Virgin Islands Water Resources Research Institute Annual Technical Report FY 2012

Introduction

The United States Virgin Islands (USVI) is located between the Atlantic Ocean and the Caribbean Sea in an area about 1,200 miles southeast of Miami, Florida and 80 miles southeast of San Juan, Puerto Rico. The USVI consists of four principal islands, St. Thomas, St. Croix, Water Island and St. John. These islands along with other small cays in the group have a combined area of approximately 137 square miles. The islands are principally of volcanic origin and are consequently relatively mountainous.

Historically, rain water harvesting had been a principal source of potable water for the residents of the USVI with some reliance on ground water. Surface water supplies are virtually non-existent. In recent times, desalinated water has satisfied most of the needs of the population of about 115,000 persons and is the source of water for the islands' limited public water distribution systems. Rising costs of energy have caused water from this source to be increasingly expensive. Wastewater disposal continues to be a concern in the USVI where maintenance of a pristine environment is a key factor in the tourism-based economy.

The Virgin Islands Water Resources Research Institute (VI WRRI) is hosted by the USVI's only institution of higher education, the University of the Virgin Islands (UVI). Founded in 1962, UVI is a land-grant, Historically Black College or University (HBCU) and has a student population of about 2,500. It has campuses on both St. Thomas and St. Croix and a research station and a learning center on St. John. UVI is primarily an undergraduate institution but there are also graduate programs in Business, Teacher Education, Public Administration, Mathematics and Marine Science. As is the case throughout the U. S. Virgin Islands community, the university s population consists of a diversified mix of persons coming from not only the USVI and the Caribbean area but from the U. S. mainland and other areas throughout the world. UVI maintains many active collaborative relationships with a wide range of universities in order to maximize its ability to serve the needs of the Virgin Islands' community.

The VI WRRI is one of the smaller institutes in the U. S. Geological Survey's State Water Institute Program. It has no full-time staff and in order to make maximum use of resources available to it, maintains no distinct facilities at UVI but works collaboratively with other UVI units and with entities outside of the university. It has always kept a focus on addressing water resources research issues particularly relevant to tropical island communities and is known for work done in areas such as rain water harvesting, development of alternative on-site sewage disposal systems and investigation of applicable indicators in typical water supply systems. The research, information dissemination and training activities conducted by the VI WRRI are guided by an advisory group and a strong emphasis is placed on addressing water resources issues that are of particular relevance to small insular communities.

Research Program Introduction

During the period March 1, 2012 to February 28, 2013, the U. S. Geological Survey supported five research projects through the Virgin Islands Water Resources Research Institute. Two of these were started during a previous reporting period. One of these was completed in this year and it focused on the identification of waterborne contaminants entering the St. Thomas East End Reserve. The other projects will be continuing with no-cost extensions into the following year. Two of these projects are examining problems having to do with use of water for agricultural purposes. One of the other projects is addressing terrestrial sediment delivery into embayments and the final project is investigating rainfall rates across local microclimates using high-resolution mapping.

Evaluating Drought Tolerance of Virgin Islands Native Trees Suitable for Landscaping

Basic Information

Title:	Evaluating Drought Tolerance of Virgin Islands Native Trees Suitable for Landscaping
Project Number:	2011VI184B
Start Date:	3/1/2011
End Date:	5/30/2013
Funding Source:	104B
Congressional District:	VI
Research Category:	Not Applicable
Focus Category:	Drought, Conservation, Water Quantity
Descriptors:	
Principal Investigators:	Michael Morgan, Thomas W. Zimmerman

Publications

1. Cuffy, K., M. Morgan, T.W.Zimmerman, (2013) Evaluation of Drought Tolerance in 3 Native Tree Species with Landscape Potential, a Biometric Approach. Poster Presented at UVI Student Science Symposium (March 23, 2013).
2. Morgan, M., K. Cuffy, and T.W. Zimmerman. (2013) Evaluation of Drought Tolerance in 4 Native Tree Species Suitable for Landscaping: A Soil Water& Biometric Approach. Poster presented at UVI Research Day (April 6, 2013).

EVALUATION OF DROUGHT TOLERANCE IN SEVEN NATIVE TREE SPECIES WITH LANDSCAPE POTENTIAL: A BIOMETRIC AND SOIL-WATER RELATIONS APPROACH

Problem and Research Objectives

New urban and residential developments require landscape planting. Research in the Biotechnology and Agroforestry Program at the University of the Virgin Islands Agriculture Experiment Station (UVI-AES) supports the preservation of native flora through investigations into the propagation of native plant species. One of the program's goals is to provide research supporting local plant nurseries growing native plants for their use in landscaping around homes and businesses. The demand for ornamental plants is rising as the islands of St. Croix, St. Thomas, and St. John become more urbanized. Plant nurseries are a growing segment of the local economy. Programs that promote using native, ornamental plants within their native range have recently become successful in several states and a similar approach in the US Virgin Islands is strongly advocated by the US Forest Service (Overton, et al., 2006).

