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National Ecosystem and Ecosystem Service Mapping Pilot for a Suite of Prioritised Services

Appendices

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Department of Arts, Heritage,
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National Ecosystem and Ecosystem Service Mapping Pilot for a Suite of Prioritised Services- Appendices

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Appendix A Findings of the Review of Mapping and Assessment Tools

A description of the mapping and assessment tools that were reviewed together with a commentary on their applicability for the project is provided below. Open access tools are marked with an asterisk in the title.

A.1 ARIES*

ARIES (ARtificial Intelligence for Ecosystem Services) software is designed for rapid ecosystem service assessment and valuation. It considers supply, demand and flow equally in order to quantify the ecosystem service. The core purpose of the technology is to integrate socio-economic and environmental data in one system via a web-based GIS tool. It assesses benefits and has been used to model carbon sequestration, river and coastal flood regulation, freshwater supply, sediment regulation, fisheries, recreation, aesthetic viewsheds, and open-space proximity values.

ARIES outputs include maps and quantitative data on ecosystem services. It requires a good level of understanding of geospatial modelling and requires knowledge of the k.Lab software tool environment. Details of actual ecosystem services mapped and the type of attributes used or applied was not available at the time of review. It is under development for a web interface. Costings were not available.

A.2 Co$ting Nature*

Co$ting Nature is a web based policy-support tool for natural capital accounting and analysis of ecosystem services provided by natural environments. Mapped outputs are generated and the software identified beneficiaries of the ecosystem service including assessing social impacts.

The tool calculates a baseline for current ecosystem service provision and allows a series of interventions (policy options) or scenarios of change to be used to understand their impact on ecosystem service delivery. A number of ecosystems services including water, carbon, tourism and hazard mitigation are included which can be combined with maps of biodiversity to provide the cost associated with protecting nature or delivering conservation policy. It is free for non-commercial uses.

Co$ting Nature includes four ecosystem services and is a fixed web-based software with limited opportunity for adaption to reflect the research aspect of displaying ecosystems service indicators for a range of prioritised services. Therefore it was not considered further for use in the project.

A.3 EcoServ-GIS*

EcoServ-GIS[1] is a Geographic Information System (GIS) toolkit developed by Durham Wildlife Trust for mapping ecosystem services at a county or regional scale. It uses input GIS/map data to generate fine-scale maps that illustrate human need or demand for ecosystem services as well as the capacity of the natural environment to provide them.

The tool utilises a modified version of the Common International Classification for Ecosystem Services (CICES)[2] ecosystem service classification. It includes the facility to model provisioning, regulating and cultural services with an additional tool to grade green space according to the opportunities it provides for enjoying nature and wildlife (Durham Wildlife Trust, 2013). Phase 1 of the tool development was completed in December 2012, while the next phase was due to start in April 2013. The modelling system uses basic algorithms within an additive raster function environment within ArcGIS Model Builder.

EcoServ-GIS is a freely available toolkit designed to be used in conjunction with Ordnance Survey Great Britain data only using ArcGIS and would need adapting to work with OSi Ireland map data so was not considered further.

A.4 InVEST*

InVEST[3] is an open source GIS-based ecosystem service mapping and valuation tool which was created by the Natural Capital Project for mapping and valuing ecosystem services provided by land and seascapes. It operates 18 modelled ecosystems that require specific data attribute types. The 18 models are fixed and the output maps provide information about the condition of the environment and processes, with the final maps expressed as a biophysical or function quantity or a monetary valuation. It is free to access.

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[1] EcoServ-GIS http://www.durhamwt.co.uk/2013/02/version-1-of-the-ecosystem-services-mapping-toolbox-ecoserv-gis-is-now-ready-for-release/

[2] CICES http://cices.eu/

[3] InVEST http://www.naturalcapitalproject.org/InVEST.html

Due to the fixed specifications of the tool it was difficult to assess if the tool was flexible enough to be able to adapt to and explore the different opportunities for ecosystem service mapping and assessment in Ireland.

A.5 Land utilisation capability indicator (Polyscape)

Land utilisation capability indicator (LUCI, formerly known as Polyscape) is a GIS toolbox which uses multiple criteria analysis to explore the impacts of decisions on land use or management changes (Jackson et al, 2013). It was designed as a negotiation tool to enable engagement with land owners and stakeholders by incorporating local knowledge and validation into the model (Jackson et al., 2013). There are six tools included in the suite which look at current and potential impacts of land management change and synergies and trade-offs.

At present LUCI is not available for general release and is only considered on a case-by-case basis due to being a prototype. As a result it was not considered further for this project.

A.6 SCCAN

SCCAN (System Cynorthwyo Cynllunio Adnoddau Naturiol/Natural Resource Planning Support System), developed by Countryside Council for Wales and Environment Systems, is an ecosystem service mapping system that aims to assist people in taking an ecosystems approach in their decision making (Countryside Council for Wales, 2012).

The approach has been applied at a strategic/national level down to county level mapping (Countryside Council for Wales, 2012). The mapping system has subsequently been further developed to deliver into the SENCE tool, which incorporates both a top down and bottom up approach to ecosystem services modelling and mapping. This approach is flexible as it works on a variety of scales and collates information on a wide range of ecosystem services. This allows users to set priorities and assess the competing demands that are placed on natural resources. The modelling system uses an evidence based rule base and basic algorithms within an additive raster function environment to create spatially explicit mapped outputs.

A.7 SENCE

SENCE (Spatial Evidence for Natural Capital Evaluation) provides information to support evidence based decision-making on ecosystem services in a spatial context. This includes maps, diagrams and reports. It has been developed by Environment Systems Ltd and is based on the concept that any area of land, to a greater or lesser extent, is capable of contributing to one or more ecosystem services. That capability is based on factors including habitat, soil and geology, landform and hydrology, how land is managed and how it is culturally understood.

The applicability of SENCE in Ireland was considered a fit due primarily to its ability to be manipulated to accept a wide range of data sources at different scales and its ability deliver outputs for a variety of ecosystem services. SENCE is a participatory GIS system as is operated by in-house consultants. However, the concepts and approach is detailed in the *Spatial framework for assessing evidence needs for operational ecosystem approaches*[4] and *Further development of a spatial framework for mapping ecosystem services*[5]. SENCE has been applied both in the UK and overseas with the toolkit supporting the mapping and data output to meet the needs of the stakeholders in widely differing environments.

[4] http://jncc.defra.gov.uk/page-6241

[5] http://jncc.defra.gov.uk/page-6690

Appendix B Workshop 1 Outcomes

Environment SYSTEMS evidence and insight

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

Provision of National Ecosystem and Ecosystem Services map for Ireland for a suite of prioritised services

Workshop 1 (15.09.2015) Report

September 2015

Version No. 2

Fabis consulting

TEAM

National Parks & Wildlife Service

National Ecosystem and Ecosystem services Map for a Suite of Prioritised Services
Stakeholder Workshop Report

Report commissioned by National Parks and Wildlife Service of the Department of Arts, Heritage and the Gaeltacht, Ireland.

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1. Introduction

1.1. The workshop report

This report provides a summary of the first stakeholder workshop, together with pre-workshop email communications, for the project "Provision of National Ecosystem and Ecosystem Services map for Ireland for a suite of prioritised services".

The report thematically follows the workshop agenda (see Appendix 1). It is intended to provide sufficient information to allow for further input and feedback from stakeholders who attended the workshop and from those who were unable to attend.

We would welcome your views, please contact our Project Manager at Environment Systems Ltd neil.parker@envsys.co.uk (+ 44 (0)1970626688).

1.2. Ecosystem Assessment in Ireland

The focus on ecosystem services taken in this project is shaped by three main considerations:

- the economic importance of the benefits we derive from nature, making it necessary to manage the natural environment with these benefits in mind;
- the need for an integrated approach to assessing these benefits, as each area of terrestrial, freshwater or marine habitat can potentially contribute to several services; and,
- the need to consider trade-offs: Managing for one service only could lead to negative changes in other services that ultimately outweigh the gains that were envisaged to arise from management of the one service originally considered.

Through documents and efforts such as the Millennium Ecosystem Assessment, Mapping and Assessment of Ecosystems and their Services (MAES), and Ireland's National Biodiversity Plan, the need to spatially plan for and manage ecosystem services and the living processes that underpin them is gaining increasing acceptance in policy and legislation.

The ecosystem services considered are roughly split into three categories: provisioning (things directly gained from nature, such as food or timber), cultural (e.g. benefits from recreation or sense of place) and regulation & maintenance (e.g. the regulation of our climate, clean air and water). All of these groups of services rely on healthy levels of biodiversity, the underlying driver for all ecosystem services.

Due to the underpinning importance of biodiversity for ecosystem service provision, the resilience of ecosystem services is an additional consideration under the ecosystem approach. Resilience measures how healthy the ecosystems are and how likely they are to remain healthy when faced with environmental changes. Considering the resilience of a system is particularly important, as detectable changes in service provision can lag behind the changes in the environment that are ultimately causing them. The functioning biodiversity of Ireland's marine and terrestrial system are intrinsically linked to the resilience of ecosystems and this project will help map and describe these functions.

This project is a step towards establishing a National Ecosystem Assessment (NEA) for Ireland and will provide an evaluation of the data sources currently available for such an assessment. It will also identify data and knowledge gaps, which can guide future research needs.

The aims of the project are:

- Identifying the most important ecosystem services in Ireland, and understanding which habitats or ecosystems support these services;
- Developing indicators for selected ecosystem services, using existing and available data;
- Collating and preparing data, modelling and mapping the selected ecosystem services across Ireland; and,
- Presenting outputs and recommendations at a stakeholder workshop, as well as preparation of a final report outlining methods and identifying key gaps in knowledge and data

This project seeks to exploit existing data and local expert knowledge, as gained through planned stakeholder input into the project. This workshop formed part of this stakeholder engagement and also served to provide consensus on the most important ecosystem services in Ireland.

1.3. Workshop objectives

The main objectives of the workshop were to:

- Create awareness and support for of the project aims to the stakeholders;
- Discuss data availability and suitability with stakeholders;
- Provide a summary of the workshop outcomes suitable both for workshop attendees and stakeholders who could not attend; and
- Encourage further stakeholder input.

1.4. Attendees

Twenty stakeholders attended the workshop in person, an additional five stakeholders have provided feedback, comments and/or data via email.

Twelve organisations were represented:

- Bord Na Mona
- Department of Communications, Energy & Natural Resources (Geological Survey of Ireland)
- National University of Ireland Maynooth
- Office of Public Works
- Trinity College Dublin
- University College Dublin
- Department of Environment, Community and Local Government
- Environmental Protection Agency
- National Parks & Wildlife Service
- Teagasc

2. Terminology: How do we talk about ecosystem services?

Talking about ecosystem services requires a clear terminology for the services themselves, as well as the pressures on them and the ecological structures, processes and functions that underpin them.

For example, agricultural land use delivers a range of provisioning services. However, the land use activities associated with it can impact on the natural environment through, for example, habitat loss or fertiliser input. Therefore, in addition to being a provisioning service, agricultural land use is a pressure upon other services, such as natural flood control, erosion, water quality and climate regulation, as well as upon the biodiversity underpinning these services. The cascade model (Figure 1) shows the link between biophysical structures, ecosystem services, and our social / economic system.

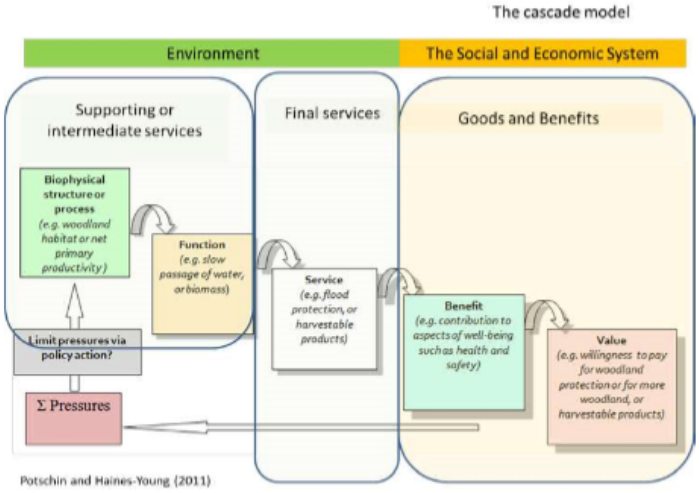

Figure 1: Cascade model of ecosystem service provision

The ecosystem service provision of an area depends on the Biophysical structures and processes that occur within it. These include features such as the way water cycles through an area. These biophysical processes depend very much on the habitats and species present in an area, both above and below ground in the soil. Therefore, mapping of habitat type can explain a large part of the biophysical processes present in an area, which, in turn, enables understanding of ecosystem service provision. Additionally, biodiversity can be mapped as the key factor underpinning the provision of all ecosystem services and creating resilience and stability of ecosystem service delivery over space and time.
The ecosystem services that are ultimately of policy concern are considered in classifications such as The Common International Classification of Ecosystem Services (CICES) as shown in Figure 2.

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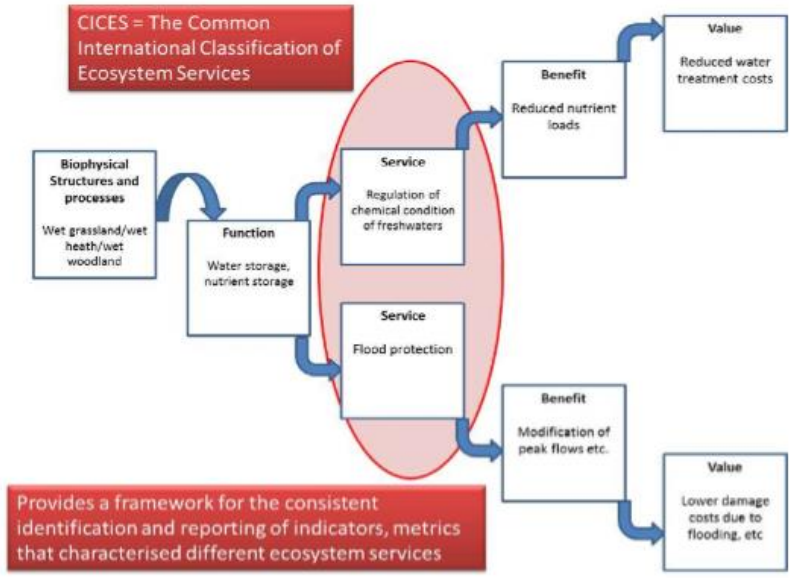

Figure 2: How habitat mapping and CICES classifications fit in an ecosystem service provision approach

The CICES classification is hierarchical in structure, splitting the most general types at the uppermost at Section level (e.g. provisioning or regulating services) successively through Division, Group and Class to Class type, the most detailed level. The example in Figure 3 shows how cereals are nested into the hierarchy. This type of framework helps to provide consistency in analysis because it helps people make consistent comparisons between studies and over time, as well as helping translate between studies that have used different ways of describing ecosystem services. It also provides a set of reporting categories and descriptors for all ecosystem service related work that reflect policy concern.

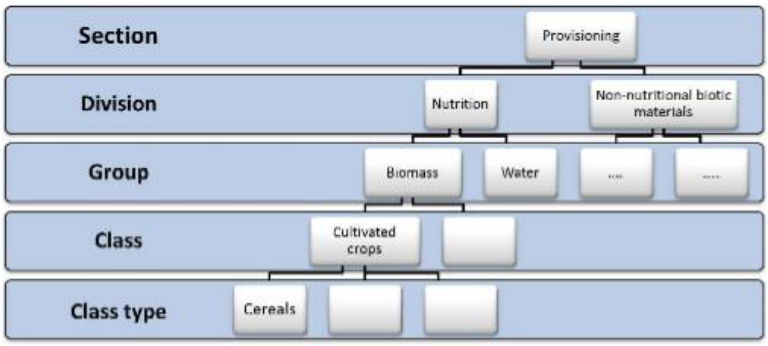

Figure 3: Structure of the CICES classification – illustrated for the case of cereals.

4

3. Approach to the project: Ecosystem service mapping

The project will use the SENCE approach to ecosystem service mapping, showing the contribution of each area of land to the services under consideration. SENCE (**S**patial **E**vidence for **N**atural **C**apital **E**valuation) is a rule-based approach developed by Environment Systems Ltd. for the JNCC. It brings together of a range of available datasets, as well as expert knowledge and local characteristics.

The SENCE approach aims at efficiently using the most suitable, existing data for analysis. Therefore, data collection, preparation (e.g. pulling together two data sets, the strength of which lie in different areas), and assessment of suitability form a major part of the project workings (see section 3.1 and 3.2) and also identify data and knowledge gaps as an output provided in addition to the maps.

The assessment of each parcel of land for the provision of each of the services to be assessed relies primarily on a set of key factors:

- Land cover (Which habitat type is present?);
- Spatial context (Where is the habitat, e.g. relating to topography, to rivers and to climatic zones);
- Underground (What type of soil and geology is the area underlain by);
- Management (Which type of management is applied to the land); and
- There are a range of cultural services that area related to the land that can be regarded as a separate group of key factors or considered under management

These key factors are weighted according to how favourable they are for the generation of each of the services and then combined in an overlay analysis (Figure 4). The results of the overlay analysis can be further improved upon by additional, supporting data, such as species records or condition assessments.

Therefore, the process of ecosystem service mapping starts by mapping as many of these biophysical proxies and supporting data as possible, at an appropriate scale for the region of interest. Then, for each ecosystem service to be mapped, the related biophysical proxies and supporting data are identified and combined in a scientific rulebase for the overlay analysis. This rulebase is based on scientific literature and expert knowledge; the process of rulebase creation also facilitates the identification of knowledge gaps.

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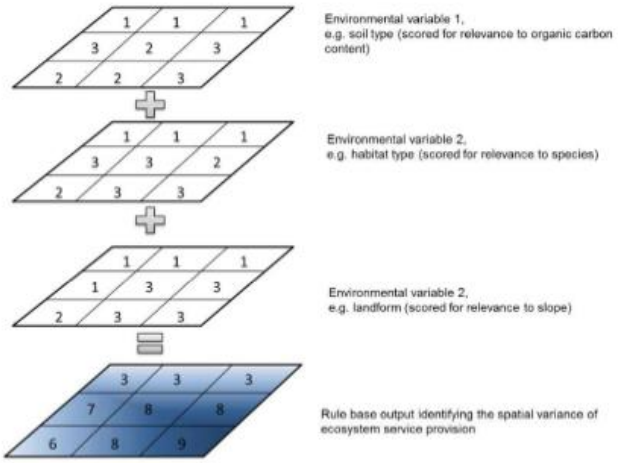

Figure 4: Schematic representation of the overlay analysis used in the SENCE approach to ecosystem service mapping.

The output consists of a set of maps, illustrating where in the landscape the generation of a service is likely to be (or predicted to be) high or low, and a set of opportunity maps, showing where in the landscape the potential for enhancement of a service is particularly great (Figure 5).

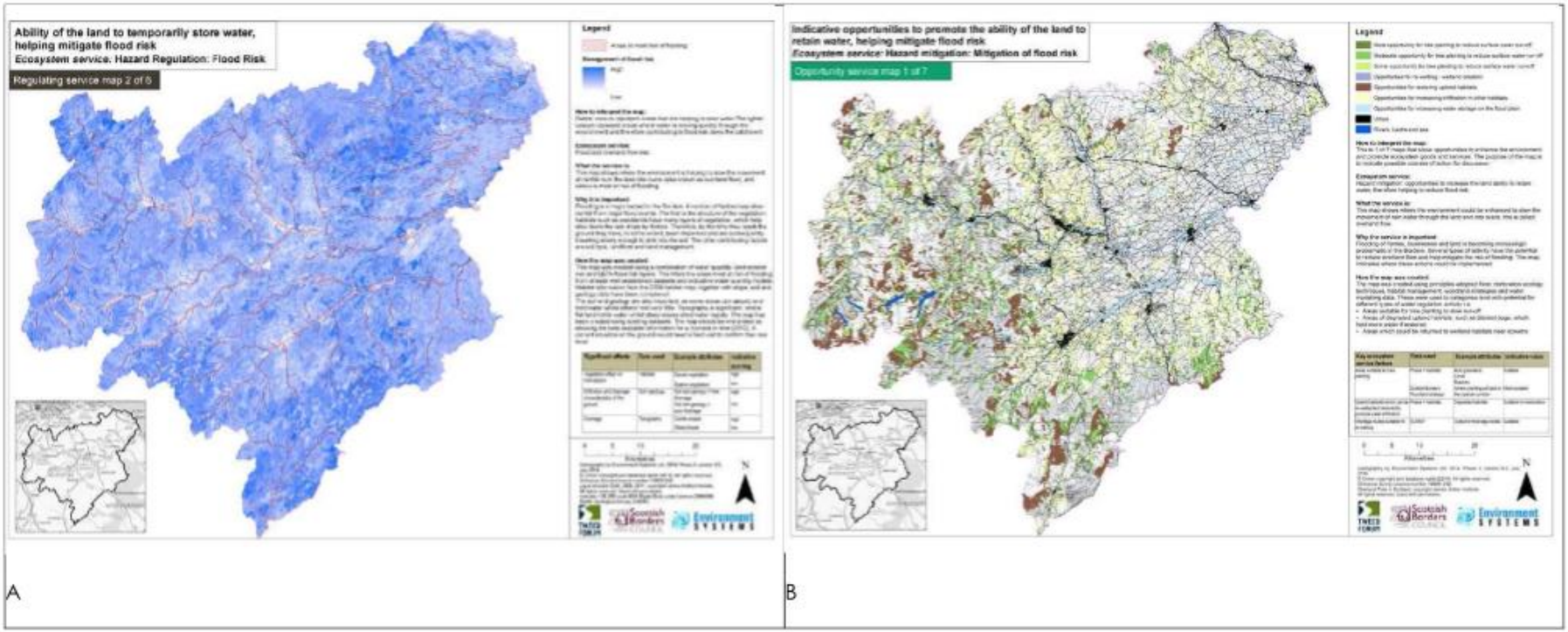

Figure 5: Example of ecosystem service maps taken from the Scottish Borders regional Land Use Pilot; 'A' shows the ability of the land to temporarily store water helping mitigate flood risk and 'B' shows existing opportunities to enhance this function.

Additionally, the overall value of each area of land is illustrated through multi-benefits maps. These maps move from the focus on individual ecosystem services and/or ecosystem service bundles, as adopted in stock and opportunity maps, to a wider focus on ecosystem service provision in general by highlighting areas that are important for the provision of multiple ecosystem services at once.

3.1. What data is available for Ireland?

The project work carried out to date has been centred on identifying data availability and suitability. This process started with NPWS sourcing in excess of 300 datasets, collected by a wide variety of institutions (See Appendix 2 for a list of data providers). The majority of these datasets map biophysical properties at a national scale (both terrestrial and marine), with a particular focus on habitat data. Other types of data include, for example, census data, environmental monitoring, historic sites and agri-environment data. Data was also provided by local authorities, so that some of the data available was identified as being suitable for use at a local planning scale. In the frame of this project, this facilitates a local case study in addition to ecosystem service mapping at a national scale. Which data is suitable for mapping of which services and at which scale will be further detailed in an ecosystem service data tool provided as one of the main outputs of this project; the tool will allow the user to look up which data is needed to map a service or which services could be mapped with the data at hand, including information on the scale of mapping possible.

Prior to the workshop, data layers that can be used for mapping of the key factors had been identified, as well as some supporting layers (Table 1).

Table 1: Datasets used for the mapping of the key factors under SENCE

Key Factor (SENCE approach)	Dataset identified/ available	Comments
Spatial context: Where is the habitat, e.g. relating to topography?	**Landform**: A digital terrain model, showing elevation, is available for the whole of Ireland with a 5m resolution; this resolution is considered suitable for mapping at national, as well as more local scales	From this dataset, additional layers can be derived; examples include slope, relevant for the speed of water flow through the landscape, and convexity, showing where water will most likely be retained in the landscape.
	Bathymetry – A bathymetry dataset with good coverage exists	Datasets on water masses and current systems will be included in all cases where this is considered to add to the final mapping output
Land cover Which habitat type is present?	**Terrestrial and Freshwater Habitats**: A Corine habitat layer with recent (2012), full coverage of Ireland forms the basis for the habitat map.	Due to limitations regarding both the habitat classes and the spatial resolution, the Corine data will be supplemented with other national scale habitat data.
	Freshwater Habitats: Data from the Water Framework Directive	This will be used to add additional information to the freshwater habitats, going beyond the classification as "Water bodies" as given in the Corine dataset.
	Terrestrial Habitat: Additional layers with more detailed data on specific habitats or habitat types	~20 datasets to be used for the national habitat layer have been selected with the help of NPWS. This includes, for example, Article 17 data, upland surveys, forestry data, and a national hedgerow dataset. In addition to the national scale habitat map, case studies can be carried out in areas with high quality habitat data. This could include areas with Fossitt data (detailed habitat classes) or areas with habitat maps derived from satellite imagery (high spatial resolution).

Key Factor (SENCE approach)	Dataset identified/ available	Comments
	Marine habitat: EMODnet map used for broadscale information, Collated Seabed Substrate data from the Marine Institute for detailed classes in inshore water	For case studies, detailed targeted habitat maps are available for four marine sites
Underground What type of soil and geology is the area affected by?	**Terrestrial soil**: Teagasc data sets on soils and subsoils will be used at all scales of mapping	
	Geology: Additionally, geological data on bedrocks exists	This will be incorporated where this will add to the final mapping output
	Marine: Layer detailing the sediment type for the majority of the marine environment within the area of interest (also used as information regarding habitats).	Bedrock information for the marine is at a much lower resolution than it is for terrestrial areas
Climate	**Rainfall**: A layer detailing the annual average rainfall throughout Ireland	Will be used for the mapping of all ecosystem services sensitive to variations in rainfall.
Management Which type of management is applied to the land?	**Terrestrial**: Data on the boundaries of various areas under differing conservation designations; **Marine**: Data on the boundaries of areas under differing conservation designations	Will also consider risk and condition data on the habitat / soil quality and pressures

3.2. Comments and discussion arising from the workshop

At the workshop and following the workshop, further data sets were identified that will be considered for use in the mapping. In addition, further information was provided about the datasets that had already been identified (Table 2). This type of feedback is particularly valuable to the project. If any further information is available, there is still the opportunity for this to be taken into account by the project. Please contact: neil.parker@envysys.co.uk

Table 2: Comments regarding data applications and sources gathered during the workshop

Key Factor (SENCE approach)	Dataset the comment refers to	Comments and information given by workshop participants
Land cover Which habitat type is present?	Water bodies – from OSi	It was suggested that this might be the most accurate spatial extent of information on ponds and water
	Spring point OSi (1:5000)	This could also add to the modelling accuracy for water quality
	Species data: various types of species data exists	Will be included in all cases where this will improve the final mapping output Species data will, for example, be used as supporting data for biodiversity value mapping, to assign a higher value to areas were species of conservation concern were observed and a lower value to areas were negative indicator species or invasive species were recorded
	Freshwater habitats / fisheries	Particularly with regards to the Freshwater Pearl Mussel, freshwater habitats are considered to be of importance, as are the fisheries taking place in freshwater environments
	Forestry	The 2007 forestry layer was mentioned to be of limited use, with the forest service national inventory having been put forward as an alternative; the Forestry 2012 data is also an option for use

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Key Factor (SENCE approach)	Dataset the comment refers to	Comments and information given by workshop participants
Underground What type of soil and geology is the area affected by?	Terrestrial soil:	In the Teagasc soils layer, the differentiation between peat and cut-away peat was based on 1995 imagery, which should be considered when using the soil layer to further inform on the type of habitat present. Once maps on cutaway-peat have been updated, maps using this layer could be updated using the new information.
	Geology:	Additionally, geological data on bedrocks exists. There is additional geology information beyond the type of bedrock; these could be of particular use to water quality modelling.
Management Which type of management is applied to the land?)	Historic features	Could be used in order to exclude sites that do not allow for modification from opportunity maps.
	Archaeological sites:	Similar to historical features, these could be used to exclude these areas from any opportunity maps, as modification of these sites is not possible
	Agri-environment programme (GLAS)	GLAS replaces previous AE schemes; it supports the 2020 strategy and the National Biodiversity plan and is, therefore, more focussed on biodiversity than previous schemes. Would data detailing which areas of land are managed under agri-environment schemes help in scoring? The shapefiles from the GLAS mapping could be incorporated into opportunity mapping. This could make it useful for later incorporation into the biodiversity layer, particularly as success indicators going beyond uptake measure have been developed. Mapped opportunity outputs could help the scheme to make the move from negative, constricting language to talking about the measures as opportunities
	Recreational data	Depending on the type of recreational use, it has been suggested that, in addition to informing about cultural value, this data could in some cases inform about pressures or exclude areas of very high value from opportunity mapping
	Land Parcel Information System (LPIS)	This will help improve the habitat map by filling in the manged landscape in terms of arable or grazing regime and could also help to roughly quantify grazing intensity
	Commonage:	Data detailing the areas managed as commonage exists. Commonage has been mentioned as an important part of Irish land management.
	Designated sites	It was put forward that only few designation will results in active management for conservation; this will have to be considered when using data on site designation as supporting layer for, for example, biodiversity value mapping
	HNV indicator: data on high nature value farmland	This data could help to differentiate between different types of farmland when mapping biodiversity value

4. Identification of the prioritised ecosystem services

To make the best ecosystem service framework for Ireland, it is important to identify the key issues and services provided. The workshop considered the suite of prioritised services (including pressures/indicators). Suggestions put forward at the 1st steering group meeting (in advance of the workshop) included:

- Biodiversity
- Natural Systems Modification
- Agriculture
- Water quality
- Forestry
- Climate change
- Food security
- Pollution
- Peat industry
- Aquaculture and Coastal Interaction
- Flooding
- Land Management and Ownership (including protected sites)
- Invasive species
- Renewable Energy

This resulted in a list of suggestions for mapping to be further discussed at the workshop; this selection was based both on the suitability of the service for mapping and the importance the steering group attributed to the service:

- Provisioning services:
  - Food
  - Timber
- Regulating services
  - Water quality
  - Coastal flooding and erosion
  - Soil erosion
- Significant functional characteristics
  - Ecological networks
  - Biodiversity
- Cultural services
  - Sense of place
  - Recreation

The prioritised services will provide example outputs for the ecosystem service maps being produced as part of this project. They will help provide an evidence-based tool for policy development and land use management decision making. Additionally, the mapping exercise will provide the opportunity to identify data and knowledge gaps relating to individual services and can, therefore, help in targeting future research.

4.1. Comments and discussion

During the discussion at the workshop the following features were mentioned by the stakeholders as of particular significance to Ireland (Table 3). The results of the session have been grouped by the titles suggested by the steering group in the pre-workshop discussions.

Table 3: Ecosystem Service Priorities identified from the workshop

Suggested ES priorities by the steering group	Priorities identified by stakeholders form the workshop
Provisioning services:	
Food	Agriculture Angling community Marine Spatial Plan Fisheries / Licensing
Timber	Forestry
Regulating services	
Water quality and Coastal flooding and erosion	Water quality

	WFD: Programmes of Measures, ICV – Catchment modelling 'Pathway' NFM- Drainage of Marginal Land Pollution (Bacterial, Chemical, Nutrients, Sediment, Organic Matter and oxygen demand) Diffuse pollution and Agriculture (Septic tanks) → Sensitivity of habitats to pollution → Karst soils and spring lines as proxies for sensitivity → quality of water entering estuaries / the coastal zone could affect shellfish / shellfish fisheries Development planning
Soil erosion	Mining – Peat extraction Erosion
Climate change regulation	GHG (Carbon) Carbon storage
Significant functional characteristics that can be mapped	
Ecological networks	Landscape diversity Resilience
Biodiversity	Peat habitats / management Marine Spatial Plan Resilience Landform change and wetland loss
Cultural services	
Sense of place	Peat – Historical, Cultural Landscape and LU patterns unique Landscape characterisation
Recreation	Recreation
	Rural economy Development and rural development Urbanisation

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All the areas identified by the steering group were confirmed by the discussion with the stakeholders in the workshop. A particular link was made to the number of services and functions relating to water quality in the freshwater, terrestrial and marine environment. In addition, the role of peat in carbon sequestration and the importance of peat in the rural economy was also identified by the workshop group. The interlinkages are shown in Figure 6:

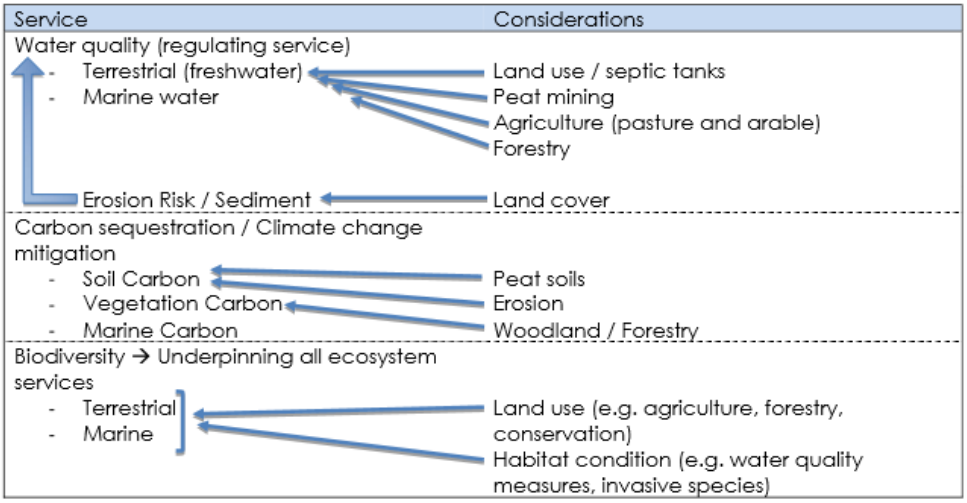

Figure 6: Interaction of key functions and ecosystem services identified

Following this discussion and the review of available data by the project team these services will be grouped into those that can be mapped as part of this project; those which could be mapped in subsequent work; and those where data gaps will need to be filled in order to progress their mapping.

5. Incorporating local knowledge into ecosystem service evaluation

The last session of the workshop sought to gather knowledge from local experts regarding considerations specific to Irish ecosystems, as this has an influence on how scoring is applied. For example, ecosystems in countries such as Ireland are heavily influenced by rainfall, which will lead to different approaches to scoring and evaluation between Ireland and drier countries.

Accumulating knowledge of the characteristics of Ireland that local experts consider unique or otherwise worthy of consideration is a way of tailoring the SENCE approach to fit Ireland.

