Comparative analysis of lists of ecosystem services classified by function

Aicha Bouredji

University of Corsica,
UMR CNRS 6240LISA,
Mariani Campus,
22 Avenue Jean Nicoli,
BP 52, Office 209, 20250 Corte, France
Email: aichabouredji@yahoo.fr

Abstract: Functional classification of ecosystem services is a very popular method, originated in the International Millennium Ecosystem Assessment Report. Other organisations have adopted this approach and have developed it by deploying it in their sustainable development strategies. These alternations prompted demands for appropriate public policies. Thus, the problem of environmental quantification appeared because it requires finely cohesive tools. To examine the compatibility of all the lists of ecosystem services, this paper proposes an inspection of the classifications proposed by eight global organisations and a comparative analysis of their rankings. This makes it possible to check whether it would be relevant to rely on these classifications for quantification. Through a thorough examination method, the compositions will be processed and enhanced. The results of this work will provide a theoretical framework as a tool to help environmental assessment. It will bring together a fixed set of services that helps implement a concrete application.

Keywords: ecosystem services; ecosystem; assessment; quantification; classification; functional approach; methodological framework; conservation; provisioning services; supporting services; regulating services; cultural services; sustainable development; ecological economics.

Reference to this paper should be made as follows: Bouredji, A. (2019) 'Comparative analysis of lists of ecosystem services classified by function', *Int. J. Environment and Sustainable Development*, Vol. 18, No. 3, pp.289–317.

Biographical notes: Aicha Bouredji is a PhD student and temporary attached for teaching and research at the University of Corsica. Her research interests include: ecological economics, assessment of management of protected areas and treatment of ecosystem services.

1 Introduction

Ecosystem services are the subject of extensive contemporary literature. Their subject attracts, intrigues and launches the debate on global environmental changes. However, their involvement in public policies has become indispensable at a time when the fragility of the biosphere is of more concern to decision-makers than ever before. Indeed, ecosystem services are always at the heart of the discussions and gain more importance in

the field of development policies and public decisions. As stated in the international report of Patil et al. (2012): "by overlooking ecosystem services, development decisions are inefficient." Thus, when focusing on scientific publications on this subject the general awareness was caused in part by the manifestation of ecological economists and biodiversity enthusiasts, such as Daly (1977), Costanza and Daly (1992) and others. These researchers are, among the many scientists, whose have raised the alarm about the importance of sustainable management of ecosystem services and the need to sustainably preserve their virtues.

Thus, resolutions have emerged in response to this type of incentive. Some authors have worked to promote the evaluation of ecological services and played a large role in the diagnosis of structures, allowing the evolution of environmental protection techniques. Among these works, there is that of Costanza et al. (1997) that attempted to assign an estimated value to ecosystem services. Their initiative engendered interactions around the subject. Discussions have therefore converged towards encouraging a monetary type of valuation of ecological services; this is the case with the proposals of Pagiola and Platais (2002), MEA (2005) and TEEB (2012). Once ecosystem services have reached the evaluation stage, things have become complicated. In part because the exercise itself requires precision and minutia difficult to achieve on the environmental context. But also, because the evaluation imposes a correct identification of the components to be evaluated. Clearly, the treatment of ecosystem services remains complex. Their definition is often called into question and their classification remains arduous and encounters some difficulties of application.

In the first place, the complications arose in the definition of an ecosystem service itself. Several questions have been asked in the literature on the exact meaning of the concept and on the list of services to be retained for this purpose. Some spoke of a service seen as a benefit, as the present report states (Millennium Ecosystem Assessment, 2005). Others have strongly opposed this conceptualisation, such as Boyd and Banzhaf (2007) and Fisher and Turner (2008) by introducing a division into three components: intermediate services, final services and benefits. This dispute is not the only example since the work of Pesche and Méral (2016) exposed the abysses around this topic in their analysis of the most influential publications. These authors have identified more than seven proposals for defining ecosystem services. First, that of Daily (1997) which evoked a definition focused on the processes of natural systems and functions. However, Kremen (2005) retained only ecosystem functionalities as ecosystem services (with a partial view of the process). Then, arrived at Hein et al. (2006) and Wallace (2007) who concluded that it is a question of products of the functions and not the functions of the ecosystem as such. At the same time, Boyd and Banzhaf (2007) retained the term entities as the most explanatory name according to him. However, Fisher et al. (2009) had another insight as they attribute the role of benefit providers to ecosystem services. Finally, Tallis et al. (2012) felt that it is more exciting to talk about co-products.

In sum, the only publication that is virtually in agreement with many of these proposals, to one detail, and which gives a general definition is (MEA, 2005). Moreover, it is for this reason that most communications with the public are constantly made based on MEA proposals. With the observation that ecosystem services are considered mainly as profits. Moreover, the work of La Notte et al. (2017) looked at the impact that ambiguities that limit the definition of the concept may have and allowed to examine their effects on the classification in general way. In this article, the treatment will be far

this problem that does not directly affect analysis since it is a comparison of predefined lists.

Nevertheless, not all scientific offers have been enough to crown the concept of ecosystem services with a single, official definition. Until today, there is not really a proposal that matches all the authors. This situation is totally assumed by the researchers, as underlined (Landers and Nahlik, 2013): "one of the most challenging aspects of the ecosystem services literature, to date, is that there is no standardization, and, therefore, communication and consistency in the field have not been achieved." Also, despite the popularity of the concept and its presence imposed in most news, it remains marginalised in some policies. At the EU level, the work of Bouwma et al. (2018) has demonstrated the rare integration of this concept in the development strategy and its marked absence. Where the authors conclude with a conviction that there is a need to improve its integration through common methods of monitoring and evaluation. Hence, the interest of this publication and its commitment to a thorough analytical approach.

For, beyond the unidentified definition of the concept, another complexity appears when quantifying ecological services. Indeed, being an essential phase for the treatment of environmental structures, it is an approach that has always required a strong investment of teams of researchers. Quantification is one of the ways scientists think about approving an assessment and judging the state of conservation; these efforts appear in various international projects such as the appearance of the European project QuESSA (Holland et al., 2014) and the mobilisations of the European Environment Agency for this purpose; and also, the IUCN-WCPA guidelines (Neugarten et al., 2018). Quantifying ecosystem services is therefore a fundamental step in attempting to assess the state of conservation of the biosphere. Whether applied for a large area or a small area, this is the only way to translate the state of a natural structure at a given moment and deduce an observation over time. It is a solid way to carry out an analysis and to constitute indicators, but on the condition that it is based on good arguments and a good methodological framework.

The assessment of ecosystem services is so difficult that every additional scientific effort could be used to improve its performance, as the major organisations agree on environmental services: "many complexities are associated with undertaking these broad valuations, including the quantification of the benefits themselves (…)" (United Nations et al., 2012a). This task of quantifying involves classifying ecosystem services by identifying their quantity, sorting out their diversity and analysing their subjectivity. As a result, a sort of categorisation has developed to facilitate the evaluator's work and to organise the services provided by nature. The goal is to create a sort of natural capital accounting system that opens the door to economic analysis and scientific diagnosis. The quantification procedure is initiated by identifying the organisation of ecosystem services according to a consistent logic. Among the few known and not necessarily all-used proposals, we have three types provided in the report of Reid et al. (2005) known as MEA in the form of: a functional classification, a second descriptive categorisation, and another, organisational classification of ecosystem services. However, it should be known that currently, the functional approach remains the most used, it has allowed the categorisation, at the international scale, of more than 24 ecosystem services to its first version. The other classifications sometimes found in reports and publications never go beyond their theoretical phase; they lack an applicable example and only provide suggestions.