Fresh water is limited on the island of St. Croix. Rainfall is seasonal. There are no perennial streams or lakes to provide fresh water. Fresh water can be obtained by collecting rainwater in cisterns for later use, from wells that tap the subterranean aquifer, or buying it from the Virgin Islands Water and Power Authority. Fresh water provided by the Virgin Islands Water and Power Authority is expensive because it comes from a desalination plant.

Plant nurseries, particularly, those specializing in showy "tropical" plants such as species in the *Heliconaceae*, *Musaceae,* and *Zingiberaceae* families, need abundant water. They cannot depend on rainfall alone in the US Virgin Islands. During the dry season, access to well, municipal water or a pond is necessary to keep these plants alive. In order to remain profitable and stay in business, plant nurseries need to produce plants at a price people are willing to pay, while generating sufficient demand for landscaping plants. Two ways to reduce costs are to closely monitor water use and to grow native plants that are adapted to the dry environment of the U.S. Virgin Islands.

According to the American Nursery Growers Association, the minimum size of a tree for planting in a landscape setting is 4 to 5 feet or (120 to 150 cm) and 0.5inches or 12.5 mm diameter 6 inches above the root collar for land scape planting. We wanted to determine how much water is needed to produce a saleable tree. We also wanted to determine how much biomass was allocated between leaves, stems and roots for the different species, and under different treatments.

Methodology

We grew four native tree species, *Andira inermis, Bucera bucida, Jacquinia arborea*, and *Pimenta racemosa,* in 11.4 L pots filled with a substrate of 50% Promix, 25% top soil, and 25% sand. There were 18 trees per specie, and each tree was assigned a treatment: 1L, 2L or 3.8 L of water per week. The pots and plants receiving 3.8L of water kept soil at field capacity or close to it. Field capacity is the ability of a soil to hold water. We calculated field capacity subtracting the dry weight of a pot before watering and then the wet weight of the pot, after excess water has drained out. Each week, height and stem diameter was measured and recorded. As per the guidelines for land scape planting, stem diameters were measured at 6" above the root collar. At the end of the experiment, 9 plants of each species were harvested, dried, separated into its components and weighed. The data was statistically analyzed using JMP. Graphs were generated in Excel. The statistics of interest were: mean, ANOVA, and Comparison of Means. Kalunda Cuffy, a second year undergraduate in the computer science program helped with plant care, data collection and entry, along with making graphics.

Principal Findings and Significance

The project will be completed by May 31st, 2013.Research is continuing on White Cedar *(Tabebuia heterophylla),* Wild Frangipani (*Plumeria alba*), and Lignumvitae (*Guaiacum officinale*). The last collection of data for these species is Friday, May 3rd, 2013. The soil water relationship data is still being analyzed.

The minimum size of a nursery grown tree according to the American Nursery Growers Association is 4 to 5 feet or (120 to 150 cm) and 0.5inches or 12.5 mm diameter 6 inches above the root collar for land scape planting. Over 7 months, the *A. inermis* saplings treated with 3.8 L of water per week reached saleable height and diameter, none of the other tree species did so.

As far as total biomass production is concerned, *A. inermis* and *B. bucera* could be grouped together in one group, with *J. arborea* and *P. racemosa* in another group ($P \leq 0.03$). Only in the case of *A. inermis* was there a significant difference in biomass production depending on how much water the plants received ($P=.0002$). Total Biomass for the other species was not significant between treatments.

All four species have different growth responses to water stress or its abundance. Root shoot ratios are a good way to compare plants of different habits, species or size. *A. inermis* trees grow along stream sides and in other moist places. *J. arborea* grows along seaside cliffs whereas the other species grow on intermediate sites. The *A. inermis* trees which received 2L and 3.8L per week had root to shoot ratios of 0.5. The *A. inermis* trees which received 1L of water a week reacted to water stress by dedicating more of its biomass to roots with a root to shoot ratio of 0.8 ($P=.07$). Surprisingly, all the *J. arborea* saplings under all treatments had a root to shoot ratio of 0.4 or 0.5. It appears that a high root to shoot ratio is not one of J. *arborea'*s adaptions to droughty conditions. It dedicates half of its biomass to leathery leaves. *P. racemosa* has a slightly higher root to shoot ratios (0.7, 0.6., 0.6) than *J. arborea* under all treatment or *A. inermis* at 2L or 3.8L. *P. racemosa* splits its biomass evenly amongst leaves and roots, with lesser amounts for the stem. It appears to balance transpiration from the leaves with water uptake from the roots. *B. bucida* dedicates over 50% of its biomass its trunk and branches. In fact, it has many small, fine branches which are better to support lots of leaves.

