AN ANALYSIS OF SEDIMENT PRODUCTION AND CONTROL IN ECUADOR'S RIO CHONE WATERSHED

GSE Global Student Embassy

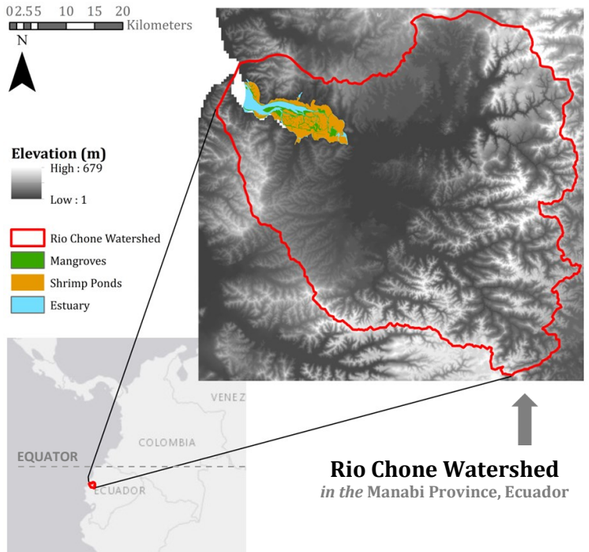
Group Members:
Francesca De Leon | Steven Johnson
Jake Marcon | Natalie Phares

Faculty Advisor:
Steve Gaines

PROJECT INTRODUCTION

Located along Ecuador's Pacific coast, the 2700km² Rio Chone watershed lies within the Manabi Province. The Rio Chone estuary (34km²), which resides at its outlet to the ocean, is an ecosystem that once housed great swaths of mangrove s and small sustenance fisheries.

The estuary is experiencing increased sedimentation rates, coinciding with a high degree of human disturbance in the estuary and upper watershed over the last five decades. The economic and environmental well-being of the area has been hindered by the increased sediment accretion. Our project aimed to identify the major sources of sediment production from within the watershed, and assess which watershed management options would be most effective in minimizing the volume of sediment delivered to the delicate estuary.



Rio Chone Watershed
in the Manabi Province, Ecuador

PROJECT OBJECTIVES

I. Calculate the volume of sediment buildup in the estuary

II. Identify the major sources of sediment production

III. Assess the effect that altering land use could have on reducing erosion rates

PROJECT MOTIVATION

WATER QUALITY
Sedimentation decreases water depths in the estuary, changing the salinity, pH, and temperature of its waters. In addition, increased turbidity influences photosynthetic rates as sunlight cannot penetrate as deep into the water column, lowering dissolved oxygen content.

BIOLOGICAL EFFECTS
An increase in the level of suspended solids affects fish both physically, leading to suffocation, abrasion, and mortality, and behaviorally, affecting migration patterns, feeding, and mating.

SOCIAL AND ECONOMIC EFFECTS
Sedimentation of an estuary can create murky water conditions, harming tourist operations and shutting down local fisheries. The root cause of the problem, upstream soil erosion, is detrimental to agricultural productivity as crop yields decrease with increased soil loss over time.

IMPLEMENTATION CONSIDERATIONS


http://mintcoinfund.org/what-is-reforestation/

Re-Vegetation

PROS	CONS
• Long-term effect, one-time effort • Carbon Sequestration • Added biodiversity benefits	• Opportunity cost • $2.75/tree (per GSE) • Erosion reduction timeline


http://eorganic.info/sites/eorganic.info/files/u257/CucStraw02.jpg

Soil Conservation (mulching)

PROS	CONS
• Immediate implementation • Income/sustenance from farming maintained • Mulching is viable in Manabi	• Requires educational outreach • Cost of mulching • Low incentives without property rights

CONCLUSIONS

- Per the BATHYMETRIC MAPS: Sedimentation of the estuary is occurring. Approximately 2 million tonnes of sediment was deposited and retained in the estuary each year from 1990 to 2011
- Per the SEDIMENT BUDGET: Of all of the geomorphic processes occurring in the Rio Chone watershed, the amount of sediment produced from sheetwash erosion on bare topsoils is the largest by several orders of magnitude
- Per the InVEST MODEL: Erosion rates in the terrestrial watershed can be reduced back down to pre-disturbance levels by reforesting, practicing soil conservation techniques, or performing a combination of the two on all lands that have been cleared of native vegetation for agricultural purposes

KEY FINDINGS : *What did the model tell us?*

The InVEST model took into account erosivity, soil erodibility, topography and land cover to estimate the amount of sediment produced from sheetwash under a given land-use regime. We discovered that erosion rates could be decreased back to pre-disturbance levels by either reforesting, employing soil conservation techniques such as mulching, or performing a combination of the two. This means that land managers could control erosion from the Rio Chone estuary without having to give up the farming activities that act as a source of income and sustenance for the native people of the Manabi province.