To achieve this, four questions were put forward for discussion. These questions and the responses are shown in the boxes below:

1. Are there habitats/species you would consider 'unique' to, or very well represented, in Ireland? (key factor: Land cover)

Alkaline fens / ferns	Lough Hyne
Atlantic blanket bog	Machair
Bombus distinguendus	Maërl (reef algae, Aran Islands)
Bombus muscorum (Aranis)	Margatifera (-ve)
Chough	Ochthebius nilssoni
Coldwater coral	Oligotrophic hardwater lakes
Cryptic wood white butterfly	Otter
Drumlins + Eskers	Petalwort
Fuschia (-ve)	Petrifying springs
Gas escape structures (sub-marine cliffs)	Raised bogs
Hyperoceanic bryophytes	Rhododendron (-ve)
Irish Damselfly	Roseate tern
Irish hare	Slender naiad
Irish pollan	Snakes (there are none)
Killarney fern	Submarine cliffs
Killarney Oakwoods	Turloughs
Crayfish	
Large, shallow lowland lakes	
Limestone pavement / Karst landscape (Burren, Ealway, Roscommon)	

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National Ecosystem and Ecosystem services Map for a Suite of Prioritised Services
Stakeholder Workshop Report

2. How does land management differ between Ireland and other countries? (key factor: Management)

Grass-based agriculture	Dispersed, rural housing
Less broad-leaved woodland	"Tidy" farms
Smaller holdings	Planning policy
Accessibility	Abandonment
More burning	Subsidy-dependent Agriculture
Low percentage of state owned land	Inheritance and change in farming approach
Smaller fields, less intensive hedgerow management	High dynamic between crop and pasture
Dense network	Density of road network – rural
Ditches?	Drainage
Stone walls	

3. Can you think of any characteristics of Ireland / Irish habitats that could affect scoring? (Relates to all four key factors)

Land ownership (private)	Peat cutting
Dispersed tenant farming	Storms and extreme weather (particularly coastal – coastal hydrodynamic)
Inheritance and change in farming approach	Public education (e.g. limited from NGOs)
Diffuse pollution from unmaintained housing/septic tanks/ cess pits etc.	Few public foot paths / rights of way
Planning policy resulting in dispersed housing.	Lack of strong NGO sector
Seasonal fertilizer system	Commonage (more sheep – more money)
Lack of Enforcement?	From over- to under-grazing
Burning as a habitat management tool (eligibility issue)	East vs. West
Scrub clearance (to make areas eligible for claiming CAP payments)	Depopulation (emigration and move to cities)
High phosphate susceptibility (Land management approach in areas of high rainfall and clay soils)	Lack of stewardship
	Illegal dumping and fly tipping

4. Which species in Ireland are of particular conservation concern? (Relates to scoring of Biodiversity Value under the SENCE framework)

Species of conservation concern	Species (non-native/invasive etc.) harming or replacing natural Irish ecosystems
• Fresh water pearl mussels	• Tree species – Ashback die back disease
• Alpine plants ('strange' distribution)	• Sitka spruce
• Bats	• Lodgepole pine
• Wet plants / ferns / bryophytes	• Seagulls
• Slugs / snails	• Grey squirrel (Interaction with Red squirrel and pine martin)
• Seabirds / migrating birds / breeding waders (curlew, lapwing)	• Shrew
• Raptors	• Gunnera – flat, wet land
• Reef-forming algae	• Rhododendron – Peat, acidic soils
• Cetaceans / marine mammals	

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National Ecosystem and Ecosystem services Map for a Suite of Prioritised Services
Stakeholder Workshop Report

- Corncrake
- White-clawed crayfish
- Greenland white-fronted goose
- Barnacle Goose
- Marsh-fritillary butterfly
- Chough
- Tree sparrow
- Bees – decline (Pesticide, habitat modification, trade and related disease)
- Japanese Knotweed
- Diadema – Not yet, but of concerns
- Crassostrea - bivalves
- Harlequin ladybird – Starting to spread
- Signal crayfish
- Lagerasiphon
- Asian Clam
- Sika deer
- Giant hogweed
- Himalayan Balsam
- Mink (widespread)

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References

Potschin, M. B., & Haines-Young, R. H. (2011). Ecosystem services Exploring a geographical perspective. Progress in Physical Geography, 35(5), 575-594.

Appendix 1 – Workshop agenda

National Ecosystem and Ecosystem Service Map for a set of Prioritised Services

Tuesday 16th September,

Agenda

10:00 - 10:30	Gather and refreshments	
10:30 - 10:40	Welcome and introductions	Gemma Weir
10:40 - 11:10	Introduction: the Ecosystem approach, ecosystem service maps and how they can be used	Katie Medcalf
11:10 - 11:30	Discussion and Questions	
11:30 - 11:50	Data - The power behind the maps – Introduction – and our vision for the project The four key factors and Irelands data	Gemma / Katie
11:50 –12:30	Creating the best maps for Ireland – Data discussion: Landform Habitat Soils Management Climate Cultural	Katie / Elsa
	Lunch	
13:30 – 13:55	Understand Ecosystem Service Terminology	Roy
13:55 – 14:10	Discussion and Questions	
14:10 – 15:00	What are our most important Ecosystem Services	Neil
15:00-15:30	How will the scoring of the services differ for Ireland Discussion and Questions	Katie
15:30 – 16:00	AOB	

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Appendix 2 – List of data providers

EPA – Water Framework Directive Data, CORINE, Water Quality Data, River and Lake Catchment Data

DAFM – Forest Service - Forest Cover Data

DAFM – LPIS data

DAFM/EPA (TCD) – Interpolated LPIS /landcover Data

DCENR – Marine Survey Data

DCENR (GSI) – Geology Data, Bathymetry & LiDAR Data

DCENR (PAD) – Administrative and Energy Resource Exploration Data

CMRC – Marine Transport Networks & Infrastructure

CSO – Census data

European Marine Observation Data Network (EMODnet) – Marine Habitat Maps

ICES – Fisheries Data

IFI – Angling Data

NEAFC – Fisheries Administrative Areas

OPW – Flood Data

OSi – Mapping Data

OSPAR – Marine Data

SEAI – Sustainable Energy Data

Teagasc – Soils & Subsoils, Landcover, Habitats and Hedgerows Data

UCD – Peatlands Data

JNCC – Marine Habitats data

Marine Institute – Data from Marine Atlas (Fishing Data, Marine Habitats)

Appendix C Workshop 2 Feedback Report

Environment SYSTEMS evidence and insight

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

Provision of National Ecosystem and Ecosystem Services map for Ireland for a suite of prioritised services

Workshop 2 (15.11.2015) Summary of stakeholder feedback

December 2015

Version No. 1

Fabis consulting

TEAM

National Parks & Wildlife Service

1. Introduction

This document provides a summary of the feedback collected during the second stakeholder workshop for the project "Provision of National Ecosystem and Ecosystem Services map for Ireland for a suite of prioritised services". Stakeholders were presented with questions regarding the draft ecosystem service maps. In addition the approach to ecosystem service mapping and the applicability of the maps to existing and future areas of research to operationalise ecosystem services concepts in Ireland was discussed.

1.1. Workshop objectives

The main objectives of the workshop were to:

- Create awareness and support for implementing the ecosystem approach with the support of stakeholders;
- Present and discuss the draft maps;
- Discuss applicability of the ecosystem approach to various fields of research and policy making; and
- Provide a summary of the workshop outcomes suitable both for workshop attendees and stakeholders who could not attend.

1.2. Attendees

Around 40 stakeholders from environmental, nature conservation, water and agricultural organisations and institutions throughout Ireland attended the workshop in person. Stakeholders included:

- National Parks & Wildlife Service
- Trinity College Dublin
- Environmental Protection Agency
- Teagasc
- Bord Na Mona
- Department of Communications, Energy & Natural Resources (Geological Survey of Ireland)
- National University of Ireland Maynooth
- Office of Public Works
- University College Dublin
- Department of Environment, Community and Local Government (DECLG),
- DAHG Built Heritage
- Marine Institute, Department of Agriculture, Food and the Marine, DECLG – Spatial Planning, Dublin City Council
- Birdwatch Ireland
- Irish Water
- Irish Forum on Natural Capital
- Woodlands of Ireland

2. Feedback regarding the draft maps

The following draft maps were presented at the workshop:

- Draft: Habitat Asset Register for Ireland
- Draft: Habitat Asset Register for Ireland – Data Sources
- Draft: Marine habitats
- Draft ES map: Soil carbon
- Draft ES map: Vegetation carbon
- Draft ES map: Marine carbon
- Draft ES map: Terrestrial food
- Draft ES map: Land temporarily storing water
- Draft ES map: Water quality
- Draft opportunity map: Indicative opportunities to enhance water quality

Stakeholder feedback

Following the presentation session to provide background information on how the project had developed and how the maps were created, the stakeholders were encouraged in their own time to review the maps and provide comment. Stakeholders were given the opportunity to review at the draft maps produced in their own time and to explore some of the issues of using the existing data to create maps. Facilitators from the project team were present for stakeholders to ask questions or make suggestions regarding possible improvements to or omissions in the maps, as well as discuss potential applications of the maps.

- Draft: Habitat Asset Register for Ireland
  - It would be good to distinguish further within bog habitats, as degraded and active bogs behave differently dependant on the ecosystem service function being assessed.
  - Distinguishing more within the areas mostly used as grazing land would be good, as the patches of semi-natural habitat can be important for ecosystem service provision in these areas.
  - Turloughs are recognised as important habitats throughout Ireland and should be included, even in a national scale map.
- Draft: Habitat Asset Register for Ireland – Data Sources
  - The area covered by Corine data is very high – Instead of only taking information regarding arable land out of LPIS, more detailed information about the type of grazing land could also be used.
- Draft: Marine habitats
  - The marine habitats beyond the 12 nautical mile boundary are also of interest for some ecosystem services. It would be better to map the whole EEZ / Ireland's continental shelf region.
- Draft ES map: Vegetation carbon
  - Dublin City Council is carrying out ecosystem service mapping in city parks; this project includes mapping of trees and the carbon potential and air potential associated with them
- Draft ES map: Marine carbon
  - No comments

- Draft ES map: Soil carbon
  - The value of peat storage could be adjusted to better represent Irish peat, particularly if degraded and functioning areas were distinguished further than they currently are.
  - There is a known data gap for acid podzols. This would be important to remark upon in the final reporting.
  - A project exists that looks at mineral soil over peat subsoils which are being drained. This data could be used to enhance the carbon maps if made available.
- Draft ES map: Terrestrial food
  - Due to the mix of wild food provision and terrestrial food provision the map is a bit difficult to interpret
  - Distinguishing further within the grassland could make mapping of food provision associated with livestock more accurate
- Draft ES map: Land temporarily storing water
  - The weighing of the layers might be a bit off, as some areas known for high water quality are currently scored quite low.
- Draft ES map: Water quality
  - Distinguish between types of pollutants: Soluble, Turbidity, Insoluble
  - Susceptibility / risk maps exist
    - WFD Risk assessments (www.wfdireland.ie/docs)
    - EPA risk assessment / ranking for septic tank inspections
  - Risk to surface water = overland flow pathway
    - This area should be red
      - Wet soils (gleys) – Teagasc
      - Low permeability subsoils - GSI
      - Low vulnerability - GSI
  - Karst areas (red circle)
    - Areas of bare karst
    - Areas of karst with soil cover + subsoil cover – can be „punctured" by sinkholes
    - Once contaminants in the ground water system, will travel km's in a day
    - No filtration
    - Ground water vulnerability map → areas at highest risk that contaminants can enter groundwater
    - Risk to surface waters is mainly through subsurface pathways
  - Soils – wet / dam / peat / deep / shallow
  - Subsoils
    - Sand, gravel, fine sand, silt → Good filtration, percolation
    - Silt/clay, Clay → Poor percolation / infiltration → surface runoff
  - Bedrock aquifers: Fracture or conduit flow – no / very little attenuation can be very rapid flow (karst
  - Sand / gravel aquifer: Intergranular flow – good filtration
  - Groundwater vulnerability: degree of protection of underlying groundwater given by subsoils. What doesn't go down goes sideways or over land

  - Groundwater recharge coefficient map: Indicates what portion of effective rainfall can infiltrate to water table
- Draft opportunity map: Indicative opportunities to enhance water quality
  - Why is the whole of Dublin an opportunity area?
  - It would be better to have the legend option specific, the gradient is confusing
  - Existing high value resource areas a bit problematic, as they currently cover many areas of degraded peat – habitat-specific options exists for these areas, for example reduced stocking density

3. Feedback on the ecosystem service approach in decision making

A questionnaire and group discussion session to gain further insight into stakeholder's thoughts on applicability of ecosystem service mapping in their areas of work was completed. The key outputs from this session included defining policy areas where the application of ecosystem services would be most effective and the usefulness of the different components of mapping ecosystem services.

3.1. Implementation of Ecosystem Services in Policy

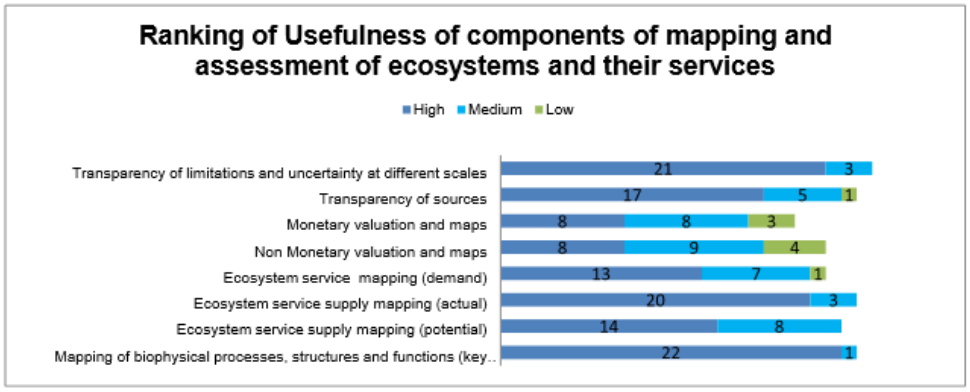
Strategic planning and natural resource management were identified as the policy areas of greatest importance where the ecosystem approach could be implemented to the most effect. This is closely followed by supporting biodiversity strategies, flood risk management and national and regional economic and spatial strategies. Other policy areas included marine spatial planning, bioenergy planning, tourism and human well-being assessments for specific projects and programme effects.

3.2. Application of the various components of Ecosystem Service Mapping

The draft maps also offered opportunity for stakeholders to discuss how useful the different components of ecosystem service mapping could be. The outcome shows that the identification of limitations to existing data and how it is applied is very useful to understand when using for decision making. At the same time the use of mapping the biophysical characteristics of ecosystems can be really useful.

It was clear that setting the baseline of actual ecosystem service supply is important to establish. This will allow for the supply and demand of those ecosystem services to be mapped and generation of opportunities to potentially deliver enhanced goods and benefits.

Valuation, both monetary and non-monetary, were not considered as useful as the other components of ecosystems service mapping. This is perhaps due to the project focusing on the biophysical characteristics of ecosystems for mapping and future valuation studies which are combined with this type of mapping may support a greater evidence base on which to create clear and transparent methods for valuation of ecosystem services.



4. Summary

The stakeholder workshop provided an opportunity for the project team to showcase the early findings of the research. This included the concepts of ecosystem services and mapping indicators of ecosystem services.

During the review session constructive ideas were suggested by the stakeholders on how different indicators could be used to enhance the drafted maps. This led into discussion groups where stakeholders could refine those ideas into comments and opinions on how the mapping and assessment of ecosystems and their services can be used to build more resilient social and economic growth by managing the environment in a more sustainable manner.

Over the following months the final maps will be completed using additional data identified during the workshop and the final project report will be prepared. The project report will detail the methods and findings of the study as well as identifying known limitations and data gaps, and recommend areas for further research and implementation of ecosystem services in Ireland.

Appendix D Ecosystem Theme, Pressure and Policy Matrix

Analysis of interaction between issues (rows) and policy relevance (columns) used for prioritisation of ecosystem services.

Note: over-arching policy drivers and legislation which cut across all areas are the EU Habitats and Birds Directives, Wildlife Acts, Actions for Biodiversity, the national biodiversity plan 2011 - 2016; and Our Sustainable Future, the sustainable development framework published in 2012.

Issue	Detailed Issue Description	Policy relevance			
		Biodiversity	Agriculture	Water Management	Soil Protection
Aquaculture + coastal area (marine, terrestrial and interface)	Lack of impact assessment for aquaculture / mariculture in Natura 2000 sites an important issue in recent years, to be rectified in response to ECJ ruling in 2008; Some concerns over nutrient enrichment and use of chemicals exceeding assimilative capacity; Shellfish: mussel bed development / seed harvesting may conflict with bird conservation, also a threat of introduced invasive species (non-native shellfish as invasive species and vectors); Ongoing controversy over impact of salmon farms on sea lice infestations in wild fish, which research suggests may be significant.	Judgment of the Court of Justice of the European Union in Case C 418/04 Commission v Ireland	National Strategic Plan for Sustainable Aquaculture 2015; Food Harvest 2020	Water Framework Directive; (which includes Shellfish Protected Areas) Bathing Water Directive, Marine Strategy Framework Directive	
Agriculture	Policies aimed at increasing agri-food output may lead to increases in nitrate runoff and intensification of grazing pressure; Ireland has a derogation from EU Nitrates Directive limits for lands where strict rules are in place, however nitrate pollution is increasing in some areas. Upland burning to encourage young shoot growth for livestock also a concern.	Food Harvest 2020; Agri-Environment Options Scheme; GLAS agri-environment scheme; NPWS Farm Plan Scheme	Food Harvest 2020; Agri-Environment Options Scheme; GLAS agri-environment scheme; NPWS Farm Plan Scheme	Water Framework Directive; Drinking Water Directive; Bathing Water Directive	EPA Soil Protection Strategy; EU Soil Thematic Strategy

Issue	Detailed Issue Description	Policy relevance			
		Biodiversity	Agriculture	Water Management	Soil Protection
Peat Industry and smaller scale turf harvesting	Whilst major impacts on peat resource and bog ecosystems relate to industrial peat harvesting for energy and horticulture, many pressing concerns relate to smaller scale peat extraction, land drainage and burning of peatland vegetation. Large scale (industrial) peat extraction saw some decline between mid-90s and 2012. The effects of peat harvesting include impacts on water quality (colour & turbidity) and flood risk, impacts on soil quality & structure, and cultural heritage impacts.	National Peatlands Strategy		Water Framework Directive; Drinking Water Directive	EPA Soil Protection Strategy; EU Soil Thematic Strategy
Forestry	Previous plans (2011-13) to divest some of national forest estate & sell harvesting rights met with public opposition, became highly politicised for a while. Main national forest company (Coillte - part-owned by government but operating as a private company) seeking to branch out into energy sector and increasingly engaged in tourism; some issues associated with acidification of surface waters from conifer plantation and extensive plantation of non-native species in peatland areas. National incentive schemes have encouraged small holders to take up forestry, often in marginal areas or farms, including planting of native species. This private plantation has been a significant proportion of forest expansion since late-1990s and remains a forest policy priority. The DAFM Forest programme 2014-2020 (https://www.agriculture.gov.ie/forestservice/) sets out to develop an internationally competitive and sustainable forest sector that provides a full range of economic, environmental and social benefits to society and which accords with the Forest Europe definition of sustainable forest management	Native Woodland Scheme	Food Harvest 2020; Agri-Environment Options Scheme; GLAS agri-environment scheme; NPWS Farm Plan Scheme	Water Framework Directive; Drinking Water Directive	EPA Soil Protection Strategy; EU Soil Thematic Strategy

Issue	Detailed Issue Description	Policy relevance			
		Biodiversity	Agriculture	Water Management	Soil Protection
Renewable energy	The last 15 years have seen increasing interest in wave and tidal energy, particularly off West coast. Wind farm development pressure has been an issue in SPAs (Birds Directive); several large scale developments have been planned or are in planning across Irish midlands, with significant public opposition (largely on aesthetic grounds), and have become highly politicised. Overall development of micro-renewables limited due to lack of supporting structures (e.g. agreement over feed-in tariffs), though grant aid schemes for homes have been popular. The use of plant biomass for energy production has increased and is projected to do so over next 5 years. This includes emerging crops such as Miscanthus, oilseed and willow, as well as use of forest residues.				
Flooding	Several counties and districts are at increasing risk of flood damage associated with higher intensity rainfall and storm surges; esp. in cities of Cork, Limerick & Dublin; also parts of Clare, Galway, Roscommon, Westmeath, and Louth. Winter 2015/2016 saw widespread, prolonged flooding and significant damage; development in flood plains a significant contributory factor. Other major flooding events also occurred in previous years (2012, 2008). The OPW Catchment Flood Risk Assessment and Management programme (CFRAM) is developing flood risk management plans for reduction and management of flood risk (http://www.cfram.ie).	Implementation of CFRAMs	Food Harvest 2020	Floods Directive; Water Framework Directive; Drinking Water Directive; Bathing Water Directive	EPA Soil Protection Strategy; EU Soil Thematic Strategy

Issue	Detailed Issue Description	Policy relevance			
		Biodiversity	Agriculture	Water Management	Soil Protection
Water quality (inland and coastal)	EPA monitors sewage discharges to surface waters and water quality in coastal zone; some concerns in recent years over the quality of wastewater treatment, though the EPA states situation is improving. This is linked to flooding, as outwash from storm drains and sewage systems, and damage to drainage infrastructure caused by flood events, impact on surface waters including drinking water supplies.	Implementation of CFRAMs; Invasive Species Action Plans; EPA catchment management programme, Regulation of Public water supplies	Food Harvest 2020; Nitrates Directive	Water Framework Directive; Drinking Water Directive; Bathing Water Directive;	EPA Soil Protection Strategy; EU Soil Thematic Strategy
Integrated Coastal Zone Management	Government commissioned a detailed and ambitious ICZM strategy in 1997, but not implemented in any coordinated or systematic manner. Strategy reviewed for Heritage Council in 2004. Will become a major policy issue in the next decade with increased demands and pressures on coastal zone ecosystems (aquaculture, tourism, sea level rise, coastal erosion, flooding & storm surge etc.).	People, Place & Policy: Growing Tourism to 2025		Water Framework Directive; Drinking Water Directive; Bathing Water Directive	
Land management and ownership (protected sites)	Land ownership & private land use planning are subject to competing pressures between management of privately owned areas and nature conservation designation of Natura 2000 sites. Conflict over turbary rights (peat extraction) has been a significant issue in the past 10 years.	County Heritage / Biodiversity Plans	Food Harvest 2020; Agri-Environment Options Scheme; GLAS agri-environment scheme; NPWS Farm Plan Scheme	Floods Directive Water Framework Directive; Drinking Water Directive; Bathing Water Directive	EPA Soil Protection Strategy; EU Soil Thematic Strategy
Food security	Food security not a significant issue - food sovereignty may be more relevant. Agri-food policy seeks to increase Ireland's global market share in livestock produce (meat, dairy etc.). Some policies / programmes promote Irish food to Irish consumers highlighting use of local produce, environmental quality etc.		Food Harvest 2020		EPA Soil Protection Strategy; EU Soil Thematic Strategy
Nitrogen deposition	The major source of N deposition in Ireland is agriculture (as NH3). Issue likely to require long term monitoring and management as policies to increase livestock production are implemented.		Food Harvest 2020; Nitrates Directive	Water Framework Directive; Drinking Water Directive	EPA Soil Protection Strategy; EU Soil Thematic Strategy

Issue	Detailed Issue Description	Policy relevance			
		Biodiversity	Agriculture	Water Management	Soil Protection
Invasive species	Some high profile invasive spp. include Rhododendron in National Parks and Natura 2000 sites, Gunnera in peatlands, Spartina in coastal flats; Some spp. associated with health impacts incl. giant hogweed. Issue has been linked to agricultural use of fertilisers.	National Invasive Species Database; Invasive Species Action Plans	GMO licencing programme		
Air pollution	Air pollution not a significant concern, largely due to prevailing winds across the country; Increasing reliance on private transport / lack of sustainable public transport options for most of the population has been associated with some recent spikes in air pollution; also, although monitoring suggests key indicators are within EU limits, some important for health are above WHO guidelines, which may be adopted in future by EU (PAH, PM10, PM2.5)....		Food Harvest 2020		
Natural system modification (e.g. land drains, canalisation etc. changing landscape processes)	Drainage of wetland and grassland sites is a major cause of ecosystem disruption - particular impacts have been peatland degradation, soil erosion and water pollution. Industrial pollution affecting natural systems (e.g. acid deposition) less of an issue than pre-2000s, though harmful algal blooms resulting from changes in nutrient cycles have impacted water quality with public health implications in some inland waters and in the coastal zone.	County Heritage / Biodiversity Plans	Food Harvest 2020; Agri-Environment Options Scheme; NPWS Farm Plan Scheme	Floods Directive; Water Framework Directive; Drinking Water Directive; Bathing Water Directive	EPA Soil Protection Strategy; EU Soil Thematic Strategy
Climate change	Ongoing political debate over role of Ireland in contributing to Europe's emissions and to mitigation strategies; no concrete adaptation strategy in place (previous strategy ended 2012). New Climate Change Bill published January 2015.	Climate Action and Low-Carbon Development Policy	Food Harvest 2020	Floods Directive; Water Framework Directive; Drinking Water Directive;	EPA Soil Protection Strategy; EU Soil Thematic Strategy

Issue	Detailed Issue Description	Policy relevance			
		Biodiversity	Agriculture	Water Management	Soil Protection
Cultural heritage	Differences in community perspectives on heritage have been polarising and a root of conflicts relating to land use, nature conservation and infrastructure development in the past 15 years. Notable examples include conflicts over landscape change at Hill of Tara, and ongoing battles over peatland conservation.	Culture 2025			
Tourism	Tourism figures increasing steadily year in year since 2010, 2015 'record; year in tourist numbers. Has been a key element of Irish policy for economic recovery since 2008, reflected across a range of policies including taxation, land use planning, FDI schemes etc.	People, Place & Policy: Growing Tourism to 2025			

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Rural Spatial planning and land use	Coastal Zone management	Marine	Urban development	Forestry / Woodland management	Landscape quality
Aquaculture + coastal area (marine, terrestrial and interface)		Judgment of the Court of Justice of the European Union in Case C 418/04 Commission v Ireland	Harnessing Our Ocean Wealth; Food Harvest 2020			Historic Landscape Characterisation in Ireland (guidance document); National Landscape Strategy for Ireland 2015-2025; DECLG Landscape Character Assessment Guidelines
Agriculture	National Spatial Strategy; Rural Planning Guidelines					National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)
Peat Industry and smaller scale turf harvesting	National Spatial Strategy; National Peatlands Strategy; Rural Development Plan					National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)
Forestry	National Spatial Strategy				Forest, Products and People (forestry policy review) 2014; Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review; Irish National Forest Standard; Code of Best Forest Practice	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Rural Spatial planning and land use	Coastal Zone management	Marine	Urban development	Forestry / Woodland management	Landscape quality
Renewable energy	National Spatial Strategy; Rural Development Plan; Wind Energy Development Guidelines 2006		Harnessing Our Ocean Wealth		Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)
Flooding	National Spatial Strategy; Rural Development Plan	National Spatial Strategy; Rural Development Plan	Harnessing Our Ocean Wealth	National Spatial Strategy	Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review	National Landscape Strategy
Water quality (inland and coastal)	National Spatial Strategy; National Peatlands Strategy; Rural Development Plan		Harnessing Our Ocean Wealth; Food Harvest 2020	Sustainable urban drainage (SuDS)	Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review	National Landscape Strategy
Integrated Coastal Zone Management	National Spatial Strategy; Rural Development Plan		Harnessing Our Ocean Wealth; Food Harvest 2020			National Landscape Strategy; National Spatial Strategy
Land management and ownership (protected sites)	Rural Development Plan; National Development Plan; National Spatial Strategy		Food Harvest 2020		Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)
Food security			Harnessing Our Ocean Wealth; Food Harvest 2020			
Nitrogen deposition						

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Rural Spatial planning and land use	Coastal Zone management	Marine	Urban development	Forestry / Woodland management	Landscape quality
Invasive species					Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review	
Air pollution			Harnessing Our Ocean Wealth			National Waste Management Policy 2012
Natural system modification (e.g. land drains, canalisation etc. changing landscape processes)			Food Harvest 2020		Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)
Climate change	Rural Development Plan; National Development Plan; National Spatial Strategy		Harnessing Our Ocean Wealth	National Development Plan; National Spatial Strategy	Forest Programme 2014 - 2020; Native Woodland (Conservation) Scheme 2015; Forest Policy Review	
Cultural heritage	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)					National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)
Tourism	Fáilte Ireland regional initiatives					National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Cultural heritage	Pollution and related health risks (e.g. air quality)	Health Promotion	Climate Change	Energy	Tourism
Aquaculture + coastal area (marine, terrestrial and interface)	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)	Marine Strategy Framework Directive. EU likely to increase regulations on use of pharmaceuticals in aquaculture over next 5 years.			Ocean Energy Strategy for Ireland (2005; has some implications for CZM); SEAI established Coastal Energy Development Unit 2008.	People, Place & Policy: Growing Tourism to 2025; National Landscape Strategy
Agriculture	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)			Climate Action and Low-Carbon Development Policy	Climate Action and Low-Carbon Development Policy	
Peat Industry and smaller scale turf harvesting	Irish National Strategic Archaeological Research Programme; National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)			Climate Action and Low-Carbon Development Policy	Climate Action and Low-Carbon Development Policy	
Forestry	Irish National Strategic Archaeological Research programme; National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)			Climate Action and Low-Carbon Development Policy	Climate Action and Low-Carbon Development Policy	People, Place & Policy: Growing Tourism to 2025

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Cultural heritage	Pollution and related health risks (e.g. air quality)	Health Promotion	Climate Change	Energy	Tourism
Renewable energy	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)			Strategy for Renewable Energy 2012 - 2020; Ocean Energy Strategy for Ireland 2005; Climate Action and Low-Carbon Development Policy	Strategy for Renewable Energy 2012 - 2020; Ocean Energy Strategy for Ireland 2005; Climate Action and Low-Carbon Development Policy	
Flooding	National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document	National Emergency Management planning (see note under Non-policy Drivers - Natural Hazards)		Climate Action and Low-Carbon Development Policy		
Water quality (inland and coastal)	Irish National Strategic Archaeological Research Programme	National Implementation Plan on Persistent Organic Pollutants 2012; National PCB Management Plan 2008; Healthy Ireland Strategy 2013 - 2025	Healthy Ireland Strategy 2013 - 2025			
Integrated Coastal Zone Management			Healthy Ireland Strategy 2013 - 2025	Climate Action and Low-Carbon Development Policy		

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Cultural heritage	Pollution and related health risks (e.g. air quality)	Health Promotion	Climate Change	Energy	Tourism
Land management and ownership (protected sites)	Irish National Strategic Archaeological Research Programme; National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)					People, Place & Policy: Growing Tourism to 2025
Food security		Healthy Ireland Strategy 2013 - 2025	Healthy Ireland Strategy 2013 - 2025	Climate Action and Low-Carbon Development Policy		
Nitrogen deposition						
Invasive species						

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Cultural heritage	Pollution and related health risks (e.g. air quality)	Health Promotion	Climate Change	Energy	Tourism
Air pollution		Air Pollution Act (Specified Fuels) Regulations 2012 ; Air Quality Standards Regulations 2011; Ozone Ambient Air Regulations 2004; (Heavy metals) & PAH in Ambient Air Regulations 2009; National Implementation Plan on Persistent Organic Pollutants 2012; National PCB Management Plan 2008; EPA Guidance on ERA for Unregulated Waste Disposal Sites 2007; National Waste Management Policy 2012	Healthy Ireland Strategy 2013 - 2025	Climate Action and Low-Carbon Development Policy		
Natural system modification (e.g. land drains, canalisation etc. changing landscape processes)	Irish National Strategic Archaeological Research Programme; National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)					

Issue	Policy relevance (Continued)					
see previous section of table for issue description	Cultural heritage	Pollution and related health risks (e.g. air quality)	Health Promotion	Climate Change	Energy	Tourism
Climate change				Climate Action and Low-Carbon Development Policy	Climate Action and Low-Carbon Development Policy	
Cultural heritage	Culture 2025; Irish National Strategic Archaeological Research Programme; National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)					Ancient Spaces Capital Grants Scheme
Tourism	Irish National Strategic Archaeological Research Programme; National Landscape Strategy; Historic Landscape Characterisation in Ireland (guidance document)			Climate Action and Low-Carbon Development Policy		People, Place & Policy: Growing Tourism to 2025

Issue	Non-policy Drivers		
see previous section of table for issue description	Economics	Natural Hazards	Societal Considerations
Aquaculture + coastal area (marine, terrestrial and interface)	Livelihood uncertainty and insecurity for fishing communities	Increased storm intensity and frequency in coastal zone emerging as a concern for aquaculture installations	
Agriculture		Increasing flood risks and higher rainfall in recent years have had locally significant impacts on farming community, particularly west of the Shannon	
Peat Industry and smaller scale turf harvesting	Perception of reliance of rural households on fuel turf for heating / cooking	Large scale peat harvesting has had aesthetic visual impacts. Effects on surface water quality. Changes in peatland hydrology may be linked to increased flood risk	Perceptions of inequality have emerged as a key social & political issue, which may be reflected in perceptions and attitudes to environmental regulation.
Forestry			Earlier proposals to sell portions of national forest estate to overseas logging firms caused significant public protest; Coillte (state forestry company) commissioned an assessment of non-market values of Ireland's forests.
Renewable energy			
Flooding		National Emergency Management planning - no formal strategy in place, but National Directorate for Fire & Emergency management has a role to play in major incidents including major pollution incidents, landslides, flooding etc.	Increasing housing demand particularly in main cities is an issue which has led to increased development in flood plains without sufficient risk assessment or mitigation.
Water quality (inland and coastal)	Lakelands and Inland Waterways Strategic Plan 2013 - 2016	National Emergency Management planning	Increased public demand for inland and coastal waters recreation - sailing, surfing, bathing etc.
Integrated Coastal Zone Management			
Land management and ownership (protected sites)			Increasing housing demand particularly in main cities

Issue	Non-policy Drivers		
see previous section of table for issue description	Economics	Natural Hazards	Societal Considerations
Food security	Development of artisan foods seen as important aspect of tourism development associated with various government financial incentive schemes.		Economic downturn from 2008 saw significant growth in local food markets and allotment gardening, still prevalent over much of the country.
Nitrogen deposition		N deposition has been associated with coastal dead zones, and harmful algal blooms in inland waterways (though P likely more important in that regard) (http://www.nine-esf.org/sites/nine-esf.org/files/ena_doc/ENA_pdfs/ENA_c17.pdf)	Harmful algal blooms made headlines from 2000 due to pet deaths and human illness caused by bathing in polluted rivers and lakes; significant improvement since then but localised instances still a concern.
Invasive species	Invasive Species Ireland has put the costs of invasive species in the Republic at over €161 million (2013)	Several invasive species pose public health risks - direct (e.g. giant hogweed) or indirect (e.g. Rhododendron) (http://invasivespeciesireland.com/toolkit/invasive-plant-management/terrestrial-plants/giant-hogweed/)	Insufficient public awareness and enforcement of legislation surrounding release of non-native species into the wild)
Air pollution			Air pollution linked to health risks.
Natural system modification (e.g. land drains, canalisation etc. changing landscape processes)	Lakelands and Inland Waterways Strategic Plan 2013 - 2016		Increasing housing demand particularly in main cities
Climate change			Survey by Sustainable Energy Authority of Ireland (2015) suggests only half of the population see climate change as a major threat to Ireland.
Cultural heritage	Economic value of Ireland's historic heritage put at over €1.5 billion in 2012, supporting over 350,000 jobs (Heritage Council, 2012).	Climate change seen as a threat to many of Ireland's historic sites, including historic natural sites / folkloric sites associated with biodiversity.	Awareness of / concern for biodiversity and other aspects of heritage declining in Ireland, according to Heritage Council surveys since 2005; however, local attachments to heritage surface as sources of conflict over land use and development panning.

