Sediment Pollutes!

Modeling sediment inputs into Maunalua Bay.

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Sediment in Maunalua Bay

Mālama Maunalua identified polluted runoff and sediment as the number one threat to Maunalua Bay (Mālama Maunalua 2009). Sediment negatively impacts coral reefs by decreasing light availability, covering and smothering, and altering habitats (Rogers 2009). Rain runoff transports sediment into streams and into the bay (Delwyn 2003). Permeable surfaces such as areas covered in vegetation absorb water, unlike impermeable surfaces such as concrete roads that do not reduce the amount of water flowing to the streams (Delwyn 2003).

It is projected that residential population will expand by 1,600 around 2020, then decrease, while overall housing units will increase (Figure 1). East Honolulu is near building capacity, therefore most new homes will result from infill and redevelopment (Stanfield, per. commun). More housing units usually results in more impermeable surfaces, therefore, it is important to mitigate sediment exports into the bay.

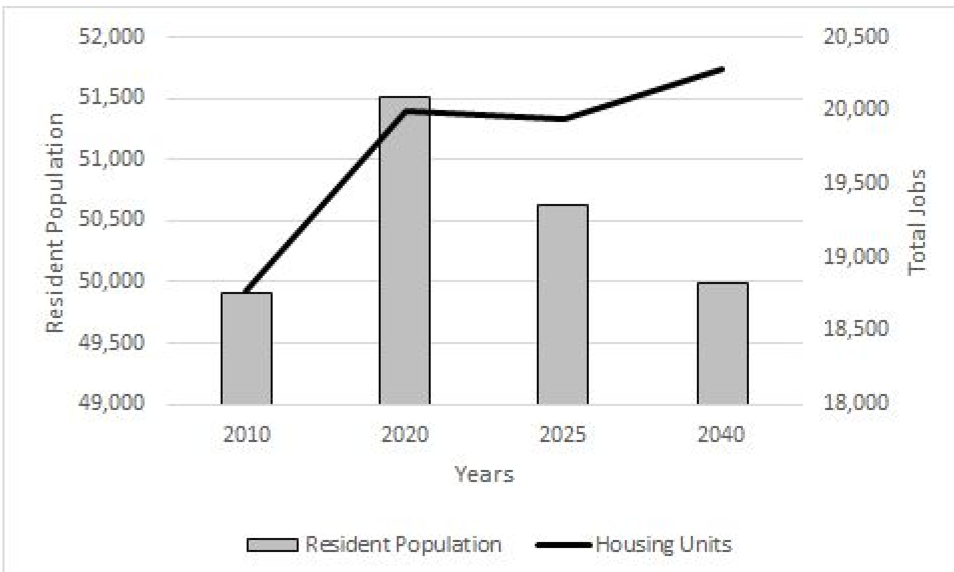


Figure 1: Projected trends for residents, housing units, and jobs in East Honolulu (Honolulu 2014).