We found that the amount of water absorbed by the soil and roots generally stayed the same week to week. There were, however, species and treatment differences. Differences amongst species at the 1L were not significant. It was significant, at the 2L level, ($P=0.03$) and the 3.8L ($P=0.001$). *A. inermis* absorbed the most water, and *P. racemosa, B. bucera* and *J. arborea* lesser but about the same amount of water ($P. = 0.03$). With trees receiving 3.8L/wk. of water species differences are more pronounced: *A. inermis >B. bucera>P. racemosa* and *J. arborea.*

Plant nursery managers want to grow trees to saleable sizes with the least amount of water. If one was to rank the trees by the water needed for growth the order would be: *B. bucera*, *A. inermis*, and *P. racemosa* and *J. arborea*. All four species tolerated low levels of watering; none of the trees shed their leaves due to water stress. However, the *B. bucera* trees were all wilted at the end of the week, and only put on additional height growth when it received 3.8L of water a week, which is surprising because the tree is often found on droughty sites such in sands on the edge of the beach. Once they received water, the leaves quickly regained turgor. Perhaps, watering twice a week with only 2L would prevent wilting and permit growth.

The *A. inermis* trees grew the fastest with 3.8L of water but continued to increase in height if they only received 2L of water a week. Therefore 3.8L a week would be needed to get the trees quickest to optimal selling size, but they can continue growth at 2L/week. If the trees were not being produced for a contract, and were just waiting for a buyer, watering the trees with 2L a week would save water and allow the trees to remain a longer time in the nursery. *Pimenta racemosa* grows best with 2L a week; 3.8 L seems to retard growth and health, particularly at early stages of plant growth. *J. arborea* grows at the same rate whether 3.8 L or 2L of water is applied during the week, so it is best to conserve water and apply 2L a week.

Conclusions

All four tree species tolerate low levels of irrigation. None of the trees lost their leaves during the course of the experiment, although there were differences in growth and biomass allocation. Irrigation in this case was performed by a hose and a bucket in the green house, but by extension could be considered as substitute for rainfall, if the trees were planted outside.

This study has implications for tree nursery managers. Ideally, they want to produce trees ready for landscape planting in the least amount of time possible with the least amount of water.

It would be worthwhile to continue this study with other tree species, and with the same species transferred into bigger pots. What was learned here can be improved and built upon. For example, increasing the sample size slightly will hopefully increase the significance of the results. With the experiences gained from the study, the techniques employed can be further refined.

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IDENTIFICATION OF WATERBORNE CONTAMINANTS ENTERING THE ST. THOMAS EAST END RESERVE

Basic Information

Title:	IDENTIFICATION OF WATERBORNE CONTAMINANTS ENTERING THE ST. THOMAS EAST END RESERVE
Project Number:	2011VI202B
Start Date:	3/1/2011
End Date:	4/30/2012
Funding Source:	104B
Congressional District:	n/a
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Water Quality, Toxic Substances
Descriptors:	None
Principal Investigators:	John F Barimo, Stanley L. Latesky

Publications

There are no publications.

IDENTIFICATION OF WATERBORNE CONTAMINANTS ENTERING THE ST. THOMAS EAST END RESERVE

Problem and Research Objectives

The St. Thomas East End Reserve (STEER) was established as a Marine Protected Area (MPA) to safeguard near-shore seagrass, mangrove and coral reef resources. It is also designated as 1 of 6 *Territorial Areas of Particular Concern* due to the MPA's proximity to the Bovoni landfill and the island's largest watershed. Anthropogenic disturbance and watershed transport of contaminants and sediments in near-shore coastal waters have been attributed to the degradation of tropical marine ecosystems as well as those within the U.S. Virgin Islands. Approximately one third of the island's population lives within this watershed which is the largest and most heavily developed watershed on St. Thomas which has been exacerbated by a 5-fold increase in the territorial population over the past 50 years.

The water and sediment samples will be analysed by state-of-the-art analytical equipment following standardized EPA methodology. Hydrocarbons, including PAHs, will be analysed using a gas chromatograph equipped with a Mass Spectrometer detector (GC/MS). Trace heavy metals will be analysed by Inductively Coupled Plasma Spectrometer equipped with a Mass Spectrometer Detector (ICP/MS). This study will also serve as training in analytical chemistry and Phase I of a graduate thesis for an enrolled student who also plans to also look at uptake of contaminants by lagoon biota; however, the later phase II is not part of this proposal. The graduate student will also act as a direct supervisor for undergraduate student workers who will also be directed by project PI's.

Data will be analysed using conventional statistical methods and identified compounds will be compared to reference sources such as commercial gasoline, dry cleaning fluids and pesticides. Metals detected will be compared to freshly sampled dust samples of African dust and if possible, ash from volcanic activity in the region. Variability due to seasonal factors will be considered as well.

Collection and operation of the analytical instruments will be used as a training tool for UVI students and they are expected to do most of the hands on work with sample collection and analysis, and will be involved with the STEER Core Planning Team regarding the selection of precise sampling locations.

