European Commission

DOPA
Digital Observatory for Protected Areas

Dead Wood and Litter Carbon Stock

Indicator name **Dead Wood Carbon Indicator (DWCI) and Litter Carbon Indicator (LCI)**

Indicator unit The dead wood carbon and litter carbon are expressed in Mg (megagrams or tonnes) of carbon per km^2. They represent an estimation of the carbon stored in the dead wood and in undecomposed leaves on the ground surface of forest areas. This carbon pool is calculated as a fraction of the aboveground biomass carbon stock, based on the methodology and using the conversion ratios provided by Harris *et al.*, 2021.

Area of interest The DWCI and the LCI have been calculated at the country level, terrestrial ecoregion level and for all protected areas and is provided for each country, each terrestrial ecoregion and each terrestrial and coastal protected area of size ≥ 1 km^2.

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 DWCI and LCI are 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? Dead wood and litter provide various ecosystem services that contribute to the maintenance of adequate levels of organic matter in the soil, thus improving soil conditions, reduce water erosion 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. Dead wood and litter represents a quite dynamic and accessible carbon stock, heavily 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 DWCI and LCI provides an estimation of the amount of carbon stocks in dead wood and undecomposed leaves on soil surface. Together with the AGCI. BGCI and SOCI, these two carbon pools contribute to the total carbon stored in forest areas (trees and soil). Dead wood and litter are a highly dynamic carbon sink, both for anthropogenic activities and natural degradation processes. They account for about 8% and 5% respectively (Pan et al., 2011) of the above ground biomass and their importance is related to the variety of ecosystem services such as the contribution, as a source of organic matter, to the improvement of chemical and physical soil properties (higher cation exchange capacity and nutrient turnaround) and soil characteristics (improved aeration, soil porosity) and to the protection from water erosion.

As derived datasets, the DWCI and LCI inherit some of the characteristics from the original data, such as the spatial (100 m) and temporal (year 2020) resolution. In addition, water bodies, urban areas, permanent snow/ice and bare area land cover classes (Land Cover CCI, 2020) are masked.

Key caveats

The DWCI and LCI are products derived from the following datasets:

- Above-ground biomass (AGB) data provided by the global terrestrial biomass map derived from Earth Observation data in the framework of the CCI BIOMASS project) funded by the European Space Agency (ESA).
- Conversion ratios provided by Harris *et al.*, 2021, which in turn depend on the biogeographic conditions (ecological zone), rainfall regime and altitude.

Currently, the Dead Wood and Litter maps that we used to produce the DWCI and LCI are recently developed, and have not yet been validated nor reviewed by any scientific organism. Therefore, they should be used with caution and as a mere indication of the amount of carbon stock in dead wood and litter.

In essence, the errors in the DWCI and LCI are mainly due to the uncertainty in the source datasets (the AGB map, the conversion ratios and the auxiliary datasets used to map these ratios) that propagates into the DWCI and LCI maps.

The biomass to carbon ratio used for these indicators are the same as for the aboveground biomass carbon indicator (AGBI): 0.5. There is however some variation of this biomass to carbon conversion factors for different biomes, taxonomic divisions and even tissue types, which may be accounted for in more detailed assessments (Martin et al., 2021; Ruesch and Gibbs, 2008; Thurner et al., 2014).

Because the DWCI and LCI are computed within the boundaries of each protected area, results will be affected by the accuracy of the available protected area boundaries.

Indicator status

The Dead Wood and Litter maps are derived from the Above Ground biomass map developed by ESA CCI BIOMASS project. They have been computed within the JRC and it will be made available on the Digital Observatory for Protected Areas main page. The computation of the Dead Wood and Litter carbon stocks and their assessment in protected areas are not yet published.

Available data and resources

Data available DWCI and LCI values are provided for each protected area of size ≥ 1 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 DWCI and LCI values are calculated from the two corresponding maps od Dead Wood and Litter biomass, which in turn are derived from the global Above Groud Biomass map developed by the CCI BIOMASS project.

The Dead Wood and Litter carbon maps estimate, with a spatial resolution of 100 m and for the reference year 2020, the amount of dead wood and of undecomposed leaves biomass in Mg/ha. Biomass Is converted into 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 procedure for the computation of Dead Wood and Litter datasets is based on the methodology provided by Harris *et al.*, 2021 and it consists in the application of conversion coefficients to the Above ground Biomass values> conversion coefficients are function of three different spatial parameters: ecological zones, annual rainfall and elevation.

The following inputs are used for the built-up of a look-up table for data conversion:

- FAO Global Ecological Zones, defined as zones or areas with broad yet relatively homogeneous natural vegetation formations, with similar physiognomy. Boundaries of the Ecological Zones approximately coincide with the map of Köppen-Trewartha climatic types.

- Monthly mean rainfall: global 30 arc-seconds (Worldclim 2) monthly data are used to derive the average annual rainfall.

- Gridded bathymetric data set (GEBCO), providing elevation data, in meters, on a 15 arc-second interval grid.

Once each input parameter is reclassed, the coefficients below (as from table S4 of Harris et al., 2021) are applied to convert Above Ground Biomass to Dead Wood and Litter values, respectively:

Climate (GEZ)	Elevation (m)	Rainfall (mm/yr)	Dead Wood fraction of AGB	Litter fraction of AGB
Tropical	<2000	<1000	0.02	0.04
Tropical	<2000	1000-1600	0.01	0.01
Tropical	<2000	>1600	0.06	0.01
Tropical	>2000	All	0.07	0.01
Temperate/Boreal	All	All	0.08	0.04

Each value from the AGB map was multiplied by the corresponding coefficient to calculate the dead wood and litter biomass fraction, respectively, and obtain the two Dead Wood and Litter biomass Maps, which inherit the spatial (100 m) and temporal (year 2020) resolution of the input AGB map.

The two maps were then converted to carbon units and overlaid with the boundaries of each country, terrestrial ecoregion and terrestrial or coastal protected area to calculate the minimum, maximum and mean of DWCI and LCI (as density, in Mg C/km^2) as well as the total DWCI and LCI stored (Mg) within each country, terrestrial ecoregion and 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 February 2023 (UNEP-WCMC & IUCN, 2023).
  - Latest version available from: www.protectedplanet.net

Country boundaries

Country boundaries are built from a combination of GAUL country boundaries and EEZ exclusive economic zones (see Bastin *et al.*, 2017).

- 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

- CCI BIOMASS global map of forest above-ground biomass v. 4, reference year 2020 (Santoro *et al*., 2023c).

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

Temperature and precipitations

- WorldClim 2, Release 2, June 2016 (Fick & Hijmans, 2017)
    - Latest version available from: www.worldclim.org/version2

Elevation (bathymetry and topography)

- GEBCO Grid (2023 Version, Weatherall *et al.*, 2014)
    - Latest version available from: http://www.gebco.net/data_and_products/gridded_bathymetry_data/

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