Data Gap Analysis for Cultural Ecosystem Services

RD1.4.1bvi

Deliverable D1: Data inventory report

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1 Summary

As part of the RESAS Strategic Research Programme WP1.4 on Sustainable and Integrated Management of Natural Assets, this report is a deliverable for RD1.4.1 Objective B (Assessing ecosystem service delivery and interactions). Its aim is to make an inventory of existing in-house and partner data that can support the creation of Cultural Ecosystem Services (CES) indicator maps for inclusion in the Natural Asset Register (NAR). The main gaps in the data will inform research priorities for the coming period. This is an internal report for the NAR development, which will be used in the ongoing consultation with Scottish Natural Heritage.

The data inventory suggests that there are a range of data sources in Scotland that can provide support for the mapping of CES. The drive towards open access can make more data available however the current nature of data provision means that they are both spatially and temporally patchy. The data represent predominantly supply of CES infrastructure rather than actual CES experience for the physical and intellectual interactions with ecosystems and landscapes, however while there are data that can provide some information for the spititual symilt and other ineteradtions there is a real gap in the data sources. This gap is closely linked with the ongoing debate regarding the definition and interpretation of the CES classes as well as the indicators that can be used for mapping these CES.

The inventory of CES indicators included in this report shows a diversity of indicators which illustrate that this is still very much an area of ongoing research. For Scotland the results so far show that there are a lot of different type of data sources which could potentially support a robust mapping of CES, however that in order to achieve that, work is needed in collaboration with SNH and other stakeholders to develop a common methodological framework that will support the integration of national and local data and the creation of robust indicators for all the CICES classes.

Future work will therefore focus on filling the knowledge gap through the development of indicators and data that will contribute to the discourse regarding the spiritual, symbolic and other interactions with ecosystems and landscapes in general and the mapping of these CES more particular.

2 Background and objectives

Context of the project

The RESAS Strategic Research Programme (SRP) [1] has funded the development of a Natural Asset Register (NAR). The Scottish Economic Strategy (Scottish Government, 2015) recognise natural assets as important components to achieving the Scottish Government's overall ambition to make Scotland a more successful country with opportunities for all. The NAR will create a publicly accessible register of Scotland's natural assets, that will improve our knowledge of how much of what is where, and which assets are at risk in particular places. The open data policy of the government means that progressively more spatial data are to be made publically available.

[1] Scottish Government's Strategic Research Programme – Theme 1 – Natural Assets

The application of Ecosystem Services in the decision making process requires an inventory of current services and examining the impact of change on future servies. Most ecosystem services (ESS) (productive, supporting and regulating services) can rely on a history of measuring and monitoring to support the mapping of the services. However the cultural services, while an important additional category, has a very different background in measuring and monitoring which does pose important challenges to the development of indicators and the availability of relevant data sources. Our ability to map the CES is important for the assessment of trade-offs between CES and the other ESS; and our ability to manage the full suite of ESS arising from particular places.

As part of the research under RD1.4.1 Objective B (Assessing ecosystem service delivery and interactions), which will provide a data for analsyis of ES relatiohsips and trade-offs, Cultural Ecosystem Services (CES) are an important component of the NAR. Currently however CES is least well developed among the ESS in terms of methods, indicators and data sources.

Development of CES mapping

The Millenium Assessment (MA, 2005) introduced the concept of ecosystem services, and they defined cultural ecosystem services as "*non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, refelction, recreation and aesthetic experiences"* (MA, 2005, p40). These benefits include cultural diversity, spiritual/religious values, recreation/tourism, social relations, educational values as well as aesthetic values, sense of place and cultural heritage.

The European project Mapping and Assessment of Ecosystems and their Services (MAES) has developed a classification for the mapping of ecosystem services – Common International Classification of Ecosystem Services CICES (Maes et al 2013). This classification includes not just physical use of ecosystems, but also the less tangible benefits from spiritual, ritual or symbolic interactions with the ecosystems (Table 1).

Early CES mapping were developed based on expert knowledge on the basis of land cover data (Burkhard et al 2015). However a range of publications have emerged that explore the mapping of CES based on existing spatial data: traditional mapping approaches (Peña et al 2015, Tratalos et al 2016, Weyland et al 2014), geo-tagged social media data (Tenerelli et al 2016, Wood et al 2013) and data gathered through stakeholder and community involvement like participatory GIS (Brown et al 2014, Garcia-Nieto et al 2015, Kopperoinen et al 2015, Pert et al 2014).

