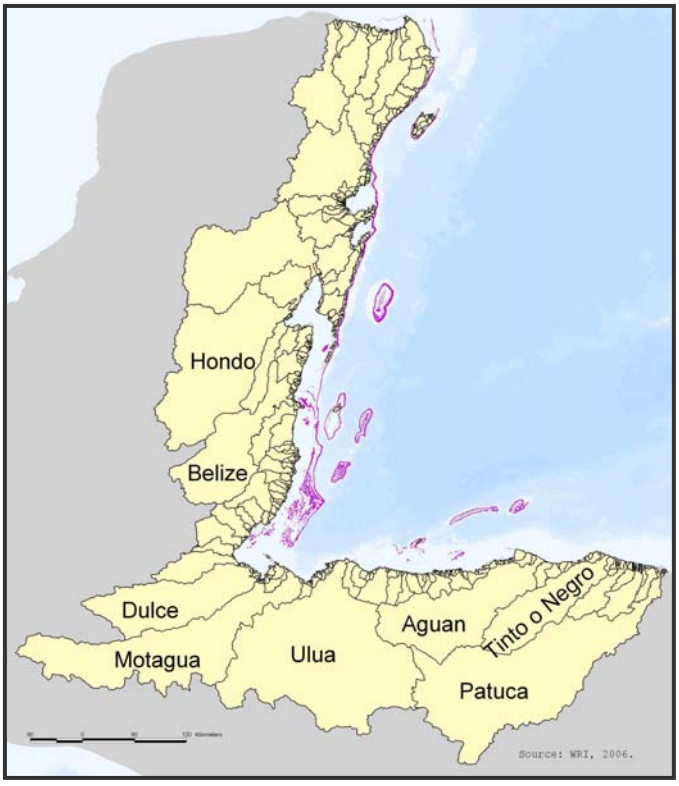
Watershed Analysis for the Mesoamerican Reef

Project Overview

This document provides a brief overview of a hydrologic analysis implemented by the World Resources Institute (WRI) as part of the International Coral Reef Action Network (ICRAN) Mesoamerican Reef (MAR) partnership. The objective of the analysis was to quantify the impact of human alteration of the landscape on land-based threats to the MAR to inform land-use planning, agricultural policy and practice, conservation priority setting, and coastal threat mitigation efforts.

Over a two year period, WRI collaborated with many partners in the region to evaluate sediment and nutrients coming from land in over 400 watersheds that discharge along the MAR. The analysis evaluates the amount of sediment and nutrients (nitrogen and phosphorous) coming from each plot of land; the amount of eroded sediment and nutrients reaching the river mouth (coastal discharge point); and the amount of sediment reaching the reef.



In addition, the analysis provides estimates of the increase in sediment and nutrient delivery resulting from human activities, and predictions of future sediment and nutrient delivery (in 2025) given varying land-use scenarios. This analysis is the first of this scope and level of detail for the MAR region.

The results provide a preliminary overview of regional patterns of sediment and nutrient runoff and delivery, and indicate how human alteration of the landscape can influence these patterns.

To ensure that the project's results and analytical methods support action in the region, WRI makes the underlying data, analytical method, and modeling tools publicly available, and has conducted training sessions with users in the region. Based on this training, regional users can implement more detailed, focused analyses for smaller areas, calibrating them to local conditions.

All data used in the analysis and all model results, accompanied by metadata, are provided on the data CD, *Watershed Analysis for the Mesoamerican Reef*, WRI/ICRAN MAR project, 2006. The data CD provides a summary report in English and Spanish describing the analysis method and results, as well as digital maps of key results.

Project Background

Shared by Mexico, Belize, Guatemala, and Honduras, the Mesoamerican Reef (MAR), stretches over 1,000 km, and is the largest continuous reef in the Western Hemisphere. Alteration of the natural landscape for development, road construction, or agriculture can have adverse impacts on coral reefs through increased delivery of sediment, nutrients, and other pollutants to coastal waters. Threats from land clearing are higher in areas of steep slope, intense precipitation, and more erodible soils.

Appropriate land-use practices in erosion-prone areas are essential for watershed management to minimize the transport of sediment, nutrients, and other pollutants to coral reefs. In the Mesoamerican region, over 300,000 hectares of land is allocated to banana, oil palm, sugar cane, citrus, and pineapple crop production. Eroded sediments and fertilizer and pesticide residues used by farms drain through rivers and streams and enter coastal waters along the Mesoamerican reef.

Source: Sylvia Marin, WWF

As part of the ICRAN MAR project, the **World Resources Institute (WRI)** partnered with **UNEP-World Conservation Monitoring Centre (WCMC)** and the **World Wildlife Fund (WWF)** to provide comprehensive watershed analysis to complement the ICRAN MAR project's activities on Sustainable Fisheries and Sustainable Tourism.

