From ridge to reef: Forecasting the effects of changing Pacific islands on reef ecosystems

Summary: In response to concerns about the health of coral reefs and terrestrial communities, USGS science is linking impacts on watersheds from invasive species, landuse transformations, and climate change to declines in reef ecosystems using mapping, monitoring and models. This work requires an improved understanding of watershed processes, the transport of sediment, and coral reef dynamics. When completed, this science will be applicable to other watersheds and could be used to couple onshore to nearshore management in the western U.S. and the developing Pacific Rim.

Degraded watersheds and impaired coastal waters threaten both traditional and modern economies, and better tools are needed by stakeholders facing pressing management decisions.

Mapping and other field measurements are being used to understand processes on the landscape, and models are being developed to show how changes in watersheds affect nearby coral reefs. The models will simulate erosion and route sediment from the ridge through the valley to nearshore waters, where ongoing work is measuring sedimentation rates and impacts on reef ecosystems. This will show how terrestrial sediment affects reef communities, and ultimately predict the effect of climate change and sea-level rise on watersheds and coastal ecosystems.

Overall, the goal of Ridge to Reef is to provide new scientific information that watershed and coastal resource managers can use to prioritize decisions for maximum benefit. The products are designed to support partner agencies and organizations that are working to promote biological conservation, watershed and reef health, reliable water supplies, and economic and social sustainability. Information from Ridge to Reef can also be used to guide approaches such as adaptive management and understand how ecosystems will respond to changes in climate.

Science on the ridge

The supply of sediment to nearshore waters has likely changed following human occupation. Native plant communities have been transformed by invasive species, wildfires, agriculture, and grazing by feral animals. This has changed the hydrologic cycle and caused reductions in vegetation canopy and root cohesion, which makes the soil more vulnerable to erosion. Sediment supply to reefs under these altered transport processes may become greater and more persistent.

We are quantifying this change by making vegetation maps of unprecedented accuracy and resolution. We will combine these maps with measures of rain throughfall, evaporation, infiltration, and root strength in both invasive species and native communities at experimental sites to show changes in resistance to erosion for landslide and overland flow. We are also collecting data to

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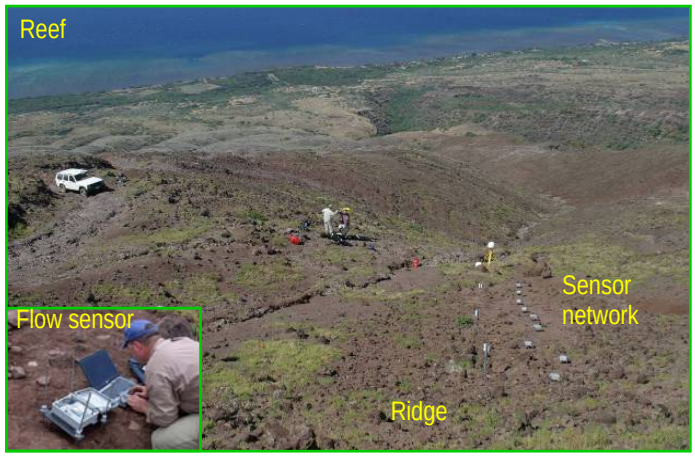
monitor changes in vegetation composition and structure in response to management actions (e.g., ungulate control) to restore native-dominated plant communities.



Although there are methods to predict soil erosion from agricultural lands, these techniques appear to not work well in areas with steep slopes. So, to forecast erosion rates we have an experimental site with a network of advanced sensors in a rapidly eroding catchment in Moloka‘i. During storms, the instruments measure the intensity and duration of rainfall, how much water is in the soil, the depth of water flowing over the hillslope, and the amount of water and sediment that runoff from the small catchment. To learn the exact sources of sediment, we are taking 3-dimensional laser scans of the catchment to measure small changes in topography.

Science along the transport path

To estimate the sediment flux onto endangered reefs, USGS has installed stream gages with suspended sediment collectors in Kauai, Moloka’i, and Kahoolawe. These gages provide ground truthing of actual fluxes onto the reef, and form the beginning of long-term data sets on sediment flux to reef communities from steep, volcanic highlands. We are also measuring rates of erosion in different setting using a network of erosion pins. These efforts complement detailed site explorations and can be used by policy makers and local communities to assess the success of mitigation efforts.

Science on the reef

There is evidence that sediment, nutrients, and other pollutants from human activities have harmed many coral reef ecosystems in the US and around the world. By examining the pathways and concentrations of sediment and other pollutants, we are learning how they stress reef communities. Remote sensing (satellite images and USGS overflights), as well as on-the-reef instruments are being used to measure turbidity, waves, currents, temperature, salinity and light penetration. We are also measuring sediment accumulation and suspended sediment concentrations. Spatial surveys with portable instruments, in addition to long-term measurements at fixed locations, provide information about different areas of the reef. This information will characterize deposition rates, sediment size distributions, wave energy associated with resuspension, and rate of sediment loss off of the reef. Laboratory and field studies of coral response to varying levels of sedimentation and decreased light availability will help set goals for managers for acceptable levels of sedimentation from adjacent watersheds, and for calibrating numerical models of wave and current processes. The models will help scientists and managers forecast the results of sedimentation events, and to begin the process of identifying threshold levels for sediment input and water clarity (turbidity) on coral reefs.

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