Grand Cayman Coastal Protection (Wave Attenuation & Erosion Reduction) Analysis (June 2016)

Summary

These data layers were created by The Nature Conservancy's Caribbean Program and the University of California-Santz Cruz's Center for Integrated Spatial Research for the Mapping Ocean Wealth project in October 2015. The goal of this project is to use science, communications, and policy work to visualize and quantify the ocean's ecosystem, so that we can make smarter investments and decisions for the ocean of tomorrow. In the Caribbean, we used the InVEST tool to model ecosystem services for coral reefs, mangroves, and seagrass beds to visualize how these coastal habitats provide benefits in terms of coastal protection and recreation/tourism. Find out more at http://oceanwealth.org

Description

Understanding the role that nearshore habitats play in the protection of coastal communities is increasingly important in the face of a changing climate and growing development pressure. The InVEST Coastal Protection model quantifies the protective benefits that natural habitats provide against erosion and inundation (flooding) in nearshore environments. It is composed of two sub-models: a Profile Generator and a Nearshore Wave and Erosion model. In the absence of local data detailing the profile of the nearshore elevations, the Profile Generator model helps you combine information about the local bathymetry and backshore to generate a 1-Dimensional (1D) cross-shore (perpendicular to the shoreline) beach profile. The Nearshore Waves and Erosion model uses the cross-shore profile (either uploaded or created using the Profile Generator) to compute summaries of nearshore wave information, and outputs the total water level at the shore, the amount of shoreline erosion, and the amount of avoided damages due to erosion (in your local currency) from a given habitat management decision that affects the amount of nearshore marine habitats (e.g., coral or oyster reefs, vegetation, sand dunes) at your site. This information can help coastal managers, planners, landowners and other stakeholders understand the coastal protection services provided by nearshore habitats, which can in turn inform coastal development strategies and permitting. The model, of course, has some limitations (see Limitations and Simplifications), however, all the science that went into this model is based on well-established models that have been developed and successfully tested by various scientists at many sites, and is expected to be useful for a wide range of management decisions.

Credits

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For more information, please refer to http://data.naturalcapitalproject.org/nightly-build/invest-users-guide/html/coastal_protection.html

Nearshore Waves and Erosion

The Nearshore Waves and Erosion (Coastal Protection) Model consists of two modules:

1. Profile Generator (Creates cross-shore transects)
2. Wave Model (Quantifies the protective benefit of habitat along the shore)

There are several tools that are used to prepare model inputs (both Profile Gen. and Wave Model), and tools to help the two models mesh with each other

1. CoastalProtection_Helper_Tools.tbx\Preprocess_PGInputs
2. CoastalProtection_Helper_Tools.tbx\Preprocess_VisualizePGOutputs
3. Profile Generator Export.tbx\Export to Spatial Features
4. CoastalProtection_Helper_Tools.tbx\Postprocess_Nearshorewaves

1. Profile Generator

This latest version of the Profile Generator is found at *(Install_root)**InVEST_3_2_0_x86**invest-3-x86**invest_nearshore_wave_and_erosion.exe* and is commonly referred to as the InVest Tier 1 Wave Model.

Model Inputs (Grand Cayman)

1. **Workspace** – Specifies where model outputs will be saved
    a. Contains two subdirectories ("intermediate" and "output")
    b. The "intermediate" folder can be used to look at intermediate data and also make any changes to the intermediate data for debugging. For every run done in a single workspace, the model will use any intermediate data in that workspace.
2. **Results Suffix** – none
3. **What Modules do you want to run?** – "Profile generator only"
4. **Land Polygon** – cayman_islands\projected\PGInputs_preprocessed\land_poly.shp.
5. **Do you want us to generate cross-shore transects?** – yes
6. **If "yes": Bathymetric Grid (DEM)** - cayman_islands\projected\GC_Bathy_Topo_to_250m_UTMWGS84_meters_focal_30m.tif. Original DEM resampled to 30-meter resolution using bilinear interpolation
7. **If "yes": Area of Interest** - AOI_WW3. Polygon that captures offshore Wavewatch III data points. Extent (394435, 554022, 2267770, 2044908 WGS1984 UTM 17N, meters)
8. **If "yes": climatic forcing** - cayman_islands/projected/__Test_Data/TEST_ClimateForcing_NoStorm.shp

9. **If "yes" Habitat Data Directory (Optional)** – cayman_islands\projected\PGInputs_preprocessed\natural_habitats. Processed habitat data including Coral, Mangrove, Eelgrass, and Soil Type layers
10. **If "yes": Man-made Structures (Optional)** – none
11. **If "yes": Maximum length of your profile (km)** – 5 (default)
12. **If "yes": Minimum profile length (m)** – 500 (default)
13. **If "yes": Minimum offshore profile length (m)** – 500 (default)
14. **If "yes": Minimum depth of your profile (m)** – 0 (default)
15. **If "yes": Maximum depth of your profile (m)** – 100 (default)
16. **If "no": Upload Your Cross-Shore Profile (Optional)** – none
17. **Smoothing Percentage** – 5 (default)
18. **Space between transects (m)** – 500
19. **Model Spatial Resolution (m) (dx)** – 30
20. **Wave Watch III Model Data (Optional)** - E:/cayman_islands/projected/WW3_global_caymans.shp

2. Wave Model

The latest wave model requires several preprocessing steps. These steps include manual mangrove shore characterization and storm modeling.