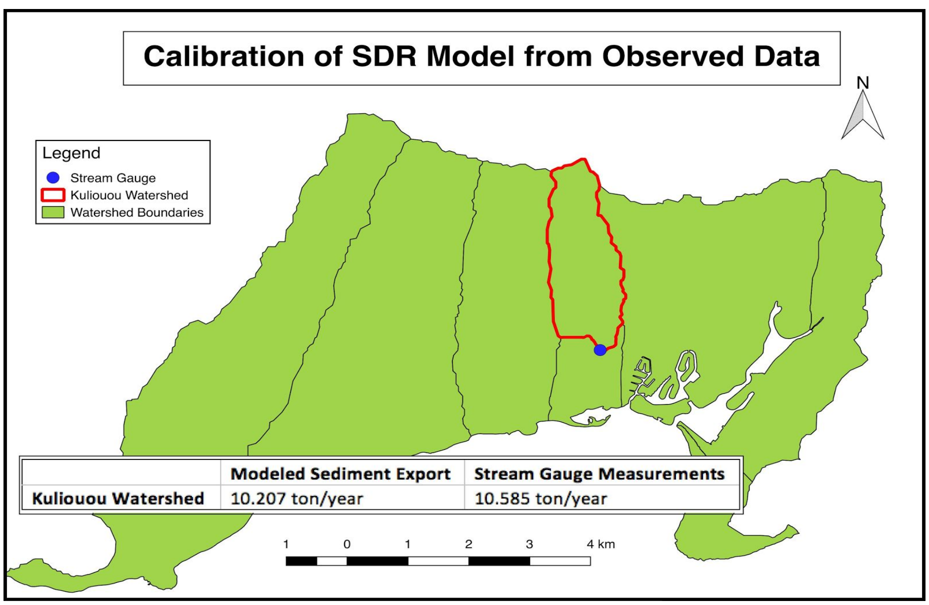
Mālama Maunalua reached out to the Natural Resources and Environmental Management program at the University of Hawaiʻi at Mānoa to investigate topics that affect Maunalua bay. Mālama Maunalua designated four main topics of interests including: water quality, economics, fisheries, invasive algae, and sediment levels. Our project focuses on how sediment carried by runoff is transported into the bay. Using a computer simulation, we predict from which watersheds and main areas within Maunalua Bay export the greatest amount of sediment. Also, we review some options for homeowners and communities to mitigate the amount of sediment reaching the streams.

What did we do?

To create effective management solutions for sediment pollution in the bay, we modeled the current sediment exports using the InVEST Sediment Delivery Model (SDR). Models are a computer simulation that makes predictions about how different events occur in nature. For our study, we used the InVEST SDR model to map sediment delivery into the bay. The model produces a simplification of reality to gain insights into sediment dynamics within the bay.

The SDR model uses the Universal Soil Loss Equation (USLE) created by the United States Department of Agriculture (USDA) and the National Resource Conservation Service to make predictions about sediment erosion and transport. This equation combines the following factors: rainfall, sediment properties, terrain slope, land cover, and land management practices. These factors are fed into the model using data, or layers from Geographic Information Systems (GIS) technology. GIS uses these layers to represent information spatially, or as a map that illustrates key information. We acquired various GIS layers from organizations such as the National Oceanic and Atmospheric Administration (NOAA), the Coastal Services Center (CSC), the Soil Survey Geographic database (SSURGO), Rainfall Atlas of Hawaiʻi, and the Hawaiʻi Statewide GIS Program. By combining these GIS layers into the InVEST SDR model, we were able to simulate how sediment is transported into the bay.

Since the InVEST model can only simulate scenarios in nature, it is important to use field collected data to compare it to, or validate it. Also, it is important to use field data to calibrate the model, which creates a relative real life situation for the model to simulate from. We accomplished this by using field data from Kewalo Marine Laboratory and United States Geological Survey. By modifying our simulation results to real life data, we made model predictions with over 96% accuracy (Figure 2).



	Modeled Sediment Export	Stream Gauge Measurements
Kuliouou Watershed	10.207 ton/year	10.585 ton/year

Figure 2. Calibration of Sediment Delivery (SDR) Model from USGS stream gauge data. Includes outputs in tons/year for Kuliouou watershed from our model and a Kuliouou stream gauge.

What did we find?

We found that the Waialaenui and Wailupe watersheds export the most sediment to the bay (Figure 3). One possible explanation for these results is the fact that Waialaenui and Wailupe have the highest populations than any other watershed (Figure 4). Another possible explanation could be the ratio of population to area of the watershed, in which Waialaenui and Wailupe are twice as high than many other watersheds (Figure 5).

