US Virgin Islands Gap Analysis Project

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The U.S. Virgin Islands (USVI) are located in the Caribbean just east of Puerto Rico in the northwestern most section of the Lesser Antilles. The USVI cover 350 km^2 and include St. Thomas, St. John, St. Croix, and a number of cays. They harbor relatively high numbers of species and substantial levels of endemism, particularly among the reptiles. The databases of species occurrence, land cover, and stewardship for the USVI GAP are being integrated with the Puerto Rico Gap Analysis Project (PRGAP) and the Puerto Rico-USVI Integrated Terrestrial-Aquatic Gap (Integrated Gap) to allow regional analyses of terrestrial and aquatic biodiversity.

USVI GAP includes 143 species of terrestrial vertebrates: 107 birds, 21 reptiles, eight amphibians and seven mammals. These include endemic, breeding resident, breeding migrant, established exotic and nonbreeding migrant species. The majority are breeding residents. Breeding migrants include birds and marine turtles - which use terrestrial habitat for nesting. Ten to 20 percent of the amphibians and reptiles are endemic. We are following the traditional GAP approach, developing geospatial information and databases on land stewardship, species occurrence, and land cover. We have developed innovations using three integrated sets of minimum mapping units to display species ranges and model predicted distributions including nested grids of two km^2 and 24 km^2 hexagons and a grid of subwatersheds and cays. We are using EO-1 ALI scenes from 2007 pan-sharpened to 10 m spatial resolution for the land cover mapping. EO-1 ALI has a spectral range similar to that of Landsat 7 ETM+ with a few additional spectral bands and a higher resolution panchromatic band. Finally, we are integrating information on canopy cover and canopy heights extracted from LIDAR data from 2004.

Results

Stewardship

We identified 88 stewardship areas for the USVI, which represent approximately 20% (7,120 ha) of the land area. Accurate spatial information was available for only 78 areas, 69 of which have some management for biodiversity conservation (Gap status 1 to 3) (Figure 1). We identified 20 stewardship areas that are managed primarily for biodiversity conservation (Gap status 1). Along with several cays (e.g., Turtledove cay, Congo cay, Cockroach cay), Status 1 lands included the land and cays under the jurisdiction of the USVI National Park Service, the Great Pond within the East End Marine Park, Sandy Point Wildlife Refuge, Buck Island Reef National Monument, Buck Island National Wildlife Refuge, Saba Island and Little St. Thomas. Land ownership of the stewardship areas is shared among 18 organizations or agencies. The primary land owners are federal agencies (61 %), followed by local government (34 %), nongovernmental organizations (4 %) and finally, private owners (1%). Area management is shared among 19 organizations. Fifty-seven percent of the total stewardship area is managed by federal agencies, 33% by local governmental agencies, 7% by non-governmental organizations, 2% is co-managed by local and federal agencies, and 1% is co-managed by government agencies and NGOs. The major federal land manager is the US National Park Service, while the primary local governmental land managers are the USVI Department of Sport, Parks and Recreation together with the Department of Planning and Natural Resources (particularly the Division of Fish and Wildlife). The Nature Conservancy represents the primary nongovernmental land manager in the USVI.

