Table 4).

Forests are the most common and diverse vegetation communities found in VIIS National Park. Forest classes accounted for nearly 60% of the park and consist of nine difference forest types grouped into three subclasses: Dry Forest (47.6%), Moist Forest (9.4%), and Wetland Forest (0.5%, Table 4). Semi-Deciduous and Semi-Evergreen Forests are the most common forest types present in VIIS National Park (Table 4). These two Dry Forest classes account for 42% of the entire park area. Mangrove forests, while present, are a minor component of the park (Table 4). They only account for about 0.5% (16.7 ha, 41.3 acres) of the total mapped area.

Woodlands are the second most common community types present at VIIS National Park (Table 4). Woodlands account for 653.1 ha (18.2%, 1,613.8 acres) of the entire map area. They consist of four Upland woodland classes and one Wetland class. Semi-Deciduous Woodland is the most common woodland class encountered. Mangrove woodlands are also present but account for < 0.1% of the map area (Table 4).

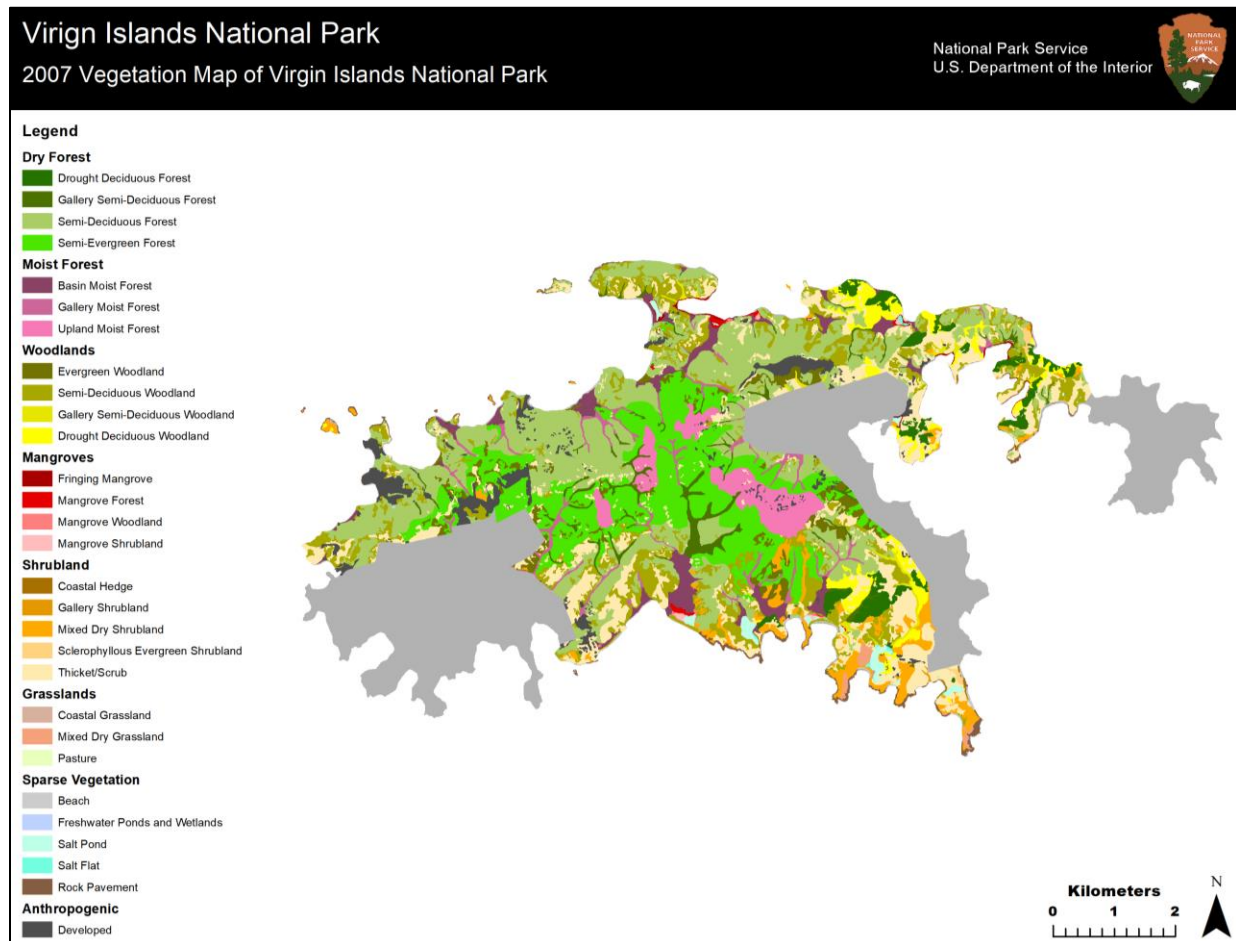


Figure 7. 2007 South Florida Caribbean Network vegetation map of Virgin Islands National Park.

Table 4. Area and percent cover for the thematic classes mapped in the 2007 SFCN vegetation map.

Formation Class	Formation Subclass	Alliance (Thematic Class)	Area (Ha)	Map Area (%)
Forests	Dry Forest	Drought Deciduous Forest	100.1	2.8%
	Dry Forest	Gallery Semi-Deciduous Forest	88.4	2.5%
	Dry Forest	Semi-Deciduous Forest	932.0	26.0%
	Dry Forest	Semi-Evergreen Forest	584.4	16.3%
	Dry Forest	Dry Forest Total (all)	1,704.9	47.6%
	Moist Forest	Basin Moist Forest	119.3	3.3%
	Moist Forest	Gallery Moist Forest	77.3	2.2%

Table 4 (continued). Area and percent cover for the thematic classes mapped in the 2007 SFCN vegetation map.

Formation Class	Formation Subclass	Alliance (Thematic Class)	Area (Ha)	Map Area (%)
Forests (continued)	Moist Forest	Upland Moist Forest	138.9	3.9%
	Moist Forest	Moist Forest Total (all)	335.5	9.4%
	Wetland Forest	Fringing Mangrove	10.0	0.3%
	Wetland Forest	Mangrove Forest	6.8	0.2%
	Wetland Forest	Wetland Forest Total (all)	16.7	0.5%
	Forests Total (all)	–	2,057.1	57.4%
Woodlands	Woodland	Drought Deciduous Woodland	109.9	3.1%
	Woodland	Evergreen Woodland	102.0	2.9%
	Woodland	Gallery Semi-Deciduous Woodland	23.6	0.7%
	Woodland	Semi-Deciduous Woodland	414.4	11.6%
	Woodland	Woodland Total (all)	649.9	18.1%
	Mangrove	Mangrove Woodland	3.2	0.1%
	Mangrove	Mangrove Total (all)	3.2	0.1%
	Woodland Total (all)	–	653.1	18.2%
Shrublands	Shrubland	Coastal Hedge	4.3	0.1%
	Shrubland	Gallery Shrubland	0.8	< 0.1%
	Shrubland	Mixed Dry Shrubland	126.0	3.5%
	Shrubland	Sclerophyllous Evergreen Shrubland	6.7	0.2%
	Shrubland	Thicket Scrub	491.6	13.7%
	Shrubland	Shrubland Total (all)	629.4	17.6%
	Mangrove	Mangrove Shrubland	4.2	0.1%
	Mangrove	Mangrove Total (all)	4.2	0.1%
	Shrublands Total (all)	–	633.5	17.7%
Grasslands	Grassland	Coastal Grassland	0.6	< 0.1%
	Grassland	Mixed Dry Grassland	12.7	0.4%
	Grassland	Pasture	0.6	< 0.1%
	Grassland	Grassland Total (all)	14.0	0.4%
	Grasslands Total (all)	–	14.0	0.4%
Other	Anthropogenic	Developed	143.3	4.0%
	Anthropogenic	Anthropogenic Total (all)	143.3	4.0%
	Sparse Vegetation	Beach	18.4	0.5%
	Sparse Vegetation	Freshwater Ponds	0.2	< 0.1%
	Sparse Vegetation	Rock Pavement	33.4	0.9%
	Sparse Vegetation	Salt Flat	3.5	0.1%

Table 4 (continued). Area and percent cover for the thematic classes mapped in the 2007 SFCN vegetation map.

Formation Class	Formation Subclass	Alliance (Thematic Class)	Area (Ha)	Map Area (%)
Other (continued)	Sparse Vegetation	Salt Pond	28.6	0.8%
	Sparse Vegetation	Sparse Vegetation Total (all)	84.1	2.4%
	Other Total (all)	–	227.3	6.3%
Grand Total	–	–	3,585.2	100.0%

Shrublands are almost as abundant as Woodlands (Table 4). They account for about 18% of the map area; 633.5 ha (1,565.4 acres, Table 4). Shrublands consist of five upland shrub classes and one wetland, mangrove class. The most common Shrubland class is Thicket Scrub (Table 4). This community type accounts for about 13%, 491.6 ha (1,215 acres) of the map area. Mangrove Shrublands, while present, account for about 0.1%, 4.2 ha (10.4 acres) of the area mapped (Table 4).

Grasslands are a minor component within the park. Grasslands account for < 0.4% of the total area mapped (Table 4) and consist of three types: Coastal Grasslands, Mixed Dry Grassland, and Pasture. Mixed Dry Grassland is the most common of the three types mapped (Table 4).

Anthropogenic and sparsely vegetated areas account for 6%, 227.3 ha (561.7 acres) of the total area mapped (Table 4). This ground includes Developed lands, Beaches, Freshwater Ponds, Rock Pavement, Salt Flats, and Salt Ponds. Of these, the Developed thematic classes, which includes inholding within VIIS National Park, account for about 4.0%, 143.3 ha (354.1 acres) of the total area mapped. The rest of the thematic classes, in this group, account for < 1%, each, of the total area mapped (Table 4).

Accuracy Assessment

An exact one-to-one match (complete agreement) between the Accuracy Assessment (AA) points and the thematic class on the SFCN vegetation map occurred for 109 of the 124 AA points sampled (Appendix D). Based on the total number of AA points (109) accepted, the accuracy of the SFCN vegetation map is estimated at 87.9% with a lower 90th Percentile Confidence Interval of 82.0% (Appendix D).

Out of the 29 thematic classes used on the SFCN vegetation map, 15 (51.7%) were assessed with at least one AA point (Table 5). These 15 classes accounted for 89% of the area mapped. The classes without an AA point (14) included three Forest classes; three Shrubland classes; three Grasslands classes; and five Non-vegetative classes (Table 5). These 14 classes combined for 11% of the total map area. However, the majority, 13 out of 15, accounted for < 1% each of the total area mapped (Table 5).

Table 5. Number of accuracy assessment (AA) points, class accuracy, and percent map area for all the accuracy assessment points visited to assess the accuracy of the 2007 SFCN vegetation map.

Thematic Class	Number of AA Points	User Accuracy (Commission Error, %)	Map Area (%)
Mixed Dry Shrubland	11	100%	3.5%
Gallery Semi-Deciduous Forest	5	100%	2.5%
Evergreen Woodland	4	100%	2.8%
Gallery Moist Forest	4	100%	2.2%
Coastal Hedge	3	100%	0.1%
Fringing Mangrove	1	100%	0.3%
Mangrove Woodland	1	100%	0.1%
Salt Pond	1	100%	0.8%
Semi-Evergreen Forest	12	92%	16.3%
Semi-Deciduous Woodland	21	90%	11.6%
Thicket Scrub	15	87%	13.7%
Basin Moist Forest	6	83%	3.3%
Semi-Deciduous Forest	33	79%	26.0%
Drought Deciduous Forest	4	75%	2.8%
Drought Deciduous Woodland	3	67%	3.1%
Beach	0	–	0.51%
Coastal Grassland	0	–	0.02%
Developed	0	–	4.0%
Freshwater Ponds	0	–	0.01%
Gallery Semi-Deciduous Woodland	0	–	0.66%
Gallery Shrubland	0	–	0.02%
Mangrove Forest	0	–	0.19%
Mangrove Shrubland	0	–	0.12%
Mixed Dry Grassland	0	–	0.36%
Pasture	0	–	0.02%
Rock Pavement	0	–	0.9%
Salt Flat	0	–	0.10%
Sclerophyllous Evergreen Shrubland	0	–	0.19%
Upland Moist Forest	0	–	3.9%

User map accuracy (commission errors) for the assessed classes ranged from 67% to 100% (Table 5). The majority of classes, 12, have an estimated user map accuracy greater than 80% (Table 5). These 12 classes accounted for 57.2% of the map area (Table 5). Eight of these classes were estimated to have a user map accuracy of 100% and accounted for 12.3% of the total map area (Table 5). Only three classes (Semi-Deciduous Forest, Drought Deciduous Forest, and Drought Deciduous

Woodland) had a user map accuracy below 80% (Table 5). A detailed breakdown of user (commission) and producer (omission) errors for the SFCN vegetation map is found in Appendix D.

Comparison of the UVI and SFCN Vegetation Maps

Both the UVI and SFCN vegetation maps relied on aerial imagery and photo-interpreters to delineate vegetation communities. However, the SFCN vegetation map had the benefit of having LiDAR data available; a technology and data source not readily available when the UVI vegetation map was produced. In addition, the SFCN vegetation map benefited from technological advances in aerial image acquisition that significantly improved the quality and resolution of imagery used; GPS that allowed precise spatial location determination; and GIS science that permitted the viewing, layering, and manipulation of multiple data sources simultaneously. The SFCN vegetation map also benefitted from the use of digital orthophotographs that take into account the surface elevation, topography, of the earth and camera tilt. Digital orthophotos were not available for use on the UVI vegetation map. As a result, the maps differ, slightly, in total area mapped, by about 9.7 ha (UVI 3,594.3 ha vs SFCN 3,585.2 ha).

At the patch/community level, the number and size of delineated/identified community patches between both maps is striking (Table 6). The SFCN vegetation map has approximately 2.1 times more detail, in the form of individual patches, than the UVI vegetation map does, 1,430 vs 686 patches, respectively (Table 6). Mean patch size and maximum patch size are smaller in the SFCN vegetation map than in the UVI vegetation map (Table 6). This results in the SFCN vegetation map being less homogeneous than the UVI map even though the total number of community types mapped are nearly identical, 27 vs 29 (Figure 8).

Table 6. Difference in number of patches and mean, minimum, and maximum patch size area between the 1994 UVI vegetation map and the 2007 SFCN vegetation map.

Patch Statistics	Number of patches	Mean patch size (ha)	Min patch size (ha)	Max patch size (ha)
UVI Veg Map	686	5.2	< 1	480.0
SFCN Veg Map	1,430	2.5	< 1	206.7

The greatest difference between both maps is in the total area mapped by community type. For the most part, the total area mapped by community types (Forests, Woodlands, Shrublands, Grasslands, and Other) decrease in the SFCN vegetation map (Table 7). The one exception being the Woodlands class which saw an increase of approximately 620 ha (1,532.1 acres) and included three classes (Drought Deciduous Woodland, Gallery Semi-Deciduous Woodland, and Mangrove Woodland) not present in the UVI vegetation map (Table 7). There was also a slight increase in the anthropogenic Developed mapped class between the UVI and SFCN vegetation map (Table 7). This difference in community mapped area is the result of the SFCN vegetation map having higher heterogeneity and less clumping of smaller community patches into larger landscape units.

The last major difference between both maps is their estimated accuracy. The UVI vegetation map has an estimated map accuracy of 45.9% with a lower 90th Percentile Confidence Interval of 38.5% (Appendix C) while the SFCN vegetation map accuracy is estimated at 87.9% with a lower 90th Percentile Confidence Interval of 82.0% (Appendix D). Based on this analysis, the SFCN vegetation map is a better model of the vegetation communities than the UVI vegetation map. The results from the accuracy assessment of the UVI map product should be interpreted as to when the field assessment occurred and when the map product was originally created. The field assessment occurred 9 years after the map was published and 15 years after the aerial photography used for photo-interpretation was acquired. There was probably some true vegetative change that occurred over that timeframe. However, most of the errors with the 1994 UVI map appeared to suffer from not being georeferenced properly. This led to the miss location of prominent features such as salt pond being mapped on steep inclines or ravine and gut forest spatially near by the true geological location of the gut.

Virgin Islands National Park

Comparison of UVI and SFCN vegetation maps

National Park Service
U.S. Department of the Interior

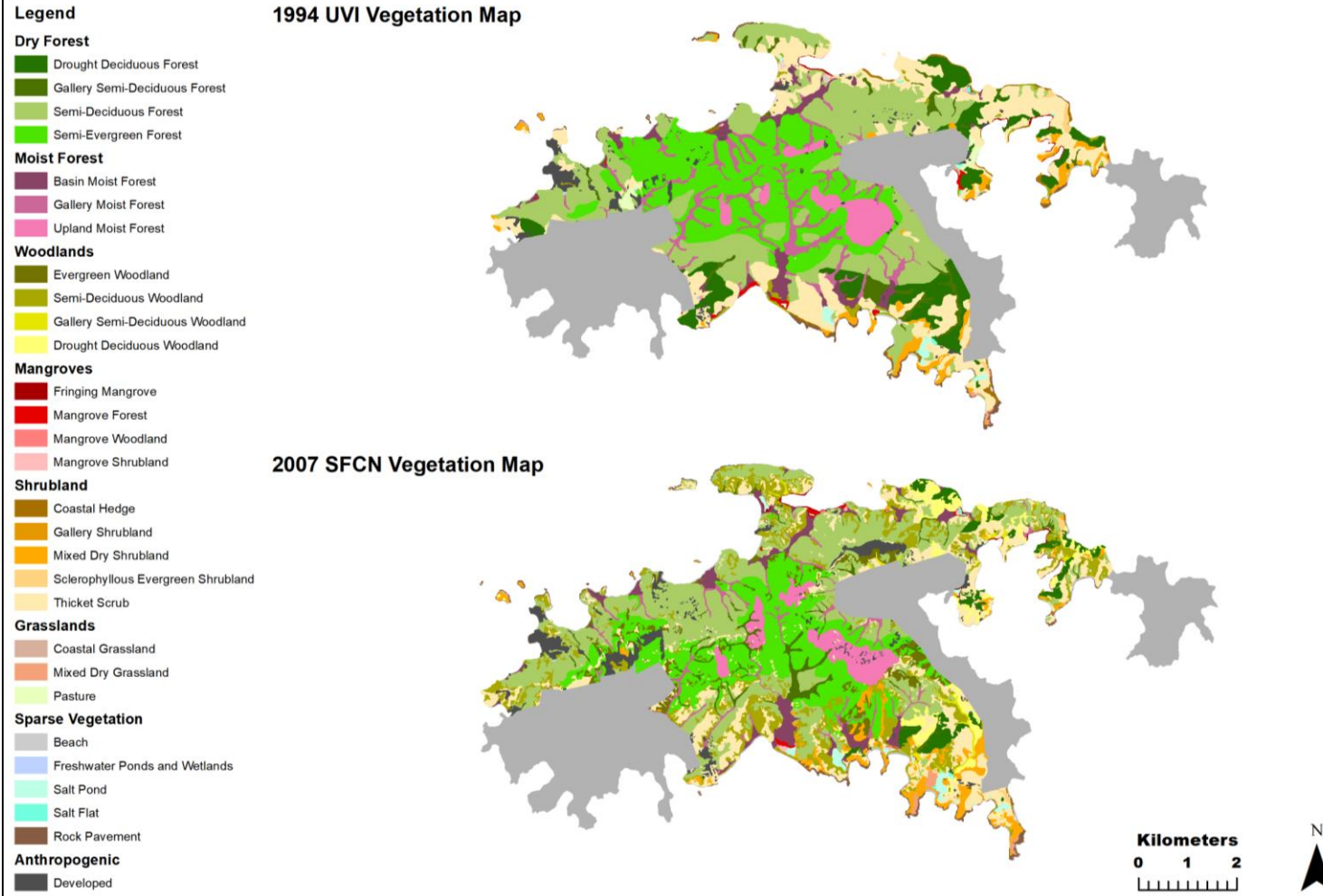


Figure 8. Comparison between the 1994 University of Virgin Islands (UVI) vegetation map and 2007 South Florida Caribbean Network (SFCN) vegetation maps of Virgin Islands National Park

Table 7. Difference in thematic class area between the 1994 UVI vegetation map and the 2007 SFCN vegetation map.