Methodology

Stock solutions of standards for anions and cations were obtained from Metrohm and Inorganic Ventures respectively. The 10,000 ppb inorganic stock solution from Inorganic Ventures contained each of the cations measured in the study. Separate 1000 ppm stock solutions of each anion were used to prepare stock solutions of each concentration for anion analysis. Compressed gases (Ar, He, H_2) were supplied by Island Gas as ultra-high purity grade. Ultimal grade acids and bases (Fisher Scientific) were used for all acid or base matrix preparations. Reagent grade (18.2 MΩ) water was prepared using a Barnstead Diamond deionization equipped with a UV lamp to remove Total Organic Carbon from the water. Feedwater for the deionizer was supplied by a Barnstead RO water system with raw water supplied by the UVI water system. Data analyses were conducted using a point calibration curve based on the standards shown below (blank, 10 ppb, 100 ppb, 1, 5, 10, 15, and 20, and 100 ppm).

Cation analyses were conducted using one of two different methods. The first method involved the use of a Varian 820-MS ICP-MS equipped with a Varian SPS-3 autosampler and a collision reaction interface. Samples were nebulized directly into the Ar plasma torch, and the metals were analysed simultaneously over the full mass range of the instrument. The second method involved the use of a Metrohm Electrochemical analyser equipped with a rotating C electrode, a glassy C auxiliary electrode, and a Ag/AgCl reference electrode. Metal ions were analysed over the range of 10 ppb to 100 ppm simultaneously. Water samples were collected and stored in clean acid-washed plastic bottles. All glassware and plasticware were washed with 2% nitric acid in water and then rinsed with 18.2 MΩ ultrapure water (Barnstead Diamond RO system feeding into a Barnstead Diamond Deionizer). For both methods, triplicate runs were done for each sample. The triplicate data were averaged and data was fit to a standard curve for each element analyzed. A set of standards were prepared by serial dilution of the commercially obtained stock solution. Interferences in some cations (e.g. As) were minimized by using the Collision Reaction Interface (CRI), using ultra-high purity hydrogen gas.

In order to remove any organic materials, water samples for inorganic analysis were digested using a CEM MARS microwave digestion system. A 5.0 mL aliquot of water was placed in the Teflon digestion vessel, 5.0 mL of Ultima grade nitric acid was then added, the vessel was sealed, and then placed in the oven. Six samples were digested simultaneously using the following method: 20 minutes pre-heating to 473 K, held at 473 K for twenty minutes, and allowed to cool for an hour. Each of the samples were clear with some suspended solids, which were filtered using a 0.2 mm syringe filter.

Results

A total of twenty-five water samples were analyzed. These samples ranged from a series of Guts or from standing water. In all cases samples were collected from multiple points within the sampling area and if possible, from multiple depths. The samples analysed represented a cross-section of locations feeding into STEER on the east end of St. In all cases, standard curves met the criteria of a correlation of greater than 0.999 (The full analytical report is available, including standard curves, from the authors (pdf format, > 50 pages). In the metal ion cases where both ICPMS and electrochemical analysis could be used, data using either ICPMS or electrochemical analysis (stripping polarography) compared closely with each other.

The data demonstrated that in the majority of the samples, very small amounts (sub-ppb) level of heavy metal ion. The largest concentration of “heavy” metal contaminants were

Al, Zn, and Cu. Some samples did show more than a trace amount of Pb, more than likely from battery decomposition, either in Bovoni or from non-standard disposal of batteries.

Conclusions

The small data set indicates little or no unexpected concentrations of cation contaminants in any of the water samples collected and analysed. The occasional sample containing high Al, Zn, and Cu can be explained by the presence of galvanized or aluminium roofing or copper plumbing, which would be expected in the run-off or from the septic systems. For numerous reasons (primarily the lack of a working instrument) we were unable to analyse any of the water samples for trace level organic contamination. We expect to be able (summer 2013) to be able to get both our Varian GCMS and our Varian LCMS working and to analyse water samples both from STEER and from run-off leading into STEER for pesticide, herbicide, and other trace-level organic contaminants (e.g. Triclosan).

Microirrigation for Sustainable Vegetable Production in the US Virgin Islands

Basic Information

Title:	Microirrigation for Sustainable Vegetable Production in the US Virgin Islands
Project Number:	2012VI212B
Start Date:	3/1/2012
End Date:	4/30/2013
Funding Source:	104B
Congressional District:	Not Applicable
Research Category:	Biological Sciences
Focus Category:	Agriculture, Irrigation, Water Use
Descriptors:	None
Principal Investigators:	Dilip Nandwani

Publication

1. Nandwani D. Evaluation of sandea for weed control in transplanted eggplant. American Society for Horticultural Science-Southern Region, Orlando, FL, 2013 (poster).

MICROIRRIGATION FOR SUSTAINABLE VEGETABLE PRODUCTION IN THE US VIRGIN ISLANDS

Problem and Research Objectives

The main water delivery system for crops grown for both research at the University of the Virgin Islands and by many of the territory of the U.S. Virgin Islands farmers is through drip irrigation. During this time there is no water shortage problem; however the US Virgin Islands experiences drought from January through March, normal dry season. Through the use of drip irrigation we have been able to conserve fresh water which is truly a valuable resource. Energy required and associated costs to desalinate large quantities of water for farming purposes is truly substantial. Through the use of drip irrigation, researchers and farmers alike have been able to utilize above ground water storage tanks as well as water catchment ponds to store large quantities of rain water in the rainy season.