The ICRAN MAR watershed analysis was developed to produce information and tools for examining the potential impact of different land use and development options in the region and the associated impacts on water quality on the MAR. The project objectives are to:

- Link patterns of land use within watersheds to the impacts at coral reefs, and identify reefs at greatest risk of degradation;
- Identify watersheds most vulnerable to erosion and those which contribute the most sediment and pollution to coastal waters;
- Adapt tools to forecast potential trends, evaluate different policy or development options, and facilitate improved land management within the region;
- Use the results of the models and diagnostic tools to help educate and encourage key stakeholders to adopt a suite of "better management practices" to reduce impacts on the coastal and marine resources.

Source: Lauretta Burke, WRI

The watershed project includes analytical components looking at land cover change and associated impacts on runoff, erosion, and sediment and pollutant delivery to and transport within coastal waters. It also includes on-the-ground activities with agricultural businesses to implement better management practices. Many local partners were consulted on modeling methods, for data input and evaluation, and on agricultural management practices. Three ICRAN partners collaborated on this effort:

- *UNEP-WCMC* – developed land cover change scenarios and provided data sets as input to the hydrologic modeling;
- *WRI* – implemented the watershed delineation and hydrologic analysis for the MAR region, performed analysis of vulnerability to erosion, and coordinated the circulation modeling along the MAR;
- *WWF* – led the work with agri-business (banana, pineapple, citrus and sugar) to implement better management practices, focused on reducing the presence of pesticides in the MAR marine environment and controlling soil erosion from major commercial agricultural sectors.

Overview of the Methodology

In collaboration with partners in the MAR region, WRI:

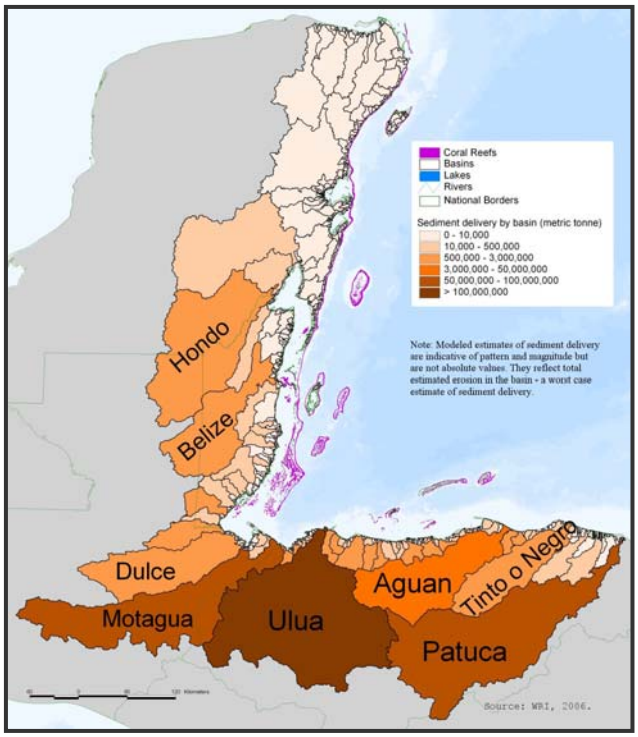
- Implemented a watershed delineation for all land areas draining along the Mesoamerican reef;
- Implemented a hydrologic analysis using the Nonpoint-Source Pollution and Erosion Comparison Tool (N-SPECT) model to examine sources of sediment and nutrients from this entire drainage area, as well as the delivery of sediment and nutrients to coastal waters;
- Applied this hydrologic analysis tool to examine sediment and nutrient delivery for several land cover scenarios (current land cover, original or "natural" land cover, and three scenarios of land cover in 2025 – scenario data provided by UNEP-WCMC);
- Provided outputs of the hydrologic analysis as inputs to a circulation model implemented by the University of Miami to examine sediment transport along the MAR; and
- Collaborated with partners on calibration and validation of model results.

Key Findings

This hydrologic analysis serves to integrate a wide range of data, and adapt modeling tools for an innovative, region-wide analysis for the MAR. The region-wide results should be considered preliminary and indicative of the overall pattern and magnitude of erosion and nutrient and sediment delivery across the region. An important aspect of the project is to provide these modeling tools to partners in the MAR region so that they might apply them at higher resolution to produce more detailed results for smaller areas within the MAR region. This approach will allow for refinement and better calibration of the model to local circumstances within the region.

The origin of sediments and nutrients reaching the MAR:

- Of the 400 watersheds in the MAR region, the Ulua watershed in Honduras was found to be the largest contributor of sediment, nitrogen, and phosphorous. Other large rivers found to be significant contributors of sediment and nutrients are the Patuca (in Honduras), Motagua (in Guatemala and Honduras), Aguan (in Honduras), Dulce (in Guatemala), Belize River (in Belize), and Tinto o Negro (in Honduras).



