Common International Classification of Ecosystem Services (CICES) V5.1

Guidance on the Application of the Revised Structure

by

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Executive Summary

Background

i. The version of the *Common International Classification of Ecosystem Services* (CICES) in current use (V4.3) was published in 2013. On the basis of the experience gained by the user community its structure and scope has been reviewed, and a fully revised version (V5.1) has been developed. This document describes the revision and the process underlying it. Tables setting out the new version and its relationship to V4.3 can be downloaded from www.cices.eu.

ii. The work on 'Version 5' was informed by a review of the relevant scientific literature, the results of the 2016 Survey conducted by Fabis Consulting Ltd. for the EEA, and workshops held in 2016 as part of the EU-funded ESMERALDA and OpenNESS Projects. The revision has also been shaped by discussion at a meeting hosted by the United Nations Statistical Division (UNSD), in New York, in June 2016 which was supported by the EEA, and a subsequent workshop in Wageningen, in November 2016, co-organised between the EEA, US-EPA and UNSD. The resulting final draft proposal was circulated again to members of the EU KIP INCA project and a small group of European and international experts associated with the SEEA technical review committee as V5.0. This review round resulted in final modifications which form the basis for the current updated version (V5.1) that is being presented to the London Group.

Scope and focus of Version 5.1

iii. In CICES ecosystem services are defined as the *contributions* that ecosystems make to human well-being, and distinct from the goods and benefits that people subsequently derive from them. These contributions are framed in terms of 'what ecosystems do' for people. Thus, in the revised version the definition of each service identifies both the purposes or uses that people have for the different kinds of ecosystem service *and* the particular ecosystem attributes or behaviours that support them

iv. CICES aims to classify the contributions that ecosystems make to human well-being that arise from living processes. Although biotic ecosystem outputs remain the focus in V5.1, feedback from the user community to broaden the classification to cover abiotic outputs has been addressed. The new version allows users to select only those ecosystem services that depend on living systems (i.e. biodiversity in its broadest sense) or to include the non-living parts of ecosystems that can also contribute to human well-being.

v. The importance of providing detailed guidance to help people apply the classification was one of the key points to arise from the consultation on V5.1. The more formal and systematic definitions provided in V5.1 will help people identify more easily what the different services categories cover. The new structure also provides examples of the services themselves and types of associated benefit. In order to help users to work in more informal settings with the classification, suggestions for simpler non-technical names for services are also provided in the new classification structure.

Compatibility with V4.3

vi. The hierarchal structure that was the basis of CICES V4.3 has been retained; at the highest level in the classification services are grouped according into three Sections that relate to whether the contributions to human well-being support a) the provisioning of material and energy needs, b) regulation and maintenance of the environment for humans, or c) the non-material characteristics of ecosystems that affect physical and mental states of people.

vii. Although the majority of the classes included in V4.3 carry over to V5.1, their ordering and coding has been modified in the new version to enable users to more easily aggregate Classes for reporting purposes. The classification structure for provisioning services has, for example, been modified in V5.1 to permit aggregation where no 'end use' is known so that the classification can be more easily used for accounting purposes. A full set of equivalences at Class level have been provided to enable users to make the transition to V5.1.

viii. In response to the difficulties that some users had in using CICES V4.3 to classify cultural ecosystem services, the definitions in this Section of the classification have been revised to better distinguish services from benefits. Thus, cultural services are now seen as the characteristics of elements of nature that provide *opportunities* for people to derive cultural goods or benefits. In the new version, cultural services are grouped into those opportunities that are realised from direct contact with nature or a more remote type of interaction; in the case of direct contact services are further classified according to whether the interaction is active or passive.

CICES as a reference classification

ix. In addition to providing a way to classify ecosystem services, CICES was also intended as a reference classification that would allow translation between different ecosystem service classification systems, such as those used by the Millennium Ecosystem Assessment (MA), The Economics of Ecosystems and Biodiversity (TEEB). This feature has been retained in V5.1, and equivalence tables will be provided via the CICES web-site (www.cices.eu). Draft Tables for equivalences between CICES V5.1 and the USEPA FEGS[1] (Landers et al. 2016) categories are also available.

[1] https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-classification-system

1. Introduction

1.1. The Common International Classification of Ecosystem Services (CICES) has been designed to help measure, account for, and assess ecosystem services. Although it was developed in the context of work on the System of Environmental and Economic Accounting (SEEA) that is being led by the United Nations Statistical Division (UNSD), it has been used widely in ecosystem services research for designing indicators, mapping and for valuation.

1.2. The version of CICES in widespread use (V.4.3) was published at the beginning of 2013[2]. This version developed from work started in 2009, which took as a starting point the approach of the Millennium Ecosystem Assessment (MA, 2005) for describing ecosystem services, and then refined it to reflect some of the key issues identified in the wider research literature. As a result of the considerable body of work that has been built up around its application since 2013 and the clarification of key related concepts in ecosystem accounting, a review of its structure has been undertaken and this has provided the basis of the revised structure described in this document.

1.3. The work on 'Version 5' was informed by the results of the 2016 Survey conducted by Fabis Consulting Ltd. for the European Environment Agency (EEA), the results of which can be found on the CICES website (www.cices.eu)[3] (See also Appendix 2). Valuable input was also obtained from two workshops organised as part of the EU-funded ESMERALDA Project (www.esmeralda-project.eu). The first was jointly held with the European Environment Agency in February 2016, entitled Customisation of CICES across Member States. The second was on Flexible Methods for Ecosystem Service Mapping and Assessing, held at the University of Nottingham in April 2016 (Potschin and Haines-Young 2016a). The work in ESMERALDA built on the practical thinking on CICES that was begun earlier in the EU-funded OpenNESS Project (www.openness-project.eu) (see Czúcz et al., 2016; Haines-Young et al., 2016).

1.4. The revision represented by V5.1 has also been shaped by discussion at a meeting hosted by the United Nations Statistical Division (UNSD), in New York, in June 2016[4] and a subsequent workshop in Wageningen, in November 2016, co-organised between the EEA, The United States Environmental Protection Agency (US-EPA) and UNSD and hosted by Wageningen University. The workshops explored the characteristics and approaches of different ecosystem service classification systems in the context of ecosystem accounting. This helped to clarify key concepts in ecosystem service classification of relevance to ecosystem accounting (e.g. the definition of 'final ecosystem service') and provided input to developing further guidance on the development of experimental ecosystem accounts within the SEEA process.

1.5. The 2016 consultation and workshops suggested that it would be helpful to support the use of CICES with detailed technical guidance. This document aims to fulfil that role. It is intended for those seeking to understand the rationale that underpins the classification and so apply it in a rigorous way. Despite the clear logic of the idea of ecosystem services, their naming and

[2] For a history of the development of CICES see Potschin and Haines-Young (2016a) and the documents on the CICES website (www.cices.eu).

[3] The CICES 2016 survey and its results have been described in Deliverable 2 under the EEA contract No EEA/NSS/16/002. Over 220 people responded to the on-line survey; 59% had experience in using CICES V4.3, and the remainder interest in the problem of classifying ecosystem services more generally.

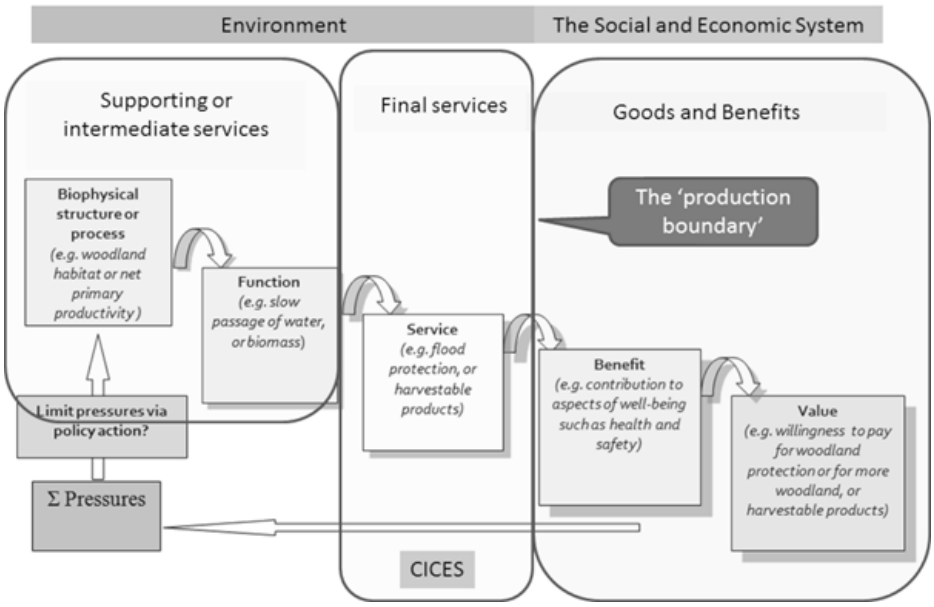
[4] Supported by the EEA.

classification has proved to be a complex undertaking, especially in the context of ecosystem accounting. In the time since its publication in 2013, V4.3 of CICES has been used widely (for a review see Haines-Young et. al, 2016). This revision seeks to build on the experience gained and to provide a more robust and easily understood tool for future work in accounting, mapping and ecosystem assessments more generally.

2. CICES: Conceptual Background

2.1. The cascade model (Figure 1) provides the conceptual framework in which CICES is set. CICES seeks to classify final ecosystem services, which are defined as the contributions that ecosystems (i.e. living systems) make to human well-being. These services are final in that they are the outputs of ecosystems (whether natural, semi-natural or highly modified) that most directly affect the well-being of people.

Figure 1: The cascade model (Potschin and Haines-Young, 2016b)



Final services

2.2. A fundamental characteristic of final services is that they retain a connection to the underlying ecosystem functions, processes and structures that generate them. On the 'supply side' of the cascade, the idea of 'function' is used to highlight those characteristics of the living system that come together to make something a service.

2.3. In the case of wood used for timber, for example, these would include the attributes that make the particular wood material 'workable', say as a building material, and would include such things as the hardness, strength, and durability of the wood fibre. These attributes will all depend in turn on the underlying structural properties of the woodland, which includes tree composition, soil type, nutrient status and the growth processes that have shaped the stand being used for wood. The volume of timber ready to be cut is taken to be the service in CICES.

2.4. Services, in the cascade, give rise to goods and benefits, as in the case of timber when it is harvested and the 'production boundary' is crossed. The concepts of goods and benefits are essentially regarded as the same kind of thing in the cascade model; they are one-step removed from the ecosystem, and are the things that ultimately have value for people. Sometimes goods are seen representing as more tangible things, like the processed timber

that can have a monetary value. In some situations, the ecosystem 'outputs' can be less tangible, and in this case are often described simply as benefits. In the case of woodland, for example, these can include enabling a woodland structure which facilitates recreation as a cultural service.

Final services and context

2.5. Although the threshold for what constitutes a final service is well defined in theory, in practice whether something is regarded as a final service depends on context. For example, if the water in a lake is used directly as a source for drinking, then it could be regarded as a final service. If, however, the focus is on the service of recreational fishing, the fish caught would be regarded as a final service. This means that each ecosystem provides a range of ecosystem services that make contributions to human benefit in many different ways. Further guidance on this question can be found in chapter 5 of the 2017 draft of the Revised SEEA EEA Technical Recommendations[5], in particular Table 5.2.

2.6. The problem of context dependency makes the classification of final ecosystem services difficult. Thus, while CICES seeks to provide a classification of final services, the table developed should be regarded as providing a classification of potential (i.e. putative) final services. It is up to the user to decide whether in a particular application context, the service is to be regarded as final or not, or whether the particular ecosystem property or behaviour is regarded as having a more 'intermediate' status (and could thus better be described via an assessment of ecosystem condition).

2.7. In some of the literature on ecosystem services, flows that have an intermediate status are sometimes described as 'intermediate services', which operate alongside more basic ecological structures and processes, or 'supporting services', to underpin the output of final services. CICES does not attempt to identify or classify all the things that play this underpinning role, and indeed this guidance avoids the use of the terms 'intermediate' and 'supporting services' entirely; for a more detailed discussion of this issue see, for example, Potschin-Young et al. (2017). This is not to say that these kinds of thing are unimportant, rather that they are not regarded as services. These could likely be better documented in other ecosystem accounts in terms of the structures, processes and functions that give rise to services. These underpinning elements ultimately determine the capacity of the ecosystem to deliver particular services that can be represented by concepts other than that of a service, say in terms of measures of ecosystem condition.

Abiotic ecosystem outputs

2.8. CICES focuses on defining final ecosystem services that depend on living systems. This is not to say that many of the physical characteristics and behaviours of physical systems that are part of nature are unimportant to people, but rather to emphasise the fundamental contribution that biodiversity makes to human well-being. In this respect, CICES follows the tradition of the Millennium Ecosystem Assessment (MA, 2005) and initiatives such as The Economics of

[5] https://unstats.un.org/unsd/envaccounting/eea_project/TR_consultation/SEEA_EEA_Tech_Rec_Consultation_Draft_II_v4.1_March2017.pdf

Ecosystems and Biodiversity (TEEB)[6] and the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES)[7].