Currently the most popular data for CES mapping are those of visitor numbers. However while this approach may provide evidence of a 'market' for the habitat, it does not necessarily capture all aspects of cultural services. It underestimates the value of particular habitats /landscape features that have high conservation status, are remote and have symbolic or emblematic value. These elements have a place in the CICES classification, but this rapidly developing discourse still faces major challenges to indentify suitable indicators, data sources and methods to create a comprehensive CES map.

Table 1: Cultural Ecosystem Services Classification from CICES V4 - 3 (Maes et al, 2013),

	Division	Group	Class
Cultural [environmental settings]	1 Physical and intellectual interactions with biota, ecosystems, and land-/seascapes	1.1 Physical and experiential interactions	1.1.1 Experiential use of plants, animals and land-/ seascapes in different environmental settings
			1.1.2 Physical use of land-/seascapes in different environmental settings
		1.2 Intellectual and representative interactions	1.2.1 Scientific
			1.2.2 Educational
			1.2.3 Heritage, cultural
			1.2.4 Entertainment
			1.2.5 Aesthetic
	2 Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	2.1 Spiritual and/or emblematic	2.1.1 Symbolic
			2.1.2 Sacred and/or religious
		2.2 Other cultural outputs	2.2.1 Existence
			2.2.2 Bequest

Aim of this report

The primary aim of this report is to produce an inventory of existing in-house and partner (SNH, Historic Environment Scotland (HES), Scottish Evironment Protection Agency (SEPA), Forestry Commission (FC), etc.) data that can support the creation of CES indicators based on the CICES classification (Table 1). These CES indicators will be used to help to populate the NAR. A secondary aim is to explore CES indicators that are emerging in the literature and examine the main gaps in the data. These gaps will identify our research priorities for the coming period. This is an internal report to support the development of the NAR, however it will also be used for the ongoing engagement of the project with SNH.

In the following sections the methodology used for the inventory of the data sources in Scotland and the approach used for the assessment of these data sources in the context of the CES CICES classification is presented in section 3.1. Combined with an inventory of indicators (section 3.2), they are the basis of the methods used for data gaps analysis in section 3.3. The results of the inventory and the data gaps analysis (section 4) will be used to discuss and identify key issues and priorities to address in the coming years (section 5).

3 Methodology of data inventory and data gap analysis

3.1 Inventory of available data in Scotland

There are a wide range of relevant data source available in Scotland that could provide relevant information to support the mapping of CES. They include national data that could inform the potential or supply of certain CES like the presence of wildlife, particular habitats/ landscapes (SNH) or cultural heritage features (HES). Data about actual CES are available through visitor numbers to tourist attractions and national and local surveys (Recreation Survey[2], Household survey[3] and

[2] http: http://www.snh.gov.uk/land-and-sea/managing-recreation-and-access/increasing-participation/measuring-participation/

woodland surveys[4]). In addition to these national data, there are data held and created by local authorities (for example: core path network infrastructure and local landscape designations) and local CES related projects in partnership with local community and stakeholders from SNH (APPENDIX 1).

For the data gap analysis a review of the national data sources has been conducted. While the local case studies are important to enhance our understanding of the relationship between people and natural environment, this inventory has not included case study data at this stage. However, through the partnership information from SNH and 'snowball effect' a number of additional data sources are included.

For the data inventory the following repositories have been examined for the presence of relevant data sources for the mapping of CES based on CICES classification:

- The **data.gov.uk-website** is a general repository for UK governmental data including spatial data as part of their open data policy.
- **Historic Environment Scotland** (HES) has an extensive set of spatial databases about historic features in the Scottish landscape.
- **Scottish Natural Heritage** (SNH) holds a repository (Natural Spaces) with important data about protected areas, habitats and landscapes. In addition relevant data have been gathered through local partnerships (see KE1 report).
- **Forestry Commission** provides a range of statistical data in relation to Scottish forests.
- **Scottish Statistics** (Household survey etc)
- **Visit Scotland** has created spatial data for there website to present the many aspects of Scotland to the attention of visitors.

