



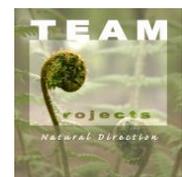
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Land temporarily storing water: Indicator document -
Ecosystem Service Modelling & Rule-base development

What the service is 2

Scientific framework for modelling ‘Areas of land that temporarily store water’ 3

Supporting evidence: References 6



Indicator	CICES classification
AREAS OF LAND THAT TEMPORARILY STORE WATER (FLOOD CONTROL) Section: Regulation & Maintenance	Class: Hydrological cycle and water flow maintenance CICES IE Sub Classes: Water storage Mitigation of peak flows (esp. winter)
Scale	CICES Cascade Level¹
Strategic/National/Regional/Local	Structure/Function/Service/Benefit/Value

¹Potschin, 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

Excess water in the landscape can cause flooding events which can lead to severe social and economic consequences. Conversely, too little water over a long period causes drought conditions and water restrictions. The regulation of water is complex and is affected by obvious factors such as climate (rainfall in particular), but also less obvious ones such as topography, soil, vegetation and land cover type (especially sealed surfaces, such as concrete and tarmac).

At its simplest, soil temporarily stores water that falls as rain as it percolates through the system towards rivers and streams, or into the groundwater resource. The ability of soil to perform this function depends on its texture, depth and organic matter content, as well as the overall context of the soil in the landscape. Habitat, through its link to vegetation type and soil type, has an important influence on the amount of overland flow. This is linked largely to the structure of the vegetation present and its effects on infiltration (the process by which water on the ground surface enters the soil). Steep slopes shed water more rapidly than shallow slopes. Steep slopes are also more likely to be in the upper reaches of catchments and are characterised by small streams with rocky banks, which in times of heavy rainfall can quickly rise.

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 temporarily store water'

Overview	<p>The regulation of water is complex and is affected by a number of factors; climate (rainfall in particular), soils, vegetation and land cover type. There is good supporting evidence regarding the factors influencing this indicator, with the most important material summarised here</p>
Soil	<p>The ability of soil to perform this function depends on its texture, depth and organic matter content, as well as the overall context of the soil in the landscape (Gupta and Larson, 1979; Brady and Weil, 2002; Farmer et al., 2003; Baines, 2008).</p> <p>The role of mineral soils in water regulation depends very much on the clay content within both the topsoil and subsoil horizons, as clay soils impede the percolation of water through the profile, causing the surface of the soil to become waterlogged quickly (Gupta and Larson, 1979; Winter et al., 1998; Brady and Weil, 2002).</p> <p>Conversely, sandy soils have very effective drainage (Small, 1989; Winter et al., 1998) and hold little water (Gupta and Larson, 1979). Soils with high silt content can become 'capped' by an impenetrable layer of particles when they dry out and this again can lead to higher overland flows, even when the soil is not fully at field capacity, i.e. its maximum water retention capacity (Dominati et al. 2010).</p> <p>Organo-mineral soils can either act as a water store or a water-shedding resource (Winter et al., 1998) depending on the subsoil clay content (Gupta and Larson, 1979; Ward and Robinson, 1989), the water inputs to the system and slope of the area (Farmer et al., 2003).</p> <p>Heavy clay soils with unstable soil structures resist infiltration and encourage run off (Brady and Weil, 2002). Organic soils are highly absorbent (Baines, 2008) and have high capacity to store water after a rainfall event (Holden, 2005; Acreman et al., 2011; Bain et al., 2011).</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>

