A Reforestation Profile of the U.S. Virgin Islands

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Abstract

This article profiles past and present deforestation and reforestation in the U.S. Virgin Islands, along with the geography and ecology of the three islands. The islands of St. Thomas and St. John form one ecological and cultural unit, whereas St. Croix, located approximately 40 mi to the south, makes up another unit. Different periods of human occupation have left their marks on the islands, including extinctions and introductions of plant and animal species. Owing to the small size and population density of the U.S. Virgin Islands, tree planting is generally for landscaping or small-scale ecological restoration projects rather than timber production. Therefore, trees are grown in containers and tend to be planted as saplings rather than as seedlings.

Introduction

The U.S. Virgin Islands (USVI) is an unincorporated territory of the United States and is composed of three principal islands: St. Croix, St. John, and St. Thomas. The islands are located in the Caribbean Sea, east of Puerto Rico (figure 1). St. Croix is 1,136 mi (1828 km) from Miami, and St. Thomas and St. John are approximately 1,640 mi (2640 km) from New York City. Cuba and Jamaica are closer to the continental United States than either the USVI or another U.S. territory, Puerto Rico. On a clear day, one can look over the sea from the island of St. Croix and see the islands of St. Thomas, St. John, Tortola, and Virgin Gorda to the north (figure 2).

Although all three USVI islands are administratively treated as one unit, St. John and St. Thomas are part of the Virgin Islands archipelago and St. Croix

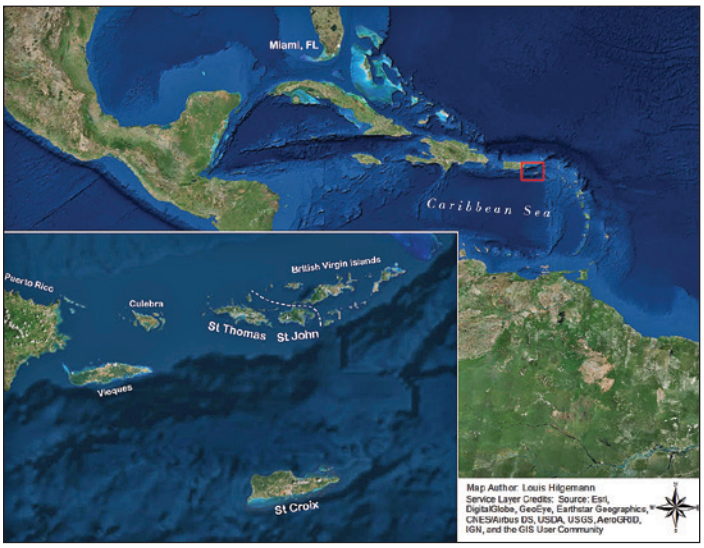


Figure 1. Map of the U.S. Virgin Islands in reference to the continental United States, Puerto Rico, the island of Hispaniola, Cuba, and Jamaica. (Map created by Louis Hilgemann)

Figure 2. View from St. Croix of U.S. Virgin Islands St. Thomas (left) and St. John (center) and British Virgin Islands. (Photo by Michael Morgan, 2016)

is not. St. Thomas and St. John are historically and ecologically very different from St. Croix. The island of St. Croix is approximately 40 mi (64 km) to the south of the other islands. St. Thomas and St. John are only 4 mi (6.5 km) apart from each other. The Virgin Islands archipelago also includes Culebra and Vieques, which belong to Puerto Rico, and Tortola, Virgin Gorda, Jost Van Dyke, and Anegada, which comprise the British Virgin Islands. Both the USVI and British Virgin Islands have several dozen smaller islands and islets associated with them.

U.S. citizenship was granted to Virgin Islanders in 1927. People who live in USVI cannot vote in presidential elections because the USVI is not a State. They do however, elect local officials, the governor, and a delegate to Congress with restricted voting rights. The majority of people living in the USVI are of African descent. The population density on all three islands is such that they are considered urban or urbanizing. Currently, the main economic activity of all three USVI islands is tourism (Chakroff 2010).

Topography

St. Croix

St. Croix is the largest of the three islands. It is 28 mi long and shaped like a teardrop running from east to west, with a total area of 83 mi^2 (215 km^2). The easternmost tip is about 1 mi (1.6 km) wide, and the widest point, mid-island, is about 6 mi (9.7 km) wide. The island had two towns: Christiansted on the north shore and Frederiksted in the west. The population from the 2010 census is 51,000.

The island has a mountainous spine running east to west. The highest point is Mount Eagle (1,165 ft [3580m]) (figure 3). A fertile coastal plain is in the wide part of the island where sugarcane was once cultivated. In pre-Columbian and colonial times, streams flowed year-round to the ocean and were navigable by canoe or rowboat. In more recent decades, however, these streams flow to the sea only when rainfall is abundant. In the hillier parts of the island, ravines drain off excess rainfall. Soils tend to have a limestone origin with pH above 8.

Forest cover of the island (figure 3) is 56.1 percent in 2014, an increase from 49.6 percent in 2009