REFERENCES

Coello, S., D. Proano-Leroux & D. J. Robadue (1993). Special area management planning in Ecuador's Rio Chone Estuary. In *The Eighth Symposium on Coastal and Ocean Management.* New Orleans, Louisiana

Marden, M., A. Herzig & L. Basher (2014). Erosion process contribution to sediment yield before and after the establishment of exotic forest: Waipaoa catchment, New Zealand. *Geomorphology*, 226, 162-174

Stram, D. L., C. R. Kincaid & D. E. Campbell (2005). Water quality modeling in the Rio Chone estuary. *Journal of Coastal Research,* 797-810

Wilber, D. H. & D. G. Clark (2001). Biological effects of suspended sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. *North American Journal of Fisheries Management,* 21, 855-875

ACKNOWLEDGEMENTS

Dr. Steven Gaines
Dr. Derek Booth
William Brandt
Lucas Oshun
Ramiro Medina
Ben Best
Dr. Stuart Hamilton
Mayra Vera
Dr. Tom Dunne
Dr. Allison Horst

For more information email:
chonegroves@lists.bren.ucsb.edu
Or visit:
www.chonegroves.com

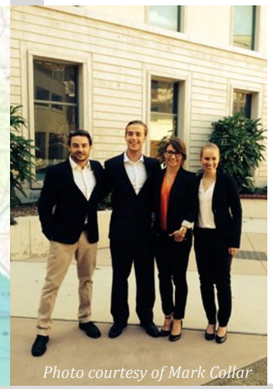


Photo courtesy of Mark Collar

AN ANALYSIS OF SEDIMENT PRODUCTION AND CONTROL IN ECUADOR'S RIO CHONE WATERSHED | Spring 2015 | Brief

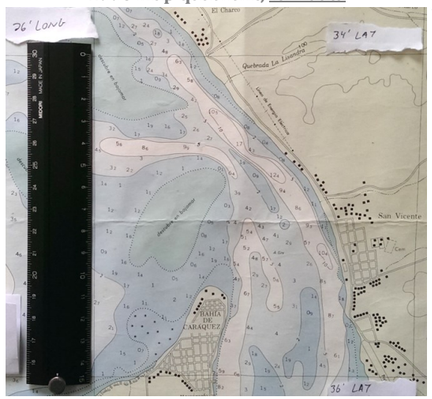
OBJECTIVE 1 : Bathymetric Maps

1. Obtained bathymetric maps from 1990 and 2011 from Ecuador's Navy
2. Digitized maps to show depth change in the estuary over the 21 year study period
3. Calculated an average annual accretion rate, extrapolated to entire area of the estuary

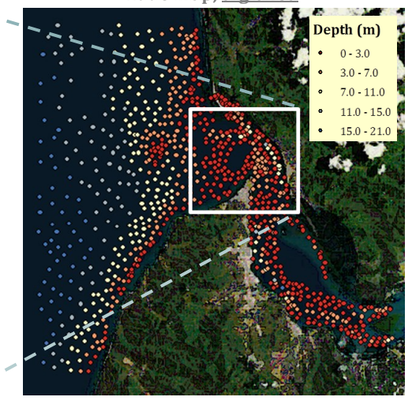
THEORY : *What will bathymetric maps tell us?*

To quantify sedimentation in the Rio Chone estuary, we compared depth measurements from bathymetric maps created in 1990 and 2011. The estuary's biodiversity and value to human use is threatened, as some regions have seen accretion of up to seven meters of sediment over the assessed period of 21 years. Bathymetric maps were used to prove that sedimentation of the estuary is occurring, and to allow a crude rate of accretion to be calculated.

1990 map quadrant, raw data



1990 map, digitized



METHODOLOGY

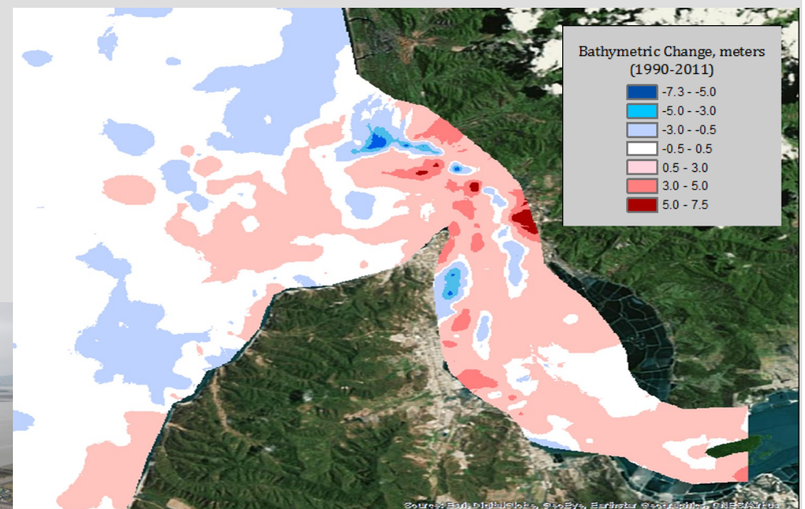
Pictures of maps were taken noting longitude and latitude, then images were georeferenced and depth points input.

