Assessment of investments in watershed restoration in the Guánica Bay / Rio Loco Watershed

EXECUTIVE SUMMARY

- Current management actions are targeting the most appropriate and cost effective land cover classes (i.e., agriculture and bare lands) for LBSP abatement within the Guánica watershed.
- Future restoration efforts should continue to make progress on other priority watershed restoration actions identified in the watershed management plan while also identifying opportunities to provide interagency support to improve Clean Water Act enforcement and prevention of future LBSP threats.
- The OpenNSPECT model can begin to provide insight into the effectiveness of watershed restoration practices; however, in situ monitoring will be key to evaluating the performance of management actions and informing adaptive management needs.

INTRODUCTION

In 2008 the Guánica Bay Watershed Management Plan (WMP) was developed to identify principle sources of pollution that threaten coral reef habitats in southwest Puerto Rico. GIS analysis, field investigations, and former research indicated that loss of highly erodible soils on steep slopes was a primary source of sediment loadings to Guánica Bay (Warne et al. 2005; CWP, 2008). Specifically, agriculture, bare lands, and reservoirs along the Rio Loco were identified as the principle contributors of erosion and sediment loadings in the watershed. From this information, a series of restoration techniques were identified to target these sources of pollution and reduce erosion and stabilize bare soil sediments the watershed; among which was the recommendation to utilize hydroseeding on highly erodible bare lands.

Over the past 3 years, NOAA's Restoration Center and their partners have leveraged over $250,000 to stabilize 20 acres of highly erodible lands (HELs) in the Guánica Watershed using hydroseeding. Funding was leveraged from NOAA's CRCP, USFWS, USDA, Puerto Rico's Department of Natural and Environmental Resources, National Fish and Wildlife Federation, Southwest soil conservation district, and local municipalities. In 2011, NOAA's Restoration Center and their partners developed a regionally adapted hydroseed (i.e., bermuda and rye seeds, hydromulch, and fertilizer) and tested its application and efficacy on stabilizing HELs in the Guánica Watershed. The hydroseeding proved to be highly effective with vegetation established within 5 days of application and an 80 to 95% plant survival rate. A recent study modeled the potential LBSP reductions associated with hydroseeding and found that sediment yields were reduced by greater than 80% (Figueroa-Sánchez et al., 2015). This equates to approximately 530 metric tons of sediment transport prevented per acre hydroseeded per year.

Although hydroseeding has proven successful at the project scale, questions remained regarding the efficacy of current watershed restoration efforts at the broader watershed scale. This study was conducted to provide an initial assessment of current investments in watershed restoration in the Guánica Bay / Rio Loco (GB/RL) watershed with a particular focus on hydroseeding. To do this, sediment loadings were quantified from each of the contributing land covers within the watershed to determine if current investments are targeting the principle sources of pollution and whether there are additional pollution sources that should be considered. This information was also used to evaluate opportunities to utilize this and other recent studies to establish targets for restoration. Ultimately, this study is intended to be used to inform the potential need for adaptive management.

METHODS

Sediment loadings were quantified for the GB/RL watershed using the Open-Source version of the Nonpoint Source Pollution and Erosion Comparison Tool (OpenNSPECT). OpenNSPECT examines the relationship between land cover, nonpoint sources of pollution, and erosion and it can be used with any watershed as long as the user has access to the required data (NOAA, 2014). To operate, OpenNSPECT requires the following spatial data: elevation, land cover, precipitation, soil, and pollutant coefficients associated with land classes. All datasets applied for this study had a 30 meter resolution; equating to a grid cell size of approximately 0.25 acres. Land cover classifications were based on 2001 imagery. As such, this data represents a snapshot in time, which limits the ability to accurately detect the acreage of bare land during the present date. For detailed information on OpenNSPECT calculations in the GB/RL watershed consult Figueroa-Sánchez et al., 2015.

Sediment loadings and areas, quantified through OpenNSPECT, were categorized and summed by NOAA Coastal Change Analysis Program's (C-CAPs) standard classification scheme (NOAA C-CAP, 2015). The individual land classes are grouped within the following general classifications: Unclassified, Developed Land, Agricultural Land, Forested Land, Scrub Land, Barren Land, Palustrine Wetlands, Estuarine Wetlands and Water and Submerged Lands. Sediment loadings and area were grouped by C-CAP land cover classifications using zonal statistics in ArcGIS. To simplify presentation of the data, NOAA C-CAP land cover classifications were further categorized by agriculture (cultivated land, pasture/hay), developed land (Developed, Low Intensity, Developed, Medium Intensity, Developed, Open Space, and Developed, High Intensity), and wetland (Water, Estuarine Forested Wetland, Palustrine Emergent Wetland, Unconsolidated Shore, Palustrine Forested Wetland). Bare Land, Grassland, and Evergreen Forest were not combined with other land cover classes.

