

Report as of FY2010 for 2009VI152B: "Investigation of Sediment Export from St Thomas Watersheds"

Publications

- Water Resources Research Institute Reports:
 - ◆ Benoit, Gaboury, Donna Nemeth, 2011, Investigation of Sediment Export from St. Thomas Watersheds, Virgin Islands Water Resources Research Institute, University of the Virgin Islands, St. Thomas, U. S. Virgin Islands, 34 pages.

Report Follows

PROBLEM AND RESEARCH OBJECTIVES

Coral reefs and other vulnerable nearshore marine resources of the United States Virgin Islands are suffering from the impacts of multiple stressors. Among the most important of these is fine-grained sediment eroded from land and delivered by guts to the coastal zone. Steep slopes, erodible soils, widespread soil disturbance (for land development and road building), and inadequate use of erosion prevention and control measures lead to accelerated erosion and sediment export. Short distances and steep slopes mean that USVI watersheds are closely coupled with adjacent marine ecosystems.

Corals must clear themselves of deposited sediments to obtain prey and, more importantly, to allow symbiotic zooxanthellae to photosynthesize. Even non-deposited sediments can shade corals, reducing photosynthetic efficiency. Dealing with fine sediments requires expenditure of unnecessary energy, which when combined with predation, elevated temperatures, disease, predation, and physical disturbance can cause coral morbidity and mortality. A better understanding of erosion, transport, and delivery of fine-grained sediments would inform better management to protect fragile coral reef ecosystems from the impacts of onshore land development.

METHODOLOGY

There are several approaches to understanding erosion and sediment fluxes:

- examining the sources of eroded material,
- measuring the transport of sediment,
- and assessing the impact and final repository of eroded material.

The first and last methods (source and sink evaluation) have the advantage of yielding net effects and of integrating the impact of processes over long time periods. They have the disadvantage of being insensitive to short term processes, so they reveal less information about mechanisms. We combined short-term, real-time measurements with longer-term integrative analyses to harness the advantages of both approaches.

Stream Monitoring

A goal of this study was to continuously monitor discharge and suspended matter in Dorothea gut for a period of at least a year. This was facilitated by installing a V notch weir as an addition to an existing broad crested weir built by the USGS.

A YSI 6920 Multi Parameter Water Quality sonde was deployed in Dorothea Gut by attaching it in the pool behind the weir. The sonde was equipped with probes to measure pressure (stage/water depth), turbidity (a surrogate for suspended sediment), temperature, dissolved solids, dissolved oxygen (DO), and pH.

Rain gauging

In conjunction with the stream monitoring, we deployed two Rainwise RAINLOGGER digital rain gauge/data logger systems.

Coastal Pond Sediment Accumulation Rate Analysis

Sediment cores were collected from ponds along the coast of St Thomas. Geologically, these systems tend to be small embayments whose connection to the sea has been closed by some combination of reef building and longshore drift creating berms rising 1 to 2 m above sea level.

PRINCIPAL FINDINGS AND SIGNIFICANCE

General Findings

Compared to much of St. Thomas, especially the eastern end, the watersheds of the four ponds tested have relatively low levels of land development. This sampling bias is because there are no ponds on the island that have watersheds that are both large and heavily developed. We judged larger watersheds to be more likely yield results that were more representative. In the future we will study some ponds with smaller watersheds with higher levels of land development, though there are not many candidates.

Evaluating the four ponds measured so far, Sediment Accumulation Rates (SARs) are low. A simple calculation can be used to place the SARs in the context of erosion rates in their watersheds. Sediments in these ponds typically have a bulk density of 0.3 g/cm^3 . (We use this term in the sense of dry mass per volume.) A SAR of 0.1 cm/yr then translates to deposition of about $3000 \text{ kg ha}^{-1} \text{ yr}^{-1}$ in the ponds. For a pond with a watershed 40 times its size that would mean an erosion rate of $75 \text{ kg ha}^{-1} \text{ yr}^{-1}$, which is considered to be a very low value. Looking at the four ponds, we calculate delivery rates of 103, 75, 220 and $1250 \text{ kg ha}^{-1} \text{ yr}^{-1}$, assuming 100% capture. These values compare favorably with those measured on St John for hillslope plots ($10 - 270 \text{ kg ha}^{-1} \text{ yr}^{-1}$) and zero and first order catchments (10 and $80 \text{ kg ha}^{-1} \text{ yr}^{-1}$).

Considering the steepness of the slopes and level of development, we expected SARs to be higher. This only occurred in Sapphire Pond, which is both small in comparison to its watershed, and whose local land use (pasture or former pasture) could be expected to generate a large amount of eroded sediment. The low SAR values we measured imply either that (1) the ponds are very inefficient sediment traps, (2) erosion is minimal, or (3) transport of eroded material is negligible. We believe that mechanisms 2 or 3 are the most likely explanations for the low SARs. (1) Based on the size of the ponds compared to their watersheds, the depth of added water that would need to be added before they would overflow, typical rainfall amounts, and the amount of runoff that would be generated per storm, the ponds should be able to contain most of the inflow they receive, except in very large storms. Water residence times thus being high, and settling depths short, the ponds should be efficient sediment traps. (2) Much of the watershed area of these ponds is undisturbed. On St John, it was found that disturbed lands (especially unpaved roads) were the main source of eroded material. In the watershed of these ponds, most land can be expected to produce little eroded material, despite their steep slopes. (3) Much of the steep uplands above these ponds are upslope from undisturbed, vegetated lands. They should not generate significant overland flow that could carry eroded material. Thus, even if significant erosion does occur, much of the material is likely to be redeposited before it can reach the ponds.

Conclusion

The management implication of these results is important. Erosion from undisturbed watersheds on St Thomas is naturally low. The nature of soils, vegetation, and climate is such that little material is eroded or that which is quickly redeposited despite steep slopes. This means that small areas of disturbed soils, mainly associated with land development, can contribute a vastly disproportionate share of sediment to downslope ecosystems. On the positive side, because these developed areas tend to be small (typically the size of building lots), erosion control measures can be employed cost effectively. Also, because there is an obvious link between the erosion source and an individual developer or builder, responsibility is clear and enforcement should be straightforward.

Additionally ...

- Eight student term papers for the course Caribbean Coastal Development were based on data collected for this project.
- Two peer-reviewed papers are in preparation based on this project. Working titles are:
 - Continuous monitoring to assess stream export of sediment from Dorothea Gut watershed in St Thomas, USVI
 - Watershed erosion as revealed by sediment capture in coastal ponds of St Thomas, USVI
- Results of the research were presented in two Yale courses: F&ES 729 Caribbean Coastal Development, and F&ES 708 Biogeochemistry and Pollution
- The research was highlighted in a talk in the Yale School of Forestry and Environmental Studies faculty seminar series.