2.9. When CICES V4.3 was released, a rudimentary table of abiotic ecosystem outputs was provided using the same classification logic as for those ecosystem services that depend on living systems (and water). This approach was also followed for V5.1. However, this has been extended, and a spreadsheet filter tool is available to allow users to integrate biotic and abiotic categories into the same table if they need it; over half of the people who responded to the 2016 Survey on CICES suggested that a classification of abiotic outputs would be useful.

2.10. Although ecosystem services are fundamentally those ecosystem outputs arising from living structures and processes, the problem with excluding abiotic ecosystem outputs from CICES is mainly a practical one. Our review suggests that when in situations involving non-experts, stakeholders see the distinction as fairly arbitrary, and things like wind power, salt and snow are all seen as useful things that 'nature' can provide. While CICES is primarily intended as a classification of the ways that living systems can contribute to human well-being, it has to be acknowledged that the boundary between biotic and abiotic ecosystem services is difficult to define in practice. Other approaches for the classification of ecosystem services, such as the North American FEGS and NESCS tools[8], include some abiotic components in their list of ecosystem services.

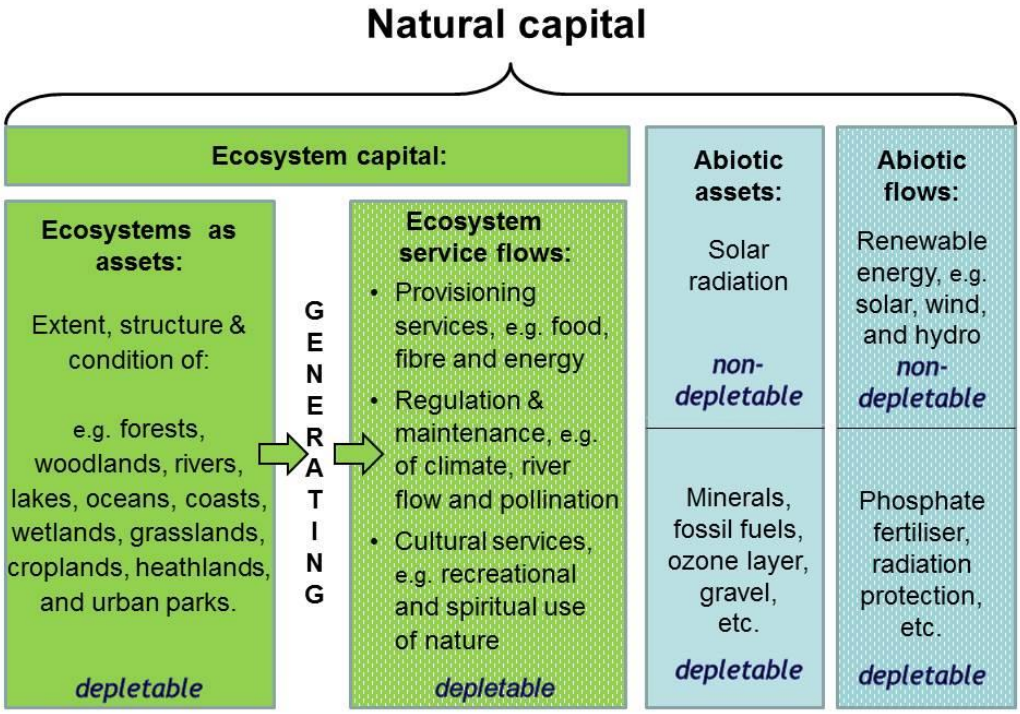
2.11. The status of 'water' illustrates the issue of placing biotic and abiotic ecosystem outputs. Insofar as water is not directly produced by living systems, it is difficult to see water as an ecosystem service similar to those based on biomass (or 'biodiversity' more generally). However, the MA, TEEB and IPBES have conventionally regarded it as an ecosystem service; it was therefore included as such in CICES V4.3. One reason for producing V5.1 of CICES was to ensure greater logical coherence between the natural science understanding of the world as a geo-physical system and the focus of CICES on defining outputs from living systems as ecosystem services. As a consequence, water was included under abiotic outputs in CICES V5.1 because hydrological cycles are mainly driven by geo-physical processes.

2.12. The approach adopted for classifying abiotic ecosystem outputs in V5.1, and the examples used is broadly consistent with the approach suggested by Van der Meulen et al. (2016), although their suggestion for the inclusion of carrier services (relating, for example, to the use of rivers for transport) has not been taken up. It is considered that 'space', per se, is not an ecosystem service and is better covered in land accounting systems (such as the SEEA Central Framework[9] which seeks to document both the stock of different land types and their uses). CICES does, however, cover the various factors (both biotic and abiotic) that might regulate the ability to use rivers and estuaries for navigation.

[6] http://www.teebweb.org/
[7] http://www.ipbes.net/
[8] More information on FEGS (FIinal Ecosystem Goods and Services) can be found under: https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-classification-system and https://gispub4.epa.gov/FEGS/; Information on NESCS (National Ecosystem Service Classification System) can be found at: https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-classification-system.
[9] see https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf

2.11 The move to including abiotic ecosystem outputs more formally in the structure of CICES also reflects recent discussions about what constitute natural capital, which has also been defined in a number of different ways. The approach used in developing CICES V5.1 follows the EU MAES process which considers natural capital to include all natural resources that human society draws upon, i.e. both earth's ecosystems and the underpinning geo-physical systems (see Figure 2). CICES V5.1 therefore potentially provides an appropriate entry-point for describing and measuring natural capital.

Figure 2: Components of natural capital, developed from the natural capital figure in the EU MAES report on *Mapping and assessment of ecosystems and their services* (European Commission, 2013).



2.13. Figure 2 makes a distinction between ecosystem capital and abiotic resources, although for some cases there is no clear-cut boundary between biotic and abiotic components. However, this distinction helps to identify and classify different types of natural capital, which is important in the context of developing a natural capital accounting approach. Patrick ten Brink (2015) provides further detailed discussion of the concept of natural capital that is aligned with the main components set out above.

2.14. The close association between biotic ecosystem services and abiotic ecosystem outputs are is recognised by using a single Table to represent them in V5.1; for V4.3 they were in separate tables which differed in structure. Using the EXCEL spreadsheet for V5.1 that accompanies this document users can select from this overarching Table only the biotic classes that developed out of the revision of V4.3 by filtering for 'CICES'. If abiotic outputs need to be considered then the filter 'CICES extended' can be used.

3. Using CICES V5.1

3.1. The purpose of these guidelines is primarily to help people use V5.1 effectively. Given that some readers may be familiar with V4.3, we have included a discussion of those things that have changed. Our discussion also emphasises the features of both versions that are important to understand in order for the classifications to be applied in repeatable and consistent ways. The guidance provides a full cross-reference between V4.3 and V5.1, so that users can switch easily between them. Although the survey of people who had used CICES V4.3 suggests a number of ways in which the classification could be improved, a key conclusion was not so much that the structure of the classification was problematic, but that the definitions and assumptions were not fully documented. The purpose of these guidelines is to provide this supporting documentation. The discussion and guidelines that follow should be used in conjunction with the full table for CICES V5.1 that can be downloaded from the CICES website (see also Appendix 1).

3.2. CICES was always also intended as a reference classification of ecosystem services that would allow a cross-reading between different ecosystem service classification systems, for example from the MA to CICES or from CICES to the approach used in the UK National Ecosystem Assessment. This was one reason why CICES was developed with a hierarchical structure that had nested levels that went from general to more specific categories. It was also one reason why CICES initially remained close to the early classification systems, such as the MA or TEEB. The current version of CICES retains the ability to support cross-referencing in order to facilitate international comparison. To enable this function to be used in practice a web-based translation tool was been developed for V4.3[10]. For V5.1, spreadsheet filter tools are available.

Defining ecosystem services in CICES V5.1

3.3. CICES V5.1 (and indeed V4.3) is built on the principle that a classification of services needs to describe the contribution that ecosystems make to human well-being, defined in terms of 'what ecosystems do'. Thus, in the classification the definition of a service needs to highlight the ecological outcomes that particular ecosystem characteristics or processes generate, that can ultimately benefit people. The aim has therefore been to build a classification that identifies the purposes or uses that people have for the different kinds of ecosystem service and associate them with the particular ecosystem attributes or behaviours that support them.

3.4. In this sense, CICES is similar to statistical classifications such as COICOP, which is the Classification of Individual Consumption According to Purpose used in the System of National accounts[11]. COICOP is described as being a 'functional' classification, designed to classify certain transactions of producers and of three institutional sectors, namely household, general government and non-profit institutions serving households; the classification is said to be 'functional' because it identifies 'functions' - in the sense of 'purposes' or 'objectives' for which these groups of trans-actors engage in certain transactions[12].

[10] See: http://openness.hugin.com/example/cices; at this stage the tool does not extend to FEGS and NESCS, but separate draft correspondence tables are available for FEGS.

[11] See: https://stats.oecd.org/glossary/detail.asp?ID=352

[12] Note, while CICES is a functional classification it is not a classification of *ecosystem functions* as defined in section 2, although the idea of an ecosystem function entails the identification of the properties of ecosystems that in aggregation generate flows that contribute to human well-being (i.e. ecosystem services).

3.5. To emphasise the 'purposeful' nature of CICES, the definition of each service is made up of two parts, namely a clause describing the biophysical output (i.e. the 'ecological clause' noting what the ecosystem does) and a clause describing the contribution it makes to an eventual use or benefit ('use clause').

3.5.1. Hence the service 'Wild animals (terrestrial and aquatic) for used nutrition' would be defined as 'non-domesticated, wild animal species and their outputs (ecological clause) [.....] that can be harvested and used as a raw material for the production of food (use clause)'. Similarly, the service of 'pest control' would be 'the reduction by biological interactions of the incidence of species (ecological clause) [.....] that damage or reduce the output of food, material or energy from ecosystems, or their cultural importance, by the consumption of biomass or the spreading of disease (use clause)'.

3.6. In developing the two-part definition structure the ambition has been to clarify the terminology surrounding the ecosystem service terms used in CICES, which was one of the major points identified in the consultation leading up to this release. That same consultation did however note the need for simplicity in terminology, especially when using the classification with non-expert audiences. Thus, to complement the complexity that is required for technical clarity, V5.1 also suggests simpler descriptors that can be used as a short-hand for each service. For instance, the technical name for the Class 'Buffering and attenuation of mass movement' can be replaced by the simpler descriptor 'Stopping landslides and avalanches harming people'. Both are, however, underpinned by the definition 'The reduction in the speed of movement of solid material by virtue of the stabilising effects of the presence of plants and animals […] that mitigates or prevents potential damage to human use of the environment or human health and safety.

3.7. The use of CICES for ecosystem accounting requires that the methodological principles set out in the UNSD Handbook on Experimental Ecosystem Accounting (SEEA EEA) are followed. This relates primarily to two aspects: (a) the question of the economic production boundary; and (b) the need to identify beneficiaries for a final ecosystem service to exist in the sense defined by the SEEA. The concept of the 'economic production boundary' (beyond which activities and natural outputs are already recorded in national accounting systems) is discussed in Para 2.4, above. The identification of beneficiaries that make concrete use of potential final ecosystem services is another key requirement of ecosystem accounting (to develop supply and use accounts for ecosystem services) and is also discussed in the SEEA guidance. The columns for 'use clause' and 'example benefit' in the Excel sheet that codifies CICES V5.1 provide explanations that can be taken as guidance for identifying potential beneficiaries. This task will mainly rely, however, on the knowledge of, and research on, actual beneficiaries in each respective application of CICES for the purpose of ecosystem accounting. Statistical classifications, such as the Statistical Classification of Economic Activities in the European Community (NACE), can help to identify key beneficiary categories. Useful guidance for identifying beneficiaries can also be drawn from US National Ecosystem Service Classification System (NESCS, see paragraph 2.9).

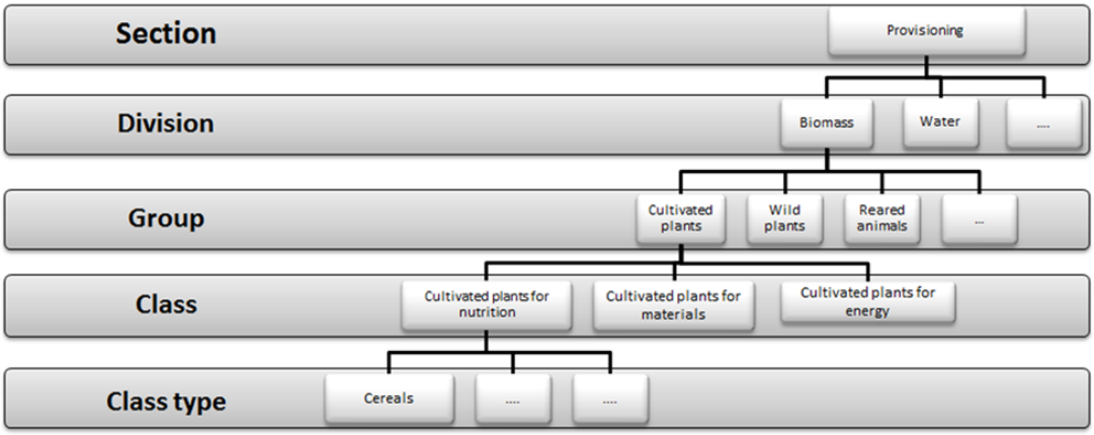
CICES V5.1: Classification Structure

3.8. When the initial version of CICES was created in 2009, it was decided that the system should use terminology that people were familiar with wherever possible. Thus, CICES took as its

starting point the typology of ecosystem services suggested in the Millennium Ecosystem Assessment (MA, 2005). However, given that any classification has to be internally consistent, the structure initially proposed and developed further in V5.1 has been refined to align better with the principles of ecosystem accounting and to address key issues identified in the wider research literature. For example, as noted above, the scope of CICES has focussed on identifying what are considered to be 'final services'. The structure of CICES has also been designed around the idea of a hierarchy, to accommodate the fact that people work at different thematic as well as spatial scales and may need to aggregate classes in different ways.

