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

GSE Global Student Embassy

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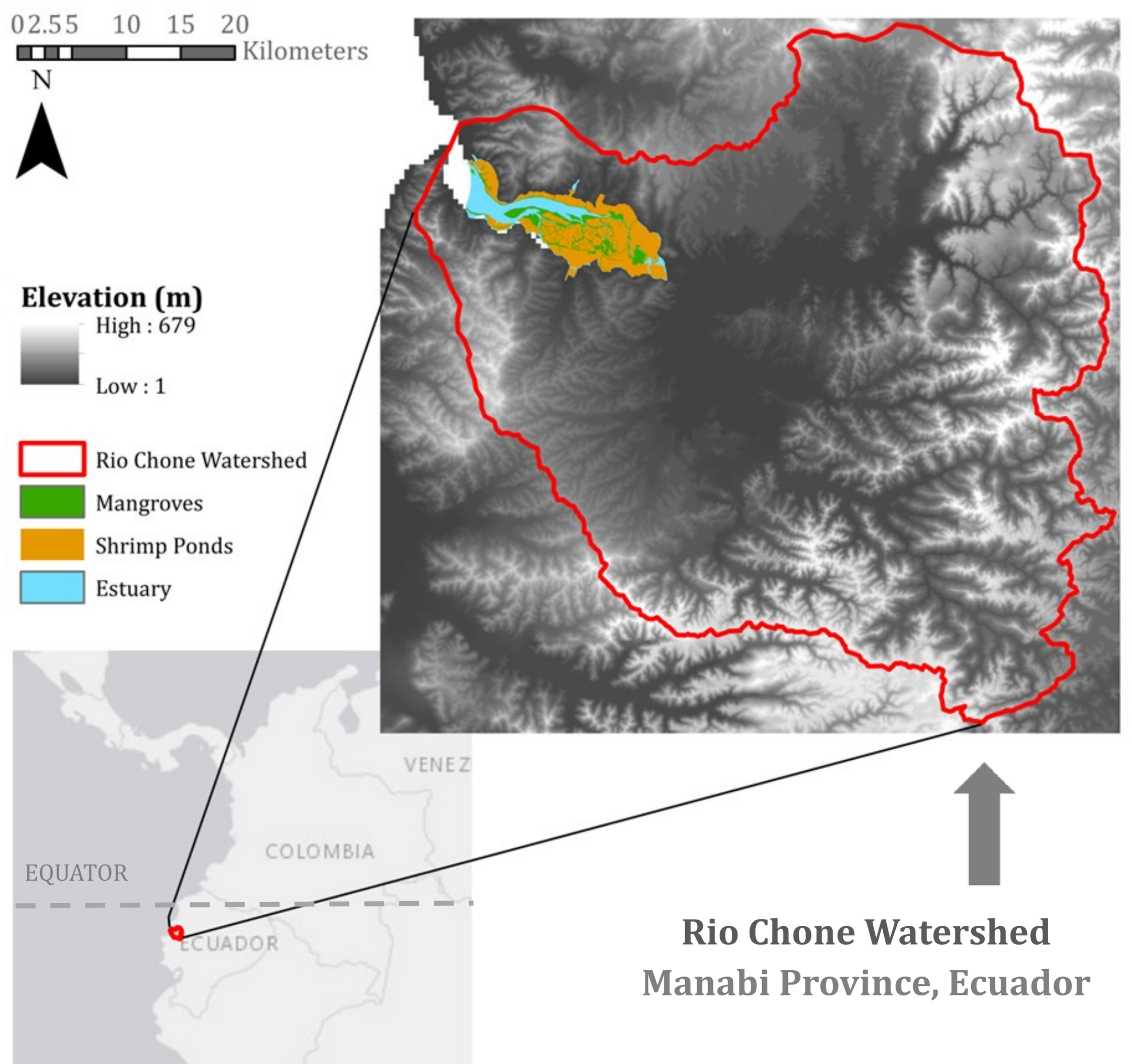
PROJECT INTRODUCTION

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 mangroves 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 estuarine ecosystems.



