Mapping Ocean Wealth Mangrove Blue Carbon App Metadata

Mangrove Carbon Storage

Total mangrove carbon storage represents the sum of the aboveground carbon values and the soil organic carbon values attributed to mangrove forests. Mapped values are expressed as Mg (Megagrams) of Carbon Dioxide equivalents per hectare. 1 Megagram is equal to 1 metric tonne.

Above-ground estimates of mangrove carbon were obtained from Simard et al. 2019. The data were derived from a remotely-sensed canopy height measurements and region-specific allometric models and validated using in-situ measurements in field plots across three continents. This was converted mean AGB carbon using the stoichiometric factor of 0.451 (Simard et al. 2019), and then to mean AGB CO_2 using a conversion factor of 3.67 (Howard et al. 2014).

Soil organic carbon data are from Sanderman et al. (2018), which employed a machine-learning statistical model applied to a database of soil carbon measurements, resulting in a model of soil organic carbon density at 30m resolution. SOC was converted to CO_2 using a conversion factor of 3.67 (Howard et al. 2014)

Both datasets were aggregated to national level statistics expressed as mean Mg CO_2 ha $^{-1}$. To calculate national-level estimates of carbon for each metric, these national means were multiplied by national-level area estimates derived from Global Mangrove Watch 2016 dataset (http://data.unep-wcmc.org/datasets/45; Bunting et al., 2018).

It should be noted that both above and belowground carbon models were derived based on a map of mangrove cover developed by Giri et al. (2011), and that there is a slight mismatch between this dataset and the more recent Global Mangrove Watch dataset.

Avoided Mangrove Loss

We extracted mangrove extents from the Global Mangrove Watch (GMW) (http://data.unep-wcmc.org/datasets/45; Bunting et al., 2018) for 1996, 2007, 2010 and 2016 timesteps to calculate rates of mangrove loss. The mangrove footprint was split into 6,274 individual typological units based on their proximity to coastal geomorphological features (Worthington and Spalding, 2018). Transboundary typological units (with the exception of the Sundarbans, which was split between India and Bangladesh based on the international border) were assigned to country within which the majority of the unit's area was found.

To calculate the mangrove biomass and soil carbon values, we began by deriving the maximum mangrove footprint as the union of all timestep extents from the Global Mangrove Watch. We used country level data on the mean above ground biomass (AGB) (Mg ha^{-1}) of mangroves from Simard et al. (2019). This was converted mean AGB carbon using the stoichiometric factor of 0.451 (Simard et al. 2019), and then to mean AGB CO_2 using a conversion factor of 3.67 . It should be noted that there was a mismatch in the spatial extent of the mangrove footprint between the Simard et al. (2019) dataset and the GMW dataset used to examine loss; however, Simard et al. (2019) represents the most up-to-date and consistent assessment of mangrove AGB.

We used a global map of soil organic carbon at 30 m resolution (Sanderman et al. 2018) for mangrove soil organic carbon (SOC). The data were aggregated to national level statistics. As with the AGB, the SOC data was based on the mangrove footprint of Giri et al. (2011) rather than the updated GMW mangrove extents. SOC was converted to SOC CO_2 using a conversion factor of 3.67 (Howard et al. 2014). 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.

Mangrove loss over the study period was assessed by subtracting the 2016 extent from the maximum mangrove footprint (the union of the 1996, 2007, 2010 and 2016 timesteps) and therefore represents gross loss without accounting for gains or regeneration (i.e. net loss). This gross loss was converted to an annual rate for the 20-year period. Yearly avoided CO_2 loss was the sum of SOC and AGB CO_2 multiplied by the annual gross loss rate.

Mangrove Restoration

The potential restorable mangrove area in each typological unit was calculated by subtracting the area converted to urban land or eroded from the area of gross loss (as described above). As such, this is a conservative estimate of mangrove restoration potential because it does not include areas where mangroves were lost prior to 1996. Restorable area at the scale of individual typological units was aggregated to country level statistics.

Urban areas, defined as man-made building structures with a vertical component, were identified from the Global Urban Footprint (GUF) dataset (Esch et al. 2011, 2017), and areas of gross loss that intersected with the GUF were classed as urbanized. Areas of erosion were identified using a combination of the extent of global mudflats for the year 2016 (Murray et al., 2019), extent of bare ground (Hansen et al. 2013) and water occurrence change intensity (Pekel et al. 2016). The bare ground data were derived from Landsat 7 ETM+ cloud-free composites to estimate the minimum percentage of bare ground per pixel for the circa 2010 peak growing season (Hansen et al. 2013). For this analysis a pixel was classified as bare if it had ≥50% bare ground. Water occurrence change was calculated by matching monthly observations between two time periods (1984-1999 and 2000-2015) and identifying percentage change in water presence (Pekel et al. 2016). We identified areas within a 100m buffer of the coastline (coastline from a modified version of GADM https://gadm.org/) that had had a ≥20% increase in water intensity between the two time periods. Areas of erosion were identified by overlaying mudflat presence, extent of bare grounds and water occurrence change on top of the areas of mangrove gross loss. Erosion was assumed in those loss areas where water occurrence changed intensity or mudflats were present. In addition, areas were assigned to erosion if loss areas were overlaid by combinations of two or more of the following layers: mudflats, bare ground, and/or water occurrence change intensity. Areas of erosion were removed if they intersected with the GUF or layers representing Global Tree Canopy Cover for circa 2010 (Hansen et al. 2013) or Global 30m Cropland Extent (Gumma et al. 2017; Massey et al. 2017; Oliphant et al. 2017; Phalke et al. 2017; Teluguntla et al. 2017; Xiong et al. 2017; Zhong et al. 2017). Potential benefits from restoration were calculated by multiplying the country level area of restorable mangrove by a global carbon sequestration value of 6.4 (Griscom et al 2017) and converting to CO_2 equivalent using a conversion factor of 3.67 (Howard et al. 2014).

Estimates of Blue Carbon from avoided mangrove loss and mangrove restoration are from a forthcoming publication by Griscom et al. *National Potential for Natural Climate Solutions in the Tropics* (2019)