3.9. At the highest or most general level are three of the four categories used in the MA: 'provisioning', 'regulation and maintenance', and 'cultural' (Figure 3); so-called supporting services are not recognised in CICES (see Part 2, above). Below these 'Sections' are a series of 'Divisions', 'Groups' and 'Classes'. Figure 3 shows the way in which the hierarchical structure works for Provisioning Services.

Figure 3: The hierarchical structure of CICES V5.1, illustrated with reference to a provisioning service 'cultivated plants' which at Group level has no end-use associated with it; this category is subsequently disaggregated at class level as 'Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes' which is defined as 'the ecological contribution to the growth of cultivated, land-based crops that can be harvested and used as raw material for the production of food'. This can be represented as 'cereals' at class type level).



3.10. The hierarchical structure illustrated in Figure 3 is designed to allow users to go to the most appropriate level of detail required by their application and also to be able to group or combine results when making comparisons or more generalised reports.

3.11. Thus, moving down from Section through to Division, Group and Class, the 'services' are increasingly more specific but remain nested within the broader categories that sit above them. Therefore, there is 'dependency' in the sense that the characteristics used to define services at the lower levels are inherited from the Sections, Divisions and Groups above them. There is also a sense of 'taxonomy' in that elements within the same Group or Class are conceptually more similar to each other in the ways they are used by people than to services elsewhere in the classification. At any level in the hierarchy, the categories are intended to be exclusive so that CICES can be regarded as a classification system, rather than an arbitrary nomenclature.

Table 1: Definition and background notes on the three major Sections in CICES V5.1 (see text for further discussion – used in conjunction with accompanying spreadsheet).

Provisioning	• **This Section covers all nutritional, non-nutritional material and energetic outputs from living systems as well as abiotic outputs (including water).** • The Division level makes a distinction between biomass-based (biotic) provisioning services and the aqueous and non-aqueous abiotic ecosystem outputs. *In the full CICES 5.1 Table, the entries for water have been labelled Provisioning (abiotic) as opposed to Provisioning (biotic), and so they may be excluded or included in the listing of ecosystem services as users require. Given that in V5.1 abiotic ecosystem outputs can now be viewed alongside those arising from living systems, users can display the full listing by selecting 'CICES' and 'CICES extended' using the filter provided with any other filters switched off.*
Regulation and Maintenance	• **All the ways in which living organisms can mediate or moderate the ambient environment that affects human health, safety or comfort, together with abiotic equivalents.** • The Division level therefore covers (i) the 'transformation of biochemical or physical inputs to ecosystems' in the form of wastes, toxic substances and other nuisances; and (ii) the 'regulation of physical, chemical, biological conditions, which categorizes the various ways in which living systems can mediate the physico-chemical and biological environment of people in a beneficial way. • *In the full CICES 5.1 Table, the entries for regulating and maintenance that cover the contributions that living systems make to human well-being are labelled 'biotic'. However, given that in V5.1 abiotic ecosystem outputs can now be viewed alongside those arising from living systems, users can display the full listing by selecting 'CICES' and 'CICES extended' using the filter provided with any other filters switched off.*
Cultural	• **All the non-material, and normally non-rival and non-consumptive, outputs of ecosystems (biotic and abiotic) that affect physical and mental states of people.** • Cultural services are primarily regarded as the environmental settings, locations or situations that give rise to changes in the physical or mental states of people, where the character of those settings is fundamentally dependent on living processes; they can involve individual species, habitats and whole ecosystems. • The settings can be semi-natural as well as natural settings (i.e. can include cultural landscapes) providing the characteristics being considered are dependent on *in-situ* living processes. • In the classification we make the distinction between cultural services that are enabled as a result of direct or indirect interactions of people and living systems. • *In the full CICES 5.1 Table, the entries for cultural services that cover the contributions that living systems make to human well-being are labelled 'biotic'. However, given that in V5.1 abiotic ecosystem outputs can now be viewed alongside those arising from living systems, users can display the full listing by selecting 'CICES' and 'CICES extended' using the filter provided with any other filters switched off.*

Coding CICES Classes

3.12. A requirement that arose in relation to the use of V4.3 was the need for a numerical coding system for the categories at the different levels within the classification. This is now provided as one of the columns in the full CICES V5.1 Table. Each category at the Class level is assigned a unique four-digit code. The coding system takes account that users may want to consider abiotic ecosystem outputs alongside those arising from living processes; thus, biotic

provisioning, regulation and maintenance, and cultural services are labelled at Section level as 1, 2, and 3 respectively, while the abiotic outputs have codes with the leading digit 4, 5, 6 at the highest level.

3.13. Although CICES at the Class level is intended to be exhaustive, the facility for defining an 'other category' under the three sections has now been provided to enable users to cover for contexts or services not yet included in CICES. In the coding system the categories for this purpose at the lower levels are labelled with an 'X'. It is intended that users assign these codes for themselves. They may nest them with it existing Divisions or Groups, by substituting the appropriate code for that level.

Aggregation and CICES V5.1 as a defining and reporting structure

3.14. The consultation on the revision of V4.3 suggested that some users required the ability to aggregate across CICES Classes, or at least to combine Classes for reporting purposes. A particular issue was that where in the case of provisioning services 'end-use' is not known, Classes for nutrition, materials and energy needed to be aggregated and reported as a broader unit.

3.15. The need to aggregate and report on services where information on end-use was not available was a major factor in the revision for V5.1. Thus in the redesign the categories 'biomass' 'water' and 'non-aqueous natural abiotic ecosystem outputs' were used to make the distinction between types of provisioning output at Division level, then within the biomass-based set, the Groups for cultivated plants, reared and wild animals etc. covered all end-uses (except genetic) whether it was for nutrition, materials or energy. The new class structure is the point at which the specific type of end use is used to make an assignment.

3.16. The problem of aggregation when end-use is not known was one identified most keenly by the accounting community. When using V5.1, therefore we suggest that use is made of the Group level for reporting purposes, with the three-digit code used to refer to the category being considered and an 'X' to denote no assignment at Class level. Thus the Group 'Cultivated terrestrial plants for nutrition, materials or energy' could be denoted as 1.1.1.X.

3.17. Where measurement units permit aggregation to Group and Division levels in the CICES hierarchy, aggregation is also possible. For example, in the case of water, if no distinction is needed between surface and ground sources in terms of drinking water then volumes extracted, say, can be reported at Group level and coded as 4.1.[1,2].1. Where any ambiguity might arise in terms of the way users combine categories for reporting purposes, then it is suggested that 'bracketing' provides an appropriate notation to show the way categories are aggregated.

3.18. The ability to aggregate at the Class, or indeed the Group and Division levels, also depends on the metric used to characterise the categories concerned, and whether the aggregation makes sense in physical or biological terms; for an extended discussion see the paper presented at the London Group meeting in autumn 2016 (Petersen and Haines-Young, 2016).

3.19. The distinction between the use of the classification to define ecosystem services, and the use of the classification as a set of reporting categories was an important point that emerged from

the consultation on V4.3. The consultation revealed that users had employed CICES in both ways.

3.20. It is important that these two perspectives on the classification (defining and reporting) are recognised and that users are clear about how they are applying it. While CICES is primarily a *defining* system it is clearly efficient and simpler if the services can be defined *and* reported using the same structure. However, if it makes sense for reporting purposes to aggregate or combine Classes etc., users are free to do so. In that case, the CICES Classes and codes can be used to denote what customised categories have been created.

Example services and benefits

3.21. Examples of each service Class have been provided in the full CICES table, alongside example benefits; where possible examples are supported by reference to the literature. These examples are intended to help users understand what the Class entails, and to clarify the distinction between services and associated benefits. The consultation on V4.3 identified that the blurring of the service/benefit boundary was a particular problem for users. The revision has sought to overcome this by providing a formal and systematic definition for each class; the examples seek to take this clarification process further. Where appropriate we have provided examples for terrestrial and marine systems; the latter were taken from the study by Royo Gelabert (2016) which reviewed the use of CICES in the context of developing an operational EU policy-based marine ecosystem (services) assessment framework; this work only dealt with biotic ecosystem outputs.

3.22. In V5.1 services are conceptually different from benefits because the things considered as services are still part of the ecosystem that generates them. For the benefit to be realised some transformation by human action or perspective that lies outside that ecosystem is needed. For example, in the case of the Class 'Wild plants (terrestrial and aquatic) used for nutrition' the example service given is 'the harvestable volume of wild berries' and an associated benefit 'quantity of jam produced'.

3.23. The examples given in the full V5.1 Table are not intended to be exhaustive but merely indicative. In some cases, they have been supported by reference to the literature, and it is intended that this database will develop as other applications are reported. Furthermore, a link is planned to a set of 'CICES' consistent indicators (from the published literature), so that users can examine how others have quantified and reported the various service types (cf. Czúcz et al., 2016).

3.24. The issue of how to quantify different services is an important one, and it should be noted that measurement units have not been provided as part of the definition of the Classes. Rather, the intention is that the classification is generic in structure. The classification recognises that it may be possible to quantify a given service in a number of different ways, sometimes using proxy measures (Haines-Young et al., 2016) where direct measurement is not possible. This approach was decided on the basis of the assumption that the functioning of any classification depends to a large degree on its practical application by users in concrete cases. Given the multitude of different contexts within which CICES is expected to be applied it

seemed best to give freedom to users in identifying appropriate measurement units, depending on each specific application context and the available data.

4. Moving from CICES V4.3 to V5.1

4.1. In developing V5.1, a number of changes have been made to V4.3. The full table for V5.1 provides equivalents both in terms of the terminology and coding so that full backward compatibility exists. The structure of V4.3 has been retained where possible to simplify the transition to the new version. In the sections that follow, the rationale for the structure adopted in V5.1 is outlined and the major differences with the earlier version are noted.

Provisioning services (biotic)

4.2. The structure of the Provisioning section for V5.1 has been modified from V4.3, with 'Biomass' and 'Genetic material from all biota' being used to distinguish biotic ecosystem outputs from abiotic ones at Division level.

4.3. For the categories in the Biomass Division the Group structure has been designed to deal with situations where no end-use is known, as might arise in an accounting context. As a result a number of new categories were formed at Class level. However, most of the V4.3 Classes carry over to the new structure.

4.4. Only one V4.3 class was dropped in V5.1, namely 'Materials from plants, algae and animals for agricultural use'. The rationale for doing this was to avoid overlap with categories dealing with Cultivated Plants and Reared animals.

4.5. The consultation revealed that definition of the Classes within the Groups for Cultivated Plants and reared Animals was seen as problematic in accounting applications because of the significant human input needed for their production. Some people argued that instead, ecosystem processes that enable crop and animal growth, such as nutrient cycling, should be recognised as the relevant ecosystem contribution. In order to reflect this position the definitions for these classes refer to the ecological contribution to the provision of nutrition, material and energy output. However, our consultation and literature review found that many ecosystem service applications outside accounting took the volume of crop before harvest, or the number of reared animals grazed, as the final service. This was because it is difficult disaggregate the contribution that ecological and economic production systems make to the final output. In other words such provisioning services are seen as a form of 'co-production' by people and nature that is complex and difficult to disentangle. Indeed, they may only be measurable using proxies of the kind already found in the literature. Thus the definitions of provision services involving cultivated plants and reared animals in V5.1 follows the framing used by the SEEA, which views them in terms of the contribution of nature. In practical terms, however, V5.1 acknowledges that operationally it might only be possible to follow the so-called 'harvest approach' also discussed in the SEEA EEA Guidance[13].

4.6. The harvest approach recognises the difficulty of identifying the contribution of ecological processes, and suggests that the harvested amount is taken as the final output and an agreed proportion is attributed to the ecosystem and to the economic production system. Thus, in

[13] *".....it may be appropriate to apply the harvest approach for cultivated crops and other plants, based on the assumption that the various flows, such as pollination, nutrients from the soil, and water, that constitute inputs into the growth of the mature crop are in fixed proportion to the quantities of harvested product" (SEEA EEA para 3.30)*

V5.1, we define the services for cultivated plants and reared animals as the *contributions* that ecosystem make to their production but recognise that they may be quantified using proxy measures such as volumes of harvest biomass. If disaggregation of the 'co-production' is needed, then this is perhaps best done in monetary or energetic terms, for example, and external to any classification structure such as CICES.