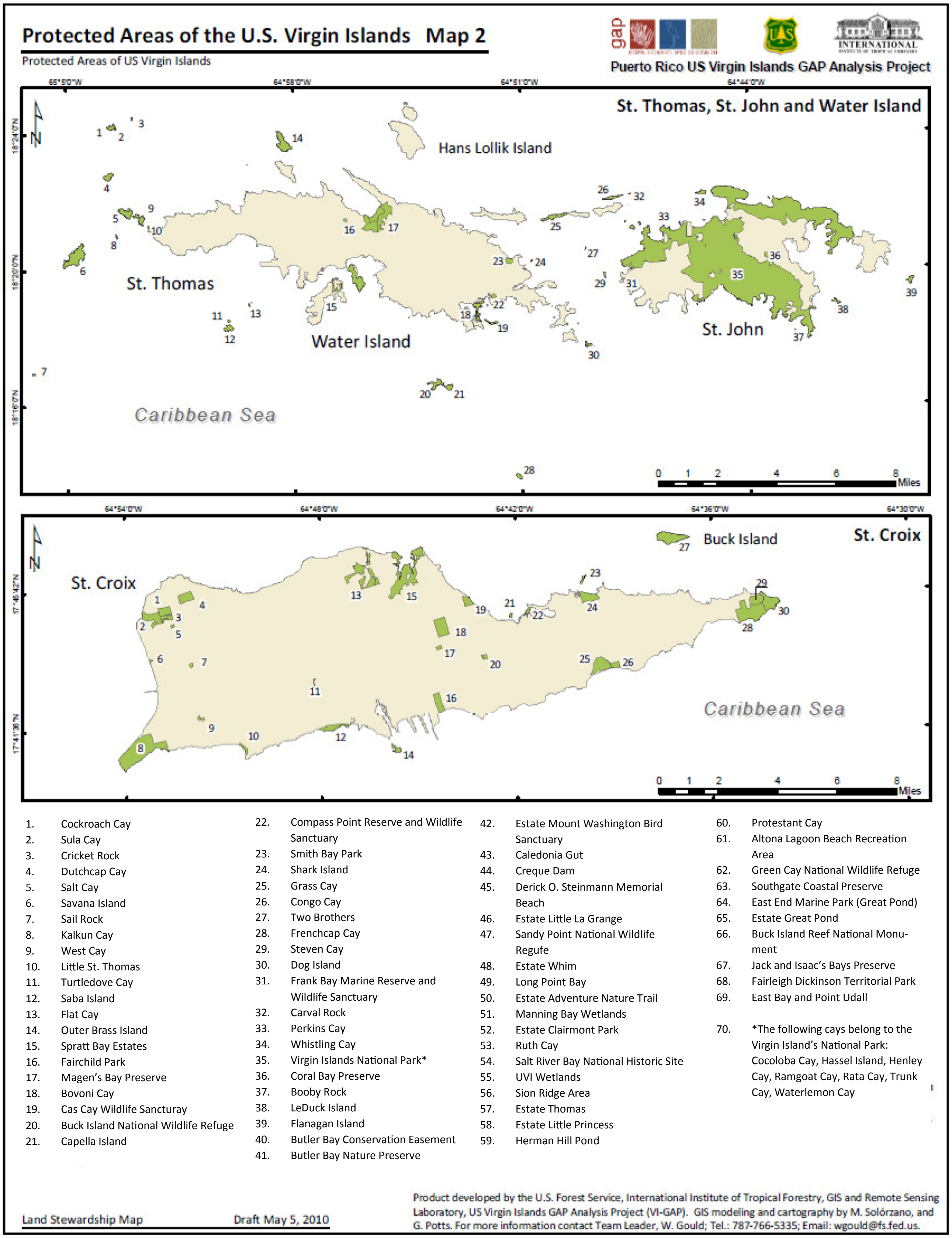

Figure 1. Protected areas (Gap status 1, 2 and 3) in the U.S. Virgin Islands.

Land cover

Traditionally, GAP projects have relied on satellite imagery from Landsat 5 TM and Landsat 7 ETM+ to provide the spatial and spectral information to derive land cover habitat maps at 30 m spatial resolution. Puerto Rico GAP (Gould et al. 2008) incorporated the Landsat 7 ETM+ 15m panchromatic band to enhance the spatial resolution and infrared bands in order to improve the delineation of habitats at the sub-pixel level in complex tropical landscapes. Current Landsat 7 ETM+ imagery and scene acquisition is limited by the scan line correction (SLC) error, horizontal lines with no data that appear across the entire image since July 2003, and the Long Term Acquisition Plan (LTAP), the use of a set of criteria that includes cloud-cover forecasts (Landsat Project Science Office, 1998) to guide Landsat image collections. These limitations make the collection of new images and the use of existing images for tropical humid regions with a high potential for cloud cover difficult.

For the USVI GAP, alternative imagery was used from the Advanced Land Imager (ALI) onboard the Earth Observation 1 (EO-1) satellite. EO-1 was launched by the US Geological Survey (USGS) in 2000 as a one year technical mission for data continuity assessment for the Landsat programs <http://eo1.usgs.gov/ali.php>. The advantages of EO-1 ALI over Landsat 7 ETM+ include: improved spectral resolution, 9 bands covering blue to short wave infrared wavelengths compared to 6 bands on the ETM+; better radiometric resolution, 16-bit rather than 8 bit; a 10m panchromatic band; and off NADIR viewing angles for image collections. One major disadvantage of the EO-1 ALI sensor is that no significant archive of imagery covering the USVI was readily available. Data collections have to be scheduled through a Data Acquisition Request (DAR) with the EROS data center. Other limitations include a smaller swath width (37 km) compared to Landsat 7 (185 km) and the lack of a thermal band on the ALI sensor. Images were collected between April 2007 until September 2007.

