Ecosystem Services

These are the expected ecosystem service values for a fully restored mangrove ecosystem. They do not represent net gain as we would expect these places to have some value, even in the absence of mangroves. They have been calculated for areas of loss only, and do not include estimates for degraded areas. Statistics have been calculated based on individual typological units (See metadata for Mangrove Classification and Statistics) and to the jurisdictional, regional, and global level. Jurisdiction and region-level statistics are based on the sum of the values from the typological units assigned to that jurisdiction or region. Typological units have been assigned to the country in which they predominantly located.

Soil Organic Carbon (SOC) from mangroves is based on a methodology developed by Sanderman et al. (2018) to produce a global map of soil organic carbon at 30 m resolution for multiple depths. The original mapping was based on the Giri et al. (2011) maps and needed to be updated to cover the Maximum Mangrove Area from 1996 – 2016 developed for this project based on data from Global Mangrove Watch. Based on the baseline maps of SOC, changes in soil carbon over time were estimated based on changes in remote sensing data assuming a quasi-steady state over the period.

The updated model used the 3D spatial prediction approach for modeling SOC (soil organic carbon density), which is explained in detail in the PSM with R book. An ensemble system of Machine Learning algorithms (as implemented in the SuperLearner package) was used in combination with the most detailed remote sensing data available to the project team already (for the full list of covariates see Sanderman et al. 2018). All code used to generate global SOC for Mangrove forests is available at: https://github.com/whrc/Mangrove-Soil-Carbon (processing steps in R with tiling and parallelization are explained in detail in this tutorial: https://github.com/Envirometrix/BigSpatialDataR).

The adjustments to the 3D spatial prediction includes:

- new updated global mangrove coverage map ("GMW_1996_2016_Union.shp"),
- new ALOS-based DEM of the world AW3D30 v18.04 (focus on mangrove areas),
- new radar ALOS-based PALSAR radar images of the world (focus on mangrove areas),
- additional SOC points (ca 550) published in Rovai et al. (2018).

To ensure temporal coverage we limit the Landsat NIR, SWIR and similar RS data to only 2000–2010 period. This will allow us to generate a baseline map of SOC for mangrove areas.

For training point data we used the same soil profile data used for the Sanderman et al. (2018), and which is available publicly from: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/OCYUIT and the additional SOC points from Rovai et al. (2018).

The data represent the total amount of carbon stored in mangrove soils down to 100 cm. The values in the dataset are expressed in Megagrams per ha [a megagram is equal to one metric tonne]. The mean of the values falling within the 2016 extent of each typological unit was then multiplied by the area of the typological unit to estimate the total carbon within the typological

unit. For those typological units where there had be complete loss in mangrove extent (n = 879) or where the mangrove extent was too small to be captured in the soil carbon layer (n = 62), the mean values was calculated from the nearest typological unit of the same class (estuary, fringe or lagoon). That value was then multiplied by the area of restorable mangroves from loss to estimate the expected soil carbon storage values from the restorable areas from loss if mangroves within the typological unit were to be fully restored.

Aboveground Biomass values were derived from Hutchinson et al. (2013) and refitted to Global Mangrove Watch 2016 extent dataset. The units of the original dataset were in Megagrams per ha [a megagram is equal to one metric tonne]. A conversion factor of .475 was applied to convert mangrove biomass to carbon per Hamilton and Friess (2016). A mean of the values falling within a typological unit was then multiplied by the area of the typological unit to estimate the total carbon within the typological unit. That value was then multiplied by the area of restorable mangroves from loss to estimate the expected aboveground biomass values from the restorable areas from loss if mangroves within the typological unit were to be fully restored.

People Protected values were derived from the dataset produced by Beck et al. (2018). The data were provided as point values at 20km resolution. Each point was buffered by 10km and typological units that intersected the buffer we assigned its value. If the buffer intersected more than one typological unit, the coastal protect values were disaggregated based on the relative sizes of the intersecting typological units. These input maps and models are highly dependent on the precise juxtaposition of people, mangroves and wave environments and it is not possible to extrapolate directly from these datasets to the restorable areas. For this reason, we show the total numbers of people protected per mangrove unit, as well as dividing the total by mangrove extent to give a crude indicator of the relative value of mangroves per unit area (such numbers should be considered indicative only). Note that the coastal protection model values are based on a mangrove extent from Giri (2010).

Commercial fish and invertebrate enhancement values are based on a model, informed by field data, to estimate the number of additional individuals added to the ecosystem per 100m2 of mangroves across the world. The team identified ~40 species of commercially important fish and invertebrates which are strongly mangrove affiliated and enhanced by mangroves. The environmental variables that contribute to the overall fish enhancement value of a mangrove include salinity, sea surface temperature, productivity, mangrove edge length and area, and mangrove habitat type. Results are expressed in number of individuals per year. For finfish this figure represents young-of -the-year (juvenile fish, excluding planktonic fry); or invertebrates such as mud crabs and mangrove cockles this represents all size classes. The numbers do not represent catchable stock as natural mortality would reduce these numbers, in some cases considerably, before they reach fishable age.

We first calculated the values per the area of each typological unit, and then multiplied multiplied by the restorable area within a typological to estimate the enhancement values from if mangroves within the typological unit were to be fully restored.

The commercial fish covered include representatives from all regions, however they do not include all commercial species enhanced by mangroves- only those strongly affiliated with mangroves and so estimates may be conservative. Further, there is a possible sampling bias between regions and so results are most useful for comparing enhancement within regions, and should be viewed with caution in making inter-regional comparisons.