However, the choice of the deployed approach directly influences the economic evaluation exercise. On the one hand, categorisation facilitates identification, and this, through a well-defined organisational framework appropriate to the nature of the services being evaluated. Obviously, it must be well based on the involvement of specialists to ensure the success of the procedure. On the other hand, categorisation avoids confusion that may occur at the time of treatment. A good categorisation is therefore one that facilitates the treatment of ecosystem services by offering them a correct and rational distribution; especially at the time of the calculations. The classification by function has big part of its characteristics and has spread because of its clarity and ease of implementation. As confirmed Chevassus-au-Louis (2012): "the classification proposed in 2005 by the Millennium Ecosystem Assessment (MEA) (2005) is by far the best known and most used in-service evaluation studies." This method is so well-known that it is present in several recent scientific events such as the French scientific report of the Ministry of Energy Transition and Solidarity (Therond et al., 2016) and the publication of the working group of the study on the Importance of Nature to Canadians (Groupe de travail de l'Étude sur l'importance de la nature pour les Canadiens, 2017).

Thus, the use of function-based methods of classifying ecosystem services is increasing and the question is whether these applications are truly reliable. Of course, many critics have flooded about it, but the goal here is to play the role of an observer in a situation of choosing a ranking in environmental services that he identifies. This publication is not dwelled on the substantive problem that other authors have continually dealt with. But, it will try through the analysis of what already exists to form to a practical tool for exercise the quantification. In this regard, several international organisations have chosen to deploy the functional classification for their biodiversity conservation strategy, namely: Mace et al (2011) is known as UK NEA, TEEB (2012), International Union for the Conservation of Nature France (2012) known as IUCN, The Ecosystem Services in Wallonie Project (2016) is known as Wal-ES, Puydarrieux et al. (2017) is known as EFESE, FAO (2018) and Haines-Young and Potschin (2018) is known as CICES V.5. For this, this paper aims to answer this question through a documentary analysis and an application to lift the veil on the strength of classifications at the level of these seven publications. For any environmental assessment needs homogeneity and tool consistency. The treatment all these lists and their comparison with the MEA list as the source of the method it will illuminate the procedure.

Through this analysis, the goal is to know if it would be possible to rely on predefined lists of ecosystem services, currently available in the literature, to try to carry out a quantisation and evaluation exercise. To answer this problem, comparative analysis will be realised of the substance and form of seven different official classifications. By comparing them with the initial proposal, it would be quite obvious to draw conclusions about this type of categorisation. Finally, this work will provide a more appropriate configuration for an environmental assessment and provide quantification assistance.

2 Method

Ecological functions are the source of the benefits humans derive from the natural environment and this generates an offer of multiple ecosystem services. Thus, environmental conservation policies intervene in level of the state of ecosystems to maintain the sustainability of their operation. For this, it was necessary to admit them into

a classification system. When thinking about the function-based thinking of available ecosystem services, the publication of Reid et al. (2005) (MEA) have effects. Automatically guided towards four divisions: supporting services, regulating services, provisioning services and cultural services. This distribution has been strongly integrated and it is often reflected in functional descriptions.

The eight referred organisations all have one thing in common, which is categorisation by function. They are all interested in promoting sustainable development (fighting for the same main objective). Although they nature are organisations with an international or nationally known impact and often exported outside the territory. Each of them exposes its own distribution of ecosystem services and allows access to the data to the public (sign of all transparency). Therefore, the procedure is as follows: an analysis is realised at the level of each distribution (each composition of lists by function). By consulting all available lists and listing all services at the eight organisations overall, under each function it is about exploration. This makes a total of 32 lists to process. At the end, the conclusions will be drawn after the partial examinations and then for all the parties. Then, verification if those proposed lists will follow the same way since they started from the same classification.

The installation of this work was arranged based on a documentary research and a constitution of a database especially prepared for this purpose. The handling has become carried out on each publication and it looked at the fundamental components of each exposed list. Thus, to carry out this analysis we list the database in the form of a group respecting the following reflection:

First, a group of reference lists

1 Under this category, the lists presented in the MEA report in 2005 will be collected. As they offer the first listing of ecosystem services according to the functional approach, they symbolise a reference to consult. It is imperative to integrate them as benchmark lists to make the comparison. Knowing that these lists are the most popular in terms of the categorisation of ecological services, their use can be frequent (sometimes with some apprehension). The strength characteristics of these lists are their enjoyment of an international stamp and their added value resulting from work that favours decision-making. They have been proposed as the fruit of a thorough and recognised research action.

Second, a group of inspired international lists

This group brings together all the lists that were inspired by the reference lists of 2000s (proposed by the MEA) who are then reworked and published internationally. There are four ones of them and these are:

2 First, the lists proposed by The Economics of Ecosystems and Biodiversity (TEEB) in 2012. Very reputed and to its credit, this study was undertaken within the framework of the United Nations Environment Program to integrate ecosystem services in the global decision-making framework. Its appearance was due to the desire to allow the evaluation of natural capital. The distribution that has been proposed has been inspired by MEA proposals and encourages interest to be analysed.

3 Secondly, the classification of the International Union for Conservation of Nature (IUCN) is applied at France, in 2012. They were strongly based on MEA lists in the structure and basic reflection. However, the organisation has made the choice to introduce some modifications and to appropriate an additional configuration. Looking at these mutations will help to see if the differences are important and if they are well justified. Indeed, this association is strongly interested in the management of ecosystems and tries through its experiences to deepen scientific research. It enjoys exceptional dynamism to process information on the environment and its composition. Being interested in the lists they offer can have a non-marginal effect on our analysis.

4 Also, the distribution of the services of the Food and Agriculture Organization of the United Nations (FAO) of 2018. FAO is its strategy on the sustainability of the use of natural resources and his interested in strongly to ecosystem services.
The organisation operates differently, adopting a development strategy based on personalised and sought-after lists of services and slightly inspired by those of the MEA. The organisation also shows an interest in agriculture and its development. Its presence in the batch to be analysed is essential for experimentation.

5 Finally, in this category, the well-known lists of the Common International Classification of Ecosystem Services (CICES) of Haines-Young and Potschin (2018). They represent the result of an initiative to establish a common and international classification. This strong European approach has been initiated by the European Environment Agency to facilitate environmental accounting and the assessment of ecosystems and their services. A first version of classification was proposed in 2013, then revised to arrive at an improved and very recent version that we retain here. The European Environment Agency therefore wanted to standardise integrated environmental and economic accounting through a revisiting of the classification. For this reason, it is interested to explore the content of these lists knowing that they were, at first, inspired by MEA and TEEB and readjusted.