Preprocessing included atmospheric correction - with each band corrected individually - using IDRISI Taiga software and the ATMOS module, full radiative transfer model. Each band was then exported into ERDAS Imagine 9.3 to add initial projection information and the bands were stacked into one image file with the panchromatic band left separate. The sea was then masked out of the imagery using a manually digitized coastline based on 2004 aerial photos buffered by 20 meters in order not to mask out any coastal features that might not perfectly match the coastline file. The 10m panchromatic band was then used to sharpen the nine 30m reflectance bands using the Principle Component Analysis spatial enhancement in ERDAS 9.3. Each image was then reprojected to state plane, NAD 83 and georectified to a 2004 aerial photo mosaic of the U.S. Virgin Islands.

We created a cloud and cloud-shadow free image from each scene for classification. Three masks were created using Principle Component Analysis (PCA) on the visible (blue, green and red bands) and the near infrared (NIR) to short wave infrared (SWIR) bands separately. A cloud mask was created using PCA on the visible bands and a cloud-shadow mask was created using PCA on the NIR to SWIR bands. The cloud mask captured most of the urban pixels due to spectral similarity with cloud pixels so we created an urban mask using inverse PCA that could be subtracted from the cloud mask.

We stratified the imagery using geoclimatic zones and classified using an unsupervised Kohonen's Self-Organizing Map (SOM) neural network with IDRISI Taiga software. The input for the neural network included the nine spectral bands of each ALI image as well as a Soil-Adjusted Total Vegetation index (SATVI) product. The SATVI product is sensitive to green and senescent vegetation and helps reduce noise created by variation of topographic illumination within a scene as well as additional shadowing caused by the viewing angle of the satellite. The neural network classification was refined into useful land cover types through visual interpretation using field information, site visits, aerial photography from 1999, 2004, and 2007, and by comparing classification results to previous land cover maps (Conservation Data Center 2000, Kennaway et al. 2008). Reports focusing on specific areas within the U.S. Virgin Islands (Daley 2009, Weaver 2006a, Weaver 2006b, Damman and Nellis 1992) provided additional information for interpretation.

We used three EO-1 ALI images for the St. Croix land cover classification (Figure 2). The best cloud free image (June 14, 2007) was used as a base image. Images from June 24, 2007 and September 14, 2007 were used to fill in missing data due to cloud cover and cloud shadow. This provided an 89% cloud and cloud shadow free image for St. Croix. The remaining 11% of missing data was taken from two Landsat 7 ETM+ images from January 31, 2009 and February 16, 2009. The Landsat images were processed and classified using the same procedure used with the EO-1 ALI images. They were then pan sharpened to 15m spatial resolution, misaimed, and classified using the SOM neural network. The resulting classification was then resampled to 10m and manually edited to match the ALI classification.

The initial land cover classification included closed forest, open forest, shrubland, open forest shrubland and scrub, natural grasslands, maintained grasslands, urban, water and mangrove. These were then manually edited to clean confused classes. Additionally, discrete raw LiDAR data collected in January and February 2004 by 3001 Inc. (US Army Corps of Engineers contractor) covering St. Thomas, St. John and the east and west sections of St. Croix were processed using FUSION/LDV 2.70 processing software (McGaughey 2009). Various products were derived from the LIDAR data: bare earth surface elevations, canopy cover, and canopy height. These were used to refine the land cover classification, for example, to separate closed woody vegetation based on canopy height, i.e., closed shrubland, closed forest, and gallery forest.

A number of ancillary layers were used to stratify the classification to provide a detailed land cover classification of habitat. These layers included the National Wetland Inventory (NWI), Geology and 30m Digital Elevation Models from the USGS and U.S. Environmental Protection Agency (USEPA) National Hydrography Dataset (NHD), NOAA Environmental Sensitivity Index (ESI), Holdridge Ecological Life Zones, the Natural Resources Conservation Service Soil Survey of the USVI and a number of derived products created at the IITF GIS and Remote Sensing laboratory such as bare earth surfaces, canopy cover, canopy height, landforms, coastline, slope, aspect and watersheds. The final land cover classification for St. Croix consisted of fifty one classes at 10m spatial resolution (Figure 2).