1. Mangrove shorelines – The user has the option to override the DEM for mangrove shorelines. The user can specify slope, slope depth start, max land elevation, mangrove surge measured, mangrove surge correction. These values were not modified and the original DEM was used for both Regional and Grand Cayman analysis
2. Climate Forcing – No storm was modeled for both regions. Normal conditions were applied to the model
    a. Wave Height – 1 meter
    b. Wind Speed – 0
    c. Surge – 0
    d. Wave Period – 5 seconds

3. Model Results

Note: InVEST online documentation does not apply to this version of the wave model.

The model outputs are several text files with the Profile ID as the unique identifier. Several steps are required after a successful wave model to accurately view the model results. The wave model will attempt to calculate "Beach and Mud Erosion" on rocky shore points and provide meaningless results.

Using the Shore Points generated in “Export to Spatial Features” tool, Profile IDs associated with rocky shorelines receive “-1” values for “Beach and Mud Erosion” metrics on rocky shorelines. The Soil Type layer is used to select shore points with rocky shores. After rocky shores are identified and flagged. The tables are formatted (comma separated values) and joined to the shore points. The postprocessed Coastal Protection results are in feature class format. Descriptions below provided by Greg Guannel

1. WaveReductionTotal
    a. 'WaveHReduc' - The percent reduction of wave height, over the whole profile. Whatever reduced the wave height compared to having no habitats at all.
    b. 'WaveEnReduc' - The percent reduction of wave energy, over the whole profile. Whatever reduced the wave height compared to having no habitats at all.
2. WaveReductionShore
    a. 'WaveHReduc' - The percent reduction of wave height, in the nearshore region (shore to 100 m offshore). Whatever reduced the wave height compared to having no habitats at all.
    b. WaveEnReduc' - The percent reduction of wave energy, in the nearshore region (shore to 100 m offshore). Whatever reduced the wave height compared to having no habitats at all.
3. WaveCharacteristics
    a. 'WaveH_Hab' - The average wave height, in the nearshore region (shore to 100 m offshore). Yes Habitats. Units are Meters
    b. 'WaveH_NoHab' - The average wave height, in the nearshore region (shore to 100 m offshore). No Habitats. Units are Meters
    c. 'WaveEn_Hab' - The average wave energy, in the nearshore region (shore to 100 m offshore). Yes Habitats. Units are kW/m
    d. 'WaveEn_NoHab' - The average wave energy, in the nearshore region (shore to 100 m offshore). No Habitats. Units are kW/m
4. BeachTransport
    a. 'TotalWaterLevel_veg' - The sum of surge and run-up at the shoreline, Yes Habitats. Units are Meters
    b. 'TotalWaterLevel_noveg' - The sum of surge and runup at the shoreline, No Habitats. Units are Meters
    c. 'ErosionPot_veg' – The relative strength of erosive and nourishing forces at the beach. The higher the number, the stronger the erosive forces. Yes Habitats. Units are kW/m
    d. 'ErosionPot_noveg' - The relative strength of erosive and nourishing forces at the beach. The higher the number, the stronger the erosive forces. No Habitats. Units are kW/m
5. BeachMudErosion
    a. 'BeachErosion' – The distance from shoreline of beach erosion. Yes Habitats. Units are Meters
    b. 'BeachErosion_noveg' – The distance from shore of beach erosion. No Habitats. Units are Meters

c. 'MudErosion' – The volume of mud eroded. Yes Habitats. Units are volume per unit longshore distance of shoreline: m^3/m
d. 'MudErosion_noveg' – The volume of mud eroded. No Habitats. Units are volume per unit longshore distance of shoreline: m^3/m

4. Appendix

3.1 Data Formatting

Note: As mentioned by NatCap, all this information is in a developing-state and may change in the future

1. Land Polygon -
2. Climate Forcing Data – Point file depicting storm conditions. Since a storm was not modeled, only normal conditions were modeled. The points are in the same location as the WaveWatchIII data and contain the following integer fields and corresponding values:
    - WaveHeight – 1 (meters)
    - Surge – 0 (meters)
    - WavePeriod – 5 (seconds)
    - WindSpeed - 0 (knots?)
3. WaveWatchIII (WW3) – High resolution wind/wave statistics point shapefile curated by Greg Guannel depicting “normal” conditions. This is a high resolution version of the WW3 data supplied with the InVest download: *(Install_root)\InVEST_3_2_0_x86\CoastalProtection\Input\WaveWatchIII.shp*.