Formation Class	Formation Subclass	Alliance (Thematic Class)	UVI Map Area (Ha)	SFCN Map Area (Ha)	Difference (Ha)	Percent Change
Forests	Dry Forest	Drought Deciduous Forest	301.5	100.1	-201.5	-0.7
	Dry Forest	Gallery Semi-Deciduous Forest	75.7	88.4	12.7	0.2
	Dry Forest	Semi-Deciduous Forest	941.7	932.0	-9.7	0.0
	Dry Forest	Semi-Evergreen Forest	789.5	584.4	-205.1	-0.3
	Dry Forest	Dry Forest Total (all)	2,108.5	1704.9	-403.6	-0.2
	Moist Forest	Basin Moist Forest	113.1	119.3	6.2	0.1
	Moist Forest	Gallery Moist Forest	212.4	77.3	-135.0	-0.6
	Moist Forest	Upland Moist Forest	126.3	138.9	12.7	0.1
	Moist Forest	Moist Forest Total (all)	451.7	335.5	-116.2	-0.3
	Mangrove	Fringing Mangrove	9.7	10.0	0.3	0.0
	Mangrove	Mangrove Forest	12.5	6.8	-5.7	-0.5
	Mangrove	Mangrove Forest Total (all)	22.2	16.7	-5.4	-0.2
	Forests Total (all)	–	2,582.3	2057.1	-525.2	-0.2
Woodlands	Woodland	Drought Deciduous Woodland	0.0	109.9	109.9	–
	Woodland	Evergreen Woodland	3.0	102.0	99.0	33.1
	Woodland	Gallery Semi-Deciduous Woodland	0.0	23.6	23.6	–
	Woodland	Semi-Deciduous Woodland	33.0	414.4	381.4	11.6
	Woodland	Woodland Total (all)	36.0	649.9	613.9	17.1
	Mangrove	Mangrove Woodland	0.0	3.2	3.2	–
	Mangrove	Mangrove Total (all)	0.0	3.2	3.2	–
	Woodland Total (all)	–	36.0	653.1	617.2	17.1
Shrublands	Shrubland	Coastal Hedge	29.0	4.3	-24.7	-0.9
	Shrubland	Gallery Shrubland	0.8	0.8	0.0	-0.1
	Shrubland	Mixed Dry Shrubland	100.5	126.0	25.5	0.3
	Shrubland	Sclerophyllous Evergreen Shrubland	10.0	6.7	-3.4	-0.3

Table 7 (continued). Difference in thematic class area between the 1994 UVI vegetation map and the 2007 SFCN vegetation map.

Formation Class	Formation Subclass	Alliance (Thematic Class)	UVI Map Area (Ha)	SFCN Map Area (Ha)	Difference (Ha)	Percent Change
Shrublands (continued)	Shrubland	Thicket Scrub	628.4	491.6	-136.8	-0.2
	Shrubland	Shrubland Total (all)	768.8	629.4	-139.5	-0.2
	Mangrove	Mangrove Shrubland	7.6	4.2	-3.5	-0.5
	Mangrove	Mangrove Total (all)	7.6	4.2	-3.5	-0.5
	Shrublands Total (all)	–	776.5	633.5	-143.0	-0.2
Grasslands	Grassland	Coastal Grassland	0.9	0.6	-0.3	-0.3
	Grassland	Mixed Dry Grassland	5.7	12.7	7.1	1.2
	Grassland	Pasture	20.5	0.6	-19.9	-1.0
	Grassland	Grassland Total (all)	27.1	14.0	-13.1	-0.5
	Grasslands Total (all)	–	27.1	14.0	-13.1	-0.5
Other	Anthropogenic	Developed	84.2	143.3	59.1	0.7
	Anthropogenic	Anthropogenic Total (all)	84.2	143.3	59.1	0.7
	Sparse Vegetation	Beach	16.6	18.4	1.8	0.1
	Sparse Vegetation	Freshwater Ponds and Wetlands	1.2	0.2	-1.0	-0.8
	Sparse Vegetation	Rock Pavement	40.6	33.4	-7.2	-0.2
	Sparse Vegetation	Salt Flat	6.1	3.5	-2.6	-0.4
	Sparse Vegetation	Salt Pond	22.3	28.6	6.3	0.3
	Sparse Vegetation	Sparse Vegetation Total (all)	86.7	84.1	-2.6	0.0
	Other Total (all)	–	170.9	227.3	56.4	0.3
Total	–	–	3,594.3	3,585.2	-9.2	–

Conclusion

The 1994 UVI vegetation map of VIIS National Park consists of 686 polygons and has an estimated accuracy, based on the 2009 assessment, of 45.9% with a lower 90th Percentile Confidence Interval of 38.5%. In contrast, the new, Phase 2, SFCN vegetation map consists of 1,430 polygons and has an estimated accuracy of 87.9% with a lower 90th Percentile Confidence Interval of 82.0%. At the community level, the number and size of delineated community types between both maps is significant. The new SFCN vegetation map has approximately 2.1 times more detail, in the form of individual patches, than the UVI vegetation map does, 1,430 vs 686 patches, respectively. Furthermore, mean patch size and maximum patch size are smaller in the SFCN vegetation map than in the UVI vegetation map. This results in the SFCN vegetation map being less homogeneous than the UVI map even though the total number of community types mapped are nearly identical, 27 vs 29.

The SFCN vegetation map (Phase 2) serves as a baseline of plant communities for VIIS National Park. It provides land-cover information for NPS park managers and scientists for use in park management, resource management, research, and monitoring. Furthermore, this map will allow park managers to track and document changes in vegetation resulting from natural successional processes, disturbance events, sea level rise, and/or management decisions for years to come.

All data products including the 2007 aerial imagery used to produce the new SFCN National Park vegetation map, the field data, field photos, and associated geospatial information are available for download from the NPS Integrated Resource Management Applications (IRMA) datastore.

Literature Cited

- Acevedo-Rodríguez, P., and Collaborators. 1996. Flora of St. John, U.S. Virgin Islands. The New York Botanical Garden, Bronx, New York. 582 pp.
- Askins, R. A., D. N. Ewert, and R. L. Norton. 1989. Abundance of wintering migrants in fragmented and continuous forests in the U.S. Virgin Islands. Pages 197–206 in Proceedings of Manomet Symposium, Smithsonian Institution Press, Washington, D.C.
- Beard, J. S. 1944. Climax vegetation in tropical America. *Ecology* 25:127–158.
- Beard, J. S. 1949. Natural vegetation of the windward and leeward Islands. *Oxford Forestry Memoirs* 21: 1–192.
- Beard, J. S. 1955. The classification of tropical American vegetation types. *Ecology* 36(1): 89–100.
- Britton, N. L. 1918. The flora of the American Virgin Islands. *Brooklyn Botanical Garden Memoirs* 1: 19–118.
- Britton, N. L., and P. Wilson. 1923–1926. Botany of Porto Rico and the Virgin Islands. New York Academy of Sciences, New York.
- Cangialosi, J. P., A. S. Latto, and R. Berg. 2017. National Hurricane Center tropical cyclone report: Hurricane Irma (AL112017). Available at: https://www.nhc.noaa.gov/data/tcr/AL112017_Irma.pdf
- CH2M Hill, Inc. 1979. A sediment reduction program. Prepared for department of conservation and cultural affairs, government of the U.S. Virgin Islands.
- Eggers, H. F. A. 1879. The flora of St. Croix and the Virgin Islands. Government Printing Office, Washington, D.C.
- Gamon, J. A., and J. S. Surfus. 1999. Assessing leaf pigment content and activity with a reflectometer. *New Phytologist* 143:105–117.
- Gibney, E. 2004. A field guide to native trees & plants of East End, St. John, U.S. Virgin Islands. Center for the Environment, Inc., St. John, U.S. Virgin Islands. 86 pp.
- Gibney, E., T. Thomas, R. O'Reilly, and B. Devine. 2000. U.S. Virgin Islands vegetation community classification: basic community descriptions – habitat mapping in support of land use and biodiversity planning in the Virgin Islands. Eastern Caribbean Data Center, University of the Virgin Islands, St. Thomas, U.S. Virgin Islands.
- Gitelson, A. A., Y. J. Kaufman, R. Stark, and D. Rundquist. 2002. Novel algorithms for remote estimation of vegetation fraction. 2002. *Remote Sensing of Environment* 80:76–87.

- Knight, D. 2001. Annaberg: An updated survey of the Annaberg factory complex, Virgin Islands National Park, St. John, USVI, with overviews of contributing sites within the Annaberg historic district. Virgin Islands Historical and Genealogical Research Center, St. John, U.S. Virgin Islands. 215 pp.
- Knight, D. 2010. A timeline of the establishment of the town of Cruz Bay, St. John. St. John Historical Society 11(2). Available from <https://stjohnhistoricalsociety.org/a-timeline-of-the-establishment-of-the-town-of-cruz-bay-st-john-2/>.
- Krebs, H. 1847. Et bidrag til St. Thomas' flora. Naturhist. Tidsskr. 1847: 291–302.
- Lea, C. 2010. Thematic accuracy assessment procedures. Version 2.0. National Park Service Vegetation Inventory. National Park Service, Fort Collins, CO.
- Loftus, W. 2003. Inventory of fishes in inland fresh and brackish-water habitats of Virgin Islands National Park: final project report. USGS, Florida Integrated Science Center, Center for Water and Restoration Studies. Homestead, FL. 56 pp.
- Millspaugh, C. F. 1902. Flora of the island of St. Croix. Field Columbian Museum. Publication 68-1 (7). Chicago, Illinois. 546 pp.
- NOAA (National Oceanic and Atmospheric Administration). 2001. Benthic habitats of Puerto Rico and the U.S. Virgin Islands. Map. National Centers for Coastal Ocean Science Biogeography Program, NOAA, Silver Spring, MD.
- Oldendorp, C. G. A. 1777. History of the mission of the evangelical brethren of the Caribbean Islands of St. Thomas, St. Croix, and St. John. Translated from German in 1987 by A. R. Highfield and V. Barac, edited by J. J. Bossard. Karoma Publishers, Ann Arbor, MI.
- Owens, T. 1999. USGS-NPS Vegetation Mapping Inventory Program. North American Science Symposium: Toward a unified framework for inventory and monitoring forest ecosystems resources. Guadalajara, Mexico, November 1–6, 1998.
- Patterson, M. E., A. J. Atkinson, B. D. Witcher, K. R. T. Whelan, W. J. Miller, R. J. Waara, J. M. Patterson, B. I. Ruttenberg, A. D. Davis, R. Urgelles, and R. B. Shamblin. 2008. South Florida / Caribbean Network vital signs monitoring plan. Natural Resource Report NPS/SFCN/NRR—2008/063. National Park Service, Fort Collins, CO.
- Rankin, D. W. 2002. Geology of St. John, U.S. Virgin Islands [U.S. Geological Survey Professional Paper 1631]. Washington, D.C.: U.S. Department of the Interior, U.S. Geological Survey. Available from <https://pubs.usgs.gov/pp/p1631/P1631-tag.pdf>
- Rogers, C. S., and R. Teytaud. 1988. Marine and terrestrial ecosystems of the Virgin Islands National Park and Biosphere Reserve: St. Thomas, U.S. Virgin Islands, National Park Service Biosphere Reserve Report 29, 112 pp.

- Ruiz, P. L., J. P. Sah, J. R. Snyder, and M. S. Ross. 2012. Mapping and assessing fire damage on broadleaved forest communities on Big Cypress National Preserve. 60 pp. Report to the USGS, Southeast Ecological Science Center. 11 September 2012.
- Schlechtendal, D. F. L. 1828–1831. *Florula insulae Sti. Thomae Indiae Occidentalis*. *Linnaea* 3: 78–93, 251–276; 5: 177–200, 682–688; 6:722–772.
- Studd, S. E., D. Drake, M. Villarreal, E. Fallon, and L. L. Crumbacher. 2013. Vegetation inventory, mapping and classification report, Fort Bowie National Historic Site. Natural Resource Report NPS/SODN/NRR-2013/673. National Park Service, Fort Collins, Colorado. Available at: <https://irma.nps.gov/DataStore/Reference/Profile/2195865> (last accessed July 2019).
- Thomas, T., and B. Devine. 2005. Island peak to coral reef: a field guide to the plant and marine communities of the Virgin Islands. University of the Virgin Islands, St. Thomas, U.S. Virgin Islands. 214 pp.
- Urban, I. 1902. *Notae bibliographicae peregrinatorum indiae occidentalis botanicorum*. *Symb. Ant.* 3: 14–158.
- Warren, G., and G. Metternicht. 2005. Agricultural applications of high-resolution digital multispectral imagery: evaluating within-field spatial variability of Canola (*Brassica napus*) in Western Australia. *Photogrammetric Engineering and Remote Sensing* 71(5):595-602.
- Weaver, P. L. 2006. A summary of 20 years of forest monitoring in Cinnamon Bay watershed, St. John, U.S. Virgin Islands. Gen. Tech. Rep. IITF-34. San Juan, PR: U.S. Department of Agriculture Forest Service, International Institute of Tropical Forestry. 35 pp.
- West, H. 1793. *Bidrag til beskrivelse over Ste. Croix med en kort udsigt over St. Thomas, St. Jean, Tortola, Spanishtown, og Crabeneiland*. Friderik Wilhelm Thiele, Copenhagen.
- Wild, K. 2011. Cultural Resource of the Virgin Islands National Park and Coral Reef National Monument. Unpublished manuscript.
- Winks, R. 1997. Laurance S. Rockefeller: catalyst for conservation. Island Press, Washington, D.C.
- Woodbury, R. O., and P. L. Weaver. 1987. The vegetation of St. John and Hassel Island, U.S. Virgin Islands. U.S. Department of the Interior, National Park Service, Southeast Regional Office, Research/ Resources Management Report SER-83. 103 pp.
- Zar, J. H. 1999. *Biostatistical Analysis*, 4th edition. Prentice Hall, Upper Saddle River, NJ.

Appendix A. Vegetation Classification System

Contents

	Page
I. Forests.....	A-5
Moist Forest.....	A-5
I.A1N.a. Lowland tropical/subtropical seasonal evergreen forest (Caribbean Formation)	A-5
1. Upland Moist Forest (UMF) (Virgin Islands Sub-formation)	A-5
2. Gallery Moist Forest (GMF) (Virgin Islands Sub-formation).....	A-6
3. Basin Moist Forest (BMF) (Virgin Islands Sub-formation).....	A-6
Dry Forest.....	A-7
I.B.1.N.a. Lowland tropical/subtropical semi-deciduous forest (Caribbean Formation)	A-8
1. Semi-Evergreen Forest (SEF) (Virgin Islands Sub-formation)	A-8
2. Semi-Deciduous Forest (SDF) (Virgin Islands Sub-formation).....	A-8
3. Gallery Semi-Deciduous Forest (GSDF) (Virgin Islands Sub-formation)	A-9
I.C.1.N.a. Lowland or submontane tropical/subtropical drought deciduous Forest (Caribbean Formation)	A-10
1. Drought Deciduous Forest (DDF) (Virgin Islands Sub-formation)	A-10
Mangrove Forest.....	A-11
I.A.5.N.e. Tidally flooded tropical/subtropical broad-leaved evergreen sclerophyllous forest (Caribbean Formation)	A-11
1. Mangrove Forest (MF) (Virgin Islands Sub-formation).....	A-11
III.A.1.N.g. Semi-permanently flooded tropical or subtropical broad-leaved evergreen shrubland (Caribbean Formation).....	A-12
1. Fringing Mangrove (FM) (Virgin Islands Sub-formation).....	A-12
II. Woodland	A-14
Dry Woodlands.....	A-14

Contents (continued)

	Page
II.A.1.N.a. Tropical/subtropical broad-leaved evergreen woodland (Caribbean Formation)	A-14
1. Evergreen Woodland (EW) (Virgin Islands Sub-formation).....	A-14
II.C.1.N.a. Tropical/subtropical semi-deciduous woodland (Caribbean Formation)	A-15
1. Semi-Deciduous Woodland (SDW) (Virgin Islands Sub-formation).....	A-15
2. Gallery Semi-Deciduous Woodland (GSDW) (Virgin Islands Sub-formation)	A-16
II.B.1.N.a. Lowland or submontane broad-leaved drought deciduous woodland (Caribbean Formation)	A-17
1. Drought Deciduous Woodland (DDW) (Virgin Islands Sub-formation)	A-17
Mangrove Woodlands	A-18
II.A.1.N.e. Tidally flooded tropical/subtropical broad-leaved evergreen woodland (Caribbean Formation)	A-18
1. Mangrove Woodland (MW) (Virgin Islands Sub-formation)	A-18
III. Shrublands.....	A-20
Dry Shrublands.....	A-20
III.A.1.N.b. Tropical/subtropical broad-leaved evergreen shrubland (Caribbean Formation)	A-20
1. Coastal Hedge (CH) (Virgin Islands Sub-formation).....	A-20
2. Gallery Shrubland (GS) (Virgin Islands Sub-formation)	A-21
III.A.1.N.c. Sclerophyllous tropical/subtropical broad-leaved evergreen shrubland (Caribbean Formation)	A-22
1. Sclerophyllous Evergreen Shrubland (SES) (Virgin Islands Sub-formation)	A-22
III.B.1.N.a. Lowland drought deciduous shrubland (Caribbean Formation)	A-23
1. Thicket/Scrub (TS) (Virgin Islands Sub-formation).....	A-23
2. Mixed Dry Shrubland (MDS) (Virgin Islands Sub-formation)	A-24
Mangrove Shrublands.....	A-25

Contents (continued)

	Page
III.A.1.N.h. Tidally flooded tropical or subtropical broad-leaved evergreen shrubland (Caribbean Formation).....	A-25
1. Mangrove Shrubland (MS) (Virgin Islands Sub-formation)	A-25
IV. Grasslands.....	A-27
Grassland	A-27
IV.A.1.N.a. Tall tropical/subtropical grassland (Caribbean Formation)	A-27
1. Coastal Grassland (CG) (Virgin Islands Sub-formation)	A-27
IV.A.3.N. Tropical/Subtropical grassland with a shrub layer, natural or semi-natural (Caribbean Formation)	A-28
1. Mixed Dry Grassland (MG) (Virgin Islands Sub-formation).....	A-28
IV.A.1.N.d. Short sod tropical/subtropical grassland (Caribbean Formation)	A-28
1. Pasture (P) (Virgin Islands Sub-formation).....	A-28
V. Other.....	A-30
Sparse Vegetation.....	A-30
V.A.1.N.a. Cliffs with sparse vascular vegetation (Caribbean Formation).....	A-30
1. Rock Pavement (RP) (Virgin Islands Sub-formation).....	A-30
V.C.2.N.b. Intermittently flooded sand beaches and shores (Caribbean Formation).....	A-30
1. Beach (B) (Virgin Islands Sub-formation)	A-30
V.C.4.N.b. Intermittently flooded mud flat (Caribbean Formation)	A-31
1. Salt Pond (SP) (Virgin Islands Sub-formation).....	A-31
2. Salt Flat (SF) (Virgin Islands Sub-formation).....	A-32
3. Freshwater Ponds and Wetlands (FP) (Virgin Islands Sub-formation)	A-33
Anthropogenic	A-34
V.D.1.N. Developed Areas.....	A-34
1. Development (D) (Virgin Islands Sub-formation)	A-34

Disclaimer

Gibney, Thomas, O'Reilly and Devine developed a comprehensive U.S. Virgin Islands (USVI) vegetation community classification system (Gibney *et al.* 2000). Thomas and Devine updated this vegetation classification system as part of the University of the Virgin Islands (UVI) rapid ecological assessment which resulted in the UVI vegetation map of St. John (Thomas and Devine 2005). The classification system used in this project, and presented herein, draws from Gibney *et al.* (2000), Thomas and Devine (2005), and knowledge gained in the field in the creation of the updated vegetation map of Virgin Islands National Park.