The focus of the inventory is the identification of data that are able to inform the NAR about the different type of CES delivered by natural environment (ecosystems, habitats, species, and landscapes). The objective of the approach is to provide a basis for the development of a robust methodological approach for the creation of CES data to be included in the NAR later in the project. The approach will include data from participatory processes and local case studies for the more challenging spiritual and symbolic CES classes of CICES.

For each of the data identified the following information has been captured:

- the **origin**, that is the organisation responsible for the creation of the data,
- the **data source**, which is the name of the data
- **type of data** identifies whether it is survey data or spatial data (point, line or polygon)
- **theme**, a general theme of the data is identified
- **spatial context** has been identified as well as partially spatial data which have ben mapped by spatial units using spatial statistical methods
- Where possible a **weblink** to the data sources has been included.

For each of the data sources provisional links to the CICES CES classes are created based on an interpretation of the potential indicators that can be generated using the data.

[3] http://statistics.gov.scot/data/scottish-household-survey
[4] http: http://scotland.forestry.gov.uk/supporting/strategy-policy-guidance/native-woodland-survey-of-scotland-nwss

3.2 Inventory of CES indicators

The development of CES indicators has emerged from the ESS concept. Several reviews of ESS and CES have recently been published (Egoh et al 2012, Hernandez-Moricillo et al 2013, LaRosa et al 2016, MAES 2015, Malinga et al 2015), that have indicators associated with them. The review papers are used to create a preliminary inventory of indicators for this report. Additional literature on CES indicators have been reviewed to identify the development of CES indicators (Albert et al, 2016a, Albert et al 2016b, Syrbe et al 2012, Peña et al 2015).

From the review papers the indicators identified are captured and they are interpretated for their role in the CICES classification. The main objective is to get an overview of the development and use of CES indicators and their link to the CICES classification. Together with the national data inventory this will inform the CES data gap analysis for Scotland.

3.3 CICES based classification of CES – data gap analysis

The results of both the data and indicator inventory are evaluated to assess the main gaps in the data for the creation of CICES based CES indicators for Scotland. The assessment will identify the data gaps for each of the CICES CES classes. 'Data gaps' in this context will include both the absence of data and the constaints by data/indicator quality. The data gap analysis will therefore include an assessment of the quality of the data (spatial resolution, format, sampling size etc) and the potential of the data to create robust indicators which can meet quality criteria (Church et al 2014).

4 Results

4.1 Data inventory

Among the data sources indentified (APPENDIX 2) there are a number of different type of data sources that data inventory has been able to identify:

- Data repositories (spatial and survey data)
- Web based and interactive spatial data (national and case study data)

The data repositories are created as part of the government's commitment to open data. The data inventory has shown that the data repositories of Scottish Natural Heritage (SNH), Historic Environmental Scotland (HES), and Forestry Commission (FC) hold an important collection of data, but these data largely represent the potential for the CES rather than the actual experience of CES.

The data repository data.gov.uk is a larger UK level data repository which includes data from government departments and agencies as well as public bodies and local authorities. However, the data.gov.uk repository is depending on the organisation sharing the information through the repository for example local authority spatial data about their core path network is currently only available for a small number of authorities.

Data regarding visitor numbers are collected though through a number of different surveys: Recreation Survey (SNH), Household Survey, Forest Surveys (FC public opinion and quality of experience), and Visitor attrachtion monitoring (VisitScotland). These survey data are based on different sampling strategies and they have different spatial context and representation.

In relation to the data repositories there are a range of different web-based data source of those Visit Scotland has probably the most comprehensive spatial data regarding the availability of visitor attractions and a range of different leisure activities, which are categorised in a way that closely aligns with CES classification. Potentially the database supporting the web-site can hold potentially a large amount of relevant information that can support the delivery of a range of different CES indicators.

An initial interpretation of the data contribution to particular CICES CES classes (APPENDIX 2) show as expected that there are many more data that can represent the CES classes for physical and intellectual interactions with biota, ecosystems and land-/seascapes than data that can represent the CES classes for the spiritual, symbolic and other interactions with with biota, ecosystems and land-/seascapes (Table 1).

The data are diverse in their data format. A large number of the rather simple supply and demand CES indicators can be generated. However as Tratalos et al (2016) conclude in their paper, while these type of indicators are relatively easy to generate their quality as indicators need to be questioned and suggest that further research is needed to develop robust indicators for CES. The inventory of CES indicators included in this report shows a clear lack of consistency in the use of indicators and supports the suggestion by Tratalos et al 2016.