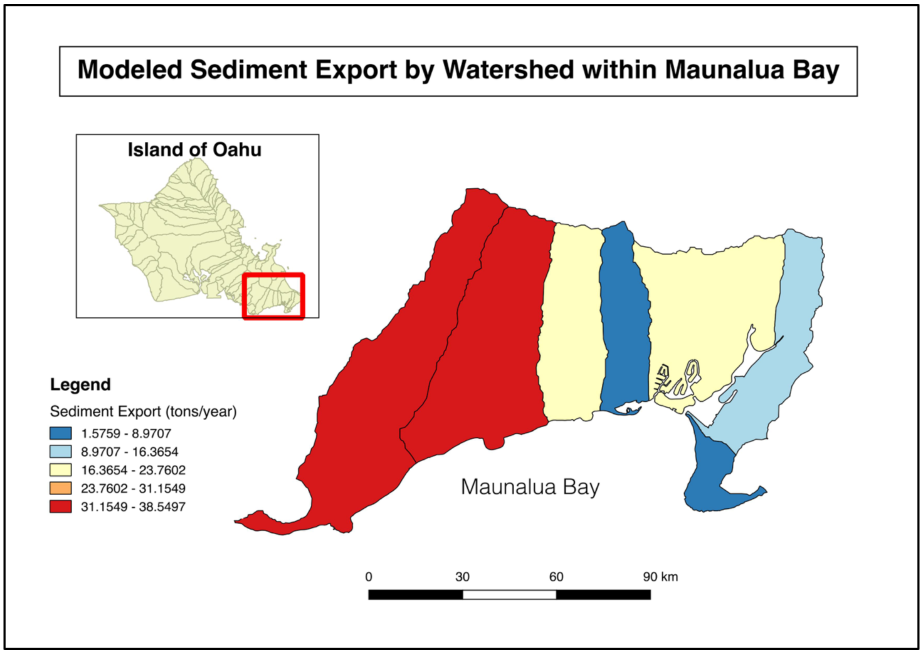


Figure 3. Modeled sediment export by watershed within Maunalua Bay.

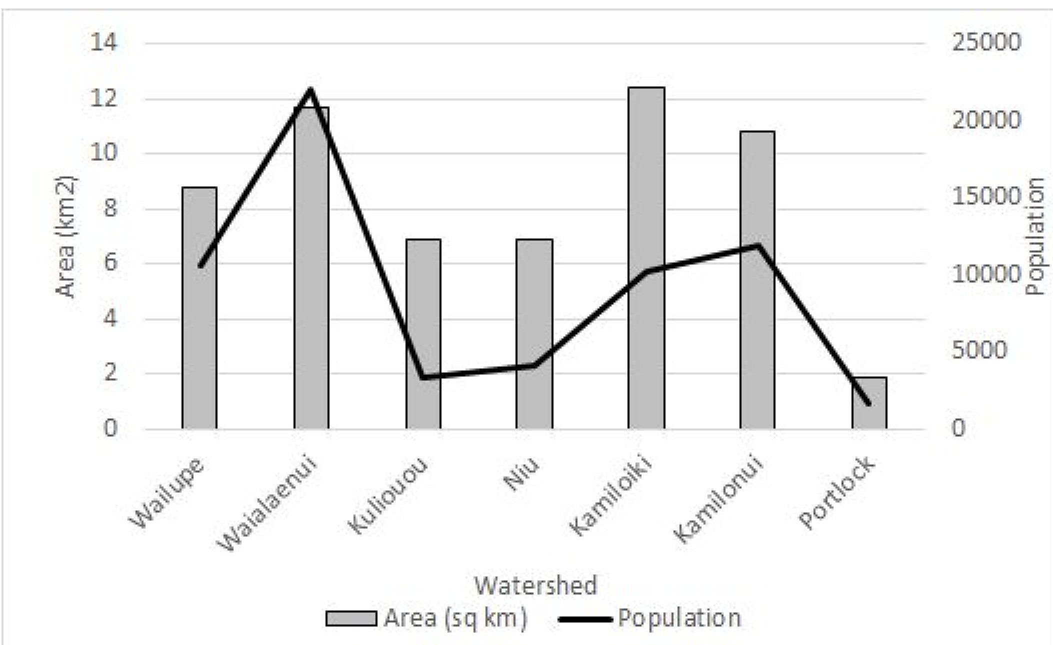


Figure 4: Area and population size of each watershed (CRAMP 2011).