Finally, a group of inspired national lists

To expand the analysis, it was further by adding lists of national and regional ecosystem services from some countries to verify their interaction with other classifications. They were chosen after extensive bibliographic research and represent the few lists disclosed to the public. They are in total three and are as follows:

6 First, the well-known list of UK National Ecosystem Assessment (UKNEA) published by Mace et al. (2011). In its focus perspective to propose a conceptual framework that brings together all the issues around the valuation of ecosystem services. The report brings together an extraordinary amount of information and draws on several surveys. He draws an interesting classification and gives lists that we have integrated into our field of analysis. Knowing first that they all were originally inspired by the MEA.

7 Similarly, the Wal-ES typology has been proposed in Belgium in 2016 and brings together well-established lists. Continually evolving, this digital regional platform has been set up to this cause to expose its sixty ecosystem services. Its main purpose

is to reveal all the services provided of the ecosystems of the territory to act for a sustainable development. They are interesting to dissect in the sense that they are part of the most recent proposals. Their main inspiration was European CICES lists.

8 Finally, another proposal for the national and local scale in France is appeared under the directives of the Ministry of the Environment, in 2017. Under the title of French evaluation of ecosystems and ecosystem services (EFESE). This approach was aimed at helping decision-making to better manage biodiversity. Mainly based on interdisciplinarity and pooling efforts, the teams aimed for a multidimensional evaluation. The lists proposed under this governance are inspired by the MEA and other sources resulting from state policies such as those of England and Spain. So, they offer an interesting vision to explore necessarily.

To follow this configuration help to better conclude on the contents of all lists. The idea is to zoom in on the content of reference lists (those of the MEA) so famous for its results after a colossal work involving a hundred researchers. Then to compared them with the contents of all lists inspired and recently proposed by UK NEA of Mace et al. (2011), TEEB (2012), International Union for the Conservation of Nature France (IUCN) (2012), The Ecosystem Services in Wallonie Project (Wal-ES), (2016), Puydarrieux et al. (EFESE), (2017), FAO (2018) and Haines-Young and Potschin (CICES) (2018). With the idea that these have been developed and modified in the hope of a better configuration.

In a first step and in this functional framework, to see at the level of each distribution is important whether there is the possibility of correlating the classifications with each other and of detecting divergences. This first practice it does on a case by case basis. The procedure brings together the terms put in place to form the titles of ecosystem services by trying not to merge the nominations even in the case of resemblance. The only case where it mutates the resemblances between them is only when they are faithfully synonymous. This operation is repeated at the 32 service lists, knowing that each list lists several services.

Once the first step is done, the distribution of the services in the lists is projected for compare them visually. The form that each list takes on the radar determines the degree of its dispersion compared to the other classifications and all the services of a distribution. At the same time, the proportion of each list is analysed. That makes it possible to determine the size in relation to the total number of services under the same distribution. This proportion is: the sum of the terms (thus services) used by each organisation on the sum of the crossed terms for the eight institutions; knowing that they all share the same weight. For example, a list that records a proportion of 100% is the one that retains all possible terms (all lists combined) in its classification for a given function.

Also, the membership rate of each list to another is supervised. In the form of a ratio by couple of lists it that was concluded like this: for a list A and a list B, constituted respectively, of n and m ecosystem services (ES). The membership rate from list A to list B is the result of:

$$MR(AB) = \frac{\sum_0^n ESA \cap ESB}{\sum_0^n ESA}$$

Thus, the membership rate of list B to list A is:

$$MR(BA) = \frac{\sum_0^m ESB \cap ESA}{\sum_0^m ESB}$$

With $MR(AA) = MR(BB) = 1$.

This rate is calculated for each pair of lists, which gives 64 combinations under each function. This allows to see the degree of belonging of each list to its neighbours and to judge its composition by means of this parameter. The total combinations deployed at the end of the analysis is therefore 256 resulting values.

Then, basically, each time the eight lists intersect on the same service of the same distribution, this one is reported. The goal is to stumble over as many crossovers as possible to finally propose a classification of ecosystem services by function commonly share by all. This one will be proposed after the referencing of two categories of services:

- A group of ecosystem services that belong to a singular list named in this analysis: single list services.
- The other group of ecosystem services belonging to more than one list, but in no case to all the lists in this study, it is designated as the group of multi-list services. With the possibility of belonging to a family of two, three, four, five or six lists.
- One last set, shared by all lists or most lists (on a scale of $[(n - 1) / n]$ and/or $[(n - 2) / n]$) that named: common services group. Where n is the total number of services in a distribution.

In this way, it is possible to cross the points of convergence and divergence, to form common classification composed of two types of ecosystem services by function: so-called fixed services and so-called variable services. Where, the fixed services will represent the services accepted by all and which are part of the group of common services. Conversely, variable services will be those added irregularly from one list to another and are part of single-list and multi-list services.

It will finally be possible to conclude on the usefulness of the distribution by function and to leave arguments out of it. If the lists are similar overall, this means that the method has a robustness that allows it to be applicable to a direct quantisation exercise. If not, it will prove that it is still difficult to rely on such an approach in its current state. A new theoretical framework will therefore be proposed to optimise classification by function.

3 Results

As previously stated, a classification based on function identification imposes the division into four categories: supporting services, regulatory services, provisioning services and cultural services. The eight lists chosen: [MEA, 2005; Mace et al. (UK NEA), 2011; TEEB, 2012; International Union for the Conservation of Nature France (IUCN), 2012; The Ecosystem Services in Wallonie Project (Wal-ES), 2016; Puydarrieux et al. (EFESE), 2017; FAO, 2018; Haines-Young and Potschin (CICES), 2018] all agree on this categorisation and on the denominations of its four parts. Thus, the treatment is carried out in four times by type of category. Although all eight proposals are known through the quality research they conduct, and their teams have good profiles,

they sometimes have points of distinction. Their openly and internationally widespread classification does not necessarily fit on the terms expressing the services. Despite the deployment of the same reflection and the same methodological framework. After a thorough analysis of database, it was obtained the following results.

3.1 The shared classification of provisioning services lists

Provisioning services are readily available and easily held in ecosystems. By analysing the eight lists in this category, a total obtained of ten ecosystem services that are listed on all lists. The collection of this category of service is concretised in the census of all the contents of the lots of lists chosen. Ecosystem provisioning services are listed in their entirety as follows:

1 agrofuels (AG)

2 fibres/materials/raw materials (FM)

3 genetic resources (GR)

4 biochemistry, natural medicines and pharmaceuticals (medical resources) (B-NM-Ph)

5 freshwater (FW)

6 food/food products (F)

7 energy (E)

8 the air (A)

9 omnibus resources (OR)

10 biomass (B).

Initially, it notes that the terms used to express these services are sometimes simple, and sometimes to the more unclear senses. Sometimes it is just simple words like air and fresh water. But sometimes, a set of more complex words, such as for example biochemistry, natural medicines and pharmaceuticals (medical resources), who can house several components. At the same time, when it comes to fibres, materials and raw materials, the components can be numerous in relation to a service such as air which only materialises in one direction.

So, the terminologies do not seem consistent generally and give us a first idea of how they are chosen. Not all designation is at the same height and do not commonly appear to form. But overall, some terms look a little similar. Evoking fibres materials and raw materials is very broad compared to OR or GR for example. This shows that the choice of the term expressing an ecosystem service certainly has an impact on the announced repertoire. Thus, one can have in this case one-way services and others with composite sense. Which conceives the possible presence of sub-services. In the case of an assessment for example (or in the case of an environmental accounting) this aspect to a weight. Which leads to judge this mixture as being unsuitable with such practices, in its current state. Where is seen at least as a factor that causes confusion (especially if environmental sub-services accumulate).