Species Distribution Modeling

We are currently modeling species distributions for our final gap assessments.

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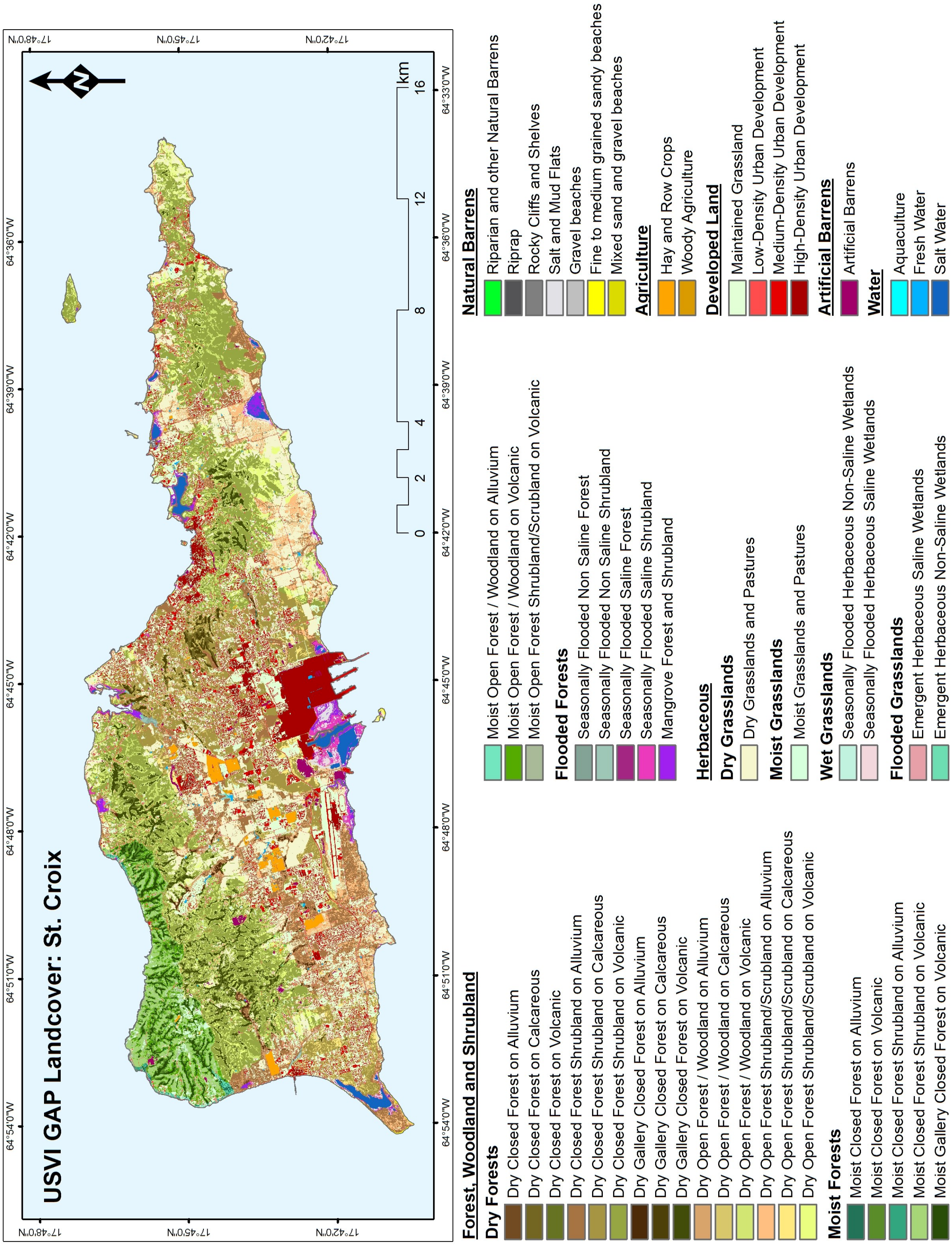

Figure 2. Land Cover of St. Croix in the U.S. Virgin Islands.

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