OBJECTIVE 1: *BATHYMETRIC MAPS*

To quantify sedimentation in the estuary, we compared depth measurements from bathymetric maps created in 1990 and 2011. Bathymetric maps were used to prove that sedimentation of the estuary is occurring, and to allow a crude rate of accretion to be calculated.

RESULTS

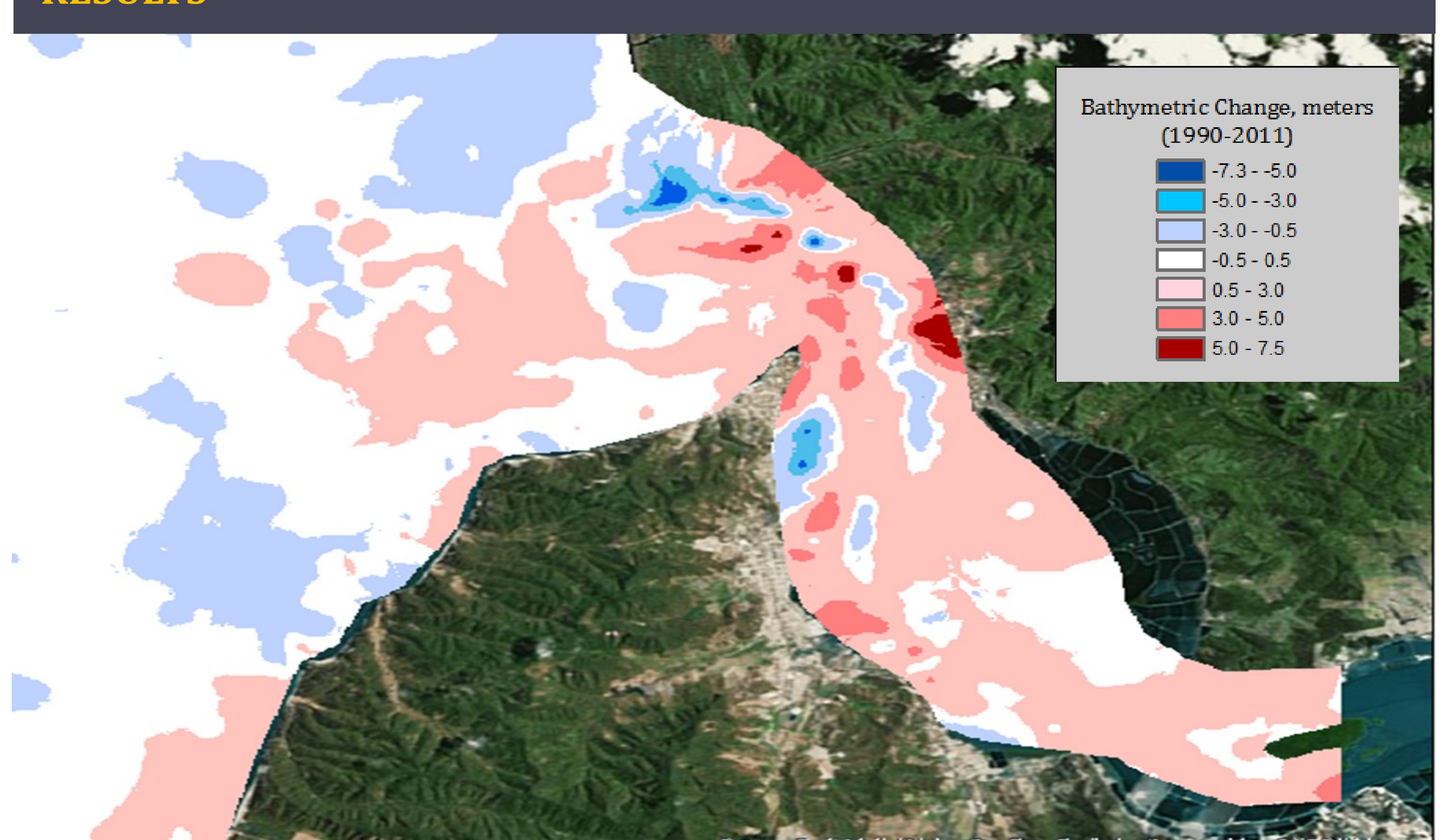



Photo courtesy of Steven Johnson

Accretion rate estimate:

2 million tonnes per year

PROJECT MOTIVATION : *Why is sedimentation a problem?*

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.