But let's first look at the distribution of these ten services, which is shown on the Figure 1, where the composition of each list proposed by batch of organisations is displayed properly.

Obviously, from Figure 1 the eight lists are not alike. The listing of the provisioning services is not common according to the contents of the publications of these institutions, and this, despite the use of the same functional approach. The only concomitance is observed between the FAO list, that of the UK NEA and TEEB. They represent a perfectly identical classification. On the other hand, there are certainly points of intersection between all the lists, but in no other case a perfect resemblance. This confirms that there are inevitably readjustments that were made to the first version proposed by the reference list. Sometimes important approximations and sometimes marginal degree, this it pushes to check the proportions obtained by each list.

First, according to the results of Figure 2, the longest provisioning list is it is the one of IUCN. It brings together the largest number of ecosystem services under this category with a rate of 80% of components. Then followed by the proposal of the MEA and CICES commonly; which aggregate more than 60% of the services. This means that eventually IUCN extended the reference list by instructing additional elements, while the CICES remained on the same size of departure. Of course, here there are talking about form and not content. It ranks after all other lists that agree on the same proportion of 40%. They are therefore not very broad and do not bring together more than half of the provisioning services.

Figure 1 Distribution of provisioning services in the lists of MEA, UK NEA, TEEB, IUCN, Wal-ES, EFESE, FAO, CICES

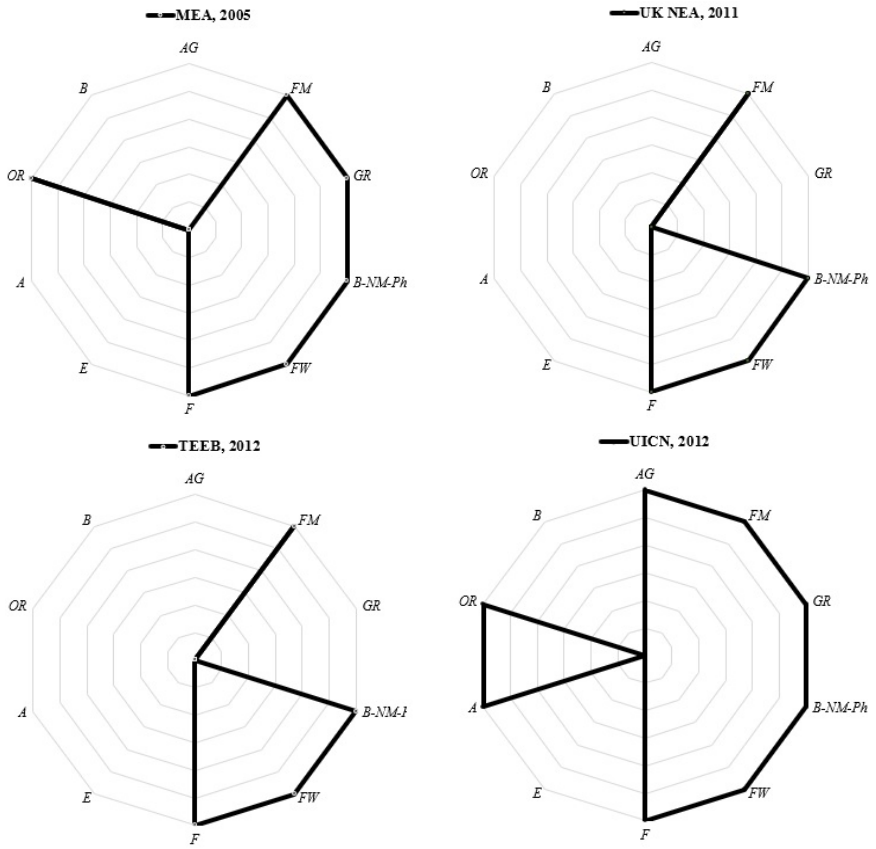


Figure 1 Distribution of provisioning services in the lists of MEA, UK NEA, TEEB, IUCN, Wal-ES, EFESE, FAO, CICES (continued)

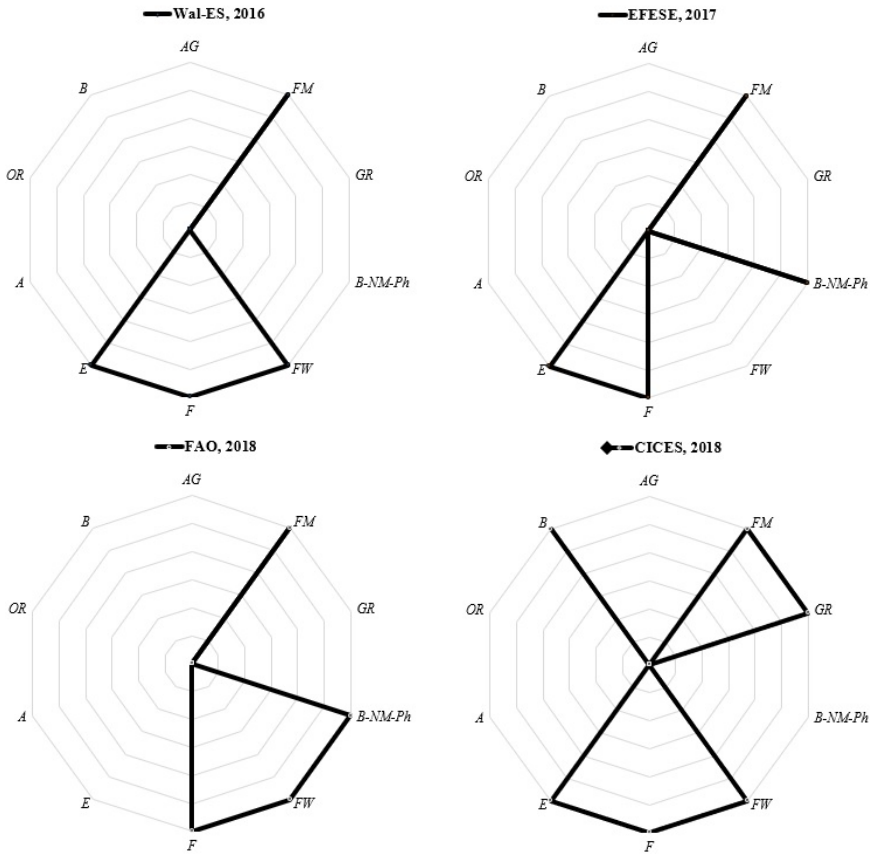
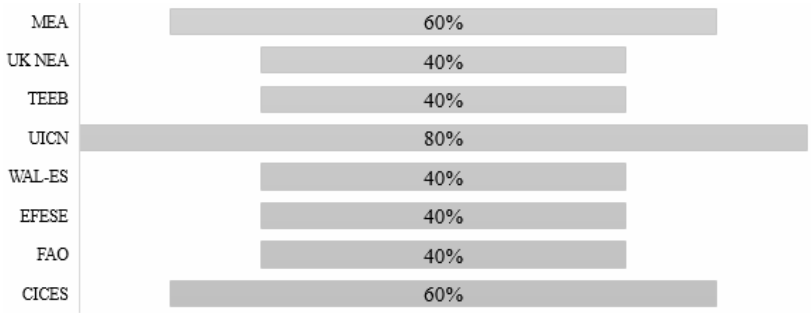


Figure 2 Sizes of the study provisioning services lists



However, by analysing the content, it is fended that there are exactly two common points present at the level of the ten lists at the same time: ‘fibres/materials/raw materials’ and ‘food/food products’. This means that, in practice, these organisations are bringing in common absolutely on only two out of ten provisioning services (a very small proportion). However, up to 88% and 75%, freshwater and medical resources are

respectively crossroads between our lists. We can say that these four services are confirmed provisioning services that have kept pace since their first categorisation in the 2000s.

