

Report as of FY2009 for 2008VI114B: "A Comparative Analysis of St. Croix Waterways; "

Publications

- Other Publications:
 - ◆ Daley, Brian, Forest, May 2009, Agriculture and Development in a Changing Landscape: Land-cover Change Analysis of St. Croix, USVI using Landsat Satellites from 1992 to 2002, Technical Bulletin #13, Virgin Islands Agricultural Experiment Station, University of the Virgin Islands, St. Croix, U. S. Virgin Islands.
 - ◆ Daley, Brian, Tristian Muhammad, Hema Balkaran, June 2009, A Comparative Analysis of Soil Characteristics in St. Croix's Waterways: A Look at the Dirt in our Guts, Student Research Bulletin, Virgin Islands Agricultural Experiment Station, University of the Virgin Islands, St. Croix, U. S. Virgin Islands.

Report Follows

PROBLEM AND RESEARCH OBJECTIVES

The Virgin Islands territory is a dynamic ever-changing landscape. Human land uses such as agriculture and residential development are the primary activities determining land cover of the islands. Land uses that result in the loss of forest cover are frequently associated with subsequent decreases in water quality and negatively affect an aquifer's ability to naturally recharge. Unhealthy waterways exhibit increases in sedimentation, erosion, water speed, water temperature and evaporation. This can result in decreased water quality, lowering water tables and increased costs for the farms and communities that rely on these resources. Over the past two decades the water table in St. Croix has been steadily lowering

There is no known territory-wide health analysis of Virgin Islands' waterways. Within the territory, these natural waterways are referred to as guts. Guts in the Virgin Islands tend to be ephemeral, meaning they are dry for portions of the year. This project will be a preliminary study on how to efficiently accomplish a comprehensive gut health analysis using GIS (Geographic Information Systems) and GPS (Global Positioning System) technology. To this end, findings of a recent AES (Agricultural Experiment Station) land cover change analysis will be combined with field collected data on waterways. By comparing data from forested, deforested and recently reforested waterways, we will be able to describe and quantify the impact various land-uses have on our water resources.

This project will analyze the condition of waterways on St. Croix using state of art GIS and GPS technology. This research project will compare soil and water permeability characteristics from waterways in three distinct land uses. The comparative analysis will be a dynamic combination of field data with current remote sensing research on land cover change in St. Croix between 1992 and 2002. In the process, we will train UVI students to collect field data and provide them with certification in GIS software. Students will present their research in poster format and results will be made available to the community in the form of fact sheets. In keeping with UVI's mission, students will be educated and trained to use this technology during the project.

METHODOLOGY

Students will conduct the ArcGIS 9.2 certification workshop in a UVI computer lab in St. Croix. After the training, we will lead the students in creating digital map layers that delineate the primary waterway or guts in each watershed on St. Croix. The students will create buffers around the guts and then overlay it on a forest cover change layer recently created by UVI-AES. This polygon layer identifies all areas on St. Croix that were deforested or reforested during a recent 10-year period. Students will identify 30 data collection points by intersecting the two layers and choosing 10 points in each category (stable, deforested and reforested) of guts.

Using a Trimble GPS unit we will go to the ten waterways in each category and collect data on forest canopy, land use, topography, and soils characteristics from the USDA-NRCS soils tests. Soils tests will include aggregate stability, water nitrate levels, salinity tests, slake test, and bulk density test. These tests relate to water quality and water movement through the soil indicating what is happening during and after rain events. (Direct sampling of the water in guts can not be done with systematic regularity due to their ephemeral nature.) Some of the tests will be conducted at the UVI-AES lab. When field data collection is completed the students and staff will analyze the data using GIS and statistical methods. The scientific results of this study will be shared with the academic and technical community by archiving the findings with the Virgin Islands Information Council (GIC) and UVI's CDC. The results will be summarized and presented to the Virgin Islands community during a public seminar at the conclusion of the project and also distributed as a fact sheet.

PRINCIPAL ACCOMPLISHMENTS AND SIGNIFICANCE

The results support our original hypothesis that soil in forested sites would have superior characteristics to soil in change areas. Forested guts had the greatest average slope and their banks are significantly steeper than deforested sites (Table 1). Although steep slopes are more prone to erosion, we observed less erosion in the forested sites. Water infiltration rates are influenced by several factors such as soil particle size and soil organic material, but water infiltrated soil in stable forest sites significantly faster than in deforested and reforested sites. Average soil moisture did not differ between sites, with most sites registering on the lowest end of the range. We attribute this to the prolonged dry-period before our sampling and not to an accurate measure of soil organic matter.