The use of drip irrigation is a great asset when it comes time for the application of fertilizers. Unlike the common local application of granular fertilizer, which is spread around the field or around the base of a sizeable plant, drip irrigation affords the efficiency of applying water soluble fertilizers within inches of a relatively newly planted seedling and throughout the life of the plant. This allows for remediating specific nutrient deficiencies that can occur in local high pH calcareous soils. Chemigation through drip irrigation delivers pesticides in the root zone of the plants.

The precision obtained through drip application is safer, more accurate and uses far less material due to the accuracy. Using pesticides such as DuPont Coragen, Venom, other commercial pesticides and soluble fertilizers are more efficient use of drip irrigation which saves in labor costs.

Objectives

a) Develop and evaluate improved water management practices using microirrigation in selected vegetables.
b) Evaluate the effect of varying rates of irrigation on the yield and growth of selected vegetables.
c) Determine the minimum water requirements for selected vegetables.

Methodology

- Three experiments were conducted in field plots at the University of the Virgin Islands Agricultural Experiment Station, Albert A. Sheen campus and at the Sejah farm, Kingshill. Cucumber and eggplant trials conducted at the UVI-AES field plot in the growing season of 2012 and tomato trial conducted at Sejah farm, Kingshill in the growing seasons of 2012-2013.

- Seeds, potting trays, potting mix and drip supplies ordered off-island and locally after approval of project and project account establishment.

- An advertisement for the student aid prepared, circulated and applications invited for the position. Interviews conducted and a UVI Undergraduate student Ms. Vernecia Philips was hired. Ms. Philip didn't complete her appointment period, therefore, another student aid Mr. Mark Sinanan of UVI hired.

- Seeds of cucumber var. `Eureka' planted in 'seedling trays' containing potting mix in the greenhouse. Seedlings were transplanted in the field approximately 10 days after germination.

- An experimental plot (90'x75') selected at the USDA field and cucumber transplants planted in three rows spaced 1.2 m apart, with 12 plants per row spaced at 0.6m along the row. The experimental design was randomized complete blocks, with 3 replications. Standard conventional system applied for the production e.g. fertilizer applications, planting densities and pest control. Microirrigation: Water was applied to maintain soil moisture levels equivalent to 20, 40, 60 kPa. Tensiometers were placed at a depth of 15 cm, in the middle rows of plots, to monitor soil moisture in the plant root-zone. The irrigation system monitored daily and turned on when tensiometer readings exceed the specified level for each treatment.

- The weather station at the University of the Virgin Islands-Agricultural Experiment Station used to provide the necessary meteorological data for irrigation scheduling.

- Data were collected on rainfall, water used, yield, and other plant characteristics.

- In eggplant, three cultivars ca. 'Nadia', 'Hansel' and 'Magal' were grown in conventional management system at the Agricultural Experiment Station of the University of the Virgin Islands in St. Croix (Kemble *et.al*., 1998)

- The experimental design was complete randomize block in three replications. Weed control was done mechanically or with herbicide application.

- Data on plant height, marketable yield and fruit size were recorded.

- At the Sejah farm, field plot (30'x152') selected, cleared and prepared for the tomato experiment. Untreated seeds procured from Harris seeds, NY and planted in compost in the greenhouse and other cultural practices adopted as per National Organic Program (NOP).

- A randomized complete block design with three replication used. Four cultivars of tomato (determinate type) `Mountain Fresh' (MF), `Red Defender' (RD), `Security 28' (SY) and `Defiant' (DF) used for the experiment. Tomato transplants of all four cultivars (4-5 weeks) planted in the field.

- OMRI listed fertilizers and insecticides ordered and applied. Drip irrigation (low pressure, gravity based) used and water requirement monitored.

- Data on yield (numbers and total weight) and marketable fruits collected from multiple harvests throughout the growing season.

Principal Findings and Significance

- Moisture level -30pka produced highest yield compared to -60pka and -90pka. -90pka moisture level was high and produced low marketable fruits.

- Injecting Malathion, Sevin or Venom on a rotation as needed once the pest reaches levels were they can no longer be controlled using topical application, often bring the situation under control.

- In eggplant, var. ‘Hansel’ produced highest yield (30.57ton/ha) and lowest in ‘Magal’ (12.16ton/ha). Average marketable fruits number was higher (14/plant) in `Hansel’. Spider mites infestation (2-3%) occurred in plots and controlled by miticides.

- All four varieties of tomato produced marketable fruits. Trial needs to be repeated in order to collect data and results.

- In tomato trial, total 18,750 gallon water used in drip irrigation from December 2012 to March 2013 (Dec. 2012-2400gal, January 2013-4950gal, February 2013-6100gal, March 2013-6300gal).

- Frequent rainfall and insect pests damage was an issue and trial needs to be repeated in order to collect data and results.

- Water is a rare commodity on a semiarid island and the Virgin Islands stakeholders are concerned to use this precious resource as efficiently as possible. Fertigation and chemigation are new technologies for utilizing a drip irrigation system to apply fertilizer and pesticides.

