RSTC5 WP.9
Date: 17 July 2019
Original: English

Fifth Meeting of the Regional Scientific and Technical Committee for the GEF Pacific Ridge to Reef Programme

Nadi, Fiji 28th July 2019

Technical paper on the development and application of the R2R prioritisation model to inform Ridge to Reef management in Vanuatu catchments

Overview – Ridge to Reef framework

Goal

Develop a decision support tool to spatially prioritise national conservation efforts from Ridge toReef

Objectives

- Develop a Ridge to Reef framework
- Develop spatial prioritisation approach (e.g., scenario planning)
- Identify priority areas for conservation

Approach overview

To spatially prioritise conservation efforts across the country of Vanuatu based on downstream coral reef impacts, we will determine the impacts of current land-use on coral reefs and trace those back to the areas driving these impacts within each watershed. In order to do so, we will adapt and apply a linked land-sea modeling framework previously developed for quantifying the effect of nutrient enriched groundwater and sediment stream runoff on coral reefs in Hawaii and Fiji [1-3].

The framework, adapted to Vanuatu, will link InVEST Sediment Delivery Ratio (SDR) to seascape models calibrated with existing empirical and remote sensing data available for the region. Although nutrients are associated with sediment runoff and agriculture expansion, we will not explicitly model nutrient runoff here because of the lack of spatial information on local fertiliser application rates.

First, we will adapt, calibrate and apply the land-sea framework, which connects land and marine models (Fig. 1). To measure proxies of ecological resilience, the benthic coral reef models will focus on hard corals or reef calcifiers, which are known to respond to sediment runoff [4] and therefore support aspects of coral reef ecological resilience [5]. For the coral reef fish models, fish indicators relevant to decision makers (e.g., important subsistence and cultural resources) will be modeled according to their ecological role: (1) browsers, (2) grazers, (3) scrapers, and (4) predators [6]. Second, we will develop a spatial prioritisation approach at the national scale in consultation with decision makers. For instance, a scenario planning approach can consider land-use change scenarios that represent extreme projections of where deforestation could occur using national land-use classification system, agriculture practices, and geographical conditions [1]. Last, we will identify priority areas for conservation using a spatial analysis approach [8]. For instance, we can assess the impact of future scenarios on coral reefs and identify priority areas in specific watersheds, where avoiding deforestation through conservation can foster coral reef resilience [1].

The Ridge to Reef framework is made up of three key components: (1) Land models (i.e., InVEST SDR), (2) a land-sea link model (coastal sediment plume model), and (3) marine models (e.g., spatial predictive models). Sediment export (t.yr-1) will be modeled at the resolution of the Digital Elevation Model (DEM) resolution (~30 m x 30 m) for each watershed using the InVEST SDR, based on current land-use, topography, soil types, and rainfall data (Fig 1). Bathymetry and habitat maps will be coupled with GIS-based models, to generate marine driver grid data (geography and habitat) (Fig 1) [1-2,8]. The land-sea link model will diffuse the modeled sediment export (t.yr-1) from pour points representing stream mouths into the coastal zone based on nearshore marine conditions (e.g., depth, currents, wave power), using GIS distance-based models (Fig 1) [1-2]. The coral reef predictive models will use Boosted Regression Trees (BRT) calibrated on local coral reef survey data and generate response curves representing the relationships of each individual driver to each coral reef indicator, to enable predictive maps of the benthic (% cover) and fish (biomass or abundance) indicators (Fig 1) [1-3, 8]. Once calibrated on local data, we can apply this linked land-sea framework as a decision-support tool with locally relevant land-use change scenarios to identify coral reef areas vulnerable to sediment, which we will trace back to identify priority watersheds for forest conservation or restoration to promote coral reef resilience (Fig 1) [1].