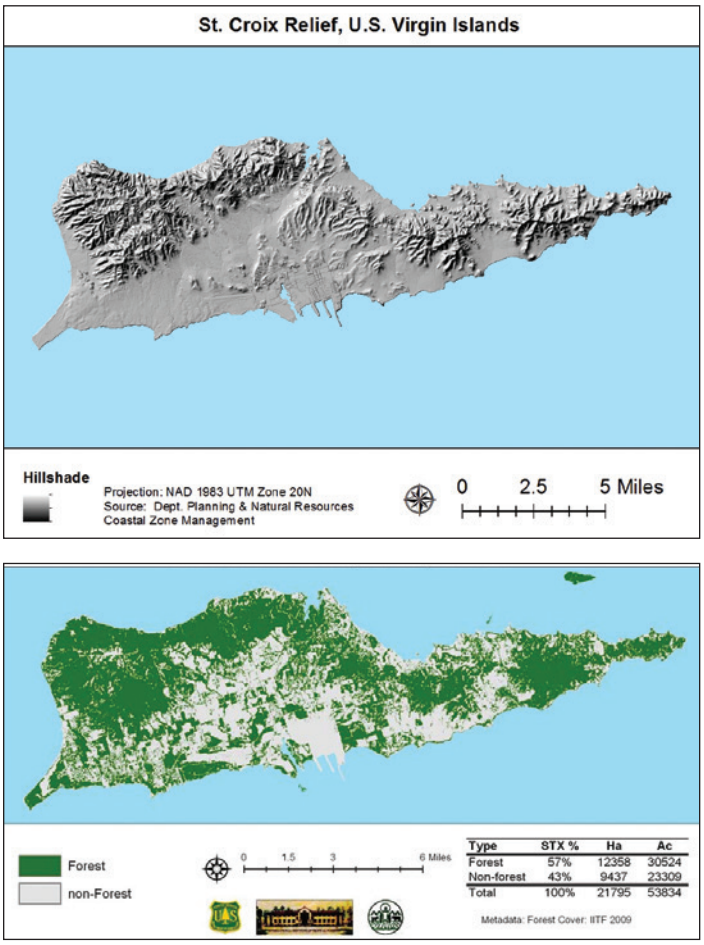


Figure 3. Topographic (top) and forest cover (bottom) maps of St. Croix. (Topographic map created by Louis Hilgemann; forest cover map created by Geographic Consulting, LLC, for Chackroff, 2010)

(Brandeis and Turner 2013, Marcano and Williamson 2017). The predominant vegetation type on St. Croix is mostly subtropical secondary dry forest or thorn woodland dominated by almost pure stands of white leadtree (*Leucaena leucocephala* [Lam.] de Wit), an invasive exotic tree species (figure 4). It is locally known as tan-tan. Only 3 percent of the forest cover is considered mature secondary forest; the hilly northwest quadrant of the island is locally referred to as "the rainforest," but is really subtropical moist forest in its undisturbed condition (Brandeis and Oswalt 2004).

St. Croix is separated from the other islands in the Virgin Islands archipelago and from Puerto Rico by deep marine trenches. This isolation from the other Virgin Islands is reflected in the ecological and human history of the island and its limited suite of native plants and animals.

Figure 4. Typical stands of white leadtree, locally called tan-tan (*Leucaena leucocephala*). This pioneer species forms almost pure dense stands on disturbed sites, with a tree every 2 to 3 ft (60 to 90 cm). (Photos by Michael Morgan, 2016)

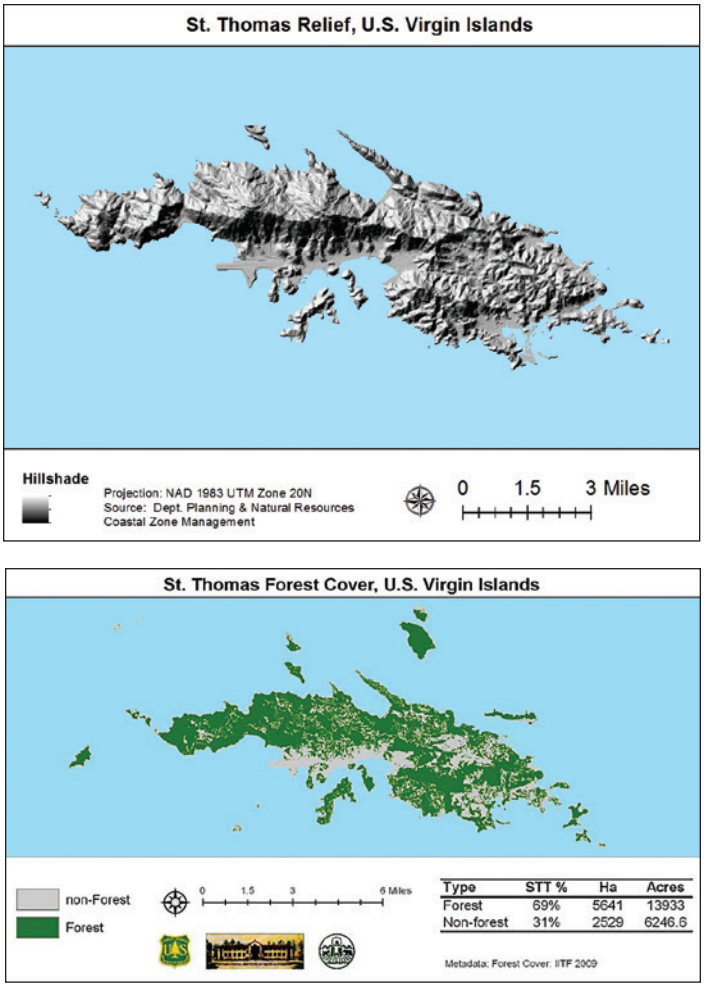


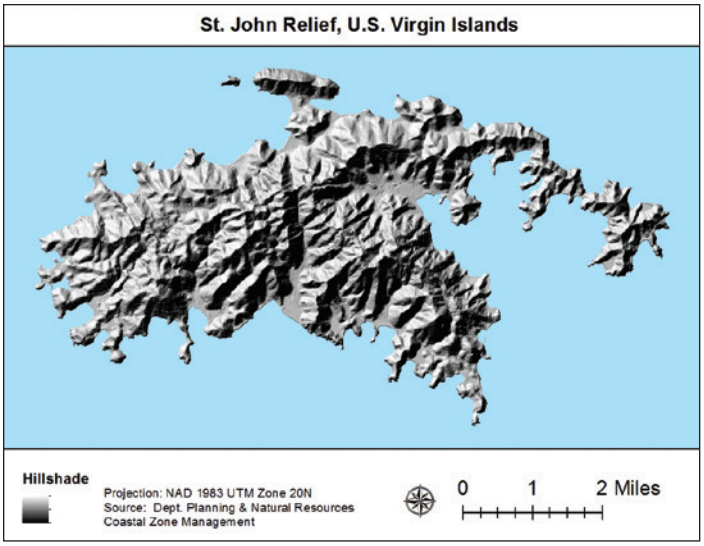
Figure 5. Topographic (top) and forest cover (bottom) maps of St. Thomas. (Topographic map created by Louis Hilgemann; forest cover map created by Geographic Consulting, LLC, for Chackroff, 2010)

St. Thomas

St. Thomas is one-third the size of St. Croix but with the same amount of people. It is so hilly (figure 5) that the airport had to be built on top of dredging spoil that was used to fill in a shallow part of the ocean. The island's total area is 31 mi^2 (82 km^2). The highest point is Crown Mountain (1,550 ft [475 m]). The island has only one town, Charlotte Amalie, which also functions as the capitol of the USVI. The island had 43.6 percent forest cover in 2014 down from 50.1 percent in 2009 (Brandeis and Turner 2013, Marcano-Vega and Williamson 2017). In 2004, 8 percent of the existing forest on St. Thomas was considered mature secondary forest (Brandeis and Oswalt 2004) (figure 5). Most of the forest is considered tropical or subtropical moist forest, with the eastern portion of the island being subtropical dry forest or thorn woodland. Ravines, locally called "ghuts" or "guts," drain the islands after rainfall events. Soils tend to have volcanic origins.

