Designing Sustainable Landscapes:
Sea level rise metric

A project of the University of Massachusetts Landscape Ecology Lab

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- North Atlantic Landscape Conservation Cooperative (US Fish and Wildlife Service, Northeast Region)
- Northeast Climate Science Center (USGS)
- University of Massachusetts, Amherst

Reference:

McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2017. Designing sustainable landscapes: sea level rise metric. Report to the North Atlantic Conservation Cooperative, US Fish and Wildlife Service, Northeast Region.

General description

The sea level rise metric estimates the probability of the focal cell being unable to adapt to predicted inundation by sea level rise (SLR). Whether a site gets inundated by salt water permanently due to sea level rise or intermittently via storm surges associated with sea level rise determines whether an ecosystem can persist at a site and thus its ability to support a characteristic plant and animal community. Based on a sea level rise inundation model developed by USGS Woods Hole (Lentz et al. 2015).

The sea level rise metric (**Fig. 1**) is an element of the ecological integrity analysis of the Designing Sustainable Landscapes (DSL) project (see technical document on integrity, McGarigal et al 2017). Consisting of a composite of 21 stressor and resiliency metrics, the index of ecological integrity (IEI) assesses the relative intactness and resiliency to environmental change of ecological systems throughout the northeast. As a stressor metric, sea level rise ranges from 0 (no effect from sea level rise) to 1 (severe effect). Sea level rise is only applied to future time steps; for 2010, the value of sea level rise is always zero.

Use and interpretation of this layer

There are a number of assumptions inherent to the SLR model. See Lentz et al. (2015) for details.

Derivation of this layer

Data sources

This layer is based on a model of the probability of dynamic response to sea level rise provided by Erika Lentz at the USGS Woods Hole Coastal and Marine Science Center. The following inputs were used, and are described more fully in Lentz et al. (2015).

- Global sea-level projections from the 2014 International Panel on Climate Change (IPCC) Fifth Assessment Report (AR5).

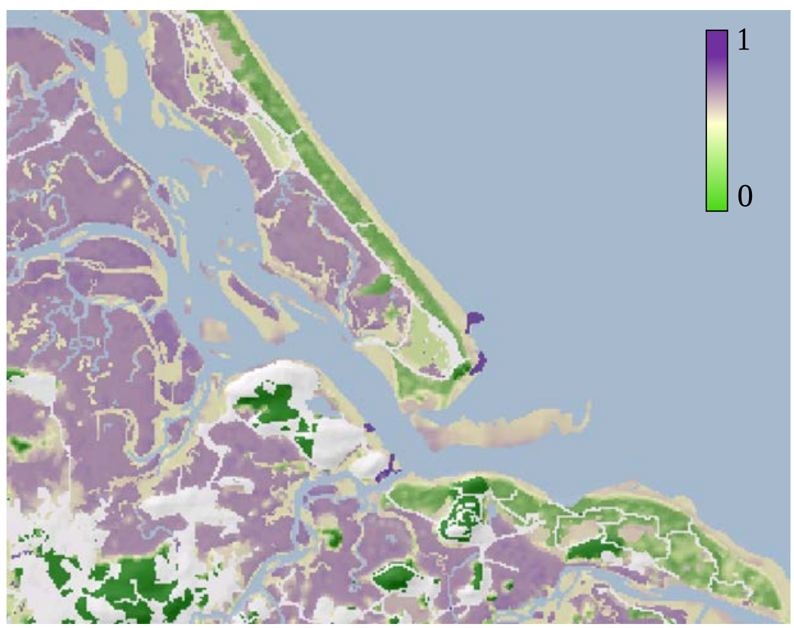

Figure 1. An example of the sea level rise metric, at mouth of Plum Island Sound, Massachusetts. The metric is not calculated for development, in light gray, nor marine, blue-gray.

- Vertical land movement rates (estimates of isostatic rebound).
- Digital elevation model (DEM) from the National Elevation Dataset (NED).
- Bathymetric data from the National Oceanic and Atmospheric Administration National Geophysical Data Center's Coastal Relief Model (CRM).
- Ecological systems map (DSLland). All of these metrics are based on development, roads, and some formation-level ecological systems in the ecological systems map (see DSLland document, McGarigal et al 2017, for details).

Algorithm

Lentz et al. (2015) used a Bayesian network model to estimate probabilities of static response (inundation in systems that cannot adapt to sea level rise) vs. dynamic response (in systems that can adapt to sea level rise) in coastal ecosystems. Probabilities of static vs. dynamic response were assigned by generalized land cover types and amount of projected sea level rise, thus more adaptable systems such as marshes or beaches are more likely to exhibit a dynamic response moderate sea level rise, until they are overwhelmed with greater sea level rise, while less adaptable systems such as forest are more likely to exhibit a static response with moderate sea level rise.

We converted Lentz et al.'s probability of dynamic response into a stressor metric using the following steps:

1. Clean up missing data. Lentz's original model had missing data due to artifacts in the DEM, and for some other intertidal cells. Erika Lentz provided us with a grid marking artifacts. We used a Gaussian weighted mean (SD = 30 m, max radius 1 km) stratified by ecological system to replace missing values due to artifacts and in intertidal cells. In cells where there were no other values in the same system within 1 km, the same kernel was used without filtering based on system (this was very rare).
2. Set all developed cells to no data.
3. Take the complement to convert to a stressor metric (higher values = more stress).
4. Set no data cells in uplands to 1 (these are inland areas that will not be inundated).
5. Smooth with a 3×3 focal mean, stratified by ecological system, to smooth some of the pixilation in the SLR data which we think was caused by noise in the DEM.

GIS metadata

The sea level rise metric is distributed as a geoTIFF raster (30 m cells), with cell values that range in theory from 0 (no sea level rise stress) to 1 (high stress); in practice they range from 0 to 0.797. This data product can be found at McGarigal et al (2017).

Literature cited

Lentz EE, SR Stippa, ER Thieler, NG Plant, DB Gesch, and RM Horton. 2015. Evaluating coastal landscape response to sea-level rise in the northeastern United States—Approach and methods: U.S. Geological Survey Open-File Report 2014–1252, 26 p., http://dx.doi.org/10.3133/ofr20141252 ISSN 2331–1258 (online).

McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2017. Designing sustainable landscapes products, including technical documentation and data products. https://scholarworks.umass.edu/designing_sustainable_landscapes/