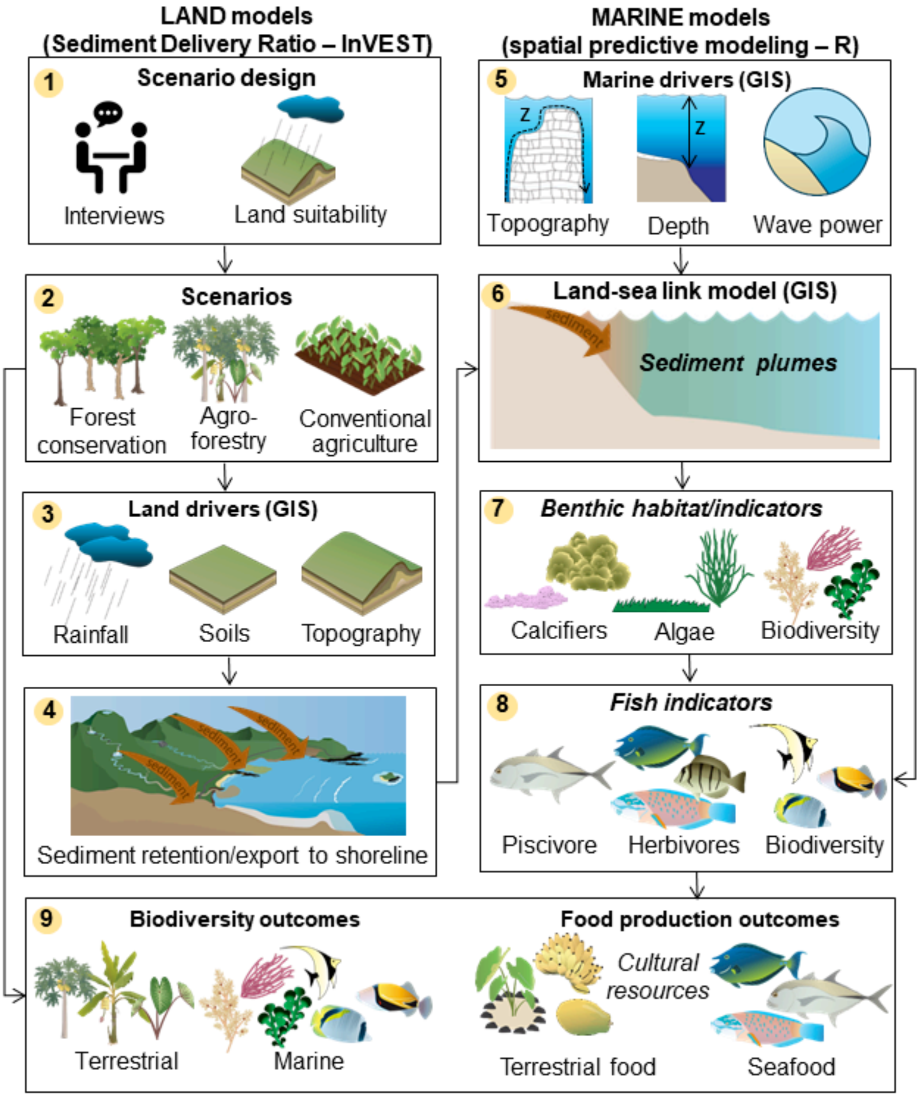

Figure 1. Conceptual Rridge to Reef framework overview.

Data requirements

This table provides a description of all the available input variables necessary to implement the terrestrial and marine models. Each metric is classified by type, including data source and the analytical tool used to generate each metric.

Table 1: Ridge-to-reef framework input data descriptions and processing methods

Type	Metric	Source	Description	Analytical tool
TERRESTRIAL MODEL INPUTS – InVEST SDR				
Topography	Elevation	DEM	Average elevation (m)	ArcGIS Mosaic tool
Rainfall	Rainfall erosivity	World Clim Rainfall	Depends on the intensity and duration of rainfall in region, greater intensity and duration results in higher erosion potential. $(MJ \cdot mm \cdot (ha \cdot h \cdot yr)^{-1})$	R script
Soil type	Soil erodibility	WISE soil database	A measure of the soil particles susceptibility to runoff (tons·ha·h·[ha·MJ·mm])	ArcGIS raster calculator tool
Land use	Land cover type	Land cover map	Spatial representation of land use and land cover type	ArcGIS polygon to raster tool
Watershed	Boundaries	DEM	Boundaries of watersheds contributing to a point of interest where water quality will be analyzed	ArcHydro toolbox
MARINE MODEL INPUTS				
Runoff	Sediment	InVEST SDR	Proxy for sediment runoff $(t.yr^{-1})$	GIS-based models
Oceano-graphy	Current	HYCOM	Current speed and directionality	Marine Geospatial Ecology Tools
	Wave height	AVISO wave model	Significant wave height (m)	Marine Geospatial Ecology Tools
Geo-graphy	Depth	Bathy-metry	Average depth (m)	ArcGIS Spatial Analyst tools
	Distance to shore	Coastline	Distance to nearest land (m)	ArcGIS Spatial Analyst Euclidean Distance tool
Topo-graphy	Bathymetric position index	Bathy-metry	Mean values indicate a location's position relative to the surrounding area; values can be positive (ridges), negative (valleys), or zero (flat or constant slope)	Benthic Terrain Modeler tool
	Slope	Bathy-metry	Maximum rate of change from a cell to its neighbors	ArcGIS Slope tool
Habitat exposure	Surface aspect (standard deviation)	Bathy-metry	Slope direction (degrees)	ArcGIS Aspect tool