On the bottom, also several multi-list services that can belong to a family of multiple lists at once. Most importantly, there are three single-list services from two separate lists, IUCN and CICES. These are clearly agrofuels, biomass and the air. It considerate that they are pure additions (which can also justify the length of the lists they propose).

Regarding the similarities, it is noted at first that the lists involve themselves in each other, but at different proportion. First, the reference list partly blends with all others, but strongly with the IUCN list. The classification of the UK NEA, TEEB and FAO are limping well or almost perfectly with all the other lists. Also, the proposals of WAL-ES and EFESE share the same membership levels vis-à-vis the other lists. Finally, the classification of CICES remains the most distant from the others with a minimum rate of 50%. Here, some similarities can be justified by the effect of influence that some lists have on others; sometimes even arrive at perfect conformity. Basically, the lists share crossover points at one time or another. With a more marginal degree for the contents of the CICES list (see Table 1).

Table 1 Level of ownership among the eight provisioning services classes in the study

	MEA	*UK NEA*	*TEEB*	*UICN*	*WAL-ES*	*EFESE*	*FAO*	*CICES*
MEA	*1.00*	0.67	0.67	0.83	0.50	0.50	0.67	0.67
UK NEA	1.00	*1.00*	1.00	1.00	0.75	0.75	1.00	0.75
TEEB	1.00	1.00	*1.00*	0.75	0.75	0.75	1.00	0.75
UICN	0.75	0.50	0.50	*1.00*	0.38	0.38	0.50	0.50
WAL-ES	0.75	0.75	0.75	0.75	*1.00*	0.75	0.75	1.00
EFESE	0.75	0.75	0.75	0.75	0.75	*1.00*	0.75	0.75
FAO	1.00	1.00	1.00	1.00	0.75	0.75	*1.00*	0.75
CICES	0.67	0.50	0.50	0.50	0.67	0.50	0.50	*1.00*

Table 2 Fixed and variable provisioning services after crossing the lists

Fixed provisioning services	Freshwater
	Fibres/materials/raw materials
	Food/food products
	Medical resources
Variable provisioning services	Agrofuel
	Genetic resources
	Energy
	The air
	Omnibus resources
	Biomass
	… (other)

Thus, the main finding is that the eight lists do not all coincide with each other. Despite some similarities, it is not possible to speak of a common, precise and exhaustive list of provisioning services. But the lack of cross makes it possible to conclude on the types of provisioning services.

Under a fixed and variable service's doctrine, the result obtained is four fixed ecosystem services belonging to this category and six variable services. Of course, in addition to these, it may be possible to have other variable services to add by the decision makers during a quantitative or evaluative work.

3.2 Shared classification of supporting services lists

Supporting services are these indispensable structures to produce the other services generated by ecosystems. They are characterised by a more subjective presence compared to other types of services and are perpetuated frequently over a longer period than their peers. Support services are very large habitat generators and contributors to soil formation and stabilisation. These services have a fundamental role in maintaining the overall balance. As part of this analysis and in the same configuration as the previous type of services, with question to identify all the ecosystem services supported by the eight organisations. Thus, this leads to the list of seven components:

1 habitat supply (species habitats) (HS)

2 formation and retention of soils (F-RS)

3 the nutrient cycle (NC)

4 photosynthesis (P)

5 primary production (PP)

6 the water cycle (W-C)

7 maintaining genetic diversity (MG).

At first glance here again, the terms used to express these services can sometimes fill a given service (as is the case with photosynthesis) or externalise several meanings and target sub-services (such is the case of HS where this service can be converted according to the type of habitat). But, in all the lists under this category, the listed services seem largely different from each other and do not appear to be fusional. What discards the idea of grouping, they are very dissimilar and project each one towards a distinct direction. In any case, the seven components of this category are shared across our eight lists, as shown in Figure 3.

Only on this category, CICES group and Wal-ES do not present any provisioning service. These two units chose to classify by function only in three categories by eliminating supporting services. According to their comments, this decision was taken as part of a reflection based on the notion of final services generated by ecosystems and directly used by humans.

Figure 3 Distribution of supporting services in lists of MEA, UK NEA, TEEB, UICN, Wal-ES, EFESE, FAO and CICES