I. Forests

Moist Forest

Forests grow to 5 m or taller, have greater than or equal to 60% tree cover, and trees tend to grow closely together with interlocking canopies. Forests are split into moist and dry forests. Moist forests are tropical and subtropical seasonal evergreen forests, composed of 70% or more broad-leaved evergreen trees, and are subject to some foliage reduction in the dry season. Moist forests develop in coastal watershed basins, riparian habitats associated with drainage guts, swales which carry runoff from upper elevations, and upland locations elevated enough to experience over 1200 mm annual rainfall. A dry period of two to four months is common. These are the true forests of the USVI, where over 100 tree species grow 10–30 m tall. Shorter moist forest formations usually have two canopy strata (synusia) whereas taller formations have three (Gibney *et al.* 2000).

I.A1N.a. Lowland tropical/subtropical seasonal evergreen forest (Caribbean Formation)

1. Upland Moist Forest (UMF) (Virgin Islands Sub-formation)

Description:

75% of trees are evergreen (Thomas and Devine 2005). This community is confined to mountain summits, ridges, and upper north aspects of the taller mountains. The continuous canopy forms at about 15 m with a small tree/shrub layer often found at 5–10 m. Some emergent trees may be as tall as 25 m, although at present they are often shorter. Low shrubs, herbs and epiphytes range from absent to abundant. Recent hurricane disturbance has temporarily increased vine, herb and small shrub growth (Gibney *et al.* 2000).

Common plant species:

Tabebuia heterophylla, *Guapira fragrans*, *Pimenta racemosa*, *Capparis flexuosa*, *Coccothrinax alta*, *Ocotea coriacea*, and *Eugenia biflora*.

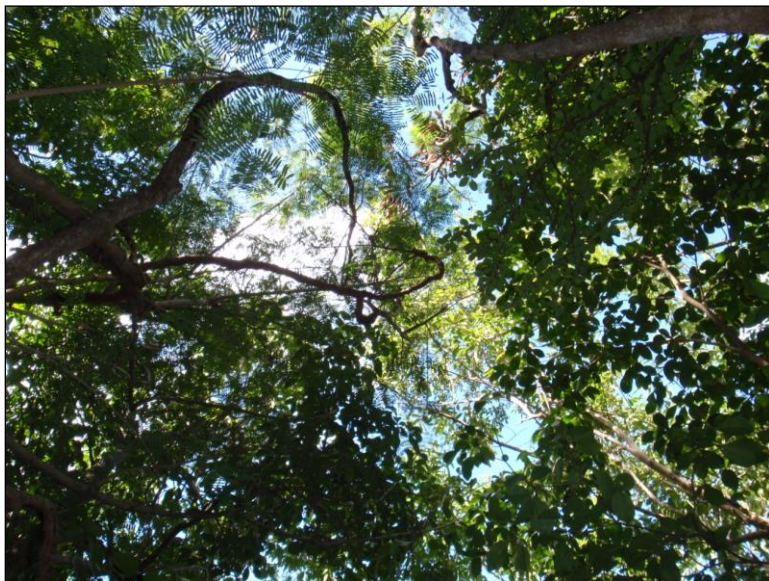


Photo A-1. Upland Moist Forest.

2. Gallery Moist Forest (GMF) (Virgin Islands Sub-formation)

Description:

75% of trees are evergreen (Thomas and Devine 2005). These are riparian communities found in ravines and guts draining large upland watersheds. The moist ravines and guts with the gentlest slopes support the tallest trees on the islands, some over 30 m. Although several emergent species are deciduous, the dominant species are generally evergreen. Frequent flash floods result in younger trees and less pronounced strata in this type of forest. The shrub layer is extremely variable and fewer herbs, shrubs, epiphytes and vines persist. In many locations, the introduced, deciduous fruit tree Genip (*Melicoccus bijugatus*) may dominate (Gibney *et al.* 2000).

Common plant species:

Ceiba pentandra, *Melicoccus bijugatus*, *Eugenia biflora*, *Coccothrinax alta*, *Cordia collococca*, *Guapira fragrans*, *Capparis indica*, *Ocotea coriacea*, *Pharus lappulaceus*, *Andira inermis*, and *Hura crepitans*.



Photo A-2. Gallery Moist Forest.

3. Basin Moist Forest (BMF) (Virgin Islands Sub-formation)

Description:

Ranges from up to 75% evergreen trees to over 75% deciduous trees (based on field observations*). This community is found at sea level in protected valleys (Reef Bay, Coral Bay) (Thomas and Devine 2005). These forests exist in coastal basins and lowland areas, generally along the coast, in areas of low slope where runoff from large upland watersheds collects (Gibney *et al.* 2000). These forest types are well represented on all the Virgin Islands. The forest is normally comprised of 3 synusia. Emergent species may reach 25 m or more. A continuous canopy is formed at 15–18 m and a lower layer at 5–10 m. A lower shrub layer may be common or moderately well developed. Herbs and vines are found in significant numbers in a well-developed community. Epiphytes and ferns are rare (Gibney *et al.* 2000). Thomas and Devine (2005) describe this community as having 75%

evergreen trees. However, we have found this community is often dominated by Genip (*Melicoccus bijugatus*) which is deciduous. We therefore propose to re-define this range to include over 75% deciduous trees.

Common plant species:

Melicoccus bijugatus, *Guapira fragrans*, *Triphasia trifolia*, *Capparis indica*, *Capparis flexuosa*, *Tamarindus indica*, and *Eugenia biflora*.



Photo A-3. Basin Moist Forest.

Dry Forest

Forests grow to 5 m or taller, have greater than or equal to 60% tree cover, and trees tend to grow closely together with interlocking canopies. Forests are split into moist and dry forests. Dry forests grow to 5 m or taller and have greater than 60% tree cover. Vegetation composition in dry forests is influenced by numerous factors, including prevailing wind patterns and velocity, length of dry season (number of months with less than 50 mm rainfall), aspect, and slope. Dry forests receive 850–1100 mm annual rainfall. They are found at lower elevations (below 300 m) on sunnier, windier, steeper slopes with thin rocky soils. Steep slopes, strong winds, and salt spray may alter forest diversity and composition and reduce climax vegetation height. Dry forests generally have two tree strata at most, with a maximum height of 15–20 m. With increasing aridness, vegetation may exhibit deciduous leaf specializations, while dry evergreen vegetation may exhibit greater sclerophylly (hard and stiff leaves which retain water). Different types of dry forest may mix together and make classifications difficult to distinguish (Gibney *et al.* 2000).

I.B.1.N.a. Lowland tropical/subtropical semi-deciduous forest (Caribbean Formation)

1. Semi-Evergreen Forest (SEF) (Virgin Islands Sub-formation)

Description:

70 to 75% of trees are evergreen (Thomas and Devine 2005). This community marks the transition between moist and dry forest and is found on slopes above Maho Bay, Cinnamon Bay, and Trunk Bay (Thomas and Devine 2005). This forest cover type is very similar in distribution to the semi deciduous type and in many locations graded into it. It is generally found above 250 m in elevation, on northwest facing slopes below moist forest levels. Species composition changes to include a shift toward a greater majority of evergreen species (Gibney *et al.* 2000).

Common plant species:

Eugenia biflora, *Coccothrinax alta*, *Guapira fragrans*, *Melicoccus bijugatus*, *Anthurium crenatum*, *Bursera simaruba*, *Bourreria succulenta*, *Capparis indica*, *Maytenus laevigata*, *Leucaena leucocephala*, and *Citharexylum fruticosum*.



Photo A-4. Semi-Evergreen Forest.

2. Semi-Deciduous Forest (SDF) (Virgin Islands Sub-formation)

Description:

25% of trees are evergreen and 75% are deciduous. This community is found on north facing hillsides (above Leinster Bay) (Thomas and Devine 2005). This forest group contains a number of fairly distinct forest types, which vary in physiognomy, composition and in degree of human modification (Gibney *et al.* 2000). This is the dominant forest cover throughout the Virgin Islands and on the island of St. John. In most cases these forests may be found on north facing hillsides, at upper southern facing elevations below 250 m, in basins without large watersheds, along smaller guts and ravines, and mixed with dry deciduous forests on lower south facing slopes (Gibney *et al.* 2000).

Common plant species:

Melicoccus bijugatus, *Guapira fragrans*, *Eugenia biflora*, *Coccothrinax alta*, *Leucaena leucocephala*, *Bursera simaruba*, *Triphasia trifolia*, *Pisonia subcordata*, *Capparis indica*, and *Acacia retusa*.



Photo A-5. Semi-Deciduous Forest.

3. Gallery Semi-Deciduous Forest (GSDF) (Virgin Islands Sub-formation)

Description:

75% of trees are deciduous. This community is found on smaller guts and ravines dominated by dry forests (East End and uplands in the southeast corner of St. John) (Thomas and Devine 2005). This forest type is limited to the smaller riparian corridors such as ravines, guts and intermittent streams found within dry forest watersheds (Gibney *et al.* 2000). Additional moisture is available to the vegetation as a result of runoff. The taller dry forest species find their maximum height in these locations. Shrub and herb community development are variable (Gibney *et al.* 2000).

Common plant species:

Melicoccus bijugatus, *Coccothrinax alta*, *Eugenia biflora*, *Guapira fragrans*, *Leucaena leucocephala*, and *Maytenus laevigata*.



Photo A-6. Gallery Semi-Deciduous Forest.

I.C.1.N.a. Lowland or submontane tropical/subtropical drought deciduous Forest (Caribbean Formation)

1. Drought Deciduous Forest (DDF) (Virgin Islands Sub-formation)

Description:

Over 75% deciduous tree species such as *Bursera simaruba* and *Guapira fragrans* (Thomas and Devine 2005). It usually has two layers: an upper layer with a main canopy averaging 7–10 m with some trees up to 15 m tall, and a lower layer with sparse to abundant shrubs and an herb layer that tends to die back during dry periods (Thomas and Devine 2005). Structure and species composition is much the same as semi-deciduous forests, but this type is characterized by greater than 75% deciduous species. Species may have differing leaf phenology under varying climatic conditions, being evergreen in one location and deciduous in another (Gibney *et al.* 2000). This community may be difficult to delineate other than during the annual dry season from January – May. The formation is found mainly at lower elevations below 250 m, on south and southwest facing slopes toward the drier East End locations and in south and west aspects along the north shores. (Gibney *et al.* 2000). This community is found at East End and uplands in the southeast corner of St. John (Thomas and Devine 2005).

Common plant species:

Melicoccus bijugatus, *Acacia retusa*, *Guapira fragrans*, *Bursera simaruba*, *Erythroxylum brevipes*, *Leucaena leucocephala*, *Eugenia biflora*, *Capparis flexuosa*, *Citharexylum fruticosum*, *Randia aculeata*, and *Piscidia carthagenensis*.



Photo A-7. Drought Deciduous Forest

Mangrove Forest

Mangrove forest found in coastal habitats that are seasonally, tidally, or semi-permanently flooded by salt water. Mangroves are evergreen tree and shrub species that span tropical and subtropical regions throughout the world. The mangrove species found in the USVI are: the red mangrove (*Rhizophora mangle*) which grows at the water's edge, the black mangrove (*Avicennia germinans*) which tolerates the most saline and saturated soils, and the white mangrove (*Laguncularia racemosa*) which is the least tolerant of soil saturation. Buttonwood (*Conocarpus erectus*) is often associated with mangrove communities and can grow in dry soils and rocky shores (Thomas and Devine 2005).

I.A.5.N.e. Tidally flooded tropical/subtropical broad-leaved evergreen sclerophyllous forest (Caribbean Formation)

1. Mangrove Forest (MF) (Virgin Islands Sub-formation)

Description:

Mangroves are 5 m in height or taller and dense, forming a closed canopy. This community is similar to a Mangrove Woodland but is denser such that the tree canopy is closed. This community is found in the moister parts of the island, often where large watersheds drain into moist basins, and can reach 15 m in height (Thomas and Devine 2005). Mangrove Forests are usually dominated by *Rhizophora mangle*, though *Avicennia germinans* and *Laguncularia racemosa* are also found herein (Gibney *et al.* 2000).

Common plant species:

Avicennia germinans, *Laguncularia racemosa*, and *Rhizophora mangle*.



Photo A- 8. Mangrove Forest.

III.A.1.N.g. Semi-permanently flooded tropical or subtropical broad-leaved evergreen shrubland (Caribbean Formation)

1. *Fringing Mangrove (FM) (Virgin Islands Sub-formation)*

Description:

Coastal shoreline and salt pond vegetation that is semi-permanently and tidally flooded (Thomas and Devine 2005). This community is quite common to all islands of the USVI (Gibney *et al.* 2000).

Common plant species:

Rhizophora mangle, *Avicennia germinans*, *Laguncularia racemosa*, and *Thespesia populnea*.



Photo A-9. Fringing Mangrove.

II. Woodland

Dry Woodlands

Woodlands grow to 5 m or taller, have 25–60% tree cover, and are characterized by an open, non-interlocking tree canopy. Palm groves are the only naturally occurring woodlands in the USVI, as woodlands throughout the USVI are often a remnant of anthropogenic land uses. Woodlands are shaped by the same forces that form dry forests, so substantial dry forest species are found herein. Canopy height varies greatly from 8–20 m, depending on human modifications, hurricane effects, and available soil moisture. Different types of woodland grade into one another and may be difficult to differentiate (Gibney *et al.* 2000).

II.A.1.N.a. Tropical/subtropical broad-leaved evergreen woodland (Caribbean Formation)

1. Evergreen Woodland (EW) (Virgin Islands Sub-formation)

Description:

Usually composed of about 75% broadleaf evergreen palms, largely the Teyer Palm (*Coccothrinax alta*) (Thomas and Devine 2005). This community grows in small patches near coastlines and hillsides ranging from near sea level to an altitude a little over 305 m in both dry and moist forests (Thomas and Devine 2005). This community is found throughout the USVI and on some offshore cays where landscape modifications have taken place. In a number of locations it may occur as a coconut palm woodland in basin or coastal areas (Gibney *et al.* 2000).

Common plant species:

Coccothrinax alta, *Cocos nucifera*, *Guapira fragrans*, *Bursera simaruba*, *Eugenia sp.*, and *Pimenta racemosa*.



Photo A-10. Evergreen Woodland.

II.C.1.N.a. Tropical/subtropical semi-deciduous woodland (Caribbean Formation)

1. *Semi-Deciduous Woodland (SDW) (Virgin Islands Sub-formation)*

Description:

Usually composed of about 75% broadleaf evergreen palms*. Found on abandoned agricultural areas in the south of St. John (Thomas and Devine 2005). This vegetation community is characterized by an open canopy comprised mainly of common native and naturalized exotic plants (Gibney *et al.* 2000). The size range varies considerably with past land use history and may range from 5–25 m. Canopy cover is open, from 25–60% commonly. These areas are typically influenced by hurricane winds which reduce canopy cover temporarily (Gibney *et al.* 2000).

Common plant species:

Acacia macracantha, *Leucaena leucocephala*, *Bursera simaruba*, *Acacia retusa*, *Randia aculeata*, *Pisonia subcordata*, *Pilosocereus royenii*, *Cassine xylocarpa*, *Citharexylum fruticosum*, *Melicoccus bijugatus*, *Capparis indica*, *Bourreria succulenta*, and *Tillandsia utriculata*.



Photo A-11. Semi-Deciduous Woodland.

2. Gallery Semi-Deciduous Woodland (GSDW) (Virgin Islands Sub-formation)

Description:

Up to 75% of trees are deciduous. This community results from extensive land clearing. Though described the same as the Semi-deciduous Forest, trees herein may reach greater heights due to greater moisture availability (Thomas and Devine 2005). It is primarily found in guts and ravines at low elevation and appears as strips of open canopy woodland where the guts pass through cleared areas (Gibney *et al.* 2000).

Common plant species:

Leucaena leucocephala, *Randia aculeata*, *Bursera simaruba*, *Capparis cynophallophora*, *Capparis indica*, *Cassine xylocarpa*, *Cordia dentata*, and *Acacia retusa*.



Photo A-12. Gallery Semi-Deciduous Woodland.

II.B.1.N.a. Lowland or submontane broad-leaved drought deciduous woodland (Caribbean Formation)

1. Drought Deciduous Woodland (DDW) (Virgin Islands Sub-formation)

Description:

Over 75% of trees are deciduous. Found as a patchy community (Thomas and Devine 2005). Similar species composition and community structure make it difficult to distinguish this community from other woodland types such as the semi-deciduous woodland (Gibney *et al.* 2000).

Common plant species:

Leucaena leucocephala, *Bursera simaruba*, *Cassine xylocarpa*, *Agave missionum*, *Schaefferia frutescens*, *Bourreria succulenta*, and *Acacia retusa*.

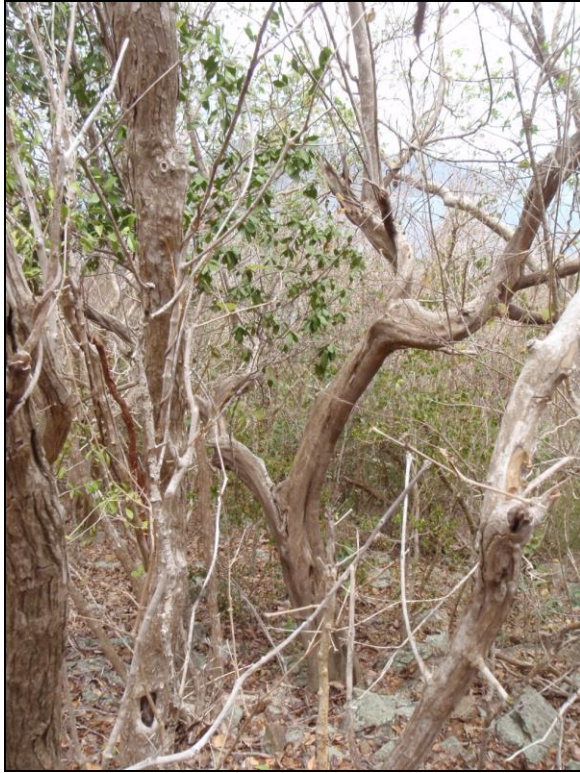


Photo A-13. Drought Deciduous Woodland.

Mangrove Woodlands

Mangrove forest found in coastal habitats that are seasonally, tidally, or semi-permanently flooded by salt water. Mangroves are evergreen tree and shrub species that span tropical and subtropical regions throughout the world. The mangrove species found in the USVI are: the red mangrove (*Rhizophora mangle*) which grows at the water's edge, the black mangrove (*Avicennia germinans*) which tolerates the most saline and saturated soils, and the white mangrove (*Laguncularia racemosa*) which is the least tolerant of soil saturation. Buttonwood (*Conocarpus erectus*) is often associated with mangrove communities and can grow in dry soils and rocky shores (Thomas and Devine 2005).