4.7. In addition to the nutritional Classes for cultivated plants and reared animals, the same definitional structure is adopted for materials and from plant and animal sources (1.1.1.2 & 1.1.3.2) and energy derived from these same sources (1.1.1.3 & 1.1.3.3). Again, it is assumed that the matter of the scale of the contribution that ecosystems make is to be settled outside the classification structure.

4.8. As noted above, the major difference in structure between V4.3 and V5.1 is the addition of Classes; within the Biomass category at Group level these were for material and energetic outputs derived from 'wild plants, wild plants, fungi, algae and bacteria' and 'wild animals' respectively (1.1.5.2, 1.1.5.3, 1.1.6.2 and 1.1.6.3). These were introduced to provide consistency with the structure developed for the nutritional classes under Biomass, and to permit aggregation across Classes, as outlined in the section 3.14ff, above.

4.9. The distinction made between terrestrial and aquatic ecosystem outputs in V4.3 has been retained in V5.1. Classes distinguishing the contributions to nutritional, material and energetic outputs made in the context of in-situ aquaculture are therefore available in V5.1 for both plants (1.1.2.1, 1.1.2.2 and 1.1.2.3) and animals (1.1.4.1, 1.1.4.2 and 1.1.4.3).

4.10. The new Division 'Genetic material from all biota' has also been introduced in V5.1 to distinguish this increasingly important service from other types of material output. This Division provides Classes to cover the collection of materials for the establishment of maintenance of new stands or population of plants or animals, the use of plants and animals at the whole organism level for breeding purposes, and gene extraction. The collection of materials, such as seeds or spores, for reproduction is therefore excluded from the other classes dealing with 'materials'. It should also be noted that the service 'maintenance of nursery populations', which is under the regulating and maintenance section of CICES is distinct from the collection of materials for establishing or maintaining a population. This is because the former generally deals with outputs at the habitat level and covers situations where there are natural intra-ecosystem transfers, involving, say, migratory species. The Classes under provisioning for collecting reproductive materials from plants or animals deal with situations where people actively gather materials for use elsewhere.

Provisioning services (abiotic)

4.11. An important difference between V5.1 and V4.3 is that while the accompanying table for abiotic outputs in V4.3 only suggested a classification to Group level, the integration of these categories with biotic ecosystem outputs has enabled the classification to be extended to Class level. The classification follows the same definitional logic as services derived from living systems.

4.12. The coding used for water-related classes has been changed in V5.1, compared to V4.3. All water classes are assigned to the Provisioning section '4', which also covers other abiotic nutritional, material and energetic ecosystem outputs.

4.13. The placing within the classification of the nutritional, material and energetic ecosystem outputs based on water has already been discussed (see para 2.8ff). Extending the coverage of abiotic ecosystem outputs, especially those related to energy, meant that the number of Classes relating to water had to be increased. While the surface and ground water Classes for drinking water and materials use in V4.3 were retained new Classes for 'Energy derived from Freshwater Systems' and 'Energy Derived from Coastal and Marine Systems' have been added (4.2.1.3 and 4.2.1.4).

Regulating and Maintenance Services (biotic)

4.14. In the revision for V5.1, the V4.3 Groups for 'Mediation by Biota' and 'Mediation by Ecosystems' have been merged recognising that it is often hard to distinguish them (e.g. Maes et al., 2014). The V4.3 Division 'Mediation of waste, toxics and other nuisances', in which they sat, has been split between 'wastes' and 'nuisances' at Group level in V5.1, with the latter covering smell, noise and visual impacts at Class level. In addition, all have been assigned to a new Division 'Transformation of biochemical or physical inputs to ecosystems' which replaces 'Mediation of waste, toxics and other nuisances'. The aim of this change was to more broadly capture the ways in which living systems can transform impacts arising from people's activities and achieve beneficial environmental outcomes.

4.15. Further changes at Division and Group level under Regulation and Maintenance in V5.1, are that 'Mediation of Flows' and 'Maintenance of physical, chemical and biological conditions' have been merged into a single Division 'Regulation of physical, chemical, biological conditions' which is split at Group level into six sub-categories; this was done because it was conceptually difficult, for example, to conceptually separate the regulation of flows from the mediation of physical conditions.

4.16. Within the broader Division of 'Regulation of physical, chemical, biological conditions'the following changes were made at class level:

4.16.1. The V4.3 class 'Dilution by atmosphere, freshwater and marine ecosystems' has been deleted, and moved to the abiotic extension since it is not generally dependent on living processes.

4.16.2. The class 'Fire protection' has been added; this class was not explicitly covered in V4.3, and was identified as important in the customised national version of CICES V4.3 made in Belgium, and in the work on indicators in the ESMERALDA Project (Czúcz et al., 2016; Haines-Young et al., 2016). The class would cover situations where, for example, a particular ecological structure, such as a grassland corridor or a wetland area, prevents or mitigates the risk of fire spreading between forest stands. The inclusion of this new class is, however, problematic for some of those consulted because all kinds of biomass can enable fire to spread as well as the difficulty of attributing fire risk reduction to human intervention or specific ecosystem features . However, despite arguments against it the new class was included to make the classification as comprehensive as possible.

4.16.3. The 'final' status of the classes under the Group 'Soil formation and composition' has also been questioned; however, the classes assigned to it have been retained and the group renamed 'Regulation of soil quality' to emphasise that the classes included

do not represent soil formation in general, but the processes that ensure that soil continues to do what people want. The concept of soil quality[14] is essentially a utilitarian one, and so this renaming of the Group fits with the classification approach adopted for V5.1.

4.16.4. Pollination and seed dispersal which formed a single Class in V4.3 have been split into two for V5.1 in response to comments received during the consultation on the earlier version.

4.16.5. Maes et al. (2014) noted the difficulty in V4.3 of distinguishing between the Classes under the Group 'Water Conditions' and those under the Group 'Mediation of waste, toxics and other nuisances'. The Group was originally introduced to cover the regulation of water quality/quantity included in the MA listing of ecosystem services. The Group has been retained but the definitions modified to minimise the potential overlap; the Classes are intended cover more the maintenance of water quality, say via the removal of nutrients in runoff, whereas those under 'Transformation of biochemical or physical inputs to ecosystems', explicitly cover the processing of human wastes.

4.16.6. The V4.3 Group 'Atmospheric composition and climate regulation' has been changed to 'Atmospheric composition and conditions' in V5.1, and the naming of the classes refined to distinguish the 'Regulation of the chemical composition of the atmosphere' from the 'Regulation of temperature and humidity, including ventilation and transpiration'. The former is designed to include the regulation of greenhouse gases, and can therefore cover services at global scale, whereas the latter may take services at more local scales, but not exclusively so. Moreover, it should also be noted that the regulation of the chemical composition of the atmosphere is not simply equivalent to 'carbon sequestration', because there are greenhouse gasses other than CO_2. 'Carbon sequestration' is not an ecosystem services in V5.1, but regarded more as an ecosystem function. Nevertheless, it is acknowledged that it can be used as a proxy measure of the regulating effect that ecosystem can have in relation to one important constituent of the atmosphere.

Regulating and Maintenance Services (abiotic)

4.17. The structure of the abiotic extension of V5.1 follows that of the biotic elements. As noted above, along with the dilution effects of atmosphere, the dilution of wastes and toxic substances in freshwater and marine water bodies are covered under 'Mediation of waste, toxics and other nuisances by non-living processes'. This class was previously part of V4.3.

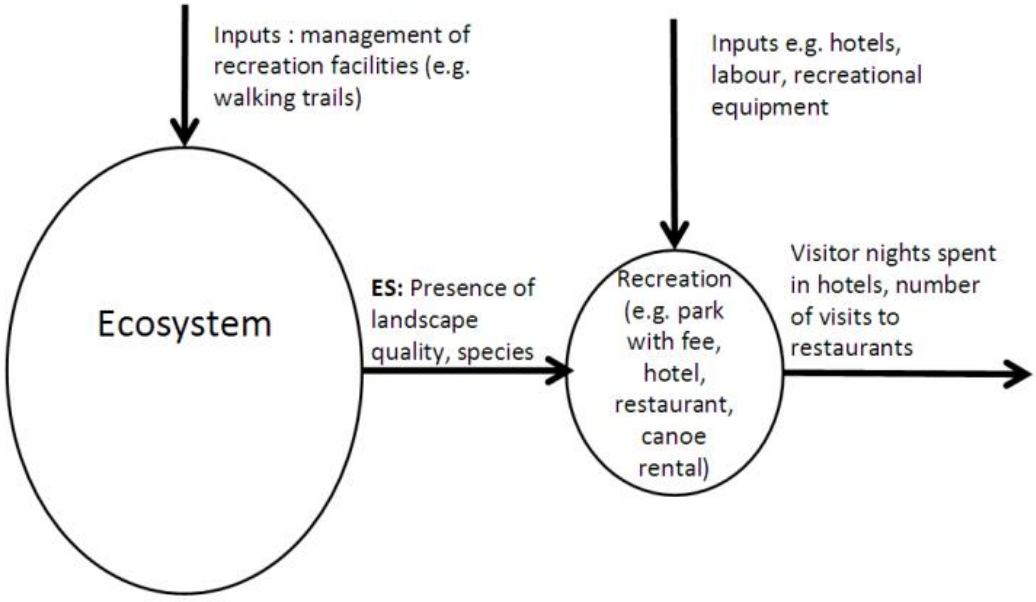
[14] For example, Soil Science Society of America's Ad Hoc Committee on Soil Quality (S-581) defines soil quality as *the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation*.

Cultural Services (biotic)

4.18. Although it is recognised that all services can have a cultural dimension or significance, Cultural services have been retained at Section level in V5.1 as a way of identifying the intangible ecosystem outputs that enable a range of experiential and intellectual activities. The approach adopted is to identify the characteristics of ecosystems that enable cultural benefits to be enjoyed. This is consistent with the approach suggested for 'recreational services, for example, in the SEEA-EEA guidance (Figure 4).

4.19. In the 2016 consultation on the use of V4.3, the structure of the classification of cultural services was identified as problematic as it did not clearly distinguish between services and benefits in the terminology used. The Section 'Cultural Services' now covers all the ways that living systems contribute to or enable cultural benefits to be realised. Thus, in applying the classification, it is important to distinguish between what people do or feel in cultural terms from the properties of the ecosystem that enable, facilitate or support those activities or feelings. For example, a recreational activity, such as walking, is not regarded as an ecosystem service for the purpose of ecosystem accounting, but rather a benefit or 'cultural good'. The service provided by the ecosystem is the opportunity or characteristics of the environmental setting or location that enables that activity and determines its quality for people.

Figure 4: Representation of recreation in the SEEA-EEA (after European Commission, Organisation for Economic Co-operation and Development, United Nations and World Bank., 2013)



4.20. The definitions of the Classes denoting the different cultural services have all been refined in V5.1 to reflect that it is the ecosystem characteristics that enable an outcome that represent the service and not the outcomes themselves. The other changes made in the revision include:

4.20.1. At the Division level, the split in cultural services is between those characteristics of living systems that are experienced either 'in-situ' or 'remote' (i.e. Divisions: 'Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting' vs 'Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting').

4.20.2. The Direct interactions are divided at Group level between those enabling physical or active engagement with the living environment or those enabling more passive or intellectual interactions. The latter cover ecosystem characteristics that enable scientific investigation, education and training and interactions that relate to culture, heritage, and aesthetic experiences. The Indirect interactions at Group level includes classes that relate to ecosystem characteristics that underpin symbolic and religious meaning, entertainment, and things which are important to people by their very existence or their presumed importance to future generations. All of these classes were present in V4.3; the ordering and hence coding has been changed in V5.1 for greater consistency.

4.21. The work on indicators that have been used in the wider ecosystem service literature in the ESMERALDA Project suggested that 'maintenance of traditional ecological knowledge' and 'creation and maintenance of social relations' are two potential gaps in the structure of CICES at the Class level in relation to cultural services. In V5.1, the Class relating to scientific knowledge (3.1.2.1) has been extended to include traditional knowledge. A Class relating to social relations has not been included as it relates to outcomes within the social system, such as conflicts, trade-offs and values. Moreover, good social relations are not exclusively cultural issues, but can be determined by factors relating to the sufficiency of provisioning outputs or impacts of different actors on regulating services, for example.

Cultural Services (abiotic)

4.22. The structure of the abiotic extension of V5.1 for Cultural Services enabled by the character of the physical environment follows that of the biotic elements. This enables setting or locations such as caves, or beaches to be included in the classification. It also enables topographic or geomorphological features that underpin cultural, symbolic or religious beliefs to be referenced.

4.23. Many cultural experiences that are enabled by nature depend on combination of biotic and abiotic characteristics of the environment. Where the two components are difficult to separate, they can be reported under the structure for biotic services since this is more refined than the abiotic extension. A note should be made in relation to the reporting category about which elements are combined.