The origin of sediments and nutrients reaching the MAR:

- Most of the sediment and nutrients delivered by watersheds along the MAR originate in Honduras. It is estimated that over 80% of sediment and over half of all nutrients (both nitrogen and phosphorous) originate in Honduras.

- Guatemala was identified as a source of about one-sixth of all sediments and about one-quarter of all nitrogen and phosphorous entering coastal waters along the MAR.

- The modeling suggests that compared to the other countries, relatively minor percentages of the regional sediment load come from Belize and Mexico. Belize contributes between 10-15% of nutrients and Mexico is estimated to contribute about 5%of the nutrients from all modeled watersheds. The estimate for Mexico is probably an underestimate, as the contribution of underground rivers is not included in this analysis.

Runoff, erosion, and nutrient delivery to coastal waters are increasing:

- As a result of human alteration of the landscape, runoff and associated river discharge at river mouths has nearly doubled; sediment delivery at river mouths has increased by a factor of 20; nitrogen delivery has increased by a factor of 3, and phosphorous delivery by a factor of 7. (Ratios are based on model results for current (2003/04) land cover and on hypothetical natural (unaltered) land cover.)

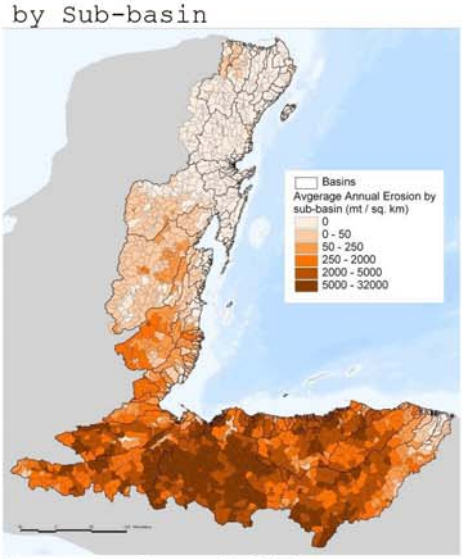
The potential impacts of development and land-use paths are varied:

- Under land-use scenarios which favor free markets and little policy regarding the environment, nutrient delivery is likely to increase by about 10% by 2025, while sediment delivery might increase by 13% or more.

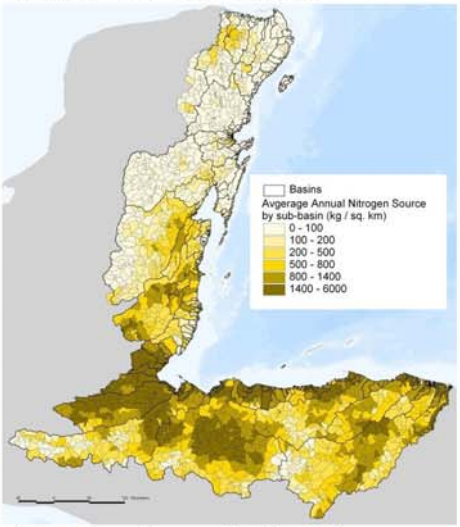
- If environmental policies that favor sustainable development are implemented, nutrient and sediment delivery are likely to be reduced by at least 5% from current levels, fostering recovery of degraded corals.

- Implementation of better agricultural management practices will yield additional reductions in sediment and nutrient delivery beyond those evaluated in this study, which has focused on the effect of changes in land cover.

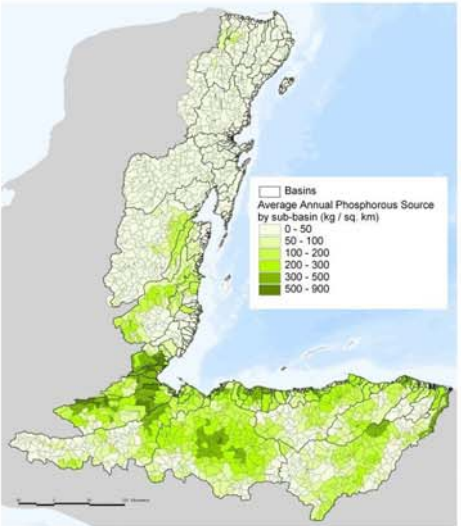
Average Annual Soil Erosion by Sub-basin