St. John

St. John is east of St. Thomas with a total land area of 20 mi^2 (51 km^2). The landscape rises quickly from the coast to form an upland ridge (figure 6). The highest point is Bordeaux Mountain (1,227 ft [778 m]). Two settlements are of note: Coral Bay and Cruz Bay. The population from the 2010 census is 4,170. The forest cover on St. John was 81.3 percent in 2014, down from 85.1 percent in 2009. About 20 percent could be considered mature secondary forest. The eastern part of the island is drier than the rest. About 60 percent of the island is protected as part of the Virgin Islands National Park (figure 6). Like St. Thomas, soils in St. John tend to have volcanic origins (Brandeis and Oswalt 2004, Brandeis and Turner 2013, Marcano-Vega and Williamson 2017).



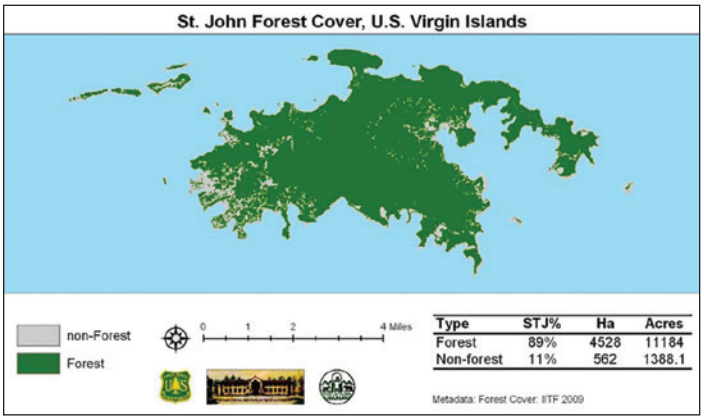


Figure 6. Topographic (top) and forest cover (bottom) maps of St. John. (Topographic map created by Louis Hilgemann; forest cover map created by Geographic Consulting, LLC, for Chackroff, 2010)

Climate

All three USVI islands are significantly below the Tropic of Cancer, with St. Thomas and St. John being at 18°20' N latitude and St. Croix at 17°44' N. Therefore, the climate and vegetation should be considered tropical based on a mean temperature of 75 °F (24 °C) or above. Thomas and Devine (2005) report an average annual temperature of 79 °F (26 °C). According to more recent climate data, the mean USVI temperature is 81.6 °F (27.6 °C) (World Climate Guide 2013). Government and scientific documents, however, often consider the islands to be "subtropical" because of the moderating effect that the ocean has upon the climate, and because the winter winds out of the north keep average "bio-temperatures" just below 75 °F (24 °C) (Ewel and Whitmore 1973, Holdridge 1979).

Average yearly rainfall on the three islands is 55 in (1,400 mm), although rainfall amounts vary among islands and even within individual islands (Thomas and Devine 2005). For example, St. Croix is generally drier than St. Thomas or St. John (Weaver 2006a). On St. Croix, a marked east-to-west rainfall gradient has resulted in thorn woodland on the east end and subtropical moist forest in the northwest of the island. This gradient exists but is less pronounced on the other islands. Also north-facing slopes are wetter than south-facing slopes, especially on St. Thomas and St. John (figure 7). Rainfall can vary dramatically from year to year, due to the presence or absence of hurricanes and droughts.

The rainiest months are April and November, the dry season is from January through March, and most rain falls during the hurricane season (June through November). The winds come predominantly out of the east, and in certain times, bring Saharan dust from Africa.

Figure 7. The incidence of green plants differs significantly between the north side of this hill (left) and the south side of the hill. The view is from Goathill on St. Croix facing directly east toward Point Udall, the easternmost point in the United States. (Photo by Michael Morgan, 2010)

Plant Communities

Using the Holdridge life zone system, two main types of woody plant communities are found on the USVI: moist subtropical forest and dry subtropical forest (Chakroff 2010, Ewel and Whitmore 1973). The reason these forests are considered subtropical and not tropical is because Holdridge uses "bio-temperature" and not mean temperature to classify life zones (Holdridge 1979). Bio-temperatures are calculated using average temperatures, but with an important

caveat: temperatures ≤ 0 °C (32 °F) are all treated as 0 °C (32 °F) and temperatures ≥ 30 °C (86 °F) are all treated as 30 °C (86 °F).

Although maps divide the islands into dry forest and moist forest (figure 8), the reality is much more complex. The islands' landscapes are a mosaic of the two forest types, depending on the presence of watercourses, aspect, slope, soil, and past disturbances. Moist (sub) tropical forests are evergreen, with the presence of palms, and occur in areas that generally receive 25 to 50 in (1,000 to 2,000 mm) of rainfall annually (Ewel and Whitmore 1973, Holdridge 1979). These forests are found on the higher mountains above 1,000 ft (300 m) or in valleys where water from mountain streams collect (figure 9). Dry subtropical forests are either deciduous or semi-deciduous depending on the moisture stress they receive. These forests are the most common type of forest found in the USVI. Some trees lose all of their leaves during the dry season; other trees have sclerophyllous or leathery leaves to conserve water. These forests grow in areas that receive 12.5 to 25 in (500 to 1,000 mm) of rain annually (Ewel and Whitmore 1973, Holdridge 1979) (figure 10).