Customising CICES

4.24. The consultation on the use of CICES in 2016 suggested the ability to customise classifications to reflect the character and terminology used in different ecosystems might be helpful. We examined this possibility by considering the case of marine ecosystems by reviewing the work on V4.3 by Royo Gelabert (2016), which synthesised relevant work commissioned by the European Environment Agency (EEA). We found that the terminology used to denote the Classes in V5.1 was sufficiently generic to cover the V4.3 Classes seen as 'relevant' to marine ecosystems in the EEA work; although the specific marine customisation of class names and definitions is useful in a marine assessment context and can be used effectively with appropriate cross-referencing. Nevertheless, we concluded that if such an approach was

adopted and extended to a number of different ecosystems then the multiplication of different terminologies would probably lead to confusion at this early stage of revision and, thus, some guidance on how to do that would be helpful.

4.25. If 'customisation' is needed by users of V5.1 then we recommend that:

4.25.1. Relevant ecosystem specific examples of services Classes are added to the CICES Table to illustrate what they cover in different situations; we have therefore added examples from the marine work synthesised by Royo Gelabert (2016) to the Excel Spreadsheet for V5.1.

4.25.2. The device of assigning 'simple descriptors' alongside the formal CICES Classes (or groupings of them) is used (see Section 3.6), providing that a cross reference to the formal Classes also provided as done the work commissioned by the EEA.

4.25.3. Where only some CICES Classes are seen as 'relevant' to a particular ecosystem type, these are noted; as an example in the Excel Spreadsheet that sets out V5.1 we have included a column that indicates those CICES 5.1 Biotic Classes that were seen as relevant in the marine situation by the synthesis work of Royo Gelabert (2016).

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Appendix 1: Overview of CICES V5.1 (see accompanying spreadsheet for full details)

Provisioning

Filter	Section	Division	Group	Class	Code	Class type	V4.3 Equivalent	Code(4.3)
CICES	Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes	1.1.1.1	Crops by amount, type (e.g. cereals, root crops, soft fruit, etc.)	Cultivated crops	1.1.1.1
CICES	Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing	1.1.1.2	Material by amount, type, use, media (land, soil, freshwater, marine)	Fibres and other materials from plants, algae and animals for direct use or processing	1.2.1.1
CICES	Provisioning (Biotic)	Biomass	Cultivated terrestrial plants for nutrition, materials or energy	Cultivated plants (including fungi, algae) grown as a source of energy	1.1.1.3	By amount, type, source	Plant-based resources	1.3.1.1
CICES	Provisioning (Biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy	Cultivated plants grown for nutritional purposes by in- situ aquaculture	1.1.2.1	Plants, algae by amount, type	Plants and algae from in-situ aquaculture	1.1.1.5
CICES	Provisioning (Biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy	Cultivated plants grown for material purposes by in- situ aquaculture (excluding genetic materials)	1.1.2.2	Plants, algae by amount, type	Plants and algae from in-situ aquaculture	1.1.1.5
CICES	Provisioning (Biotic)	Biomass	Cultivated aquatic plants for nutrition, materials or energy	Cultivated plants grown as a source of energy by in-situ aquaculture	1.1.2.3	Plants, algae by amount, type	Plants and algae from in-situ aquaculture	1.1.1.5
CICES	Provisioning (Biotic)	Biomass	Reared animals for nutrition, materials or energy	Animals reared to provide nutrition	1.1.3.1	Animals, products by amount, type (e.g. beef, dairy)	Reared animals and their outputs	1.1.1.2
CICES	Provisioning (Biotic)	Biomass	Reared animals for nutrition, materials or energy	Fibres and other materials from reared animals for direct use or processing (excluding genetic materials)	1.1.3.2	Material by amount, type, use, media (land, soil, freshwater, marine)	Materials from plants, algae and animals for agricultural use	1.2.1.2
CICES	Provisioning (Biotic)	Biomass	Reared animals for nutrition, materials or energy	Animals reared to provide energy (including mechanical)	1.1.3.3	By amount, type, source	Animal-based resources	1.3.1.2
CICES	Provisioning (Biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy	Animals reared by in-situ aquaculture for nutritional purposes	1.1.4.1	Animals by amount, type	Animals from in-situ aquaculture	1.1.1.6
CICES	Provisioning (Biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy	Animals reared by in-situ aquaculture for material purposes (excluding genetic materials)	1.1.4.2	Animals by amount, type	Animals from in-situ aquaculture	1.1.1.6
CICES	Provisioning (Biotic)	Biomass	Reared aquatic animals for nutrition, materials or energy	Animals reared by in-situ aquaculture as an energy source	1.1.4.3	Animals by amount, type	Animals from in-situ aquaculture	1.1.1.6

Provisioning (Water – also included in abiotic Table)

Filter	Section	Division	Group	Class	Code	Class type	V4.3 Equivalent	Code(4.3)
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water for drinking	4.2.1.1	By amount, type, source	Surface water for drinking	1.1.2.1
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water used as a material (non-drinking purposes)	4.2.1.2	By amount & source	Surface water for non-drinking purposes	1.2.2.1
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Freshwater surface water used as an energy source	4.2.1.3	By amount, type, source	Not recognised in V4.3	N/A
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Coastal and marine water used as energy source	4.2.1.4	By amount, type, source	Not recognised in V4.3	N/A
CICES Extended	Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water for drinking	4.2.2.1	By amount, type, source	Ground water for drinking	1.1.2.2
CICES Extended	Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water used as a material (non-drinking purposes)	4.2.2.2	By amount & source	Ground water as source of energy	1.2.2.2
CICES Extended	Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water used as an energy source	4.2.2.3	By amount & source	Ground water for non-drinking purposes	N/A
CICES Extended	Provisioning (Abiotic)	Water	Other aqueous ecosystem outputs	Other	4.2.X.X	Use nested codes to allocate other provisioning services from non-living systems to appropriate Groups and Classes	Not recognised in V4.3	N/A

Regulation and Maintenance

Filter	Section	Division	Group	Class	Code	Class type	V4.3 Equivalent	Code(4.3)
CICES	Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Bio-remediation by micro-organisms, algae, plants, and animals	2.1.1.1	By type of living system or by waste or subsistence type	Bio-remediation by micro-organisms, algae, plants, and animals	2.1.1.1
CICES	Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	2.1.1.2	By type of living system, or by water or substance type	Filtration/sequestration/storage/accumulation by micro-organisms, algae,	2.1.1.2
CICES	Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin	Smell reduction	2.1.2.1	By type of living system	Mediation of smell/noise/visual impacts	2.1.2.3
CICES	Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin	Noise attenuation	2.1.2.2	By type of living system	Mediation of smell/noise/visual impacts	2.1.2.3
CICES	Regulation & Maintenance (Biotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin	Visual screening	2.1.2.3	By type of living system	Mediation of smell/noise/visual impacts	2.1.2.3
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Control of erosion rates	2.2.1.1	By reduction in risk, area protected	Stabilisation and control of erosion rates	2.2.1.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Buffering and attenuation of mass movement	2.2.1.2	By reduction in risk, area protected	Buffering and attenuation of mass flows	2.2.1.2
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Hydrological cycle and water flow regulation (Including flood control)	2.2.1.3	By depth/volumes	Hydrological cycle and water flow maintenance	2.2.2.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Storm protection	2.2.1.4	By reduction in risk, area protected	Storm protection	2.2.3.1
CICES	Regulation & Maintenance	Regulation of physical, chemical, biological	Regulation of baseline flows and extreme	Fire protection	2.2.1.5	By reduction in risk, area protected	Not recognised in V4.3	N/A
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination (or 'gamete' dispersal in a marine context)	2.2.2.1	By amount and pollinator	Pollination and seed dispersal	2.3.1.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Seed dispersal	2.2.2.2	By amount and dispersal agent	Pollination and seed dispersal	2.3.1.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Maintaining nursery populations and habitats (Including gene pool protection)	2.2.2.3	By amount and source	Maintaining nursery populations and habitats	2.3.1.2
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Pest and disease control	Pest control (including invasive species)	2.2.3.1	By reduction in incidence, risk, area protected by type of living system	Pest control	2.3.2.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Pest and disease control	Disease control	2.2.3.2	By reduction in incidence, risk, area protected by type of living system	Disease control	2.3.2.2
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of soil quality	Weathering processes and their effect on soil quality	2.2.4.1	By amount/concentration and source	Weathering processes	2.3.3.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Regulation of soil quality	Decomposition and fixing processes and their effect on soil quality	2.2.4.2	By amount/concentration and source	Decomposition and fixing processes	2.3.3.2
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Water conditions	Regulation of the chemical condition of freshwaters by living processes	2.2.5.1	By type of living system	Chemical condition of freshwaters	2.3.4.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Water conditions	Regulation of the chemical condition of salt waters by living processes	2.2.5.2	By type of living system	Chemical condition of salt waters	2.3.4.2
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions	Regulation of chemical composition of atmosphere	2.2.6.1	By contribution of type of living system to amount, concentration or climatic parameter	Global climate regulation by reduction of greenhouse gas	2.3.5.1
CICES	Regulation & Maintenance (Biotic)	Regulation of physical, chemical, biological conditions	Atmospheric composition and conditions	Regulation of temperature and humidity, including ventilation and transpiration	2.2.6.2	By contribution of type of living system to amount, concentration or climatic parameter	Micro and regional climate regulation	2.3.5.2
CICES	Regulation & Maintenance (Biotic)	Other types of regulation and maintenance service by living processes	Other	Other	2.3.X.X	Use nested codes to allocate other regulating and maintenance services from living systems to	Not recognised in V4.3	N/A

Cultural

Filter	Section	Division	Group	Class	Code	Class type	V4.3 Equivalent	Code(4.3)
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3.1.1.1	By type of living system or environmental setting	Experiential use of plants, animals and land-/seascapes in different environmental	3.1.1.1
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	3.1.1.2	By type of living system or environmental setting	Physical use of land-/seascapes in different environmental settings	3.1.1.2
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	3.1.2.1	By type of living system or environmental setting	Scientific	3.1.2.1
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable education and training	3.1.2.2	By type of living system or environmental setting	Educational	3.1.2.2
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that are resonant in terms of culture or heritage	3.1.2.3	By type of living system or environmental setting	Heritage, cultural	3.1.2.3
CICES	Cultural (Biotic)	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Intellectual and representative interactions with natural environment	Characteristics of living systems that enable aesthetic experiences	3.1.2.4	By type of living system or environmental setting	Aesthetic	3.1.2.5
CICES	Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have symbolic meaning	3.2.1.1	By type of living system or environmental setting	Symbolic	3.2.1.1
CICES	Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have sacred or religious meaning	3.2.1.2	By type of living system or environmental setting	Sacred and/or religious	3.2.1.2
CICES	Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems used for entertainment or representation	3.2.1.3	By type of living system or environmental setting	Entertainment	3.1.2.4
CICES	Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an existence value	3.2.2.1	By type of living system or environmental setting	Existence	3.2.2.1
CICES	Cultural (Biotic)	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an bequest value	3.2.2.2	By type of living system or environmental setting	Bequest	3.2.2.2
CICES	Cultural (Biotic)	Other characteristics of living systems that have cultural significance	Other	Other	3.3.X.X	Use nested codes to allocate other cultural services from living systems to appropriate Groups and Classes	Not recognised in V4.3	N/A

Abiotic extension

Note water is also included in the main CICES table (see text); for completeness it is also included here.

