

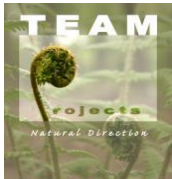


Soil carbon: Indicator document - Ecosystem Service Modelling & Rule-base development

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Indicator	CICES classification
SOIL CARBON (REGULATION OF GREENHOUSE GASES (CARBON))	<p>Section: Regulation & Maintenance</p> <p>Classes: Global climate regulation by reduction of greenhouse gas concentrations</p> <p>CICES IE Sub-class: Areas important for emissions reduction</p>
Scale	CICES Cascade Level ¹
Strategic/National/Regional/Local	Structure/Function/Service/Benefit/Value

¹ Potschin, M. and R. Haines-Young (2016): Frameworks for ecosystem assessments. In: Potschin, M., Haines-Young, R., Fish, R. and Turner, R.K. (eds) Routledge Handbook of Ecosystem Services. Routledge, London and New York, pp 125-143.

What the service is

Soil carbon storage is an important ecosystem service as it can help mitigate climate change by storing CO₂ and preventing its release into the atmosphere. It occurs as the result of the interactions between different ecological processes. The amount of organic matter present within the soil profile is an important component of the service. Soil organic matter is a heterogeneous mixture of organic compounds that are highly enriched in carbon, ranging in decomposition state from fresh plant residues (leaf litter), to highly decomposed material known as humus.

The soil organic carbon levels of different soil types are directly related to the amount of organic matter contained in the soil from growth and death of plant roots and foliage, as well as indirectly from the transfer of carbon-enriched compounds from roots to soil microbes. Inorganic carbon from the mineral component of the soil is not readily released to the atmosphere or water from the soil so it has not been considered in this analysis.

The scientific framework outlined below helps to determine the type of data that could be used for modelling of this service, and provides general guidance which indicators are likely to have a positive or negative impact on service provision.

Scientific framework for modelling Soil Carbon

Overview:	<p>There is good evidence on the role of soil type, landform and habitats in soil carbon storage mainly from literature concerning the terrestrial environment. The most relevant material is summarised here.</p> <p>An important component of soil carbon storage is the amount of organic matter present within the soil profile (Six et al., 2002). Soil organic carbon (SOC) levels of different soil types are directly related to the amount of organic matter contained within the soil from growth and death of plant roots and foliage (Melillo et al., 1989; Rasse et al., 2005), as well as indirectly from the transfer of carbon-enriched compounds from roots to soil microbes (Helal and Sauerbeck, 1986; Wardle, 1992).</p>
Soil systems	<p>In temperate climates, it has been estimated that soils are more important for carbon storage than vegetation (Milne and Brown, 1997; Alonso et al., 2012).</p> <p>In Wetland systems which lack oxygen, organic carbon accrues faster than in most other systems. Due to few organisms being able to tolerate anaerobic environments, respiration rates are low, which causes low rates of CO₂ release (Brady and Weil, 2002; Bain et al., 2011). In addition, the low temperatures and acidic conditions present in wetlands further slow the decomposition rate, causing dead plant material to build up in layers of organic matter (Lindsay, 2010; Bain et al., 2011). In these waterlogged systems the most important vegetation contributors to soil carbon build up are species such as Sphagnum mosses (Lindsay, 2010; Bain et al., 2011). That Sphagnum sp. do not facilitate methane release in the way vascular plants do is an additional factor contributing to climate change mitigation by Sphagnum dominated peatlands (Frenzel and Karofeld, 2000; Lindsay, 2010). The significance of vegetation for soil carbon in these wetland systems is therefore scored based on the amount of Sphagnum present (or inferred from the habitat type) and on the likely perturbation of the system. The presence of vascular plants, or of particularly wet</p>

	<p>microclimates with no oxic zone above the water table, are indicators of peatlands with high methane emissions (MacDonald et al., 1998; Kayranli et al., 2010).</p> <p>Within dry soil systems, vegetation has a different interaction with soil types. Here, carbon is respired by plant roots, soil microbial communities and other communities that feed on plant litter (Singh and Gupta, 1977; Brady and Weil, 2002). Therefore, the depth and quantity of roots and depth of plant litter will be key features in scoring the carbon potential of these vegetation types. Within dry soil systems the likelihood of organic matter in the soil profile being used in respiration is related to its depth, with carbon deep in the profile less likely to be utilised (Singh and Gupta, 1977; Fontaine et al., 2007). This carbon at depth can be an important part of the carbon sink (Milne and Brown, 1997; Alonso et al., 2012). Where the habitats are disturbed (e.g. re-sown grassland) (Hagon et al., 2013), carbon is likely to be utilised, as exposure to oxygen in the perturbation allows micro-organisms to respire (Brady and Weil, 2002), input of new carbon promotes the usage of ancient, buried carbon (Fontaine et al., 2007) and micro aggregates stabilising soil organic matter are broken down (Six et al., 2002).</p> <p>Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide⁵; Teagasc, 2007).</p>
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⁵ <http://gis.teagasc.ie/soils/soilguide.php>

Management	<p>Negative management practices leading to the release of carbon include:</p> <ul style="list-style-type: none"> • Drainage (Armentano and Menges, 1986, Bellamy et al. 2005, Holman 2009, Natural England 2010) • Ploughing (Holden et al. 2004, Bain et al. 2011) • Overgrazing (Britton et al. 2005) • Management causing soil erosion (Eswaran et al. 1993, Davari et al. 2010) • Management which causes soil compaction (Dominati et al. 2010) • Applying lime or fertiliser (West and McBride 2005, Biasi et al. 2008) • Clear felling large areas (Eswaran et al. 1993, Foley et al. 2005, Davari et al. 2010) • Tilling on organic soils (Dawson and Smith 2007) • Planting root crops which disturb the soil • Peat harvesting <p>Positive management practices leading to increased storing of carbon include:</p> <ul style="list-style-type: none"> • Improvement of species diversity of grassland through species management (Fornara and Tilman 2008, Mommer et al 2010) • Reduction of grazing to avoid overstocking (Britton et al. 2005) • Improvement of soil structure • Retention of permanent pasture over cropping where feasible • Drain blocking (Armentano and Menges, 1986, Bellamy et al. 2005, Holman 2009)
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Supporting evidence: References

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