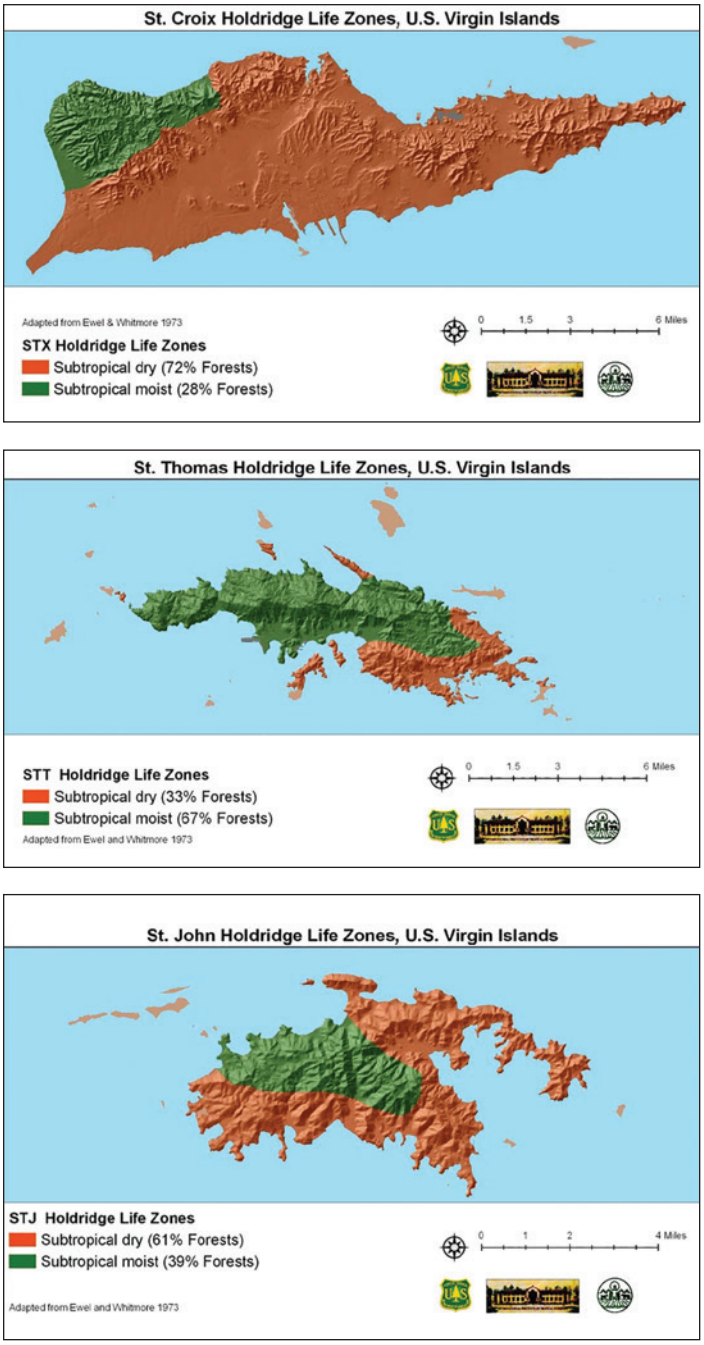


Figure 8. Holdridge zones of St. Croix, St. Thomas, and St. John showing subtropical dry forest and subtropical moist forest. (Maps created by Geographic Consulting LLC for Chackroff, 2010, adapted from Ewel and Whitmore, 1973)

Figure 9. Subtropical moist forests of USVI. Top: St. Croix, view from Mount Eagle (1,155 ft [355m]). Bottom: St. Thomas, note the presence of silvery crowned Tyre Palm (*Coccothrinax barbadensis*) poking above the main canopy; this species is much more common on St. Thomas and St. John than St. Croix. (Photos by Michael Morgan, 2014.)

Figure 10. Subtropical dry forests of the U.S.Virgin Islands. Top: Buck Island, National Monument, St. Croix; note the reddish trunk of Turpentine tree (*Bursera simaruba*). Bottom: east end of St. Croix during the dry season; note many trees have lost their leaves. (Photos by Michael Morgan, 2012.)

Other plant communities found on the three USVI islands include thorn scrub, mangroves, coastal grasslands and scrub, rock pavements, salt ponds and salt flats, sandy beaches, and rocky beaches. Thorn woodland and scrub forests are characterized by short-statured trees and bushes with thorns. Cacti are often present. These forests occur in areas, such as the eastern third of St. Croix, that receive 10 to 20 in (250 to 500 mm) of rain annually (Holdridge 1979) (figure 11). Mangrove forests are subtropical tree communities that grow in the presence of salt water. Formerly, the biggest expanse of mangrove forest in the eastern Caribbean existed on St. Croix at Krauss Lagoon, but, in the 1960s, it was mostly destroyed and filled in to make room for an aluminum smelter, an oil refinery, and a container port. Mangroves now mainly exist as shallow coastal fringes to the islands (figure 12). All of the islands are surrounded by coral reefs.

Figure 11. Tropical thorn woodland (top) and tropical thorn scrub (bottom) on U.S. Virgin Islands (Photos by Michael Morgan, 2016.)

Figure 12. Top: black mangrove (*Avicennia germinans*); note the presence of pneumatophores in the foreground. Bottom: red mangrove (*Mangle rhizophora*) in the U.S. Virgin Islands. (Photos by Michael Morgan, 2017.)

History

Different groups of people arrived and impacted the natural environment of the islands over the centuries. The timeline of the Virgin Islands includes a prehistoric or (prehuman) period, an Amerindian phase, a period of European discovery, a colonial period, and then a modern period starting in 1917, when the United States purchased what is now the USVI from Denmark. Each period is marked by periods of forestation and deforestation, as well as the extinction and introduction of various plant and animal species.

Prehistory (≈8000 B.C.E. to 1000 B.C.E.)

The first phase of island history is perhaps best considered a period of afforestation. The last Ice Age was ending, the world had a cooler, drier climate, and sea levels were approximately 390 ft (120 m) lower than present levels. The landscape of these islands was grassland and savanna (Weaver 2006a). When the climate became warmer, the ice began to melt. Sea levels rose and the climate became wetter. Savannas turned into forests; what once were mountains turned into islands (Weaver 2006a).

St. Thomas, St. John, and the rest of the Virgin Islands archipelago were connected to Puerto Rico via a land bridge that is now, because it is under water, called the Puerto Rican Bank. The Virgin Islands archipelago would have had the same suite of plants and animals as Puerto Rico. St. Croix was always an island, however. The colonization of St. Croix by plants was limited to only species whose seeds could be transported by the wind, the sea, or by birds and bats. Animals were limited to whatever could fly, float, or swim to St. Croix.