⁵<http://gis.teagasc.ie/soils/soilguide.php>

<p>Soil systems</p>	<p>Peat based wetland systems have a relatively high capacity to absorb high rainfall (Baines, 2008), which in turn reduces the amount of run-off until the peat system is saturated and additional water inputs run off the soil surface (Holden, 2005; Acreman et al., 2011; Bain et al., 2011).</p> <p>Mineral soil systems are very dependent on particle size, organic matter content (Gupta and Larson, 1979; Brady and Weil, 2002) and compaction (Dominati et al., 2010).</p> <p>Mechanical and biological soil management practices, which improve the structure of the soil by allowing more air into the system, reduce compaction and allow the soil to store more water (Brady and Weil, 2002; Lavelle et al., 2006; Bhogal et al., 2009).</p>
<p>Geology</p>	<p>The underlying geology affects the soil type, as it is the parent material which determines the mineral composition and particle size of the soil (Jenny, 1994; Cottle, 2004). Geology also has an effect on topography (Cottle, 2004), the course of rivers and, within rock, throughflow characteristics. These drive the drainage cycle (Small, 1989; Ward and Robinson, 1989) and determine whether an aquifer forms (Fetter, 1994; Winter et al., 1998).</p>
<p>Landform</p>	<p>Steep slopes shed water more rapidly than shallow slopes (Reaney et al., 2011). Steep slopes are also more likely to be in the upper reaches of catchments, which in times of heavy rainfall can quickly rise (Hanna et al., 1982). In the lower reaches, where the land is relatively flat or gently sloping, rivers are generally wider and the flow rate of the water is slower (Small, 1989). When flood waters arrive in the lower reaches, the banks of the river can be breached and water inundates the surrounding flood plains (Middelkoop and Van Der Perk, 1998; Rotherham, 2008).</p> <p>The drainage density of an area is significant for the speed with which water travels through the system (Small, 1989). Simple barriers, such as hedgerows, can have a profound effect on the speed at which water moves through the hydrological cycle (Heathwaite et al., 2005).</p>
<p>Habitat</p>	<p>Habitat, through its link to vegetation type and soil type, has an important influence on water quantity. This is linked largely to the structure of the vegetation present. Mature woodland provides the most vegetative benefits to water quantity regulation (Nisbet et al., 2011) through the following processes:</p> <ul style="list-style-type: none"> • Vegetation cover provides a number of functions in relation to rainfall interception. It dissipates its energy and reduces its erosivity. It delays its

movement, increases the opportunity for evaporation or absorption into the soil and allows the soil to store water for longer (Teklehaimanot et al., 1991; Crockford and Richardson, 2000; Farmer et al., 2003; Baines, 2008).

- The structural diversity slows overland flows and creates root channels, both of which increases the chance of water infiltrating the soil.
- The retention of water in the soil is increased through enhancing organic soil content (Gupta and Larson, 1979; Brady and Weil, 2002) from leaf litter (Melilo et al., 1989; Angers and Caron, 1998; Rasse et al., 2005).

In many areas an increase in built up infrastructure (namely concrete or tarmac surfaces) that is unable to absorb rainfall has resulted in the alteration of water flow and increased the risk of surface water flooding (Bolund and Hunhammar, 1999; Pauleit and Duhme, 2000; Perry and Nawaz, 2008; Van Wyk, 2014).

Biomass and canopy height are important influences on water quantity. The more levels of vegetation structure within the canopy, the higher the interception rate and transpiration potential (Teklehaimanot et al., 1991; Crockford and Richardson, 2000; Viramontes and Descroix, 2003). Additionally, the efficiency of interception of precipitation is influenced by leaf area, which differs between tree species (Crockford and Richardson 2000).

The distribution of roots in the soil profile determines how different vegetation types absorb soil water (Brady and Weil, 2002). Deep rooted plants are able to effectively slow water movement (Calder et al., 2008). The root system opens the soil structure, creating a large capacity for water storage (Angers and Caron, 1998; Gyssels et al., 2005; Lavelle et al., 2006). The roots of shallow rooting species, such as annuals, have little effect on water holding capacity.

Above ground species richness of vegetation can result in varying rooting depths being present in an area (Silvertown, 2004; Mommer et al., 2010) with varying influences on the soil water storage potential (Angers and Caron, 1998; Gyssels et al., 2005; Lavelle et al., 2006). Species diversity can also mean a varied structure of the vegetation present within an area, with several structurally diverse layers of vegetation intercepting more water (Farmer et al., 2003).

Macro fauna, especially earthworms, have a strong influence on soil water holding capacity by aerating the soil and maintaining an open structure, which is more effective at storing water (Brussaard, 1997; Carter, 2004; Lavelle et al., 2006).

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