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

OBJECTIVE 2 : *SEDIMENT BUDGET*

Unpaved Roads → Streambanks → Sheetwash → * Animal Burrows → * Mass Wasting → * Threethrow → * Gullying → **Sediment Budget**

Relative contribution of each source

* = Relative size of contribution to overall sediment load found to be negligible, excluded from budget

RESULTS

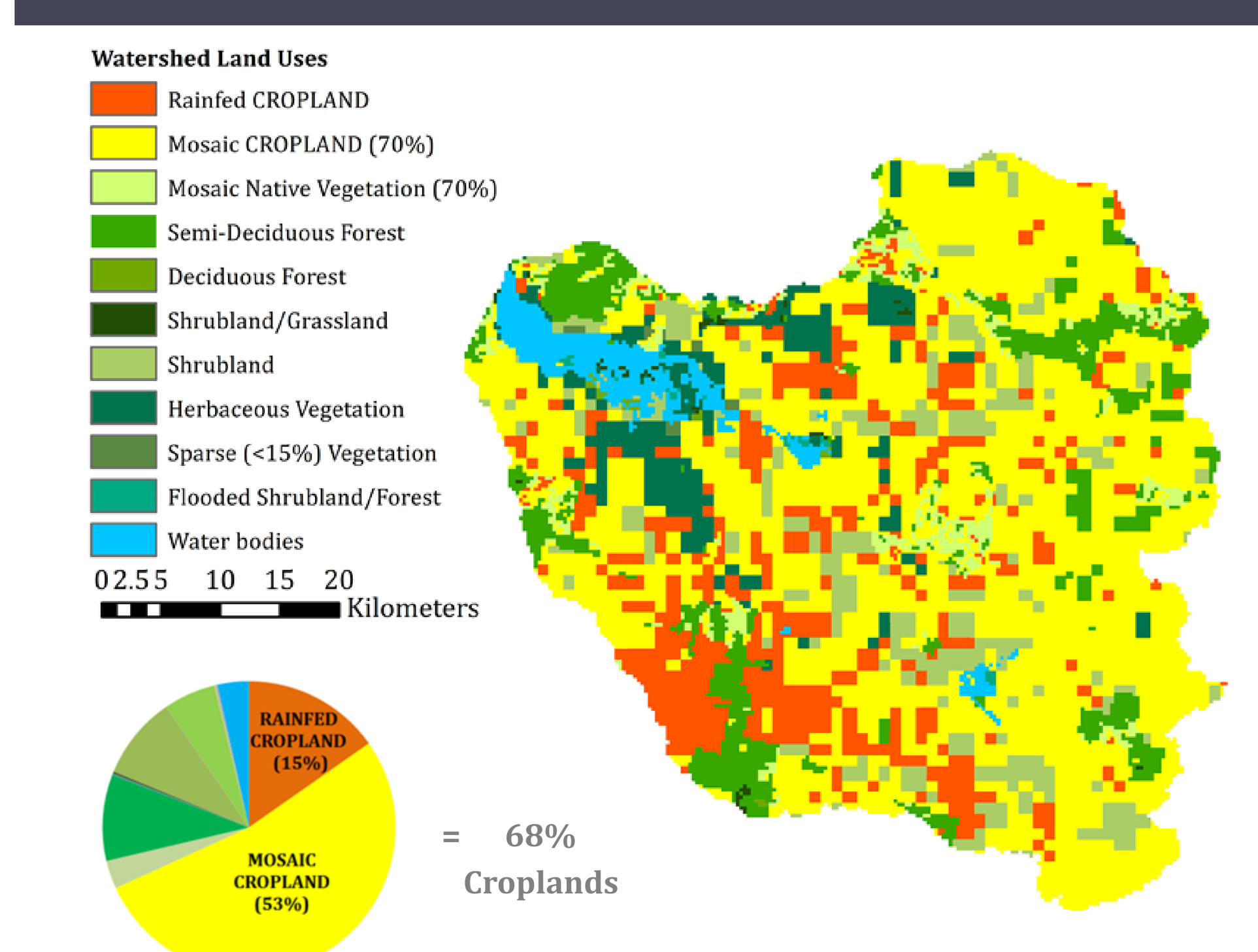
Erosional Process	Total Sediment Contribution (Million Tonnes/Year)
Streambank Erosion	0.02
Unpaved Roads	0.2—0.4
Sheetwash	50