Issue	Non-policy Drivers		
see previous section of table for issue description	Economics	Natural Hazards	Societal Considerations
Tourism	Fáilte Ireland surveys reveal overseas visitors' perceptions of Ireland's environment and heritage seen as the key reasons for travelling to the country. Promotion & development of Wild Atlantic Way has been a key attraction in 2015.		Irish Film Commission and Irish Film Board Strategy both promoting Ireland heavily as a film location following major investments & financing of global film & television events in past 20 years - linked to increased tourism numbers in recent years.

Appendix E Waterford Symposium Ecosystem Service Prioritisations and Groupings

The table below shows the prioritisation of services by each of the four Waterford[6] workshop breakout groups (Agro-ecosystems, Forests, Freshwater, and Marine). Priorities are indicated by an 'x'. Also shown are the suggested merging of CICES classes by each group., Each colour block represents one proposed, merged class (e.g. Agro-ecosystems group proposed merging four classes under Provisioning/Biomass/Water into one class (as indicated by purple colour)).

Section	Division	Group	Class	Agro-ecosystems	Forest	Freshwater	Marine
Provisioning	Nutrition	Biomass	Cultivated crops	x			
			Reared animals and their outputs	x			
			Wild plants, algae and their outputs		x	x	x
			Wild animals and their outputs		x	x	x
			Plants and algae from in-situ aquaculture				
			Animals from in-situ aquaculture				x
		Water	Surface water for drinking	x	x	x	
			Ground water for drinking	x		x	
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing		x		
			Materials from plants, algae and animals for agricultural use		x		
			Genetic materials from all biota		x		x
		Water	Surface water for non-drinking purposes	x		x	
			Ground water for non-drinking purposes	x		x	
	Energy	Biomass-	Plant-based resources	x	x		x

[6] Symposium on the Mapping and Assessment of Ecosystem Services, hosted by National Biodiversity Data Centre in Waterford IT February 2014.

Section	Division	Group	Class	Agro-ecosystems	Forest	Freshwater	Marine
		based energy sources					
			Animal-based resources				x
		Mechanical energy	Animal-based energy				
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals			x	x
			Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals			x	x
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	x	x	x	
			Dilution by atmosphere, freshwater and marine ecosystems			x	
			Mediation of smell/noise/visual impacts				
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates		x		x
			Buffering and attenuation of mass flows			x	
		Liquid flows	Hydrological cycle and water flow maintenance	x	x	x	x
			Flood protection	x		x	x
		Gaseous / air flows	Storm protection	x		x	x
			Ventilation and transpiration				
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	x		x	

Section	Division	Group	Class	Agro-ecosystems	Forest	Freshwater	Marine
			Maintaining nursery populations and habitats		x	x	x
		Pest and disease control	Pest control			x	
			Disease control				
		Soil formation and composition	Weathering processes			x	
			Decomposition and fixing processes	x		x	
		Water conditions	Chemical condition of freshwaters	x		x	
			Chemical condition of salt waters				
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	x	x	x	x
			Micro and regional climate regulation		x		x
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings		x	x	x
			Physical use of land-/seascapes in different environmental settings	x		x	x
		Intellectual and representativ	Scientific	x	x	x	x

Section	Division	Group	Class	Agro-ecosystems	Forest	Freshwater	Marine
		e interactions					
			Educational		x	x	x
			Heritage, cultural	x	x	x	x
			Entertainment		x		
			Aesthetic	x	x	x	
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	x	x		
			Sacred and/or religious				
		Other cultural outputs	Existence		x		x
			Bequest		x		x

Appendix F CICES Sub-classes for Ireland

These sub-classes also form part of the MS Access Database containing the All Ireland Matrix and which also indicates the relationship to mapped outputs.

See table below for additional information sources and references.

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Cultivated crops	Grain crops	The top four commercially grown grain crops in Ireland are wheat, barley (feed and malting), oats and maize; associated with large areas of land principally in the east and south east. (1)	Agriculture, Water, Pollution, Health, Climate change	Grain crops, pollinated crops, market vegetables	Areas of land supporting food production
Cultivated crops	Pollinated crops	Includes soft & hard fruits, some salad and other vegetables, foliage & amenity plants (bulbs etc.), related nursery stock, rape and other emerging oil seeds (e.g. Camelina, flax, hemp). Represents large areas of agricultural land esp. in east & south of the country, also widely grown in market gardens, community allotments etc. A good indicator of economic importance of ES bundles associated with pollinators. (2)	Agriculture, Water, Pollution, Health, Climate change	Grain crops, pollinated crops, market vegetables	Areas of land supporting food production
Cultivated crops	Market vegetables	Other field vegetables not dependent upon pollinators (or not directly dependent on pollination in Ireland, e.g. seeds imported) - principally root vegetables. Again, large areas of agricultural land devoted to these crops in east and south, but also widespread in west and north. Also widely grown in market gardens, community allotments etc. (3)	Agriculture, Water, Pollution, Health, Climate change	Grain crops, pollinated crops, market vegetables	Areas of land supporting food production
Reared animals and their outputs	Dairy and Beef cattle	Cattle production - the major land use in the country. No significant difference in land cover or ecosystem service associations between beef and dairy, although damp grasslands / wet meadows more commonly associated with beef. (4)	Agriculture, Water, Pollution, Health, Climate change	Dairy & Beef, Lamb & Forage	Areas of land supporting food production
Reared animals and their outputs	Sheep	Second most important reared-animal output, covers many similar areas & habitats to cattle, but also widespread in upland areas not suited to cattle. Other reared animals are excluded - while some (poultry, pigs) are economically important, rearing is either largely indoors or not directly dependent on ecosystems; others (deer, goat) are on comparatively minor scales, possibly not sufficient for modelling. (4)	Agriculture, Water, Pollution, Health, Climate change	Dairy & Beef, Lamb & Forage	Areas of land supporting food production

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Wild plants, algae and their outputs	Wild plants, fruits and fungi	Anecdotal evidence suggests that foraging for wild species is increasingly of interest with small but growing commercial value especially in artisan food sector and farmers markets, receiving some government support. Includes woodland, heath and peatland fruits, leaves and nuts, and field & woodland fungi. Peatland fruits emerging in artisanal / health food markets, have future potential. (5)	Agriculture, Tourism, Health, Heritage	Wild plants, fruits and fungi	Areas of land supporting food production
Wild animals and their outputs	Wildfowl	Wildfowl hunting is a popular activity in inland and coastal wetlands and waterways. A 2007 study estimates game shooting involves over 300,000 hunters and generates €41 million for the economy annually. (6)	Agriculture, Tourism, Heritage	Wildfowl, game birds, deer	Areas of land supporting food production
Wild animals and their outputs	Terrestrial game birds	Economic figures for hunting terrestrial game birds do not distinguish between the different forms of game bird hunting (e.g. managed driven bird shoots, rough shooting), but is needed to differentiate from perspective of land & resource management and conservation strategies. (6)	Agriculture, Tourism, Heritage	Wildfowl, game birds, deer	Areas of land supporting food production
Wild animals and their outputs	Deer	The same 2007 study as for game birds, indicates 3,000 licensed deer hunters generating in excess of €8 million per annum. Less culturally significant, but wild venison traded and shared locally is notable from perspective of local food resources. (6, 7)	Agriculture, Tourism, Heritage	Wildfowl, game birds, deer	Areas of land supporting food production
Wild animals and their outputs	Wild salmonid spp.	Includes salmon, brown & rainbow trout and sea trout, in freshwater and coastal areas. Significant and growing economic potential. (8)	Aquaculture, Pollution, Marine, Water, Tourism, Heritage, Health, Climate change	-	Class not mapped
Wild animals and their outputs	Other fish species caught for food	All other fish species caught for food outside commercial sea fisheries. Coastal species include mackerel, herring and numerous flat fish. Many inland species which were formerly important food sources are no longer exploited due to their rarity and legal protection (eel, arctic charr, pollan). These could potentially be re-established as commercial stocks pending successful conservation measures (8, 9)	Aquaculture, Pollution, Marine, Tourism, Heritage, Health, Climate change	-	Class not mapped
Wild animals and their outputs	Coastal shellfish harvest (inshore)	Several species harvested commercially. Rapid development of inshore shellfisheries in late 1990s demonstrated economic potential, but resulted in severe stock depletion in some areas. Mostly licensed now in designated shellfish producing sites, but non-commercial harvesting for personal consumption occurs around the coast. Key species include mussels, clams, cockles, whelks, crab and lobster. (10)	Aquaculture, Pollution, Marine, Tourism, Heritage, Health, Climate change	Coastal shellfish harvest (intertidal) & Commercial sea fisheries	Marine areas that provide food

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Wild animals and their outputs	Commercial sea fisheries	More than a dozen economically important species, but principle species for nursery mapping may include mackerel, hake, whiting, cod, plaice, herring, monkfish, horse mackerel. (11)	Aquaculture, Marine, Tourism, Heritage, Health, Climate change	Coastal shellfish harvest (intertidal) & Commercial sea fisheries	Marine areas that provide food
Plants and algae from in-situ aquaculture	Red / Green / Yellow / Brown algae (splash zone to lower shore)	Several species are used and sold commercially for food, particularly dillisk, carrageen moss, sea lettuce, kelp and some wracks. Also important for use as food additives, emulsifiers, and as animal feed. (12)	Aquaculture, Marine, Pollution, Tourism, Heritage, Health, Climate change	Red / Green / Yellow / Brown algae (splash zone to lower shore)	Marine areas that provide food
Animals from in-situ aquaculture	Coastal aquaculture - finfish (Salmonids)	Reared fish production almost entirely coastal concentrated along the coast west from Cork to Donegal. Salmon is the primary species. (13)	Aquaculture, Marine, Tourism, Heritage, Health, Climate change	Coastal aquaculture, freshwater aquaculture and coastal mariculture	Marine areas that provide food
Animals from in-situ aquaculture	Freshwater aquaculture - finfish (Salmonids)	Freshwater salmon and trout farming distributed throughout the country for commercial food production. Both species and others such as perch also reared for sport and to support restocking programmes in inland waters. Other food species being developed. (13)	Aquaculture, Marine, Pollution, Tourism, Heritage, Health, Climate change	Coastal aquaculture, freshwater aquaculture and coastal mariculture	Marine areas that provide food
Animals from in-situ aquaculture	Coastal mariculture - oysters	Several economically important shellfish now raised around the coast. The markets are somewhat different for each species, so it may be useful to separate the species - also, lobsters and urchins generally reared in more sheltered bays and deeper waters, other species less dependent on shelter. This sub-class does not include indoors shellfish production (e.g. in Co. Louth), which is significant economically but linked to marine genetic resources, more so than to coastal mariculture. (13, 14)	Aquaculture, Marine, Water. Pollution, Health, Climate change	Coastal aquaculture, freshwater aquaculture and coastal mariculture	Marine areas that provide food
Animals from in-situ aquaculture	Coastal mariculture - abalone				
Animals from in-situ aquaculture	Coastal mariculture - mussels				
Animals from in-situ aquaculture	Coastal mariculture - clams				

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Animals from in-situ aquaculture	Coastal mariculture - scallop				
Animals from in-situ aquaculture	Coastal mariculture - lobster				
Animals from in-situ aquaculture	Coastal mariculture - urchin				
Surface water for drinking	Inland waters used for potable water distribution	Major reservoirs supplying mains distribution, and smaller surface waters used in group water schemes and local residential supply. (15)	Water, Agriculture, Pollution, Health, Energy, Climate change	-	Class not mapped
Fibres and other materials from plants, algae and animals for direct use or processing	Red / Green / Yellow / Brown algae (splash zone to lower shore), Subtidal / lower shore Kelp & Maerl beds	Several species of algae are commercially valuable for use in cosmetics and personal care products, in the pharma-chem sector, and as fertilisers. (12, 16)	Aquaculture, Marine, Pollution, Health, Agriculture, Climate change	-	Class not mapped
Fibres and other materials from plants, algae and animals for direct use or processing	Non-food outputs from farmed animals	Includes raw and processed wool and hides and other animal products not destined for human consumption. (17)	Agriculture, Heritage, Climate change, Pollution	-	Class not mapped

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Fibres and other materials from plants, algae and animals for direct use or processing	Forestry plantation	Forestry remains a key economic activity and land use sector (in 2015, forestry accounted for 10.5% of terrestrial land use; steady since 2012 but on upward trend since 1950s), and incentive schemes have been successful in attracting smallholders to develop lands for plantation, including native woodland schemes etc. Wood mainly used in construction and paper production. (18)	Agriculture, Water, Pollution, Climate change, Heritage	-	Class not mapped
Materials from plants, algae and animals for agricultural use	Forage	Fodder and bedding production often occurs as rotation in lands otherwise used for pasture, but locally-extensive areas are dedicated to permanent fodder production. Outputs include grass silage, hay, fodder rape, beets, and maize. (19)	Agriculture, Water, Pollution, Health, Climate change	-	Areas of land supporting food production
Genetic materials from all biota	Red / Green / Yellow / Brown algae (splash zone to lower shore), Subtidal / lower shore Kelp & Maerl beds	Genetic resources important in the nutraceutical, pharmaceutical and biotech industries - several species of particular interest for drug development. (12, 16)	Aquaculture, Marine, Pollution, Health, Agriculture, Climate change	-	Class not mapped
Genetic materials from all biota	Wild fish and shellfish	Research has highlighted important genetic diversity within fish species in Irish waters, representing important genetic resources for conservation and management of wild stocks, and for future development of aquaculture sector, particularly in breeding for fitness and resistance to pathogens. Wild caught fish also important as source of farm stock. (20)	Aquaculture, Marine, Pollution, Health, Agriculture, Climate change	-	Class not mapped
Genetic materials from all biota	Crop Wild Relatives	Crop wild relatives include all wild species that are genetically related to cultivated crops. Essential for crop diversification, resistance breeding, and future resilience in food systems. In Ireland this includes a large number of wild grasses and broad leaved species across all habitat types, but particularly in woodland, heath, grassland, hedgerow and peatland habitats. Irish Crop Wild Relative Database and distribution maps developed by National Biodiversity Data Centre. (21)	Agriculture, Heritage, Health, Climate change	-	Class not mapped
Plant-based resources	Energy crops	An emerging area of crop production, including oilseed rape, Miscanthus (elephant grass), and short-rotation coppicing of willow, hazel and other woody species. (22)	Agriculture, Energy, Climate change, Pollution, Water	-	Class not mapped

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Plant-based resources	Peatland used for turf harvesting	Includes peatlands used for large scale energy production and milled peat for compost (managed / harvested by Bord Na Móna) and numerous bogs used by individuals or local commercial turf suppliers. (23)	Energy, Heritage, Climate change, Water, Agriculture	-	Class not mapped
Hydrological cycle and water flow maintenance	Water storage	Terrestrial habitats and wetlands important for the storage and sustained / mediated release of freshwater; includes all woodlands, dry & wet grasslands, upland heaths, peatlands and swamps etc.	Water, Agriculture, Pollution, Climate change, Health	Water Storage & Mitigation of peak flows	Land that temporarily stores water
Hydrological cycle and water flow maintenance	Mitigation of peak flows (esp. in winter)	Habitats which provide a particular service in buffering against flood risk, or which otherwise store water during periods of highest rainfall; includes callows and callow lakes, turloughs, reed beds, wet woodlands, wet grasslands, and undrained peatlands.	Water, Agriculture, Pollution, Climate change, Health	Water Storage & Mitigation of peak flows	Land that temporarily stores water
Chemical condition of freshwaters	Terrestrial & freshwater habitats which provide nutrient retention and pH buffering	Terrestrial and wetland habitats which regulate inputs of naturally-occurring nutrients into water resources, and which mediate pH regimes, or whose degradation or management approaches may significantly increase nutrient inputs or pH balance. This includes woodlands (conifer plantation has been linked to acidification), grasslands, heaths, peatlands (peatland degradation linked to nutrient excess and acidification) and other wetlands; involves uptake by plants as well as processes in soils.	Water, Agriculture, Pollution, Climate change, Health	Terrestrial & freshwater habitats which provide nutrient retention and pH buffering	Areas of land promoting good water quality
Chemical condition of salt waters	Coastal habitats which provide nutrient retention and pH buffering	Coastal habitats which regulate inputs of naturally-occurring nutrients into water resources, and which mediate pH regimes, or whose degradation or management approaches may significantly increase nutrient inputs or pH balance. This includes salt marshes, tidal rivers & associated wetlands, estuaries, small sheltered bays, and lagoons.	Water, Marine, Aquaculture, Agriculture, Pollution, Climate change, Health	-	Class not mapped
Global climate regulation by reduction of greenhouse gas concentrations	Areas important for emissions reduction	Habitats which are important for carbon storage, or whose degradation poses particular risks of greenhouse gas release. Includes soil and biomass in peatlands and other freshwater wetlands, woodlands, heath, semi-natural grasslands, and coastal marshes and flats. Influenced by species composition, soils, geology, drainage, aspect etc.	Climate change, Agriculture, Marine, Health	Soil Carbon	Soil Carbon

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Global climate regulation by reduction of greenhouse gas concentrations	Areas important for emissions reduction	Habitats which are important for carbon storage, or whose degradation poses particular risks of greenhouse gas release. Includes soil and biomass in peatlands and other freshwater wetlands, woodlands, heath, semi-natural grasslands, and coastal marshes and flats. Influenced by species composition, soils, geology, drainage, aspect etc.	Climate change, Agriculture, Marine, Health	Vegetated Carbon	Vegetated land that stores carbon
Global climate regulation by reduction of greenhouse gas concentrations	Areas important for emissions reduction	Marine sediments and areas of open water which are important for carbon storage, or whose degradation poses particular risks of greenhouse gas release.	Climate change, Agriculture, Marine, Health	Marine Carbon	Marine sediments that store carbon
Mediation by ecosystems	Areas important for reducing pathogen & nutrient pollution risks	Habitats which are associated with filtration, sequestration or assimilation of pollutants, including toxins and pathogenic organisms.	Health, Water, Pollution, Agriculture, Aquaculture, Climate change, Tourism	-	Class not mapped
Experiential use of plants, animals and land-/seascapes in different environmental settings	Settings for open-air activities (e.g. Golfing, Music festivals, Walking, biking, Bird watching in terrestrial & coastal (semi-) natural landscapes)	These three 'activities' sub-classes cover a range of locations associated with recreation and passive tourism. Tourism increasingly focuses on attracting and catering to specialist interests - hiking, surfing, whale-watching, boating etc. It is useful therefore to separate outdoor recreational activities across these three natural settings. These include all restorative, athletic and adventure pursuits. (24)	Heritage, Tourism, Health, Climate change, Water, Marine, Agriculture	-	Class not mapped

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Experiential use of plants, animals and land-/seascapes in different environmental settings	Settings for water-based activities (e.g. boating / sailing, eco-tourism, bird watching on inland waterways and in coastal zone)	These three 'activities' sub-classes cover a range of locations associated with recreation and passive tourism. Tourism increasingly focuses on attracting and catering to specialist interests - hiking, surfing, whale-watching, boating etc. It is useful therefore to separate outdoor recreational activities across these three natural settings. These include all restorative, athletic and adventure pursuits. (24)	Heritage, Tourism, Health, Climate change, Water, Marine, Agriculture	-	Class not mapped
Experiential use of plants, animals and land-/seascapes in different environmental settings	Settings for underwater activities (e.g. diving in coastal and inland waters)	These three 'activities' sub-classes cover a range of locations associated with recreation and passive tourism. Tourism increasingly focuses on attracting and catering to specialist interests - hiking, surfing, whale-watching, boating etc. It is useful therefore to separate outdoor recreational activities across these three natural settings. These include all restorative, athletic and adventure pursuits. (24)	Heritage, Tourism, Health, Climate change, Water, Marine, Agriculture	-	Class not mapped
Physical use of land-/seascapes in different environmental settings	Habitats / species used for hunting and angling	The large numbers of people engaged in hunting and angling indicate the cultural and recreational significance of these activities beyond mere food provision. These pursuits are increasingly part of the tourism base in Ireland. (6, 25)	Tourism, Heritage, Water, Agriculture, Marine	-	Class not mapped
Physical use of land-/seascapes in different environmental settings	Peatland sites associated with turbary	Recent conflicts relating to conservation of Irish peatlands often centred on turbary rights, i.e. the ancient right to cut peat for personal fuel use in peatland areas. Whilst turf harvests are associated with environmental and economic impacts, harvesting of turf for fuel is certainly seen as an important element of cultural identity and sense of place in many localities. (26)	Energy, Climate change, Agriculture, Heritage	-	Class not mapped

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Scientific	Living resources of value for scientific study	This covers all aspects of biodiversity - including habitats, species, genetic resources and ecosystem processes - which are of interest to science and technological research and development, from blue-sky research to commercially-directed studies.	Education & Science, Heritage, Health, Water, Agriculture, Aquaculture, Marine, Pollution, Climate change	-	Class not mapped
Educational	Settings and species for outdoor education	This broad category covers the use of habitats and species in formal and informal education, including school nature walks and observation, woodland schools and other outdoor classroom activities.	Education & Science, Heritage	-	Class not mapped
Heritage, cultural	Historic and archaeological landscapes / features associated with biodiversity	Some sites on the Record of Monuments and Places are associated with certain habitats or with natural / semi-natural landscape features (e.g. ring forts, fulacht fiadh and souterrains sometimes associated with semi-natural grasslands, old church yards and cemeteries sometimes associated with high floristic diversity), which become intrinsic parts of the cultural setting and are ecologically important in their own right. This is a key issue for cultural heritage conservation and management and a potential source of conflict (e.g. if grazing animals brush against the monument toppling the stones). (27)	Heritage, Tourism, Water, Agriculture, Climate change	-	Class not mapped
Heritage, cultural	Folkloric sites associated with nature, Symbolic species and habitats in oral and written traditions	Many species are important motifs in Irish art, music and literature, and in folklore and mythology (e.g. the blackbird, oak, ash, yew, salmon, golden eagle). Several habitats also have similar associations, especially woodlands, peatlands and rivers (symbolism associated with the Liffey, Barrow, Nore, Suir, Shannon etc.). (28)	Heritage, Tourism, Water, Climate change	-	Class not mapped
Heritage, cultural	Habitats associated with traditional agricultural practices	This includes habitats and landscapes associated with extensive agriculture such as low-intensity and traditional grazing practices and commonage, often linked with high nature value farmland (machairs, limestone pavements, upland heaths etc.). (29)	Agriculture, Heritage, Tourism	-	Class not mapped

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Heritage, cultural	Habitats and species associated with traditional crafts and arts	This covers habitats which are used or managed for the production of materials used in traditional crafts - including reedbeds associated with thatching, willow-coppice associated with weaving, small plots managed for flax growing associated with linen production, and agricultural lands associated with traditional wool production. These crafts are / were practiced widely all over Ireland in the past and now have an 'arts and craft' following. They are recognised as an important aspect of Ireland's heritage; also an important part of the tourism base. Links to traditional building skills and maintenance of historic buildings, increasingly important to the construction sector. (30)	Agriculture, Heritage, Tourism, Health	-	Class not mapped
Entertainment	Freshwater settings associated with spectator sports	These sub-classes are closely linked to the 'experiential use of settings' open-air, underwater, and water-based activities, but more specifically relate to settings which are managed or promoted for commercial sport and sports tourism - e.g. coasts used for surfing or sailing tournaments, lakes used for triathlons, championship golf links, rivers used for angling competitions etc. (31)	Tourism, Heritage, Water, Agriculture, Marine, Health, Climate change	-	Class not mapped
	Coastal settings associated with spectator sports				
	Terrestrial settings associated with spectator sports				
Aesthetic	Areas of outstanding natural beauty, and natural sites of significant artistic value	Areas of particularly unique or valued scenic character, including those valued for artistic inspiration. Whilst the AONB designation is limited to Northern Ireland (not used officially in the Republic), there are many scenic routes and beauty spots recognised or designated by local authorities and highlighted on tourist maps and trails. Examples include the Cliffs of Moher, the Sally Gap in Wicklow, Ring of Kerry, the Wild Atlantic Way, Ireland's Ancient East etc. Several iconic mountain, coast and lakeland landscapes are associated with Irish artists or art movements. (32)	Heritage, Tourism, Agriculture, Climate change, Pollution, Health	-	Class not mapped

CICES CLASS	CICES Sub-classes for Ireland	Explanatory notes (plus references)	Major policy areas (in addition to Biodiversity and Sustainable Development)	Data to Map Services	Mapped outputs in Irish pilot
Symbolic, Sacred and / or religious	Sacred and historic landscapes / features	Linked to the 'natural beauty' sub-class, but specifically relates to areas that are largely or primarily of interest due to spiritual / religious associations. This includes Sacred Natural Sites - those areas of pilgrimage or reverence which have particular biodiversity value, especially those for which biodiversity has some historic association. Examples include the Skellig Islands, Clonmacnoise and Glendalough, and Croagh Patrick, all of which are in or adjacent to protected areas, and many holy wells throughout the country. (33)	Heritage, Tourism, Agriculture, Climate change, Pollution	-	Class not mapped
Existence	High biodiversity areas, Protected natural and historic sites, and Locally important habitats, species and landscape features	Habitats, species and landscape elements which are regarded for their intrinsic value - this includes elements of biodiversity which people feel should be protected, or for which they are willing to pay for protection, as they constitute part of local and national identity, or are associated with sense of place and time. Nationally, these are demonstrated by National Parks, botanic gardens & arboreta, nature reserves and formal conservation designations (national and international), but locally it includes elements of biodiversity which form part of local aesthetic character.	Heritage, Tourism, Agriculture, Climate change, Pollution	-	Class not mapped
Bequest	Protected natural and historic sites	Linked to the 'existence' class, but more specifically relates to the protection of habitats and landscape elements for the benefit of future generations (be it economic, social or cultural benefit). Potentially very extensive but demonstrated by National Parks and Gardens, designated heritage sites, formal statutory designations for nature conservation and Protected and Recorded monuments.	Heritage, Tourism, Agriculture, Climate change, Pollution	-	Class not mapped

Additional information and references:

1.	The top four grain crops by production (tons/yr), based on agriculture statistics held by the Central Statistics Office (CSO); see www.cso.ie); Also: Lydon, K., and Smith, G. (2014) CORINE landcover 2012, Ireland: Final Report. Environmental Protection Agency, Wexford. 55pp
2.	This category includes all fruits and vegetables directly dependent upon (or supported by) pollination for the production of the harvestable crop (most hard and soft fruits, root vegetables, legumes, brassicas etc.), as well as honey. These are produced in a variety of locations, from large scale commercial farming to smaller market gardens, home gardens, community allotments etc. Department of Agriculture, Food and the Marine (DAFM) (2013) Soft Fruit and Protected Vegetable Census 2013. DAFM, Dublin 63pp. National Biodiversity Data Centre (2015) All-Ireland Pollinator Plan, Data Centre Series No.3, Waterford DAFM (2009) National Field Vegetable Census 2009. DAFM, Dublin 66pp.
3.	This category includes those field vegetables and amenity plants and plant-derived products not directly dependent upon pollination for the production of the harvestable crop in Ireland. This includes certain parthenocarpic varieties, mushrooms, and varieties which may be grown from imported seed, as well as numerous amenity products such as cut flowers, bulbs, display foliage, and various gardening products and treatments such as bark mulch and soil improvers based on plant materials (e.g. Sphagnum). As with (2) above, these plants / products are grown in a variety of locations. See also: Bord Bia (2015) Amenity Sector Full Year 2014 – Management Report. Bord Bia, Dublin 48pp. Bord Bia (2011) National Amenity Census 2011. Bord Bia, Dublin 62pp.
4.	Based on agriculture statistics held by the Central Statistics Office (www.cso.ie) Also: Gillmor, D. A. (1987). Concentration of enterprises and spatial change in the agriculture of the Republic of Ireland. Transactions of the Institute of British Geographers, 12(2); 204-216. Anderson, R., (2013) Biodiversity Change in the Irish Uplands – the Effects of Grazing Management. Unpublished PhD Thesis National University of Ireland, Cork, 220pp Van Rensburg, T.M., Murphy, E., Rocks, P. (2009) Commonage land and farmer uptake of the rural environment protection scheme in Ireland. Land Use Policy, 26 (2); 345–355.
5.	Carruthers, C., Burns, A., Elliott, G. (2015) Gastronomic tourism: development, sustainability and applications – a case study of County Cork, Republic of Ireland. In: Hindley, C. (ed) The Routledge Handbook of Sustainable Food and Gastronomy. Routledge, London and New York. pp360 – 369; White Lennon, B., and Doyle, E. (2013) Wild Food - Nature's Harvest: How to Gather, Cook and Preserve. O'Brien Press, Dublin. 256pp
6.	Scallan, D., (2007) A Socioeconomic Assessment of Hunting in the Republic of Ireland - Interim Summary Report for the European Commission and the Federation of Associations for Hunting and Conservation of the EU (FACE). National University of Ireland, Galway. 41pp; Scallan, D (2013) A Socio-economic Assessment of the Value of Hunting in Ireland. Report for the Federation of Field Sports of Ireland and the National Association of Regional Game Councils.
7.	Annett, J.A. (2015) Deer Management in Ireland – A Framework for Action. Department of Agriculture, Food and the Marine, Dublin. 38pp

8.	Inland Fisheries Ireland (2015) National Strategy for Angling Development (NSAD) 2015-2020. IFI, Dublin. 34pp Tourism Development International (2013) Socio-Economic Study of Recreational Angling in Ireland. IFI, Dublin. 161pp. Other data available at http://www.fisheriesireland.ie.
9.	Viable fisheries still existed for Pollan as recently as 2004 – see: Rosell R., et al. (2004) Conservation of the Irish Populations of the Pollan Coregonus autumnalis. Biology and Environment: Proceedings of the Royal Irish Academy Vol. 104B, 3, 67-72. Harrod, C., Griffiths, D., McCarthy, T. K., & Rosell, R. (2001). The Irish pollan, Coregonus autumnalis: options for its conservation. Journal of Fish Biology, 59(sA), 339-355 Arctic char has minor commercial value at present in Ireland but is commercially important elsewhere in Europe; whilst increasingly threatened and rare at the national level, the species is now being farmed in Ireland (http://www.fisheriesireland.ie/fish-species/arctic-char.html); see also: Maitland, P.S., Winfield, I.J., McCarthy, I. & Igoe, F. 2007. The status of Arctic charr Salvelinus alpinus in Britain and Ireland. Ecology of Freshwater Fish 16(1): 6–19.
10.	Marine Institute (2015) Stock Book: Annual Review of Fish Stocks in 2015 with Management Advice for 2016. Marine Institute, Galway. 481pp. Marine Institute (2014) Atlas of Commercial Fisheries Around Ireland; Second Edition. Marine Institute, Galway. 62pp. BIM (2008) The Seafood Development Operational Programme 2007-2013. BIM, Dublin. 108pp
11.	Species prioritised based on references at (10) above, and from Sea Fisheries Protection Authority figures 2013 & 2014 (http://www.sfpa.ie): also: FAO (2006) Fishery Country Profile: Ireland. FAO, Rome.
12.	BIM (2012) A Market Analysis towards the Further Development of Seaweed Aquaculture in Ireland. BIM, Dublin. 52pp. Werner, A., Clarke, D., Kraan, S. (2004) Strategic Review of the Feasibility of Seaweed Aquaculture in Ireland. Marine Institute, Galway. 123pp. See also: http://www.seaweed.ie
13.	BIM (2016) BIM Annual Aquaculture Survey 2016. BIM, Dublin. 16pp.
14.	MERC Consultants (2008) Status of Irish Aquaculture, 2007. BIM, Dublin. 144pp Department of Agriculture, food and the Marine (DAFM) (2015) National Strategic Plan for Sustainable Aquaculture Development – Draft for Public Consultation. DAFM, Dublin. 109pp
15.	Doris et al. (2015) Drinking Water Report 2014. EPA, Wexford. 54pp. Russi D., ten Brink P., Farmer A., Badura T., Coates D., Förster J., Kumar R. and Davidson N. (2012) The Economics of Ecosystems and Biodiversity for Water and Wetlands. Final Consultation Draft.
16.	Murray, P. M., Moane, S., Collins, C., Beletskaya, T., Thomas, O. P., Duarte, A. W., . & McHugh, E. (2013). Sustainable production of biologically active molecules of marine based origin. New Biotechnology, 30(6), 839-850. Joint Committee on Environment, Culture, and the Gaeltacht (2015) 31st Dáil Éireann / 24th Seanad Éireann; Report on the Committee on Developing the Seaweed Industry in Ireland. Houses of the Oireachtas, Dublin. 35pp

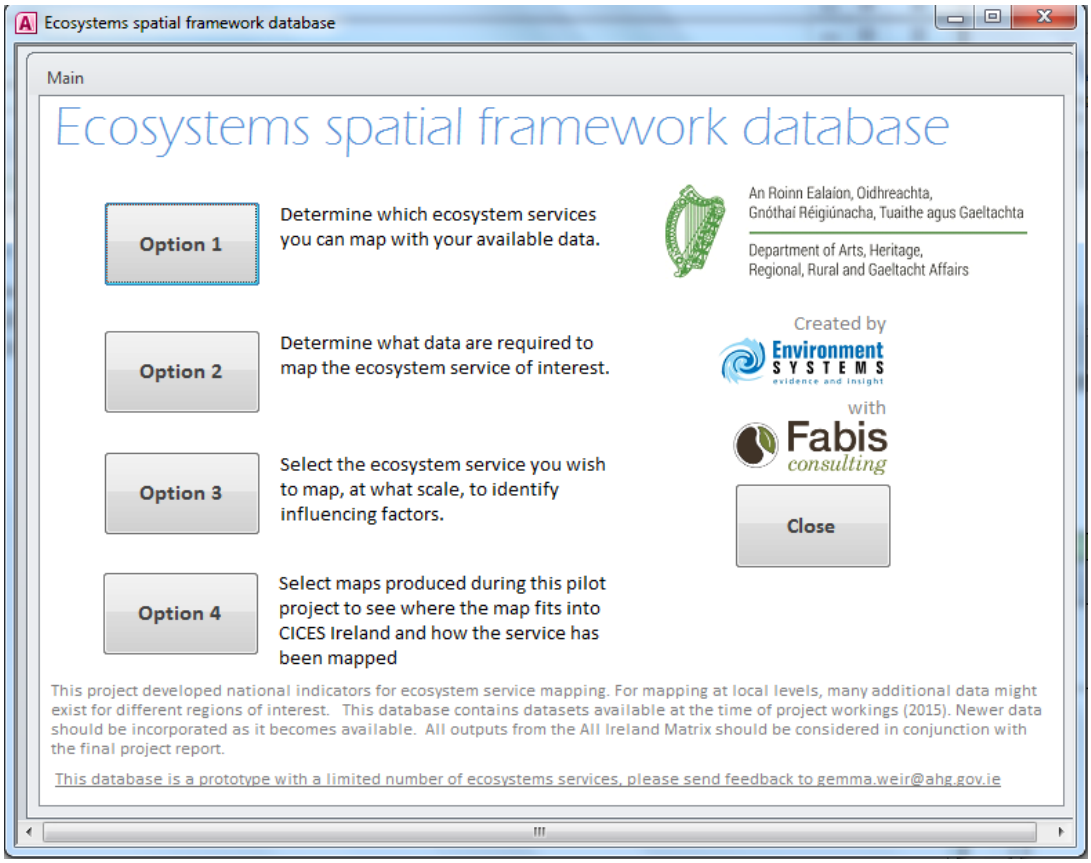
17.	CSO data on wool production and exports combined with other textiles so no wool-specific figures available; CSO figures for all textiles, including part-processed wool, show export value increasing in past 10 years; wool value on Agricultural Price Index down 2005 to 2010, recovering significantly year on year since 2010. Pers. comms. (Vincent Pierce, Lawrence Pierce Ltd, Rathnew, Co. Wicklow; Geoff Coller, Irish Sheep Shearing Association) indicate current market value of all Irish raw wool (shorn and hides) is around €32 million per year. Bulk of sales (~90%) are to China, though growing home markets in insulation and textiles. Significant local tourism benefits associated with national and international shearing festivals which are held here.
18.	DAFM (2015) Ireland's Forests – Annual Statistics, 2015. DAFM, Dublin 66pp. Irish Forestry and Forest Products Association (2012) An overview of the Irish forestry and forest products sector 2012. IBEC, Dublin 88pp.
19.	Based on data from CSO annual statistics for Agriculture Area Used and Crop Production, available via http://www.cso.ie
20.	Ferguson, A. (1989). Genetic differences among brown trout, Salmo trutta, stocks and their importance for the conservation and management of the species. Freshwater biology, 21(1), 35-46. Ferguson, A. J. B. T., Taggart, J. B., Prodöhl, P. A., McMeel, O., Thompson, C., Stone, C., & Hynes, R. A. (1995). The application of molecular markers to the study and conservation of fish populations, with special reference to Salmo. Journal of Fish Biology, 47(sA); 103-126. Karvonen, A., Aalto-Araneda, M., Virtala, A. M., Kortet, R., Koski, P., & Hyvärinen, P. (2016). Enriched rearing environment and wild genetic background can enhance survival and disease resistance of salmonid fishes during parasite epidemics. Journal of Applied Ecology, 53(1); 213-221.
21.	The Irish Crop Wild Relative Database is under development at the National Biodiversity Data Centre, with some species maps available via the NBDC website at: http://maps.biodiversityireland.ie/#/DataSet/73/Geographical
22. 23.	Styles, D., Thorne, F., Jones, M.B. (2008) Energy crops in Ireland: An economic comparison of willow and Miscanthus production with conventional farming systems, Biomass and Bioenergy, 32(5); 407 – 421. Styles, D., Jones, M.B. (2007) Energy Crops in Ireland: An Assessment of their Potential Contribution to Sustainable Agriculture, Electricity and Heat Production. EPA, Wexford. 80pp
24.	Tuohy, A, Bazilian, M., Doherty, R., O Gallachoir, B., O' Malley, M.J. (2009) Burning Peat in Ireland: An Electricity Market Dispatch Perspective, Energy Policy 37(8); 3035 – 3042 Fu, M., Kelly, J. A., & Clinch, J. P. (2014). Residential solid fuel use: Modelling the impacts and policy implications of natural resource access, temperature, income, gas infrastructure and government regulation. Applied Geography, 52, 1-13. Fáilte Ireland (2007) Tourism Product Development Strategy 2007-2013. Fáilte Ireland, Dublin. 97pp. Fáilte Ireland (2009) Determination of Waters of National Tourism Significance and Associated Water Quality Status. Fáilte Ireland, Dublin. 52pp. Judith A. Annett Countryside Consulting (2013) Lakelands and Inland Waterways StrategicPlan; 2013-2016 Mid-term review. Waterways Ireland, Dublin. Fáilte Ireland (2016) Cultural product usage among overseas tourists in 2014. Fáilte Ireland, Dublin 9pp. Fáilte Ireland (2016) Activity product usage among overseas tourists in 2014. Fáilte Ireland, Dublin 9pp.
25.	Inland Fisheries Ireland (2015) National Strategy for Angling Development. IFI, Dublin.