OpenNSPECT, like all models, makes some assumptions and has some limitations. In this case, some of the major assumptions are:

1. This is a surface water flow model; there is no ground water tracking and no storm water diversions included. Water simply flows downhill.

2. Erosion modeled with the Universal Soil Loss Equation is sheet and rill erosion and does not account for mass land movement such as landslides.
3. There is no time-dependency in the model. As a result, processes such as downstream sediment redeposition or nutrient uptake are not simulated. Therefore, the actual values produced by OpenNSPECT are probably overestimates for what would be measured in the field for a receiving water body. They should be considered worst-case values.

That being said, OpenNSPECT's greatest strength is in comparisons between the effects of different land cover scenarios while holding all these assumptions constant. Therefore, looking at the relative differences between land cover classifications are assumed to be fairly accurate, even when care should be taken in the interpretation of empirical model outputs.

The data was analyzed to address three specific questions, including:

1- What land cover classes cover the greatest amount of area in the watershed?
2- What land cover classes are the principle sources of sediment loadings to Guánica Bay?
3- What land cover classes contribute the greatest sediment loads per area (aka sediment yields)?

Answers to these questions are then used to evaluate the efficacy of current watershed restoration efforts and the potential need for adaptive management.

RESULTS

The GB/RL watershed is dominated by evergreen forest (51%) and grassland (26%); these two land covers combined encompass nearly 70,000 acres of the total watershed area (Figure 1). The remainder of the watershed area was split between agricultural (e.g., cultivated land, pasture/hay), scrub/shrub habitat, developed land, wetland, and bare land classes. Agriculture, particularly cultivated land, and bare land are associated with land disturbances that have been identified as important contributors of sediment loadings in GB/RL watershed (CWP, 2008). Agriculture and bare land encompass 8,079 acres and 58 acres of the RL/GB watershed, respectively.

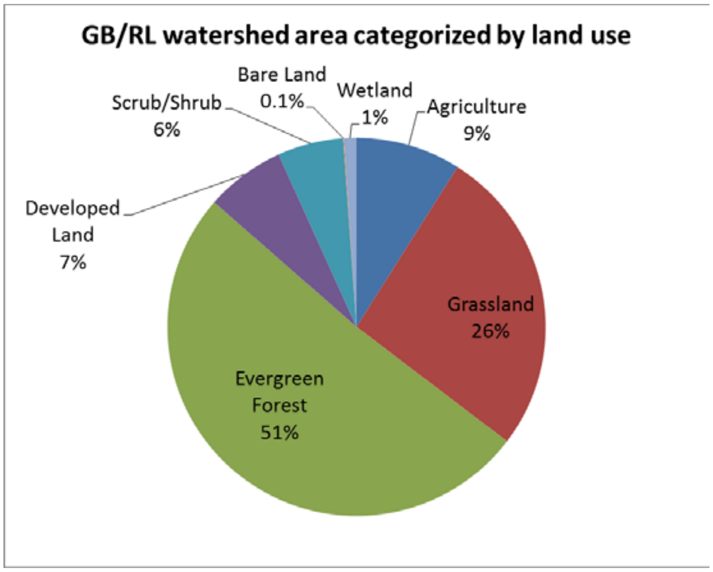

Figure 1. Watershed area categorized by land use and described as a percentage of the total area. The total watershed is 90,022 acres.

Grassland and agriculture are the greatest contributors of sediment loadings to the watershed; contributing over 66 million metric tons of sediment annually equating to over 89% of total watershed sediment loads (Figure 2). Evergreen forest, developed land, scrub/shrub, bareland, and wetland provide the remaining 10.4% of the sediment loads in the watershed. Surprisingly, bare land only contributes 0.2 percent of total watershed sediment loads.