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 being delivered to 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.

OBJECTIVE 3 : *MODELING SHEETWASH & EFFECTS OF LAND USE*

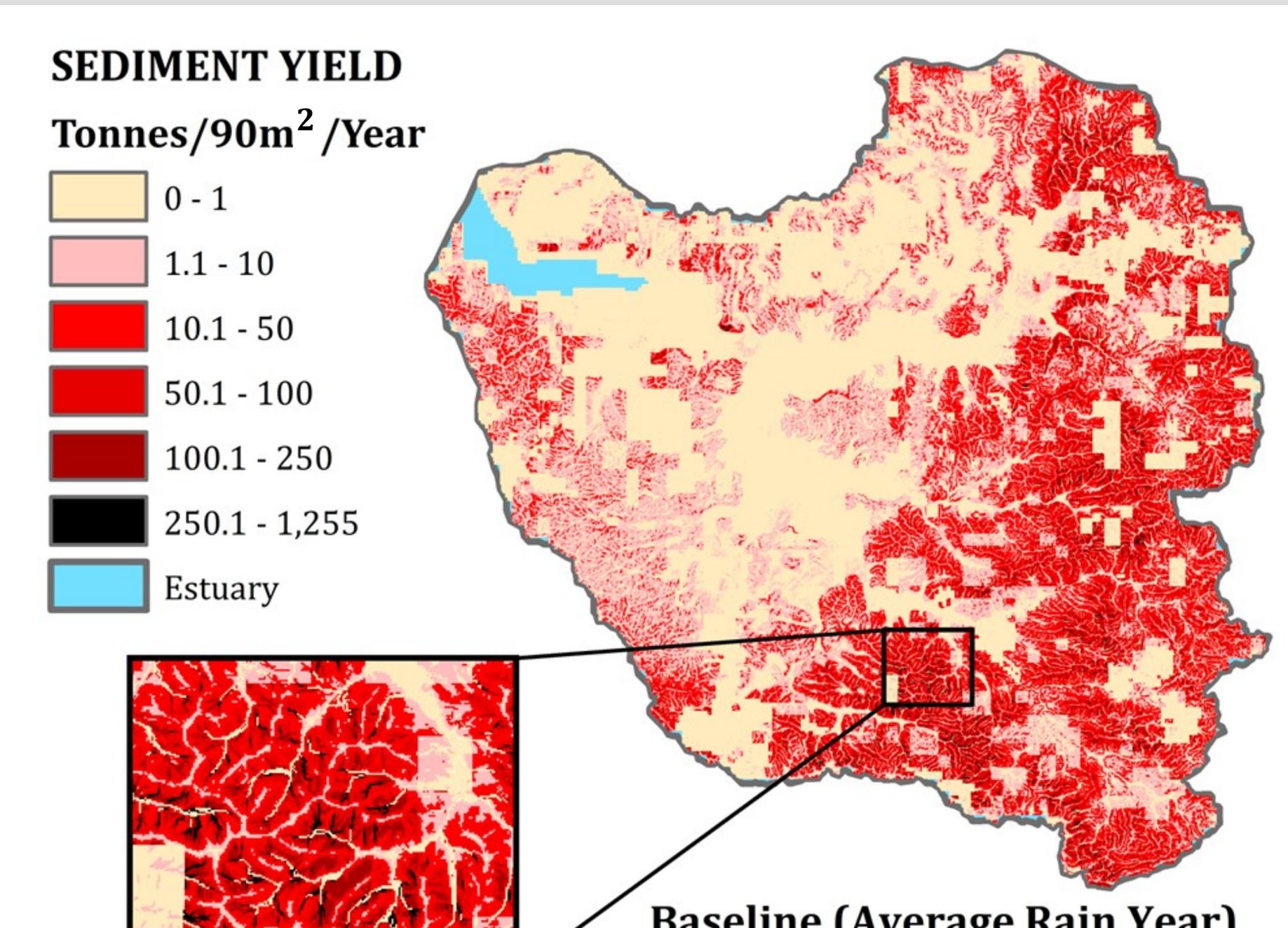


ENVIRONMENTAL MODELING

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



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

IMPLEMENTATION CONSIDERATIONS

Re-Vegetation


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

PROS:
- Long-term effect, one-time effort
- Carbon Sequestration