26.	See Fu et al. (2014) at (23) above. Also: Bullock, C. H., & Collier, M. (2011). When the public good conflicts with an apparent preference for unsustainable behaviour. Ecological Economics, 70(5), 971-977.
27.	Aalen, F. H., Whelan, K., & Stout, M. (2010). Atlas of the Irish rural landscape. Cork University Press, Cork. 432pp. Latocha, A. (2015). Past Human Activities Recorded in the Landscape: A Case Study from the Glenveagh National Park, Ireland. Landscape Research, 40(3), 338-358. Gearey, B. R., Fletcher, W., & Fyfe, R. (2014). Managing, Valuing, and Protecting Heritage Resources in the Twenty-First Century: Peatland Archaeology, the Ecosystem Services Framework, and the Kyoto Protocol. Conservation and Management of Archaeological Sites, 16(3), 236-244. The biodiversity value of historic sites is increasingly recognised in site management planning; see e.g.: Halpin, S., Kretsch, C., & Keeley, B. (2004) Archaeological, Ecological & Structural Survey of Cargin Church, County Galway. Moore Group, Galway 70pp.
28.	Knowlton, E.C. (1929) Nature in Older Irish. Proceedings of the Modern Language Association, 44(1); 92-122 Foster, J.W. (ed) (1999) Nature in Ireland: A Scientific and Cultural History. McGill-Queen's University Press 658pp
29.	O'Rourke, E., Kramm, N., & Chisholm, N. (2012). The influence of farming styles on the management of the Iveragh uplands, southwest Ireland. Land Use Policy, 29(4), 805-816. Heritage Council (2010) Case Studies on High Nature Value Farming in Ireland - North Connemara and the Aran Islands. Heritage Council, Kilkenny 16pp.
30.	Traditional crafts are practiced widely all over Ireland and recognised as an important aspect of Ireland's heritage and tourism base. The Heritage Council highlights the importance of traditional building skills as part of Ireland's built & architectural heritage; maintenance of historic buildings, including specialist services such as thatching, increasingly important to construction sector since downturn. Heritage Council (2010) Ireland's thatched roofs. Heritage Council, Kilkenny; Ecorys (2012) Economic Value of Ireland's Historic Environment. Final report to the Heritage Council, Kilkenny 94pp. Mottiar, Z., Quinn, B., Ryan, T,, Stacey, J. (2013). Building Collaboration Between the Arts & Culture and Tourism Sectors in the West of Ireland. Fáilte Ireland, Dublin 71pp.
31.	North / South Interparliamentary Association (2014) Sports Tourism: Background briefing prepared by the Research and Information Service (RaISe) of the Northern Ireland Assembly and of the Library & Research Service of the Houses of the Oireachtas. Houses of the Oireachtais, Dublin 35pp.
32.	Carpenter, A. (ed) (2014) Art and Architecture of Ireland. Yale University Press, New Haven and London 2528pp See http://www.failteireland.ie/ for details on Bord Fáilte's tourism initiatives Ireland's Ancient East and Wild Atlantic Way
33.	For examples, see: Department of Environment, Heritage and Local Government (2009) The Monastic City of Clonmacnoise and its Cultural Landscape, Candidate World Heritage Site: World Heritage Site Draft Management Plan 2009 - 2014. Department of Environment, Heritage and Local Government, Dublin 219pp.

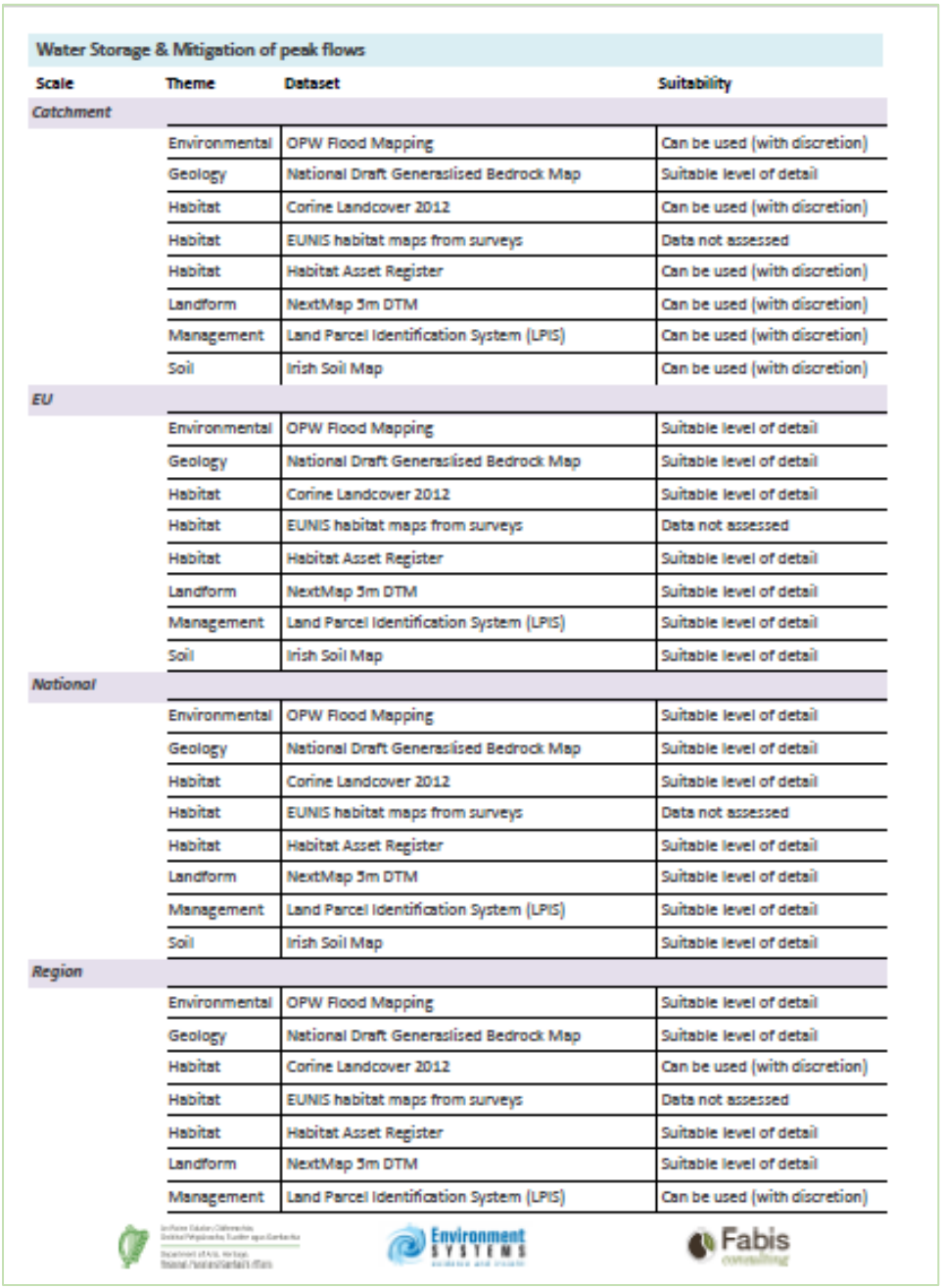
34. Department of Environment, Heritage and Local Government (2008) Skellig Michael World Heritage Site Management Plan 2008–2018. Department of Environment, Heritage and Local Government, Dublin 138pp

Appendix G Example Outputs "All Ireland Matrix"

These screengrabs show example outputs from the MS Access Database which utilises a copy of the All Ireland Matrix table



User selects 1 of 4 options for report.



Water Storage & Mitigation of peak flows

Scale	Theme	Dataset	Suitability
Catchment			
	Environmental	OPW Flood Mapping	Can be used (with discretion)
	Geology	National Draft Generaslised Bedrock Map	Suitable level of detail
	Habitat	Corine Landcover 2012	Can be used (with discretion)
	Habitat	EUNIS habitat maps from surveys	Data not assessed
	Habitat	Habitat Asset Register	Can be used (with discretion)
	Landform	NextMap 5m DTM	Can be used (with discretion)
	Management	Land Parcel Identification System (LPIS)	Can be used (with discretion)
	Soil	Irish Soil Map	Can be used (with discretion)
EU			
	Environmental	OPW Flood Mapping	Suitable level of detail
	Geology	National Draft Generaslised Bedrock Map	Suitable level of detail
	Habitat	Corine Landcover 2012	Suitable level of detail
	Habitat	EUNIS habitat maps from surveys	Data not assessed
	Habitat	Habitat Asset Register	Suitable level of detail
	Landform	NextMap 5m DTM	Suitable level of detail
	Management	Land Parcel Identification System (LPIS)	Suitable level of detail
	Soil	Irish Soil Map	Suitable level of detail
National			
	Environmental	OPW Flood Mapping	Suitable level of detail
	Geology	National Draft Generaslised Bedrock Map	Suitable level of detail
	Habitat	Corine Landcover 2012	Suitable level of detail
	Habitat	EUNIS habitat maps from surveys	Data not assessed
	Habitat	Habitat Asset Register	Suitable level of detail
	Landform	NextMap 5m DTM	Suitable level of detail
	Management	Land Parcel Identification System (LPIS)	Suitable level of detail
	Soil	Irish Soil Map	Suitable level of detail
Region			
	Environmental	OPW Flood Mapping	Suitable level of detail
	Geology	National Draft Generaslised Bedrock Map	Suitable level of detail
	Habitat	Corine Landcover 2012	Can be used (with discretion)
	Habitat	EUNIS habitat maps from surveys	Data not assessed
	Habitat	Habitat Asset Register	Suitable level of detail
	Landform	NextMap 5m DTM	Suitable level of detail
	Management	Land Parcel Identification System (LPIS)	Can be used (with discretion)

Sample Report: Option 1 – List of services and scales that can be mapped using the selected datasets

Option 2 Report - For soil carbon at a national scale you will require at least one of the following dataset(s) from each theme:

CICES Sub-classes	Explanatory note	Major policy areas	Maps
Areas important for emissions reduction	Habitats which are important for carbon storage, or whose degradation poses particular risks of greenhouse gas release. Includes soil and biomass in peatlands and other freshwater wetlands, woodlands, heath, semi-natural grasslands, and coastal marshes and flats. Influenced by species composition, soils, geology, drainage, aspect etc.	Climate change, Agriculture, Marine, Health	Areas of land that stores carbon

Data are provided on an 'as is', 'as available' basis. NPWS does not guarantee the accuracy, timeliness, completeness, performance or fitness for a particular purpose of the data. NPWS do not guarantee that the digital data are free of minor errors that may materially affect performance. It is the users' responsibility to ensure that the data are fit for any intended use, particularly when combining data of different temporal and/or spatial scale

Habitat

Suitability	Likely Source	Availability	Terms	Link
Dataset essential to map this service				
Corine Landcover 2012				
Suitable level of detail	EPA	Downloadable	Must acknowledge source and does not include Commercial use	Download 'Corine Landcover 2012'
EUNIS habitat maps from surveys				
Data not assessed	European Marine Observation Data Network	Downloadable	Must acknowledge source	Download 'EUNIS habitat maps from surveys'
Habitat Asset Register				
Suitable level of detail	NPWS	Potential restrictions and copyright	Check licensing conditions	Contact NPWS
Indicative Habitat Map of Ireland				
Can be used (with discretion)	Teagasc	Potential restrictions and copyright	Check licensing conditions	Contact Teagasc

This project developed national indicators for ecosystem service mapping. Therefore, not all available datasets with non-national coverage are included in this database. Depending on the region of interest and service mapped additional, beneficial data could be available.

Page 1 of 4

Sample Report: Option 2 – For selected services at selected scales you will require at least one of the following datasets from each theme. Hyperlinks are included to where selected data sets can be downloaded.

National Ecosystem and Ecosystem Service Mapping Pilot for a Suite of Prioritised Services

Environment SYSTEMS evidence and insight

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

Ecosystem Service Modelling

Marine food

Rule-base development

Contents

What the service is 1

Scientific framework for modelling 'marine food provision' 2

National Parks & Wildlife Service

Fabis consulting

TEAM

National Ecosystem and Ecosystem Service Mapping Pilot for a Suite of Prioritised Services

Strategic level map **MARINE FOOD PROVISION** **Marine areas that provide food (Marine food (Provision))**	**CICES Classes:** • Wild plants, algae and their outputs • Wild animals and their outputs • Plants and algae from in-situ aquaculture • Animals from in-situ aquaculture. **Cascade Level[1]:** ~~Structure/Function~~/Service/~~Benefit/Value~~

What the service is

This service includes everything taken from the sea for human consumption. This includes fish (marine and diadromous), shellfish, crustaceans and algae, both from wild harvest and from aquaculture.

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.

[1] Potschin, Marion, and Roy Haines-Young. "Frameworks for ecosystem assessments." Potschin, M., Haines-Young, R., Fish, R. and Turner, RK (eds) Routledge Handbook of Ecosystem Services. Routledge, London and New York (2016): 125.

1

Sample Report: Option 3 – Provides the 'Scientific Framework' for the relevant service or function.

Option 4 outputs the indicator documents, (including map) for the services and functions mapped as part of this pilot (full documents are included in Appendix L)

Appendix H Data Audit for Mapping Ecosystem Indicators

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
EMODnet	Predicted habitats – North Sea and Celtic Sea	'substrate' and 'Allcombd_1'	Marine habitat information with full coverage	Less than 'Collated seabed substrate' (Marine Institute, pers. com.)	250m grid (Marine Institute, pers. com.)	Confidence assessment
Marine Institute	Dredge Fishing Activity	'Gear_Type' and 'Species'	Spatial information regarding fisheries effort	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Line Fishing Activity	'Gear_Type' and 'Species'	Spatial information regarding fisheries effort	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Net Fishing Activity	'Gear_Type' and 'Species'	Spatial information regarding fisheries effort	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Bottom Trawl Fishing Activity	'Gear_Type' and 'Species'	Spatial information regarding fisheries effort	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Mid-water Trawl Fishing Activity	'Gear_Type' and 'Species'	Spatial information regarding fisheries effort	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Pot Fishing Activity	'Gear_Type' and 'Species'	Spatial information regarding fisheries effort	Not assessed – no metadata	Not assessed – no metadata	N
NPWS	Article 17 2007 – 2012 Species Assessments	Included in species coincidence layer	Field survey species records	Differing btw. species	Differing btw. species	For most species
GSI	Irish Bathymetry - INFOMAR and Related Surveys_111m	Raster dataset: Raster value used	Highest resolution and most comprehensive bathymetry dataset available	Not assessed – not filled in in metadata	111m	Y
Marine Institute	Biologically Sensitive Area	'NAME'	Management data on sites under conservation designation	Not assessed – no metadata	Not assessed – no metadata	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Marine Institute	Collated Seabed Substrate	'EUNIS'	Marine substrate layer with most detail (resolution, EUNIS level 4) for <100m depth, offshore less detail (Marine Institute, pers. com.); used in conjunction with 'Predicted habitats – North Sea and Celtic Sea'	Differing within the layer (data from multibeam, singlebeam, modelled, etc.)	Not assessed – no metadata	N
CMRC	Commercial Ports	Whole SHP used as 'commercial port'	Presence of commercial ports can affect provision of marine ES	High	Vector Scale: 50.000	Y
EPA	Dumping at Sea Boundaries	'Description'	Dumping relevant for mapping of marine ES	Not assessed – no metadata	Not assessed – no metadata	N
CMRC	Fishing Ports	Whole SHP used as 'Sea fishing spots'	Contains information on harvest from marine – relevant for marine food provision	Not assessed – information not recorded in metadata	Not assessed – information not recorded in metadata	Y
Marine Institute	Greencastle Codling Area	'NAME'	Management data on sites under conservation designation	High	Not assessed – information not recorded in metadata	Y
CMRC	Local Ferry Ports	Whole SHP used as 'Local Ferry Ports'	Presence of artificial structures and harbour related activities can affect some marine services mapped	High	Scale (vector): 50.000	Y
CMRC	Marinas	'FUEL' and 'TOILETS'	Presence of fuel and toilets can give indication of the likelihood of pollution affecting the marina	High	Scale (vector): 100.000	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Marine Institute	Marine Institute - Conductivity, Temperature and Depth Data	'bot_depth'	Used to fill in gaps in the bathymetry layer	Low (column 'descriptio' contains many 'NULL', 'no valid data', and 'untrustworthy data'; no metadata available)	Not assessed – no metadata	N
DCENR – PAD	Currently Designated Irish Continental Shelf	Whole SHP used as 'EEZ'	Used to determine the area of interest for marine mapping	Not assessed – no metadata	Not assessed – no metadata	N
CMRC	Marine Data Buoys	'TYPE'	Presence of artificial structures affects some marine services mapped	High	Scale (vector): 100.000	Y
Marine Institute	Arklow Bank Wind Park Connection Cable	Whole SHP used as 'Arklow Bank'	Presence of artificial structures affects some marine services mapped	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Fishing Intensity by vessels >15m in length - Passive	'Passive'	Measure of fisheries effort, indicator of the amount of marine food obtained from the area	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Fishing Intensity by vessels >15m in length - Mobile Seine	'MobileSein'	Measure of fisheries effort, indicator of the amount of marine food obtained from the area	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Fishing Intensity by vessels >15m in length - Mobile Bottom	'MobileBott'	Measure of fisheries effort, indicator of the amount of marine food obtained from the area	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Fishing Intensity by vessels >15m in length - Mobile Other	'MobileOthe'	Measure of fisheries effort, indicator of the amount of marine food obtained from the area	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Fishing Intensity by vessels >15m in length - All Gears	'AllGears'	Measure of fisheries effort, indicator of the amount of marine food obtained from the area	Not assessed – no metadata	Not assessed – no metadata	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Marine Institute	Shipping Navigation Channel	Whole SHP used as 'Shipping Navigation Channel'	Presence of shipping traffic can affect some of the marine services mapped	Not assessed – no metadata	Not assessed – no metadata	N
CMRC	Navigation Aids	'Type'	Presence of artificial structures affects some marine services mapped	High	Scale (vector): 50.000	Y
DCENR - PAD	Offshore Commercial Field	Whole SHP used as 'Offshore commercial field'	Presence of field can affect marine biodiversity	Not assessed – no metadata	Not assessed – no metadata	N
DCENR - PAD	Offshore Gas Line	Whole SHP used as 'Offshore gas line'	Presence of artificial structures affects some marine services mapped	Not assessed – no metadata	Not assessed – no metadata	N
OSPAR	OSPAR Wind farms	'No_of_wind' and 'Current_St'	Presence of artificial structures affects some marine services mapped	Not assessed – no metadata	Not assessed – no metadata	N
CMRC	Periwinkle Access Points	'ACCESS' and 'HARVESTED'	Gives indication of areas contributing to marine food provision	Medium (High thematic accuracy, but only 124 sites sampled)	GPS recording accuracy ~12m	Y
DCENR - PAD	Platforms	Whole SHP used as 'Platforms'	Presence of artificial structures affects some marine services mapped	Not assessed – no metadata	Not assessed – no metadata	N
DCENR - PAD	Shellfish Waters Directive	'PROT_TYPE'	Management data on sites under conservation designation			N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	Terrestrial Special Areas of Conservation (SAC's)	Whole SHP used as 'SACs'	Incorporated into designations layer (Management data on sites under conservation designation)	High	High	Y
NPWS	Offshore Special Areas of Conservation (SAC's)	Whole SHP used as 'offshore SACs'	Management data on sites under conservation designation	High	High	Y
NPWS	Special Protection Areas (SPA's)	Whole SHP used as 'SPAs'	Incorporated into designations layer (Management data on sites under conservation designation)	High	High	Y
NPWS	Natural Heritage Areas (NHA's)	Whole SHP used as 'NHAs'	Incorporated into designations layer (Management data on sites under conservation designation)	High	High	Y
NPWS	proposed Natural Heritage Areas (pNHAs)	Whole SHP used as 'pNHAs'	Incorporated into designations layer (Management data on sites under conservation designation)	High	High	Y
DCENR – GSI	Groundwater Recharge	'Drainage' and 'Perm_Desc'	Information relevant to interaction of soil profile with water (both water quality and temporary water storage)	Medium	Scale (Vector) 50.000	Y
DCENR – GSI	Groundwater Sand and Gravel Aquifers	'AQUIFER'	Productivity of aquifer can give indication how much the area contributes to water filtration	Medium	Scale (vector) 50.000	Y
DCENR – GSI	Groundwater Aquifers	'Aquifer_De'	Productivity of aquifer can give indication how much the area contributes to water filtration	Medium	Scale (vector) 100.000	Y
DCENR – GSI	National Draft Generalised Bedrock Map (Groundwater Rockunits)	'Descript_1'	Bedrock map with full coverage, summarised appropriately for ES mapping (NPWS, pers. com.)	Medium	Medium	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	NextMap 5m DTM	Raster data, raster value on elevation used	Landform, i.e. slope, one of the key factors for modelling the provision of many ecosystem services	High	5m	Y
Teagasc	Teagasc Soils	'IFS_SOIL' and 'PAR_MAT'	Soil one of the key factors for modelling the provision of many ecosystem services	Medium	Scale (vector) 1:100,000 – 1:150,000	Project report
Teagasc	Teagasc Subsoils	'Group' and 'Texture'	Soil one of the key factors for modelling the provision of many ecosystem services; texture important for interaction with water filtering through	Medium	Scale (vector) 1:50,000	Project report
DCENR	Seismic Surveys 3D	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR	Seismic Surveys 2D	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR	Current_Authorisations_Jan2015	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	Y
EMODnet	OSPAR Threatened and/or Declining Habitats 2013	Dataset not used	Habitat data covered through 'Predicted habitats – North Sea and Celtic Sea' and 'Collated Seabed Substrate' (based on Marine Institute (pers. com.))	Not assessed – data not used	Not assessed – data not used	Y
EMODnet	Predicted broad-scale EUNIS habitats – Atlantic area	Dataset not used	Habitat data covered through 'Predicted habitats – North Sea and Celtic Sea' and 'Collated Seabed Substrate' (based on Marine Institute recommendations)	Not assessed – data not used	Not assessed – data not used	Project report

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
EMODnet	Biological Zones – Atlantic area	Dataset not used	Habitat data covered through 'Predicted habitats – North Sea and Celtic Sea' and 'Collated Seabed Substrate' (based on Marine Institute recommendations)	Not assessed – no metadata	Not assessed – no metadata	N
GSI	Bathymetry 500m grid	Dataset not used	Irish Bathymetry – INFOMAR and Related Surveys with slightly better coverage	Not assessed – no metadata	Not assessed – no metadata	N
GSI	Irish Bathymetry - INFOMAR and Related Surveys_250m	Dataset not used	Irish Bathymetry – INFOMAR and Related Surveys with higher resolution	Not assessed – not filled in in metadata	250m	Y
GSI	Irish Bathymetry - INFOMAR and Related Surveys_500m	Dataset not used	Irish Bathymetry – INFOMAR and Related Surveys with higher resolution	Not assessed – not filled in in metadata	500m	Y
Marine Institute	Clew Bay Marine Habitats	Dataset not used	Detailed, but spatially limited coverage – not suitable for EEZ-scale mapping	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Kenmare River Marine Habitats	Dataset not used	Detailed, but spatially limited coverage – not suitable for EEZ-scale mapping	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Kilkieran Bay Marine Habitats	Dataset not used	Detailed, but spatially limited coverage – not suitable for EEZ-scale mapping	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Roaringwater Bay Marine Habitats	Dataset not used	Detailed, but spatially limited coverage – not suitable for EEZ-scale mapping	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Valentia Marine Habitats	Dataset not used	Detailed, but spatially limited coverage – not suitable for EEZ-scale mapping	Not assessed – dataset not used	Not assessed – dataset not used	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
CMRC	Diving and Sub-aqua Clubs	Dataset not used	Cultural services not mapped	Not assessed – dataset not used	Not assessed – dataset not used	Y
EPA	Dumping at Sea Chemical Monitoring	Dataset not used	Point data, difficult to incorporate into EEZ-scale mapping	Not assessed – no metadata	Not assessed – no metadata	N
SEAI	Wind Speed Atlas	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
NEAFC	NEAFC Closure Areas	Dataset not used	Outside of AOI	Not assessed – dataset not used	Not assessed – dataset not used	N
ICES	ICES Areas	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
ICES	ICES EcoRegions	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
ICES	ICES Statistical Rectangles	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
International Maritime Organisation	Particularly Sensitive Sea Area	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
International Maritime Organisation	Particularly Sensitive Sea Area – Ship Routing	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
DCENR – PAD	Exclusive Economic Zone (200nm)	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
NEAFC	NEAFC Mid Atlantic Closure Areas	Dataset not used	Not within the area of interest	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Galway Bay 1/4 Scale Wave Energy Test Site	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Belmullet Full Scale Wave Energy Test Site	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Contaminants in Shellfish - Benzopryene	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Marine Institute	Contaminants in Shellfish - Fluoranthene	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Contaminants in Shellfish - Polychlorinated Biphenyl Congener 153	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Contaminants in Shellfish - Breakdown product of pesticide Dichloro-diphenyl-trichlorethane	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Contaminants in Shellfish - Cadmium	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Contaminants in Shellfish - Mercury	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Contaminants in Shellfish - Lead	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Predominant Habitat Confidence	Dataset not used	Data not relevant for mapping process, could be used to provide indication of reliability of marine services mapped	Not assessed – no metadata	Not assessed – no metadata	N
Marine Institute	Traffic Separation Exclusion Zone	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Hydro Electric Plants	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	International Ferry Routes	Dataset not used	Areas with high occurrence of shipping traffic covered through Shipping Navigation Channel	Not assessed – dataset not used	Not assessed – dataset not used	N
Marine Institute	Local Ferry Routes	Dataset not used	Areas with high occurrence of shipping traffic covered through Shipping Navigation Channel	Not assessed – dataset not used	Not assessed – dataset not used	N
DCENR – PAD	Exclusive Economic Zone (200nm)	Dataset not used	Not relevant for services mapped	Not assessed – dataset not used	Not assessed – dataset not used	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Marine Institute	MFSD Predominant Habitat Type	Dataset not used	Habitat data covered through 'Predicted habitats – North Sea and Celtic Sea' and 'Collated Seabed Substrate' (based on Marine Institute (pers. com.))	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Offshore Fault	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Offshore Geology	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Igneous	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Intrusive Body	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Ridge	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Tectonic Element	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
OSPAR	OSPAR Munitions Encounters	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
OSPAR	OSPAR Historic Dumpsites	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
OSPAR	OSPAR Regions	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
OSPAR	OSPAR Special Habitats	Dataset not used	Habitat data covered through 'Predicted habitats – North Sea and Celtic Sea' and 'Collated Seabed Substrate' (based on Marine Institute (pers. com.))	Not assessed – data not used	Not assessed – data not used	Y
NPWS	Site Specific Conservation Objectives	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
EPA	Hydrometric Areas	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
EPA	WATER_RiverBasin	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
Marine Institute	Wave Energy Resources	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Exploration Wells	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
NPWS	Rep_Counties_IG_Irish1	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
EPA	Water Framework Directive - Article 5 Point Pressures	Dataset not used	Without additional information, difficult to quantify how strongly to weigh each data point; point data difficult at national scale	Not assessed – data not used	Not assessed – data not used	Y
EPA	New WFD Ground Water Bodies 18/05/2015	Dataset not used	Groundwater recharge and aquifer data used to incorporate ground water processes	Not assessed – data not used	Not assessed – data not used	Y
EPA	WFD Risk Tables (All Waterbodies) Results	Dataset not used	Water quality mapping shows contribution of land to water quality, not current status	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	General near surface current	Dataset not used	Mapping at this time did not incorporate processes in the water column	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Irish slope current	Dataset not used	Mapping at this time did not incorporate processes in the water column	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Irish coastal current	Dataset not used	Mapping at this time did not incorporate processes in the water column	Not assessed – data not used	Not assessed – data not used	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
DCENR - PAD	Western Irish Sea gyre	Dataset not used	Mapping at this time did not incorporate processes in the water column	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Season density driven transport	Dataset not used	Mapping at this time did not incorporate processes in the water column	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Low water mass movement	Dataset not used	Mapping at this time did not incorporate processes in the water column	Not assessed – data not used	Not assessed – data not used	N
DCENR - PAD	Upper water mass movement	Dataset not used	Mapping at this time did not incorporate processes in the water column	Not assessed – data not used	Not assessed – data not used	N
NPWS	Margaritifera Sensitive Areas	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	Y
DCENR - GSI	Bedrock Geology - 1:100,000	Dataset not used	National Draft Generalised Bedrock Map used instead	Not assessed – data not used	Not assessed – data not used	N
DCENR – GSI	Bedrock Geology - 1:500,000	Dataset not used	National Draft Generalised Bedrock Map used instead	Medium	Medium	Y
DCENR – GSI	Bedrock Boreholes	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR – GSI	Groundwater Wells	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	Y
DCENR – GSI	Karst Features	Dataset not used	Bedrock data and soil data used instead	Not assessed – data not used	Not assessed – data not used	Y
DCENR – GSI	Source Protection Areas (GSI & EPA)	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	Y
DCENR – GSI	Geotechnical Boreholes & Report areas	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	Y
DCENR – GSI	Groundwater Vulnerability	Dataset not used	Information on aquifers and groundwater recharge used instead	Not assessed – data not used	Not assessed – data not used	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
DCENR – GSI	Groundwater Tracer Lines	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR – GSI	Mineral Locations & Quarry Directory	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
DCENR - GSI	Quaternary Geology	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	N
Carlow County Council	Carlow Pilot Habitat Mapping Project	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Cavan County Council	Cavan Wetland Survey	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Cavan County Council	Habitat Mapping of Habitats in County Cavan	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Clare County Council	Foss, P.J. & Crushell, P. (2008) The County Clare Wetlands Survey 2008 Desk Survey & GIS Preparation. Report prepared for Clare County Council and The Heritage Council. pp. 142	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Clare County Council	Conaghan, J. & Fuller, J., 2004, An ecological survey of habitat cover in the Shannon/Newmarket-on-Fergus region of south Co. Clare, Unpublished report and GIS commissioned by Clare County Council.	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Clare County Council	Various Habitat Surveys (Hurley Keenan Habitat Map, Lough Derg Habitats, South Clare Habitat Map, Tubridy Habitat Survey)	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Cork County Council	Blarney Electoral District Habitat Survey and Mapping 2008	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Cork County Council	Survey & Mapping of Habitats in the Carrigaline Electoral Area	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Cork County Council	Midleton Electoral Area Habitat Survey & Mapping – Phases I, II & III	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Donegal County Council	Pilot Ecological Study of Two Donegal Islands: Inishfree Upper and Inishmeane	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Dublin City Council	Dublin City Local Area Surveys	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Dun Laoghaire - Rathdown County Council	Dun Laoghaire - Rathdown Local Area Surveys and Rare Plant Locations	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Fingal County Council	Fingal Local Area Surveys	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Galway City Council	Galway City Habitat Inventory	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Galway County Council	West County Galway Hedgerow Survey and County Galway Townland Hedgerow Survey	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Galway County Council	Galway Wetlands Scoping Study	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Galway County Council	Galway County Local Area Surveys	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Kerry County Council	Surveys of Tarbert, Ballybunnion, Listowel, Tralee and Cahersiveen; Species surveys	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Kildare County Council	Crushell, P., Foss, P.J., O'Loughlin, B. & Wilson, F. (2012) Title: County Kildare Wetland Survey	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Laois County Council	Hickey, B. & Tubridy, M (2005) Laois Habitats Survey 2005; Hickey, B. & Tubridy, M (2006) Laois Habitats Survey 2006; Hickey, B. & Tubridy, M (2007) Laois Habitats Survey 2007; Hickey, B. & Tubridy, M (2008) Laois Habitats Survey 2008; Hickey, B. & Tubridy, M (2009) Habitats Survey (Phase V) County Laois 2009	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Louth County Council	Foss, P.J., Crushell, P. & O'Loughlin, B. & Wilson, F. (2011) Louth Wetland Identification Survey. Part 1: Main Report. Report prepared for Louth County Council and The Heritage Council. pp. 101 - Foss, P.J., Crushell, P. & O'Loughlin, B. & Wilson, F. (2012) Louth Wetland Survey II. Part 1: Main Report. Report prepared for Louth County Council and The Heritage Council. pp. 107	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Mayo County Council	Mayo Local Area Surveys	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Y
Meath County Council	Fossitt Meath Coastal Habitats 2004 - 2006	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Meath County Council	County Meath Wetlands and Coastal Habitat Survey - August 2010	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Monaghan County Council	Foss, P.J. & Crushell, P. (2007) Monaghan Fen Survey 2007. Report for the Monaghan County Council & National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Ireland. Volumes 1-3; Foss, P.J. & Crushell, P. (2010) The County Monaghan Wetlands Map Desk Survey & GIS Preparation, Report prepared for Monaghan County Council and The Heritage Council; Foss, P.J., Crushell, P. & Wilson, F. (2011) Wetland Survey County Monaghan. Report prepared for Monaghan County Council and The Heritage Council; Foss, P.J. & Crushell, P. (2012) Wetland Survey County Monaghan II. Report prepared for Monaghan County Council and The Heritage Council.	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
Offaly County Council	Meehan, R. & Tubridy, M. (2006) County Offaly Esker Study 2006	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Roscommon County Council	RPS (2010) Habitat Mapping of Habitats in County Roscommon	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
South Dublin County Council	South Dublin Local Surveys	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
South Tipperary County Council	Survey along River Suir, South Tipperary	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Waterford County Council	Waterford Wetland Survey & Surveys of Dungarvan, Tramore and Tramore Town	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Waterford County Council	A Survey of Aquatic and Terrestrial Invertebrate Communities in Co. Waterford's Wetlands (2009)	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Westmeath County Council	Westmeath fen, Peatland & Ecological Sites	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Wicklow County Council	Wicklow Urban Habitat Mapping	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Wicklow County Council	Wilson, F. & Foss, P.J. (2011) Title: The County Wicklow Wetland Survey.	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
NPWS	Marine trial monitoring in Roaringwater Bay SAC (site code 000101)	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	Survey of possible Marsh Fritillary sites in Co Louth, Meath and Monaghan	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Y
NPWS	Marsh Fritillary Survey of the Burren SACs	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Y
NPWS	Hen Harrier Threat Response Plan	Dataset not used	Not relevant to services mapped	Not assessed – data not used	Not assessed – data not used	Y
NPWS	Clara Bog High Bog Ecological Survey	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	Project report
Dept. Of Environment, Community and Local Government	OPW Flood Mapping	Dataset not used	Not relevant for services mapped (Map shows contribution of land to temporary water storage, not which areas are currently at risk of flooding)	Not assessed – data not used	Not assessed – data not used	N
SEAI	Terrestrial Wind Speed	Dataset not used	Not relevant for services mapped	Not assessed – data not used	Not assessed – data not used	N
Tellus Border	Streamwaters	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N
Tellus Border	Stream sediment	Dataset not used	Regional data, not suitable for national scale mapping	Not assessed – data not used	Not assessed – data not used	N