4.2 Data gap analysis

The number of available data sources is encouraging and the link created between the data and the CICES classes (APPENDIX 3) is tentatively based on the interpretation of current literature.

The best represented classes are 1.1.2 active use of land-/seascape and 1.2.3 the historic and cultural heritage. For class 1.1.2 there are a number of data that include access routes for outdoor activities (like walking and cycling). It can be argued that designated areas for conservation should be included as areas where people can use the land-/seascape for watching wildlife as an outdoor activity. The key gap in the data for this class is that they need to be linked to actual use, i.e. visitor numbers. Class 1.2.3 can draw on a range of data from HES that represent the cultural heritage, however among the data sources included there is a certain overlap while at the same, like the listed buildings are more commonly found in an urban context rather than a more remote setting. The main gap in this class is link between these national data sets and local histories which provide local communities with a sense of place.

The group of physical and experiental interactions (class 1.1.1 and 1.1.2) are most popularly represented by visitor numbers. The web-based maps for Visit Scotland (www.visitscotland.com) suggests that there is an important geo-data based of visitor attractions. For example among the visitor attractions are those that are categorised for their interactions with wildlife. The gap in this data is that further analysis is necessary to anonymise the data and to create a sound indicator which incorporate the visitor number statistics.

Within the group of intellectual and representative interactions (1.2.1 to 1.2.5), the classes 1.2.1 Scientific and 1.2.2 Educational are difficult to distinquish as those areas and habitats that have scientific interest often also provide an educational role. Currently there is no database with unique and dedicated education centres in Scotland. In reality it will be rather difficult to identify clear education roles without duplication with those provided by visitor centres of visitor attractions that provide physical interaction with ecosystems (group 1.1).

Thanks to projects by Film Scotland and Nature & Art there are spatial data that identify the areas that have inspired different art forms (film, television, novels, poem, and music). These data for class 1.2.4 (Entertainment) show how the Scottish land-/seascape can be experienced through different media. In the same way online photos from social media (Flickr etc) can be a route in for an 'arm chair' experience of Scottish wildlife and landscapes. The information from Film Scotland and Nature & Art are valuable however currently they are not yet available as a time series. The data will be used to explore and develop robust indicators for class 1.2.4.

The class 1.2.5 (Aesthetics) is open to many different interpretations which is represented in the literature (Burkhard et al 2015, Fry et al 2009, Peña et al 2015, Plieninger, et al 2013). However Scotland has a number of designated areas that represent aesthetic values, in particular national scenic areas, remoteness/wildness, special local landscape, and gardens/designed landscapes. The data gap is in an assessment of aesthetic values outside designated areas.

Finally the classes in the division 2 of spiritual, symbolic and other interations are the most difficult to capture and therefore only few data sources are linked to these classes. It is not just an issue of a data gap but also a gap in agreement on how to interpret the classes and how to create robust indicators for these classes. It is by far the most difficult aspect of the CICES classification. The data sources identified in APPENDIX 3for this division are incomplete largely because the classes are not yet clearly defined. However these data sources can provide a framework for the creating new data to fill the current gaps through a range of stakeholder participatory methods.

The inventory of indicators from a number of recent review papers (APPENDIX 4**Error! Reference source not found.**) shows that there is not yet consensus regarding suitable indicators for different types of CES. The current interpretation of available data as well as the data's suitability to provide sound indicators for the CICES CES classes require further debate and research and will continue for the duration of this project. In addition more indepth research is necessary to develop and test the sound indicators for the CICES classes and a methodological approach to the aggregation of different indicators in CES classes to CES groups and CES divisions.

5 Discussion

The data inventory has shown that there are a range of data sources in Scotland that can support the mapping of CES. However, while there are visitor survey data providing in formation about the visitor number by broad habitat and visitor attraction only, they represent a small proportion of the different dimensions of CES. The CICES classification recognises that visitor numbers are not the only way to identify culturally important areas.