Kriging was used to interpolate a smooth surface layer based on the given points for each map, allowing a subtraction of the two digitized layers to be performed. A final smooth surface map of the change in bathymetry over time was produced.

RESULTS

The results of our bathymetric map analysis show a notable change in depth from 1990 to 2011. Red demarks areas that have seen an increase in bathymetric elevation from 1990 to 2011, while blue demarks a decrease.

The maximum decrease in bathymetric elevation was 7.3 meters, with a maximum increase of 7.5 meters. Based on these findings we conclude that the Rio Chone estuary has experienced a net decrease in bathymetric elevation over time.



Accretion rate estimate:
2 million tonnes/year

Photo courtesy of Steven Johnson

OBJECTIVE 2 : Sediment Budget

THEORY: *What is a sediment budget?*

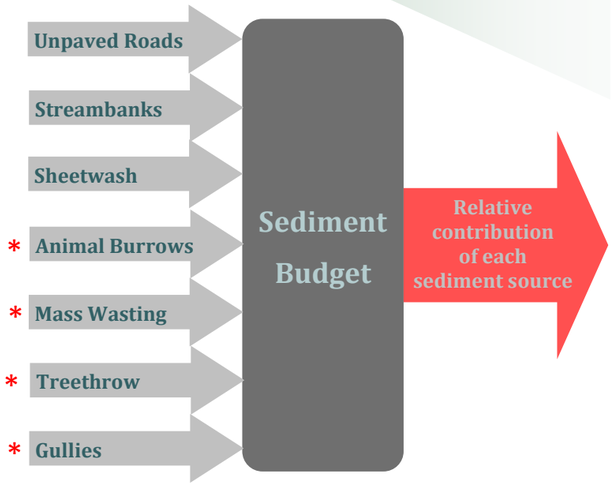
Sediment budgets are a management tool used to analyze and describe the different sediment inputs (sources) and outputs (sinks) in a watershed or sub-watershed.

There are a variety of geomorphic processes that can lead to sediment generation. It was important for our group to determine the main sources of sediment versus those that have little impact on the total volume of material making its way into the Rio Chone estuary from the river channel delivery network. Identifying the most substantial sediment contributors allowed us to prioritize the rest of our analyses on those geomorphic processes that would have the largest impact on reducing delivered sediment loads if addressed.

RESULTS

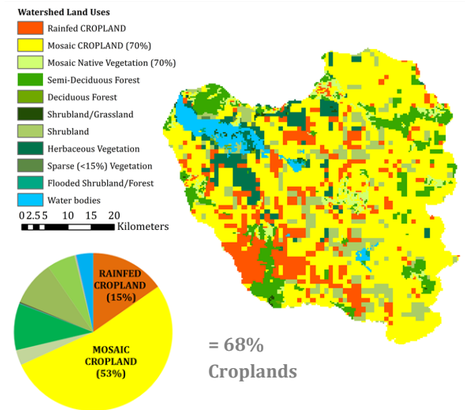
Erosional Process	Total Sediment Contribution (Million Tonnes/Year)
Streambank Erosion	0.02
Unpaved Roads	0.2—0.4
Sheetwash	50

The MODEL



* = Relative size of contribution to overall sediment load found to be negligible, not quantified in sediment budget

OBJECTIVE 3 : Modeling Sheetwash & Affects of Land Use



= 68% Croplands

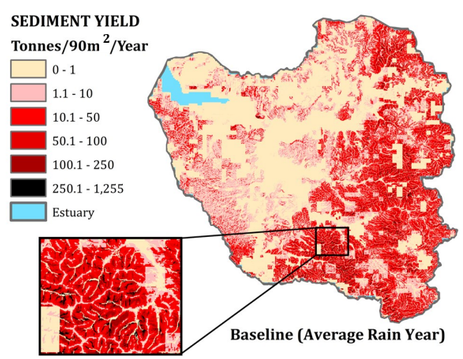
ENVIRONMENTAL MODELING

To estimate the volume of sediment produced from surface water erosion (sheetwash and rilling) we used the InVEST Sediment Retention Model. InVEST pairs the Revised Universal Soil Loss Equation with Global Information System (GIS) technologies to estimate the amount and location of sediment produced from eroded topsoils.

Our study area is comprised of 68% cropland. As such, over two-thirds of the watershed has been cleared of native vegetation for farming practices, and has now become vulnerable to surface water erosion as topsoils have been exposed. To assess the impact altering land use on cultivated parcels could have on reducing erosion rates, we modeled different land use scenarios and compared the amount of sediment each scenario produced.

RESULTS

Scenario	Sediment Export (Million Tonnes/Year)
100% Native Vegetation (Pre-Disturbance)	5
Baseline for an Average Rain Year	50
Baseline for an El Nino Rain Year	180
100% Deforestation (Worst-Case)	90
100% Soil Conservation (Buffer Strip-Cropping)	30
100% Soil Conservation (Mulching)	3



AN ANALYSIS OF SEDIMENT PRODUCTION AND CONTROL IN ECUADOR'S RIO CHONE WATERSHED | Spring 2015 | Brief