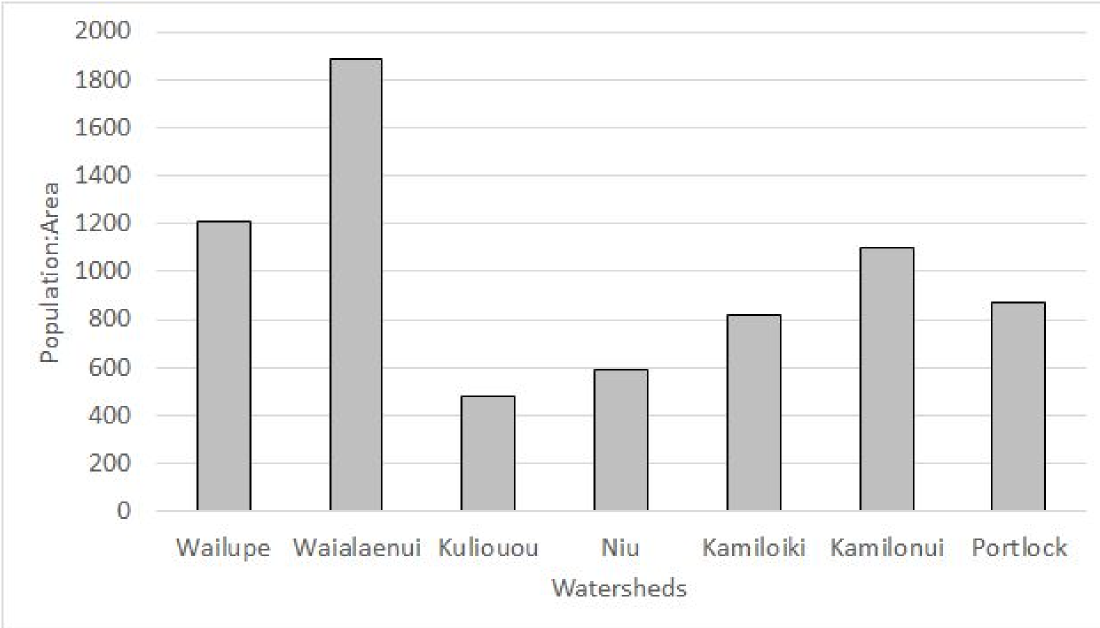


Figure 5: Ratio of total population to total area of each watershed (CRAMP 2011).

Out of 12 land types, the three main types that have the highest contribution to sediment export are upslope conservation areas, urban areas and cultivated/agriculture/farming area (Figure 6). The conservation lands are the largest contributors of sediment for two reasons: first, the upslope terrain is extremely steep and second, these areas receive more frequent and more intense rainfall than the lower elevation areas. This is classified as a natural source of sediment export, and thus it is important that this land remains conservation land.The second and third sources of sediment are coming from anthropogenic, or man made sources include the valley and ridge neighborhoods and cultivated lands within the Maunalua Bay watersheds. Valley and ridge neighborhoods cause moderate levels of sediment erosion and transport over large areas because of increased area of impervious surfaces (which increase the amount and rate of storm runoff) combined with sloped areas and increased sediment exposure (i.e., construction, poorly-designed development, trails, and gardens). Cultivated or farmed lands cause high levels of sediment erosion and transport in localized areas due to large areas of tilling and sediment exposure.