First Peoples (1000 B.C.E. to 1515 C.E.)

This is the Amerindian period during which people arrived in roughly two waves. People started to leave South America in 2,000 B.C.E., and over generations, travelled by raft and canoe up the chain of islands that forms the Antilles (Highfield 1995, Rouse 1992). The first groups of people arrived in the Virgin Islands around 1,000 B.C.E. It appears that these groups stayed mainly on the shorelines of the islands, gathering shellfish, fishing, hunting, and gathering edible plants. They left little evidence of their presence in the Virgin Islands other than shell middens. Maybe these first people should be considered visitors rather than settlers (Highfield 1995, Rouse 1992).

The very first peoples were replaced in about 0 to 100 C.E. by other, more numerous Amerindian groups, also originally from northern South America. In addition to fishing, hunting, and gathering, they also farmed (Rouse 1992). They were present on the islands until approximately 1515, when war with the Spanish forced the abandonment of St. Croix and the other Virgin Islands (Highfield 1995).

These first peoples had both positive and negative impacts upon the islands' ecosystems. They caused the extinction of some endemic animal species via overhunting. For example, bones of extinct animals, such as the St. Croix macaw (*Ara autochtones*) and the Antillean Cave rail (*Nesotrochis debooyi*), have been discovered in pre-Columbian kitchen middens on St. Croix (Highfield 1995, Olson 1978, Wetmore 1918, Wetmore 1937).

The Amerindians who farmed brought with them food crops, large-seeded fruit trees, and animals from northern South America (Highfield 1995, Rouse 1990). Each fruit of the mammey apple (*Mammea americana* L.) has one or two seeds inside that are far too large to be dispersed by any bird or bat. They also brought the fruit tree genip (*Meliococcus bijugatus* Jacq.), which nowadays is so common it is considered to be an invasive exotic, yet scientists believe it to have been present in the islands for at least 1,000 years (Francis 1992, Little and Wadsworth 1964). A large forest rodent from northern South America, the agouti (*Dasyprocta* spp.), was brought to serve as a source of meat. In addition to being tasty, agoutis are important dispersers of tree seeds. Their presence in the Virgin Islands is known via excavated kitchen middens (Highfield 1995, Rouse 1992). Although locally extinct, agoutis are still found on other islands of the Lesser Antilles.

Archaeological evidence shows that St. Thomas and St. John supported only three or four villages each because they were so rugged and without permanent streams (Dookhan 1973). Because St. Croix has abundant flat land for agriculture and, during this time, some small rivers, it supported more people. Remains of around 20 villages have been found. Archaeologists believe that at its peak, the Amerindian population

was 3,000 to 5,000 (Highfield 1995). Because they farmed, these early people would have to clear land for crops and cut down trees for home construction, canoes, and firewood.

Discovery and Abandonment (1493–1615 C.E.)

In 1493, Columbus visited St. Croix on his second visit to the New World and skirmished with the Amerindian residents. The next day, he sailed to the archipelago of islands he saw across the water. He called them the Virgin Islands after a St. Ursula, who had a multitude of virgin followers. Soon after European arrival, an approximately 100-year period of reforestation by way of abandonment occurred. By 1515, most inhabitants of St. Croix and the other Virgin Islands either were dead through war and disease, enslaved, or fled to more remote islands. Although the Virgin Islands were considered abandoned, Spain did not bother to colonize them because the Spaniards were too busy extorting gold and silver from the mainland of the Americas to care much for small Caribbean islands (Knight 1990).

In the late 16th century, ships of Spain's European rivals (England, Holland, and France) cruised the Caribbean; the Virgin Islands were a perfect place to lie in wait for a Spanish galleon laden with gold and silver leaving Puerto Rico for Spain. In 1595, Sir Francis Drake, a famous 16th century English sea captain launched an unsuccessful attack on the port and fortress of San Juan, Puerto Rico from the Virgin Islands. Drake's Channel, the channel between the islands of St. John and Tortola that was named after Sir Francis Drake, is a vestige from the era of piracy.

During the time of Amerindian abandonment and Spanish neglect, the fields around Amerindian settlements would have had time to turn into forest, although some localized woodcutting must have been performed by visiting ships for repairs and fuel. The introduction of livestock, like goats and pigs, to provide fresh meat to passing ships probably made the main impact upon the islands forests during that time (Knight 1990). These farm animals soon went feral. Shipboard rats were also probably another introduction to the islands.

First Colonies (1615–1733 C.E.)

In 1615, a Dutchman established a settlement on the island of Tortola in what is now the British Virgin Islands. This was followed by English and Dutch settlements on opposite sides of St. Croix in 1625 and a Dutch settlement on St. Thomas in 1656. In 1672, the Danes established possession of St. Thomas and claimed St. John. St. Croix became a French colony from 1650 to 1695 and was sold to the Danish in 1733.

The first African slaves arrived in St. Thomas in 1672 (Hall 1985) after which deforestation of the islands began in earnest to clear land for crops and to construct buildings. Slaves were essential to the success of the new colonies. Soon, lumber from all three islands of the (now) USVI was exported to other islands or to Europe. Tobacco, cotton, and sugarcane followed (Hall 1985). Slaves were bought from Africa because the English, French, and Dutch colonists kept dying of fever and disease, especially the European indentured servants and convicts who were supposed to supply the manual labor for the colonies. Of the first 190 Danish colonists sent to St. Thomas, only 29 were alive after a year (Dookhan 1974). Africans also died at alarming rates, but were used to working in tropical heat and were slightly more resistant to tropical diseases. On St. Croix, under the mistaken belief that forests cause fevers, large expanses of the island were set on fire to clear land and prevent fevers (Highfield 2013).

It appears that introductions of horses, cattle, and other "Old World" livestock like goats, sheep, pigs, and chickens continued during this period. Herds of wild horses in 17th century St. Croix were referenced (Highfield 2013). Two tree species with African origins, tamarind (*Tamarindus indica* L.) and baobab (*Adansonia digitata* L.), were likely introduced to the Virgin Islands during the 17th century. Tamarind trees are still found in the hundreds, whereas only a dozen or more baobab trees, some of which are more than 300 years old, can be found (Nicholls 2006). Another interesting African addition to the islands is the Guinea fowl (*Numidea meleagris* L.), which has been present in the Caribbean basin since as early as the 1500s. Flocks of them are often seen on St. Croix (Bond 1993).