II.A.1.N.e. Tidally flooded tropical/subtropical broad-leaved evergreen woodland (Caribbean Formation)

1. Mangrove Woodland (MW) (Virgin Islands Sub-formation)

Description:

Mangroves are 5 m in height or taller and sparse, forming an open canopy. This community is similar to a Mangrove Forest but is less dense such that the tree canopy is open. This woodland type lies at the drier, shoreward extreme of the tidally flooded areas and may be dominated by *Avicennia germinans*, *Laguncularia racemosa* and *Conocarpus erectus* (Gibney *et al.* 2000).

Common plant species:

Avicennia germinans, *Laguncularia racemosa*, *Rhizophora mangle*, *Conocarpus erectus*, *Thespesia populnea*, and *Tillandsia utriculata*.



Photo A-14. Mangrove Woodland

III. Shrublands

Dry Shrublands

Shrublands grow up to 5 m in height and have 25% or more shrub cover. By definition shrublands have less than 25% tree cover – otherwise they'd be classified as woodland. Shrubs are generally multiple stemmed, bushy and interlocking. Aspect, elevation, and land use history profoundly impact shrublands. Shrublands are found in dry locations, at low elevations, and thrive in harsh conditions such as low moisture, thin soils, erosion, strong winds, intense sunlight, and salt spray. Thorny shrubs, cacti, and succulents are common in some locations. Harsh conditions often limit vegetation height at 3 m. These are transitional communities, where succession brings different cover types, such that it is difficult to distinguish between different types of shrublands (Gibney *et al.* 2000).

III.A.1.N.b. Tropical/subtropical broad-leaved evergreen shrubland (Caribbean Formation)

1. Coastal Hedge (CH) (Virgin Islands Sub-formation)

Description:

Contains at least 75% evergreen species (Thomas and Devine 2005). This community is shaped by wind shear and salt spray into dense patches (Gibney *et al.* 2000). These are very low growing and limited to less than 1 m, though sometimes up to 3 m in height. The formation may occur on the berms of beaches, seaward of salt ponds and flats or above rocky coasts or pavement. Hedge effect from wind is the prevailing structural architect for the environment as almost all of the species found here are capable of greater height in less hostile environments (Gibney *et al.* 2000). Plants herein are wind and salt adapted and have small, succulent, stiff and leathery, or waxy evergreen leaves (Thomas and Devine 2005). Epiphytes, smaller cacti, and orchids may be found growing on rocks. This community is found on east, southeast or northeast coastal areas, including beach berms seaward of salt ponds and above rocky coasts or pavement (Thomas and Devine 2005).

Common plant species:

Coccoloba uvifera, *Cassine xylocarpa*, *Pilosocereus royenii*, *Croton rigidus*, *Melocactus intortus*, *Caesalpinia bonduc*, *Acacia tortuosa*, *Randia aculeata*, *Pisonia subcordata*, *Piscidia carthagenensis*, and *Tillandsia utriculata*.



Photo A-15. Coastal Hedge.

2. Gallery Shrubland (GS) (Virgin Islands Sub-formation)

Description:

75% evergreen and 25% deciduous species. Vegetation ranges from 1–10 m depending on available moisture and land use history (Thomas and Devine 2005). These cover types are found most commonly in small guts and ravines where water catchment provides additional soil moisture. Many evergreen species are common to these locations and height of the vegetation is typically at the taller end of the spectrum. They may form very dense communities in these areas and may remain as a result of land use history, being transitional stages to other community types (Gibney *et al.* 2000). Previous land-clearing results in very dense manifestations of this vegetation community (Thomas and Devine 2005).

Common plant species:

Coccoloba uvifera, *Acacia tortuosa*, *Bursera simaruba*, *Cassine xylocarpa*.



Photo A-16. Gallery Shrubland.

III.A.1.N.c. Sclerophyllous tropical/subtropical broad-leaved evergreen shrubland (Caribbean Formation)

1. Sclerophyllous Evergreen Shrubland (SES) (Virgin Islands Sub-formation)

Description:

Usually 75% or more evergreen species. This community is uncommon but forms narrow strands along coastlines in places such as Menneback Bay (north end) and Drunk Bay (Thomas and Devine 2005). Plants exhibit a strong degree of sclerophylly (they have small, tough leaves) and evergreen species become somewhat more numerous (Gibney *et al.* 2000). Other types of shrubland grade into this community type due to slight changes in moisture, aspect, and thin soils. It is difficult to distinguish between this community and a Coastal Hedge (Gibney *et al.* 2000). Rare plants growing in this community type are extremely vulnerable to disturbances (Thomas and Devine 2005).

Common plant species:

Coccoloba uvifera, *Acacia tortuosa*, *Cassine xylocarpa*, *Croton rigidus*, *Jacquinia berterii*, *Pilosocereus royenii*, *Piscidia carthagenensis*, and *Randia aculeata*.



Photo A-17. Sclerophyllous Evergreen Shrubland.

III.B.1.N.a. Lowland drought deciduous shrubland (Caribbean Formation)

1. Thicket/Scrub (TS) (Virgin Islands Sub-formation)

Description:

Ranges from 75% evergreen, to mixed evergreen-deciduous (25%–75% each), to over 75% deciduous species (Thomas and Devine 2005). This community is common and is characterized by thorny scrub communities which generally have a very dense and closed vegetation cover (Gibney *et al.* 2000). Plants average 3–4 m in height though there are occasional emergent trees. This community may have uniform height as a mono-specific stand, or structural variety as a mixture of two species. It may also exist in many locations as a transitional stage into taller woodlands or dry forests. Land use history influences the distribution of this community (Gibney *et al.* 2000). This vegetation community is found on south facing slopes on eastern and southern hillsides such as above Leinster Bay and on Ram Head (Thomas and Devine 2005). We have found this vegetation community to have mostly deciduous species and range from mostly natural to extremely degraded. Thorny or spiny plants are commonly stunted. Tree and shrub species are often exotic (such as *Leucaena leucocephala*).

Common plant species:

Leucaena leucocephala, *Acacia retusa*, *Guapira fragrans*, *Tillandsia utriculata*, *Pilosocereus royenii*, *Capparis indica*, *Capparis flexuosa*, *Erythroxylum brevipes*, *Eugenia biflora*, *Bourreria succulenta*, *Agave missionum*, *Urochloa maxima*, *Croton rigidus*, and *Citharexylum fruticosum*.



Photo A-18. Thicket/Scrub.

2. *Mixed Dry Shrubland (MDS) (Virgin Islands Sub-formation)*

Description:

Ranges from 75% evergreen, to mixed evergreen-deciduous (25%–75% each), to over 75% deciduous species (Thomas and Devine 2005). This vegetation community has a diverse range of compositions of mostly native plants (Gibney *et al.* 2000). This community is common to drier parts, east and south shore headlands, and low elevations, though in some places it may extend as far up as 275 m on south facing slopes. This community can be found at Ram Head in St. John (Thomas and Devine 2005). Vegetation heights range from 1–10 m, with taller plants forming a canopy layer of larger individuals found in moister areas, and shorter plants found in areas exposed to the elements (Gibney *et al.* 2000). Thorny shrubs and succulents including scattered cacti and agave can be found in drier variations of this community type. Based on field observations, Mixed Dry Shrublands with low canopy cover are characterized by vegetation heights of 2–5 m and less than 60% vegetation cover. These may include stands of small trees or shrubs of *Bursera simaruba*. Mixed Dry Shrublands with high canopy cover are characterized by shorter vegetation heights of 1–3 m and more than 60% vegetation cover. These are usually dominated by *Lantana involucrata*, *Tillandsia utriculata*, and cacti species.

Common plant species:

Pilosocereus royerii, *Leucaena leucocephala*, *Bursera simaruba*, *Lantana involucrata*, *Tillandsia utriculata*, *Urochloa maxima*, *Capparis flexuosa*, *Croton rigidus*, *Capparis cynophallophora*, *Acacia muricata*, *Cassine xylocarpa*, *Croton* spp., *Melocactus intortus*, and *Agave missionum*.



Photo A-19. Mixed Dry Shrubland.

Mangrove Shrublands

Mangrove forest found in coastal habitats that are seasonally, tidally, or semi-permanently flooded by salt water. Mangroves are evergreen tree and shrub species that span tropical and subtropical regions throughout the world. The mangrove species found in the USVI are: the red mangrove (*Rhizophora mangle*) which grows at the water's edge, the black mangrove (*Avicennia germinans*) which tolerates the most saline and saturated soils, and the white mangrove (*Laguncularia racemosa*) which is the least tolerant of soil saturation. Buttonwood (*Conocarpus erectus*) is often associated with mangrove communities and can grow in dry soils and rocky shores (Thomas and Devine 2005).

III.A.1.N.h. Tidally flooded tropical or subtropical broad-leaved evergreen shrubland (Caribbean Formation)

1. Mangrove Shrubland (MS) (Virgin Islands Sub-formation)

Description:

This vegetation community ranges from 0.5–5 m in height and often occurs in the driest parts of the island (Thomas and Devine 2005). This community forms non-tidal shrublands or scrub mangrove thickets dominated by *Rhizophora mangle* (Gibney *et al.* 2000). This community grows on more stressed sites than Mangrove Forests or Mangrove Woodlands and so has sparser mangrove cover and shorter individuals (mostly 1.5–2 m tall and usually shorter than 5m) (Gibney *et al.* 2000).

Common plant species:

Rhizophora mangle, *Avicennia germinans*, and *Laguncularia racemosa*.



Photo A-20. Mangrove Shrubland.

IV. Grasslands

Herbaceous vegetation communities have more than 50% cover of grasses and generally less than 25% cover of trees and shrubs. These vegetation communities are found in flat or moderate slopes. They occur in coastal areas with very low rainfall, or in areas with past anthropogenic land use including grazing or agriculture. Coastal grasslands are a naturally occurring herbaceous community, whereas mixed grasslands are anthropogenic in origin (Thomas and Devine 2005).

Grassland

IV.A.1.N.a. Tall tropical/subtropical grassland (Caribbean Formation)

1. Coastal Grassland (CG) (Virgin Islands Sub-formation)

Description:

Native grass species comprise more than 50% of the total cover (Thomas and Devine 2005). Extremes of wind, salt spray and low moisture sometimes combine to form communities of grasses adapted to these harsh conditions (Gibney *et al.* 2000). This community includes short and tall native grasses (such as *Sporobolus* spp. and *Setaria setosa*), succulents (such as *Talinum triangulare* and *Melocactus intortus*), some shrubs (such as *Croton* spp.), and some trees (such as *Guapira fragrans*, *Pisonia subcordata*, and *Cordia* spp.) (Thomas and Devine 2005).

Common plant species:

Urochloa maxima, *Stachytarpheta jamaicensis*, *Jacquemontia pentanthos*, *Commelina erecta*, *Chloris barbata*, *Capparis flexuosa*, *Canavalia rosea*, and *Acacia macracantha*.



Photo A-21. Coastal Grassland.

IV.A.3.N. Tropical/Subtropical grassland with a shrub layer, natural or semi-natural (Caribbean Formation)

1. Mixed Dry Grassland (MG) (Virgin Islands Sub-formation)

Description:

Grass species comprise more than 50% of the total cover (Thomas and Devine 2005). This is a transitional community undergoing successional changes and develops in abandoned or rarely used pastures after management (usually via fires and grazing) has stopped. It is usually formed by selective grazing of livestock that shun spiny and/or poisonous plants (Gibney *et al.* 2000). Non-spiny trees and shrubs including *Cordia alba*, *Psidium guajava*, *Croton spp.* may account for 10–25% cover. Mixed grasslands may continue to develop into a shrubland, woodland, or forest (Thomas and Devine 2005).

Common plant species:

Melocactus intortus, *Cassine xylocarpa*, *Chloris barbata*, *Croton rigidus*, *Urochloa maxima*, *Lantana urticifolia*, *Agave missionum*, and *Plumeria alba*.



Photo A-22. Mixed Dry Grassland.

IV.A.1.N.d. Short sod tropical/subtropical grassland (Caribbean Formation)

1. Pasture (P) (Virgin Islands Sub-formation)

Description:

Planted and cultivated areas subject to maintenance by grazing and fire (Gibney *et al.* 2000). This community is found on the eastern sections of St. John. Grasses form at least 50% of the total cover (Thomas and Devine 2005) and can be accompanied by a very low (less than 10%) incidence of shrub and tree species (Gibney *et al.* 2000). Since this community is under current anthropogenic use (actively maintained by fire and grazing) we are including it in the Non-vegetative category for the purposes of this vegetation mapping project.

Common plant species:

Tabebuia heterophylla, *Psidium guajava*, and *Urochloa maximum*.



Photo A-23. Pasture.

V. Other

Non-vegetative classes, comprising the last seven classes in this vegetation mapping project, are communities where vegetation cover is generally less than 10%.

Sparse Vegetation

V.A.1.N.a. Cliffs with sparse vascular vegetation (Caribbean Formation)

1. Rock Pavement (RP) (Virgin Islands Sub-formation)

Description:

Coastal cliffs, rocky outcrops, boulder fields and landslide areas with less than 10% vegetative cover (Gibney *et al.* 2000).



Photo A- 24. Rock Pavement.

V.C.2.N.b. Intermittently flooded sand beaches and shores (Caribbean Formation)

1. Beach (B) (Virgin Islands Sub-formation)

Description:

Shoreline beaches of sand, cobble, or gravel covered by less than 10% vegetation (Gibney *et al.* 2000).



Photo A-25. Beach.

V.C.4.N.b. Intermittently flooded mud flat (Caribbean Formation)

1. Salt Pond (SP) (Virgin Islands Sub-formation)

Description:

A semi-permanently flooded coastal pond that has gradually formed in sheltered bays or inlets which were once open to the sea. It is usually formed at the bottom of steep watershed areas subject to heavy freshwater influx. It is usually surrounded by shrubs and fringing mangroves (Thomas and Devine 2005).

Common plant species:

Rhizophora mangle, *Laguncularia racemosa*, and *Avicennia germinans*.



Photo A- 26. Salt Pond.

2. Salt Flat (SF) (Virgin Islands Sub-formation)

Description:

This community forms in level areas such as coastal ponds, sand, and mud flats behind barrier beaches and mangroves (Gibney *et al.* 2000). A Salt Flat is a Salt Pond that has collected sediment for thousands of years and filled enough to eliminate surface water. Succulent herbs including *Sesuvium portulacastrum*, *Bacopa monnieri*, and *Sporobolus virginicus* thrive herein (Thomas and Devine 2005).

Common plant species:

Sesuvium portulacastrum and *Sporobolus virginicus*.



Photo A-27. Salt Flat.

3. Freshwater Ponds and Wetlands (FP) (Virgin Islands Sub-formation)

Description:

Permanent freshwater catchment and drainage areas (Gibney *et al.* 2000). These are usually small and found at the bases of drainage guts near coastal areas (Thomas and Devine 2005).



Photo A-28. Freshwater Ponds and Wetlands.

Anthropogenic

V.D.1.N. Developed Areas

1. Development (D) (Virgin Islands Sub-formation)

Description:

Areas permanently altered for the purpose of residential, commercial and industrial uses (Gibney *et al.* 2000).



Photo A-29. Development.

Appendix B. Photo-interpreter Key

Contents

	Page
Moist Forests.....	B-3
1. Upland Moist Forest (UMF) Virgin Islands Sub-formation	B-3
2. Gallery Moist Forest (GMF) Virgin Islands Sub-formation.....	B-3
3. Basin Moist Forest (BMF) Virgin Islands Sub-formation	B-4
Dry Forests.....	B-7
4. Semi-Evergreen Forest (SEF) Virgin Islands Sub-formation	B-7
5. Semi-Deciduous Forest (SDF) Virgin Islands Sub-formation.....	B-7
6. Gallery Semi-Deciduous Forest (GSDF) Virgin Islands Sub-formation	B-7
7. Drought Deciduous Forest (DDF) Virgin Islands Sub-formation	B-9
Mangrove Forests.....	B-12
8. Mangrove Forest (MF) Virgin Islands Sub-formation.....	B-12
9. Fringing Mangrove (FM) Virgin Islands Sub-formation.....	B-13
Dry Woodlands	B-15
10. Evergreen Woodland (EW) Virgin Islands Sub-formation.....	B-15
11. Semi-Deciduous Woodland (SDW) Virgin Islands Sub-formation.....	B-16
12. Gallery Semi-Deciduous Woodland (GSDW) Virgin Islands Sub-formation.....	B-17
13. Drought Deciduous Woodland (DDW) Virgin Islands Sub-formation	B-18
Mangrove Woodland	B-19
14. Mangrove Woodland (MW) Virgin Islands Sub-formation	B-19
Dry Shrublands	B-20
15. Coastal Hedge (CH) Virgin Islands Sub-formation.....	B-20
16. Gallery Shrubland (GS) Virgin Islands Sub-formation	B-21
17. Thicket/Scrub (TS) Virgin Islands Sub-formation.....	B-22
18. Sclerophyllous Evergreen Shrubland (SES) Virgin Islands Sub-formation	B-22
19. Mixed Dry Shrubland (MDS) Virgin Islands Sub-formation	B-23

Contents (continued)

	Page
Mangrove Shrubland.....	B-25
20. Mangrove Shrubland (MS) Virgin Islands Sub-formation	B-25
Grasslands	B-26
21. Coastal Grassland (CG) Virgin Islands Sub-formation	B-26
22. Mixed Dry Grassland (MG) Virgin Islands Sub-formation.....	B-27
23. Pasture (P) Virgin Islands Sub-formation.....	B-28
Other	B-29
24. Rock Pavement (RP) Virgin Islands Sub-formation.....	B-29
25. Beach (B) Virgin Islands Sub-formation	B-29
26. Salt Pond (SP) Virgin Islands Sub-formation.....	B-29
27. Salt Flat (SF) Virgin Islands Sub-formation.....	B-30
28. Freshwater Ponds and Wetlands (FP) Virgin Islands Sub-formation	B-31
29. Developed Areas (D) Virgin Islands Sub-formation	B-31

Moist Forests

1. Upland Moist Forest (UMF) Virgin Islands Sub-formation

Class Description:

75% of trees are evergreen (Thomas and Devine 2005). This community is confined to mountain summits, ridges, and upper north aspects of the taller mountains. The continuous canopy forms at about 15 m with a small tree/shrub layer often found at 5–10 m. Some emergent trees may be as tall as 25 m, although at present they are often shorter. Low shrubs, herbs and epiphytes range from absent to abundant. Recent hurricane disturbance has temporarily increased vine, herb and small shrub growth (Gibney *et al.* 2000).

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

2. Gallery Moist Forest (GMF) Virgin Islands Sub-formation

Class Description:

75% of trees are evergreen (Thomas and Devine 2005). These are riparian communities found in ravines and guts draining large upland watersheds. The moist ravines and guts with the gentlest slopes support the tallest trees on the islands, some over 30 m. Although several emergent species are deciduous, the dominant species are generally evergreen. Frequent flash floods result in younger trees and less pronounced strata in this type of forest. The shrub layer is extremely variable and fewer herbs, shrubs, epiphytes and vines persist. In many locations, the introduced, deciduous fruit tree Genip (*Melicoccus bijugatus*) may dominate (Gibney *et al.* 2000).

Mapping Description:

Mapped where the majority component of the tree canopy coverage was 60% or more, 5 meters or more in height and more than 75% were classified as evergreen trees, except *Melicoccus bijugatus*.