Appendix I Data Audit for the Habitat Asset Register

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	Turloughs – Polygons (Research project by Trinity College Dublin)	Whole SHP attributed 'Turlough' as class	Used in combination with Turloughs – Points; best available data on this habitat	High	Medium	Project report available
NPWS	Turloughs – Points (Article 17)	Whole SHP attributed 'Turlough' as class	Used in combination with Turloughs – Polygons; best available data on this habitat	Medium	Low	Project report available
Forest Service	FIPS - Forest Cover (2007 / 2012)	Refer to the main report for creation of intermediate layers	Most recent data on forestry land use; post-2007 data from forestry 2012 was merged into the 2007 layer due to some issues with source data corruption	Medium	Medium	Report available
Department of Agriculture, Food and the Marine	Forestry12	Refer to the main report for creation of intermediate layers	Used to add post-2007 entries to the forestry 2007 dataset; due to compromised data, the dataset was not used in its entirety	Not specified – no metadata	Not specified – no metadata	N
DAFM	LPIS	Refer to the main report for creation of intermediate layers	Used to cover arable land and pasture sites	Not specified – no metadata	Not specified – no metadata	N
OSi/EPA	Lake Segments (Derived from OSi 1:50,000)	Joined with AR1712_Lake_Habitat_Lookup_Table.xlsx; column: Annex1	Spatial data on lake locations (type of lake joined from Article 17 data)	High	1:50k	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	Article 17 2007 - 2012 Habitat Assessments	Habitats Directive Annex habitats – field & desk (see Table below)		High	High	Y
NPWS	Saltmarsh Monitoring Project 2006 - 2008	HABITAT (excluding some mosaic classes e.g. 'Blanket bog, some MSM', '1420 Mediterranean scrub', 'Other (non-saltmarsh)'	Best available data on saltmarsh habitats according to NPWS	High (mostly derived from field survey)	High (GPS data collected on site, supported by OSi data)	Y
NPWS	National Survey of Native Woodlands 2003 - 2008	H_FOSSCODE	Information on native woodlands of higher accuracy than FIPS (and could include woodlands not covered in FIPS)	High (mostly based on field survey, with original survey site selection using FIPS)	20m*20m is minimum mapping area	Y
NPWS	The Irish Semi-natural Grasslands Survey 2007-2012	FOSS_HAB (excluding 'CD6', 'CM2', 'FS', 'FS1', 'FS2', 'HH3', 'HH4', 'PF', 'PF1', 'PF2', 'PF3'	Best available data on grassland; note that some counties might be covered more comprehensively by the grassland survey than others	High (field survey and inventory data)	12-figure Irish grid reference	Y
NPWS	Raised Bog Monitoring Project 2013	Data in 5 SHPs; column 'Class' in RBMA13_high_bog_ cutaway_2004_5_10_ full, column 'Ecotope' in rest	Combination of sources to provide national distribution of raised bog according to NPWS	Medium	Medium	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
OSi	OSi Discovery Series	Column 'FC_NAME' for BasemapIE_IG_Q1_08; remainder column 'Class' (Attributes: 'NationalSecondaryRoad', 'Motorway', 'NationalPrimaryRoads', 'RegionalRoads')	Best available data on paved over areas	High (but with some areas with compromised data)	High	Y
EPA	Corine Landcover 2012	CODE_12	Full coverage of Southern Ireland	Low	Low	Y
NPWS	Ancient and long-established Woodland Inventory 2010	CLASS	Best available data on ancient woodlands (particularly important for biodiversity)	High	From orthophotos at 1:40.000	Y
UCD	Derived Irish Peatlands Map	category (excluding 'Non Peat')	Comprehensive national extent of peatlands (but low spatial and thematic resolutions and no information on peatland condition or use)	Authors accuracy assessment suggests high, but not 100%, accuracy	Low	Y
NPWS	National Survey of Upland Habitats	'PRIMARY_FO' and 'PRIMARY_AN'	Additional coverage of upland areas	High	High	Y
OSi	Article 17 Coast	Data not used	OSi vector :1:50K used for delineation of coastline for Art17	High	High	N
Teagasc / Nova / UCD	Burren Habitats Map	Data not used	Data not received	Not evaluated – data not received	Not evaluated – data not received	N
EPA	Corine Landcover 2006 (REVISED)	Data not used	More recent set of Corine data available	Not evaluated – more recent data used	Not evaluated – more recent data used	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
EPA	Corine Landcover Changes 1990 to 2012	Data not used	Habitat Asset Register shows current land cover, not land cover change	Not evaluated – data not relevant	Not evaluated – data not relevant	Y
EPA	Corine Landcover 2012 Documents	Data not used	Not spatial data, supporting document PDF	N/A – not spatial data	N/A – not spatial data	N/A
EPA	River Segments	Data not used	Would get lost at 50m grid squares (or take over, if rivers were treated with preference over other habitats)	High	1:50k	N
NPWS	Margaritifera Upland Grazing Assessment	Data not used	Data for 3 catchments only; therefore, cannot usefully be incorporated at a national scale	Not specified – no metadata	Not specified – no metadata	N
Teagasc	Indicative Habitat Map of Ireland	Data not used	Corine data considered to be the more reliable base layer	Not specified – no metadata	Not specified – no metadata	N
Coillte Teoranta	Blanket Bog Restoration Project Habitats in Ireland LIFE Project (EU Project Number: Life 02 Nat/Irl/8490.):	Data not used	Data not received	Not evaluated – data not received	Not evaluated – data not received	N
Coillte Teoranta	Restoring Priority Woodland Habitats in Ireland LIFE Project:	Data not used	Data not received	Not evaluated – data not received	Not evaluated – data not received	N
Coillte Teoranta	Restoring Raised Bog in Ireland (LIFE04 NAT/IE/000121) and Demonstrating Best Practice in Raised Bog Restoration in Ireland (LIFE09 NAT/IE/000222)	Data not used	Data not received	Not evaluated – data not received	Not evaluated – data not received	N

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	Inventory of Irish Coastal Lagoons 2007	Data not used	Best available resource for mapping lagoon extent nationally	High	High	Y
NPWS	National Seacliff Survey 2009 - 2011	Data not used	Discrete habitat	High	1:5000	Y
NPWS	Coastal Monitoring Project 2004 - 2006	Data not used	Article 17 data is primarily based on this dataset, but incorporates some additional information from other sources	High	~ 1:40.000	Y
NPWS	National Juniper Survey 2009 - 2012	Data not used in the Habitat Asset Register	Discrete habitat – minimum convex polygons not habitat polygons	Not recorded in metadata	High	Y
NPWS	National Limestone Pavement Monitoring Project	Data not used	Superseded by Article 17 distribution	High	1:2500	Y
NPWS	Raised Bog Monitoring Project	Data not used	Data contained in another, more comprehensive dataset on raised bogs	Not evaluated – more comprehensive data used	Not evaluated – more comprehensive data used	Y
NPWS	Blanket Bog NHA Project 2003-2004	Data not used	Superseded by NPWS Art17 2013 Blanket Bog extent	Not evaluated – ongoing project	Not evaluated – ongoing project	Y
NPWS	Sand Dune Monitoring Project 2011	Data not used	Data also contained in the Article 17 datasets regarding sand dunes	Not evaluated – Article 17 data used	Not evaluated – Article 17 data used	Y
NPWS	Combined spatial dataset derived from Sand dune habitat spatial data and Coastal Monitoring spatial data	Data not used	Article 17 data on habitats included in these projects was used instead (as these build on this project)	Not evaluated – Article 17 data used	Not evaluated – Article 17 data used	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	Biomar Project	Data not used	Accuracy cannot be assessed (no metadata); project not recommended by NPWS for habitat conflation	Not specified – no metadata	Not specified – no metadata	N
NPWS	Consolidated national distribution of subtidal Zostera habitat	Data not used	Not part of terrestrial habitat conflation	Not evaluated – not terrestrial	Not evaluated – not terrestrial	Y
NPWS	Clara Bog High Bog Ecological Survey	Data not used	Local data, not suitable for incorporation at a national scale (some detail incorporated in Art17 Raised Bog data)	Not evaluated – local data	Not evaluated – local data	Report available
NPWS	NPWS Indicative Habitat Mapping of SAC's and SPA's	Data not used	Additional habitat data on designated sites only, would cause skewing of the overall data with regards to habitat classes (e.g. Some habitats might only be recorded within designated sites, but that does not mean they are absent outside)	Not evaluated – local data	Not evaluated – local data	Y
NPWS	Wicklow Uplands SAC Vegetation and Habitat Map	Data not used	Local data, not suitable for incorporation at a national scale (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Y
NPWS	Ballycroy National Park Habitat Map	Data not used	Local data, not suitable for incorporation at a national scale (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Y
NPWS	Burren National Park Habitat Map	Data not used	Local data, not suitable for incorporation at a national scale (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Y

Dataset Owner/ Provider	Dataset Title	Attribute column used	Reason	Data reliability	Spatial resolution	Metadata available
NPWS	Connemara National Park Habitat Map	Data not used	Local data, not suitable for incorporation at a national scale (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Y
NPWS	Glenveigh National Park Habitat Map	Data not used	Local data, not suitable for incorporation at a national scale (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Y
NPWS	Killarney National Park Habitat Map	Data not used	Local data, not suitable for incorporation at a national scale (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Y
NPWS	Turf Cutting Impact Assessment	Data not used	Would require further consultation with relevant NPWS staff; only covers a selection of sites (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Report available
NPWS	Results of a two-year monitoring survey of Annex I Old sessile oak woods (91A0) and Alluvial forests (91E0) in Ireland.	Data not used	Survey of a sample of specific Article 17 sites; spatial extent covered through Article 17 data for these habitats (some detail incorporated in Art17 annex habitat distributions)	Not evaluated – local data	Not evaluated – local data	Y

Article 17 Code	Article 17 Habitat	Attribute column used	Reason
21A0	Machair*	Whole SHP attributed '21A0' as class	
91A0	Old oak woodlands	Whole SHP attributed '91A0' as class	
91D0	Bog woodland*	Whole SHP attributed '91D0' as class	
91E0	Residual alluvial forests*	Whole SHP attributed '91E0' as class	
91J0	Taxus baccata woods	Whole SHP attributed '91J0' as class	
1110	Sandbanks	Data not used	Not part of terrestrial habitat conflation
1130	Estuaries	Data not used	Not part of terrestrial habitat conflation
1140	Tidal mudflats	Data not used	Not part of terrestrial habitat conflation
1150	Lagoons*	Whole SHP attributed '1150' as class	
1160	Large shallow inlets and bays	Data not used	Not part of terrestrial habitat conflation
1170	Reefs	Data not used	Not part of terrestrial habitat conflation
1210	Drift lines	Data not used	Discrete habitat
1220	Perennial vegetation of stony banks	Data not used	Discrete habitat
1230	Sea cliffs	Data not used	Discrete habitat/SHP type: Line
1310	Salicornia mud	Data not used	Taken from the salt marsh monitoring project
1320	Spartinion	Data not used	Taken from the salt marsh monitoring project
1330	Atlantic salt meadows	Data not used	Taken from the salt marsh monitoring project
1410	Mediterranean salt meadows	Data not used	Taken from the salt marsh monitoring project
1420	Halophilous scrub	Data not used	Discrete habitat/ SHP not spatially explicit
2110	Embryonic shifting dunes	Whole SHP attributed '2110' as class	
2120	Marram dunes (white dunes)	Whole SHP attributed '2120' as class	
2130	Fixed dunes (grey dunes)*	Whole SHP attributed '2130' as class	
2140	Decalcified empetrum dunes*	Data not used	Discrete habitat/ SHP point file
2150	Decalcified dune heath*	Data not used	Discrete habitat/ SHP point file
2170	Dunes with creeping willow	Whole SHP attributed '2170' as class	
2190	Dune slack	Whole SHP attributed '2190' as class	
3110	Oligotrophic soft water lakes	Used AR1712_Lake_Habitat_Lookup_Table	Article 17 information linked to WFD spatial data

Article 17 Code	Article 17 Habitat	Attribute column used	Reason
3130	Soft water lakes with base rich influences	Used AR1712_Lake_Habitat_Lookup_Table	Article 17 information linked to WFD spatial data
3140	Hard water lakes	Used AR1712_Lake_Habitat_Lookup_Table	Article 17 information linked to WFD spatial data
3150	Natural eutrophic lakes	Used AR1712_Lake_Habitat_Lookup_Table	Article 17 information linked to WFD spatial data
3160	Dystrophic lakes	Used AR1712_Lake_Habitat_Lookup_Table	Article 17 information linked to WFD spatial data
3180	Turloughs*	Data not used	Turlough database provided separately by NPWS; data not spatially explicit
3260	Floating river vegetation	Data not used	Discrete habitat
3270	Chenopodium rubri	Data not used	Discrete habitat; SHP point file
4010	Wet heath	Whole SHP attributed '4010' as class	
4030	Dry heaths	Whole SHP attributed '4030' as class	
4060	Alpine and subalpine heath	Whole SHP attributed '4060' as class	
5130	Juniper scrub	Data not used	Discrete habitat; Juniper bushes appear in different habitats, overall habitat of more relevance to ES mapping
6130	Calaminarian grassland	Data not used	Discrete habitat/ SHP point file
6210	Orchid-rich calcareous grassland*	Whole SHP attributed '6210' as class	
6230	Species-rich nardus upland grassland*	Whole SHP attributed '6230' as class	
6410	Molinia meadows	Whole SHP attributed '6410' as class	
6430	Hydrophilous tall herb	Whole SHP attributed '6430' as class	
6510	Lowland hay meadows	Whole SHP attributed '6510' as class	
7110	Raised bog (active)*	Data not used	Data not spatially explicit
7120	Degraded raised bogs	Data not used	Data not spatially explicit
7130	Blanket bog (active)*	Whole SHP attributed '7130' as class	
7140	Transition mires	ANNEX_CODE (excluding 'N/A', 'NOT CLASSIFIED', 'UNCLASSIFIED'	
7150	Rhynchosporion depressions	Data not used	Discrete habitat
7210	Cladium fen*	Whole SHP attributed '7210' as class	

Article 17 Code	Article 17 Habitat	Attribute column used	Reason
7220	Petrifying springs*	Data not used	Discrete habitat; sensitive data
7230	Alkaline fens	ANNEX_CODE (excluding 'N/A', 'NOT CLASSIFIED', 'UNCLASSIFIED'	
8110	Siliceous scree	Whole SHP attributed '8110' as class	
8120	Eutric scree	Whole SHP attributed '8120' as class	
8210	Calcareous rocky slopes	Whole SHP attributed '8210' as class	
8220	Siliceous rocky slopes	Whole SHP attributed '8220' as class	
8240	Limestone pavement*	Whole SHP attributed '8240' as class	
8310	Caves	Data not used	Discrete habitat
8330	Sea caves	Data not used	Not part of terrestrial habitat conflation

Appendix J Percentage Covered by Data Sources in the HAR

Data source	Percentage covered in HAR
LPIS 2009-2013	61.759
Corine	11.789
Article 17	9.800
FIPS – Forest Cover	8.014
Derived Irish Peatlands Map	3.685
Lake Segments – WFD	1.761
OSi Discovery Series	1.171
OSi 5000 Series Vector Data – Irish Grid	0.489
Raised Bog Monitoring Project 2013 – unsurveyed prior 2007	0.439
Irish Semi-natural Grasslands Survey 2007-2012	0.318
Ancient and long-established Woodland Inventory 2010	0.210
Raised Bog Monitoring Project 2013 - habitats prior 2007	0.147
Raised Bog Monitoring Project 2013 - ecotope map	0.094
Polygon and point data buffered by area on Turloughs	0.092
Saltmarsh Monitoring Project 2006-2008	0.091
National Survey of Native Woodlands 2003-2008	0.077
National Survey of Upland Habitats	0.056
Raised Bog Monitoring Project 2013 – habitats 2007-13	0.008
Raised Bog Monitoring Project 2013 - High bog cutaway	0.001

Appendix K Description of LPIS-derived Habitat Classes in Terms of Ecosystem Service Provision

Class description in terms of ecosystem services

- Arable: The whole management unit is part of arable rotation. Likely high input and periods of bare ground.
- Arable mosaic: Only part of the management unit is part of arable rotation. Other types of habitats in between arable areas break up the areas with high input and periods of bare ground. Other habitats could be grasslands, built up areas, bogs, or woodlands. In either case, management of the other habitat is likely going to be less intensive.
- Improved grass (LPIS): Grassland is associated with continuous cover, which will impact upon ecosystem service provision. Grassland classed as improved is likely to be managed intensively with regards to fertiliser input and stocking density. Information on fertiliser application rates and stocking density was not available during the project but could be used in an update.
- Improved grass (LPIS) Mosaic: Other, non-grass habitats are contained in the same management unit as the improved grassland (e.g. built-up areas or woodland (not arable, as that would be considered arable mosaic). This mosaic habitat is likely to receive less fertiliser and possibly less intensive grazing regime.
- Rough Grazing (LPIS): Rough grazing is considered to be found on poor quality land unsuitable for crop production, difficult to improve for greater biomass (silage/hay) and often in difficult to access locations. The stocking density is often lower than more improved fields and is likely only subject to nutrient enrichment from livestock faecal matter, trampling and occasional cutting.
- Rough Grazing (LPIS) Mosaic: Other, non-grass habitats are contained in the same management unit as the Rough Grazing. The other habitat is likely to contain land uses such as open water or built-up areas and therefore less likely to contain livestock.
- Grassland Natural (LPIS): Natural grassland contains classes that are managed with little fertiliser input and, if any, low stocking densities. Based on this continuous cover, likely being more species rich and a varied height structure than more intensively managed systems it is likely to more readily process nutrients and water.

- Grassland Natural (LPIS) Mosaic: Other, non-grass habitats are contained in the same management unit as the natural grassland. As woodland, as well as bog data, is included from other datasets higher up in data conflation order, the habitat mixed with the natural grassland is likely to be of less ES value than natural grassland.

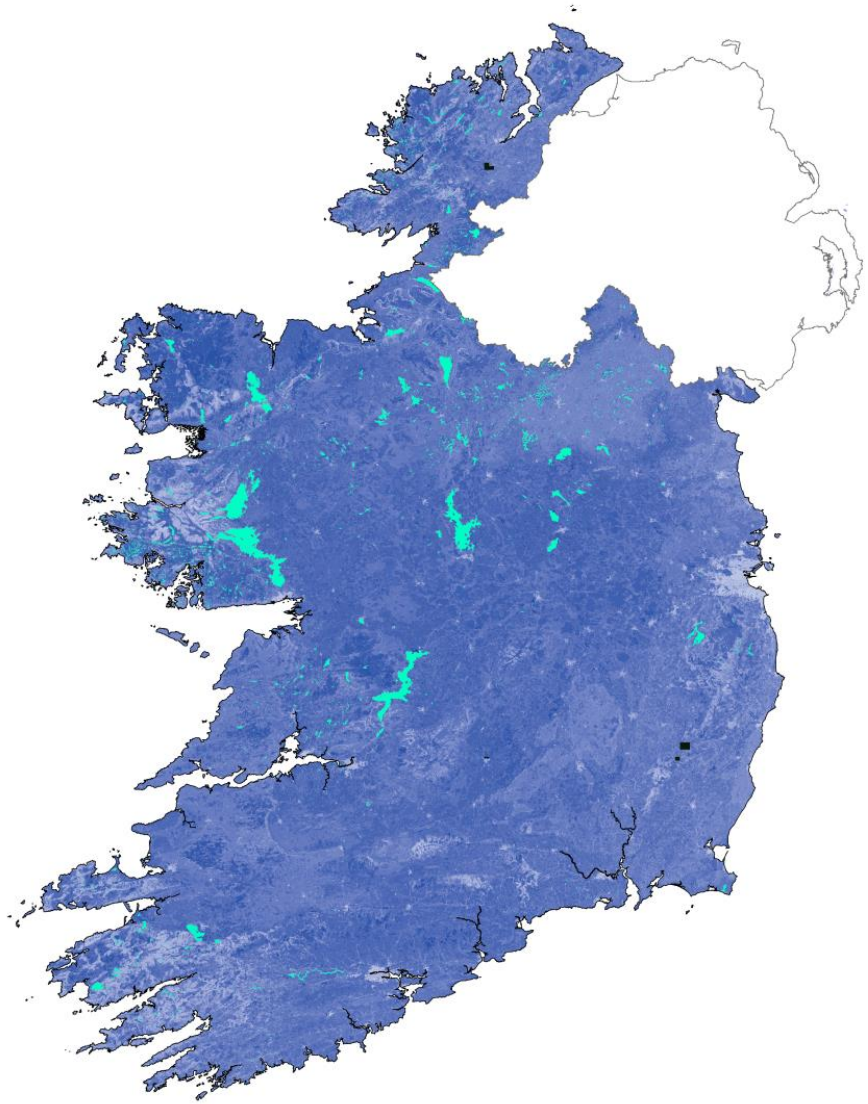
Appendix L Indicator documents providing the technical background to each service mapped

Indicator documents for the following ecosystem services are included in this Appendix L:

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

Land that temporarily stores water
Ecosystem service: **Regulation of flows (Regulating)**

29/03/2016



Legend

Higher contribution to temporary water storage

Lower contribution to temporary water storage

Freshwater

Compromised data in urban input

How to interpret the map:
Darker colours represent areas that are helping to slow water. The lighter colours represent areas where water is moving quickly through the environment and therefore contributing to flood risk down the catchment.

Ecosystem service:
Regulation and mediation of liquid flows - Land that temporary stores water helping to mitigate flooding

What the service is:
This map shows where the environment is helping to slow the movement of surface water run-off over the land into rivers (also known as overland flow), and where is most at risk of flooding.

Why it is important:
Increased climate variability will increase the risk of both floods and drought, both of which will be mitigated against to varying degrees by vegetation and substrate. For example, habitats such as woodlands have many layers of vegetation, which help slow down the rain drops by friction. Therefore, by the time they reach the ground they have, to some extent, been dispersed and are subsequently travelling slowly enough to sink into the soil.
The other contributing factors are soil type, landform and land management.

How the map was created:
This map was created using a combination of datasets. Habitat information from the derived habitat map, together with slope, soil and geology data have been considered. The soil and geology are also important, as some areas can absorb and hold water whilst others hold very little. Topography is significant, where flat land holds water whilst steep slopes shed water rapidly. The map should be interpreted as showing the best information with the current data available.

Valuation Example:

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Mediation of liquid flows for flood protection – by land cover, soils and slope.	Vegetation effect on interception	Habitats	Dense vegetation	high
			Sparse vegetation	low
	Infiltration and drainage characteristics of the ground	Soil / geology	Free draining soils and permeable rock	high
			Poor draining soils and impermeable rock	low
	Drainage	Topography	Gentle slopes	high
			Steep slopes	low

0 20 40 60 80 100
Kilometres

N

Cartography by Environment Systems Ltd, May 2016.
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© Ordnance Survey Ireland / Government of Ireland [2016].
Contains data prepared by the Environmental Protection Agency based on Ordnance Survey Ireland information.
For full list of datasets used for this map, please refer to the final project report.

An Roinn Ealaíon, Oidhreachtaí agus Gaeltachta
Department of Arts, Heritage and the Gaeltacht
National Parks & Wildlife Service

Environment SYSTEMS evidence and insight

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 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

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.

Service indicator(s) mapped

This ecosystem service was mapped using information about habitats, substrate, landform and land management.

Habitat structure influences water quantity regulation through its capacity to intercept water. Habitat structure and species composition also influence soil quality and the time taken for water to infiltrate through the soil, influencing the severity of surface run-off.

Soil structure, the combination of topsoil and subsoil, determines the capacity of soil to hold water and regulate flows; fine-grained soils such as clays have small pores between their particles, and can retain water, depending on their condition. Medium grained, sandy soils have little retention capacity. Organic matter increases the pore size of soils, so that soils with higher organic matter content are able to store more water, and thereby provide greater flow attenuation. Geology also affects water-holding capacity through its influence on soil generation and ground water storage.

Landform has been considered on the basis that steep slopes shed water while basins collect water.

Land management can moderate or enhance each of the other indicators. For example, intense grazing regimes, or trafficking by heavy machinery can lead to soil compaction, resulting in lower soil pore space. A long history of cultivation can degrade the level of soil organic matter through oxidisation.

Datasets used	**Dataset requirements[2]**
Habitat Asset Register[3]	Essential
Teagasc Soil	Essential
Teagasc Subsoil	Essential
National Draft Generalised Bedrock Map	Essential
NextMap 5m DTM	Essential
Article 17 – 6130	Desirable
Article 17 – 5130	Desirable
Article 17 – 2140	Desirable
Article 17 – 2150	Desirable
Groundwater Recharge	Desirable

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

This map was created using a combination of datasets. Habitat information from the habitat asset register, together with slope, soil and geology data have been considered. Soils and geology are important, because some areas can absorb and hold water whilst others hold very little. Topography is also significant, as flat land has the capacity to hold water, whilst steep slopes shed water rapidly.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the national/strategic scale, and a field visit should be conducted before decisions are made regarding a particular location.

Scoring

Significant Effects	**Datasets used**	**Example attributes**	**Indicative scoring[4]**
Above ground habitat structure, especially where there are multiple layers of vegetation. Amount of leaf litter, water uptake through roots, vegetation species type and likely rooting depth leading to, prevention of surface runoff	Habitat Asset Register	Broadleaved woodland	High
		Semi-natural dry grassland	Medium
		Built environment	Disbenefit
Capability to absorb water and hold water	Teagasc Soil	AeoUND (Aeolian (undifferentiated)	High
		AminPD (Acid Deep Poorly Drained Mineral)	Medium
		BminSPPT (Basic Shallow Poorly Drained Peaty Mineral)	Low
Capability to absorb water and hold water	Teagasc Subsoil	Alluvium, Silty	High
		Till, Sandy	Medium
		Esker composed of gravels, Acidic.	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Rate of infiltration and water holding capacity	National Draft Generalised Bedrock Map	Dinantian Lower Impure Limestones	High
		Namurian Sandstones	Medium
		Cambrian Metasediments	Low
Contribution to surface water runoff or storage	NextMap 5m DTM	None	High
		None	Medium
		None	Low
		>18°	Disbenefit
Above ground habitat structure, especially where there are multiple layers of vegetation. Amount of leaf litter, water uptake through roots, vegetation species type and likely rooting depth leading to, prevention of surface runoff.	Article17 - 6130	None	High
		None	Medium
		6130	Low
Above ground habitat structure of Juniper heath	Article17 - 5130	None	High
		5130	Medium
		None	Low
Buffered point data to show where dune heath might help retain water in some sandy soils	Article17 - 2140	None	High
		None	Medium
		2140	Low
Buffered point data to show where dune heath might help retain water in some sandy soils	Article17 - 2150	None	High
		None	Medium
		2150	Low
Speed of water movement through the soil	Groundwater Recharge	None	High
		DRY, High	Medium
		Water, Low	Low

Data gaps associated with this map during the pilot project

This service has been developed using the above available datasets for the key factors available to the project team in autumn 2015. The outputs could be enhanced in the future by integration of higher resolution data from the EPA Integrated Catchment Management plans and OPW CFRAMS programmes respectively.

The data used includes habitat cover, soils, geology and topography. This provides a good indication of how water is naturally stored by different ecosystems.

Inclusion of data such as drainage networks (e.g. non-river channels that water flows through after heavy rainfall events) could be included to determine where exactly water will travel through the landscape. Depth of soils profiles (particularly peat depth) could add a greater level of detail to the mapping of this service.

Incorporation of rainfall data could highlight areas under particular pressure, which could be considered in conjunction with this map to identify which catchments have a high flood risk and why the flood risk in these regions is higher than in other areas.

NOTE – Whilst the Habitat Asset Register (HAR) is based on the best data currently available, it does contain some inherent limitations due to the manner in which LPIS categorises permanent pasture. This may lead to an underestimation of semi-natural grassland and heaths. For details, please refer to the section on data gaps and the section on the preparation of LPIS data for usage in the HAR. Additionally, habitat condition data was not available on a national scale for all habitats, but could form another proxy for ecosystem service provision.

Scientific framework for modelling 'Areas of land that temporarily store water'

Overview	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
Soil	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). 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). 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). 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).

	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).
	Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide[5]; Teagasc, 2007).