The Sugar Years (1730–1917 C.E.)

By the early 1700s, agriculture—cotton, tobacco, and especially sugar—was not working out so well on St. Thomas. The island is very hilly, and cultivated soils erode away on steep slopes. The economy started to put more emphasis on trade because of the deepwater harbor at Charlotte Amalie, which was described "as the place you have to go through, to get to any other place in the Caribbean" (Dookhan 1974).

It was not until 1718, 46 years after the settlement of St. Thomas, that the Danes made an active attempt to colonize St. John, even though the two islands are only 4 mi apart (Weaver 2006b). It was just too hilly and rugged. In fact, earlier in the 17th century, because both St. Thomas and St. John were so rugged and forested, the French governor of another Caribbean island, St. Kitts, used the two islands as penal colonies where he could exile dissidents to his rule (Du Tertre 1978).

By 1728, no large trees remained on St. John, and by the 1760s, plantations occupied 98 percent of the island, yet only 35 to 40 percent of the island had been completely cleared. This last fact had positive implications for the natural reforestation of the island in future years because seed sources remained for many, if not all, of the original plant species on the island (Weaver 2006b).

The Danes looked longingly at the flatter, fertile island of St. Croix, abandoned by French settlers since 1695. The forests had had 35 years to recover. Aide et al. (2000) noted that, in Puerto Rico, it usually takes only 35 to 40 years for a regrown forest to recover the original number of stems per acre, biomass, and basal area of the original forest, although it takes at least 80 years (if at all) for the new forest to have the same species composition as the original forest.

In 1730, France sold St. Croix to the Danes. The land began to be cleared in earnest for sugarcane in the wetter western half of the island and cotton in the eastern half. Reimert Haagensen (1995), an early Danish settler of 18th century St. Croix, wrote that many trees were burnt on site in the process of clearing land simply because they were too big to cut up and move. Some tree species, however, such as lignumvitae (*Guaiacum officinale* L.) and fustic (*Maclura tinctoria* (L) Steud) were left standing because they were so valuable. Spanish cedar (*Cedrela odorata* L) was used for canoes and shipbuilding (Carstens 1997). Another timber species exported from St. Croix was maststick or mastwood (*Sideroxylon foetidissisum* Jacq.). As its name suggests, this species was used for ship masts because of its straightness (Highfield 2013).

In the 1750s, sugarcane production took off on St. Croix with the arrival of 1,000 Irish settlers and their accompanying slaves from the Caribbean island of Monserrat (Hall 1985). In addition, more slaves were imported from Africa. By 1796, one-half of the island was devoted to sugar plantations, with their accompanying pastures and garden allotments for the plantation slaves, and the other one-half was devoted to cotton and pasture. The population of St. Croix reached 30,000 by 1800 (Weaver 2006a). By the 1820s, however, the island's sugarcane industry started to decline as other tropical countries started to cultivate sugarcane, and a method was developed to extract sugar from sugar beets. In 1803, the King of Denmark ended the importation of new slaves, and, in 1848, slavery was abolished, resulting in a shortage of labor. Agriculture shifted from sugar to livestock, although it was not until 1963 that the last sugarcane harvest occurred on St. Croix (Dookhan 1974).

Very early on, St. Thomas and St. John started to differ from St. Croix. Nearly from the very start, St. Thomas was more of a port of commerce for the other islands rather than a center of agricultural production. In the 1750s, the population was already 50-percent urban (by the 1840s it was 80-percent urban), whereas St. Croix was 75-percent rural, and St. John was described as "a mere sheep path" (Dookhan 1974). After the early 1700s, very little plantation agriculture was on St. Thomas, but the island had plenty of cattle grazing, charcoal making, and subsistence agriculture. On both St. Thomas and St. John, trees on steep slopes were only selectively cut (Gibney 2017).

Besides clearing the land for agriculture, some Danish forestry activity occurred, which mainly resulted in the introduction of new tree species. For example, little leaf or West Indian mahogany (*Swietenia mahoganii* (L) Jacq.) was introduced to St. Croix from Jamaica in the 1770s (Weaver 2006a). Big leaf or Honduran mahogany (*Swietenia macrophylla* King)

was introduced in 1907. Mangos (*Mangifera indica* L.) and tibbets (*Albizia lebbek* L. Benth.) were introduced from Asia (Nicholls 2006). White lead tree or tan-tan (*Leucaneana leucocephala* Lam. de Wilt) is a small tree ubiquitous on St. Croix and is believed to have been introduced by one of two Danish agricultural experiment stations on St. Croix between 1890 and 1910 as a forage species. In 1793, the English Captain Bligh brought cuttings of breadfruit (*Artocarpus attilus* Parkinson Fosberg) from Polynesia to the British colonies of the Caribbean as an alternative starchy staple food for African slaves. Although not initially well received as a food source, breadfruit is now part of traditional Virgin Islands cooking (Little and Wadsworth 1964).

The Danes also impacted the ecosystems of the islands in other ways. In the 1790s, they introduced white-tailed deer (*Odocoileus virginiana* Zimmermann) as a game species. The deer continue to be abundant on St. Croix and St. John and negatively affect forest regeneration. The South Asian mongoose (*Herpestes auropunctatus* Hodgson) was introduced in 1884 in an effort to control rats in the cane fields. Instead of exterminating rats, however, they preyed upon ground nesting birds and their eggs. The mongoose introduction led to the extinction of an endemic snake, the St. Croix racer (*Borikenophis sanctaecrucis*) and eradicated the St. Croix ground lizard (*Ameiva polops*) from the island. These days, the lizard is found only on Buck Island and three islets off the coast of St. Croix (Weaver 2006a).

Modern Times (1917 C.E. to the Present)

After the sugarcane industry declined, the islands stopped being profitable for Denmark and became a financial burden. In 1917, the United States bought the three islands from Denmark due to St. Thomas' strategic location in the Caribbean. Forests began to grow back as agricultural fields were abandoned and people emigrated. St. Croix has transitioned from an almost completely forested landscape to almost completely deforested during the height of sugarcane production (Chakroff 2010), to modern times where data indicate a steady state of over 50 percent forested landscape (Chakroff 2010).