Filter	Section	Division	Group	Class	Code	Class type	V4.3 Equivalent	Code(4.3)
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water for drinking	4.2.1.1	By amount, type, source	Surface water for drinking	1.1.2.1
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Surface water used as a material (non-drinking purposes)	4.2.1.2	By amount & source	Surface water for non-drinking purposes	1.2.2.1
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Freshwater surface water used as an energy source	4.2.1.3	By amount, type, source	Not recognised in V4.3	N/A
CICES Extended	Provisioning (Abiotic)	Water	Surface water used for nutrition, materials or energy	Coastal and marine water used as energy source	4.2.1.4	By amount, type, source	Not recognised in V4.3	N/A
CICES Extended	Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water for drinking	4.2.2.1	By amount, type, source	Ground water for drinking	1.1.2.2
CICES Extended	Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water used as a material (non-drinking purposes)	4.2.2.2	By amount & source	Ground water as source of energy	1.2.2.2
CICES Extended	Provisioning (Abiotic)	Water	Ground water for used for nutrition, materials or energy	Ground water used as an energy source	4.2.2.3	By amount & source	Ground water for non-drinking purposes	N/A
CICES Extended	Provisioning (Abiotic)	Water	Other aqueous ecosystem outputs	Other	4.2.X.X	Use nested codes to allocate other provisioning services from non-living systems to appropriate	Not recognised in V4.3	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or energy	Mineral substances used for nutrition	4.3.1.1	Amount by type	Minerals	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or energy	Mineral substances used for material purposes	4.3.1.2	Amount by type	Solid	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Mineral substances used for nutrition, materials or	Mineral substances used for as an energy source	4.3.1.3	Amount by type	N/A	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Non-mineral substances or ecosystem properties used for nutrition, materials or	Non-mineral substances or ecosystem properties used for nutrition	4.3.2.1	Amount by type	Non-mineral	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Non-mineral substances or ecosystem properties used for nutrition, materials or	Non-mineral substances used for materials	4.3.2.2	Amount by type	Gas	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Non-mineral substances or ecosystem properties used for nutrition, materials or energy	Wind energy	4.3.2.3	Amount by type	Wind	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Non-mineral substances or ecosystem properties used for nutrition, materials or energy	Solar energy	4.3.2.4	Amount by type	Solar	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Non-mineral substances or ecosystem properties used for nutrition, materials or	Geothermal	4.3.2.5	Amount by type	Geo-thermal	N/A
CICES Extended	Provisioning (Abiotic)	Non-aqueous natural abiotic ecosystem outputs	Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or	Other	4.3.2.6	Use nested codes to allocate other provisioning services from non-living systems to appropriate Groups and Classes	Not recognised in V4.3	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes	Dilution by freshwater and marine ecosystems	5.1.1.1	Amount by type	Dilution by freshwater and marine ecosystems	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes	Dilution by atmosphere	5.1.1.2	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of waste, toxics and other nuisances by non-living processes	Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)	5.1.1.3	Amount by type	Mediation of waste, toxics and other nuisances, by natural chemical and physical processes	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Transformation of biochemical or physical inputs to ecosystems	Mediation of nuisances of anthropogenic origin	Mediation of nuisances by abiotic structures or processes	5.1.2.1	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Mass flows	5.2.1.1	Amount by type	Mediation of flows by natural abiotic structures	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Liquid flows	5.2.1.2	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events	Gaseous flows	5.2.1.3	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Regulation of physical, chemical, biological conditions	Maintenance of physical, chemical, abiotic conditions	Maintenance and regulation by inorganic natural chemical and physical processes	5.2.2.1	Amount by type	Maintenance of physical, chemical, abiotic conditions	N/A
CICES Extended	Regulation & Maintenance (Abiotic)	Other type of regulation and maintenance service by abiotic processes	Other	Other	5.3.X.X	Use nested codes to allocate other provisioning services from non-living systems to appropriate Groups and Classes	Not recognised in V4.3	N/A
CICES Extended	Cultural (Abiotic)	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Physical and experiential interactions with natural abiotic components of the environment	Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions	6.1.1.1	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Cultural (Abiotic)	Direct, in-situ and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Intellectual and representative interactions with abiotic components of the natural environment	Natural, abiotic characteristics of nature that enable intellectual interactions	6.1.2.1	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Cultural (Abiotic)	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with the abiotic components of the natural environment	Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions	6.2.1.1	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Cultural (Abiotic)	Indirect, remote, often indoor interactions with physical systems that do not require presence in the environmental setting	Other abiotic characteristics that have a non-use value	Natural, abiotic characteristics or features of nature that have either an existence or bequest value	6.2.2.1	Amount by type	Not recognised in V4.3	N/A
CICES Extended	Cultural (Abiotic)	Other abiotic characteristics of nature that have cultural significance	Other	Other	6.3.X.X	Use nested codes to allocate other provisioning services from non-living systems to appropriate Groups and Classes	Not recognised in V4.3	N/A

Appendix 2: Report of Results of a Survey to Assess the Use of CICES, 2016

European Environment Agency

Support to EEA tasks under the EU MAES process
Negotiated procedure No EEA/NSS/16/002

Report of Results of a Survey to Assess the Use of CICES, 2016 (Deliverable 2)

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1. Introduction

The Common International Classification of Ecosystem Services (CICES) was designed to help measure, account for and assess ecosystem services. Although it was developed in the context of work on the System of Environmental and Economic Accounting (SEEA) that is being led by the United Nations Statistical Division (UNSD), it has been used widely in ecosystem services research for designing indicators, mapping and for valuation.

The current version of CICES (V. 4.3) was published at the beginning of 2013; this report takes stock of feedback from users, based on a questionnaire survey. The results will help identify the kinds of guidance people might need in using CICES, and to look at whether any changes in its structure or terminology might be needed to adapt it to national statistical systems and better link to other international statistical classifications, or to make it more generally useful and easier to understand for mapping and other purposes. The outcome of this work is expected to be useful in the context of wider international initiatives on the problem of classifying ecosystem services.

2. The structure of the survey and general pattern of responses

The survey was designed to gather responses from those who have used CICES and those who have not. The views of users were clearly important because the goal was to draw on this body of experience to identify where the strengths and weaknesses of V4.3 lie, and potentially how the structure might be improved. However, in designing the questionnaire it was also felt important to explore whether 'non-users' had in fact heard of CICES, and if they had what alternatives they had used in their work; this kind of information was considered to be helpful in terms of potentially identifying the limitations to using CICES and its general relevance. Those opening the questionnaire were directed to a different set of questions depending on whether they identified themselves as CICES users or not; a full copy of the questionnaire can be found in Appendix 1.

Altogether, 327 people attempted the questionnaire (317 before the deadline of 1/4/2016; all responses have, however, been used), from which there were 222 useable responses, in the sense that they provided answers to some or all of the questions posed in the main body of the survey; 125 (59%) recoded that they were CICES users and 87 (41%) that they were not.

2.1 Findings from the CICES user group

Table 1: Application areas covered by CICES users (multiple responses were permitted)

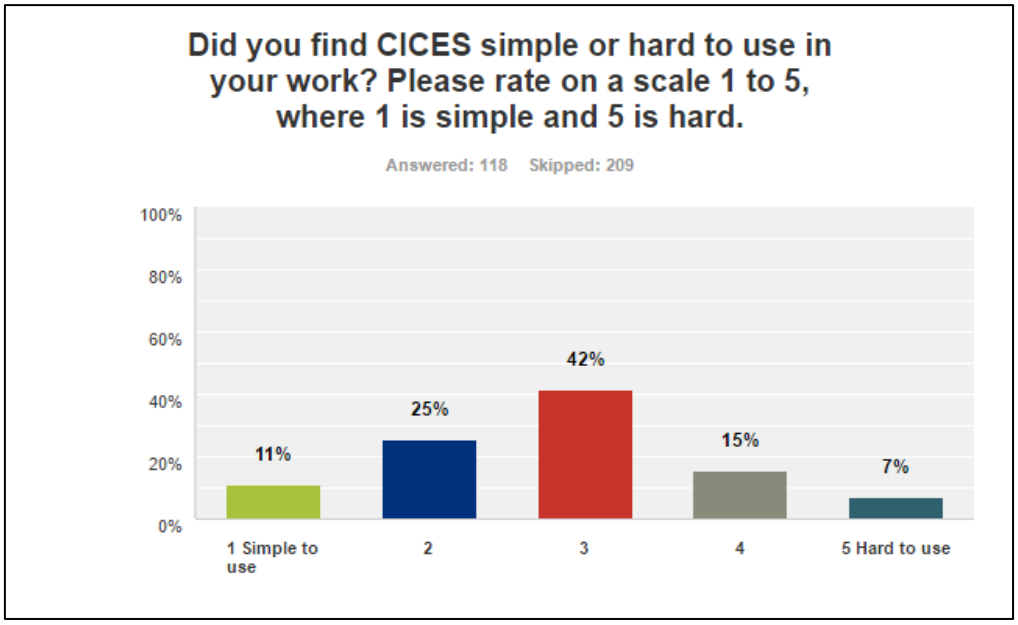
Applicaton area	Per Cent	Number
Mapping and ecosystem assessment	77%	94
Valuation	37%	45
The development of indicators	35%	43
Stakeholder Engagement	25%	30
Modelling	24%	29
Environmental Accounting	19%	23
Other	12%	15
The development of ecological production functions	3%	3

The CICES user group were asked to identify the broad application area in which they are working. The majority selected 'mapping and ecosystem assessment' (77%), followed by 'valuation' (37%) and 'the development of indicators' (35%); only 19% selected environmental accounting. Amongst the 'other catgory' users identified areas such as:

- Citizen mapping of ES using a Smartphone App (MapNet);
- Using CICES for development of classifications of the ecological capital;
- Development of and 'app' focussed on urban recreation;
- Conceptual framing of ES and their inter-relationships;
- Creating a list of ES, case study templates and questionnaires; and,
- Collecting information to inform decisions relating to licensing , river basin management, flood risk strategy, SEA.

The question was flowed-up by one asking them to rate the ease of use of CICES. They were asked to use a five-point rating scale from 'simple' to 'hard'. While the majority (42%) found it moderately simple to use, more than three quarters of the people who responded rated at this level *or simpler* (Figure 1). Two open-ended questions (Q5 and Q6) were then used to identify what people though its main strengths and weaknesses were. The results from questions were code according to a set of general thematic areas and the results summaries in Tables 2 and 3. The full coding for these questions is provided in Appendix 2.

Figure 1: Ease of use for CICES



Within the set of 89 responses to the question about the advantages of CICES, those coded as relating to the system logic, its hierarchical structure its function as a standard and is coverage were the most common (Table 2). Those coded up as the 'logical' group included comments such as "its logic and definitions are clear and easy to follow" (ID: 4652222310), "Classification CICES is a simple to use and concretized" (ID: 4565886105), and "I like the parallels to the cascade model, which I personally find intuitive" (ID: 4498945266).

Table 2: Advantages of CICES identified by users

Coding Criteria	No of Reponses
Logical	17
Hierarchy	15
Standard	14
Coverage	14
Understanding	8
Other	4
Reference	3
Clarity	3
Communication tool	3
Examples	3
Integrated	1
Detail	1
Clear	1
Applicability	1
Flexibility	1
Total	89

Comments relating to the advantages of the hierarchical structure of CICES included comments such as "The different level of generality (levels) of the classification are useful" (ID: 4614264366), and "hierarchical structure is easy to understand, the system can easily be enhanced (concrete examples) or modify (delimitation of classes / class types) compatibility to the satellite accounts of the system of economic and environmental accounts (SEEA)" (ID: 4485414289).

Standardisation and coverage were the other most frequently cited advantageous characteristics of CICES, with comments such as "What is really useful is to have an international recognized classification of ES, which puts together MEA and TEEB ideas. To have only one reference is really laudable." (ID: 4539395544), and "it's very comprehensive" (ID: 4556074058). It is important to note, however, that many comments included several characteristics of CICES and the simple coding shown in Table 2 does not reflects the richness of some of the comments. For example, on response saw that advantage of CICES very much as a 'package', adding that an important feature was "The conceptual background (in particular the cascade), the hierarchical structure, the comprehensive list of services, the international collaboration or agreement it's based on." (ID: 4502584805).

In the context of the revision process that has prompted this study it is clearly important to identify those characteristics of CICES that users found problematic. Thus question 6 examined perceived shortcomings. Again the responses have been coded (Appendix 2) and the results summarised here (Table 3).

Table 3: Shortcomings of CICES identified in Survey

Coding Criteria	Number of Reponses
Complexity	16
Framing of cultural services	13
Terminology needs to be clarified	11
Lack of abiotic classification	6
Lack of definition of functions	5
Uncertain coding	4
Difficult to apply	4
Problematic classification of water	3
Role of biodiversity unclear	3
Conceptual framing	3
Relationship to benefits	2
Link to indicators needed	2
Mix of services and benefit	2
Not an accepted standard	2
Overlaps in categories	2
Link to supporting services needed	2
Extend to trade-offs	1
Gaps in coverage	1
Inflexible	1
Difficult to apply to marine	1
Coverage of urban	1
Difficulty of adding a spatial reference	1
Weak conceptualisation	1
Better description	1
Lack of guidance	1
Grand Total	89

An interesting feature of the responses was that characteristics of CICES that some thought were 'advantages' (Q5) were found to be 'shortcomings' by others. For example, in contrast to those users who found CICES to the simple to use its 'complexity' was cited as a shortcoming in a number of responses to Q6. One person surveyed suggested that "Its comprehensive nature although useful from a technical perspective is too detailed for use in stakeholder engagement where far simpler categorisations are needed." (ID: 4485558848).

Another observed that "The need for generic classes applied at a high level of aggregation makes it sometimes difficult to apply to place based studies. Translation of culturally meaningful ES terminology from a local setting does not always fit neatly. Especially for cultural services" (ID: 4501256540). The classification of regulating services was also highlighted as presenting difficulties for some: "The section regulating services is very complex. Not so useful for communication purpose." (ID: 4636153238). To a large extent the complexity issue therefore related more to the use of CICES as a communications tool with non-experts, rather than technical complexity of applying the system.

The classification of cultural ecosystem services in the current version of CICES was, however, the most frequently cited area of the classification that caused concern. A longer response by one of the people surveyed included the comment that "Cultural services need to be improved. Not clear where certain services (such as local identity, sense of place or attachment to a landscape) fit within CICES…." (ID: 4544465806). Another felt that "CES are not well thought through. Many are as a matter of fact benefits or hard to distinguish. Maybe also thinking about to whom might help." (ID: 4542099850). The consistency of these comments on cultural services seems to point to an important area of the classification that might need to be considered in any revision. This issue links

closely with the need to clarify terminology, that was cited as the third most frequently cited shortcoming.

As Table 3 shows the list of feature of CICES regarded as shortcomings was longer than that for the positive features, which seems to reflect the fact that individuals were identifying particular, detailed issues that they wanted to share. These included the relationship of the services to underling functions and benefits, and the need to link the categories in CICES to indicators more explicitly. An important theme identified in the less frequently cited topics in Table 3 was the fact that some users found it difficult to use the system in particular application contexts, such as the urban and the marine.