An important challenge for CES mapping raised emerged during the stakeholder meeting with SNH (KE1). There are currently many different initiatives and case studies in relation to CES and mapping of CES, however there is a need for a way to bring the outcome of these projects together in a more coherent way [KE1 meeting notes]. The data inventory illustrates that in priniciple current Scottish data sources provide great opportunity for the creation of indicators for most of the CICES CES classes. However there is still considerable ambiguity about the interpretation of the CES classes and limited published research about the quality of the indicators currently most commonly used. In addition to the quality of existing CES indicators, the process will be greatly enhanced if the

methodological approach to their mapping is able to systematically integrate local study data with national data.

Therefore the results of this report are a comprehensive but not exhaustive inventory. It is a first step towards the development of a framework for capturing and assessing CES data resources for their value for mapping CES. During the remaining of the project work will focus towards clarifying the interpretation of classes and developing innovative methods for the creation and mapping of CES indicators. The current database created for this report will evolve and periodically be updated. This report is therefore part of a work in progress and reports on the process and results of the data inventory and the data gap analysis to date.

This report has helped us refine plans for further research in the coming year and together with the report on social science methods (D2) and a further stakeholder meeting (KE2) will inform the key research priorities. Although visitor number data are available they are not necessarily suitable to measure all the classes and dimensions of the CICES classification. However methods should be explored to integrate the current national survey data about visitor numbers and experiences of CES with the data sources about the potential for CES in an area. The integration could lead to the visitor number data provding a way to weigh the different CES indicators for their national importance/popularity rather than as individual indicators. In addition modelling approaches for visitor use of habitats or landscapesshould be explored that take into account proximity to urban centres as well as visitor number data.

Finally RD 1.4.1 and the NAR aim to map the ESS by EUNIS classes, which are based on discrete habitats. However given the nature of CES some of the indicator data will go beyond the boundary of broad habitat types to unique landscapes. It would be valuable to conduct a study in to the impact of mapping CES and ESS more widely by different spatial mapping units, i.e. EUNSIS classes, landscape character areas, local authorities or km2. An experiment for the mapping of CES based on different mapping units will be conducted as part of the development of prototype maps (D3).

Therefore our next steps in this research are to develop a number of prototype maps that explore different ways of using the available data sources and that will advance the development of a more comprehensive methodology for mapping CES.

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APPENDIX 1: SNH community partnerships

Projects/partnerships	Methodology for CES	Web-link to method	Data [5]
Carse of Stirling Partnership	stakeholder workshops - including mapping of benefits provided by the Carse of Stirling	http://my.stirling.gov.uk/services/community-life-and-leisure/your-community/community-information/stirling-carse	
Pentland Hills Regional Park	information to users about provision and monitoring use	http://www.edinburgh.gov.uk/pentlandhills/site/index.php	route/path provision and visitor number for the areas including a range of activities
Galloway and southern Ayrshire Biosphere	Sense of Place - storytelling	http://www.gsabiosphere.org.uk/get-involved/sense-of-place/	
Strathard –	community mapping for community action plans	http://www.thecommunitypartnership.org.uk/project/strathard-a-place-to-live-work-play/	
Wigtown Machars/Nairn –	community workshops in 5 different communities - identification of places and features related to CES	in SNH report (chapters 4 & 5)	table and map of material from workshops (features and association with ES (hardcopy report)
Carse of Gowrie Sustainability Group –			
John Muir Way		http://johnmuirway.org/	route map of coast to coast route
EcoCoLife Steering Group - http://www.ecocolife.org.uk/	EcoServ to map demand and supply for certain Ess	http://ecosystemsknowledge.net/ecoserv-gis (NB: find information under Case Studies tab)	There are maps for all project areas within the CSGN.
Seven Lochs Wetland Park EcoServe - case studies	interactive mapping by local area (7 separate areas)	http://sevenlochs.org/interactive-map	interactive map of nature, heritage, activities and future plans for each of the seven areas
Cultural aspects of Scotland's landscapes		File on page "Nature and Art"	Spatial data for range of different media of Cultural Association - mapping project
Place-book Scotland –	Web-based PPGIS based on sharing photos, videos, music and words	http://www.placebookscotland.co.uk/	
Landscapes of Scotland (with creative associations from the National Libraries Scotland)	heuristic mapping process based on SNH/HS expert knowledge	http://www.snh.gov.uk/docs/A736384.pdf	
Year of Natural Scotland products with Creative Scotland	Collection of films and television programmes that showcase important element of natural Scotland – through locations, narrative elements or features some special landscape, wildlife or biodiversity element.	http://www.naturalscotlandfilms.org.uk/locations.html	film location map (89 locations) - downloadable (and downloaded) in KML format (P:\Human\CuturalServices\RESAS 2016-2021\Spatialdata\YoNS Film Locations.kml)

[5] The nature of the available data could not be assessed for all of the projects/partnerships.