Little written information can be found about St. Thomas, but this is what the botanist and lifelong St. John resident, Eleanor Gibney (2017) has to say: "The reason there's few records from St. Thomas is that no one ever did much about tree planting—but because of the lack of plantation agriculture after the early 1700s, clearing was patchy and small scale over most of the island, so recovery was fairly fast with the seed sources nearby. On both St. Thomas and St. John, the steep slopes were often only selectively cut. But there was a lot of livestock grazing and fuel-wood/charcoal cutting on both islands. St. John (and British Virgin Islands) wood resources were heavily exported to both St Thomas and St Croix, up through the mid-20th century. I can remember the burlap sacks—crocus bags—full of charcoal sitting on the Cruz Bay dock in the early 1960s, waiting for transport. It's hard to over-emphasize how heavily the St Thomas/St John population was centered in Charlotte Amalie and how really empty the country was until the 1960s."

Meanwhile, on the island of St. John in 1917, only 3 percent of the land was cultivated, much of it was grazed, and the rest was forested. Oil from the leaves of the bay rum tree (*Pimenta racemosa* [Mill.] J.W [Moore)] was the primary export of that island at its peak in 1920 (Weaver 2006b). Wild donkeys, sometimes thought to have existed since colonial times, only became wild during the late 1970s. Gibney (2017) writes: "before that every donkey was (very much) owned, but after about 1970 people let them wander off—because cars and trucks were abundant enough to do the heavy carrying...." Currently, both wild donkeys and deer negatively impact forest regeneration in the Virgin Islands National Park.

Things were quiet in the USVI until the 1950s, when the Virgin Islands Tourism Board was created to promote tourism, especially to St. Thomas and St. John. Industry was attracted to St. Croix via tax breaks. An aluminum smelter was established in 1962 and then an oil refinery in 1964. A serious environmental impact of these two large installations was the destruction of the 1,000-ac (405-ha) Krause Lagoon, the largest expanse of mangroves in the Eastern Caribbean, to build a port so raw materials could be processed and refined oil and aluminum exported. The aluminum smelter closed in the 1990s, and the refinery stopped refining in 2012, although it is currently a storage facility.

Forestry and Tree Planting Activities in the 21st Century

In the 1930s, the Federal Government began to show interest in the forests and natural areas of the USVI. During the Great Depression, a short-lived Federal public works program was created to plant shade trees in pastures and windbreaks (Weaver 2006a). In 1956, the Virgin Islands National Park was created by Congress on the island of St. John. The park protects 60 percent of the island. Meanwhile, the U.S. Department of Agriculture (USDA), Forest Service acquired a 150-ac (60-ha) tract on St. Croix called Estate Thomas for forestry experiments, in particular, provenance trials of various tree species such as mahogany (*Swietenia* spp.), teak (*Tectona grandis* L.f.), Spanish cedar (*Cedrela odorata* l.), and Caribbean pine (*Pinus caribaea* Morelet.). It is currently used for monitoring natural forest succession and environmental education.

As far as the authors know, very little forestry activity (urban or otherwise) is currently on St. Thomas. The territorial park of Magen's Bay has an arboretum. The only other forestry activity we know about is the cryptic tale of aerial seeding of St. Thomas with seeds of flamboyant (*Delonix regia* L.) by the founder of the *Virgin Islands Daily News* and a pilot friend in 1947 or 1950. Flamboyant or flame tree is now a common pan-tropical ornamental tree with attractive red flowers, although it is originally from Madagascar (Nicholls 2006).

The primary protected area in the USVI is the Virgin Islands National Park on St. John. Other protected natural areas include Buck Island National Monument off the coast of St. Croix and Hassel Island off the coast of St. Thomas; both are administered by the National Park Service. Salt River Columbus Landing is a park jointly administered by the National Park Service and the Virgin Islands Department of Planning and Natural Resources. The U.S. Fish and Wildlife Service administer Sandy Point National Wildlife Refuge (NWR) on St. Croix, along with two islets: Green Cay and Ruth Cay. The Nature Conservancy manages Jack and Isaac's Bay on the East End of St. Croix. The nongovernmental organization, or NGO, St. Croix Environmental Association manages the Southgate Reserve on the northeastern shore of St. Croix (Weaver 2006a).

Figure 13. Reforestation project at a forest stewardship property. (Photo by Michael Morgan, 2015)

The USDA Forest Service State and Private Forestry program funds the Forest Stewardship, Forest Legacy, and Urban and Community Forestry programs, which are administered through the Virgin Islands Department of Agriculture Forestry Division. The Stewardship Program has provided technical assistance to forest owners across the territory since 1998. Thus far, 45 private properties have been enrolled in the Stewardship Program, which offers a property tax reduction in return for active forest management. This generally involves maintaining existing forest cover and biodiversity enrichment by planting native trees species (figure 13).

The Forest Legacy program seeks to identify and preserve ecologically, historically, and culturally important forested land, either by outright purchase or through conservation easements. Priority tracts were identified by the Forest Stewardship Coordinating Committee after public meetings discussions with natural resource professionals through an Assessment of Need process. The main priority area is in northwest St. Croix due to its rich biodiversity and cultural significance as a Maroon (runaway slave) area. To date, several properties have been purchased through the Legacy Program totaling 215 ac (87 ha), with plans to someday create a territorial park.

The Urban and Community Forestry Program (U&CFP) offers opportunities to provide and enhance the islands' urban forests by providing small grants to organizations interested in projects related to tree planting, tree preservation, educational workshops, skills trainings, and inventory. The U&CFP recently partnered with a homeowner's association to transform

a former empty lot dump site into a beautiful community park with many native tree species (figure 14). The program also funded a project that installed permeable pavement in a downtown area to mitigate storm water runoff and preserve historic mahogany trees. U&CFP also sponsored a survey of trees on the public roads of St. Croix. More than 9,000 trees were inventoried and assessed for health by Geographic Consulting, LLC. Based on these data, species lists and protocols were developed for installation of roadside and urban trees. The protocols were adopted by multiple government and nonprofit organizations, and posters with these Urban Forestry Best Management Practices (BMPs) were printed and distributed. Additionally, demonstration tree-planting projects using these BMPs were completed in high-visibility sites including main roads and in front of the airport of St. Croix. It should also be mentioned that the Virgin Islands Department of Agriculture Forestry Division is working on nursery renovations to meet the demand for native shade and fruit trees for various planting projects and for the public.