Conclusions

- Drip irrigation has been very beneficial though it has not been easy to get 12 or 15ml drip tape. Regional supplier have only been able to get 8ml and 10 ml low flow drip tape, the 15ml is very difficult to obtain and generally has to be ordered off-island which can be very pricy once shipping to the Virgin Islands is added.

- Frequent rainfall and insect pests damage was an issue in cucumber and trial need to needs to be repeated in order to collect data and results.

- Water is a rare commodity on a semiarid island and the Virgin Islands stakeholders are concerned to use this precious resource as efficiently as possible. Fertigation and chemigation are new technologies for utilizing a drip irrigation system to apply fertilizer and pesticides.

- The study provided vegetables yield response with respect to irrigation amounts and method of determination of amounts and would be useful to producers for planning purposes and water management of the crops. Data being analyzed to determine significance differences among treatments.

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Terrestrial Sediment Delivery and Nearshore Water Turbidity A Case Study From the East End of St. Croix, USVI

Basic Information

Title:	Terrestrial Sediment Delivery and Nearshore Water Turbidity A Case Study From the East End of St. Croix, USVI
Project Number:	2012VI220B
Start Date:	3/1/2012
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	Not Applicable
Research Category:	Water Quality
Focus Category:	Hydrology, Sediments, Water Quality
Descriptors:	None
Principal Investigators:	Kynoch Reale-Munroe, Bernard Fernando Castillo, Carlos E Ramos-Scharron

Publications

1. Student poster presentation by Nathan Gubser, Threats to our Reefs: Sediment Based Pollutant Regulation and Mitigation. UVI 2012 Research Day. April 2012.
2. Student poster presentation by Anthonio Forbes, Shelsa Marcel, Bernard Castillo II and Kynoch Reale-Munroe. Threats to our Reefs: Establishing Baseline Data for Total Maximum Daily Loads (TMDLs) Development. UVI 2012 ECS Summer Research Symposium. July 2012.
3. Poster presentation by Kynoch Reale-Munroe. Threats to our Reefs: Quantifying Sediment and Organic Material Production Rates from Erosion Processes in Small Subtropical Watersheds on the East End of St. Croix. USVI. UVI 2012 Research Day. April 2012.

TERRESTRIAL SEDIMENT DELIVERY AND NEARSHORE WATER TURBIDITY – A CASE STUDY FROM THE EAST END OF ST. CROIX, USVI

Problem and Research Objectives

Water quality plays a critical role in maintaining biological integrity and preserving natural resources in aquatic ecosystems. In October 2010 United States' Environmental Protection Agency (EPA) published a list of impaired and threatened waters in the U.S. Virgin Islands (USVI) that are targeted for the development of future Total Maximum Daily Load (TMDL) limits in the territory. The most common reported causes of impairment in near-shore waters were sedimentation, effluent discharges, dissolved oxygen (DO) deficiencies and bacterial contamination (US EPA, 2010). Of the 33 listed sites for St. Croix, 28 or 85% of the reported impairments were associated with high turbidity.

The government of the US Virgin Islands approved legislature that allocated 155.4 km^2 of offshore marine habitat to the St. Croix East End Marine Park (STXEEMP) to protect the largest island barrier reef system in the Caribbean. Federal and territorial coastal managers consider the watersheds that drain into the STXEEMP to be priorities for protection and restoration. Currently, there are 19 ambient water-quality monitoring sites that are managed by the Department of Planning and Natural Resources (DPNR) and located in the STXEEMP. Eight of the 19 sites are currently listed as impaired. Seven of the eight impairment issues are due to turbidity, primarily as a result of land-based sources of sediment.

The small watershed that discharges into Boiler Bay is located within a no take management zone of the STXEEMP and has been identified as a major source of erosion and sedimentation. A preexisting 180 m long dirt road that is now used as a foot trail is experiencing massive erosion that directly discharges into the bay. Recent studies have estimated that 2.5 tons of sediment is annually delivered to Boiler Bay from the existing trail. However, the nature and extent of the sedimentation events in the water column have not been sufficiently captured.

The primary objectives of the study were (1) to link rainfall events to terrestrial erosion data and turbidity concentrations in the receiving water column and (2) to characterize the nature and extent of turbidity during ambient and sedimentation events for potential TMDL development.

Methodology

Precipitation

Precipitation events will be monitored by a tipping bucket rain gauge located on site. Precipitation data will be downloaded once a month and will be used to generate a 15-min rainfall intensity database to calculate daily, monthly, and individual storm event precipitation totals and to maintain a daily record of antecedent precipitation index (API). Storm total and API have been previously used to better predict the relationship between rainfall patterns and the generation of runoff and sediment from small catchments. Precipitation will also be used to estimate sediment delivery rates from the Boiler Bay trail based on previously collected erosion data.