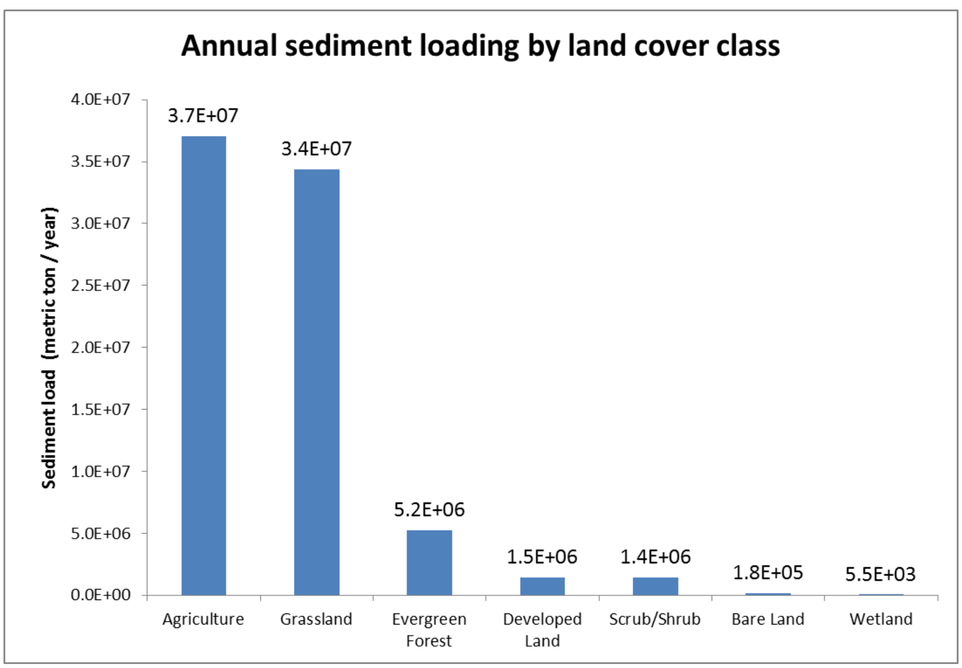

Figure 2. Total annual sediment load contributions by land cover classification. Estimates are provided in units of metric tons per year.

However, when sediment loads are converted to yields, by standardizing loads by area, agriculture and bare lands are the largest contributors of sediment yields. On average, agriculture and bare lands contribute over 4,500 and 3,000 metric tons of sediment per acre per year, respectively. These sediment yields were over twice that estimated for grassland. Remaining land cover classes, developed land, scrub/shrub, evergreen forest, wetland, contributed significantly less annual sediment yields.

Table 3. Mean annual sediment load per area for each land cover classification. Units are provided in metric tons per acre.

Land cover classification	Sediment Yield (Metric tons/acre/year)
Agriculture	4589
Bare Land	3169
Grassland	1448
Developed Land	237
Scrub/Shrub	280
Evergreen Forest	114
Wetland	6

MANAGEMENT IMPLICATIONS

Since 2010, NOAA has provided $1,246,000 to abate land-based sources of pollution in the Guánica watershed. This funding has been matched with an additional $5.4 million (direct and in-kind) from USDA NRCS, USFWS, EPA, NFWF, local municipalities, and grantee match. The majority of this funding has gone to support watershed restoration efforts on private farms and bare lands. This study indicates that agriculture and bare land are the primary sources of sediment yields in the GB/RL watershed. Assuming costs for watershed restoration are relatively equivalent across the watershed, watershed restoration investments that target agriculture and bare land would be the most cost effective approach to reducing sediment loadings to Guánica Bay. That being said, grassland is the third largest contributor to sediment yields and the second greatest contributor to sediment loads to Guánica Bay. Therefore, it would be beneficial to further evaluate this land cover classification to determine if there are activities contributing to these sediment loads and, if so, inform additional management needs.

The development of watershed restoration targets and performance metrics could greatly enhance our ability to evaluate and convey watershed restoration success. This and other reports can provide initial insight into how we could potentially establish targets for watershed restoration, provide metrics of success, and evaluate the cost effectiveness of watershed restoration practices. For example, the data suggest that there are only 58 acres of bareland in the GB/RL watershed. This bareland could easily be stabilized using hydroseeding at roughly $10,000 an acre, or a total of $580,000 to stabilize all bareland in the watershed. Furthermore, previous studies indicate that hydroseeding will prevent up to 530 metric tons of sediment transport per acre hydroseeded per year, which equates to 30,740 metric tons per year for 58 acres of bare land hydroseeded. This information could then be converted to cost per metric ton of sediment prevented to provide a metric for comparing cost effectiveness or watershed restoration practices across the watershed.

However, it is important to understand the limitations of OpenNSPECT, and modeling in general, when using this information to establish targets and define metrics for evaluating the success watershed restoration efforts. Specifically, LBSP threats are closely linked to land-based activities and are dynamic through time, but models only provide a 'snapshot in time'. Therefore, the information in this report can be used to generally guide management targets with the recognition that improved enforcement, education, and outreach will be key to preventing the creation of new LBSP threats and ultimately abating LBSP long-term. In addition, the information provided in this report has not been calibrated to the region; therefore, there is a need for in situ monitoring to refine estimates of watershed sediment loads and quantify the benefits of watershed restoration techniques.

In summary, this study found that current management actions are targeting the most appropriate and cost effective land cover classes for LBSP abatement. Future restoration efforts should continue to make progress on other priority watershed restoration actions identified in the watershed management plan. Most notably, restoration of the Guánica lagoon to restore historic hydrology and watershed detention times and evaluation of potential sediment contributions from the artificial reservoirs within the watershed. In addition, given that LBSP is intricately linked to communities and their land-based activities, future LBSP management efforts should work towards improving Clean Water Act enforcement and prevention of future LBSP threats. Lastly, in situ monitoring should be built into watershed restoration efforts to provide a means for evaluating the performance of management actions and informing adaptive management needs.

LITERATURE CITED

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