An Roinn
Ealaíon, Oidhreachta agus Gaeltachta
Department of
Arts, Heritage and the Gaeltacht

Land promoting good water quality: Indicator document - Ecosystem Service Modelling & Rule-base development

Indicator	CICES classification
AREAS OF LAND PROMOTING GOOD WATER QUALITY - (REGULATION OF WATER QUALITY)	**Section**: Regulation & Maintenance **Classes:** Bio-remediation by micro-organisms, algae, plants, and animals; Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals. **CICES IE Sub Classes:** Terrestrial & freshwater habitats which provide nutrient retention and pH buffering
Scale	**CICES Cascade Level[1]**
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

Clean water is a key benefit of the ecosystem service 'the purification of water by the land that effects human health and wellbeing' and can have significant economic consequences. The chemical composition and appearance of water is influenced by both natural processes and human activities. The ability of soils to filter sediments varies with soil type and management and landform. Steep slopes shed water more rapidly than shallow slopes. Habitats will influence filtration differently primarily depending on the density and structure of the vegetation but also due to their interaction with supported flora. Some species of plants assist with water purification by up-taking ion's selectively, thereby reducing chemical pollution. Plant roots trap and prevent particulate matter reaching the water courses. This map largely considered particulate matter and water quality issues.

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 'Areas of land that helps to purify water'

Overview:	Water quality is a key ecosystem service that affects human health and wellbeing and can have significant economic consequences (Hallberg, 1987; Gleick, 1993). Water quality is influenced by both natural processes (e.g. filtration in peatland) and human activities (e.g. fertiliser application) (Acreman et al., 2011). There is good evidence on the role that soil type, landform and habitats play in purifying water. The most relevant material is summarised here.
Soil	During its percolation through the soil, water can interact with the soil chemistry and any deposits from human activity taking place on the soil surface. In this way pollutants and excess nutrients can be added to or removed from the water (Arya and Paris, 1981; Dominati et al., 2010). Clay soils impede water movement, leading to a slow percolation rate of water through the profile, and quickly become waterlogged (Gupta and Larson, 1979; Winter et al., 1998; Brady and Weil, 2002). When waterlogged, water will run off the surface of soils (Beven and Wood, 1983; Small, 1989; Ward and Robinson, 1990) and collect surface pollutants, which are then incorporated directly into the soil system and water cycle (Withers and Lord, 2002; Heathwaite et al., 2005). Sandy soils drain quickly (Small, 1989; Winter et al., 1998) and hold little water (Gupta and Larson, 1979), but can have a useful filtration effect and form good aquifers (Jones et al., 2011). The underlying mineralogy of the soil has an effect on filtration rates, as the mineral component of the soil acts as an ion exchange site (Ward and Robinson, 1990). Due to the presence of ion exchange sites clay soils have greater capacity to adsorb charged particles from water than sandy soil (Brady and Weil, 2002). Neutral soils have the highest capacity to reduce water pollution during filtering, as at this pH ion exchange capacity is high (Brady and Weil, 2002). Acid soils are less effective as water purifiers, as they have a low ion exchange capacity (Bache et al. 1984). The peat component of the topsoil can be a source of suspended solid particles, which are released into the water (Bardy and Weil 2002, Walling and Fang 2003). Although these are not deleterious to human health, they are now perceived as undesirable and extra effort is needed to remove them from potable water. In eroded systems (or where there is an incomplete Sphagnum layer (Holden et al., 2008)) the suspended

	solid component of the water running through, and off the peat can be significant (Lucas and Davis, 1961; Evans et al., 2006; Bain et al., 2011). Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide[3]; Teagasc, 2007).
Soil systems	The health, or functional capacity, of soil systems has an influence on water quality (Brussaard, 1997; Wall and Moore, 1999). Soil systems which have active microbial and geochemical interactions are able to react with particulates, metals and nutrients from the water, incorporating them into the soil (Fetter, 1994; Brussaard, 1997; Lavelle, 2006).

[3] http://gis.teagasc.ie/soils/soilguide.php

Landform	Landform has an influence on water quality regulation. Of particular importance is slope. Steep slopes shed water more rapidly than shallow slopes (Reaney et al., 2011). The water has higher energy and is able to carry more particulate matter within it, picked up from the land surface (Stone and Hilborn, 2000; Reaney et al., 2011). Flood water in the lower reaches of a catchment, can contain high levels of sediment and pollutants from upstream (Middelkoop and Van Der Perk 1998, Small 1989), and pick up additional materials from the flood plain and any urban areas. These pollutants return to the river when flood waters recede (Malmon et al., 2002; Rotherham, 2008).
Habitat	Habitat, through its link to vegetation and soil type, strongly influences water quality. Some species of plants assist with water purification (Baker and Brooks, 1989). Several mechanisms allow plants to take up extra metals and impurities from water and soil (Baker and Brooks, 1989; Raskin et al., 1994). Certain wetland plants (e.g. Phragmites australis) have microbial species associated with their roots that oxygenate the system, which creates conditions that assist metal uptake by the plants (Armstrong et al., 2000; Weis and Weis, 2004). These therefore have the potential to enhance the natural purification process (Shutes, 2001). Below ground features have a positive impact on water quality, especially where roots and their associated microrrhizal communities remove unwanted nutrients and organic content from water (Virginia et al., 1986; Brussaard, 1997; Lavelle et al. 2006). The microrrhizae associations and the macro and micro fauna in mineral soils influence oxygen concentration levels. Increased oxygen availability allows more

	particulates, metals and nutrients to be taken up by the plants and increases the level of purification (Carter, 2004; Lavelle et al., 2006). Diversity causing full resource utilisation within the root network causes root channels. These allow for more water to filter through the soil column (Mommer et al., 2010). High levels of stygofauna in the groundwater can benefit water quality in aquifers (Boulton et al., 2008). Therefore, the greater the below ground biodiversity, the greater the contribution of the system to purification.
Management	Negative management, leading to reduced water quality regulation, includes: • Overstocking and poor animal management in upland areas leading to soil erosion (Curtis, 1983; Swinton et al., 2007) • Poorly managed use of chemicals in grassland for livestock management (McCracken et al., 2011) • Drainage of peatlands and other wetlands providing a water storage function (Holden et al., 2004; Bain et al., 2011; Alonso et al., 2012) • Extensive use of chemicals in arable and cereal production, especially at sites adjoining water courses (Hallberg, 1987; Heathwaite et al., 2005) • Sediment runoff from Forestry / Forest management activities Positive management, leading to increased water quality regulation includes: • Restoration of peatlands and other wetlands functioning as water storage areas (Bain et al., 2011; Van der Wal et al., 2011) • Good animal management in upland areas (e.g. stocking densities not too high) (Medina-Roldán et al., 2012) • Well managed use of chemicals in arable and cereal production and the use of buffer strips to prevent spray drift of pesticides, especially at sites adjoining water courses (Heathwaite et al., 2005; Lane et al., 2006)

Supporting evidence: References

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