APPENDIX 2: Inventory of available national level data

Origin	Data source	Type of data	Theme [6]	Spatial aspect[7]	Web/hyper-link
CEH	land cover data	polygon	land cover	spatial	
Forestry Commission	Ancient woodland		woodland	spatial	https://data.gov.uk/dataset/ancient-woodland-inventory-scotland1
Forest Commision	Public Opinion about forests	national survey	woodland	non spatial	http://www.forestry.gov.uk/forestry/infd-5zyl9w
Forestry Commisison	Caledonian Woodland inverventory	polygon	woodland	spatial	
Forestry Commission	Woodland in and around urban areas	polygon	woodland	spatial	https://data.gov.uk/dataset/woodlands-in-around-towns-wiat
Forestry commission	National Forest Inventory	polygon	woodland	spatial	
Forestry Commission	Quality of experinece in woodland	surveys of individual woodland	woodland	partially spatial	http://www.forestry.gov.uk/forestry/infd-5wwjpt
Forestry Commission	Visits to woodland	survey on all woodland	woodland	non spatial	http://www.forestry.gov.uk/forestry/infd-5wcmr4
Heritage Path	Heritage paths	line	recreation, historic	Spatial	http://www.heritagepaths.co.uk/
Historic Environmental Scotland	Historic land use	polygon	historic	spatial	https://data.gov.uk/dataset/national-record-of-the-historic-environment-historic-land-use-assessment
Historic Environmental Scotland	Scheduled Monuments	polygon	historic	spatial	https://data.gov.uk/dataset/scheduled-monuments-dataset2
Historic Environmental Scotland	Listed buildings	point	historic	spatial	
Historic Environmental Scotland	Battlefields	polygon	historic	spatial	https://data.gov.uk/dataset/battlefields-inventory-boundaries-dataset
Historic Environmental Scotland	HES Canmore mapping_2016	point	historic	spatial	https://canmore.org.uk/content/resources
Historic Environmental Scotland	World Heritage sites		Historic	spatial	http://gateway.snh.gov.uk/natural-spaces/index.jsp
Historic Environmental Scotland	HES conservation areas		historic	spatial	
John Muir Trust	Property of the John Muir Trust	map images	biodiversity	spatial	https://www.johnmuirtrust.org/trust-land
Natural Scoltand Films	films - natural scotland	point	art / media	spatial	
OS	Integrated Transport Network	line	access	spatial	
RSPB from HES	RSPB nature reserves	data of bird santuaries	wildlife (birds)	spatial	
Scottish Household data	Outdoor Visits	national survey	recreation	partially spatial	
Scottish Household data	Sports	national survey	recreation	partially spatial	
Scottish Natural Heritage	Natural Features	ratio for Scotland	biodiversity	spatial	http://statistics.gov.scot/data/natural-features

[6] Themes: **recreation** = leisure activities, **historic** = historic and cultural heritage, **biodiversity** = nature conservation, **wildlife** = specific interest, **art/media** = representation and inspiration in different forms of art and media, **landscape** = experience of the context beyond individual habitats.
[7] **Spatial** = geodatabase, **Partially Spatial** = possible link to geodatabase, **Non-Spatial** = no link to geodatabase.