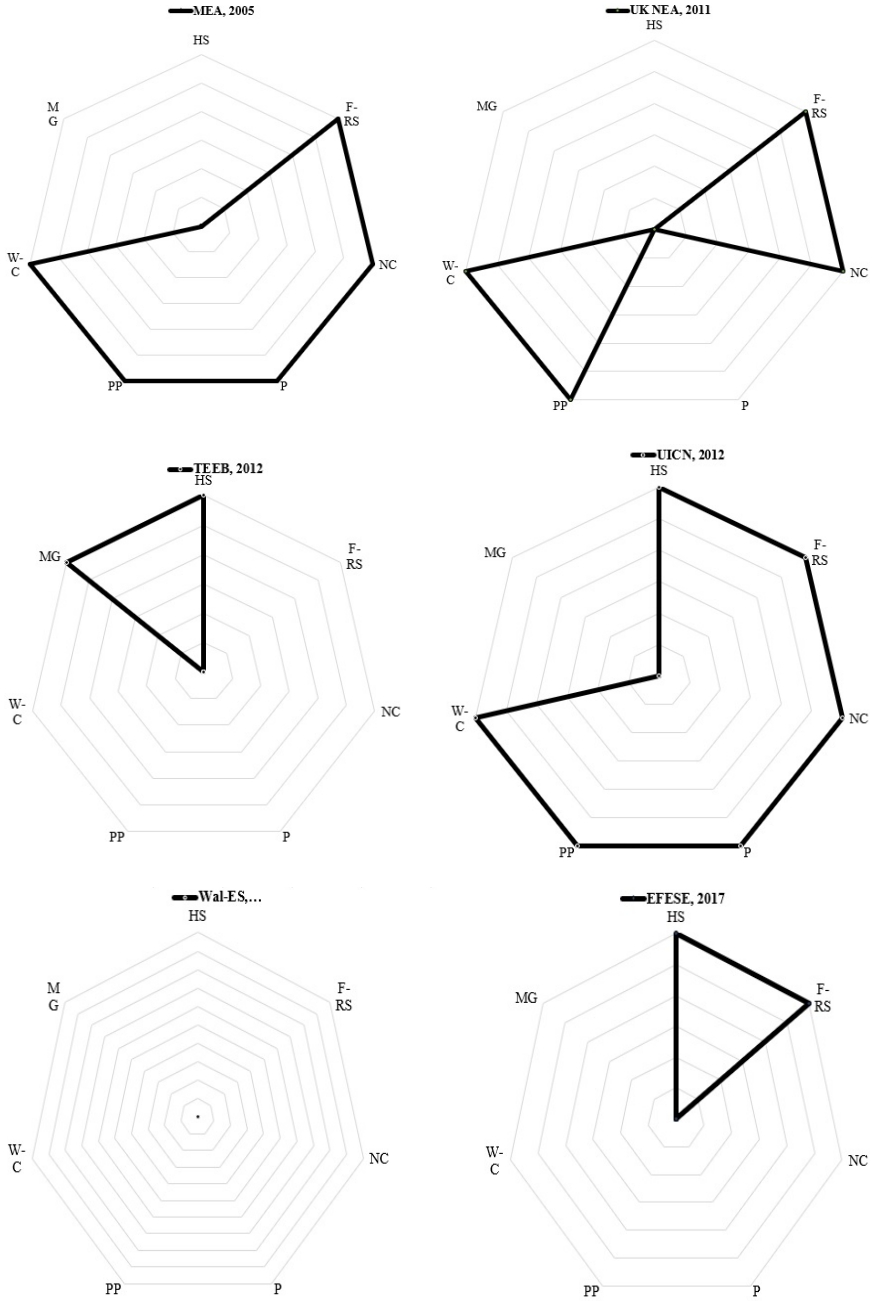
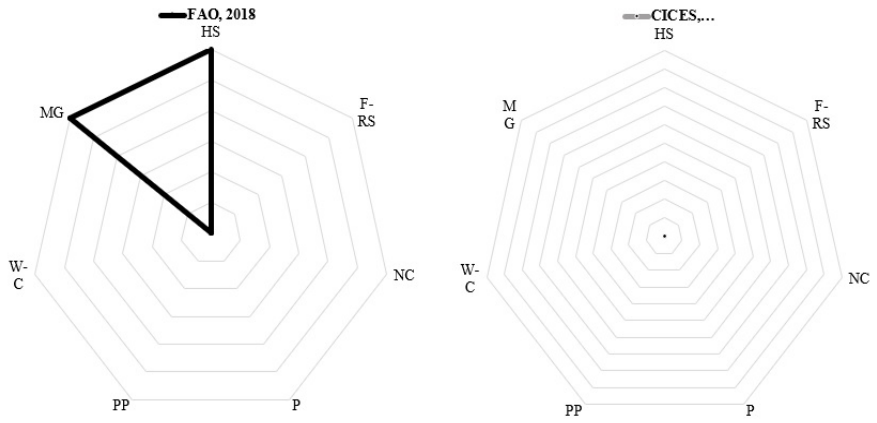


Figure 3 Distribution of supporting services in lists of MEA, UK NEA, TEEB, UICN, Wal-ES, EFESE, FAO and CICES (continued)

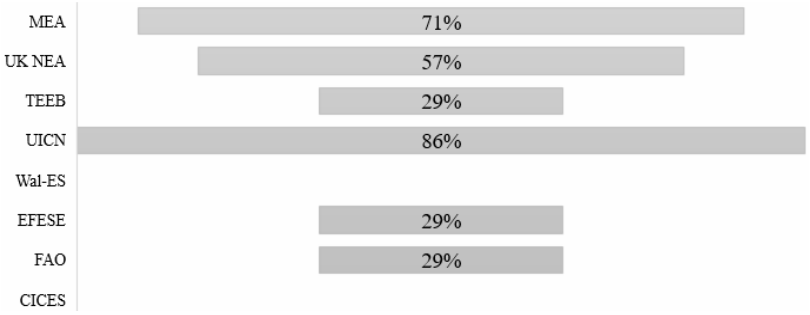


The CICES organisation justifies its choice by highlighting: "the exclusion of supporting services or intermediaries does not imply that they are irrelevant or that they can be neglected. It is a conscious choice, designed to focus efforts on a better description of the boundary between ecosystems and society, where ecosystem outcomes are transformed into benefits that contribute to human well-being" (Haines-Young and Potschin, 2012). It should be noted that such an approach has also been supported by the MEA report, where services of this type have been dismissed with the motivation that they are not directly used by the people. As a result, the analysis and comparison under this category are relied on the other six lists.

Here in Figure 3, it is directly observed a great resemblance between the profiles of the MEA and IUCN proposals. In addition to a perfect resemblance between the distribution of FAO services and TEEB. But again, the overview does not allow to see much interaction and crossover between the compositions. Again, it is impossible to have a list of standardised supporting services.

In terms of length, the most developed list is again that of IUCN which reaches 86% of the listed supporting services (see Figure 4). It is followed directly by the reference list at a close proportion. FAO, EFESE and TEEB summarise supporting services under two broad categories only. Thus, they hold the smallest lists (with a proportion of only 29%).

Figure 4 Sizes of the study supporting services lists



Basically, the distribution of supporting services is like this: no single-list service is available. This means the absence of common point between the four lists. However, the group of multi-list support services are all family type of two, three and four lists.

Therefore, it is remembered that despite the small number of services available under this category, there are only two services in common (in terms of majority) between the six lists at once. The two crossing points are: HS and F-RS. Although the proposals of MEA and IUCN are very close to each other, this does not mean that they are completely identical. On the other hand, the absence of the 'HS' service in the components of the MEA list remains an unexplained element.

Here again, it is fended that the choice of categories seems divergent between the eight organisations. But those who abstained, the remaining do not finally achieve the same results. This already suggests that there may be various ways to categorise supporting services and that the lists proposed in the literature do not seem very fixed at this time.

By channelling the similarity rates between the eight supporting services lists, it is can say that have a mixture of elements as shown in Table 3. Some lists overlap perfectly in others, for example the list UK NEA in relation with the contents of the MEA and IUCN. Or, those that mirror the proposals of TEEB and FAO.

As sometimes, other lists that do not mark any link on this category such as: FAO that does not share any services with the MEA, UK NEA and a few with the proposals of IUCN and EFESE. It is therefore retained relations that are less close than those of the previous classification, and this, despite the small number of employees. In addition to the lack of proposals WAL-ES and CICES which unfortunately do not spare supporting services.

Table 3 Level of ownership among the eight supporting services classes in the study

	MEA	*UK NEA*	*TEEB*	*UICN*	*WAL-ES*	*EFESE*	*FAO*	*CICES*
MEA	*1.00*	0.80	0.00	1.00	/	0.20	0.00	/
UK NEA	1.00	*1.00*	0.00	1.00	/	0.25	0.00	/
TEEB	0.00	0.00	*1.00*	0.50	/	0.50	1.00	/
UICN	0.83	0.67	0.17	*1.00*	/	0.33	0.17	/
WAL-ES	/	/	/	/	/	/	/	/
EFESE	0.50	0.00	0.50	1.00	/	*1.00*	0.50	/
FAO	0.00	0.00	1.00	0.50	/	0.50	*1.00*	/
CICES	/	/	/	/	/	/	/	/

Table 4 Fixed and variable supporting services after crossing the lists

Fixed supporting services	The habitat supply
	Formation and retention of soils
Variable supporting services	The nutrient cycle
	Photosynthesis
	Primary production
	The water cycle
	Maintaining genetic diversity
	… (other)

It is thus noted that for our final classification of support services that there are only two fixed services generated from this cross with a majority presence (67%): the HS and the F-RS and five variable services are identified.