Terrestrial Runoff

Crest gages will be used in an attempt to differentiate periods when runoff was delivered from periods when no runoff was generated and delivered to Boiler Bay. A crest gage is a low tech and inexpensive device used to register the maximum stage (i.e., water level) for a given runoff event or for a given time period. Gages are typically used in remote locations to record the maximum flood level in a stream but have also been used to gage the elevation of sub- surface soil saturation levels. The gage consists in two PVC tubes of different diameters and roughly equal length. Holes are carved into the bottom part of the large diameter PVC tube and this is secured vertically in a location where runoff is expected to flow. A handful of powdered corks are placed inside the tube before inserting the small diameter tube and placing a cap. When flow occurs the maximum water level is recorded by the markings of the powdered cork on the inner PVC tube. Although this method will not allow the estimation of total runoff entering Boiler Bay, it will allow us to differentiate which rainfall events yielded runoff. Crest gages will be checked on a weekly basis or just prior and immediately following announced major rainfall events.

Turbidity

The proposed study includes the use of a U.S. EPA approved (YSI 6820/6920) sonde, capable of measuring and recording real-time turbidity shifts, as well as temperature, DO and conductivity in the receiving water column. The use of this turbidity data logger would allow us to clearly quantify and link terrestrial sediment transport with its impacts on water quality conditions in Boiler Bay.

The sonde will be mounted approximately 70 m north and 10 m east the point of direct discharge. The sonde location was identified based on both visual observations of the direction that the sediment plume travels when it enters the bay and by determining the relative velocity and direction of local currents. The average depth in Boiler Bay is approximately 10-20 feet. The sonde will be mounted approximately 5 feet above the marine surface bottom and below wave break depths to minimize potential interference from bottom sediments or bubbles caused by surge or wave action.

Turbidity data, as well as temperature, conductivity and DO logged by the sonde will be downloaded and analyzed approximately once a month. After the data is downloaded, it will be correlated with rainfall data that is collected on-site, as the timescale resolution is the same. The turbidity data will also be compared to the catchment-scale sediment delivery rates and analyzed for trends and seasonality. The sonde will be cleaned and calibrated on a bi-weekly schedule and batteries will be replaced. The sonde will be brought to the laboratory and cleaned in an "as needed" basis.

Principal Findings and Significance

On May 18th, 2012 a YSI 6920V2 sonde was mounted in the bay and a HOBO® tipping-bucket rain gage was re-installed at the Boiler Bay study site. The sonde was deployed in hopes of capturing baseline water quality data and sedimentation events from an eroding gut. The rain gage collected precipitation events for direct correlation of expected sedimentation events onto the reef from runoff. Calibration and antifouling of the sonde occurred approximately twice a month, or every 12 days. Maintenance and minor repairs of the equipment were performed in EVC 208 at the University of the Virgin Islands, Albert A. Sheen campus.

Five months of event-based, precipitation data was collected using the tipping bucket rain gage. Seven months of five-minute interval data was collected by the sonde.

Turbidity data, as well as temperature, conductivity and DO were logged and downloaded from the sonde in approximately 10-day increments (a limitation of battery life).

Enough high resolution, real-time turbidity data was collected from this study to have confidence in defining the characteristics of what ambient, baseline data should look like at the site.

Students Antonio Forbes and Shelsa Marcel molded this project to fit their specific research interests. We worked closely to finalize their project for presentation at the UVI Summer Research Symposium, titled "Threats to our Reefs: Establishing Baseline Data for Total Maximum Daily Load (TMDL) Development."

On January 16th, 2013 an abstract related to this work was submitted to the 2013 Puerto Rico Water & Environment Association Exhibition & Technical Conference. The conference is slated for May 22 -24 in San Juan, Puerto Rico.

Problems Encountered

During the study period, we observed that there was not enough rainfall to generate significant terrestrial runoff. As a result, were unable to link rainfall events to turbidity concentrations in the bay. For this reason, we applied for a no-cost extension. The intent is to continue monitoring during the next hurricane season, commencing on June 1st through November 30th 2013, in hopes of capturing and characterizing a runoff event.

We experienced a corruption in the data-logger for the rain gage in October 2012, which was during the last two months of the data collection period. However, we were able to obtain the missing data from the Very Long Baseline Array (VLBA) station located just 1,073 meters (0.67 mi) southwest of the location of our rain gage.

One turbidity dataset in June was compromised, due to an octopus taking up residence in the protective cage surrounding the probes. Another turbidity dataset in July was unusable, as a result of contaminated calibration solution. Both datasets were omitted from the study.

Work Left to be done
To satisfy the objectives, monitoring of precipitation and turbidity will continue during the next hurricane season (June – November 2013) in hopes to characterize the nature and extent of turbidity during sedimentation events.

High-Resolution Mapping of Rainfall Rates Across the St Thomas Microclimates

Basic Information

Title:	High-Resolution Mapping of Rainfall Rates Across the St Thomas Microclimates
Project Number:	2012VI222B
Start Date:	3/1/2012
End Date:	8/31/2013
Funding Source:	104B
Congressional District:	Not Applicable
Research Category:	Engineering
Focus Category:	Water Quantity, Water Supply, Models
Descriptors:	None
Principal Investigators:	David C Morris

Publication

1. Morris, David; Drost, Don; Richardson, Dwayne, 2013, High-Resolution Mapping of Rainfall Rates Across the St Thomas Microclimates, in Proceedings of the 11th International Precipitation Conference, Ede-Wageningen, The Netherlands, pages TBA.