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

Soil systems	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). 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). 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).
Geology	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).
Landform	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). 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).
Habitat	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: • 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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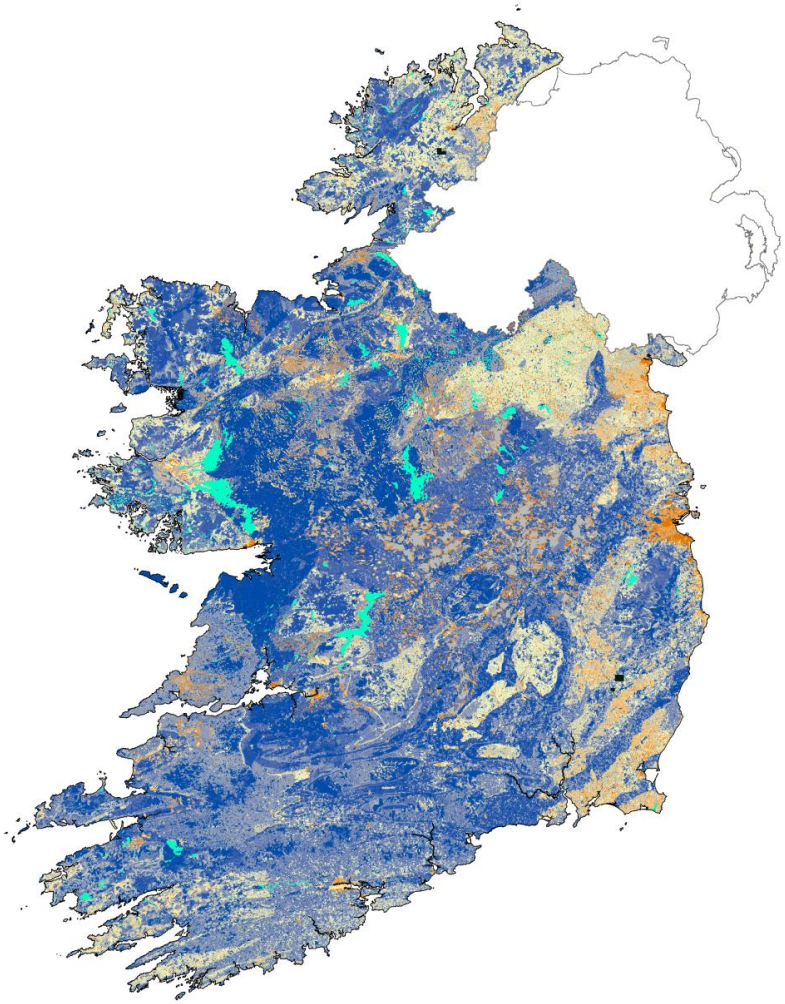
Land promoting good water quality: Indicator document - Ecosystem Service Modelling & Rule-base development

Areas of land promoting good water quality
Ecosystem service: **Regulation of water quality**

29/03/2016



Legend

Higher contribution to promoting good water quality

Some disbenefit to promoting good water quality

Freshwater

Compromised data in urban input

How to interpret the map:
The darkest colours represent land that contributes most to filtering sediment from the water and, therefore, 'better' water quality. Lighter colours represent land that may be inputting impurities into the water environment.

Ecosystem service:
Regulating and maintaining chemical condition of freshwater – Water Quality Regulation

What the service is:
Contribution of the land to the filtration and supply of fresh water.

Why it is important:
Pure clean water is essential for human health and underpins the whole environment.

How the map was created:
The map has been created using information on soil type from the Teagasc national soils and subsoils datasets, landform in terms of slope angle and habitats from the compiled habitat map. It uses scientific knowledge to model which areas of land are likely to be filtrating water and which areas of land are potentially having an adverse effect by inputting impurities. The map should be interpreted as showing the best information with the current data available. The map is intended for use at a strategic scale. If information is needed about current site specific water quality a detailed field survey should be undertaken.

Valuation Example:

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Water Quality Regulation	Land cover effect on	Habitat	Woodland Hedge Heathland Bog Arable	med/high med med med/low low/neg
	Filtration effect of the soils	Soils	Brown earths Peaty soils	med/high low
	Slope is linked to flow rate	Elevation – slope based on DTM	Steep slopes	Negative

0 20 40 60 80 100
Kilometres

N

Cartography by Environment Systems Ltd, May 2016.
Ordnance Survey Ireland Licence No EN 0059216
© Ordnance Survey Ireland / Government of Ireland [2016].
Contains data prepared by the Environmental Protection Agency based on Ordnance Survey Ireland information.
For full list of datasets used for this map, please refer to the final project report.

An Roinn Ealaíon, Oidhreachta agus Gaeltachta
Department of Arts, Heritage and the Gaeltacht
National Parks & Wildlife Service

Environment SYSTEMS evidence and insight

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.

Service indicator(s) mapped

This ecosystem service was mapped using information about habitats, substrate, landform and land management.

Habitats exert an influence on water quality through their effects on below-ground systems (e.g. stabilising soil and preventing erosion, enhancing soil structure and the actions of roots themselves in cat-ion exchange as plants take up minerals from the soil water matrix). The microorganisms which live on the root systems of many wetland species also uptake pollutants from water, effectively purifying it.

During its percolation through the soil, water can interact with the soil chemistry resulting in impurities becoming chelated to the soil particles. Similarly, water also percolates through the underlying geology where impurities may be removed.

Landform has been considered on the basis that steep slopes shed water, while basins collect water. Floodplains may be more susceptible to accumulating impurities as they are deposited by flood water.

Land management can affect water quality both positively and negatively. For example, agricultural practices can determine the level of nitrogen and pesticide inputs into water courses, while targeted wetland creation schemes can be used to filter sewage waste and heavy metal impurities.

Datasets used	**Dataset requirement[2]**
Habitat Asset Register[3]	Essential
Teagasc Soils	Essential
NextMap 5m DTM	Essential
Conservation Designations	Beneficial

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

The map has been created using information on soil type from the Teagasc national soils and subsoils datasets, landform in terms of slope angle, and habitats from the derived habitat map. It uses scientific

knowledge to model which areas of land are likely to be filtrating sediment and particulate matter from water and which areas of land are potentially having an adverse effect by inputting impurities.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the strategic /national scale; if information is needed about current site-specific water quality a detailed field survey should be undertaken.

Scoring

Significant Effects	**Datasets used**	**Example attributes**	**Indicative scoring[4]**
Amount of leaf litter, nutrient uptake through roots, vegetation species type, and prevention of surface runoff.	Habitat Asset Register	Broadleaved forest	High
		Natural grasslands	Medium
		Isolated Spartina clumps on mud (5%)	Low
		Arable, Built Environment	Disbenefit
Contribution to surface water runoff or storage.	NextMap 5m DTM	None	High
		None	Medium
		None	Low
		>18°	Disbenefit

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Significant Effects	Datasets used	Example attributes	Indicative scoring
Capability to immobilise impurities e.g. % clay & organic matter, rate of water infiltration.	Teagasc Soil	AminDW (Acid Deep Well Drained Mineral)	High
		AlluvMIN (Mineral Alluvium)	Medium
		AminPDPT(Acid Poorly Drained Peaty Mineral)	Low
		Cut (Cutover/Cutaway Peat)	Disbenefit
Capability to immobilise impurities e.g. % clay & organic matter, rate of water infiltration.	Teagasc Subsoil	None	High
		None	Medium
		None	Low
		Cutover raised peat	Disbenefit
Rate of water infiltration	Groundwater Recharge	None	High
		None	Medium
		None	Low
		DRY	Disbenefit
Capability to immobilise impurities rate of water infiltration.	Groundwater Aquifers	Locally Important Aquifer – Karstified	High
		Regionally Important Aquifer – Moderately productive bedrock	Medium
		None	Low
		Poor Aquifer – Unproductive bedrock	Disbenefit

Data gaps associated with this map during the pilot project

Livestock rearing is a potential contributor to water pollution; therefore, stocking density would be an important indicator that could be added to the model to assess the distribution of this service throughout land used for grazing.

Similarly, exact locations of point sources of pollution would increase the model accuracy, as they would help to identify areas where the land is of dis-benefit to this service.

To add to this map, drainage channels throughout Ireland could be used (together with the direction of flow within rivers) to model where pollutants are likely to end up and which rivers could be at a risk of pollution. This has not been done, as the current project looks specifically at the contribution of areas of land to the provision of this service, which is independent of drainage channels and river flow.

Spreading of artificial and natural fertilisers (slurry) is a major factor influencing this service, but currently not incorporated into the ES map. Teagasc is currently involved in a project on Nutrient planning, the results of which could be incorporated into future map updates.

This map focusses on risk of sediment being dissolved in the water, not on individual pollutants such as nitrogen or phosphorus.

NOTE – Whilst the Habitat Asset Register (HAR) is based on the best data currently available, it does contain some inherent limitations due to the manner in which LPIS categorises permanent pasture. This may lead to an underestimation of semi-natural grassland and heaths. For details, please refer to the section on data gaps and the section on the preparation of LPIS data for usage in the HAR.

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)

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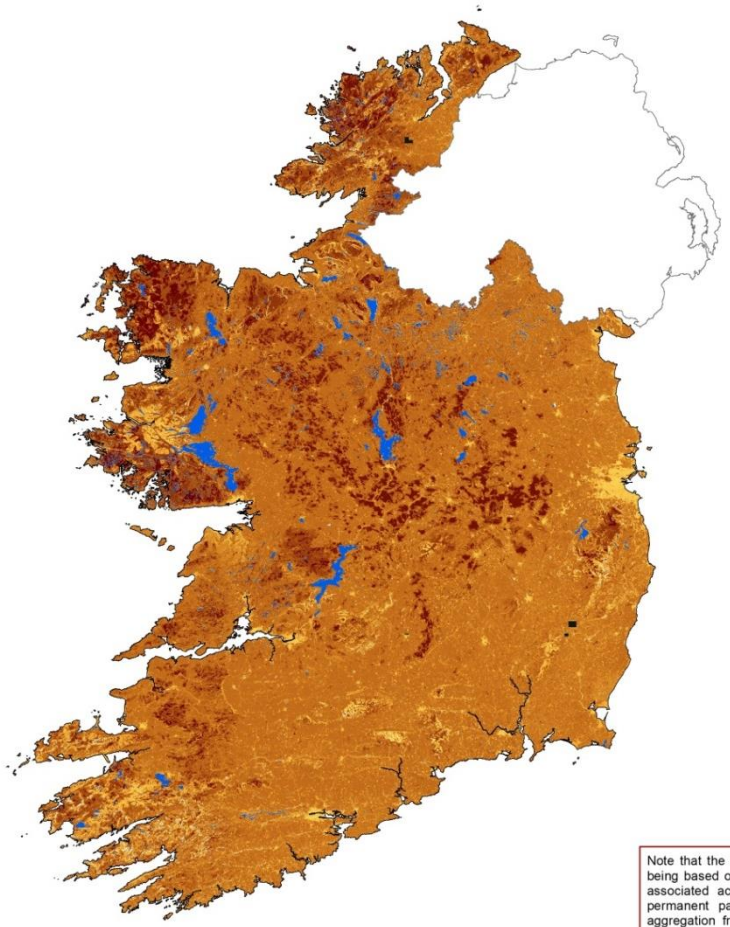
Soil carbon: Indicator document - Ecosystem Service Modelling & Rule-base development

Soil Carbon

Ecosystem service: **Regulation of greenhouse gases (carbon)**

29/03/2016



Note that the Habitat Asset Register (HAR) has, whilst being based on the best data currently available, some associated accuracy limitations, particularly regarding permanent pasture and other information based on aggregation from the LPIS information and an under-estimate of species rich grassland and heath. For details, please refer to the section on data gaps and the section on the preparation of LPIS data for usage in the HAR.

Legend

- Higher contribution to carbon sequestration
- Moderate contribution to carbon sequestration
- Lower contribution to carbon sequestration
- Freshwater
- Compromised data in urban input

How to interpret the map:
The darkest colours represent areas with high level of organic soil carbon overlain by vegetation which is actively helping the soil to store carbon. Lighter colours represent sandy soils with little organic carbon, which are regularly disturbed where carbon is released into the atmosphere.

Ecosystem service:
Climate change (regulation) - storage of carbon within soils

What the service is:
Soil organic matter is a heterogeneous mixture of organic compounds that are highly enriched in carbon, ranging in decomposition from fresh plant residues (leaf litter), to highly decomposed material known as humus. Organic carbon levels of different soil types are directly related to the amount of organic matter contained in 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. Peat based soils contain the most carbon whilst sandy soils contain much less.

Why it is important:
Carbon storage in the soil is known as a major carbon sink; the more carbon stored in the soil, the less greenhouse gases are released into the atmosphere. Soil carbon storage results from interactions of different ecological processes.

How the map was created:
Information about soil type, landform and vegetation together with the management information (ploughing, for example, reducing potential for holding soil carbon), that are available, have been weighted (valued) and combined. The map has been created using existing datasets; including the Teagasc national soils and subsoils datasets and the derived habitat map. This does not include information on disturbance, which is particularly relevant on peatlands. The map should be interpreted as showing the best information with the current data available. The map is intended for use at a strategic scale. If exact carbon budgets are required for a specific site, field work should be carried out.

Valuation example:

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Soil carbon resource: Organic carbon stored in soils	Presence of organic carbon in the soil	Soils and subsoils	Organic soils	high
			Mineral soils	low
	Topography suitable for soil carbon accruement	Slope	Little slope	high
			Steep slopes	low
	Vegetation cycle accrues / releases soil carbon	Land cover	Semi-natural wetlands	high
			High intensity agriculture	low

0 20 40 60 80 100
Kilometres

N

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

National Parks & Wildlife Service

Environment SYSTEMS evidence and insight

Indicator	CICES classification
SOIL CARBON (REGULATION OF GREENHOUSE GASES (CARBON))	**Section**: Regulation & Maintenance **Classes:** Global climate regulation by reduction of greenhouse gas concentrations **CICES IE Sub-class:** Areas important for emissions reduction
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 CO_2 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.

Service indicator(s) mapped

Soil type, habitat, landform and land management were the indicators used to map the service.

Soil data were used to identify areas of mineral, organo-mineral and organic soils. Mineral soils have the lowest carbon content, while organic soils (including peat) have the highest carbon content. Soil drainage was also assessed, as waterlogged, oxygen-poor soils have slower microbial cycling and therefore act as a carbon store (when they are actively forming peat), while dry, well-aerated soils have much faster carbon-cycling and tend to retain lower levels of carbon in the soil.

Habitat data were used to assess the contribution of the vegetation to below-ground carbon storage. Deep-rooted perennial species can facilitate an increase in soil carbon over time through root exudates and decay of leaf litter.

Landform data were used to indicate the effects of topography on soil depth; gentler slopes, which retain deeper soils, and are more likely to accumulate carbon in the soil than steeper slopes, where soils are shallower and water flow is faster. Where depressions occur, organic matter can accumulate due to wetter conditions.

Land management was assessed as positive or negative. Positive management includes reduction of grazing, retention of permanent pasture over cropping, and drain blocking. Negative management includes clear felling large areas, tillage or planting forestry on organic soils, ploughing and drainage of land.

Datasets used	**Dataset requirement[2]**
Habitat Asset Register[3]	Essential
Teagasc Soils	Essential
NextMap 5m DTM	Essential
Conservation Designations	Beneficial

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

Information about soil type, landform and vegetation, together with available management information have been weighted (scored) and combined. The map has been created using existing datasets; including the Teagasc national soils and subsoils datasets and the derived habitat map.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the strategic scale, and a field visit should be conducted before decisions are made regarding a particular location. If exact carbon budgets are required for a specific site, field work should be carried out.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring[4]
Level of topsoil disturbance, carbon cycling through roots and detritus	Habitat Asset Register	Semi-natural broadleaved woodland	High
		Semi-natural grassland	Medium
		Saltmarsh – Spartina mosaic	Low
		Build environment	Disbenefit
Slope gradient affecting soil depth	NextMap 5m DTM	None	High
		None	Medium
		None	Low
		11°-18°; >18°	Disbenefit
Carbon content, texture and drainage properties	Teagasc Soils	FenPt ; RsPt	High
		AminSP, GGr	Medium
		AlluvMIN, Asi	Low

[4]The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Data gaps associated with this map during the pilot project

Management and habitat condition are major factors in determining soil carbon storage, neither of which could be fully incorporated into mapping at this stage. Disturbance of peatlands is important, as these areas sequester high amounts of carbon when in good condition, but release carbon into the atmosphere when disturbed (a project looking at the condition of peatlands is currently underway).

Depth of the soil profile (in particular peat depth) should ideally be included for mapping of this service.

Erosion is a major factor in determining how stable the soil profile is. Slope and habitat in conjunction form an additional indicator which could be added to the model to increase the accuracy regarding the effect soil erosion has on soil carbon storage.

The manner in which the LPIS system categorises Permanent Pasture may lead to an overestimation of the amount of grassland that is actually heavily improved. The Guide to Land Eligibility Direct Payment Schemes 2015 states that "Permanent grassland includes productive ryegrass dominated swards, less productive swards that include rush and other non-grass herbaceous species and grassland that includes heather which is grazable and where grass and herbaceous species are not

predominant". This may lead to areas that are not overlain by better resolution habitat data being categorised as Permanent Pasture when they may contain other habitats such as Heaths or Blanket Bogs.

Additionally, as the data does not record percentage cover of the individual classes, the classes used are conservative best estimates. In case of a mix of an arable class and a grassland type, the area will appear as arable, even though in reality 90% of the area could be grassland. However, in the final HAR only ~1.5% or Ireland's terrestrial extent are covered by mosaic classes from LPIS, making this a minor issue with regards to overall accuracy for ecosystem service mapping

Scientific framework for modelling Soil Carbon

Overview:	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. 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).
Soil systems	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). 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 CO_2 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 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). 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). Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide[5]; Teagasc, 2007).

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

Management	Negative management practices leading to the release of carbon include: • 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 Positive management practices leading to increased storing of carbon include: • 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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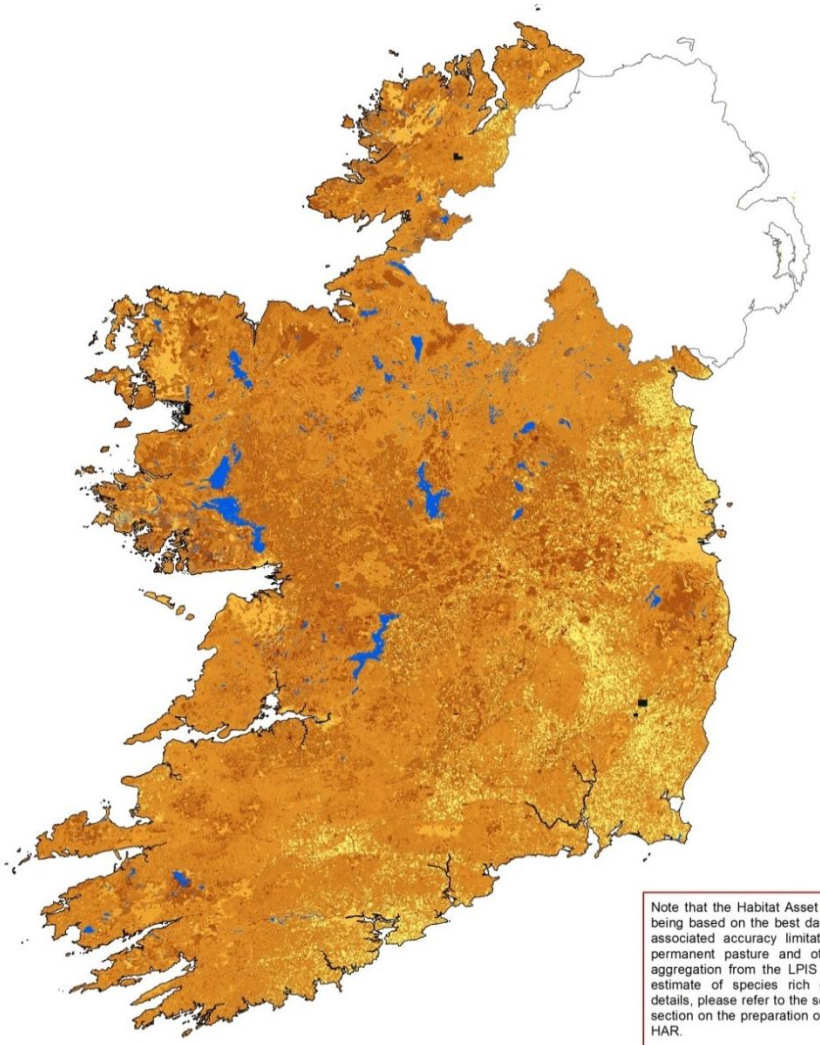
Vegetation carbon: Indicator document - Ecosystem Service Modelling & Rule-base development

Vegetation Carbon

Ecosystem service: **Regulation of greenhouse gases (carbon)**

29/03/2016



Note that the Habitat Asset Register (HAR) has, whilst being based on the best data currently available, some associated accuracy limitations, particularly regarding permanent pasture and other information based on aggregation from the LPIS information and an under-estimate of species rich grassland and heath. For details, please refer to the section on data gaps and the section on the preparation of LPIS data for usage in the HAR.

Legend

- Higher contribution to carbon sequestration
- Moderate contribution to carbon sequestration
- Lower contribution to carbon sequestration
- Freshwater
- Compromised data in urban input

How to interpret the map:
The darkest colours represent areas where there is more carbon storage in the vegetation. Lighter colours represent areas of land where vegetated carbon is removed from the land each year.

Ecosystem service:
Climate change (regulation) - storage of carbon within vegetation.

What the service is:
Atmospheric carbon is sequestrated by and stored in vegetation through the process of photosynthesis, resulting in vegetative growth. The more biomass present in the vegetation the more carbon that is stored, with mature woodland of higher importance and grasslands and bare ground providing a lesser amount of carbon storage.

Why it is important:
Terrestrial ecosystems such as woodlands help to mitigate climate change by binding carbon within its biomass, thereby reducing greenhouse gas concentrations.

How the map was created:
Data analysis identified areas of significant carbon storage within vegetation. Information derived from existing habitat and land management data. This included a habitat map derived from Corine, FIPS Forest 07 and Forest 12 and NPWS (Article 17, National Survey of Native Woodlands 2003-2008; and Ancient and Long-established Woodland Inventory 2010) datasets. Vegetation is valued high to low according to both its above and below ground likely sequestration of carbon.
The map should be interpreted as showing the best information using the data currently available.

Valuation Example

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Vegetation carbon resource: how much carbon is stored in the vegetation	Biomass present	Habitats	Woody species	high
			Bare ground	low
	Biomass removal	Management	Ancient woodland	high
			High intensity agriculture	low

0 10 20 30 40 50
Kilometres

N

Cartography by Environment Systems Ltd, May 2016.
Ordnance Survey Ireland Licence No EN 0059216
© Ordnance Survey Ireland / Government of Ireland [2016].
Contains data prepared by the Environmental Protection Agency based on Ordnance Survey Ireland information.
For full list of datasets used for this map, please refer to the final project report.

An Roinn Ealaíon, Oidhreachta agus Gaeltachta
Department of Arts, Heritage and the Gaeltacht
National Parks & Wildlife Service

Environment SYSTEMS evidence and insight

Indicator	CICES classification
VEGETATION CARBON STORAGE Vegetation carbon (Regulation of greenhouse gases (carbon))	**Section**: Regulation & Maintenance **Class:** Global climate regulation by reduction of greenhouse gas concentrations Filtration / sequestration / storage / accumulation by micro-organisms, algae, plants, and animals **CICES IE Sub-class:** Areas important for emissions reduction
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

This is an important ecosystem service as it can help mitigate climate change by storing CO_2 and preventing its release into the atmosphere. Atmospheric carbon is sequestrated by, and stored in vegetation through the process of photosynthesis, resulting in vegetative growth. The more biomass present in the vegetation the more carbon that is stored, with mature woodland providing higher storage, grasslands providing little, and bare ground providing none.

Service indicator(s) mapped

This is an important ecosystem service as it can help mitigate climate change by storing CO_2 and preventing its release.

Vegetation carbon storage occurs in living plant biomass both above-ground in the form of stems, trunks, leaves and branches, and below-ground in the form of roots and rhizomes. This is a temporary form of carbon storage. As the vegetation dies back the plant material is broken down by decomposer organisms, releasing carbon back into the soil and atmosphere. Plants which generate the largest living biomass, and have the longest lifespan, store the highest levels of carbon.

Datasets used	Dataset requirement [2]
Habitat Asset Register [3]	Essential
Teagasc Soil	Beneficial
Conservation Designations	Beneficial

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

Information was derived from existing habitat and land management data. This includes the Habitat Asset Register for Ireland. Vegetation has been valued high to low according to both its above ground and below ground likely sequestration of carbon. In addition to habitat data, the effects of soil and conservation designations were considered.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring [4]
Level of biomass within habitat, longevity of species.	Habitat Asset Register	Woodland	High
		Raised Bog – Marginal Ecotope	Medium
		Coniferous woodland - Felled	Low
Effect of soil type on plant growth and longevity.	Teagasc Soil	None	High
		None	Medium
		AminSW, GQz	Low
Areas under conservation likely to have less vegetation removed through management	Conservation Designations	None	High
		None	Medium
		Area under designation	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Data gaps associated with this map during the pilot project

Habitat cover as an indicator for vegetation carbon storage could be enhanced by the addition of nationwide condition data of semi-natural habitats. Direct measurements of biomass cover and density e.g. ancient woodlands with diverse understorey and ground flora will contain more vegetation carbon than semi-mature plantation woodland with no understorey.

NOTE – Whilst the Habitat Asset Register (HAR) is based on the best data currently available, it does contain some inherent limitations due to the manner in which LPIS categorises permanent pasture. This may lead to an underestimation of semi-natural grassland and heaths. For details, please refer to the section on data gaps and the section on the preparation of LPIS data for usage in the HAR.

Scientific framework for modelling 'vegetated carbon storage'

Overview:	Atmospheric carbon is sequestrated by, and is stored in, vegetation through the process of osmosis and plant growth (FAO, 2001). There is good supporting evidence regarding the role of soils and habitats in vegetation carbon storage and the role of above and below ground processes. The most relevant material is summarised here.
Soil	Vegetation carbon storage is influenced by soil type, with properties such as soil texture, depth, organic matter/nutrient content as well as the context of the soil in the landscape affecting the type of vegetation likely to be present (Brady and Weil, 2002; Dominati et al., 2010). Additionally, human management of soil has a strong influence on vegetation carbon storage by altering the type of vegetation found in an area (Foley et al., 2005). This is of particular relevance when modifications of the soil (e.g. drainage or fertiliser input) promote growth of plants that would not naturally be sustained by the soil type present (Foley et al., 2005; Holman, 2009; McCracken et al., 2011). While vegetation is linked to broad groups of soil type (as discussed below), association between vegetation and subdivisions of soil type is low (Rankin et al., 2007). For example, mature woodland can even develop on quite shallow and wet soils.

Soil (cont.)	Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide [5]; Teagasc, 2007).

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

Habitat and land use	The more biomass that is present in the vegetation layer, the more carbon is stored in the vegetation. Habitat type is a key determinant of vegetation carbon storage. As plant material, particularly woody tissue, contains up to 50% carbon (FAO, 2001; Thomas and Martin, 2012), a high biomass within the habitat is associated with large quantities of vegetation carbon. Consequently, on a per area basis, woodlands are the main contributor to vegetation carbon storage in temperate climates (Milne and Brown, 1997; Quine et al., 2011; Alsonso et al., 2012), with most carbon being stored in the trunks (Hagon et al., 2013). To assess the rate of carbon uptake, the age of the forest is important, as uptake is highest during the full-vigour phase (Quine et al., 2011; Alsonso et al., 2012) before levelling out in mature forests (Broadmeadow and Matthews, 2003). Most of the carbon stored in grasslands is in the soils (Bullock et al., 2011; Alonso et al., 2012; Hagon et al., 2013). Habitats managed for arable and horticultural crops store the least carbon in their vegetation (Milne and Brown, 1997; Alonso et al., 2012). An important difference between agriculturally managed and natural systems is that, in natural systems, part of the above ground biomass will be incorporated into the soil carbon store as plant litter (Melillo et al., 1989; Angers and Caron, 1998; Rasse et al., 2005). For example in heathlands, during the growth phase biomass increases, which leads to a net gain in vegetation carbon. However, after a certain time, between 18 and 27 years in Calluna vulgaris dominated heath, vegetation biomass (and carbon with it) levels out, as gain from growing plants and loss from dying plants balance out. During this time, however, stocks in the soil could keep increasing due to plant litter (Kopittke et al., 2013).

Habitat and land use (cont.)	Wetlands are considered a terrestrial carbon sink (Billett et al., 2010; Kayranli et al., 2010; Bain et al., 2011), but store the majority of the carbon in the underlying soils rather than in the vegetation (Ostle et al., 2009; Bain et al., 2011). A diverse community of soil invertebrates, particularly earthworms, can have a positive impact on soil structure by creating pores of various sizes that enable easy root penetration and increase oxygen content and water holding capacity (Brussaard, 1997; Wall and Moore, 1999; Lavelle et al., 2006). In habitats where this is the case, below ground species richness can have a positive impact on the maximum biomass that can be sustained above ground (Brussaard, 1997; Wall and Moore, 1999) and, hence, affect vegetation carbon.

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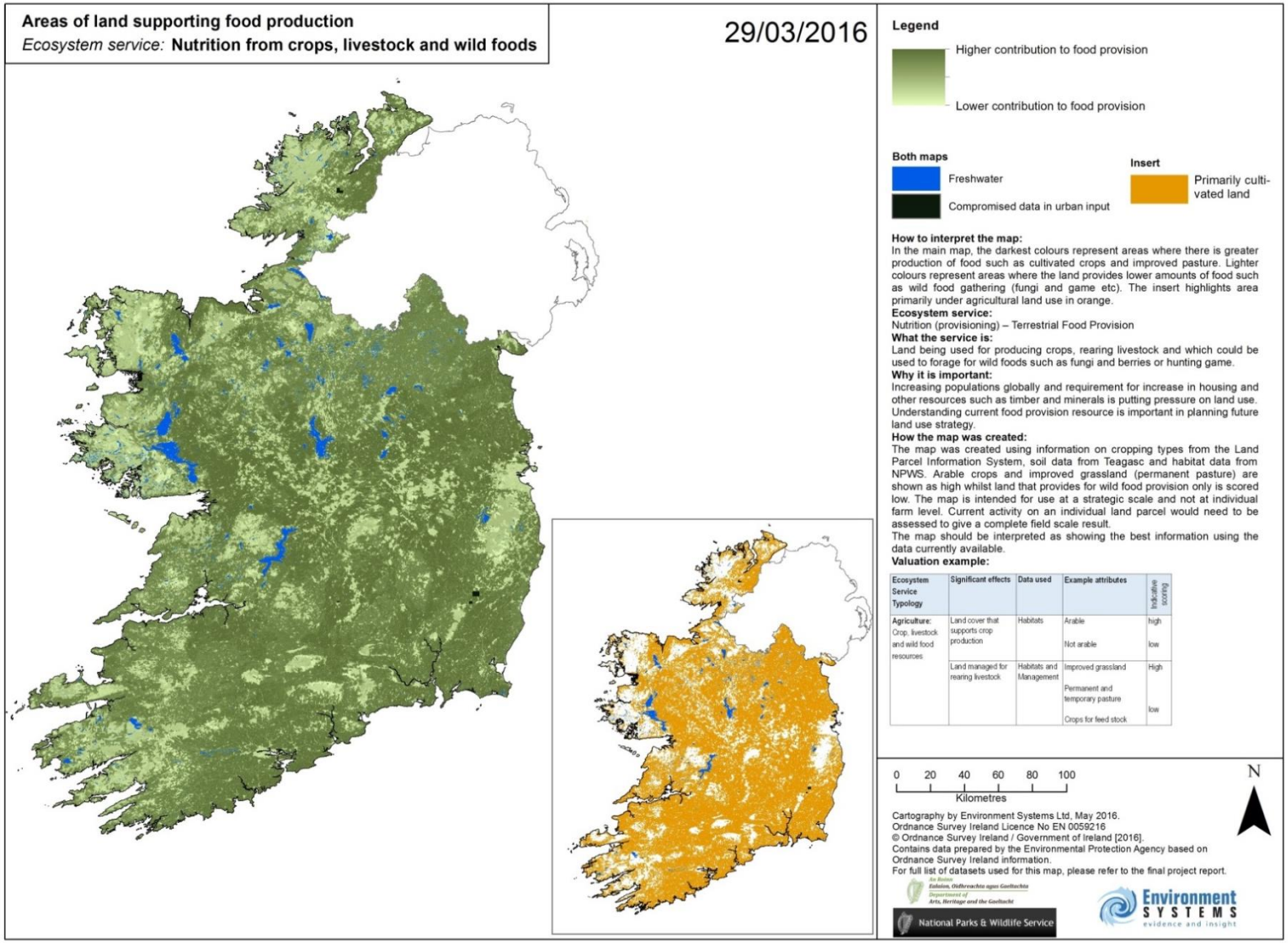
Terrestrial food: Indicator document - Ecosystem Service Modelling & Rule-base development


Areas of land supporting food production
Ecosystem service: Nutrition from crops, livestock and wild foods
29/03/2016
Legend
Higher contribution to food provision
Lower contribution to food provision
Both maps
Freshwater
Compromised data in urban input
Insert
Primarily cultivated land
How to interpret the map:
In the main map, the darkest colours represent areas where there is greater production of food such as cultivated crops and improved pasture. Lighter colours represent areas where the land provides lower amounts of food such as wild food gathering (fungi and game etc). The insert highlights area primarily under agricultural land use in orange.
Ecosystem service:
Nutrition (provisioning) – Terrestrial Food Provision
What the service is:
Land being used for producing crops, rearing livestock and which could be used to forage for wild foods such as fungi and berries or hunting game.
Why it is important:
Increasing populations globally and requirement for increase in housing and other resources such as timber and minerals is putting pressure on land use. Understanding current food provision resource is important in planning future land use strategy.
How the map was created:
The map was created using information on cropping types from the Land Parcel Information System, soil data from Teagasc and habitat data from NPWS. Arable crops and improved grassland (permanent pasture) are shown as high whilst land that provides for wild food provision only is scored low. The map is intended for use at a strategic scale and not at individual farm level. Current activity on an individual land parcel would need to be assessed to give a complete field scale result.
The map should be interpreted as showing the best information using the data currently available.
Valuation example:
Ecosystem Service Typology
Significant effects
Data used
Example attributes
Indicative scoring
Agriculture: Crop, livestock and wild food resources
Land cover that supports crop production
Habitats
Arable
high
Not arable
low
Land managed for rearing livestock
Habitats and Management
Improved grassland
High
Permanent and temporary pasture
Crops for feed stock
low
0 20 40 60 80 100
Kilometres
N
Cartography by Environment Systems Ltd, May 2016.
Ordnance Survey Ireland Licence No EN 0059216
© Ordnance Survey Ireland / Government of Ireland [2016].
Contains data prepared by the Environmental Protection Agency based on Ordnance Survey Ireland information.
For full list of datasets used for this map, please refer to the final project report.
National Parks & Wildlife Service
Environment SYSTEMS
evidence and insight

Indicator	CICES classification
TERRESTRIAL FOOD PROVISION **Areas of land supporting food production (Nutrition from crops, livestock and wild food)**	**Section**: Provisioning **Classes:** • Cultivated crops • Reared animals and their outputs • Wild plants, algae and their outputs • Wild animals and their outputs • Animals from in-situ aquaculture **CICES IE Sub-class:** • Multiple classes (see CICES for Ireland_fordb.xlsx for details)
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

The service mainly comprises land being used for producing crops and rearing livestock. In addition land which could be used to forage for wild foods such as fungi and berries or hunting game is included. Species used for food inhabiting freshwater bodies, and those which spend part of their lifecycle in freshwater and part in marine waters are also included.

Service indicator(s) mapped

This ecosystem service was mapped using the habitat conflation layer which includes data on cropping and land used for more intensive grazing. In addition habitats were considered where they formed a proxy for where species used as wild food (e.g. mushrooms for gathering) would occur. Also of relevance as they affect the amount of food produced are substrate, landform and land management.