3.3 The shared classification of regulating ecosystem services lists

Regulating services are those responsible for balancing ecosystem processes. Their impact is generally felt on the atmosphere and the quality of the climate. To verify the conformity of the services selected by the eight institutions, it is reproduced the same first procedure. First, the listing of all regulatory services is shown through the following eighteen services packages (all the lists combined):

1 climate regulation (global, regional and local) (GCR)

2 local climate and air quality (LC-AQ)

3 regulation of the local climate (RLC)

4 air quality regulation (AQR)

5 water regulation (WR)

6 erosion regulation/prevention of erosion and maintenance of soil fertility (ER)

7 pollination (Pol)

8 water purification and waste treatment/detoxification and waste degradation (WP-WT)

9 carbon sequestration and storage (CS)

10 natural hazard regulation/moderation of extreme events (moderation of extreme weather phenomena)/the regulation of natural risks/regulation of physical, chemical, biological conditions (NHR)

11 biological control/regulation of pests, infections and diseases (BC)

12 diseases regulation (DR)

13 pest regulation (PR)

14 regulation of growing and farming conditions (RG)

15 detoxification and purification in soils, air and water (pollution control) (DPSAW)

16 noise regulation (noise control)/reduction of olfactory nuisances, sound and visual (N)

17 other types of regulation and maintenance service by living processes (Otrs)

18 regulation of water circulation (RWC).

Several services fall into this category and the list appears longer than the previous ones. It seems to reflect the revealing effect of this type of ecosystem services that touches many axes. The appointments of the regulating services are sometimes very close to each other, but do not repeat themselves faithfully. The climate seems to be one of the most important elements in this classification. It is talked about climate regulation, its

geographical position, and even its relationship with the atmosphere, but by breaking down these properties on various services. The first four regulatory services could have been grouped under two main categories, for example: one will consternate the climate and the other the air quality.

Similarly, for the three services: 'WR', 'WP-WT' and 'RWC' which seem to be eligible to meet under the same title. The problem here is that some services that may be similar have terminology that point to divergent meanings. This prevents them from being united under the same title. It is not possible to mix them spontaneously, according to the way the services are entitled, any mutualisation can crush the meaning of one or the other. For this, we are forced to take these services in their original form.

Thus, the regulation of water is not synonymous with regulating the circulation of water; the first is vast, while the second is fastidious. It's therefore faced to a more meticulous treatment of the content during the comparison. The first conclusion about these combinations is therefore that it is probably possible to reduce our list of regulating services if the terms used were not spelled out. Thus, the terminology must be revisited as part of this study. But now, let's look at the distribution of regulating services packages in Figure 5.

Figure 5 Distribution of regulating services in lists of MEA, UK NEA, TEEB, Wal-ES, EFESE, FAO, CICES

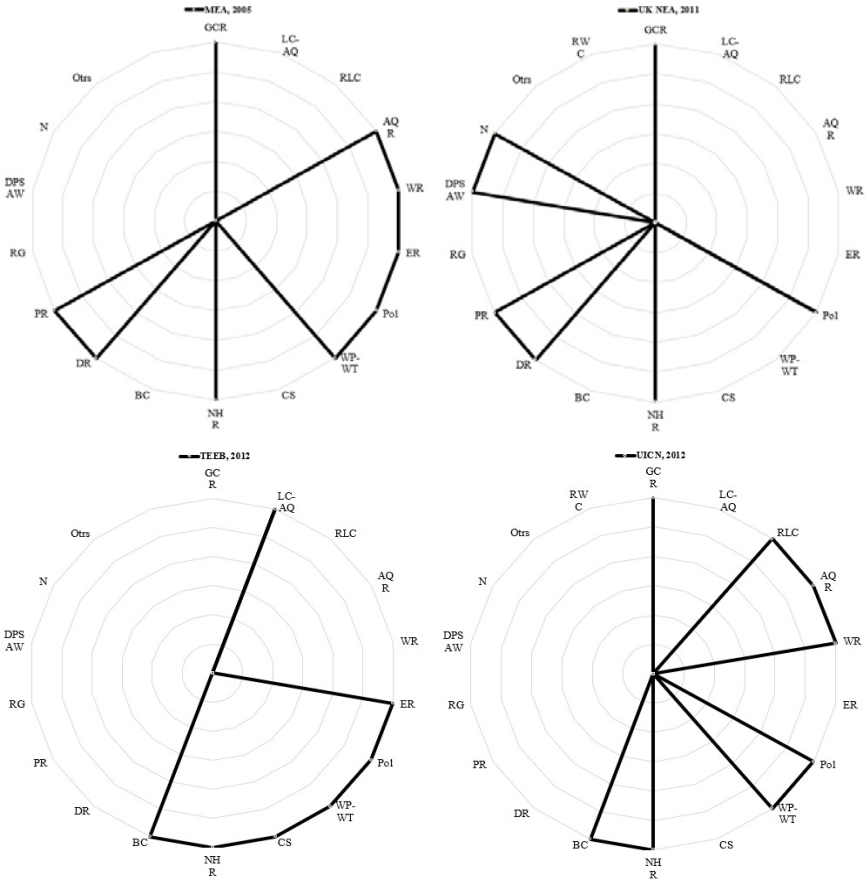
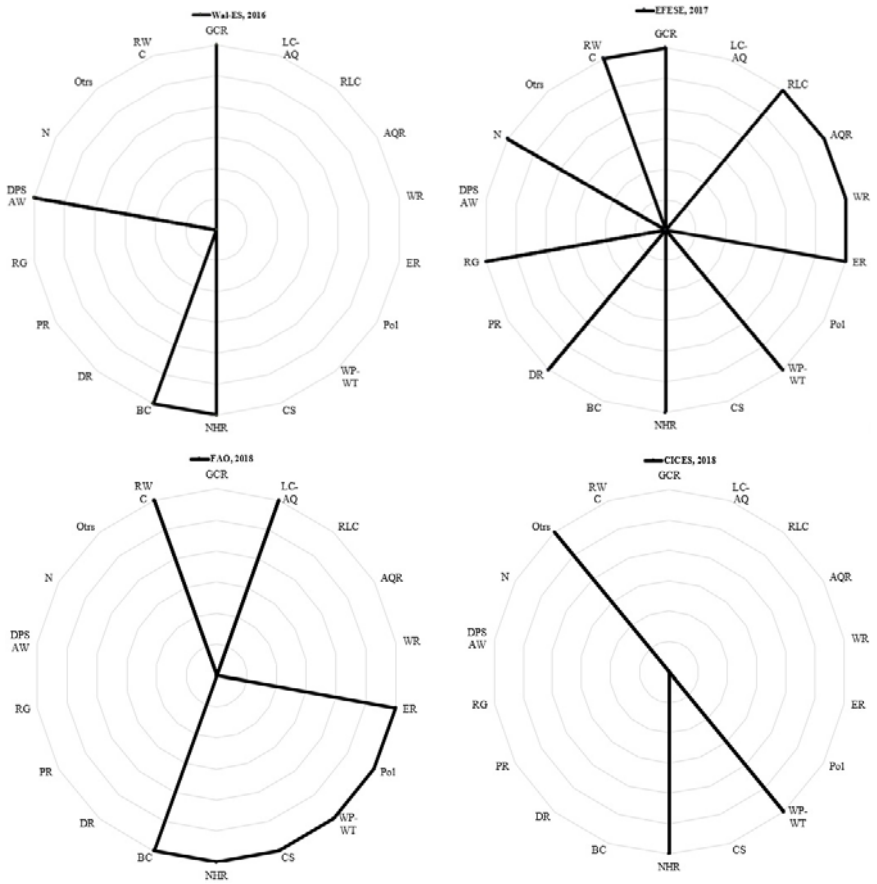