HIGH-RESOLUTION MAPPING OF RAINFALL RATES ACROSS THE ST THOMAS MICROCLIMATES

Problem and Research Objectives

Accurate and precise rainfall data with high spatial and temporal resolution are critical to a broad spectrum of public sector, private sector, and academic projects of great interest to Caribbean prosperity, yet such data are presently lacking in the USVI. Residential water supply construction (cisterns), drainage planning for public works projects, and environmental erosion studies, to name only a few applications, all rely on an accurate understanding of the actual and predicted rainfall rates at varied sites around the USVI. While historical data are available online through the US Geological Survey website, these data are, themselves, derived from only a few collection sites around the VI and are now some 20-40 years old. As global climate change drives variation in weather patterns across the Caribbean, it is critical to the next generation of construction and development planning in the USVI to rebuild and maintain a modern, high-resolution precipitation database that accurately portrays the current microclimate conditions across the region. Similar data are available across urban and rural areas throughout the continental US and should be made available as well in the USVI.

A high-density network of low-cost tipping-bucket rain gauges installed across the island of St. Thomas will provide continuous monitoring of rainfall rates and accumulation. These rainfall stations will be monitored and maintained by a team comprising both UVI faculty and undergraduate researchers and will span all the major microclimates of St Thomas to provide both local rainfall data within each microclimate region and a dynamic picture of the evolution of rainfall events as they cross the island and encounter its varied topology.

Additionally, it is a well-known issue in rain microphysics that the structure of rainfall events at modest (~1 km) resolution is largely unknown yet is important to understanding storm-evolution, evaluating the utility of radar coverage, and identifying local microclimates within the larger macroclimate region. These issues are of particular interest in the Caribbean where the prevailing winds, steep geography, and sharp ocean thermal gradients contribute to extreme variation in weather characteristics within close proximity. The close configuration of the rain sensor network proposed here will provide research-quality data on a spatial resolution seldom before achieved anywhere (though see Larsen et al. 2010) and never before achieved in the Caribbean. This set of measurements will therefore be of great value to the meteorological research community.

Methodology

The rain gauge stations include a Hydreon Optical Rain Sensor (model RG-11) together with a Davis Vantage Vue weather sensor suite. Students Dwayne Richardson and Stanley Barbel spent (combined) 9 months, building an in-laboratory testing and calibration apparatus, testing the sensors in the lab, and later installing and testing the prototype sensor in the field. Since the precision of the rainfall event start and stop times is of high importance in modeling the weather pattern evolution, care was taken understand differences in start/stop signals from these two sensors. The Davis weather sensor suites will be used to collect a full suite of weather data (wind speed, wind direction, temperature, humidity) while the RG-11 sensors, which have a much faster rainfall response-time to rainfall event starts/stops, will be used in parallel to record precise event start and stop times.

A “verification suite” of 2 weather sensors has been installed and running for several months. These two weather stations have been recording weather data and archiving it both locally and on a centralized cloud server.

The full suite of 15 sensor stations is now being installed in the field by a team of graduate and undergraduate students. When installation is completed early this summer, all 15 stations will continuously archive data both locally and on a cloud server for use both by UVI students and researchers as well as those across the scientific community.

Principal Findings and Significance

This project has been issued a no-cost extension through August 31, 2013 and will be completed by that date.

Objectives and Progress

Short-term objectives - make rainfall data available to the public in well-documented form for use in scientific, private, and public sector projects:

Rainfall and weather data from a pilot network of weather stations is connected to a publicly accessible Davis Instruments Inc. cloud archive. These data are accessible by researchers across the scientific community.

Long-term objectives - The principal and co-principal investigators pursuing scientific objectives including:

• A comparison of current monthly rainfall rates to historical rates as evidence of climate change in the Caribbean (student project) – Student Ariane Ramsundar will study this as part of a research experience for undergraduates (REU – advised by Morris).

• A comparison of relative rainfall rates across different geographical regions to quantify the contrast in water supplies across the island (student project) – Student Leo Jobsis will study this as part of an REU (advised by Morris).

• A study of the variation of rainfall rates within a single Doppler radar pixel to validate meteorological ”ground-truth” models – graduate student Pedro Nieves has made progress in developing a method of comparing radar images to rainfall point measurements. He continues work on incorporating a rainfall layer into the UVI GIS database (advised by Primack).

Remaining Tasks and Research Elements

Build-out and install weather stations to complete island-wide network. Complete analyses begun as noted above. Collaboration with Co-I Larsen on scale-invariance of Caribbean rainfall events.

Conclusions

Project is ongoing through August 31, 2013.

Information Transfer Program Introduction

None.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	12	0	0	0	12
Masters	4	0	0	0	4
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	16	0	0	0	16

Notable Awards and Achievements