Origin	Data source	Type of data	Theme [6]	Spatial aspect[7]	Web/hyper-link
Scottish Natural Heritage	Abundance of breeding birds		wildlife (birds)	spatial	SNH Stats terrestrial-breeding-birds
Scottish Natural Heritage	National Scenic areas	polygon	landscape	spatial	https://data.gov.uk/dataset/national-scenic-areas
Scottish Natural Heritage	Special Local Landscapes	polygon	landscape	spatial	by local authority
Scottish Natural Heritage	Nature and Art	point	art / media	Spatial	
Scottish Natural Heritage	Schotland's great trails	line	recreation	Spatial	http://www.snh.gov.uk/enjoying-the-outdoors/where-to-go/routes-to-explore/scotlands-great-trails/
Scottish Natural Heritage	National walking and cycling routes	line	recreation	Spatial	http://www.snh.gov.uk/enjoying-the-outdoors/where-to-go/routes-to-explore/walking-and-cycling-network/
Scottish Natural Heritage	Core Path network	line	recreation	spatial	http://www.snh.gov.uk/enjoying-the-outdoors/where-to-go/routes-to-explore/local-path-networks/
Scottish Natural Heritage	Designated areas	polygon	biodiversity	spatial	
Scottish Natural Heritage	Geological Reserve	polygon	geology	spatial	http://gateway.snh.gov.uk/natural-spaces/index.jsp
Scottish Natural Heritage	Biosphere	polygon	landscape and biodiversity	spatial	http://gateway.snh.gov.uk/natural-spaces/index.jsp
Scottish Natural Heritage	Remoteness /wildness	polygon/raster	landscape	spatial	http://gateway.snh.gov.uk/natural-spaces/index.jsp
Scottish Natural Heritage	Gardens and designated landscapes	polygon	historic	spatial	D:\CoreProgrammeCollaboration\baseline_data\historicscotland\gdl_scotland\Gardens_and_Designed_Landscapes.shp (ABARC04)
Scottish Natural Heritage	NVC habitat data	polygon	biodiversity	spatial	http://gateway.snh.gov.uk/natural-spaces/index.jsp
Scottish Natural Heritage	landscapes of Scotland	polygon	landscape	spatial	http://gateway.snh.gov.uk/natural-spaces/index.jsp
Scottish Natural Heritage	landscape character assesment	polygon	landscape	spatial	http://gateway.snh.gov.uk/natural-spaces/index.jsp
Social media	Photographs	geotagged images	location	spatial	https://www.flickr.com/, https://www.instagram.com/ and others
Visit Scotland	Visitor attraction monitor	national survey	recreation	non spatial	http://www.visitscotland.org/research_and_statistics/tourism_sectors/visitor_attractions.aspx
Year of Natural Scotland products with Creative Scotland	YoNS Film Locations	point data	art / media	spatial	http://www.naturalscotlandfilms.org.uk/locations.html

APPENDIX 3: Link data sources to CICES classes

	Physical and experiential interactions		Intellectual and representative interactions					Spiritual and/or emblematic		Other cultural outputs		Auxiliary data
	Experiential use of species and land-/seascapes	Physical use of land-/seascapes	Scientific	Educational	Heritage, cultural	Entertainment	Aesthetic	Symbolic	Sacred or religious	Existence	Bequest	
CICES class number	1.1.1	1.1.2	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	2.1.1	2.1.2	2.2.1	2.2.2	
Total data sources	8	10	3	5	11	3	8	5	2	4	1	4
Abundance of breeding birds	*											
Ancient woodland								*				
Battlefields					*							
Biosphere							*			*		
Caledonian Woodland inverventory					*		*	*				
Core Path network		*										
Designated areas			*	*						*		
films - natural scotland						*						
Gardens and designated landscapes					*		*					
Geological Reserve			*	*						*		
Heritage paths		*			*							
HES Canmore mapping_2016					*							
HES conservation areas					*							
Historic land use					*			*	*			
Integrated Transport Network												*
John Muir Trust											*	
Landscape character assesment												*
Landscapes of Scotland												*

	Physical and experiential interactions		Intellectual and representative interactions					Spiritual and/or emblematic		Other cultural outputs		Auxiliary data
	Experiential use of species and land-/seascapes	Physical use of land-/seascapes	Scientific	Educational	Heritage, cultural	Entertainment	Aesthetic	Symbolic	Sacred or religious	Existence	Bequest	
CICES class number	1.1.1	1.1.2	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	2.1.1	2.1.2	2.2.1	2.2.2	
Listed buildings					*							
National Forest Inventory	*	*			*							
National Scenic areas							*					
National walking and cycling routes		*										
Natural Features												
Nature and Art						*						
NVC habitat data												*
Outdoor Visits		*										
Photographs	*	*				*						
Public Opinion about forests	*							*				
Quality of experinece in woodland							*					
Remoteness /wildness							*					
RSPB nature reserves	*	*	*	*								
Scheduled Monuments					*							
Schotland's great trails		*										
Special Local Landscapes							*					
Sports		*										
Visitor attraction monitor	*											
Visits to woodland	*	*		*	*				*			
Woodland in and around urban areas	*	*					*					
World Heritage sites				*				*		*		