Average pH values in deforested sites were significantly higher than in other sites. This is likely due to erosion of pH neutral top-soil leading to exposure of the alkaline sub soils. There was also a trend of soil from forested sites having lower values for, electro-conductivity, temperature, and bulk density. These results are a trend only and did not meet our criteria for statistical significance. Electro-conductivity measurements for forested and reforested fell within the healthy range while deforested sites registered levels that begin to impede plant growth. St. Croix's landscape is highly fragmented and the course of a gut passes through alternating forested and deforested sections.

The conditions at the 30 data collection sites ranged from intact, native forest with deep organic soil, to exposed, treeless sites where the gut was lined with stone (rip-rap) and no soil was present. The original classification of forested, deforested and reforested was completed in 2005. The 10 forested sites were still forested, while four of the reforested sites had recently been cleared and four sites classified as deforested had young patches of secondary forest establishing. These findings emphasize variable and dynamic nature of land-cover change sites.

We conclude that land-cover change in St. Croix is directly linked to the degradation of ephemeral waterways or guts. Degradation in the Virgin Islands can be measured by decreased water infiltration rates and increased pH, bulk density and electro-conductivity. We interpret these results to be a proximal measure of soil compaction and increased runoff volume and velocity.

The results from this small-scale pilot study merit additional investigation of the watersheds of the Virgin Islands and the rates, patterns and practices of development in the territory. The first step in this process is to generate a temporal series of classified maps of the U.S Virgin Islands. This can be accomplished using traditional aerial photo interpretation methods, or with increasingly accessible satellite imagery.

Soil and water sampling on a larger scale may result in support of the prediction that forest removal also leads to increased soil temperature. To prevent damage to the island's waterways, we support the Virgin Islands law (Title 12, Chapter 3 section 123) prohibiting cutting of any trees within 25 feet of the edge of a watercourse. Enforcement of this code would simultaneously protect forests, fresh water, soil, and coastal marine systems.

Presentations arising out of this project were presented by UVI students who participated in this project. Both students were junior biology majors and they made presentations at the UVI Annual Fall Research Symposium held on the UVI St. Thomas campus on Sunday, September 21, 2009. The names of the students and the titles of their presentations were as follows:

- Balkaran, Hemma, "A Comparison of Soil Characteristics Based on Land-cover Classification in St. Croix, U. S. Virgin Islands"
- Muhammad, Tristian, "A GIS Analysis of St. Croix's Waterways"

In summary:

1. The GIS training for this project effectively prepared UVI students to execute a research project using ArcGIS 9.1 and additional tools
2. The method of using GIS technology and an existing land-cover change map for St. Croix was an effective in selecting sample sites and the USDA Soil Quality Test Kit was an effective way of collecting data from ephemeral streams during the dry season.
3. Results indicate that forested sites tend to be located on steeper slopes, yet have less erosion and significantly greater water infiltration rates than sites experiencing land-cover change.
4. Deforested sites have higher pH values due to exposure of alkaline parent material and recently reforested sites (abandoned agriculture) had potentially harmful levels of salts in the soil.

5. The other variables, while not statistically significant, also showed a trend of forested sites having relatively healthier soil characteristics, and thus supported our original predictions.
6. This method demonstrates potential for a broader application and an analysis of the territory's waterways on a watershed-by-watershed basis.

Table 1. Averages for each measurement by land-cover type.
 (Statistical differences between averages are denoted by different letters.)

Measurement	Average values by Land cover change type		
	Stable Forest (FF)	Reforestation (FN)	Deforestation (NF)
Bank slope *	27.0% a	21.0% a	10.9% b
Hill slope*	4.0% a	1.0% b	2.0% ab
Infiltration rate (cm/hr)***	597.4 a	462.0 b	271.0 bc
Relative temperature (°F)	-10.25	-9.36	-8.32
Soil moisture (g/g)	0.160	0.189	0.167
Bulk density (g/cm ³)	1.181	1.061	2.486
Electro-conductivity (dS m ⁻¹) *	0.375 a	1.219 ab	2.486 b
pH *	7.49 a	8.21 b	7.66 a

Analysis of variance using Least Squared Means with alpha level of *0.1 or ***.001