Environmental Settings:

Found at low slopes on the bottom of ravines and guts. No strong aspect for this category.

Distribution:

Found towards the center throughout the island.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows dense green vegetation with large tree tops along the gut, with moderate variability between the surrounding vegetation classifications (Figure B-1). Bare earth LiDAR (Image B) typically has low elevation in the Gallery Moist Forest category. Vegetation wedge (Image C) layer was used to ensure polygon was compassing high tree canopy areas (average 32.47 feet). The slope (Image D) signature indicates guts with surrounding steep slopes as the elevation increases. The albedo and GRVI layers (not shown) did not provide additional information to photo interpret this category.

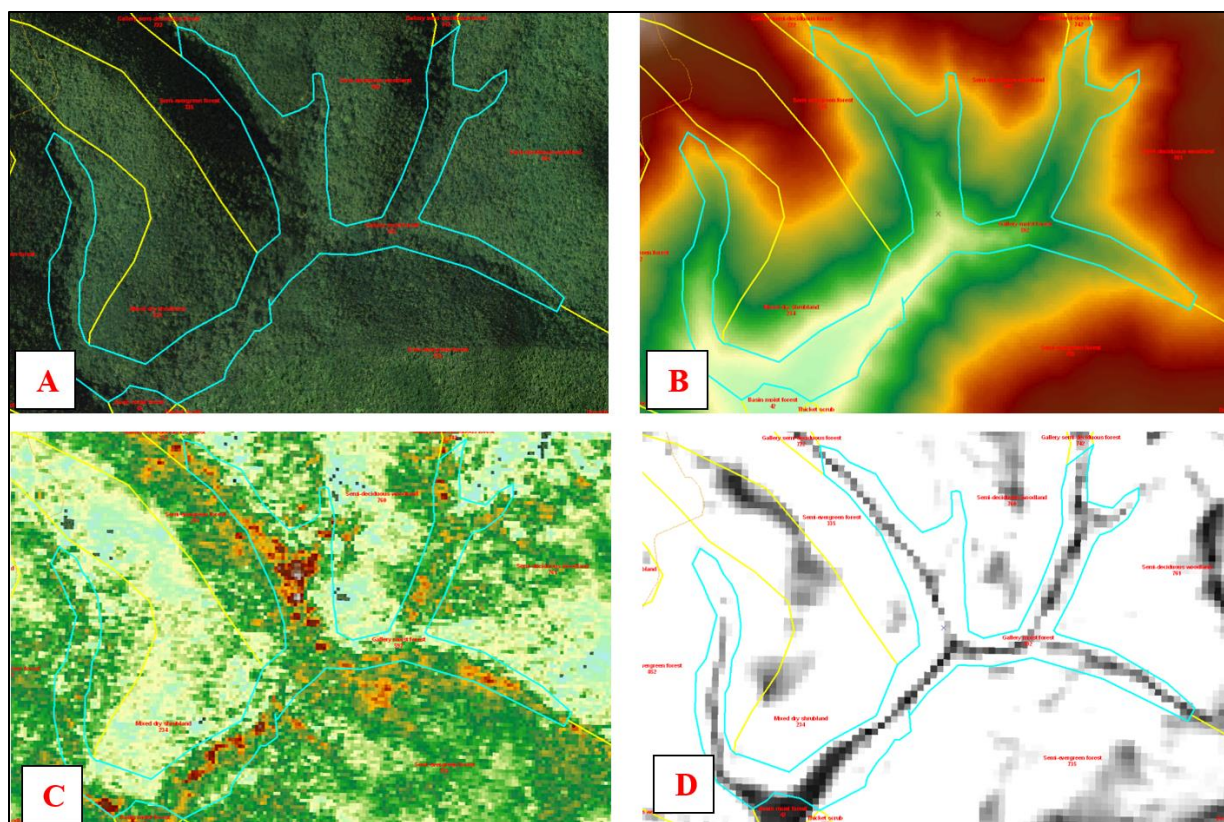


Figure B-1. RGB spectral signature (A), bare earth LiDAR (B), vegetation wedge (C), and slope (D) of a typical gallery moist forest.

3. *Basin Moist Forest (BMF) Virgin Islands Sub-formation*

Class Description:

Ranges from up to 75% evergreen trees to over 75% deciduous trees (based on field observations*). This community is found at sea level in protected valleys (Reef Bay, Coral Bay) (Thomas and Devine 2005). These forests exist in coastal basins and lowland areas, generally along the coast, in areas of low slope where runoff from large upland watersheds collects (Gibney *et al.* 2000). These forest types are well represented on all the Virgin Islands. The forest is normally comprised of 3 layers. Emergent species may reach 25 m or more. A continuous canopy is formed at 15–18 m and a lower layer at 5–10 m. A lower shrub layer may be common or moderately well developed. Herbs and vines are found in significant numbers in a well-developed community. Epiphytes and ferns are rare (Gibney *et al.* 2000).

Thomas and Devine (2005) describe this community as having 75% evergreen trees. However, we have found this community is often dominated by Genip (*Melicoccus bijugatus*) which is deciduous. We therefore propose to re-define this range to include over 75% deciduous trees.

Mapping Description:

Mapped where the majority component of the tree canopy coverage was 60% or more, 5 meters or more in height and more than 75% were classified as evergreen trees, except *Melicoccus bijugatus*.

Environmental Settings:

Found at none to low slope behind beaches. No strong aspect for this category.

Distribution:

Found throughout the island along the coast. Usually located downstream of drainage guts fanning out from the central upland areas.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows dense green vegetation with large treetops, however it does not show strong variability between the surrounding vegetation classifications (Figure B-2). Bare earth LiDAR (Image B) typically has low elevation in the Basin Moist Forest category. Vegetation wedge (Image C) signature indicates dense and high tree canopy (average 29.07 feet). Slope at a 5-meter resolution (Image D) shows a decrease in the land where the basin is. The slope layer is the strongest guide to the photo interpretation for this vegetation classification due to its fine linear definition. The albedo and GRVI layers (not shown) did not provide additional information to photo interpret this category.

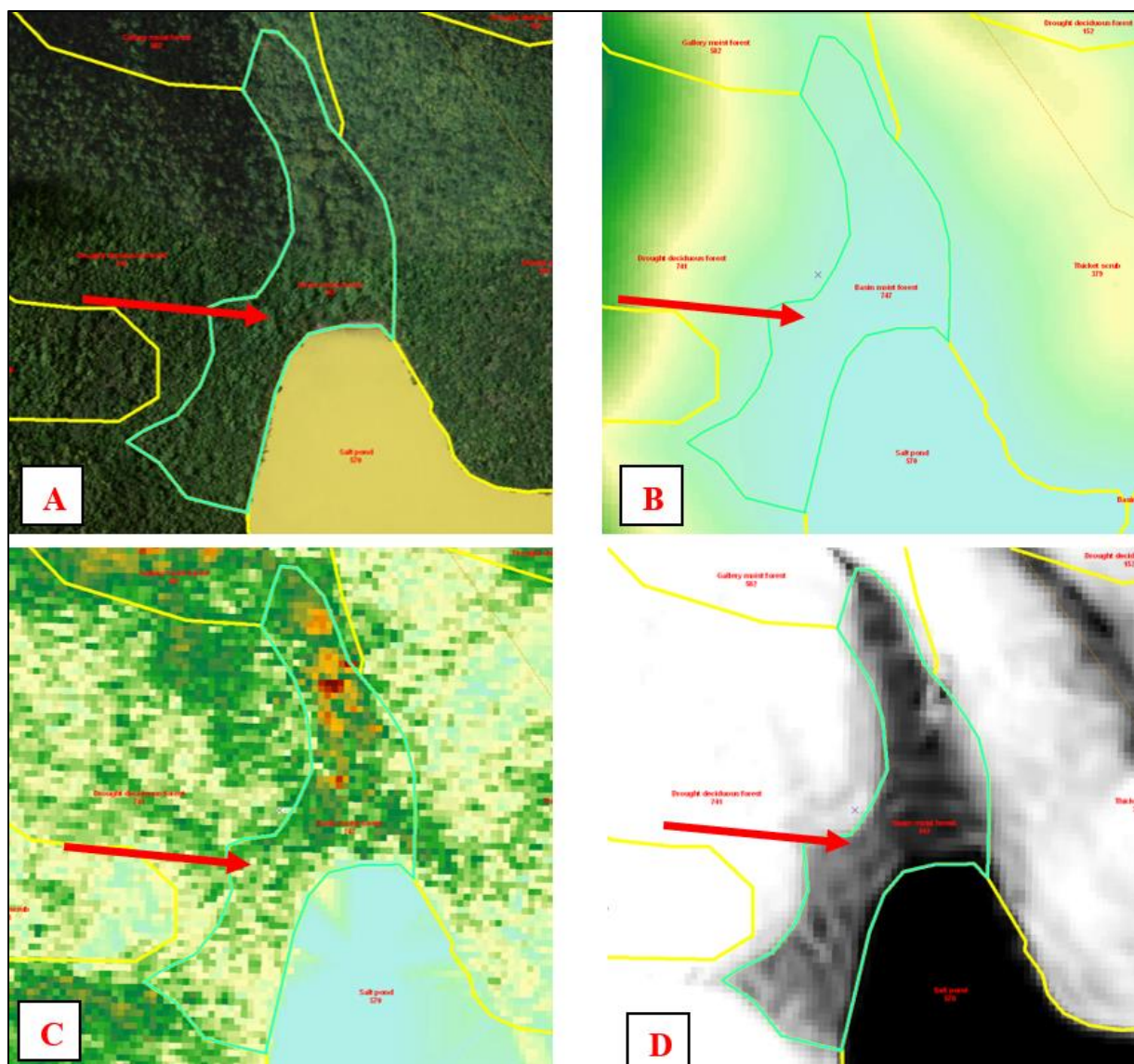


Figure B-2. RGB spectral signature (A), bare earth LiDAR (B), vegetation wedge (C), and slope (D) of a typical basin moist forest.

Dry Forests

4. *Semi-Evergreen Forest (SEF) Virgin Islands Sub-formation*

Class Description:

70 to 75% of trees are evergreen (Thomas and Devine 2005). This community marks the transition between moist and dry forest and is found on slopes above Maho Bay, Cinnamon Bay, and Trunk Bay (Thomas and Devine 2005). This forest cover type is very similar in distribution to the semi deciduous type and in many locations it grades into it. It is generally found above 250 m in elevation, on northwest facing slopes below moist forest levels. Species composition changes to include a shift toward a greater majority of evergreen species (Gibney *et al.* 2000).

Photo Interpretation Signature:

Semi-Evergreen Forest polygons were modified using the bare earth LiDAR layer to check for moderate to high altitudes. The Semi-Evergreen Forest polygons usually were positioned at higher elevations compared to Semi-Deciduous Forest. The vegetation wedge layer was used to ensure polygon was encompassing high canopy areas. In addition, field points were used as a reference.

Photo Signature Examples:

None provided.

5. *Semi-Deciduous Forest (SDF) Virgin Islands Sub-formation*

Class Description:

25% of trees are evergreen and 75% are deciduous. This community is found on north facing hillsides (above Leinster Bay) (Thomas and Devine 2005). This forest group contains a number of fairly distinct forest types, which vary in physiognomy, composition and in degree of human modification (Gibney *et al.* 2000). This is the dominant forest cover throughout the Virgin Islands and on the island of St. John. In most cases these forests may be found on north facing hillsides, at upper southern facing elevations below 250 m, in basins without large watersheds, along smaller guts and ravines, and mixed with dry deciduous forests on lower south facing slopes (Gibney *et al.* 2000).

Photo Interpretation Signature:

Semi-Deciduous Forest polygons were modified using the bare earth LiDAR to check for moderate to high altitudes. The vegetation layer was used to ensure polygon was encompassing high canopy areas. The 5m slope layer showed that the Semi-Deciduous areas were usually moderate as well. In addition, field points were used as a reference.

Photo Signature Examples:

None provided.

6. *Gallery Semi-Deciduous Forest (GSDF) Virgin Islands Sub-formation*

Class Description:

75% of trees are deciduous. This community is found on smaller guts and ravines dominated by dry forests (East End and uplands in the southeast corner of St. John) (Thomas and Devine 2005). This forest type is limited to the smaller riparian corridors such as ravines, guts and intermittent streams

found within dry forest watersheds (Gibney *et al.* 2000). Additional moisture is available to the vegetation as a result of runoff. The taller dry forest species find their maximum height in these locations. Shrub and herb community development are variable (Gibney *et al.* 2000).

Mapping Description:

Mapped where the majority component of the tree canopy coverage was 60% or more, 5 meters or more in height and at least 75% were classified as deciduous trees.

Environmental Settings:

Found at low to moderate slopes on the bottom of ravines and guts within drier forests. No strong aspect for this category.

Distribution:

Found throughout the island.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows dense green vegetation with large tree tops along the gut, with moderate variability between the surrounding vegetation classifications (Figure B-3). Bare earth LiDAR (Image B) typically has moderate elevation in the Gallery Semi-Deciduous Forest category. Vegetation wedge (Image C) layer was used to ensure polygon was compassing high tree canopy areas (average 27.67 feet). The slope (Image D) signature indicates guts with surrounding steep slopes as the elevation increases. The albedo and GRVI layers (not shown) did not provide additional information to photo interpret this category.

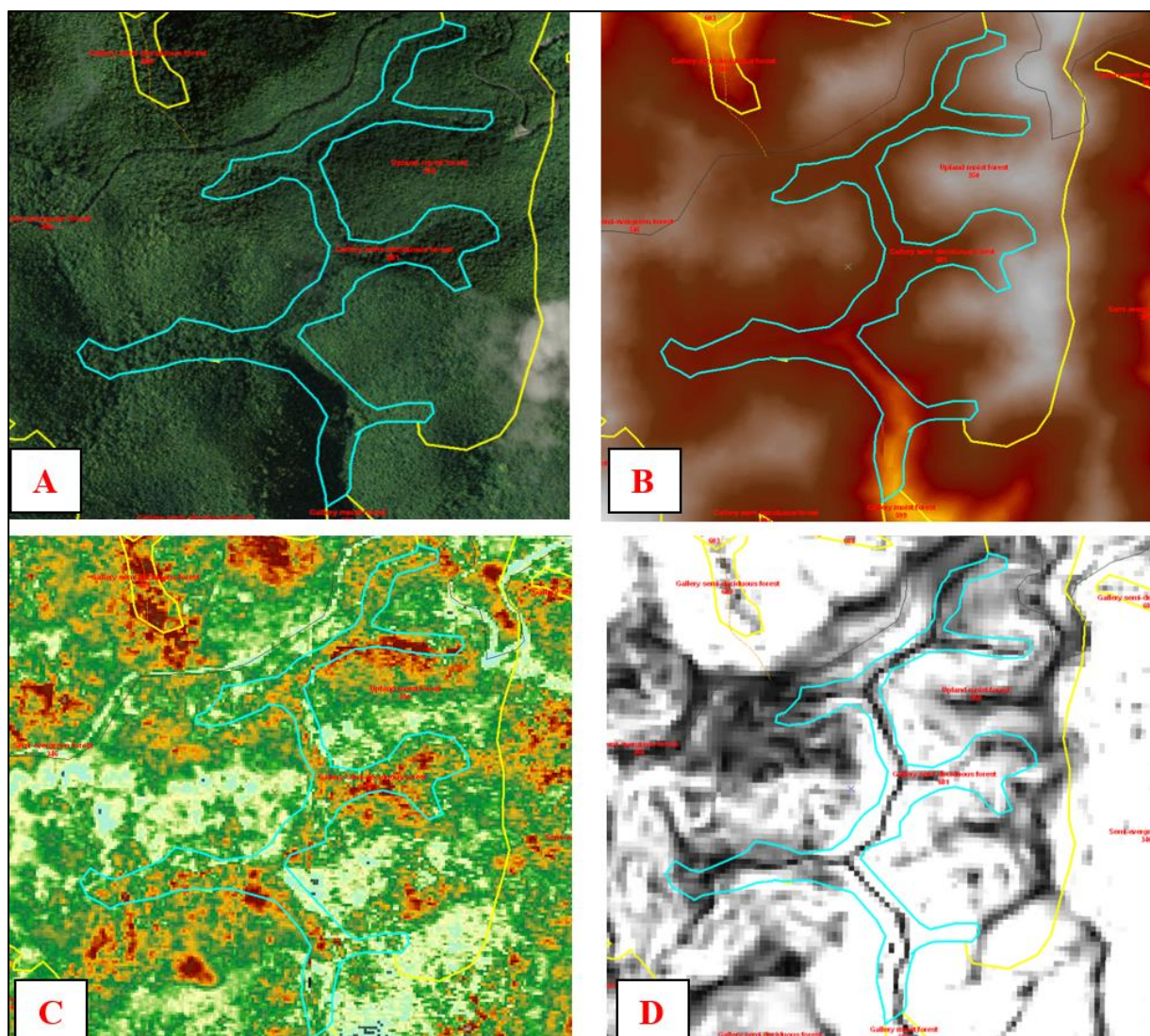


Figure B-3. RGB spectral signature (A), bare earth LiDAR (B), vegetation wedge (C), and slope (D) of a typical gallery semi-deciduous forest.

7. Drought Deciduous Forest (DDF) Virgin Islands Sub-formation

Class Description:

Over 75% deciduous tree species such as *Bursera simaruba* and *Guapira fragrans* (Thomas and Devine 2005). It usually has two layers: an upper layer with a main canopy averaging 7–10 m with some trees up to 15 m tall, and a lower layer with sparse to abundant shrubs and an herb layer that tends to die back during dry periods (Thomas and Devine 2005). Structure and species composition is much the same as semi-deciduous forests, but this type is characterized by greater than 75% deciduous species. Species may have differing leaf phenology under varying climatic conditions, being evergreen in one location and deciduous in another (Gibney *et al.* 2000). This community may be difficult to delineate other than during the annual dry season from January – May. The formation is found mainly at lower elevations below 250 m, on south and southwest facing slopes toward the drier East End locations and in south and west aspects along the north shores. (Gibney *et al.* 2000).

This community is found at East End and uplands in the southeast corner of St. John (Thomas and Devine 2005).

Mapping Description:

Mapped where the majority component of the tree canopy coverage was 60% or more, 5 meters or more in height and more than 75% were classified as deciduous trees, except *Melicoccus bijugatus*.

Environmental Settings:

Found at areas with moderate slope.

Distribution:

Found in the eastern and southern areas of the island along the coast.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows dense green vegetation with large tree tops, however it does not show strong variability between the surrounding vegetation classifications (Figure B-4). Bare earth LiDAR (Image B) typically has an average elevation of 258.53 ft in the Drought Deciduous Forest category. Wedge (Image C) layer was used to ensure polygon was compassing low to moderate tree canopy areas (average 21.79 feet). Albedo projection generated by photo manipulation in the raster calculator with the following formula $[\text{albedo}] = (\text{Red} + \text{Green} + \text{Blue})$. The albedo (Image D) signature indicates the canopy density by displaying high contrast between tree tops which are the green band (depicted as orange on the albedo layer) and the ground (depicted as green). The slope and GRVI layers (not shown) did not provide additional information to photo interpret this category.