Landform has been considered on the basis that steep slopes are more difficult to cultivate meaning they are mainly restricted to rearing livestock. Land management can moderate or enhance each of the other indicators. For example, intense grazing regimes can lead to soil compaction, resulting in lower

soil pore space. A long history of cultivation can degrade the level of soil organic matter through oxidisation.

Datasets used	Dataset requirement[2]
Habitat Asset Register[3]	Essential
NextMap 5m DTM	Desirable
Teagasc Soil	Desirable
Teagasc Subsoil	Desirable
Conservation Designation	Desirable

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

The map was created from the Habitat Asset Register (Level II) which used information on cropping types from the Land Parcel Information System as well as data habitats supporting wild food provision such as moorland and lakes. In addition soil data from Teagasc and habitat data from NPWS were considered. The map shows areas of horticultural, fruit and vegetable crops as high, as these in general have the highest nutritional value per unit of land. Arable crops and improved grassland (permanent pasture – which support grazing animals) are shown as higher than land that provides for wild food provision only, which is scored low.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the strategic/national scale and not at individual farm level. A field visit should be conducted before decisions are made regarding a particular location, to confirm land use at the field level.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring[4]
Habitat capability to provide food	Habitat Asset Register	Arable	High
		Rough Grazing (LPIS) Mosaic	Medium
		Marsh	Low
Land suitability for food production	NextMap 5m DTM	None	High
		None	Medium
		None	Low
		>18°	Disbenefit
Soil suitability for food production	Teagasc Soil	None	High
		None	Medium
		AminDW (Acid Deep Well Drained Mineral)	Low
Soil suitability for food production	Teagasc Subsoil	None	High
		None	Medium
		Alluvium, Silty	Low
Some level of wild food gathering in areas visited by many people	Conservation Designations	None	High
		None	Medium
		[whole layer]	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Data gaps associated with this map during the pilot project

The contribution of land to food provision does not solely depend on whether or not crops are grown or livestock reared on it. Additional information that would enhance this map are stocking density, the type of crop grown and estimated tonnage, or the management techniques the crop is grown under. Combining wild food and cultivated food may lead to some difficulties with map interpretation and it would be useful to break this map into its component parts. The wild food mapped element could then be supplemented with additional information of hunting licences and

returns. DAFM and Teagasc may hold additional knowledge which could help build this mapping to a further level of accuracy.

Note that this map has been prepared at a strategic level and is not suitable at zoom levels showing individual holdings or fields.

LPIS data, regarding grassland: The manner in which the LPIS system categorises Permanent Pasture may lead to an overestimation of the amount of grassland that is actually heavily improved. The Guide to Land Eligibility Direct Payment Schemes 2015[5] states that "Permanent grassland includes productive ryegrass dominated swards, less productive swards that include rush and other non-grass herbaceous species and grassland that includes heather which is grazable and where grass and herbaceous species are not predominant". This may lead to areas that are not overlain by better resolution habitat data being categorised as Permanent Pasture when it may contain other habitats such as Heaths or Blanket Bogs.

Additionally, as the data does not record percentage cover of the individual classes, the classes used are conservative best estimates. In the case of a mix of an arable class and a grassland class, the area will appear as arable, even though in reality 90% of the area could be grassland. However, in the final HAR only ~1.5% or Ireland's terrestrial extent are covered by mosaic classes from LPIS, making this a minor issue with regards to overall accuracy for ecosystem service mapping.

[5]http://www.agriculture.gov.ie/media/migration/farmingschemesandpayments/basicpaymentscheme/LandEligibility2015Booklet010515.pdf

Scientific framework for modelling 'terrestrial food provision'

Overview:	Food provision is an important ecosystem service that relies on a range of supporting services provided by various habitats (both natural as well as managed) and the species associated with them (Swinton et al., 2007; Parikh and James, 2012). There is good supporting evidence regarding the role of agriculture, other land management, semi-natural areas, substrate and landform on terrestrial food provision. The most relevant material is summarised here.
Soil and soil systems	Agriculture varies from intensive production of arable crops in lowland areas and extensive permanent grazing regimes on open moorland to intensive small-scale horticultural fruit and vegetable production on allotments and in gardens (Foley et al., 2005). Enclosed farmland is managed for food production and underpins the agri-food sector, which contributes approximately 7% to Ireland's GVA (gross value added) (Teagasc, 2015).

	The most important supporting service for agricultural production is the maintenance of soil fertility, which is fundamental to sustaining agricultural productivity (Watson et al., 2002; Altieri and Nicholls, 2003; Parikh and James, 2012). Soil carbon plays a major role in soil structure, one of the major components of soil fertility (Swinton et al., 2007; Parikh and James, 2012). Mineral soils provide good productivity and afford some of the best soils for food production, due to the balance between mineral components, organic matter, oxygen supply and water retention (Parikh and James, 2012). Organo-mineral soils are generally poorer for food production, often associated with acid upland soil and cooler, wetter climatic conditions (Brady and Weil, 2002). Organic soils can provide very good food production conditions. However, they require artificial drainage, agro-chemicals are needed to maintain a neutral pH and high nutrient levels and cause peat wastage, resulting in loss of carbon stored in the soil (Holman, 2009). Well drained and nutrient rich brown earth soils require the fewest artificial inputs to allow for them to be used for cultivation. However, any intensive use depletes soils of nutrients, which can be countered by rotation or external inputs (Parikh and James, 2012). Due to the coarse structure causing large pore spaces, sandy soils tend to drain fast and not retain enough water and nutrients for effective agricultural usage (Brady and Weil, 2002). Waterlogged systems can require substantial drainage operations to allow for them to be suitable for cultivation (Robinson and Armstrong, 1988; Ritzema, 1994; Holman 2009). The underlying geology is an important determinant of food production capability through its effect on soil type and texture (Jenny 1994; Brady and Weil, 2002). Underlying geology also affects other features of soil type, such as depth and stone content, both of which have an impact on food production (Jenny, 1994; Brady and Weil, 2002). Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide[6]; Teagasc, 2007).

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

Landform	Landform has an important influence on food production. Intensive agricultural production is limited to flat or gently sloping ground (Spencer, 1978). The maximum cut-off for the effect of slope on agriculture are generally recognised as >18° - Land too steep for arable production (machinery cannot operate) and with limited suitability for grazing (MAFF, 1988). This is particularly important when considering additional areas where agriculture could take place, whilst, when looking at existing agriculture, the relevant information is mostly contained within the land cover information.
Semi-natural habitats	Food provision is an important ecosystem service that relies on a range of supporting services provided by various habitats, natural as well as managed, and the species associated with them (Swinton et al., 2007; Parikh and James, 2012). Some semi-natural habitats are not commonly used for intensive food production and are mostly associated with wild food provision. However, many habitats are maintained by agricultural grazing systems. In these cases, maintenance of the habitat is the priority, but the area does still contribute to food production (Bullock et al., 2011). Some habitats contribute to wild food production in minor ways, such as bilberries from moorlands (Acreman et al., 2011).
Management	Management systems are one of the most important factors for food production and also influence the impact of agriculture on the delivery of other ecosystem services (Swinton et al., 2007; Davari et al., 2010). Conservation management on farmland can be seen as reducing inputs, particularly on grassland based systems. This can have the effect of lowering productivity and, therefore, food production (Lichtfouse, 2011). Grazing (both cattle for dairy and beef, and sheep) is the major land use in Ireland. Managing grassland for grazing can affect biodiversity (Anderson, 2013) as well as the provision of ecosystem services (particularly water quality) through nitrogen application, slurry, pollution, and methane. This effect can be mediated through agri-environment management (Van Rensburg et al., 2009). Below ground physical features can be modified by machinery and by some specialist grassland types to develop deep rooting systems and an open soil structure (Carter, 2004; Pagliai et al., 2004). This improves the soil aeration, drainage and nutrient availability for the grasses themselves and for subsequently planted crops, improving growth and yield (Fitter, 1991; Carter, 2004).

	The ecological assemblages of soil fauna and flora can be important factors in maintaining soil structure by encouraging strong root systems (Brussaard, 1997; Wall and Moore, 1999) and, therefore, more productive crop growth. Earthworm numbers are particularly significant for soil system health (Brussaard, 1997; Lavelle et al., 2006). Additionally, some crops are selectively bred to have a well-developed root system (Fitter, 1991). In some instances the soil is prepared to enhance below ground biodiversity, which encourages crop growth (Brussaard et al., 2007). Crops are generally monocultures and, therefore, low in species richness (McCracken et al., 2011). However, hedgerows, beetle banks and headlands provide a greater abundance of flora species diversity to be present within the intensive agricultural environment (Benton et al., 2003). This in turn can support more birds and insects, which provide natural pest control and pollination (Carvell et al., 2007; Osborne et al., 2008; Blake et al., 2011; Fabian, 2013).

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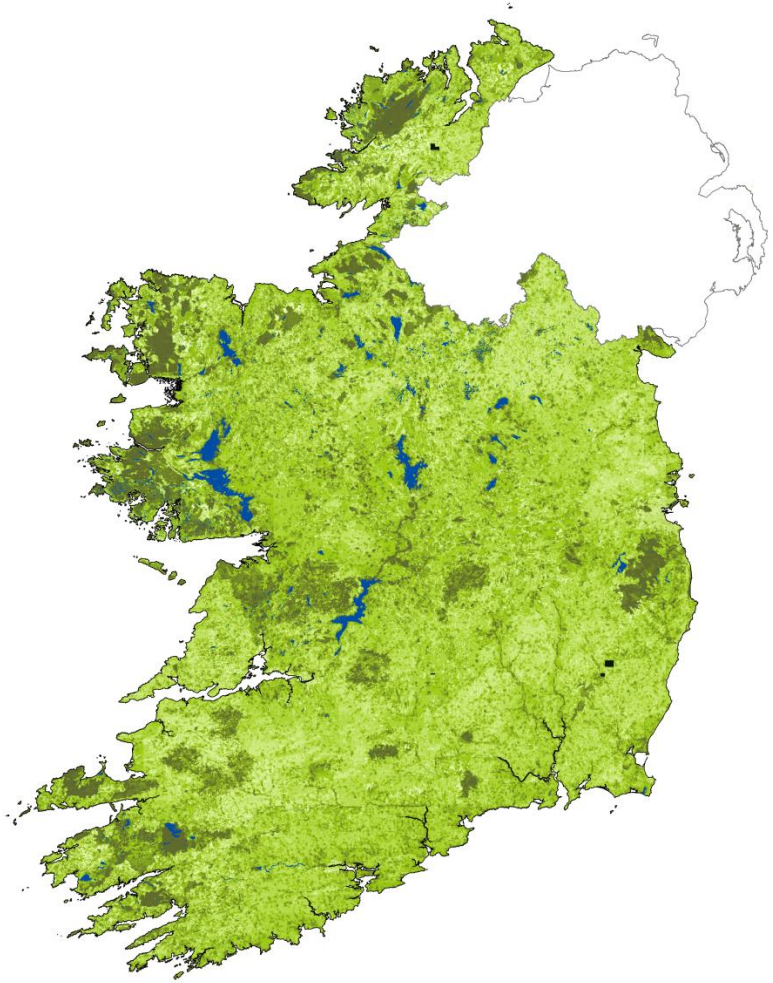
Terrestrial biodiversity: Indicator document - Ecosystem Service Modelling & Rule-base development

Terrestrial biodiversity: Habitats, management, ecological networks, and species
Function: **Naturalness, support of systems and species, and resilience**

11/05/2016



Legend

- Freshwater
- Compromised data in urban input
- Land of higher biodiversity value
- Land of lower biodiversity value

How to interpret the map:
The darkest colours represent areas with biophysical properties likely to support high levels of biodiversity, areas with good habitat connectivity, and/or many observations of species of conservation concern. Light colours represent areas not contributing as strongly to biodiversity.

Ecosystem function:
Biodiversity - Naturalness, support of systems and species, and resilience.

What the ecosystem function is:
Biodiversity includes not just the number of species, but how well the systems function, cycle nutrients and support species. Areas with higher structural diversity, that is areas where there are many different types of habitat or different layers to a habitat, such as ancient species rich woodland and wetland complex's, usually support the highest diversity as there are more ecological niches available for different species to thrive

Why it is important:
Biodiversity as a function underpins many ecosystem services; therefore, it is useful to show where the hotspots occur.

How the map was created:
Terrestrial biodiversity was mapped using habitat, management, connectivity of semi-natural habitats in ecological networks, and records of species of conservation concern as proxies.

Valuation table

Ecosystem Function	Significant effects	Data used	Example attributes	Indicative scoring
Biodiversity	Habitat effect (complexity, niche availability)	Habitat asset register	Broadleaved woodland	High
			Arable / Urban	Low
	Ecological networks	Combined ecological networks for Ireland	Part of network	High
			Not part of network	Low
	Management	Protected Sites	SAC and nature reserve Nature reserve	High Medium
	Species records	Combined records of species of conservation concern	Many records	High
			Few records	Low

0 20 40 60 80 100
Kilometres

N

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

National Parks & Wildlife Service

Environment SYSTEMS evidence and insight

Indicator	CICES classification
TERRESTRIAL BIODIVERSITY **Habitats, management, ecological networks, and species (Naturalness, support of systems and species, and resilience)**	**Section**: Regulation & Maintenance **Division:** Maintenance of physical, chemical, biological conditions **CICES IE Sub-class:**
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

Biodiversity describes the range and diversity of species and includes genetic diversity within species and between different taxa in any area. Biodiversity encompasses the concepts of resilience, with diverse systems being more able to withstand change. Systems with high biodiversity also have many levels of species from fungi and bacteria in the soil through higher plants to insects, birds and animals, this complex web-of-life that occurs within the ground and above it, forms the functioning system. Certain habitats and biogeographical regions tend to have more biodiversity than others for example an agricultural sown grass sward will support less species in the soil and in terms of plants and animals than a semi-natural heathland. Biodiversity increases with the range of different niches available, with habitats with many different types of plants with complex structures (such as broadleaved woodlands) generally having a higher biodiversity value than homogenous systems such as sown crops. Landscapes with extensive tracts of native habitats, especially where they are heterogeneous and or have a complex structure above and below the ground tend to be well adapted to fluctuations in natural cycles such as water, carbon and nutrients and tend be self-regulating.

Ecosystem services depend on living structures and processes, and in this sense they are fundamentally underpinned by 'biodiversity' in its broadest sense. Biodiversity is not an ecosystem service itself (under the CICES classification) but rather the **function** that underpins other ecosystem services. Because of its importance as an underpinning function a map has been included to help interpret the other ecosystem service maps.

This map considers terrestrial biodiversity, including rivers and estuaries.

Function indicator(s) mapped

Habitat, soil type, land management, position in the landscape and species records were the indicators used to map the service.

Some habitats are known to support higher biodiversity than others; for example deciduous woodlands generally support a larger number of species than coniferous plantations. Habitat categories can be assessed in terms of the levels of physical structure that they provide, with greater structural diversity providing more varied ecological niches. For example deciduous woodlands may contain occasional clearings, shrub and understory species, supporting far more species of fauna and flora than most grasslands, where the vegetation structure is simpler and provides fewer niches. Native habitats support greater biodiversity above and below ground than artificial or greatly modified habitats. For example a heath, though containing a comparatively limited number of plant species, would support a wider range of invertebrate, bird and mammal species than an improved grassland. Larger blocks of native habitats tend to be richer in physical and genetic diversity than smaller blocks which can be degraded by inputs from the surrounding land use. Rare native habitats which have developed over time to take advantage of particular species soil or climatic conditions can be particularly rich in biodiversity and resilience.

Species that occur in the soil have a very significant effect on the diversity of the habitat systems that develop above them. Soil can contain a vast number of micro-organisms and soil fauna. Different soil types are characterised by differing species assemblages. Soil texture, organic matter content, pH, temperature and hydrology all influence the type of communities present. Mineral soils tend to be more aerated and less acidic than organic soils, supporting a more diverse below-ground species composition. Soil types that are wetter, less oxygenated and more acidic support a smaller number of species that are adapted to surviving in these harsher conditions, but these can be genetically diverse and resilient to change.

Rare or significant species are useful when considering biodiversity as these plants and animals flourish when the supporting ecosystems is intact and functioning well, they can therefore be regarded as indicating the wealth of the underlying biodiversity.

Datasets used	Dataset requirement[2]
Habitat Asset Register[3]	Essential
Area contribution to ecological networks	Beneficial
Combined species records	Beneficial
Conservation Designations	Beneficial
Article17 – 6130	Beneficial
Article17 – 5130	Beneficial
Article17 – 2140	Beneficial
Article 17 – 2150	Beneficial
Teagasc Soil	Beneficial
Groundwater Sand and Gravel Aquifers	Beneficial
Groundwater Aquifers	Beneficial

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

A large number of habitat datasets were combined to produce a single habitat data layer (the Habitat Asset Register - HAR). This included LPIS, Article 17 habitats, Ancient and Long-established Woodland Inventory, and CORINE habitat data. Point habitat datasets were added at a later date, and are listed separately. Water Framework Directive and protected area datasets were used to assess levels of habitat quality. Attributes from each dataset were analysed and valued from high to low. The map should be interpreted as showing ecosystem service information based on the data currently available; as and when new data become available the maps can be updated. The maps are intended for use at the strategic scale, and a field visit should be conducted before decisions are made regarding a particular location.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring[4]
Number/variety of species supported by habitat type	Habitat Asset Register	Semi-natural broadleaved woodland	High
		Semi-natural grassland	Medium
		Improved grassland	Low
Presence of important habitat, number/variety of species supported	Article17 – 6130	None	High
		[whole layer]	Medium
		None	Low
Presence of important habitat, number/variety of species supported	Article17 – 5130	None	High
		[whole layer]	Medium
		None	Low
Presence of important habitat, number/variety of species supported	Article17 – 2140	None	High
		[whole layer]	Medium
		None	Low
Presence of important habitat, number/variety of species supported	Article 17 – 2150	None	High
		[whole layer]	Medium
		None	Low
Soil drainage characteristics, organic matter content, soil depth	Teagasc Soil	BminDW, IrSTLs	High
		AminPD, IrSTLPSsS	Medium
		RsPt, RsPt	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Significant Effects	Datasets used	Example attributes	Indicative scoring
Availability and quality of water to the plants and animals present	Groundwater Aquifers	None	High
		[whole layer]	Medium
		None	Low
Availability and quality of water to the plants and animals present	Groundwater Sand and Gravel Aquifers	None	High
		[whole layer]	Medium
		None	Low
Land managed for conservation is likely to support higher levels of biodiversity	Conservation designations	5	High
		3	Medium
		1	Low
Sites that are well-connected are likely to support higher levels of biodiversity	Combined ecological networks	Part of 1 eco. Network	High
		Part of 2 eco. Networks	Medium
		Part of 3 eco. Networks	Low
Number of records of different species as proxy for biodiversity hotspots	Combined coincidence of records of conservation-relevant species	>28050	High
		14100 – 18600	Medium
		4800 – 9300	Low

Data gaps associated with this map during the pilot project

Habitat condition has long been a known indicator of high biodiversity value. This is typically associated with monitoring of designated sites and habitats as a key part of EU member state reporting. To this end, some condition data regarding raised bogs, cutover and degraded bogs has been included. However, many important habitats that provide multiple ecosystem service benefits, for example fens, are not yet available in a spatial data format nationally.

Species data has, at this stage, been included as the number of different species only. This does mean that rare, but non-abundant species, have a higher impact on the recorded species coincidence than they would have if species abundance was measured. However, the value of a species of particularly high conservation concern occurring in an area without many other species records would still be under-represented. It should also be noted that there is a tendency to record species where they are already known to be present, where there is high likelihood of presence or where there is a need (such as pre-construction surveys) to survey. Areas outside of these zones are likely therefore to be under-recorded and this caused a bias around the coast and urban centres for the species coincidence layer.

NOTE – Whilst the Habitat Asset Register (HAR) is based on the best data currently available, it does contain some inherent limitations due to the manner in which LPIS categorises permanent pasture. This may lead to an underestimation of semi-natural grassland and heaths. For details, please refer to the section on data gaps and the section on the preparation of LPIS data for usage in the HAR.

Scientific framework for modelling 'terrestrial biodiversity'

Overview:	Biodiversity provides important biophysical characteristics and functions that underpins the majority of other ecosystem services and also provides benefits to most aspects of human wellbeing (Belvanera et al., 2006; Norris et al., 2011). There is good supporting evidence regarding the role of soil, habitat, and management in terrestrial biodiversity. The most relevant material is summarised here.
Soil	Soil, as a host for many forms of life and a growing medium for certain habitats, has an important influence on biodiversity (Haygarth and Ritz, 2009; Robinson et al., 2013). In general, undisturbed soil maintains a higher level of biodiversity, while disturbed and bare soils have much reduced biodiversity values (Haygarth and Ritz, 2009). Human management of the soil can be a highly relevant factor in terms of biodiversity, as can the inherent nature of the soil itself (Haygarth and Ritz, 2009; Dominati et al., 2010). Mineral soils are generally well aerated and oxygen allows a varied assemblage of species to develop (Brady and Weil, 2008). Soil pH also influences species diversity, with pH neutral soils supporting the most diverse ecosystems (Roem and Berendse, 2000; Emmett et al., 2010). Soil texture is a key factor affecting the pore size and permeability of the soil and, therefore, the amount of water and oxygen present in the soil, and the ratio to which each is present (Gupta and Larson, 1979). Clay based soils have small pore sizes and adsorb water to their surfaces, rather than allowing free flow through the soil (Gupta and Larson, 1979). Clay soils also compact easily, which leads to decreased water and oxygen holding capacity (Ball et al., 2000; Dominati et al., 2010), and reduces the amount of biodiversity supported (Emmett et al., 2010). Soils with a mixed loamy texture tend to have greater water holding capacity (Brady and Weil, 2002). Organic soils provide a highly water-logged and often very acid environment. These extreme conditions normally result in a lower biodiversity than mineral soils (Brady and Weil, 2008), although they can support scarce habitats (Littlewood et al., 2010).

Soil (cont.)	Soil macrofauna, in particular earthworms, open up the macro pore spaces in soils and play an important role in maintaining soil biodiversity by allowing water and air to move freely within the soil system (Lavelle et al., 2006; Brady and Weil, 2008). Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide[5]; Teagasc, 2007).
Habitat	The more complex the structures and the more varied the niches or locations for biodiversity development, the greater the diversity of species found in an ecosystem (Tews et al., 2004; Levine and HilleRisLambers, 2009). Time is also an important consideration. Habitats present for many centuries allow specialist species to develop and thrive (Mittelbach et al., 2007). Mature semi-natural habitats that have been present for a long period of time tend to have greater biodiversity, as over time, they can develop specialized niches (Crawley, 1997). Below ground physical features of habitats are important for biodiversity by influencing the range of species that can inhabit the soil (Wall and Moore, 1999). Below ground biological features are an important factor governing biodiversity (Haygarth and Ritz, 2009). It is largely a 'hidden' biodiversity but very important in the lifecycle of many species of insects and invertebrates (Emmett et al., 2010) and as shelter and refuge for many below-ground dwelling mammals and birds. (Brady and Weil, 2008). More diversity within the structure of the vegetation above ground provides a greater breadth of ecological niches that can be occupied by a greater number of organisms and therefore increases the overall levels of biological diversity (Tews et al., 2004; Levine and HilleRisLambers, 2009; Naeem et al., 2010).

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

	Currently there is still a lack of quantitative data that demonstrates a clear link between current biodiversity status and trend data with the delivery of ecosystem services (Norris et al., 2011), but for general relationships see Hooper et al., 2005; Balvanera et al., 2006. The criteria defined in the nature conservation review (Ratcliff, 1977), (namely, naturalness, size, diversity and connectivity) are the key evaluation factors to consider when examining and mapping biodiversity.
Land management	Management of land, air and water occurs at a variety of scales, from the localised individual field or plot level, though to the landscape level (Foley et al., 2005). At all these different spatial scales, management can have a major effect on the biodiversity of the habitats (Ratcliff 1977; Dirzo and Raven, 2003; Foley et al., 2005). Land-use change and increased pollution have been in the past, and continue to be, major drivers of change across the different habitat groups within the UK (Norris et al., 2011). There are many national (e.g. Convention on Biological Diversity), regional and local policies that seek to maintain biodiversity and prevent further decline.

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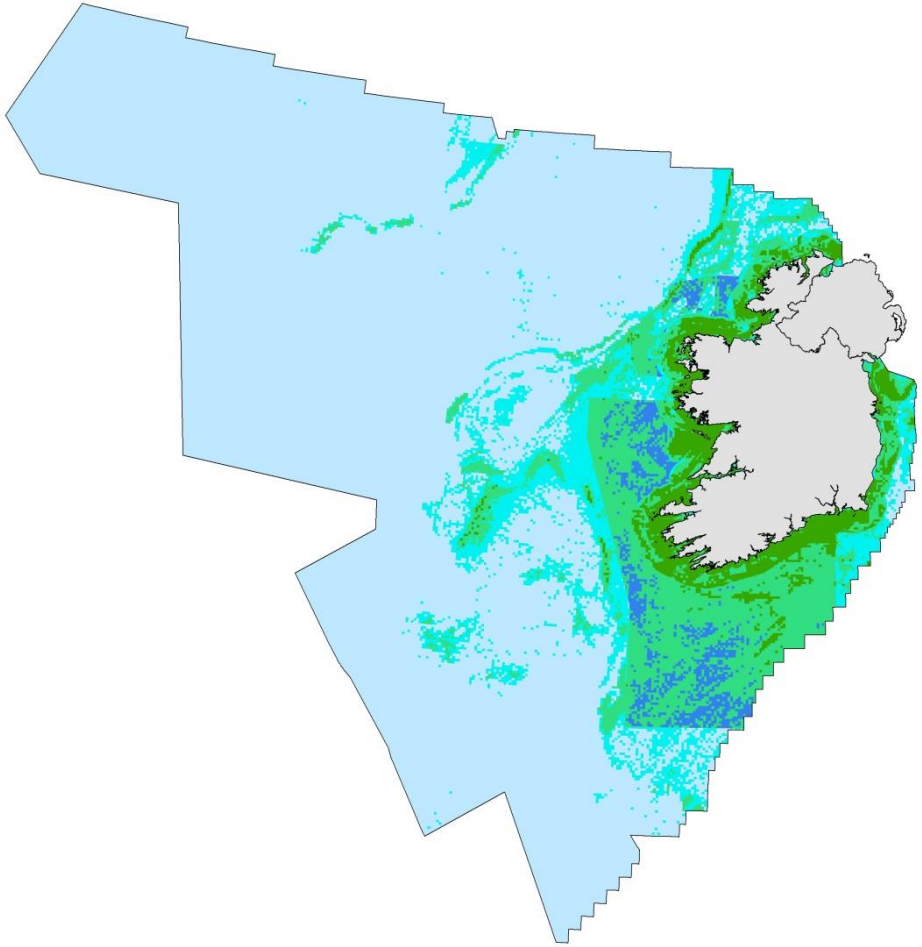
Marine areas that provide food: Indicator document - Ecosystem Service Modelling & Rule-base development

Marine areas that provide food
Ecosystem service: **Marine food (Provision)**

29/03/2016



Legend
- ES provision hotspot
- Strong ES provision
- ES provision
- Some provision
- Neutral

How to interpret the map:
Green colours represent areas with a high contribution to marine food provision, based on data on fisheries effort; turquoise and blue areas have a lower direct contribution to marine food provision.

Ecosystem service:
Food (provision) – Marine areas that provide food

What the service is:
This service includes everything taken from the sea for human consumption. This includes fish (marine and diadromous), shellfish, crustaceans, and algae, both from wild harvest and from aquaculture.

Why it is important:
Increasing populations globally create increasing demand for food provision and are putting pressure on the marine ecosystem. Understanding current food provision, particularly in the coastal zone, is important in future marine spatial planning.

How the map was created:
The most important datasets for mapping of this service are direct measures relating to fisheries. Protected areas are included in the scoring, as they can help protect fish stock and juvenile life stages. Terrestrial habitats have been included in the mapping where they are of direct relevance, such as saltmarshes, which form nursery areas and support marine fisheries. Anthropogenic structures can impact marine food provision, if they are associated with fisheries restrictions.
This map does not consider how different substratum types support marine fisheries.

Valuation example:

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Marine Food Provision	Fisheries management	Fisheries data	High intensity Low intensity	High Low
	Fisheries closures	Protected areas	None Closed for fisheries	Neutral Low
	Unharvestable areas	Dumping at sea / Windfarms	Area can be harvested Area cannot be harvested	Neutral Low

0 50 100 150 200 250
Kilometres

N

An Roinn Ealaíon, Oidhreachta agus Gaeltachta
Department of Arts, Heritage and the Gaeltacht
National Parks & Wildlife Service

Environment SYSTEMS evidence and insight

Indicator	CICES classification
MARINE FOOD PROVISION **Marine areas that provide food (Marine food (Provision)**	**Section**: Provisioning **Classes:** • Wild plants, algae and their outputs • Wild animals and their outputs • Plants and algae from in-situ aquaculture • Animals from in-situ aquaculture. **CICES IE Sub-class:** Multiple classes (see CICES for Ireland_fordb.xlsx for details)
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

This service includes everything taken from the sea for human consumption. This includes fish (marine and diadromous), shellfish, crustaceans and algae, both from wild harvest and from aquaculture.

Function indicator(s) mapped

The most important datasets for mapping this service are direct measures relating to fisheries. Protected areas are included in the scoring as they can help protect fish stock and juvenile life stages, but scoring depends on the exact legislation of the area. The Greencastle Codling Protected Area is an example of a protected areas set up with this mechanism in mind. Data on the actual fish landings could make the spatial analysis more accurate.

Terrestrial habitats have been included in the mapping where they are of direct relevance. This mostly refers to the saltmarshes included in the terrestrial map, which have been scored highly due to their nursery function supporting marine fisheries both in coastal waters and further offshore.

Areas with anthropogenic structures can impact marine food provision, if they are associated with fisheries restrictions. Dumping at sea has been considered an influencing factor, as sites known to be used for dumping of harmful substances cannot be fished. On the other hand, dumping of fish waste can, under some circumstances, attract more fish biomass to an area and, hence, increase catches.

Datasets used	Dataset requirement [2]
Habitat Asset Register [3]	Desirable
Conservation Designations	Essential
Inshore Fisheries	Essential
Dredge Fishing Activity	Essential
Line Fishing Activity	Essential
Net Fishing Activity	Essential
Bottom Trawl Fishing Activity	Essential
Mid-water Trawl Fishing Activity	Essential
Pot Fishing Activity	Essential
Fishing Intensity by vessels >15m in length – Mobile Seine	Essential
Fishing Intensity by vessels >15m in length – All Gears	Essential
Fishing Intensity by vessels >15m in length – Mobile Bottom	Essential
Fishing Intensity by vessels >15m in length – Mobile Other	Essential
Fishing Intensity by vessels >15m in length – Other	Essential
Biologically Sensitive Area	Essential
Greencastle Codling Area	Essential
Periwinkle Access Points	Beneficial
Fishing Ports	Beneficial

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

Shellfish Waters Directive	Beneficial
Commercial Ports	Beneficial
Dumping at Sea Boundaries	Beneficial
Marinas	Beneficial
Local Ferry Ports	Beneficial
Sea Fishing Spots	Beneficial

How the map was created

The terrestrial habitat is based on a habitat conflation of several datasets; it was used for this map, to include coastal and intertidal areas that play an important role in supporting the fisheries resource by fulfilling a nursery function for many commercially harvested species. The relevant terrestrial habitats for marine food provision is are saltmarshes. Fisheries data that recorded intensity on a continuous numerical scale has been grouped using histogram statistics. The resulting classes have been scored from 'high' to 'low' and were then combined into one map layer using 'overlay analysis'.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the strategic scale, and further information should be gathered before decisions are made regarding a particular location.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring [4]
Some habitats included in the terrestrial habitat layer fulfil a nursery function benefitting fisheries	Habitat Asset Register	Estuaries	High
		Coastal lagoons	Medium
		None	Low
Higher value for more desirable/valuable species for human consumption	Inshore Fisheries	Trawl (Pelagics); Aquaculture	High
		Line fishing (Gadoids); Dredge	Medium
		Line fishing; Gathering	Low
Higher value for more desirable/valuable species for human consumption	Dredge Fishing Activity	None	High
		[whole layer]	Medium
		None	Low
Higher value for more desirable/valuable species for human consumption	Line Fishing Activity	Jigging Machines, Pollack & Mackerel	High
		Handlines, Pollack & Mackerel	Medium
		Troll Lines, Squid	Low
Higher value for more desirable/valuable species for human consumption	Net Fishing Activity	Draft Net, Salmon	High
		Gill Net, Turbot	Medium
		Trammel Net, Bait	Low
Higher value for more desirable/valuable species for human consumption	Bottom Trawl Fishing Activity	Queen Scallop Bottom Trawl, Queen Scallop	High
		Bottom Trawl, Nephrops	Medium
		None	Low
Higher value for more desirable/valuable species for human consumption	Mid-water Trawl Fishing Activity	[whole layer]	High
		None	Medium
		None	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Higher value for more desirable/valuable species for human consumption	Pot Fishing Activity	Lobster	High
		Creel, Brown Crab	Medium
		Creel, Brown Crab	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – All Gears	10	High
		5	Medium
		1	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – Mobile Bottom	10	High
		5	Medium
		1	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – Mobile other	10	High
		5	Medium
		1	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – Mobile Seine	None	High
		5	Medium
		1	Low
Manual periwinkle harvest unlikely to contribute strongly to food provision	Periwinkle Access Points	None	High
		None	Medium
		[whole layer]	Low
Mark point of delivery of the service, not the service itself; due to potential pollution and lack of fishing in the direct vicinity, slightly negative impact	Fishing Ports	None	High
		None	Medium
		[Whole layer]	Low
Protected areas are considered to overall benefit fisheries by supporting stable stocks	Biologically Sensitive Area	None	High
		None	Medium
		[whole layer]	Low
Protected areas are considered to overall benefit fisheries by supporting stable stocks	Greencastle Codling Area	None	High
		None	Medium
		[whole layer]	Low
Protected areas are considered to overall benefit fisheries by supporting stable stocks	Shellfish Waters Directive	None	High
		None	Medium
		[whole layer]	Low
Fisheries activity around port area unlikely	Commercial Ports	None	High
		None	Medium
		[whole layer]	Low

Fisheries activity around marinas unlikely	Marinas	None	High
		None	Medium
		None	Low
		Fuel facilities, no toilets	Disbenefit
Fisheries activity around port area unlikely	Local Ferry Ports	None	High
		None	Medium
		None	Low
		[Whole layer]	Disbenefit
Reduced water quality can render sea food from this region unfit for human consumption	Dumping at Sea Boundaries	None	High
		None	Medium
		None	Low
		Sludge arising from the treatment of trade effluent	Disbenefit

Scoring

The map relies heavily on fisheries data, which might not have been recorded to the same extent in all areas. It is possible that recording bias causes the model to show high food provision in coastal areas, whilst neutral values further offshore could be caused by less data being recorded and available.