Average Annual Nitrogen Source by Sub-basin



Average Annual Phosphorous Source by Sub-basin

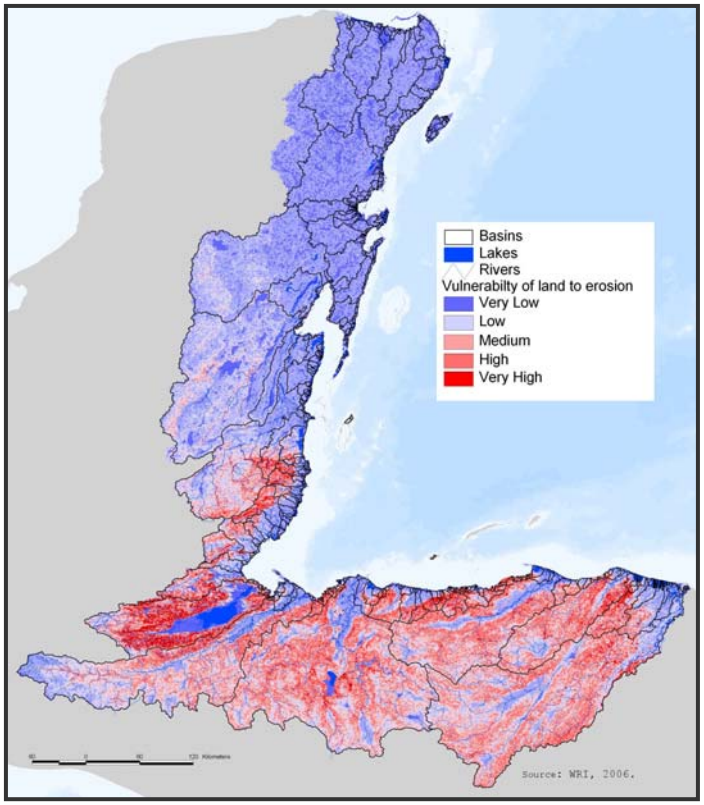


Source: WRI, 2006.

Conclusion from the Analysis

Policy action is needed to address the contributions from agricultural lands.
Most of the sediment and nutrients delivered to the MAR from watersheds in the region come from agricultural lands in Honduras and Guatemala. The contributions of Belize and Mexico are substantially less, but still pose a threat along their coasts. Promising initiatives to decrease pollution within the region are underway, including: sustainable forestry management and integrated watershed management in Guatemala; improved land use planning, reforestation and soil conservation programs in Honduras; and similar initiatives in Belize and Mexico. These important efforts need public support, recognition, and continued investment.

Results can help identify areas in need of better agricultural management.
This analysis identified vulnerable areas where conversion to an erosive land use should be avoided, or where converted conservation practices should be implemented. It also identified areas with high erosion and nutrient runoff, where better agricultural management practices should be targeted.



Policies that support sustainable development can reduce sediment and nutrient delivery.
As evidenced by our findings, land-use planning, integrated watershed management, and other policies that support sustainable development can help to lessen erosion and pollution runoff, thereby decreasing sediment and nutrients reaching the MAR.

More detailed modeling is needed to create more accurate information at higher resolutions.
Regional-scale analyses are useful for providing an overview and for prioritizing areas in which action is needed. However, local analyses provide more detailed and accurate information that policymakers need in order to target their interventions. The tools provided on the data CD, *Watershed Analysis for the Mesoamerican Reef* (WRI/ICRAN MAR project, 2006), allow users to perform more detailed analyses of sediment and nutrient delivery within smaller areas in the MAR region, such as at the watershed level.

More specifically, the model can be applied to individual watersheds or groups of watersheds using data provided or with the user's own data. More detailed local modeling will improve the accuracy of the results, by using higher resolution data on slopes and land cover, and by calibrating the model to local soils and precipitation regimes.

It would be valuable to extend the current analysis to include the effect of improved agricultural management practices on erosion and pollutant runoff. Such an extension would require detailed information on how each practice influences erosion rates and pollutant runoff. Once such information is available, it should be possible to use the model to evaluate reductions by treating each management intervention on each land cover type as a unique category with specific erosion and pollutant runoff

characteristics. For example, citrus groves with cover crops planted to reduce erosion might be treated as a separate category.

Analyses such as these can help to evaluate progress in reducing land-based sources of threat. A number of national initiatives, as well as donor-funded regional initiatives, seek to reduce or mitigate threats to the MAR. This analysis can help these initiatives to estimate their progress by giving them the information they need to ensure they are moving in the right direction.

Transnational natural resource management can be strongly supported by analyses such as these. To mitigate and reduce the land-based threats to the MAR, constructive regional cooperation among a variety of stakeholders is necessary. Examples include the multilateral cooperation agreements among the four countries involved in this analysis, and agreements between the agriculture and tourism sectors and civil society groups. This tool works across borders and sectors, creating information that allows productive discussion on threat origins and potential mitigation measures.

By sponsoring technical trainings (see right) and other activities, the International Coral Reef Action Network (ICRAN) collaboration will continue to support the application of analysis results and modeling tools in the region. For information on future ICRAN activities, visit **www.icran.org**.

The full paper and all high resolution maps are available on the CD, which is available through ICRAN MAR and WRI.

Source: ICRAN MAR

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