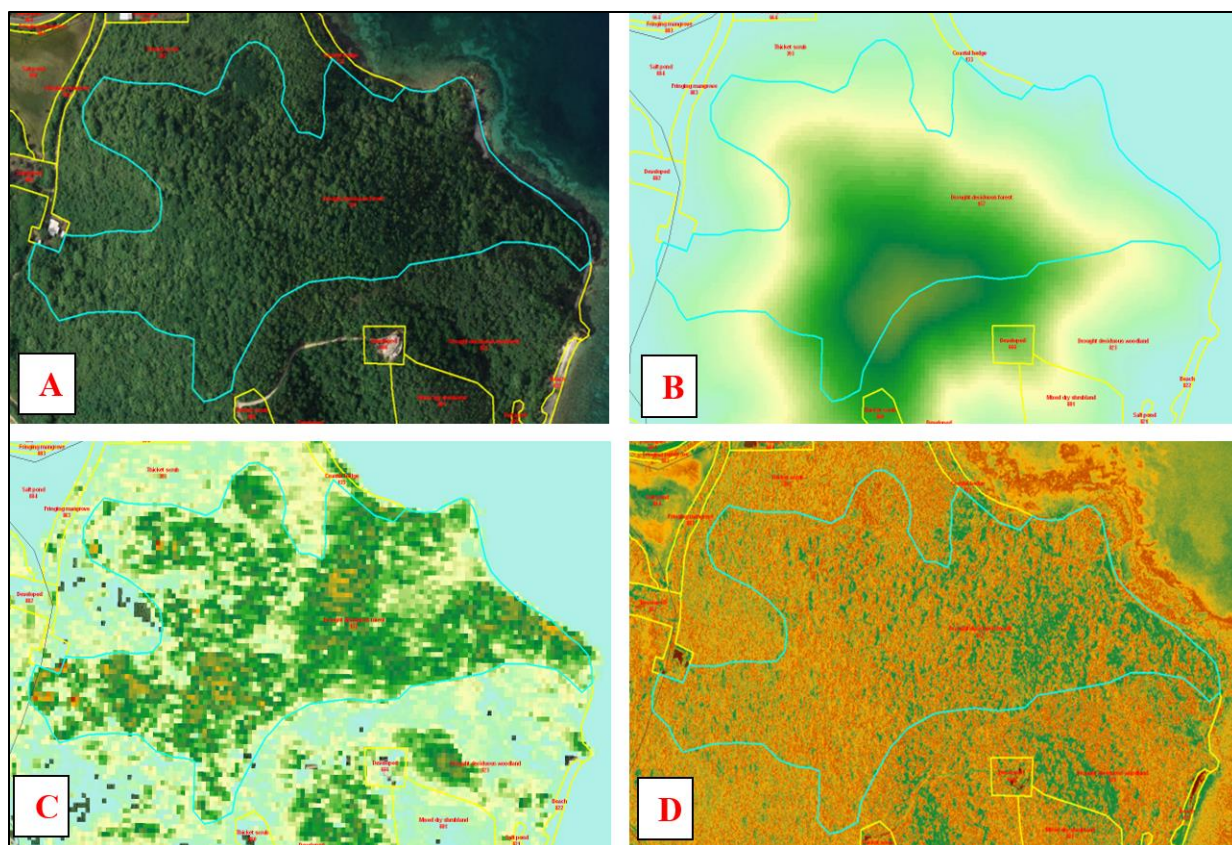


Figure B-4. RGB spectral signature (A), bare earth LiDAR (B), vegetation wedge (C), and albedo (D) of a typical drought deciduous forest.

Mangrove Forests

8. Mangrove Forest (MF) Virgin Islands Sub-formation

Class Description:

Mangroves are 5 m in height or taller and dense, forming a closed canopy. This community is similar to a Mangrove Woodland but is denser such that the tree canopy is closed. This community is found in the moister parts of the island, often where large watersheds drain into moist basins, and can reach 15 m in height (Thomas and Devine 2005). Mangrove Forests are usually dominated by *Rhizophora mangle*, though *Avicennia germinans* and *Laguncularia racemosa* are also found herein (Gibney *et al.* 2000).

Mapping Description:

Mapped where the majority component of the tree canopy coverage was closed and 5 meters or more in height.

Environmental Settings:

Found at areas with no slope behind beaches and/or surrounding salt ponds. Slope for Mangrove Forest ranges from 0.01 degrees to 5.33 degrees. No strong aspect for this category.

Distribution:

Found in the northern and southern areas of the island along the coast.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows dense green vegetation with detailed tree tops, with strong variability between the surrounding vegetation classifications (Figure B-5). Albedo projection generated by photo manipulation in the raster calculator with the following formula $[\text{albedo}] = (\text{Red} + \text{Green} + \text{Blue})$. The albedo (Image B) signature indicates the canopy density by displaying high contrast between tree tops which are the green band (depicted as orange on the albedo layer) and the ground (depicted as green). The vegetation wedge (Image C) layer was used to ensure polygon was compassing tall tree canopy areas (average 24.09 meters). Bare earth LiDAR (Image D) typically has an average elevation of 2.48 ft in the Mangrove Forest category. The slope and GRVI layers (not shown) did not provide additional information to photo interpret this category.

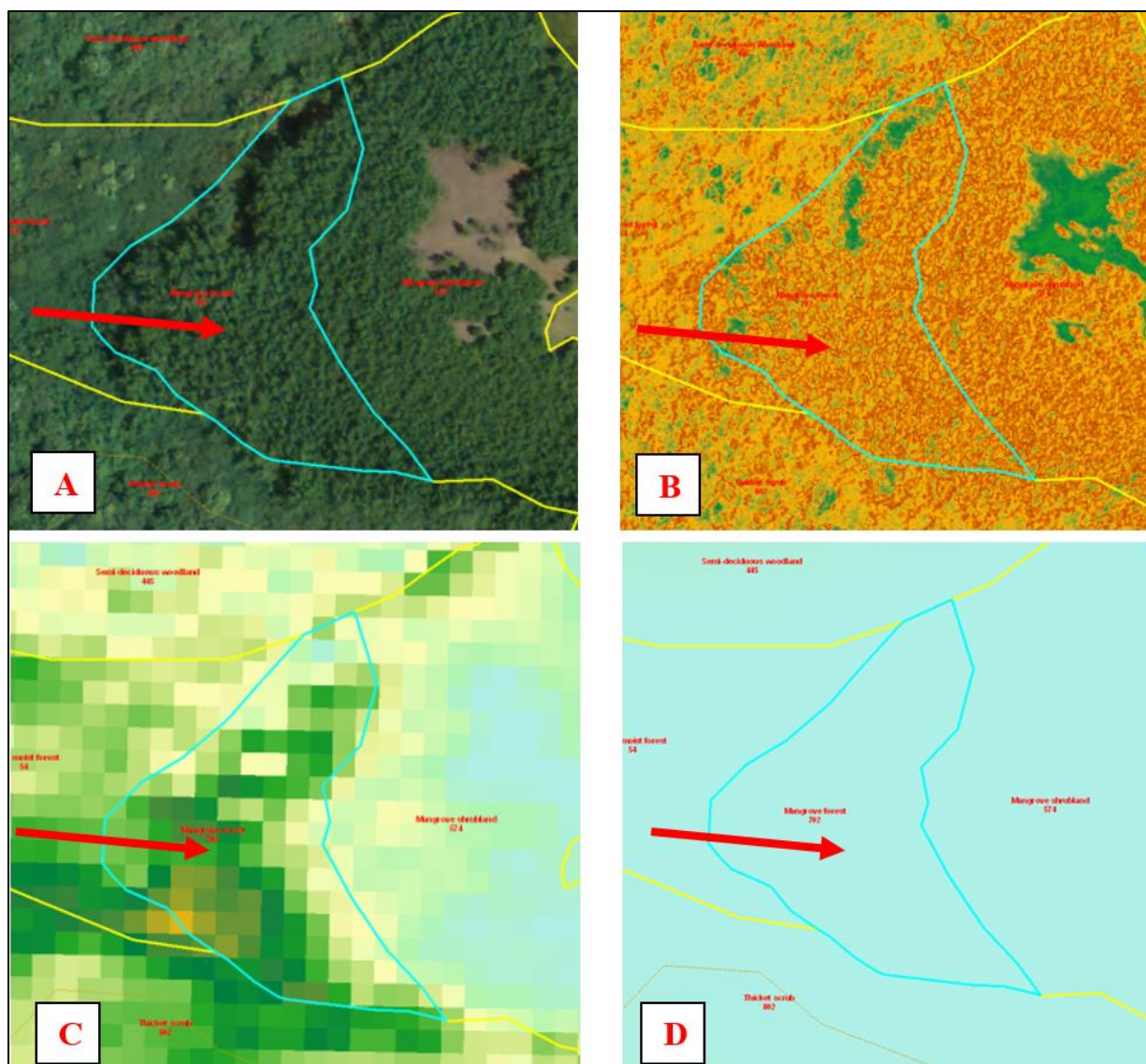


Figure B-5. RGB spectral signature (A), albedo (B), vegetation wedge (C), and bare earth LiDAR (D) of a typical mangrove forest.

9. Fringing Mangrove (FM) Virgin Islands Sub-formation

Class Description:

Coastal shoreline and salt pond vegetation that is semi-permanently and tidally flooded (Thomas and Devine 2005). This community is quite common to all islands of the USVI (Gibney *et al.* 2000).

Mapping Description:

Mapped where the majority component of the tree canopy is along shorelines and salt ponds.

Environmental Settings:

Found at areas with no slope behind beaches. Slope for Fringing Mangrove ranges from 0.10 degrees to 2.79 degrees. No strong aspect for this category.

Distribution:

Found in the northeastern part of the island along the coast.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows dense green vegetation with detailed tree tops, with strong variability between the surrounding vegetation classifications (Figure B-6). Bare earth LiDAR (Image B) typically has low elevation with an average of 3.49 ft in the Fringing Mangrove category. Vegetation wedge (Image C) layer was used to ensure polygon was compassing moderate tree canopy areas (average 11.70 feet). The GRVI layer generated by photo manipulation in the raster calculator with the following formula $[GRVI] = (\text{float}([Green]) - \text{float}([Red])) / (\text{float}([Green]) + \text{float}([Red]))$. The GRVI layer (Image D) signature indicates the canopy density by displaying high contrast between tree tops (depicted as yellow on the GRVI layer) and the ground (depicted as green). The slope and albedo layers (not shown) did not provide additional information to photo interpret this category.

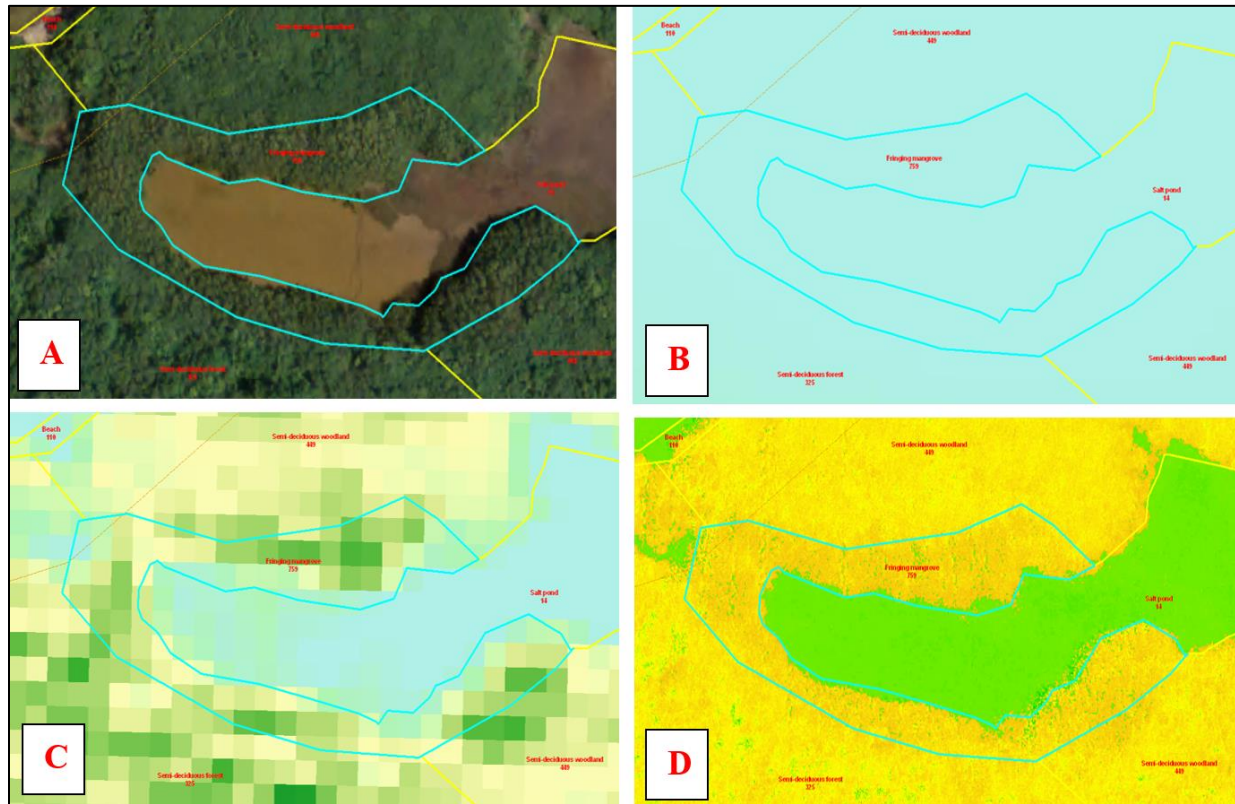


Figure B-6. RGB spectral signature (A), bare earth LiDAR (B), vegetation wedge (C), and GRVI spectral index of a typical fringing mangrove.

Dry Woodlands

10. Evergreen Woodland (EW) Virgin Islands Sub-formation

Class Description:

Usually composed of about 75% broadleaf evergreen palms, largely the Teyer Palm (*Coccothrinax alta*) (Thomas and Devine 2005). This community grows in small patches near coastlines and hillsides ranging from near sea level to an altitude a little over 305 m in both dry and moist forests (Thomas and Devine 2005). This community is found throughout the USVI and on some offshore cays where landscape modifications have taken place. In a number of locations, it may occur as a coconut palm woodland in basin or coastal areas (Gibney *et al.* 2000).

Mapping Description:

Mapped where palms were visibly present, the majority component of the tree canopy coverage was 60% or more, 5 meters or more in height and more than 75% were classified as evergreen trees.

Environmental Settings:

Found at areas with no slope behind beaches. Slope for Evergreen Woodland ranges from 0.24 degrees to 1.67 degrees. No strong aspect for this category.

Distribution:

Found in the northern half of the island along the coast.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows green vegetation with visible palms present, which represents strong variability between the surrounding vegetation classifications (Figure B-7). Bare earth LiDAR (Image B) typically has low elevation with an average of 5.48 ft in the Evergreen Woodland category. Vegetation wedge (Image C) layer was used to ensure polygon was compassing high tree canopy areas (average 32.31 feet). The slope, albedo, and GRVI layers (not shown) did not provide additional information to photo interpret this category.

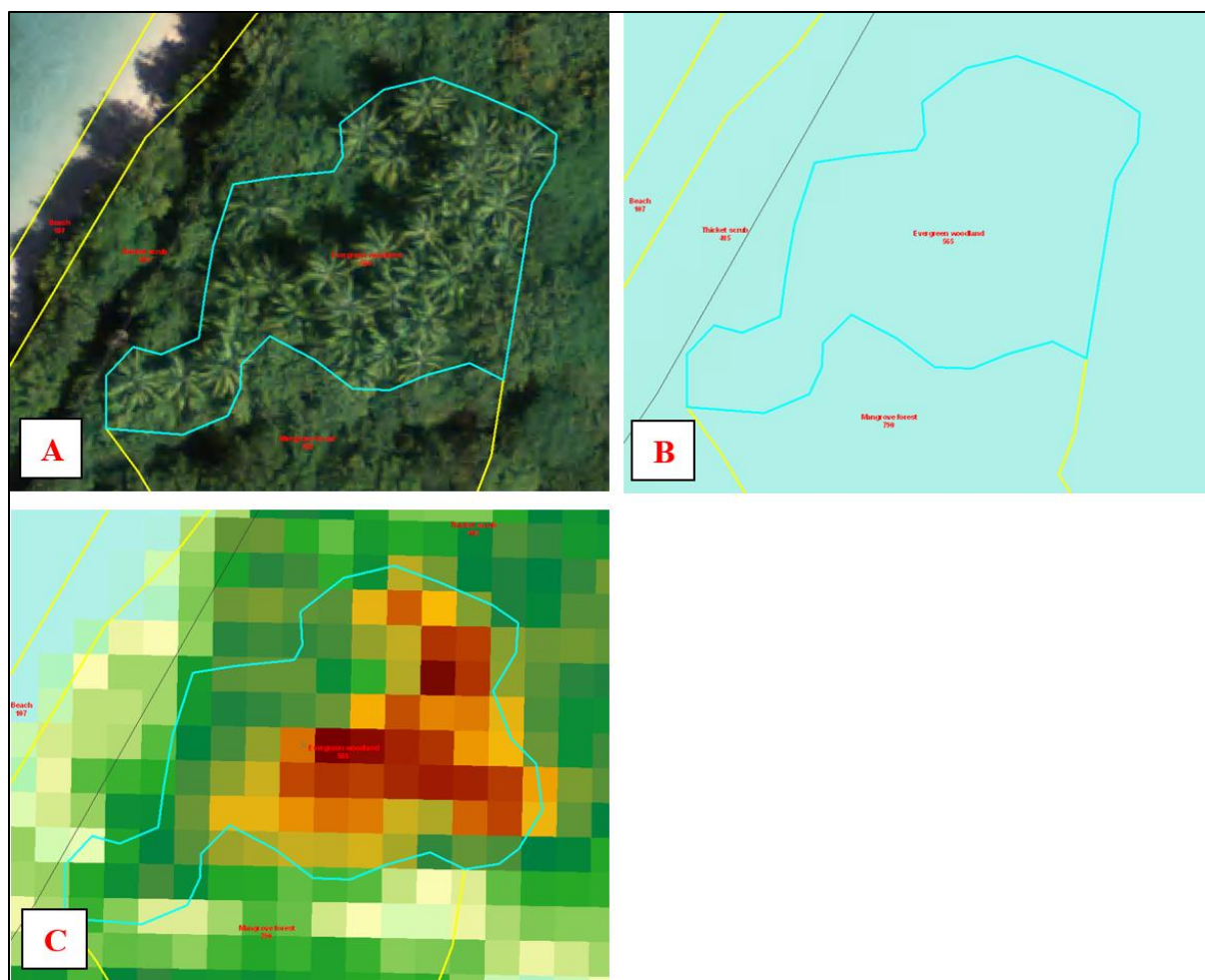


Figure B-7. RGB spectral signature (A), bare earth LidAR, and vegetation wedge (C) of a typical evergreen woodland.

11. Semi-Deciduous Woodland (SDW) Virgin Islands Sub-formation

Class Description:

Usually composed of about 75% broadleaf evergreen palms*. Found on abandoned agricultural areas in the south of St. John (Thomas and Devine 2005). This vegetation community is characterized by an open canopy comprised mainly of common native and naturalized exotic plants (Gibney *et al.* 2000). The size range varies considerably with past land use history and may range from 5–25 m. Canopy cover is open, from 25–60% commonly. These areas are typically influenced by hurricane winds which reduce canopy cover temporarily (Gibney *et al.* 2000).

We found one Coastal Woodland. The canopy was 60% gumbo limbo (*Bursera simaruba*) and 40% marble tree (*Cassine xylocarpa*). Since gumbo limbo is deciduous, the Coastal Woodland was included in this category.

