Belowground Biomass Carbon Stock

Indicator name **Belowground Biomass Carbon Indicator (BBCI)**

Indicator unit The belowground biomass carbon (BBCI) is expressed in Mg (Megagrams or Tonnes) of carbon per km^2. It represents an estimation of the carbon stored in the roots of all living trees. This carbon pool is calculated as a fraction of the aboveground biomass carbon stock using root-to-shoot ratios (R). It is derived from two main data sources: the global aboveground biomass map producedby the GlobBiomass project (globbiomass.org) and the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019).

Area of interest The BBCI has been calculated in DOPA for each terrestrial and coastal protected area of size ≥ 10 km^2 and at country and ecoregion levels.

Related targets

Sustainable Development Goal 13 on climate action

Sustainable Development Goal 15 on life on land

Aichi Biodiversity Target 11 on protected areas

Aichi Biodiversity Target 15 on contribution to carbon stocks

Policy question There are two main policy questions to which BBCI is relevant:

- How do protected areas contribute, through the conservation of vegetation resources, to the health and productivity of the ecosystems and to the sustainability of the local communities that depend on these ecosystem services derived from them? Tree-root systems provide various ecosystem services that improve soil conditions and prevent soil degradation.
- How do protected areas contribute to carbon storage and hence to offset the impacts of fossil fuel emissions and to climate change mitigation? Forests represent one of the largest terrestrial organic carbon reservoirs, and significantly contribute to the regulation of the global carbon cycle. Root biomass represents a stable and relatively inaccessible carbon stock, mainly affected by the removal of the canopy. Protected areas may contribute to biomass and carbon retention and hence to the reduction of net emissions of greenhouse gasses responsible for climate change.

Use and interpretation

The BBCI provides an estimation of the amount of carbon stocks in tree roots. Together with the AGCI and SOCI, it provides a complete overview of the total carbon stored in forest areas (trees and soil). Roots are a long term and stable carbon sink, accounting for about 0.4 of the above ground biomass across biogeographical regions, as calculated from the area-weighted mean of the R coefficients in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019). Moreover, well established and developed root systems provide various ecosystem services related to improved soil quality (higher cation exchange capacity and nutrient turnaround) and soil characteristics (improved aeration, soil porosity) as well as several soil-water-atmosphere interactions.

As a derived dataset, the BBCI inherits some of the characteristics from the original data, such as the spatial (100 m) and temporal (year 2010) resolution. In addition, water bodies, urban areas, permanent snow/ice and bare area land cover classes (Land Cover CCI, 2017) are masked.

Key caveats

The BBCI is derived from two main sources of information:

- Above-ground biomass (AGB) data provided by the global terrestrial biomass map derived from Earth Observation data in the framework of the GlobBiomass project (http://globbiomass.org/) funded by the European Space Agency (ESA).
- Chapter 4 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019), which indicates the most updated root-to-shoot ratios (R).

The IPCC Root-to-shoot ratios depend on the biogeographic conditions (ecozone), forest type, forest origin (natural or planted) and aboveground biomass density (Table 4.4 of IPCC, 2019). However, while the biomass map provides wall-to-wall global coverage, the IPCC ratios are not available for all existing combinations of the parameters indicated above. In order to estimate the root-to-shoot ratios in the classes not represented in the IPCC table , the following assumptions were made:

1. Missing ecozones in the IPCC table: use the ratio for the most similar ecozone included in the IPCC table. The similarity considers the way trees allocate biomass in the belowground component (i.e., higher ratios for dry ecozones).
2. Missing Continent for a certain ecozone in the IPCC table: use the average ratio available for other continents located in the same ecozone and same biomass class (if appropriate).
3. Missing Origin in the IPCC table: use the ratio for the same Forest type but different forest origin (if available).
4. Missing Forest type: use the ratio for the same (or most similar) Forest type but different Origin (if available).
5. Missing AGB class: use the ratio for any available AGB class under the same conditions (if available).

Similarly, some of the auxiliary dataset necessary to map the root-to-shoot ratios do not have global coverage. For instance, the Spatial Database of Planted Trees (Harris *et al.*, 2019) used to identify the forest origin currently does not provide information for China and India. A similar situation occurs with the dataset providing the extent of Quercus forests, which covers only Europe and part of Asia. However, these and new datasets are under development and new releases may allow to fill these gaps.

Currently, the BGB map that we used to produce the BGCI is recently developed, and has not yet been validated nor reviewed by any scientific organism. Therefore, it should be used with caution and as a mere indication of the amount of carbon stock in tree roots.

In essence, the errors in the BGCI are mainly due to the uncertainty in the source dataset (the AGB map, the root-to-shoot ratios and the auxiliary dataset used to map these ratios) that propagates into the BGB map, and the assumptions used for the missing ratios (for which there is no uncertainty estimate).