	Sine aspect	Bathy-metry	Sine of slope direction (derived from transforming the mean aspect into “eastness”) (degrees)	ArcGIS Spatial Analyst tools (sine function)
	Cosine aspect	Bathy-metry	Cosine of slope direction (derived from transforming the mean aspect into “northness”) (degrees)	ArcGIS Spatial Analyst tools (cosine function)
Habitat complexity	Profile curvature (mean)	Bathy-metry	Curvature values can be + (concave), - (convex), or 0 (flat). A proxy for spur and groove effects on water flow.	DEM Surface Tools Curvature tool
	Planar curvature (mean)	Bathy-metry	Curvature values can be – (concave) to + (convex), or 0 (flat) (mean). A proxy for spur and groove effects on water flow.	DEM Surface Tools Curvature tool
	Rugosity	Bathy-metry	Value range from 1 (flat) to infinity.	DEM Surface Tools Curvature tool
Benthic community	Reef calcifiers	Marine model	Spatially-explicit predicted % cover	Marine model predictions
	Coral cover	Marine model	Spatially-explicit predicted % cover	Marine model predictions
	Algae	Marine model	Spatially-explicit predicted % cover	Marine model predictions

References

[1] Delevaux J.M.S., S. Jupiter, K. Stamoulis, L.L. Bremer, et al. (2018) Scenario planning with linked land-sea models inform where forest conservation actions will promote coral reef resilience. Scientific Report. [DOI: https://www.nature.com/articles/s41598-018-29951-0]

[2] Delevaux J.M.S., R. Whittier, K.A. Stamoulis, L.L. Bremer, S. Jupiter, et al. (2018) A linked land-sea modeling framework to inform ridge-to-reef management in high oceanic islands. Journal: PLOS One. [DOI: https://doi.org/10.1371/journal.pone.0193230]

[3] Delevaux J.M.S., K.A. Stamoulis, R. Whittier, S. Jupiter, L.L. Bremer, et al. (2019) Place-based management can reduce human impacts on coral reefs in a changing climate. Ecological Applications. [DOI: https://doi.org/10.1002/eap.1891]

[4] Fabricius, K. E. Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis. Mar. Pollut. Bull. 50, 125–146 (2005).

[5] Smith, J. E. et al. Re-evaluating the health of coral reef communities: baselines and evidence for human impacts across the central Pacific. Proc R Soc B 283, 20151985 (2016).

[6] Green, A. L. & Bellwood, D. R. Monitoring functional groups of herbivorous reef fishes as indicators of coral reef resilience : a practical guide for coral reef managers in the Asia Pacific region. (IUCN, 2009).

[7] Delevaux J.M.S., K.B. Winter, S.D. Jupiter, et al. (2018) Linking land and sea through collaborative research to inform contemporary applications of Traditional Resource Management in Hawaiʻi. Sustainability 10, no. 9. [DOI: https://www.mdpi.com/2071-1050/10/9/314] (Featured in special issue: Biocultural Restoration in Hawaiʻi).

[8] Stamoulis K.A., J.M.S. Delevaux, I. Williams, et al. (2018) Seascape models reveal places to focus coral reef fisheries management. Journal: Ecological Applications. [DOI: https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/eap.1696]