Figure 14. Through the urban and community forestry program, an empty lot was transformed into a beautiful park. (Photos by Michael Morgan, 2016)

Since 2007, most tree planting on St. Croix has been performed by Geographic Consulting, LLC, an environmental-consulting service on USVI comprised of a diverse team of natural resources specialists, scientists, and field staff. Some of their projects have been ecological restoration work at Salt River National Historic Site Territorial Park where they planted 750 trees in 2007 with a 60-percent survival rate. In 2017, Geographic Consulting, LLC, is preparing for additional planting projects with the National Park Service at Salt River National Historic site and Buck Island National Monument.

In 2013, fieldwork began on a court-ordered restoration of a site that previously processed bauxite into alumina. A by-product of the process was a phytotoxic red mud, which occupied hundreds of acres along the south shore of St. Croix. The red mud is very resistant to either natural or assisted revegetation. To determine the best way to revegetate the site, Geographic Consulting, LLC, established greenhouse and field trials upon the red mud with various plant species and soil amendments. The revegetation plan called for 3,000 plants from 16 native taxa of trees, shrubs, and vines. The majority of 3,000 plants were in 3-gal (11.4-L) pots and were installed using an 18-in (46-cm) hydraulic auger mounted on a skid steer loader. The third and final stage of the revegetation planting was completed in March 2016.

Other tree planting projects on St. Croix have included the planting of 28 individuals of the federally endangered shrub *Buxus vahlii* (Baillon) at the Sandy Point NWR (figure 15) by the U.S. Fish

Figure 15. Seedlings of the federally endangered shrub *Buxus vahlii* (Baillon) have been planted at the Sandy Point National Wildlife Refuge on St. Croix. (Photo by Michael Morgan, 2017)

September 2017 Hurricane Effects

The U.S. Virgin Islands (USVI) were devastated by two Category 5 hurricanes in September 2017. Hurricane Irma struck St. Thomas and St. John on September 6, and Hurricane Maria struck St. Croix on September 19.

Hurricane Irma's winds were clocked at 185 mph (160 knots) for a 24-hour period, resulting in trees being stripped bare of leaves, being knocked down, or having broken branches. Even the grass turned brown because of the wind. At least 5 people were killed or died of hurricane-induced causes. Many buildings were destroyed or damaged. More than 5 weeks after Irma struck St. John, the island was still completely without power.

Hurricane Maria struck in the evening, dumping heavy rain until after 6 a.m. the next morning. There appeared to be localized down bursts and small tornados with the hurricane. No one was killed, but most houses received some damage. There were branches and downed trees everywhere. Unlike Hurricane Irma's effects on St. Thomas and St. John, however, plants below 10 ft (3 m) tall, especially palm trees, kept their leaves, and the grass remained green.

The hurricanes have had a significant impact on USVI forests. The tree nurseries at the Virgin Islands Department of Agriculture and at the University of the Virgin Islands Agricultural Experiment Station were completely destroyed. On a positive note, however, most of the tree seedlings inside these greenhouses survived. Once roadsides, public spaces, and yards are cleared, replanting can begin. Ideally, the right seedlings will be planted in the right places. For example, large trees will not be planted directly under powerlines. In this regard, the hurricanes may have provided an opportunity to improve future forests and landscapes.

and Wildlife Service, the University of the Virgin Islands Agroforestry program, and Geographic Consulting LLC in December 2015. In addition, 72 seedlings of other native species were planted with the Buxus. In 2017, 17 more Buxus plants were planted at Sandy Point NWR at a new site within the Sandy Point NWR. As of the time this article was written, the Buxus shrubs are still alive.

The University of the Virgin Islands Agricultural Experiment Station (UVI-AES) has had an agroforestry program since 1997 that specializes in developing protocols for the production of native tree species, especially those suitable for use in landscape plantings. Thus far, five fact sheets have been published, and five more are ready to be published in the near future.

Three research UVI-AES articles about Virgin Islands-native trees work have been published in *Tree Planters' Notes*. Two articles discuss germination for seeds of *Bursera graveolens* (Kunth) Triana and Planch (Morgan and Jose 2013) and *Bursera simaruba* (L.) Sarg. (Morgan and Zimmerman 2016), and the other describes results of an experiment about drought tolerance of five Caribbean tree species (Morgan and Zimmerman 2014). Tree seedlings produced in this program are not wasted. Some are planted out in the UVI-AES agroforestry plot as future seed sources, and the excess is donated to ecological restoration projects or other public groups.

The current demand for tree planting and the local production of planting material exists because society sees a need for ecological restoration projects and landscape plantings in public spaces as the islands become more urban. Trees tend to be grown in 3-gal pots or larger because most plantings are for the landscaping of public spaces or small ecological restoration projects. Areas to be planted tend to be measured in square yards and not acres. In spite of this demand, local native plant nurseries have trouble being sustainable. Sales and projects are small and infrequent. Transport of planting stock among islands is difficult if not impossible and may not be ecologically desirable. Other so-called nurseries and garden centers sell plants, but these businesses are really just points of resale for plants produced outside of the USVI.

Looking Forward

The values of the USVI society are changing and are putting increased emphasis on biodiversity and ecological restoration. Since the USVI continue to become more urbanized, both public and private spaces will see an increased need for landscape plantings incorporating native trees. Currently, a tree ordinance in draft form is in the USVI legislature; once passed, the law will protect historically cultural and heritage trees throughout the territory. Much potential exists for continued outreach and education on planting native species and proper pruning techniques or tree maintenance through public workshops and educational events. In addition, abandoned industrial sites are in need of ecological restoration and will also need trees and shrubs for revegetation. Planting trees and shrubs on disturbed sites reduces the amount of soil sediment that flows into the Caribbean Sea. This, in turn, protects coral reefs, which provide valuable ecological services and also make the USVI an important destination for dive tourism. Hopefully, the increased need for the ecological and aesthetic services of trees will result in increased demand for nursery-grown planting stock.

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