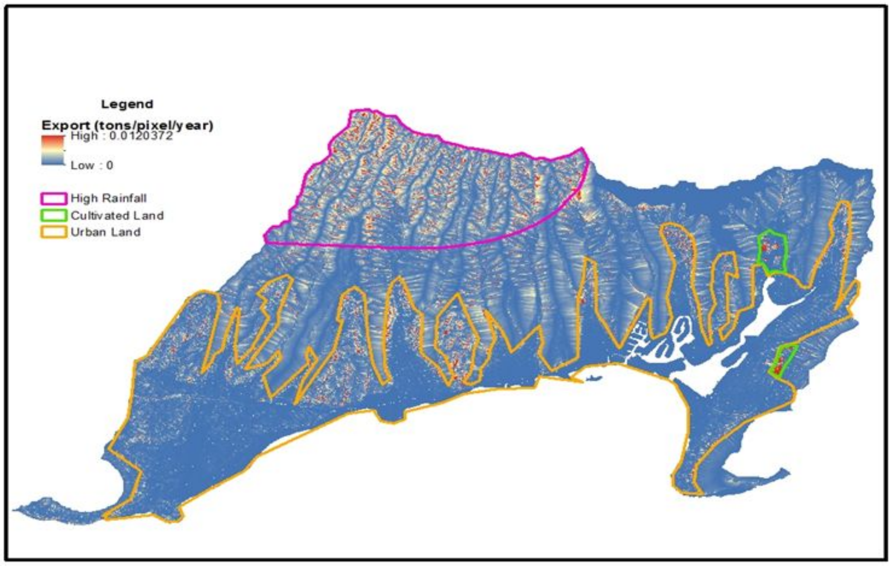


Figure 6. Modeled sediment export by land use type within Maunalua Bay.

Take Home Message and Suggestions

We suggest that sediment reduction activities focus first on the Waialaenui and Wailupe watersheds as this will have the most drastic effect on sediment loads in Maunalua Bay. Additionally, natural and human-caused sources of sediment export should be managed separately as they contribute differently to the problem. Conservation land can be protected and managed to control contributions factors such as deforestation, ungulates, and invasive plant species, while urban and cultivated land should be managed to mitigate sediment runoff.

There are several mitigation strategies that can reduce the amount of sediment entering the bay. One option for homeowners includes rain barrels which collect water from roofs to be stored for later use (EPA 2017). Rain barrels helps slow runoff into streams, and the water can be used for outdoor watering during dryer periods (EPA 2017). Another option is to build rain garden which are are small, native plant gardens lined with gravel or stones that are engineered to collect and slowly drain stormwater (EPA 2017). As the gardens collect water, they filter out sediment and various pollutants naturally and also create habitat for bees and butterflies. The gardens are an aesthetic solution to collect sediment and slow or absorb runoff (EPA 2017). Public facilities are another great location for rain barrels and gardens such as schools, parks, or churches. Additional activities include planting trees and native plants, especially around streams.

For areas that have high erosion, such as cultivated areas or recently disturbed sites, biodegradable water absorbent mats or large ropes can be used to line channelized streams (Broda 2017). These ropes can act as mini dams, slowing runoff and collecting sediment. They can also have grass seed added, allowing grass to grow and further slowing runoff (Broda 2017). Once runoff reaches channelized streams, barriers within streams channels, such as boulders or large concrete objects, can slow water velocity and collect sediment (Broda 2017).

As impermeable surfaces contribute to runoff, one way to limit runoff increase is to limit increase of impermeable surfaces, and thus urbanization, in the watershed (Delwyn 2003). Maunalua Bay Watershed has been extensively urbanized with densely packed houses, shopping units, and impervious surfaces. Residents and planners can be mindful of potential zoning changes in the future that may increase impermeable surfaces such as roads, rooftops, and concrete.

Future Studies

Completing our sediment modeling project was extremely insightful and there is still so much more to learn. There is a lot of potential for models to simulate real-life scenarios and provide useful information to organizations such as Mālama Maunalua. We suggest continuing research on the use of models in sediment export in the bay, and exploring the effectiveness and differences of models other than InVEST. Additionally, there is a need to use long term data to model the effects of sediment mitigation techniques.

For more information and access to raw data, please visit: https://scholarspace.manoa.hawaii.edu/handle/10125/44553

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