APPENDIX 4: Literature derived CES indicators

Indicators by CICES class	Literature source
1.1	
Recreational function of variable ecosystem characteristics	Albert et al (2016)
Recreation potential	Maes et al (2012) in La Rosa et al 2016
1.1.1	
Area of habitat accessible for recreation	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Distribution of wildlife/emblematic species associated with habitat	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Visitor numbers by habitat type	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Amount of visible manifestations of recreation facilities, hiking trails,	Bieling & Plienger (2013) in La Rosa et al 2016
Accessibility (recreation & tourism)	Egoh et al (2012)
Accommodation (recreation & tourism)	Egoh et al (2012)
Visitor numbers (recreation & tourism)	Egoh et al (2012)
1.1.2	
Number of bird-watchers/hunters	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Number of walking/cycling trails	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Park visitations	Brandt et al (2014) in La Rosa et al 2016
Frequency of terms used : Recreation	Fletcher et al (2014) in La Rosa et al 2016
Fish abundance (recreation & tourism)	Egoh et al (2012)
Flower viewimg (recreation & tourism)	Egoh et al (2012)
Footpaths (recreation & tourism)	Egoh et al (2012)
Urban green space (recreation & tourism)	Egoh et al (2012)
1.2.1	
Citations/distribution of research projects and number of scientific studies	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Frequency of Science exoerience	Brown et al 2012
1.2.2	
Education projects/number of didatci farms	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Willingness to pay for education	Broekx et al 2013 in La Rosa et al 2016
1.2.3	
Number of agricultural fairs	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Number of certified productes requiring traditional landscape management	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Number of historic records	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Number of monuments	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Willingness to pay for agricultural heritage	Barrena et al. (2014) in La Rosa et al 2016
Amount of visible manifestations of memorials, commemoriations, historical sites	Bieling & Plienger (2013) in La Rosa et al 2016

Indicators by CICES class	Literature source
Frequency of Cultural features	Brown et al 2012
Frequency of terms used : cultural heritage	Fletcher et al (2014) in La Rosa et al 2016
1.2.4	
Contests and competitions by habitat	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Number of publications sold	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Land cover (inspiration for culture, art and design)	Egoh et al 2012
Land use (inspiration for culture, art and design)	Egoh et al 2012
Landscape value (inspiration for culture, art and design)	Egoh et al 2012
1.2.5	
Number of photos uploaded to webportals by habitat	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Landscape aesthertics proxy	Brandt et al (2014) in La Rosa et al 2016
Frequency of Aestetic points	Brown et al 2012
Density of photographs	Casalegno et al 2013 in La Rosa et al 2016
Frequency of terms used : Aesthetic information	Fletcher et al 2014 in La Rosa et al 2016
Frequency of terms used : Inspiration for art and design	Fletcher et al 2014 in La Rosa et al 2016
Shannon's diversity Index, Shape Index and Patch Density	Frank et al 2013. 2014 in La Rosa et al 2016
Distance to Scenic site (Aesthetic enjoyment)	Egoh et al 2012
Protected Areas (Aesthetic enjoyment)	Egoh et al 2012
Cultural heritage (recreation & tourism)	Egoh et al 2012
2.1.1	
Emblematic plants/forests	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Symbolic species	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
2.1.2	
Number of sites with recognised cultural and spiritual value	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Religious monuments or trails	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
2.2.1	
Protected Areas (Natura2000, Biosphere/World Heritage sites, lanscape conservation areas)	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Willingness to pay for landscape measures in agricultural areas	MAES http://biodiversity.europa.eu/maes/mapping-ecosystems/indicators-for-cultural-services-forest
Willingness to pay for recreation/amenity/nonuse value	Liekens et al 2013
2.2.2	
Willingness to pay for recreation/amenity	Broekx et al 2013 in La Rosa et al 2016
Willingness to pay for bequest values	Broekx et al 2013 in La Rosa et al 2016
Frequency of Social Interaction	Brown et al 2012
Property value	Escobedo et al 2014 in La Rosa et al 2016
2.1	
Frequency of Spiritual locations	Brown et al 2012