To improve understanding of the fisheries resource, i.e. the supply of algae, fish, and shellfish, it would be beneficial to understand the contribution of habitats to maintaining healthy stocks. However, the relation between habitat types and individual fished species is not well enough understood. In addition, data on species-specific fishing areas was not available or does not currently exist to enable spatially explicit mapping to incorporate this concept at this time.

Scientific framework for modelling 'marine food provision'

Overview:	The oceans provide an important source of food to coastal communities and underpin economies around the world (Cochrane et al., 2009). Fishing is an important food provisioning activity providing a fundamental ecosystem service (Makino and Sakurai, 2014) through the harvesting of wild and farmed finfish, molluscs and shellfish (hereafter referred to collectively as "fish"). Fish harvesting locations range from shallow to deep water environments and are conducted by a variety of methods from small-scale artisanal fishing practices to large-scale trawling and aquaculture enterprises (Sewell and Hiscock, 2005). Fish

	stocks for food provisioning are controlled by a number of factors, which include water column properties, habitat, development opportunities, and management restrictions. Marine aquaculture (mariculture) also provides food provisioning services through the cultivation of saltwater plants/algae, most commonly macroalgae. The aquaculture industry has grown by 8.7% per year since 1970 – three times faster than agriculture (Diana et al., 2013). This makes it a fundamental contributor to the food provision service.
Water	Water properties are important considerations for marine food provision. Some of the most important supporting functions for marine food provision are nutrients/organic load, turbidity/suspensoids, sea temperature, currents, salinity, and sources of pollutants. The role of nutrients and organic compound load in the water column is accepted as fundamental in determining growth and development of algae, which underpin wild and farmed fisheries and plant/algae aquaculture (Whitney et al., 2005). Turbidity describes the optical properties of a liquid which causes light to be scattered, reducing water clarity. Suspensoids include organic or inorganic solid or colloidal particles held in suspension within a liquid. The effects of turbidity and suspensoid load in the water column can have wide ranging implications on fish stocks. In some instances, high turbidity can reduce marine fish stocks by hindering fish growth (both first maturity and maximum size), deoxygenizing the water column, clogging gills, reducing visibility of pelagic food, and by providing extra habitat for photophobic fish. Conversely, reduced visibility may increase fish survival rates by allowing concealment from predation/reducing aerial predation risk (Bruton, 1985; Kaartvedt et al., 1996). Currents provide a wealth of functions affecting fisheries and aquaculture by exchanging water. This a) changes nutrient availability (Whitney et al., 2005); b) provides a source of herbivorous food (plankton input); c) oxygenates the water column; d) provides a source of larval recruitment; e) propagates cool, nutrient rich water from poles or deep water; and f) provides an input of sediment (Crawford and Thomson, 1991). The above processes are essential supporting functions for marine food services. Water motion improves seaweed nutrient uptake and removes epiphytes and waste products (Diez et al., 2003). Salinity is essential for the spawning success of some fish species, where hyper-

	osmotic conditions are required (Westin and Nissling, 1991). Low salinity can dramatically impact the populations of shellfish (i.e. oysters) (Hofmann and Powell, 1998).
Habitat	Fisheries habitats are both complex and varied, and often species-dependent. Unlike terrestrial habitats, marine habitats tend to exist in a three dimensional setting, where the water column acts as much a part of the habitat as the substrate, geology and biology present on them. A positive relationship exists between sediment depth and the abundance of macrophytes, where macroalgae abundance increases with increases in sediment depth (Zieman et al., 1989). Roots are more readily established in fine grained sediments and may increase aquaculture success. Benthic structure may provide refuges for fish in areas where seabed relief is highly complex (Thayer and Chester, 1989), enhancing the chances of fish reaching maturity and maximum size, in turn increasing wild fish biomass. Bays, reefs and lagoons also provide areas with fish refuges and reduce damage to macroalgae by wave action. Light attenuation through the water column directly affects the photosynthetic efficiency of macroalgae, limiting cultivation, typically occurring at depths <20 m (Quartino et al., 2001). Photic zones dictate the distribution of fish (especially the distribution of photophobic/photophilic fish), which are depth dependent. Species richness for macroalgae tends to decrease at depths greater than 20m, probably due to light attenuation limiting photosynthetic efficiency (Quartino et al., 2001).
Other Effects	Primary productivity has a positive correlation with fish standing stock (Nriagu et al., 1990), particularly with phytoplankton production and the concentration of chlorophyll-α (Downing et al., 1990). These could be measured by using the Normalised Difference Vegetation Index (NDVI) in marine remote sensing imagery.
Management	Management leading to reduced biodiversity includes: • Mono-species cultivation reducing biodiversity, thus reducing natural habitat for wild faunal biomass for food provision • By-catch: fisheries waste product removed from breeding stocks but not utilised as marine food. • Environmental degradation associated with fishing techniques (i.e. bottom trawling) altering natural habitats for wild faunal biomass for

	food provision. • Unsustainable mariculture: pollution (faecal material, uneaten food, nutrients, and chemicals and drugs like pesticides, disinfectants and antibiotics) negatively impacting wild fish stocks (Cao et al., 2007); requirement of live feed for carnivorous farmed fish stocks reducing wild marine faunal stock (Benetti et al., 2006). Management, leading to increased biodiversity includes: • Sustainable fisheries practices that ensure fisheries stocks for long-term marine food provision. In 2008, 46% of fish, crustaceans and molluscs consumed by people were sourced from aquaculture projects (Jensen et al., 2014), and, as property rights strengthen for aquaculture, the aquaculture industry will invest in new technology to improve aquaculture efficiency (Anderson, 2003).

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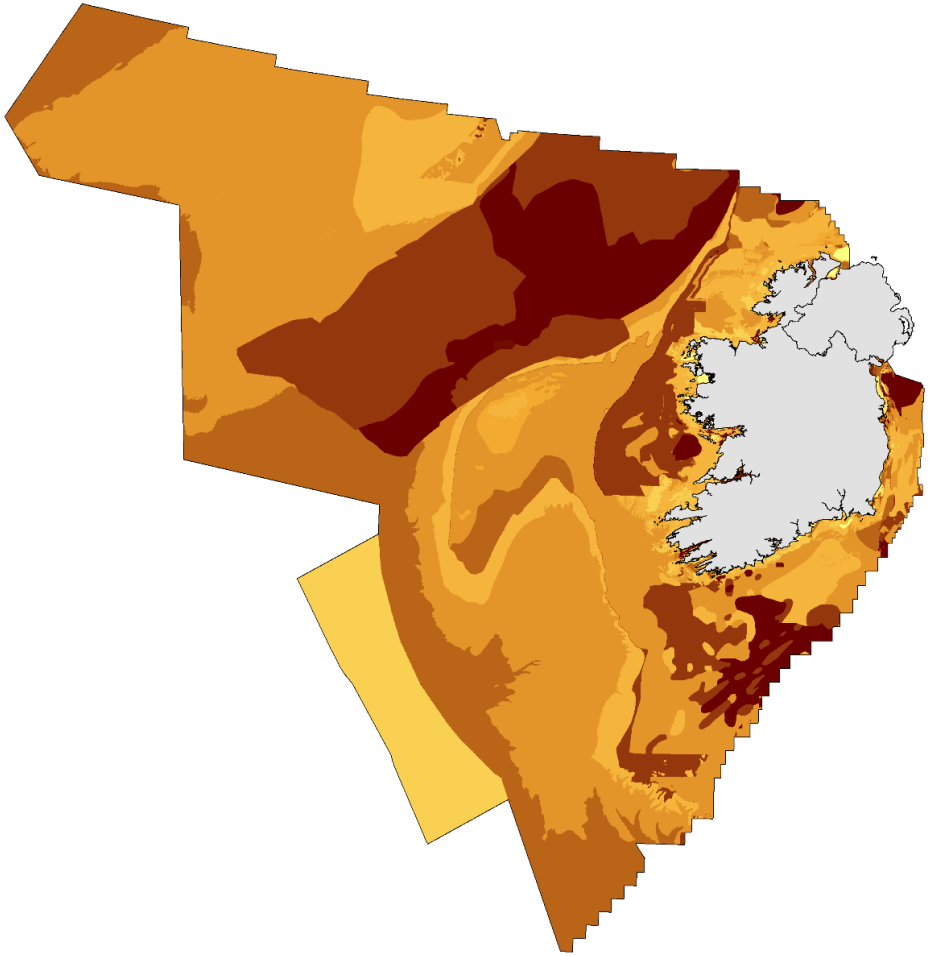
Marine Carbon: Indicator document - Ecosystem Service Modelling & Rule-base development

Marine Carbon

Ecosystem service: **Regulation of greenhouse gases (carbon)**

29/03/2016



Legend

Higher contribution to carbon sequestration
Moderate contribution to carbon sequestration
Lower contribution to carbon sequestration

How to interpret the map:
The darkest colours represent areas where there is more carbon storage in the marine environment. Lighter colours represent areas where the marine environment stores a lesser amount of carbon.

Ecosystem service:
Climate change (regulation) - storage of carbon within the marine environment.

What the service is:
Atmospheric carbon is sequestrated by and stored in the marine environment through the process of photosynthesis by phytoplankton with the resulting microbes passing into the food chain. The other main method is via dissolution and chemical reaction of carbon dioxide and water forming bicarbonate which is likely to be stored in marine sediments.

Why it is important:
The marine environment is one of the largest on Earth. The role the sea plays in storing carbon helps reduce atmospheric contributions as carbon dioxide and greenhouse gas concentrations.

How the map was created:
Data analysis identified areas of significant carbon storage in the seas surrounding Ireland. This included data from the EU Seamap (Atlantic Habitats) and collated seabed substrate. Attributes from each dataset were analysed and valued from high to low where circalittoral mud was considered to store more carbon and coarse sediments and sand likely to store less carbon. Attributes assigned with only rock or seabed were scored as neutral to negligible. The map should be interpreted as showing the best information using the data currently available.

Valuation example:

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Marine carbon resource: how much carbon is stored in the sea	Presence of silts and sediments	Habitats	Deep sediment	High
			Bare rock	Low
	Sediment disturbance	Management	Undisturbed	High
			Dredged	Low

0 50 100 150 200 250
Kilometres

N

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Department of Arts, Heritage and the Gaeltacht
National Parks & Wildlife Service
Environment SYSTEMS evidence and insight

Indicator	CICES classification
MARINE CARBON STORAGE **Marine carbon (Regulation of greenhouse gases (carbon)**	**Section**: Regulation & Maintenance **Class:** Global climate regulation by reduction of greenhouse gas concentrations **CICES IE Sub-class:** Areas important for emissions reduction
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

Atmospheric carbon is sequestrated by, and stored in, the marine environment through two main processes. The first is photosynthesis where CO_2 is used by phytoplankton and oxygen is realised. The resulting microbes that grow from the process pass into the food chain. The other main method is via dissolution and chemical reaction of carbon dioxide and water forming bicarbonate which is likely to be stored in marine sediments.

Service indicator(s) mapped

Substrate and management were the two main indicators used to map this ecosystem service.

The role of substrate type in marine carbon storage is related to the particle size distribution of the sediment. Coarse sandy sediments have large particles which allow water to flow freely through the upper part of the sediment, flushing the region with oxygen. Finer, tightly-packed sediments such as mud and clay allow less water penetration and so are less oxygenated. Higher levels of oxygenation promote greater microbial activity, leading to faster carbon cycling and lower levels of carbon retention within the sediment.

Datasets used	Dataset requirement [2]
Habitat Asset Register [3]	Beneficial
Conservation Designations	Beneficial
Collated Seabed Substrate	Essential
Predicted habitats – North Sea and Celtic Sea	Essential
Dumping at Sea Boundaries	Desirable
Dredge Fishing Activity	Essential

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

Data analysis identified areas of significant carbon storage in the seas surrounding Ireland. This included data from the 'Predicted habitats for North Sea and Celtic Sea' (EU Seamap) and collated seabed substrate. Attributes from each dataset were analysed and valued from high to low where circa-littoral mud was considered to store more carbon and coarse sediments and sand likely to store less carbon. Where only rock or seabed was mapped these were allocated as neutral to negligible carbon storage.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the strategic scale, and further information should be gathered before decisions are made regarding a particular location.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring [4]
Deep habitats are more likely to store carbon long term; re-suspension is more likely in high energy environments	Collated Seabed Substrate	Deep Circalittoral mud	High
		Deep Circalittoral sand	Medium
		Circalittoral rock	Low
Deep habitats are more likely to store carbon long term; re-suspension is more likely in high energy environments	Predicted habitats – North Sea and Celtic Sea	Mud to sandy mud, A5:37: Deep circalittoral mud	High
		Coarse sediment, A5.13: Infralittoral coarse sediment	Medium
		Seabed, High energy Circalittoral seabed	Low
Input of organic materials adds carbon to the seabed	Dumping at Sea Boundaries	None	High
		Fish waste	Medium
		Dredged Material	Low
Disturbance of loose sediment and/or biogenic reefs; release of stored carbon back into the water column	Dredge Fishing Activity	None	High
		None	Medium
		None	Low
		[whole layer]	Disbenefit

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Data gaps associated with this map during the pilot project

Depth and substrate are only used as general proxy indicators for marine carbon storage as a whole. Biomass within the sediment, for example, will differ based on how well oxygenated the area is, which could form an additional indicator. Similarly, removal of carbon from the sediment back into the water column will be higher in high energy/high disturbance environments and greater clarity in attributed data could provide a solution to this.

The map does not incorporate processes occurring within the water column, where factors such as depth of light penetration, presence of fronts, currents or eddies, as well as the depth of thermocline and halocline can affect the overall productivity of the marine carbon pump. It does also not consider the efficiency of chemical exchange of carbon at the air-water interface.

Scientific framework for modelling 'marine carbon storage'

Overview	Substrate, particularly the depth at which it occurs and how stable it is likely to be, and management were the two main indicators used to map this ecosystem service. There is a good amount of evidence regarding the effect of habitat and substrate on carbon sequestration, as well as regarding processes occurring within the water column (though the latter can be difficult to map).
Water	Existing carbon stocks are considered to be greater in deeper parts of the ocean and are likely to be better at maintaining carbon storage in the longer term. When considering sequestration of carbon dioxide, residence time in the water column will be extended below the thermocline (depths of >1000-1500 m) (Tsouris et al., 2004). However, the sequestration potential of the deep oceans is limited by the exposure of the deep ocean water to the atmosphere. The "solubility pump", where C transfers as Dissolved Inorganic Carbon (DIC) due to under-saturation, occurs in surface waters. Once the DIC has been absorbed into the mixing of ocean waters, it sinks into the deep water formations and is subsequently sequestered into the ocean floor (Hessen et al., 2004). Marine snow (aggregate particles of >0.5 mm) plays an important role in oceanic biochemical cycles (Lampitt et al., 1993). Marine snow is one of the important factors in the flux of C from surface waters to deep oceanic waters (Hessen et al. 2004), where they are sequestered once below the oceanic thermocline. However, Hessen et al. (2004) states that biological processes, such as the sinking of particles and dissolved organic matter, cannot sequester anthropogenic carbon dioxide from the atmosphere directly, though ocean warming associated with climate change may change nutrient availability in surface waters.
Biochemical Processes	Biochemical processes contribute to the uptake and storage of C in the oceans. This includes the uptake of organic C through primary production and photosynthesis, and the uptake of dissolved inorganic C through the construction of seashells or reef structures by shellfish and corals. Net primary production (NPP) is an important factor governing C sinks in the ocean but is primarily limited by the availability of nutrients in the water column to support biologically mediated C storage (Field et al., 1998). Oceanic carbon sequestration also includes seashell production and limestone-reef

	building, through the chemical incorporation of CO32- ions (Carbonate) from the water column to form CaCO3 limestone structures. The dissolution of biogenic marine carbonates (magnesian calcites from coralline algae, aragonite from corals and pteropods, and calcite from coccolithophorids and formainifera) reduces anthropogenic carbon dioxide and increases total alkalinity (Feely et al., 2004). Processes that increase total alkalinity in the upper oceans increase the uptake rate of anthropogenic carbon dioxide (Feely et al., 2004).
Benthic Sediment	Burial of organic matter in sediments leads to the long-term reduction of atmospheric carbon dioxide, therefore sediment properties are considered an important factor of oceanic carbon sequestration (Burdige, 2007).
Atmosphere-Ocean Interface	Wind driven upwelling is an important factor for marine carbon storage. Upwelling brings nutrient rich, dissolved organic carbon poor waters to the surface, where carbon dioxide uptake can occur by dissolution (the solubility pump) and primary production (the biological pump). Carbon dioxide dissolution potential is proportional to the length of time the surface waters have been exposed to the atmosphere and the buffer capacity (or Revelle Factor) – which relates to the ratio between dissolved inorganic concentration in the water and carbon dioxide concentrations in the atmosphere. If DIC concentration is lower than atmospheric carbon dioxide, C uptake can theoretically take place (Sabine et al., 2004).
Management	Management leading to reduced carbon storage and sequestration includes: • Reef-sourced aggregates • "Carbon Capture and Storage" has the short term benefit of anthropogenic carbon dioxide removal from the atmosphere, but the longer timescales (of hundreds or thousands of years) associated with ocean mixing and ventilation results in its release back into the carbon cycle.

	Positive management, leading to increased biodiversity includes: • Conservation of high C storage ecosystems and habitats by primary production – Mangroves, seagrass meadows, tidal salt marshes, kelp forests, coral reefs (though, arguably, coral reefs could be considered slight C sources rather than C sinks due to chemical interactions on a local scale (Laffoley and Grimsditch, 2009).

Supporting evidence: References

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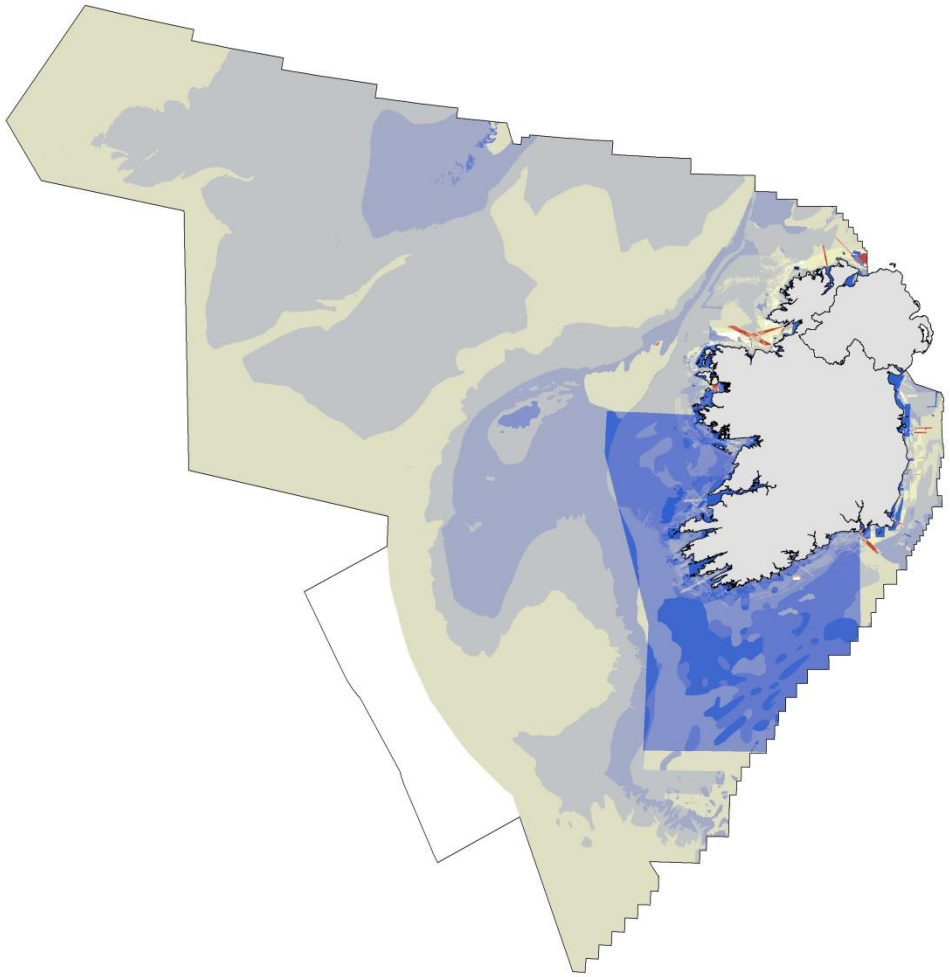
Marine biodiversity - Indicator Document: Ecosystem Function Modelling & Rule-base development

Marine Biodiversity: Habitats and management
Function: **Naturalness, support of systems and species, and resilience**

12/05/2016



Legend

Areas with high biodiversity value

Areas with average biodiversity value

Areas with some disbenefit regarding biodiversity

How to interpret the map:
The darkest colours represent areas with biophysical properties likely to support high levels of biodiversity. Light colours represent areas with a lower known contribution to biodiversity. Red colours show areas that could be an overall disbenefit to biodiversity – this happens at sites where several types of fishing activity have been recorded.

Ecosystem function:
Biodiversity - Naturalness, support of systems and species, and resilience.

What the ecosystem function is:
Biodiversity includes not just the number of species, but how well the systems function, cycle nutrients, and support species. Areas with higher structural diversity usually support higher diversity than homogenous areas. Within the water column, fronts (areas where two water masses meet) often are areas of high biodiversity (Miller and Christodoulou, 2014), as drifting plankton accumulates here, which in turn attracts species from higher trophic levels.

Why it is important:
Biodiversity as a function underpins many ecosystem services; therefore, it is useful to show where the hotspots occur.

How the map was created:
Marine biodiversity mapping used substrate and management data as proxies for the ability of an area to support biodiversity. As areas receiving high levels of daylight commonly support more biodiversity, a high biodiversity score has been added for shallow (less than 10m deep) areas.

Valuation table

Ecosystem Function	Significant effects	Data used	Example attributes	Indicative scoring
Biodiversity	Substrate effect	Sediment	Biogenic Reefs / Kelp forests	High
			Homogenous substrate	Low
	Management	Harvest	High impact methods	High
			Low impact methods	Low
	Management	Protected Sites	SAC	High
			Biologically sensitive area	Medium
	Light availability	Bathymetry	<10m deep	High
			>10m deep	Neutral

0 50 100 150 200 250
Kilometres

N

Cartography by Environment Systems Ltd, May 2016.
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© Ordnance Survey Ireland / Government of Ireland [2016].
Contains data prepared by the Environmental Protection Agency based on Ordnance Survey Ireland information.
For full list of datasets used for this map, please refer to the final project report.

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Department of Arts, Heritage and the Gaeltacht
National Parks & Wildlife Service

Environment SYSTEMS evidence and insight

Indicator	CICES classification
MARINE BIODIVERSITY **Habitats and management**	**Section**: Regulation & Maintenance **Division:** Maintenance of physical, chemical, biological conditions **CICES IE Sub-class:**
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 function is

Ecosystem services depend on living structures and processes, and in this sense they are fundamentally underpinned by 'biodiversity' in its broadest sense. However, the term 'biodiversity' is used in different ways. While the label 'biodiversity' is often used as a catch all for 'living systems', it is important to note that there is particular interest in finding out if services also depend on the diversity or variety of species or habitats, and whether service output is undermined if this variety is lost.

Certain habitats tend to have more biodiversity than others, which is related to the range of different niches available, with structurally complex areas generally possessing a higher biodiversity value than less complex systems. For this reason, anthropogenic (originating in human activity) structures that have no inherent adverse effect on marine life can be considered to enhance levels of marine biodiversity. In addition to the substrate type, oxygenation levels can be an important factor influencing marine biodiversity, with oxygen levels in estuarine sediments under eutrophication occasionally reaching levels low enough to extinguish the majority of life.

Marine biodiversity can be split into pelagic (relating to the open sea) and benthic (relating to, or occurring at, the bottom of a body of water) organisms. Amongst the latter, estimates suggest that only a very small percentage is known as of yet, which adds uncertainty to using substrates as indicators for biodiversity.

Function indicator(s) mapped

The main indicator for modelling this function, i.e. the potential areas of high marine biodiversity, is the substrate type found in an area. When considering this indicator, the highest scoring areas are those where biogenic (formed by living organisms, e.g. corals or mussels) habitats have been recorded. Glacial till habitats, on the other hand, score as quite low, as movement of currents in these areas can cause crushing of benthic organisms. The level of exposure in these areas could be another influencing factor.

Other indicators considered include any kind of anthropogenic structure that offers additional habitat complexity, which is likely to increase biodiversity in the immediate vicinity by creating additional ecological niches. Fisheries, depending on type of gear used and intensity, can have a negative effect on marine biodiversity. The strongest negative impact would be expected from bottom trawling in areas that are naturally low in disturbance, such as stable sediments or biogenic reefs, whilst the impact on mobile sediment in areas of higher exposure would be quite low.

Shallow areas, where sunlight penetrates more easily, will have more biodiversity than deeper areas, where there is less readily usable energy. Deep areas, on the other hand contain some of the most specialised and rarest species. However, due to the vast expense of deep ocean, the habitat they live in does not form biodiversity hotspots in the same way as shallow, sun-lit areas tend to.

Protected areas are considered to have a positive effect on biodiversity, even though the lack of physical boundaries in the marine environment makes this effect difficult to quantify.

Point records of marine mammal sightings were not included, as the highly mobile nature of many of these species makes the exact site of a sighting a weak indicator of the biodiversity of the area.

Datasets used	**Dataset requirement [2]**
Habitat Asset Register [3] (for estuaries, saltmarshes, coastal lagoons)	Essential

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

Collated Seabed Substrate	Essential
Predicted habitats – North Sea and Celtic Sea	Essential
Bathymetry	Essential
Conservation Designations	Beneficial
Offshore Special Areas of Conservation (SACs)	Beneficial
Inshore Fisheries	Beneficial
Dredge Fishing Activity	Beneficial
Line Fishing Activity	Beneficial
Net Fishing Activity	Beneficial
Bottom Trawl Fishing Activity	Beneficial
Mid-water Trawl Fishing Activity	Beneficial
Biologically Sensitive Area	Beneficial
Greencastle Codling Area	Beneficial
Marine Data Buoys	Beneficial
OSPAR Windfarms	Beneficial
Fishing Ports	Beneficial
Shellfish Waters Directive	Beneficial
Commercial Ports	Beneficial
Dumping at Sea Boundaries	Beneficial
Marinas	Beneficial
Navigation Aids	Beneficial
Arklow Bank Wind Park Connection Cable	Beneficial

Shipping Navigation Channel	Beneficial
Offshore Commercial Field	Beneficial
Offshore Gas Line	Beneficial
Platforms	Beneficial
Local Ferry Ports	Beneficial

How the map was created

The map used substrate data from two different layers, 'collated seabed substrate', and the 'Predicted habitats for North Sea and Celtic Sea (EUSeaMap)'. As the former is considered to be more detailed, this dataset has been given preference. EUSeaMap data was used to fill any gaps. For fisheries data that measured fishing intensity on a continuous scale, groups were formed based on histogram statistics. The resulting classes have than been scored and been combined with the remaining datasets using overlay analysis.

The map should be interpreted as showing ecosystem function information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the strategic scale, and further information should be gathered before decisions are made regarding a particular location.

Scoring

Significant Effects	**Datasets used**	**Example attributes**	**Indicative scoring [4]**
Habitats likely to be well oxygenated can support more biodiversity	Habitat asset register	Estuaries	High
		Coastal lagoons	Medium
		None	Low
Habitats likely to be well oxygenated can support more biodiversity	Collated Seabed Substrate	Circalittoral muddy sand	High
		Infralittoral rock	Medium
		Circalittoral sand	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Areas noted as having faunal communities are positive, as they provide habitats for other species; till in high energy environments is little used, as organisms can be crushed	Predicted habitats – North Sea and Celtic Sea	Rock or hard substrata with associated flora or sessile fauna	High
		Till, Moderate energy Infralittoral till	Medium
		Till, High energy Infralittoral till	Low
Shallow areas receiving more light can support more biodiversity	Bathymetry	Shallow (<10m)	High
		None	Medium
		None	Low
Areas offering protection can increase biodiversity levels	Conservation designations	Under strict management	High
		Under designation	Medium
		Under designation with exemptions	Low
Areas offering protection can increase biodiversity levels	Offshore Special Areas of Conservation (SACs)	None	High
		SAC	Medium
		None	Low
Additional structural diversity increases the number of ecological niches for species to inhabit.	Marine Data Buoys	None	High
		Buoy	Medium
		None	Low
Additional structural diversity increases the number of ecological niches for species to inhabit.	OSPAR Windfarms	None	High
		None	Medium
		Windfarms present	Low
Risk of polluted waters negative for biodiversity	Fishing Ports	None	High
		None	Medium
		None	Low
		Port with landings	Negative
Risk of polluted waters negative for biodiversity	Commercial Ports	None	High
		None	Medium
		None	Low
		Port present	Disbenefit
Additional structural diversity increases the number of ecological niches for species to inhabit.	Navigation Aids	None	High
		None	Medium
		Whole Layer	Low

Additional structural diversity increases the number of ecological niches for species to inhabit.	Arklow Bank Wind Park Connection Cable	None	High
		None	Medium
		[Whole layer]	Low
These can have a negative impact by causing disturbance	Shipping Navigation Channel	None	High
		None	Medium
		None	Low
		[Whole layer]	Disbenefit
These can have a negative impact by causing disturbance	Offshore Commercial Field	None	High
		None	Medium
		None	Low
		[Whole layer]	Disbenefit
Additional structural diversity increases the number of ecological niches for species to inhabit.	Offshore Gas Line	None	High
		None	Medium
		[Whole layer]	Low
Additional structural diversity increases the number of ecological niches for species to inhabit.	Platforms	None	High
		None	Medium
		[Whole layer]	Low
These can have a negative impact by causing disturbance	Local Ferry ports	None	High
		None	Medium
		None	Low
		[Whole layer]	Disbenefit
Areas where undesirable substances are dumped have a negative effect. Natural waste, like shells or rock armour, can add structural diversity	Dumping at Sea Boundaries	None	High
		Rock armour	Medium
		None	Low
		Waste, particularly chemicals	Disbenefit
Marinas can be negative if fuel or waste water enters the sea	Marinas	None	High
		None	Medium
		None	Low
		[whole layer]	Disbenefit
Practices removing large quantities and/or damage habitats are particularly negative	Inshore Fisheries	None	High
		None	Medium
		None	Low
		Pot	Neutral
		[whole layer]	Disbenefit

Practices removing large quantities and/or damage habitats are particularly negative	Dredge Fishing Activity	None	High
		None	Medium
		None	Low
		[whole layer]	Disbenefit
Practices removing large quantities and/or damage habitats are particularly negative	Line Fishing Activity	None	High
		None	Medium
		None	Low
		Handlines	Neutral
		Troll Lines	Disbenefit
Practices removing large quantities and/or damage habitats are particularly negative	Net Fishing Activity	None	High
		None	Medium
		None	Low
		Gill Net, Herring	Disbenefit
Practices removing large quantities and/or damage habitats are particularly negative	Bottom Trawl Fishing Activity	None	High
		None	Medium
		None	Low
		[whole layer]	Disbenefit
Practices removing large quantities and/or damage habitats are particularly negative	Mid-water Trawl Fishing Activity	None	High
		None	Medium
		None	Low
		[whole layer]	Disbenefit
Areas offering protection can increase biodiversity levels	Biologically Sensitive Area	None	High
		Biologically Sensitive Area	Medium
		None	Low
Areas offering protection can increase biodiversity levels	Greencastle Codling Area	Greencastle Codling Protected Area	High
		None	Medium
		None	Low
Areas offering protection can increase biodiversity levels	Shellfish Waters Directive	Shellfish Area	High
		None	Medium
		None	Low

Data gaps associated with this map during the pilot project

The map for marine biodiversity does not include species data. This is because many marine species are highly mobile, so that point observations included in the map could easily misrepresent the overall results. Additionally, recording is often biased to large marine species, in particular marine mammals. Therefore, incorporating species data is likely to attribute higher biodiversity value to those areas known for marine mammals, instead of mapping marine biodiversity as a whole.

The map does also not include detailed marine community mapping, as this has only been carried out for selected bays, making the data unsuitable for mapping at the scale of the whole of Ireland's designated continental shelf.

Scientific framework for modelling 'marine biodiversity indicators'

Overview	The main indicator for this map is the substrate type found in an area. Other indicators considered include any kind of anthropogenic structure that offers additional habitat complexity, which is likely to increase biodiversity in the immediate vicinity by creating additional ecological niches. Fisheries, depending on type of gear used and intensity, can have a negative effect on marine biodiversity. There is good supporting evidence regarding the contribution to biodiversity of habitat complexity and the effects of disturbance, mainly from literature concerning the terrestrial environment. The most relevant material is summarised here.
Habitat	Biodiversity is related to the range of different ecological niches available, with heterogeneous seascapes and landscapes generally possessing a higher biodiversity value than homogenous systems (Ratcliff, 1977; Tews et al., 2004). Certain habitats and biogeographical regions are potentially more biodiverse than others (Gaston, 2000. However, some of the most specialised and rarest species can occur in areas that have low average levels of biodiversity. In the marine environment this refers mostly to the deep ocean, which, due to its vast expanse, does not form biodiversity hotspots in the same way as shallow, sun-lit areas tend to. The more complex the structures and the more varied the niches or locations for biodiversity development, the greater the diversity of species found in an ecosystem (Tews et al., 2004; Levine and HilleRisLambers, 2009). Time is also an important consideration. Undisturbed habitats present for many centuries allow specialist species to develop and thrive (Mittelbach et al., 2007). However, some small perturbation of systems, particularly natural types of

	disturbance, can enhance biodiversity by creating new available niches and varied environmental conditions that enable species with traits adapted to environmental disturbances and fluctuations to colonise (Wilkinson, 1999; Roxburgh et al., 2004). The more habitat forming species present, the higher the diversity within the habitat (Knops et al., 1999; Tews et al., 2004). This is difficult to accurately compare as some communities are intrinsically more species rich than others. Detailed habitat classifications such as EUNIS Assessments, which take into account the presence of species and communities, can be added to the broader habitat classifications to model species diversity. High biodiversity of native species additionally leads to fuller resource utilisation, which makes settlement of invasive species, which could negatively affect the ecosystem, less likely (Knops et al., 1999; Stachowicy et al., 1999)
Other effects	Humans alter the composition of biological communities through a variety of management activities (Chapin et al., 2000). Some of these activities are thought to be bringing about increased rates of species invasions and extinctions (Hooper et al., 2005; Halpern et al., 2008). Increased pollution has been, and continues to be, a major driver of change across the different habitat groups within the marine environment. There are many national (e.g. Convention on Biological Diversity), regional and local policies that seek to maintain biodiversity and prevent further decline.

Supporting evidence: References

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