Photo Interpretation Signature:

Semi-Deciduous Woodland polygons were modified using LiDAR to check for low to moderate altitudes. Using the 5m slope layer, it showed that the Semi-Deciduous Woodland polygons had a very high range. The vegetation layer was used to ensure polygon was compassing moderate canopy areas. In addition, the one polygon initially labeled as Coastal Woodland was modified to fit the Semi-Deciduous Woodland category. The canopy was made up of 60% gumbo limbo (*Bursera simaruba*) and 40% marble tree (*Cassine xylocarpa*). Gumbo limbos are deciduous, so this classification should fall under the Semi-deciduous Woodland category.

Photo Signature Examples:

None provided.

12. Gallery Semi-Deciduous Woodland (GSDW) Virgin Islands Sub-formation

Class Description:

Up to 75% of trees are deciduous. This community results from extensive land clearing. Though described the same as the Semi-deciduous Forest, trees herein may reach greater heights due to greater moisture availability (Thomas and Devine 2005). It is primarily found in guts and ravines at low elevation and appears as strips of open canopy woodland where the guts pass through cleared areas (Gibney *et al.* 2000).

Mapping Description:

Mapped where the majority component of the tree canopy coverage was at most 60%, 5 meters or more in height and up to 75% classified as deciduous trees.

Environmental Settings:

Found at low to moderate slopes on the bottom of ravines and guts within drier forests. No strong aspect for this category.

Distribution:

Found on the eastern half of the island.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows dense green vegetation with large tree tops along the gut, however it does not show strong variability between the surrounding vegetation classifications (Figure B-8). Bare earth LiDAR (Image B) typically has moderate elevation in the Gallery Semi-Deciduous Woodland category. Vegetation wedge (Image C) layer was used to ensure polygon was compassing moderate tree canopy areas (average 16.16 feet). The slope (Image D) signature indicates guts with surrounding steep slopes as the elevation increases. The albedo and GRVI layers (not shown) did not provide additional information to photo interpret this category.

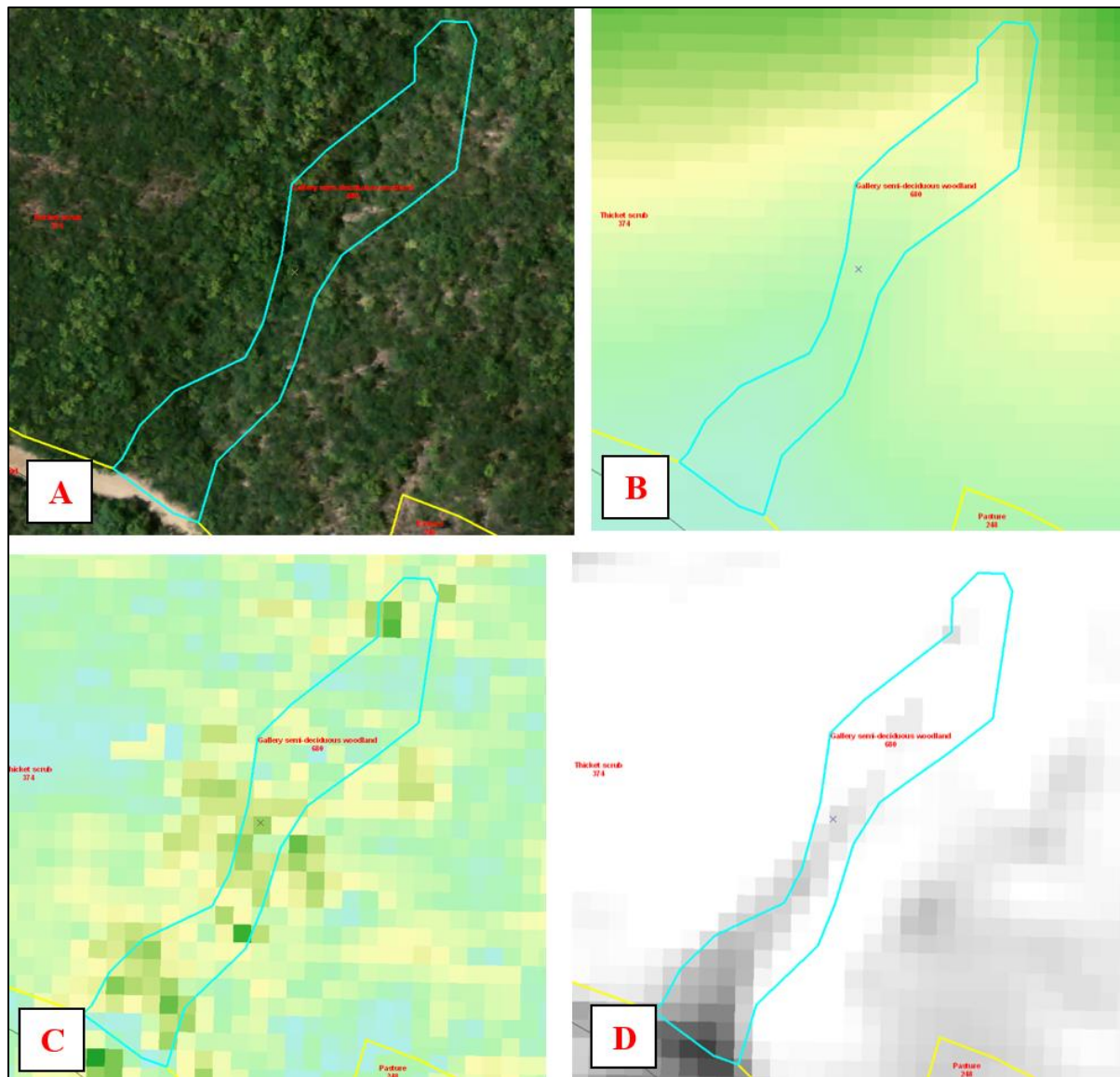


Figure B-8. RGB spectral signature (A), bare earth LiDAR (B), vegetation wedge (C), and slope of a typical gallery semi-deciduous woodland.

13. Drought Deciduous Woodland (DDW) Virgin Islands Sub-formation

Class Description:

Over 75% of trees are deciduous. Found as a patchy community (Thomas and Devine 2005). Similar species composition and community structure make it difficult to distinguish this community from other woodland types such as the semi-deciduous woodland (Gibney *et al.* 2000).

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

Mangrove Woodland

14. Mangrove Woodland (MW) Virgin Islands Sub-formation

Class Description:

Mangroves are 5 m in height or taller and sparse, forming an open canopy. This community is similar to a Mangrove Forest but is less dense such that the tree canopy is open. This woodland type lies at the drier, shoreward extreme of the tidally flooded areas and may be dominated by *Avicennia germinans*, *Laguncularia racemosa* and *Conocarpus erectus* (Gibney *et al.* 2000).

Photo Interpretation Signature:

Mangrove Woodland polygons were modified using the “albedo” layer which showed density. The ground areas appearing darker than the tree tops that were represented as the orange/red color. The bare earth LiDAR layer was used to ensure polygons were encompassing areas at low elevation. In addition, the vegetation layer was used to ensure polygon was encompassing moderate canopy areas.

Photo Signature Examples:

None provided.

Dry Shrublands

15. Coastal Hedge (CH) Virgin Islands Sub-formation

Class Description:

Contains at least 75% evergreen species (Joh and Devine 2005). This community is shaped by wind shear and salt spray into dense patches (Gibney *et al.* 2000). These are very low growing and limited to less than 1 m, though sometimes up to 3 m in height. The formation may occur on the berms of beaches, seaward of salt ponds and flats or above rocky coasts or pavement. Hedge effect from wind is the prevailing structural architect for the environment as almost all of the species found here are capable of greater height in less hostile environments (Gibney *et al.* 2000). Plants herein are wind and salt adapted and have small, succulent, stiff and leathery, or waxy evergreen leaves (Thomas and Devine 2005). Epiphytes, smaller cacti, and orchids may be found growing on rocks. This community is found on east, southeast or northeast coastal areas, including beach berms seaward of salt ponds and above rocky coasts or pavement (Thomas and Devine 2005).

Mapping Description:

Mapped where the majority shrub canopy were along the coast, shaped by wind, and 75% is less than 5 meters in height.

Environmental Settings:

Found at areas with no to slight slope. No strong aspect for this category.

Distribution:

Found in the eastern and southern areas of the island along the coast.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows patchy green vegetation shaped by wind along the coast, with moderate variability between the surrounding vegetation classifications (Figure B-9). Bare earth LiDAR (Image B) typically has an average elevation of 67.9 ft in the Coastal Hedge category. The high average elevation in this category is due to its variable positioning. It can be found along beaches, or on rocky pavement. The LiDAR calculation computes the steep rocky pavements that the Coastal Hedge is on into account. The Vegetation wedge (Image C) layer was used to ensure polygon was encompassing low to moderate tree canopy areas (average 7.02 feet). Albedo projection generated by photo manipulation in the raster calculator with the following formula $[\text{albedo}] = (\text{Red} + \text{Green} + \text{Blue})$. The albedo (Image D) signature indicates the canopy density by displaying high contrast between tree tops which are the green band (depicted as orange on the albedo layer) and the ground (depicted as green). The slope and GRVI layers (not shown) did not provide additional information to photo interpret this category.

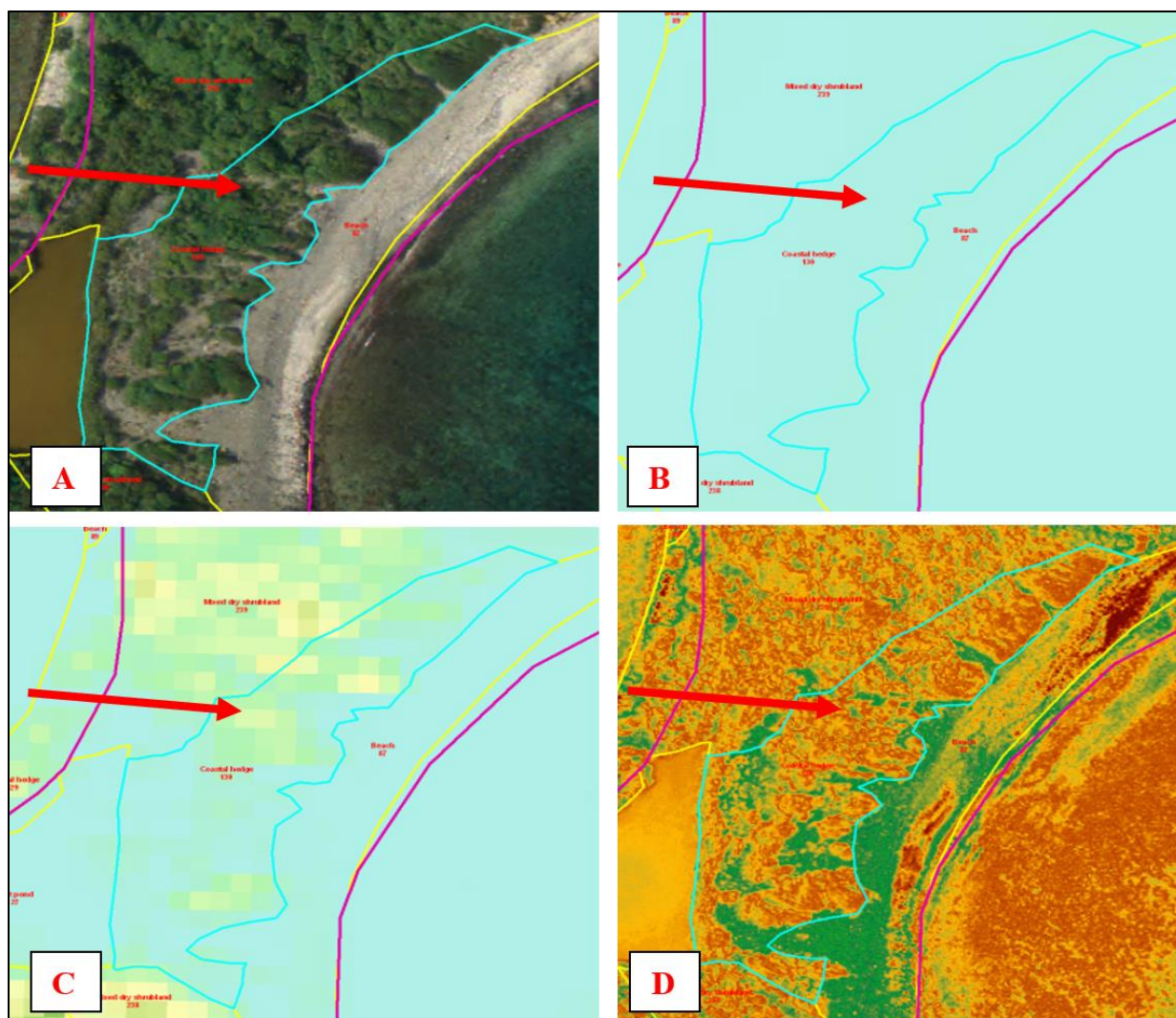


Figure B-9. RGB spectral signature (A), bare earth LiDAR (B), vegetation wedge (C), and slope (D) of a typical coastal hedge.

16. Gallery Shrubland (GS) Virgin Islands Sub-formation

Class Description:

This community is characterized by having approximately 75% evergreen and 25% deciduous species. Vegetation ranges from 1–10 m depending on available moisture and land use history (Thomas and Devine 2005). These cover types are found most commonly in small guts and ravines where water catchment provides additional soil moisture. Many evergreen species are common to these locations and height of the vegetation is typically at the taller end of the spectrum. They may form very dense communities in these areas and may remain as a result of land use history, being transitional stages to other community types (Gibney *et al.* 2000). Previous land-clearing results in very dense manifestations of this vegetation community (Thomas and Devine 2005).

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

17. Thicket/Scrub (TS) Virgin Islands Sub-formation

Class Description:

Ranges from 75% evergreen, to mixed evergreen-deciduous (25%–75% each), to over 75% deciduous species (Thomas and Devine 2005). This community is common and is characterized by thorny scrub communities which generally have a very dense and closed vegetation cover (Gibney *et al.* 2000). Plants average 3–4 m in height though there are occasional emergent trees. This community may have uniform height as a mono-specific stand, or structural variety as a mixture of two species. It may also exist in many locations as a transitional stage into taller woodlands or dry forests. Land use history influences the distribution of this community (Gibney *et al.* 2000). This vegetation community is found on south facing slopes on eastern and southern hillsides such as above Leinster Bay and on Ram Head (Thomas and Devine 2005). We have found this vegetation community to have mostly deciduous species and range from mostly natural to extremely degraded. Thorny or spiny plants are commonly stunted. Tree and shrub species are often exotic (such as *Leucaena leucocephala*).

Photo Interpretation Signature:

Thicket/Scrub polygons were modified using the vegetation layer to ensure polygon was compassing low canopy areas. Areas with TS tend to be around developed areas, and some polygons were found at higher elevations than Mixed Dry Shrubland polygons. In addition, the aerial imagery showed the Thicket/Scrub polygons as denser compared to the Mixed Dry Shrubland areas.

Photo Signature Examples:

None provided.

18. Sclerophyllous Evergreen Shrubland (SES) Virgin Islands Sub-formation

Class Description:

Usually 75% or more evergreen species. This community is uncommon but forms narrow strands along coastlines in places such as Menneback Bay (north end) and Drunk Bay (Thomas and Devine 2005). Plants exhibit a strong degree of sclerophylly (they have small, tough leaves) and evergreen species become somewhat more numerous (Gibney *et al.* 2000). Other types of shrubland grade into this community type due to slight changes in moisture, aspect, and thin soils. It is difficult to distinguish between this community and a Coastal Hedge (Gibney *et al.* 2000). Rare plants growing in this community type are extremely vulnerable to disturbances (Thomas and Devine 2005).

Photo Interpretation Signature:

Sclerophyllous Evergreen Shrubland polygons were modified using the bare earth LiDAR layer to check for low altitudes. The polygons were found along the Western or Eastern coast. The vegetation layer was used to ensure polygon was compassing low canopy areas. In addition, the field point was used as a reference.

Photo Signature Examples:

None provided.

19. Mixed Dry Shrubland (MDS) Virgin Islands Sub-formation

Class Description:

Ranges from 75% evergreen, to mixed evergreen-deciduous (25%–75% each), to over 75% deciduous species (Thomas and Devine 2005). This vegetation community has a diverse range of compositions of mostly native plants (Gibney *et al.* 2000). This community is common to drier parts, east and south shore headlands, and low elevations, though in some places it may extend as far up as 275 m on south facing slopes. This community can be found at Ram Head in St. John (Thomas and Devine 2005). Vegetation heights range from 1–10 m, with taller plants forming a canopy layer of larger individuals found in moister areas, and shorter plants found in areas exposed to the elements (Gibney *et al.* 2000). Thorny shrubs and succulents including scattered cacti and agave can be found in drier variations of this community type. Based on field observations, Mixed Dry Shrublands with low canopy cover are characterized by vegetation heights of 2–5 m and less than 60% vegetation cover. These may include stands of small trees or shrubs of *Bursera simaruba*. Mixed Dry Shrublands with high canopy cover are characterized by shorter vegetation heights of 1–3 m and more than 60% vegetation cover. These are usually dominated by *Lantana involucrata*, *Tillandsia utriculata*, and cacti species.

Mapping Description:

Mapped where the majority component of the shrub canopy coverage was open and less than 5 meters in height.

Environmental Settings:

Found at areas with moderate to steep slope in drier parts of the island. No strong aspect for this category.

Distribution:

Found in the eastern and southern areas of the island, and on cays.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows sparse green vegetation, with moderate variability between the surrounding vegetation classifications (Figure B-10). Bare earth LiDAR (Image B) varies from low to steep elevation in the Mixed Dry Shrubland category. The Vegetation wedge (Image C) layer was used to ensure polygon was encompassing low tree canopy areas (average 9.25 feet). The slope, albedo, and GRVI layers (not shown) did not provide additional information to photo interpret this category.