- Added biodiversity benefits

CONS:
- Opportunity cost
- $2.75/tree (per GSE)
- Erosion reduction timeline

Soil Conservation Techniques


http://ecorganicin.info/sites/ecorganicinfo/files/u257/

PROS:
- Immediate implementation
- Income/sustenance from farming maintained
- Mulching is viable in Manabi

CONS:
- Requires educational out reach
- Cost of mulching
- Low incentives without property rights

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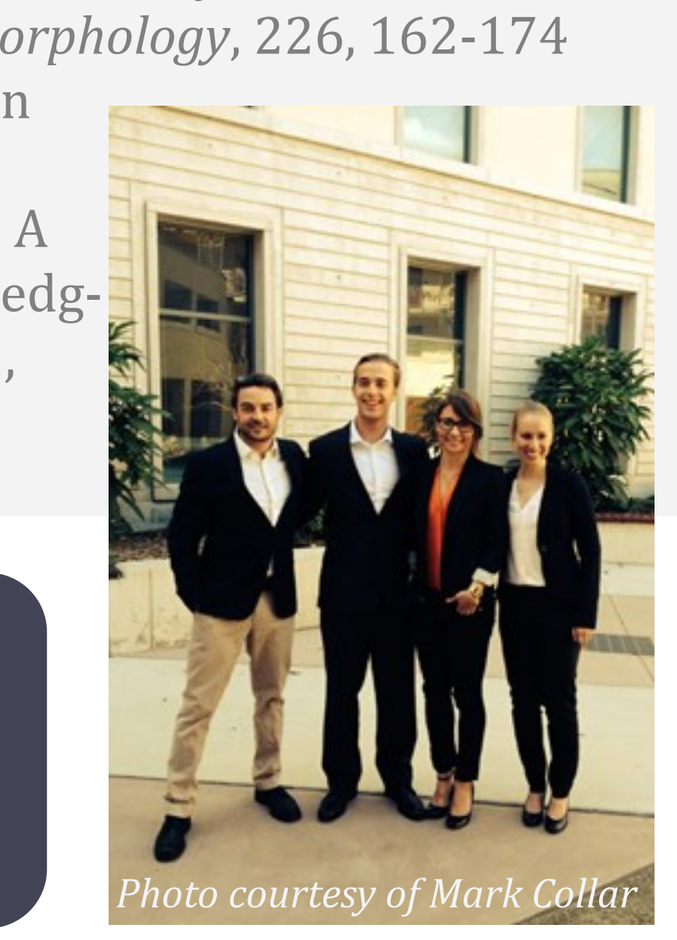
Photo courtesy of Mark Collar