For example, one respondent reflected on their work on urban ecosystems and suggested that all services must, by definition, link to one or more beneficiaries "… in planning practice when defining goals and measures it is very important to consider the complete range of ecosystem services available, and not only those actually being used. The consideration of the gap between currently used services and potentially usable services leads to important arguments for the conservation and development of the capacity (productivity) of the natural environment" (ID: 4539509178). The extent to which the identification of beneficiary groups is a perquisite for using CICES is a moot point, and certainly not one unique to this system. In fact the difficulty of identifying beneficiaries in some context is worth noting, given the desire of other respondent to have benefits and beneficiaries built into or lined to the classification. Another person surveyed cited 'coverage' as an issue for those working in the urban environment, arguing that: "Its [CICES] background is agricultural or near-natural landscapes - it does not capture well ecosystem services relevant in urban contexts - e.g. health issues are not represented" (ID: 4480094647). Whether or not "health issues" can or should be built into the classification is clearly a point that might need to be explored, not least in terms of clarifying the way specific health *benefits* can be linked to particular biophysical ecosystem characteristics or outputs that could be regarded as final services.

Comments from those working in the marine sector also indicated at better explanation of that constituted a final service in different types of environment might be necessary. One respondent, for example noted the apparent: "Lack of service definitions (one has to be guided by each class and related examples to find out what the service is actually about) and of service 'interpretations' for each 'biome' (land, freshwater, marine)" (ID: 4545109065). They went on to suggest that this was a shortcoming because "…. what makes sense for the terrestrial environment, on which the development of CICES was based, is not of direct application for the marine environment, in particular that is quite difficult (if not impossible) to perceive most of the 'regulation and maintenance' services as 'final' in that context" (ID: 4545109065). This was an issue taken up by another person working in the marine sector who also cited problems with the classification of regulating services: "Some conceptual difficulties can be encountered for example in regulating services. There is (sic) few good quality indicators that correlates with CICES, all the rest are proxies." (ID: 4539969268). They went on: "…. Difficulties in distinguishing between the supply and the demand side of ecosystem services classification. Also difficult to include some indicators that are more associate to ecosystems functions and ecosystem benefits. It might be useful to integrate these dimensions in CICES. Maybe CICES should also clearly acknowledge other uses than accounting" (ID: 4539969268). Once again, therefore, the need to clarify terminology and definitions therefore emerges as an issue that any revision must address.

2.2 Findings from those who have not used CICES

Of the 87 people who completed the survey who identified themselves as having not used CICES a third of the had not been aware of the classification system; of the remaining group roughly equal numbers were either 'aware' or 'somewhat aware' of it. When asked about which ecosystem service classification systems the MA was the most frequently cited, followed by TEEB (Table 4). Since many people reported as having used more than one system in their work, the numbers shown in Table 4 exceed the number of respondents.

Table 4: Alternative classification frameworks identified by those who had not used CICES

System	No of responses
MA	23
TEEB	11
FEGS/NESCS	3
Other	10
Blank	44

Having identified any publications arising from their work the questionnaire took the 'non-users' to the set of general questions relating to the scope of any classification that were at end of the survey, which they then answered along with the 'user' group. All of these responses are reported in the next section.

2.3 Findings from all respondents

2.3.1 Abiotic ecosystem outputs

Although the lack of a classification of abiotic services was not amongst the three 'top' shortcomings identified by CICES users shown in Table 3, the general issue was covered in a later question in the survey which asked ***all*** respondents whether abiotic ecosystem outputs should be covered in the classification (Q13). One hundred and sixty two people responded to the question; 54% said it would be useful to include abiotic outputs and 25% said that it would not, while 22% said that they could not comment. Comments from those who supported adding abiotic outputs into CICES included: "I understand that abiotic outputs may not fit in the initial rationale of ecosystem services, but I found it difficult to omit them from discussions with stakeholders as they largely contribute to scenery/use/acceptance of the landscape" (ID: 4652222310). Another suggested: "There is a need for a complementary approach for all environmental services. There are sometimes trade-offs between the use of the different resources. For environmental accounts, it would be helpful to have this extended classification" (ID: 4539420741). Several respondents suggested that since, under provisioning, water is already included in CICES, it would be more consistent to include other abiotic outputs as well (ID: 4493445824). However, comments from those who suggested extending the classification also revealed the wide range of different types of abiotic outputs that might also be considered. These included not only those suggested in the question, such as wind, hydropower and salt, but also "space (or offering territory or etc.). Also air (wind), water (transport, energy etc.), minerals (mining) are very important" (ID: 4591640851).

Those who felt that abiotic outputs should not be included in CICES cited the problem of added complexity (e.g. ID: 4570988202 and 4495118973), and the danger that "inclusion of the abiotic services into CICES could somehow destabilize ecosystem services understanding. E.g., SEEA-EEA

makes quite clear distinction between these two types of services - ESS and abiotic services. If we will go deep into physical processes and minerals, etc. (salt, crude oil, saltpetre...) …..we could lose still quite fragile definition of ESS, and it could have some undesirable consequences for one of the main purposes of ESS approach - to maintain and restore of ECOSYSTEM services" (ID: 4546977792). A number of respondents who felt that abiotic outputs should not be included argued that these factors were either already dealt with in the accompanying 'abiotic table' published with V4.3 (e.g. ID: 4502584805 and ID: 4476351443), or covered in other systems (e.g. ID: 4550890476). The latter observed that "…the abiotic section is largely covered by established resource accounting methods". Taken in conjunction with the comments from people who felt that abiotic output's should be included, these responses suggest that better information on the rationale for what was included in the classification was needed and what the scope of the system was, and whether abiotic outputs were included in the mind body of the classification uses should be given points to how they might be handled in different contexts.

2.3.2 Classifying benefits and beneficiaries

Questions 15 and 16 asked all respondents whether CICES should 'be extended' to illustrate the 'kinds of goods and benefit that services might support' and to identify 'different types of beneficiary'. In both cases the overwhelming majority (~80%) of the 158 who responded to these questions felt that in both cases these kinds of links should be made. Around 10% argued that they felt this was not needed, and around the same number said they could not comment.

Amongst those who argued that the classification should link to goods and benefits, one user observed that it should be done "But not at the expense of clarity. If this follows the current 'illustrative' section in the spreadsheet this is useful" (ID: 4550890476). In fact, a number of respondents (24) who gave a positive response to Q15 argued that the link is probably best made by way of providing examples (e.g. IDs: 4652222310, 4477764127) and that the main priority was to improve understanding (ID: 4652222310) and communication of key ideas (ID: 4512011683). Many of the comments that cited the use of examples as a way forward echoed the concern so those who felt it was undesirable to make the formal link because of the complexity that this might introduce. Amongst those who felt that the link to goods and benefits should *not* be a major focus of future work comments included "I would not make the CICES framework any more complicated than it is currently. I currently do not see the added value that the time investment would generate." (ID: 4547673465). Despite giving a positive response to the question another person surveyed was worried about the feasibility of the task: "As an example only, perhaps. It would be impossible to cover all the goods and benefits that ecosystem services support" (ID: 4482881279).

In terms of the links to beneficiaries some respondents argued that it was "crucial" (ID: 4664369261) or "critical" (ID: 4539265011) or "really important for better finance of natural capital" (ID: 4580881553). However, amongst those who gave a positive response some worried about the complexity that this might introduce: "This seems rather complex to make a full review. A general methodology to identify beneficiaries and examples might be sufficient" (ID: 4539420741). Once again a strategy based on providing examples was cited as the way forward by a number of those responding to Q16 (e.g. IDs: 4539739706 and 4480268424). As in the case of the links to goods and services, those providing a negative response to this question mainly did so on the basis of the complexity of the task and indeed the practicality. One respondent observed: "In my opinion these would make CICES to complex. There might be recognition issues if not all beneficiaries are listed"

(ID: 4544465806), while another suggested that: "The link with beneficiaries is done depending on the context. Doing this ahead of time makes the classification system more convoluted than what it should be" (ID: 4514579556). Finally, yet another added: "this is impossible. If CICES would do that, it would further funnel and limit scope of valuations and become more biased. Maybe examples for different value types could be given, always widening rather than narrowing the scope" (ID: 4476113025).

In the case of the links to goods and benefits and the links to beneficiaries, therefore, the consensus seemed to be that people felt that it would be useful to provide examples and guidance on *how* the links can be made rather than attempting to include classifications of goods and benefits, or beneficiaries within the system itself. To do so, they felt, would possibly make the system too complex and potentially limit its flexibility in any application.

2.3.4 Improving the structure and logic of CICES

Questions 17 and 18 were included in the survey to elicit suggestions on how the structure and logic of the present version of CICES might be improved. The ambition was to gather information on a wider set of issues than might have been identified in exploring what people thought were the advantages and shortcomings of the system. However, as Table 5 shows, the topics identified strongly reflected those found in the earlier questions. Moreover, for the most frequently cited issues, responses were similar in relation to the questions about structure and logic.

Table 5: Issues identified relating to CICES structure and logic (note some responses were given more than one code given the range of issues they covered)

Code	Q17 (Structure)	Q18 (Logic)
Terminology	22	3
Guidelines	13	19
Framing of cultural services	9	4
Simplify	9	7
Uncertain coding	7	7
Classification of regulating services	4	1
Examples, indicators	4	2
Link to structure and function	3	9
Link to biodiversity	2	1
Link to other classifications	2	1
Link to health	1	0
Coverage	1	0
Clarification of status of water	0	2
Clarifying production boundary	0	1
Coding	0	1
Extension to valuation	0	1
Framing	0	3
Link to beneficiaries	0	1
Relationship to abiotic outputs	0	1
Revision of soil classification	0	1
Widen consultation	0	1

Thus clarification of terminology and the provision of clear guidelines often cited, together with related issues such as the need for examples, the need for simplification and the potential revision of the classification of cultural services and some areas relating to regulating services. The strong support for providing examples was also evident from the answers to Q14; 80% of respondents felt that the CICES framework should be extended to include examples of ecosystem services in each class type and how they can be measured.

In reviewing the responses to these questions particular attention was therefore paid to new topics and alternative ways of approaching the classification task not identified elsewhere in the survey. In this context, there was an interesting observation by one respondent to Q18 on the problem of 'double counting' and that was a focus of attention in designing CICES around the concept of a 'final service':

> *"The classification system should be hierarchical and flexible. It should be explicit about the scale and resolution at which it works best, and what kinds of decision support it provides, and cannot be expected to provide. It should recognise that despite these efforts it cannot eliminate the problem of double counting which the very classification sets out to eliminate. Given the pervasiveness of double counting when dealing with plural values and functional interdependence of ecosystems and their structures, it should explore what its capabilities [are]. For example, better identification of overlapping - double counted values - can be the basis for identifying common agendas or conflicts between stakeholders. Overlapping values in an awareness raising or political debate context can be mutually supporting as evidence, rather than seen a drawback…."* (ID: 4501256540)

What is interesting here is that the respondent is suggesting that we should not necessarily attempt to design a system that prevents double counting, but rather be aware of it and in the application of the system look at where it occurs and use this information to better understand the issues that characterise a particular application. This response was coded up under the heading of 'guidelines' which clearly have to address *how* the classification is used in different *analytical contexts* as well as definitional, conceptual and framing issues. The problem of double counting is certainly one recognised by others who answered Q18 (e.g. ID: 4627662382, and 4567878839).

The need to clarify the link between services and 'biodiversity' was a further new theme to emerge in the responses to these questions, with one respondent making the suggestion in relation to Q18 that: "Even without embedding into the system, the cascade level one stuff (biodiversity, natural capital, integrity, degradation status) should be associated to framework some way, with some theoretical and practical explanation how to use them together with the framework" (ID: 4633253844). Clarification of the ways soils provide services was a further area identified where the structure of CICES might be looked at: "The system does not currently take account of the services provided by soil very well. [Our] soils scientists identified that the services provided by soil extend beyond the soil formation and composition service identified in the classification" (Q18, ID: 4534648031). This same respondent went on to observe that within the regulating category "ventilation and transpiration or dilution by atmosphere are much broader services that are harder to understand and relate to specific ecosystem types" and suggested that "they are huge categories that feel a bit meaningless when making assessments" (Q18, ID: 4534648031).

Although the link to benefits and beneficiaries was highlighted as important by a number of respondents for Q14 & 15, in terms of suggestions for alternative approaches or classification logics it was cited only by a few responses to Q17 & Q18. There was, however, one extensive comment (Q17 & 18 ID: 4614264366), which argued that to classify services two components need to be considered, the "biophysical" and "socio-economic". They observed that "It seems that an additional level to the current classification is required so that each ES is a unique combination of an ecosystem process (or element) and benefit". In terms of a way forward, they felt that "An idea could be to get a unique set of elementary services and to propose two classifications of them, one according to the underlying processes, another according to the type of benefits". Such a suggestion echoes the comments made elsewhere in the questionnaire responses involving making the link to underlying ecosystem functions more explicit, as well as the link to benefits and beneficiaries; whether this can be done in a single classification system or whether these issues are best handled by better guidance is a question that needs to be addressed in this review.

