

Measuring changes in mangrove area

Why measure mangroves?

Mangrove swamps are forested intertidal ecosystems that are distributed globally between approximately N32° (Bermuda) to S39° (Victoria, Australia). Mangroves perform critical landscape-level functions related to the regulation of freshwater, nutrients and sediment inputs into marine areas. They also help to control the quality of marine coastal waters and are of critical importance as breeding and nursery sites for birds, fish, and crustaceans. It has been estimated that nearly two thirds of all fish harvested globally in the marine environment ultimately depend on the health of tropical coastal ecosystems. Mangroves furthermore receive large inputs of matter and energy from both land and sea and constitute important pools for carbon storage (Lucas et al., 2014).

Once abundant along the world's tropical and subtropical coastlines, mangroves are in decline at a rate similar to that of terrestrial (natural) forest, with about four to five percent of the global coverage lost during the past two decades (Ramsar Convention, 2018; FAO, 2015). Significant drivers of change include removal for aquaculture, agriculture, energy exploitation and other industrial development, with an unknown proportion of the remaining mangroves fragmented and degraded (Thomas et al., 2017). Mangroves are also sensitive to climate change effects such as sea level rise, temperature extremes and geographic range, and changes in hydrology.

Information on the state and change trends of mangroves at both national and global levels is limited. This is due in part because mangroves often fall between the national jurisdictions of wetlands and for forestry, and in part because of their often remote and inaccessible locations, which make periodic mapping and monitoring by conventional means costly and time consuming. Mangrove soils hold over 6 billion tons of carbon and can sequester up to 3-4 times more carbon than their terrestrial counterparts but are categorized as forests within the UN Framework Convention on Climate Change's REDD+ scheme¹ (IUCN, 2017), and should therefore be included in national emissions reports.

Description of the method used to measure mangrove area

Global mangrove area maps were derived in two phases, initially producing a global map showing mangrove extent (for 2010) and thereafter producing six additional annual data layers (for 1996, 2007, 2008, 2009, 2015 and 2016). The method uses a combination of radar (ALOS PALSAR) and optical (Landsat-5, -7) satellite data. Approximately 15,000 Landsat scenes and 1,500 ALOS PALSAR (1 x 1 degree) mosaic tiles were used to create optical and radar image composites covering the coastlines along the tropical and sub-tropical coastlines in the Americas, Africa, Asia and Oceania. The classification was confined using a mangrove habitat mask, which defined regions where mangrove ecosystems can be expected to exist. The mangrove habitat definition was generated based on geographical parameters such as latitude, elevation and distance from ocean water. Training for the habitat mask and classification of the 2010 mangrove mask was based on randomly sampling some 38 million points using historical mangrove maps for the year 2000 (Giri et al., 2010; Spalding et al., 2010), water occurrence maps (Pekel et al, 2017), and Digital Elevation Model data (SRTM-30).

The maps for the other six epochs were derived by detection and classification of mangrove losses (defined as a decrease in radar backscatter intensity) and mangrove gains (defined as a backscatter increase) between the 2010 ALOS PALSAR data on one hand, and JERS-1 SAR (1996), ALOS PALSAR (2007, 2008 & 2009) and ALOS-2 PALSAR-2 (2015 & 2016) data on the other. The change pixels for each annual dataset were then added or removed from the 2010 baseline raster mask (buffered to allow detection of mangrove gains also immediately outside of the mask) to produce the yearly extent maps.

Classification accuracy of the 2010 baseline dataset was assessed with approximately 53,800 randomly sampled points across 20 randomly selected regions. The overall accuracy was estimated to 95.25 %, while User's (commission error) and Producer's (omission error) accuracies for the mangrove class were estimated at 97.5% and 94.0%, respectively. Classification accuracies of the changes were assessed with over 45,000 points, with an overall accuracy of 75.0 %. The User's accuracies for the loss, gain and no-change classes respectively were estimated at 66.5%, 73.1% and 83.5%. The corresponding Producer's accuracies for the three classes were estimated as 87.5%, 73.0% and 69.0%, respectively.

¹ Reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries

Limitations of the data:

- The mangroves map is a global dataset, and as such, it should not be expected to achieve the same high level of accuracy everywhere as a local scale map derived through ground surveys or the use of very high spatial resolution geospatial data. A global area mapping exercise using consistent data and methods – although supplemented with ground-based data for calibration and validation – for logistical reasons generally requires a trade-off in terms of local scale accuracy. Nonetheless, global maps can be improved locally (or nationally) by adding improved information (in-situ data and aerial or drone data) for training and re-classification.
- Several different factors can affect the classification accuracy, including satellite data availability, mangrove species composition and level of degradation.
- While the original pixel spacing of the satellite data used for the mapping is 25-30 metres, a minimum mapping unit of approximately 1 hectare is recommended due to the classification uncertainty of a single pixel. The classification errors (in particular omission errors) typically increase in regions of disturbance and fragmentation such as aquaculture ponds, as well as along riverine or coastal reef mangroves that form narrow shoreline fringes of a few pixels.
- In general, the mangrove seaward border is more accurately defined than the landward side where distinction between mangrove and certain wetland or terrestrial vegetation species can be unclear.
- Striping artefacts due to Landsat-7 scanline error are present in some areas, particularly West African regions due to lack of Landsat-5 data and persistent cloud cover.
- Known data gaps in this version (v2.0) of the dataset: Aldabra island group (Seychelles); Andaman and Nicobar Islands (India); Bermuda (U.K.); Chagos Islands; Europa Island (France); Fiji (part east of Antemeridian); Guam and Saipan (U.S.); Kiribati; Maldives; Marshall Islands; Peru (south of latitude S4°), and Wallis and Futuna Islands (France).
-

As with wetland mapping the production of high-resolution mangrove data for the entire globe is at the forefront of currently available technology and computing power. It represents a huge step forward towards reporting accurate, statistically robust mangrove data which can be updated continuously.

Calculating the area of mangrove per country

Data on mangroves area are available for 1996, 2007, 2008, 2009, 2010, 2015 and 2016). New annual data is for 2017 and 2018 will be produced during 2020. For the purpose of producing national statistics to monitor indicator 6.6.1, the year 2000 has been used as a proxy based on the 1996 annual dataset to align with this baseline with that of the surface water dataset. National mangrove extent for the year 2000 will be used as the baseline reference period. Annual mangrove extent is compared to this baseline year. Percentage change of spatial extent is calculated using the following formula:

Where β = the national spatial extent from year 2000

Where γ = the national spatial extent of any other subsequent annual period

Percentage Change in Spatial Extent= $((\beta-\gamma))/\beta \times 100$