The biomass to carbon ratio used for this indicator is the same as for the aboveground biomass carbon indicator (AGCI): 0.5. This value is considered a good approximation of the typical carbon content in the biomass of terrestrial vegetation, and is consistent with the IPCC Good Practice Guidance for LULUCF (IPCC, 2003) and in other studies (Baccini *et al.*, 2017; Zarin *et al.*, 2016; Achard *et al.*, 2014; Baccini *et al.*, 2012; Saatchi *et al.*, 2011; Gallaun *et al.*, 2010). There is however some variation of this biomass to carbon conversion factor for different tree species, different components of a tree or a stand and age of the stand, which may be accounted for in more detailed assessments (Ruesch and Gibbs, 2008; Thurner *et al.*, 2014).

Because the AGCI is computed within the boundaries of each protected area with a size of at least 10 km^2, results will be affected by the accuracy of the available protected area boundaries.

Indicator status The belowground biomass map is derived from the aboveground biomass map developed by ESA's GlobBiomass project using root-to-shoot ratios. It was derived within the JRC and it will be made available on the Digital Observatory for Protected Areas main page.

Available data and resources

Data available BBCI values are available for each protected area of size ≥ 10 km^2, and can also be compared at country and ecoregion levels, on the DOPA Explorer website: http://dopa-explorer.jrc.ec.europa.eu/dopa_explorer/.

Data updates Planned with each update of DOPA.

Codes Standard GIS operations applied to vector and raster data.

Methodology

Methodology

The BBCI is calculated from a map of belowground biomass carbon, which in turn is derived from the global terrestrial biomass map developed by the GlobBiomass project using the IPCC root-to-shoot ratios (IPCC, 2019). The belowground biomass map estimates, with a spatial resolution of 100 m and for the reference year 2010, the amount of tree root biomass in Mg/ha. The belowground biomass was converted to carbon content using the conversion factor of 0.5 (Mg C / Mg dry matter), which is consistent with the approach in the Good Practice Guidance in LULUCF by the IPCC (2003) and within the range of values (0.47 - 0.51) used in the related literature (Ruesch and Gibbs, 2008; Thurner *et al.*, 2014).

The root biomass carbon is the result of two main inputs:

- Above-ground biomass (AGB) data provided by the global terrestrial biomass map derived from Earth Observation data in the framework of the GlobBiomass project (http://globbiomass.org) funded by the European Space Agency (ESA).

- Chapter 4 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019) which indicates the most updated root-to-shoot ratios (R).

Additionally, auxiliary datasets were necessary to map the Root-to-Shoot ratios. The IPCC Root-to-shoot ratios depend on the biogeographic conditions (ecozone), forest type, forest origin (natural or planted) and the aboveground biomass density (Table 4.4 of IPCC, 2019). These were combined to create a map, which includes the different categories represented in the 2019 IPCC report. To retain the maximum amount of information from the aboveground biomass data set, and harmonize the two layers, a set of pre-processing procedures were applied for the construction of the categorical/combination layer representing the biogeographical-specific characteristics of the R.

Each value from the AGB map was multiplied by an R coefficient to calculate the belowground biomass fraction and obtain a belowground biomass map, which presents the spatial (100 m) and temporal (year 2010) resolution of the input AGB map. The belowground biomass map was then converted to carbon units and overlaid with the boundaries of each terrestrial or coastal protected area of size ≥ 10 km^2 to calculate the minimum, maximum, mean and standard deviation of BGC density (Mg C/km^2) and the stock (Mg C) in each protected area. UNESCO Biosphere Reserves were discarded as well as protected areas with known areas but undefined boundaries.

Input datasets

The indicator uses the following input datasets:

Protected Areas

- WDPA of May 2019 (UNEP-WCMC & IUCN, 2019).
  - Latest version available from: www.protectedplanet.net

Country boundaries

- Global Administrative Unit Layers (GAUL), revision 2015 (2017-02-02)
  - Latest version available from: http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

Exclusive Economic Zones

- Exclusive Economic Zones (EEZ) v9 (2016-10-21)
  - Latest version available from: http://www.marineregions.org/downloads.php

Terrestrial Ecoregions of the World

- TEOW (Olson et al., 2001)
  - Latest version available from: https://www.worldwildlife.org/publications/terrestrial-ecoregions-of-the-world

Above-Ground Biomass

- GlobBiomass global map of forest above-ground biomass (Santoro, 2018).
  - The global above-ground biomass map is available for download, in the form of 40° x 40° tiles, at: http://globbiomass.org/products/global-mapping/

Global ecological zones

- Spatial dataset of the ecological zones from FAO (2012).
  - The global ecozones spatial dataset is available for download from the FAO GeoNetwork platform at: http://www.fao.org/geonetwork/srv/en/main.home

Land Cover

- Land cover map for the year 2010 (Land Cover CCI, 2017)
  - Latest version available from: http://maps.elie.ucl.ac.be/CCI/viewer/index.php

Planted Forests

- Spatial Database of Planted Trees (SDPT Version 1.0) (March 2019)
  - Latest version available from: http://data.globalforestwatch.org/datasets/224e00192f6d408fa5147bbfc13b62dd

Tree Species of Europe

- Statistical mapping of tree species over Europe (Brus *et al.*, 2011))
  - Latest version available from http://dataservices.efi.int/tree-species-map/register.php

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