3. Key messages from the survey and next steps

A clear message that emerges from the questionnaire was that there appeared to be an established user-base for CICES. Moreover, while users identified difficulties in working with the classification, the comments suggest that many of these could potentially be overcome by providing better guidance and examples. The survey identified nearly 40 published papers and links to other sources describing work based on CICES (Appendix 3); these provide a useful starting point for developing a set of examples around which strategies for handling analytical and conceptual issues can be described.

The kinds of issue that these examples need to illustrate include the links to underlying structures, processes and functions, and the links to benefits and beneficiaries. It seems apparent that whether or not formal classifications of benefits and beneficiaries are developed in the future, these examples could serve to help users of CICES in the short to medium term. The important analytical issues that need to be considered include the problem of 'double counting' and how to handle it in the classification, and how the classification might support the analysis of 'trade-offs'.

The review of examples and applications would also be a useful way of testing the hierarchical structure of the classification – given that some users felt the need to "simplify". The extent to which examples used aggregated metrics to characterise collections of services at the group and division level, would be a particular feature to examine in the evidence-base. The lack of detailed guidelines for the application of V4.3 has clearly been a limitation for users. In addition to helping understanding, the development of new detailed guidelines would be a way of useful exposing and working through the logic of the classification, and potentially of addressing the difficulties that users identified in relation to water, soils, and especially cultural services. The detailed comments that users provided about specific services could be looked at in detail at this stage.

Whether or not the structure of the classification is simplified by modifying the hierarchal structure, it seems apparent that to support the wider range of uses that the current version of CICES has, there would be advantageous to have a less technical set of descriptors and service names that could be used with non-experts during, say, a participatory process. While it seems unlikely that a lay version of the classification could replace the more technical one (given the need for better definitions suggested by a number of respondents) the ability to have consistent but customised naming conventions that suit a wider range of applications would seem useful. The approach could also be used to cross reference service categories that make more sense in the context of specific ecosystem types, such as marine.

Appendix 1: Questionnaire

Appendix 2: Coding used for responses

Coding used for responses to Q5,

'From your experience of CICES what would you say are its most useful or helpful features?'.

For full data and coding see accompanying database.

Row Labels	Count of Code
Logical	17
Hierarchy	15
Standard	14
Coverage	14
Understanding	8
Other	4
Reference	3
Clarity	3
Communication tool	3
Examples	3
Integrated	1
Detail	1
Clear	1
Applicability	1
Flexibility	1
Grand Total	**89**

Appendix 2: Coding used for responses, cont.

Coding used for responses to Q6,

'From your experience of using CICES what would you say are its major shortcomings?'.

For full data and coding see accompanying database.

Row Labels	Count of Code
Complexity	16
Framing of cultural services	13
Terminology needs to be clarified	9
Lack of abiotic classificaiton	6
Lack of definition of functions	5
Uncertain coding	4
Difficult to apply	4
Problematic classificaiotn of water	3
Role of biodiversity unclear	3
Concpetual framing	3
Terminology	2
Relationship to benefits	2
Link to indicators needed	2
Mix of services and benefit	2
Not an accepted standard	2
Overlaps in categories	2
Link to supporting services needed	2
Difficulty of adding a spatial reference	1
Extend to trade-offs	1
Gaps in coverage	1
Inflexible	1
Difficult to apply to marine	1
Coverage of urban	1
Weak conceptualisation	1
Better description	1
Lack of guidance	1
Grand Total	**89**

Appendix 2: Coding used for responses, cont.

Coding used for responses to Q13,

'A number of people have suggested that one way to develop CICES is to include an equivalent classification of the abiotic outputs from ecosystems - to cover such things as wind, hydropower, salt, etc. Do you agree?'.

For full data and coding see accompanying database.

Row Labels	No, exclude	Yes include	Grand Total
Conceptual framing of ES	1		1
Focus on human use rther than abiotic outputs	1		1
Guidelines on application		4	4
Makes classificaiton too complex	10		10
Need a parallel classification	1	9	10
Need to be consistent (e.g. water)		3	3
Need to be inclusive		36	36
Need to be inclusive - guidelines		1	1
Need to be inclusive and link to supporting structures, processes etc.		1	1
Need to be inclusive for accounting purposes		1	1
Need to better reflect status of soils		1	1
Need to clarify role		1	1
Parallel classificaiton useful		1	1
Risks double counting	1		1
Shifts focus from biodiversity	4		4
Uncertain coding	5	4	9
Undermines defintion of ES	1		1
Unnecessary	6		6
Grand Total	**30**	**62**	**92**

Appendix 2: Coding used for responses, cont.

Coding used for responses to Q17 & Q18. For full data and coding see accompanying database; the same coding was used for each question.

'Whether you have worked with CICES or not, from your knowledge of it, do you have recommendations for how the descriptions or naming of the services can be improved? Please be as detailed as you can'. (Q17)

'Whether you have worked with CICES or not, from your knowledge of it, do you have recommendations for how the logic of the system or its classification approach could be improved? Please be as detailed as you can.' (Q18)

Code	Q17 (Stucture)	Q18 (Logic)
Terminology	22	3
Guidelines	13	19
Framing of cultural services	9	3
Simplify	9	7
Uncertain coding	7	7
Classification of regulating services	4	0
Examples, indicators	3	2
Link to structure and function	3	8
Link to biodiversity	2	0
Link to other classifications	2	1
Link to health	1	0
Coverage	1	0
Link to metrics	1	0
Clarification of status of water	0	2
Clarifying production boundary	0	1
Coding	0	1
Extension to valuation	0	1
Framing	0	3
Link to beneficiaries	0	1
Relationship to abiotic outputs	0	1
Revision of soil classification	0	1
Widen consultation	0	1

Appendix 3:

Publications and links identified by respondents using CICES in answer to question "Have the outcomes of the work in which you used CICES been published? If so please provide links or references."

Respondent	Paper	Type
4627036231	Alahuhta, J., Joensuu, I., Matero, J., Vuori, K-M. & Saastamoinen, O. 2013. Freshwater ecosystem services in Finland. Reports of the Finnish Environment Institute 16/2013. 35 p. Available at: http://hdl.handle.net/10138/39076	Paper
4485414289	Albert, C., Burkhard, B., Daube, S., Dietrich, K., Engels, B., Frommer, J., Götzl, M., Grêt-Regamey, A., Job-Hoben, B., Keller, R., Marzelli, S., Moning, C., Müller, F., Rabe, S.-E., Ring, I., Schwaiger, E., Schweppe-Kraft, B., Wüstenmann, H., 2015. Development of National Indicators for Ecosystem Services Recommendations for Germany. Discussion Paper. BfN-Skripten 410, Bon-Bad Godesberg.	Paper
4627036231	Arovuori, K. & Saastamoinen O. 2013. Classification of agricultural ecosystem goods and services in Finland. PTT Working Papers 155. 23 p. Available: http://ptt.fi/fi/prognosis/155-arovuori-kja-saastamoinen-o	Paper
4480167446	Baró F, Haase D, Gómez-Baggethun E, Frantzeskaki N (2015) Mismatches between ecosystem services supply and demand in urban areas: A quantitative assessment in five European cities. Ecol Indic 55:146–158. doi: 10.1016/j.ecolind.2015.03.013	Paper
4570763034	Bujnovský, R. 2015 Evaluation of the ecosystem services of inland waters in the Slovak Republic – to date findings. Ekológia 34, No 1, p. 19-25.	Paper
4495027295	Bürgi, M., Silbernagel, J., Wu, Jianguo, Kienast, F., 2015: Linking ecosystem services with landscape history to inform future scenarios. Landscape Ecology 30: 11-20. 3 Kienast, F., Helfenstein, J., in press: Modeling Ecosystem Services. Earthscan Routledge Handbook Series.	Paper
4476302179	Campagne, C.S., et al. The seagrass Posidonia oceanica: Ecosystem services identification and economic evaluation of goods and benefits. Mar. Pollut. Bull. (2015), http://dx.doi.org/10.1016/j.marpolbul.2015.05.061	Paper
4502584805	Grizzetti, B., Lanzanova, D., Liquete, C., Reynaud, A. (2015). Cook-book for water ecosystem service assessment and valuation. JRC report EUR 27141 EN. Luxembourg, Publications Office of the European Union. doi:10.2788/67661.	Paper
4495027295	Haines-Young, R., Potschin , M., Kienast, F., 2012: Indicators of ecosystem service potential at European scales: mapping marginal changes and trade-offs. Ecol. Indicators 21: 39-53.	Paper
4539509178	Hartje, V., Heiland, S., Kalisch, D., Schliep, R., Wüstemann, H., Kahl, R., Sander, H. (2016): Ökonomische Effekte der Ökosystemleistungen städtischer Grünräume. Abschlussbericht zum Forschungs- und Entwicklungsvorhaben (FKZ 3512 82 1400). Bundesamt für Naturschutz, Bonn. In preparation.	Paper
4495027295	Helfenstein, J., Bauer, L., Clalüna, A., Bolliger, J., Kienast, F., 2014: Landscape ecology meets landscape science. Landscape Ecology 29: 1109-1113.	Paper

4495027295	Helfenstein, J., Kienast, F., 2014: Ecosystem service state and trends at the regional to national level: a rapid assessment. Ecological Indicators 36: 11-18.	Paper
4495027295	Kienast, F., Frick, J., van Strien, M.J., Hunziker, M., 2015: The Swiss landscape monitoring program - a comprehensive indicator set to measure landscape change. Ecological Modelling 295: 136-150.	Paper
4495027295	Kienast, F., Huber, N., Hergert, R., Bolliger, J., Segura Moran, L., Hersperger, A.M., submitted: Conflicts between decentralized renewable energies and ecosystem services - a spatially-explicit quantitative assessment for Switzerland. Submitted Renewable and Sustainable Energy Reviews.	Paper
4627036231	Kniivilä, M. & Saastamoinen, O. 2013. Markkinat ekosysteemipalveluiden ohjaus- ja edistämiskeinona. PTT:n työpapereita 154. 30 s.]. Available at: http://ptt.fi/wp-content/ uploads/2013/11/tp1541.pdf	Paper
4627036231	Kniivilä, M., Arovuori, K., Auvinen, A-P., Vihervaara, P., Haltia, E. Saastamoinen, O. & Sievänen, T. 2013. Miten mitata ekosysteemipalveluita: olemassa olevat indikaattorit ja niiden kehittäminen Suomessa? PTT työpapereita 150. 68 s. Available at: http://ptt.fi/fi/prognosis/150-kniivila-(etc).	Paper
4627036231	Kosenius, A-K., Haltia, E., Horne, P., Kniivilä, M. & Saastamoinen, O. 2013. Valuation of ecosystem services? Examples and experiences on forests, peatlands, agricultural lands, and freshwaters in Finland. PTT raportteja 244. 103 s. http://ptt.fi/wp-content/uploads/2014/02/rap244.pdf	Paper
4488389181	Kostrzewski A., Mizgajski A., Stępniewska M., Tylkowski J. 2014: The use of Integrated Environmental Programme for ecosystem services assessment. Ekonomia i Środowisko 4(51), Białystok: 94-101, available in English on-line: http://www.fe.org.pl/uploads/ngrey/!%20eis51.pdf -	Paper
4555536685	Lee and Lautenbach, 2016. A quantitative review of relationships between ecosystem services, Ecological Indicator, 66, 340-351	Paper
4502584805	Liquete, C., Cid, N., Lanzanova, D., Grizzetti, B., Reynaud, A. (2016). Perspectives on the link between ecosystem services and biodiversity: The assessment of the nursery function. Ecological Indicators 63: 249–257. http://dx.doi.org/10.1016/j.ecolind.2015.11.058	Paper
4502584805	Liquete, C., Kleeschulte, S., Dige, G., Maes, J., Grizzetti, B., Olah, B., Zulian, G. (2015). Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study. Environmental Science & Policy 54: 268–280. http://dx.doi.org/10.1016/j.envsci.2015.07.009	Paper
4502584805	Liquete, C., Piroddi, C., Drakou, E.G., Gurney, L., Katsanevakis, S., Charef, A., Egoh, B. (2013). Present stage and future prospects in the analysis of marine and coastal ecosystem services: a systematic review. PLoS ONE 8(7): e67737. http://dx.doi.org/10.1371/journal.pone.0067737.	Paper
4502584805	Liquete, C., Zulian, G., Delgado, I., Stips, A., Maes, J. (2013). Assessment of coastal protection as an ecosystem service in Europe. Ecological Indicators, 30: 205–217. http://dx.doi.org/10.1016/j.ecolind.2013.02.013.	Paper
4502584805	Maes J., Barbosa A., Baranzelli C., Zulian G., Batista e Silva F., Vandecasteele I., Hiederer R., Liquete C., Paracchini M.L., Mubareka S., Jacobs-Crisioni C., Perpiña Castillo C., Lavalle C. (2015). More green infrastructure is required to maintain ecosystem services under current land-use change in Europe. Landscape Ecology 30(3): 517-534. doi: 10.1007/s10980-014-0083-2.	Paper
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