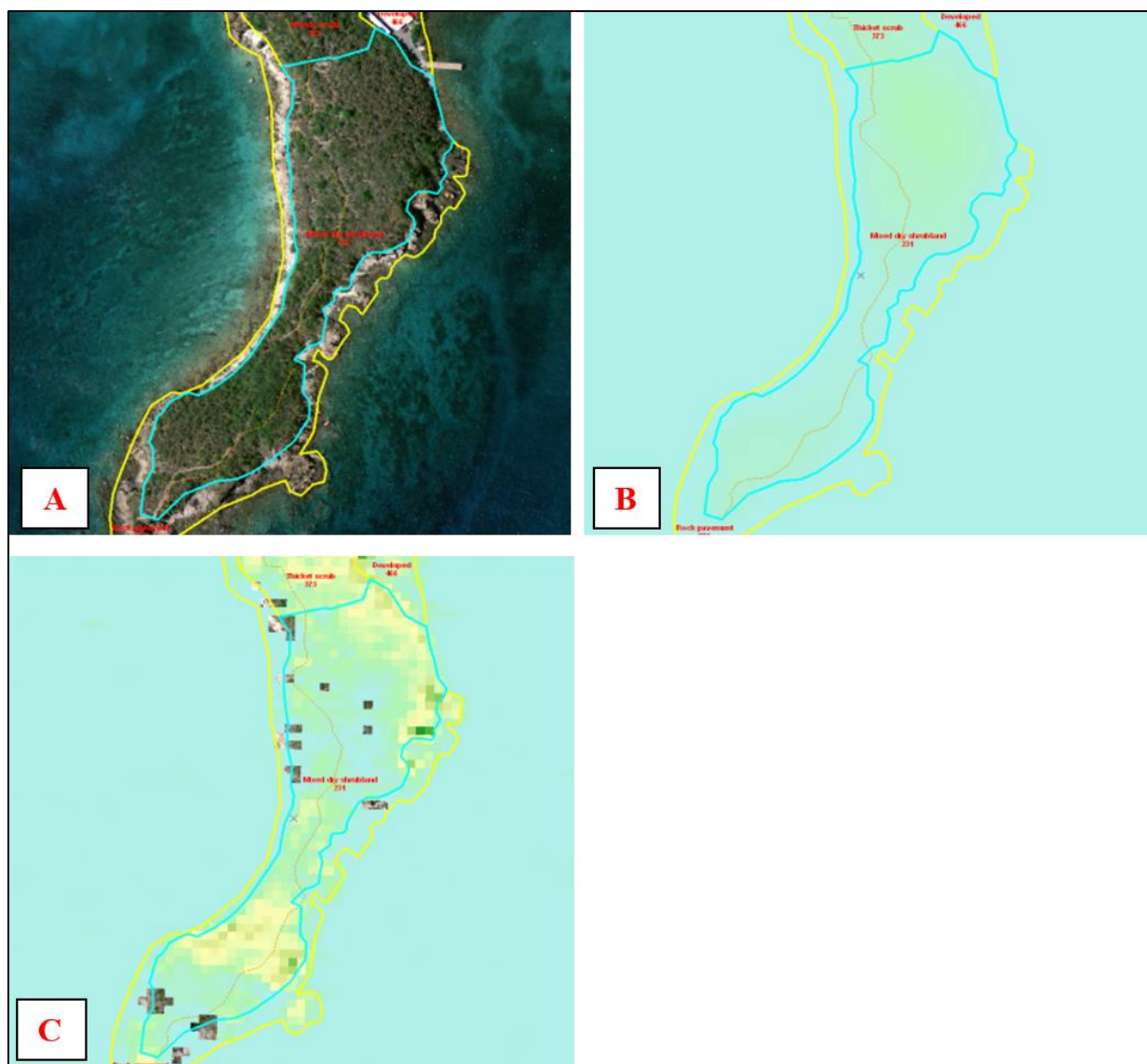


Figure B-10. RGB spectral signature (A), bare earth LIDAR (B), and vegetation wedge (C) of a typical mixed dry shrubland.

Mangrove Shrubland

20. Mangrove Shrubland (MS) Virgin Islands Sub-formation

Class Description:

This vegetation community ranges from 0.5–5 m in height and often occurs in the driest parts of the island (Thomas and Devine 2005). This community forms non-tidal shrublands or scrub mangrove thickets dominated by *Rhizophora mangle* (Gibney *et al.* 2000). This community grows on more stressed sites than Mangrove Forests or Mangrove Woodlands and so has sparser mangrove cover and shorter individuals (mostly 1.5–2 m tall and usually shorter than 5m) (Gibney *et al.* 2000).

Photo Interpretation Signature:

Mangrove Shrubland polygons were modified using the “albedo” layer which showed moderate to low density. The ground areas appearing darker than the tree tops that were represented as the orange/red color. The bare earth LiDAR layer was used to ensure polygons were encompassing areas at low elevation. In addition, the vegetation layer was used to ensure polygon was encompassing moderate canopy areas. There were no field point references for this vegetation classification.

Photo Signature Examples:

None provided.

Grasslands

21. Coastal Grassland (CG) Virgin Islands Sub-formation

Class Description:

Native grass species comprise more than 50% of the total cover (Thomas and Devine 2005). Extremes of wind, salt spray and low moisture sometimes combine to form communities of grasses adapted to these harsh conditions (Gibney *et al.* 2000). This community includes short and tall native grasses (such as *Sporobolus spp.* and *Setaria setosa*), succulents (such as *Talinum triangulare* and *Melocactus intortus*), some shrubs (such as *Croton spp.*), and some trees (such as *Guapira fragrans*, *Pisonia subcordata*, and *Cordia spp.*) (Thomas and Devine 2005).

Mapping Description:

Mapped where herb coverage is more than 50%, and less than 25% tree and shrub coverage.

Environmental Settings:

Found at areas with no to slight slope. No strong aspect for this category.

Distribution:

Found on cays.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery (Image A) shows fine light green vegetation, with high variability between the surrounding vegetation classifications (Figure B-11). Bare earth LiDAR (Image B) typically has an average elevation of 67.9 ft in the Coastal Hedge category. The high average elevation in this category is due to its variable positioning. The LiDAR calculation computes the steep rocky pavements that the Coastal Grassland is on into account. The Vegetation wedge (Image C) layer was used to ensure polygon was compassing low tree canopy areas (average 5.65 feet). The slope, albedo, and GRVI layers (not shown) did not provide additional information to photo interpret this category.

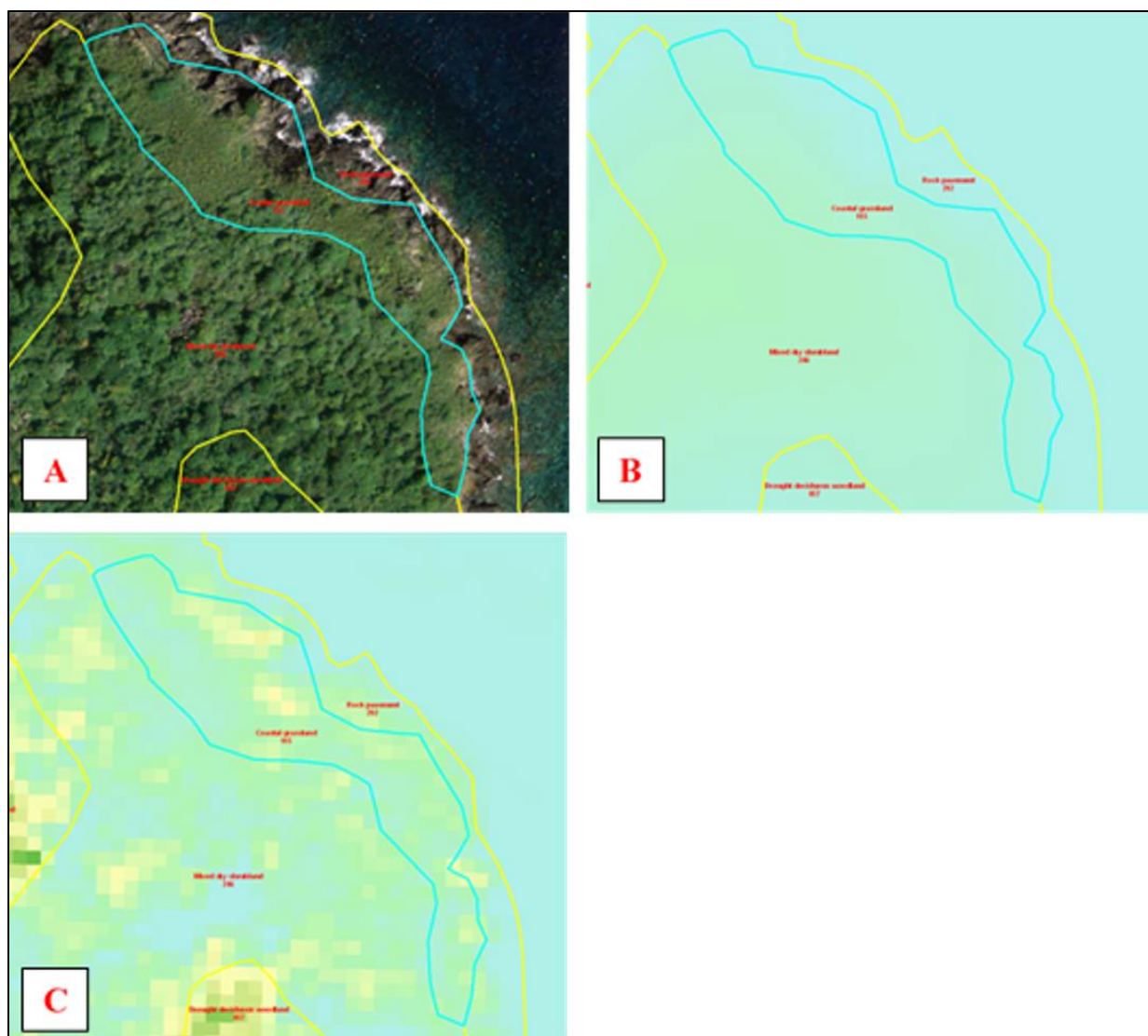


Figure B-11. RGB spectral signature (A), bare earth LiDAR (B), and vegetation wedge (C) of a typical coastal grassland.

22. Mixed Dry Grassland (MG) Virgin Islands Sub-formation

Class Description:

Grass species comprise more than 50% of the total cover (Thomas and Devine 2005). This is a transitional community undergoing successional changes and develops in abandoned or rarely used pastures after management (usually via fires and grazing) has stopped. It is usually formed by selective grazing of livestock that shun spiny and/or poisonous plants (Gibney *et al.* 2000). Non-spiny trees and shrubs including *Cordia alba*, *Psidium guajava*, *Croton spp.* may account for 10–25% cover. Mixed grasslands may continue to develop into a shrubland, woodland, or forest (Thomas and Devine 2005).

Photo Interpretation Signature:

Mixed Dry Grassland polygons were modified using the bare earth LiDAR to check for low to moderate elevation areas. In addition, the vegetation wedge layer to ensure polygon was compassing zero to low canopy areas. The 5m slope layer was used to show areas with zero to low slope.

Photo Signature Examples:

None provided.

23. Pasture (P) Virgin Islands Sub-formation

Class Description:

Planted and cultivated areas subject to maintenance by grazing and fire (Gibney *et al.* 2000). This community is found on the eastern sections of St. John. Grasses form at least 50% of the total cover (Thomas and Devine 2005) and can be accompanied by a very low (less than 10%) incidence of shrub and tree species (Gibney *et al.* 2000). Since this community is under current anthropogenic use (actively maintained by fire and grazing) we are including it in the Non-vegetative category for the purposes of this vegetation mapping project.

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

Other

24. Rock Pavement (RP) Virgin Islands Sub-formation

Class Description:

Coastal cliffs, rocky outcrops, boulder fields and landslide areas with less than 10% vegetative cover (Gibney *et al.* 2000).

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

25. Beach (B) Virgin Islands Sub-formation

Class Description:

Shoreline beaches of sand, cobble, or gravel covered by less than 10% vegetation (Gibney *et al.* 2000).

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

26. Salt Pond (SP) Virgin Islands Sub-formation

Class Description:

A semi-permanently flooded coastal pond that has gradually formed in sheltered bays or inlets which were once open to the sea. It is usually formed at the bottom of steep watershed areas subject to heavy freshwater influx. It is usually surrounded by shrubs and fringing mangroves (Thomas and Devine 2005).

Mapping Description:

Mapped where the Salt Ponds were visible in the aerial imagery.

Environmental Settings:

Found at areas with no slope behind beaches and/or surrounding salt ponds. No strong aspect for this category.

Distribution:

Found on the Eastern half of the island along the coast.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery signature indicates flooded ponds, surrounded by vegetation. The bare earth LiDAR, slope, vegetation wedge, albedo and GRVI layers (not shown) did not provide any additional information beneficial to the Salt Flat photo interpretation.

Photo Signature Examples:

None provided.

27. Salt Flat (SF) Virgin Islands Sub-formation

Class Description:

This community forms in level areas such as coastal ponds, sand, and mud flats behind barrier beaches and mangroves (Gibney *et al.* 2000). A Salt Flat is a Salt Pond that has collected sediment for thousands of years and filled enough to eliminate surface water. Succulent herbs including *Sesuvium portulacastrum*, *Bacopa monnieri*, and *Sporobolus virginicus* thrive herein (Thomas and Devine 2005).

Mapping Description:

Mapped where the Salt Flats were visible in the aerial imagery.

Environmental Settings:

Found at areas with no slope behind beaches and/or surrounding salt ponds. No strong aspect for this category.

Distribution:

Found on the Eastern half of the island along the coast.

Photo Interpretation Signature:

Aerial photograph-RGB Imagery signature indicates exposed ground layer, surrounded by vegetation (Figure B-12). The bare earth LiDAR, slope, vegetation wedge, albedo and GRVI layers (not shown) did not provide any additional information beneficial to the Salt Flat photo interpretation.



Figure B-12. RGB spectral signature of a typical salt flat.

28. Freshwater Ponds and Wetlands (FP) Virgin Islands Sub-formation

Class Description:

Permanent freshwater catchment and drainage areas (Gibney *et al.* 2000). These are usually small and found at the bases of drainage guts near coastal areas (Thomas and Devine 2005).

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

29. Developed Areas (D) Virgin Islands Sub-formation

Class Description:

Areas permanently altered for the purpose of residential, commercial and industrial uses (Gibney *et al.* 2000).

Photo Interpretation Signature:

Not described.

Photo Signature Examples:

None provided.

Appendix C. Confusion (accuracy assessment) matrix for the 1994 UVI vegetation map of Virgin Islands National Park.

Table C-1. Confusion (accuracy assessment) matrix for the 1994 UVI vegetation map.

UVI Vegetation Map Thematic Classes Assessed	Field Assessment (AA Data)																										Row Total	User's Accuracy (Commission Error) Percent
	Basin Moist Forest	Cay	Coastal Grass-land	Coastal Hedge	Deve-loped	Drought Decid-uous Forest	Drought Decid-uous Wood-land	Ever-green Wood-land	Fringing Mangrove	Gallery Moist Forest	Gallery Semi-Decid-uous Forest	Gallery Semi-Decid-uous Woodland	Gallery Shrub-land	Mangrove Forest	Mangrove Shrubland	Mangrove Woodland	Mixed Dry Grassland	Mixed Dry Shrubland	Rock Pavement	Salt Flat	Salt Pond	Sclero-phyllous Evergreen Shrubland	Semi-Deciduous Forest	Semi-Decid-uous Wood-land	Semi-Ever-green Forest	Thicket Scrub		
Basin Moist Forest	9	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	–	–	–	18	50.0%
Cay	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	100.0%
Coastal Grassland	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0%
Coastal Hedge	1	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	2	–	–	6	33.3%
Developed	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	NA
Drought Deciduous Forest	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	100.0%
Drought Deciduous Woodland	–	–	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	NA
Evergreen Woodland	1	–	–	–	1	–	–	3	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	6	50.0%
Fringing Mangrove	1	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	66.7%
Gallery Moist Forest	1	–	–	–	–	–	–	–	–	1	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	20.0%
Gallery Semi-Deciduous Forest	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	3	66.7%
Gallery Semi-Deciduous Woodland	–	–	–	–	–	–	–	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	NA
Gallery Shrubland	–	–	–	–	–	–	–	–	–	–	–	1	0	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.0%
Mangrove Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	0	–	–	–	–	–	–	–	–	–	2	–	–	2	0.0%
Mangrove Shrubland	1	–	–	1	1	–	–	–	1	–	–	–	–	2	0	1	–	–	–	–	–	1	–	–	–	–	8	0.0%
Mangrove Woodland	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	–	–	–	–	–	–	–	–	–	–	–	NA
Mixed Dry Grassland	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	3	66.7%
Mixed Dry Shrubland	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	3	10	–	–	–	–	–	–	–	–	15	66.7%
Rock Pavement	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	–	–	–	–	–	–	–	–	NA

Table C-1 (continued). Confusion (accuracy assessment) matrix for the 1994 UVI vegetation map.

UVI Vegetation Map Thematic Classes Assessed	Field Assessment (AA Data)																										Row Total	User's Accuracy (Commission Error) Percent
	Basin Moist Forest	Cay	Coastal Grass-land	Coastal Hedge	Deve-loped	Drought Decid-uous Forest	Drought Decid-uous Wood-land	Ever-green Wood-land	Fringing Mangrove	Gallery Moist Forest	Gallery Semi-Decid-uous Forest	Gallery Semi-Decid-uous Woodland	Gallery Shrub-land	Mangrove Forest	Mangrove Shrubland	Mangrove Woodland	Mixed Dry Grassland	Mixed Dry Shrubland	Rock Pavement	Salt Flat	Salt Pond	Sclero-phyllous Evergreen Shrubland	Semi-Deciduous Forest	Semi-Decid-uous Wood-land	Semi-Ever-green Forest	Thicket Scrub		
Salt Flat	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	1	–	–	–	–	–	4	50.0%
Salt Pond	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–	–	–	0	–	–	–	–	–	2	0.0%
Sclerophyllo us Evergreen Shrubland	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	100.0%
Semi-Deciduous Forest	–	–	–	–	–	–	–	1	–	–	–	–	–	2	–	–	–	1	–	–	–	–	9	1	–	2	16	56.3%
Semi-Deciduous Woodland	–	–	–	1	–	–	–	1	–	–	–	–	–	2	–	1	–	–	–	–	–	–	3	1	–	–	9	11.1%
Semi-Evergreen Forest	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	3	–	5	60.0%
Thicket Scrub	1	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	5	2	2	9	21	42.9%
Column Total	15	2	1	5	2	6	1	5	3	1	5	1	NA	9	NA	2	6	12	1	2	2	1	26	9	5	11	133	–
Producer's Accuracy (Omission Error) Percent	60.0%	100.0%	100.0%	40.0%	0.0%	33.3%	0.0%	60.0%	66.7%	100.0%	40.0%	0.0%	NA	0.0%	NA	0.0%	33.3%	83.3%	0.0%	100.0%	0.0%	100.0%	34.6%	11.1%	60.0%	81.8%	–	45.9%

Appendix D. Confusion (accuracy assessment) matrix for the 2007 SFCN vegetation map of Virgin Islands National Park.

SFCN Vegetation Map Thematic Classes Assessed	Field Assessment (AA Data)																Row Total	User's Accuracy (Commission Error)
	Basin Moist Forest	Coastal Hedge	Drought Deciduous Forest	Drought Deciduous Woodland	Evergreen Woodland	Fringing Mangrove	Gallery Moist Forest	Gallery Semi-Deciduous Forest	Gallery Semi-Deciduous Woodland	Mixed Dry Shrubland	Mangrove Woodland	Semi-Deciduous Forest	Semi-Deciduous Woodland	Semi-Evergreen Forest	Salt Pond	Thicket Scrub		
Basin Moist Forest	5	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	6	83%
Coastal Hedge	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	100%
Drought Deciduous Forest	–	–	3	–	–	–	–	–	–	–	–	1	–	–	–	–	4	75%
Drought Deciduous Woodland	–	–	–	2	–	–	–	–	–	–	–	–	1	–	–	–	3	67%
Evergreen Woodland	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	4	100%
Fringing Mangrove	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	1	100%
Gallery Moist Forest	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	4	100%
Gallery Semi-Deciduous Forest	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	5	100%
Gallery Semi-Deciduous Woodland	–	–	–	–	–	–	–	–	0	–	–	–	–	–	–	–	0	NA
Mixed Dry Shrubland	–	–	–	–	–	–	–	–	–	11	–	–	–	–	–	–	11	100%
Mangrove Woodland	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	100%
Semi-Deciduous Forest	–	–	–	–	1	–	–	–	–	–	–	26	–	6	–	–	33	79%
Semi-Deciduous Woodland	–	–	–	–	1	–	–	–	–	–	–	–	19	1	–	–	21	90%
Semi-Evergreen Forest	–	–	–	–	–	–	–	1	–	–	–	–	–	11	–	–	12	92%
Salt Pond	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	100%
Thicket Scrub	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	13	15	87%
Column Total	5	3	3	2	7	1	4	6	1	11	1	27	21	18	1	13	124	–
Producer's Accuracy (Omission Error)	100%	100%	100%	100%	57%	100%	100%	83%	0%	100%	100%	96%	90%	61%	100%	100%	–	87.9%

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 161/181580, June 2022

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525