Figure 5 Distribution of regulating services in lists of MEA, UK NEA, TEEB, Wal-ES, EFESE, FAO, CICES (continued)

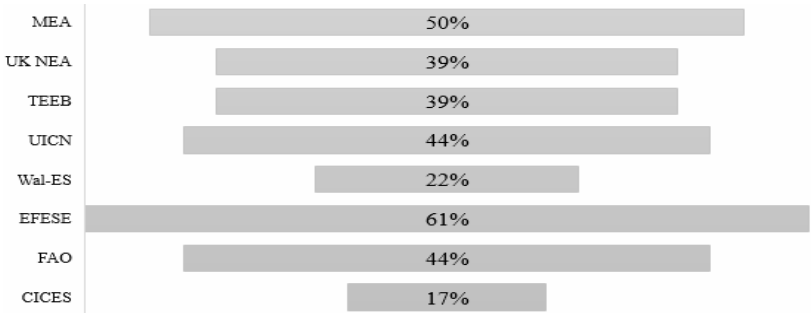


In general, the profiles do not agree on the composition of the regulating services. Thus, in terms of resemblance, the closest are the TEEB and FAO lists that share the same services classified in one detail; unlike other lists which diverge proportionally. It is noticed different forms from one list to another and especially that of the CICES which has spread the most through more or less personalised labels.

So, let's look at the membership of services to the different groups: first, we have detected the presence of two single list services under this category that are: 'RG and farming conditions' and all services under the appointment "other types of regulation and maintenance service by living processes." So, these are new regulating services compared to the rest and the main points of mismatch in an overview. It also states that the reference list has been revisited, including some added services.

On the same time, the focus on multi-list services allows us to notice that there are several strong cross points: climate regulation, pollination and WP-WT. But, especially the NHR service that leaves our lists unanimous about its integration under the class of regulatory services. All lists intersect at these four services to formulate the classification of the components of regulation.

Figure 6 Sizes of the study regulating services lists



The size of the lists published under this category is becoming less and less homogeneous except for those of CICES and Wal-ES which are very short at only 17% and 22% of the overall size. However, the list of EFESE is slightly more composed, thus demonstrating an inclusion of some services offered in addition to their version of 2005. Overall, the lists are shared with each other services and different crossing points as the shows Table 5. They are often included in each other, but not so much that they look completely alike.

Table 5 Level of ownership among the eight regulating services classes in the study

	MEA	*UK NEA*	*TEEB*	*UICN*	*WAL-ES*	*EFESE*	*FAO*	*CICES*
MEA	*1.00*	0.56	0.44	0.67	0.22	0.78	0.44	0.22
UK NEA	0.71	*1.00*	0.29	0.43	0.43	0.57	0.29	0.14
TEEB	0.57	0.29	*1.00*	0.57	0.29	0.43	1.00	0.29
UICN	0.75	0.38	0.50	*1.00*	0.38	0.38	0.50	0.25
WAL-ES	0.50	0.75	0.50	0.75	*1.00*	0.50	0.50	0.25
EFESE	0.64	0.36	0.27	0.55	0.18	*1.00*	0.36	0.18
FAO	0.50	0.25	0.88	0.50	0.25	0.50	*1.00*	0.25
CICES	0.67	0.33	0.67	0.67	0.33	0.67	0.67	*1.00*

A strong divergence is also noticed between the lists of regulating services. The profiles are very varied from one list to another, hence the high number of services. It can be said that this type of service probably gives rise to confusion and its categorisation does not seem very symmetrical. Here, the question may be to agree on terms that can better describe the service. This may be a question that should be explored further in future work. This can lead to the development of, for example, a tool such as standardised glossaries specifically designed for the treatment of ecosystem services. In any case, it is necessary to converge towards more accuracy in the choice of services. Therefore, it is retaining regulatory services in the form presented in Table 6. With a total of four fixed regulation services and fourteen variable services.

Table 6 Fixed and variable regulating services after crossing the lists

Fixed regulating services	Pollination
	Water purification and waste treatment
	Natural hazard regulation
	Climate regulation
Variable regulating services	Local climate and air quality
	Regulation of the local climate
	Air quality regulation
	Water regulation
	Erosion regulation
	Carbon sequestration and storage
	Biological control (regulation of pests, infections and diseases)
	Diseases regulation
	Pest regulation
	Regulation of growing and farming conditions
	Detoxification and purification in soils, air and water (pollution control)
	Noise regulation (noise control)
	Other types of regulation and maintenance service by living processes
	… (other)

3.4 Shared classification of cultural ecosystem services lists

The category of cultural services is certainly the most abstract. According to the definition proposed by the MEA (2005), these are the intangible benefits (spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences, etc.). Thus, this type of service is the result of human beliefs and convictions that are directly related to the environment. This appears through the bonds that man creates and develops when he expresses his attachment to certain natural structures.

Subsequently, given the prestigious place that this type of service occupies in the constitution of the identity of the society, an overview on the ecosystem services under this category are interesting to discover, so more than thirteen components in total were gathered:

1 cultural diversity (CD)

2 spiritual and religious values/spiritual experience and sense of belonging/indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting (Srv)

3 other abiotic characteristics of nature that have cultural significance (OtersC)

4 educational values (EV)

5 inspiration (I)

6 social relations (SR)

7 sense of place/landscape landscaping (SP)

8 values of cultural heritage (VCH)

9 environmental settings (Eset) (recreation, tourism, spiritual, religious)/environment of everyday/direct in-situ and outdoor interactions with living systems that depend on presence in the environmental setting/recreation and mental and physical health (Es)

10 services with a cultural dimension (SCD)

11 leisure-sized services environment for recreation/tourism/ecotourism (LSS)

12 sources of experience and knowledge/knowledge systems (SEK)

13 aesthetic awareness and inspiration in culture, art and design/sources of inspiration and values (AAI).

At first sight, the list also seems consistent and above all a little more complex. It seems that the ranking of cultural services divides the choices of our eight organisations. This is evident in the displayed distribution, with a mix of one-way services and others in the broad sense. The presence of sub-service groups is highly anticipated under certain appointments; for example, under the service 'SCD'. However, decomposition into subcomponents seems possible with very compound titles.

The first impression that can be found is the kind of instability that appears in these cultural lists. Full of services have a special meaning and far removed from others. Eventually, this finding expresses a reluctance certainly involuntary or may be due to the complex status that may have the establishment of cultural services. The link between nature and society has never been easy to value. The figure above represents the possible distributions and crossings here of our respective lists.

Figure 7 Distribution of cultural services in lists of MEA, UK NEA, TEEB, UICN, Wal-ES, EFESE, FAO, CICES

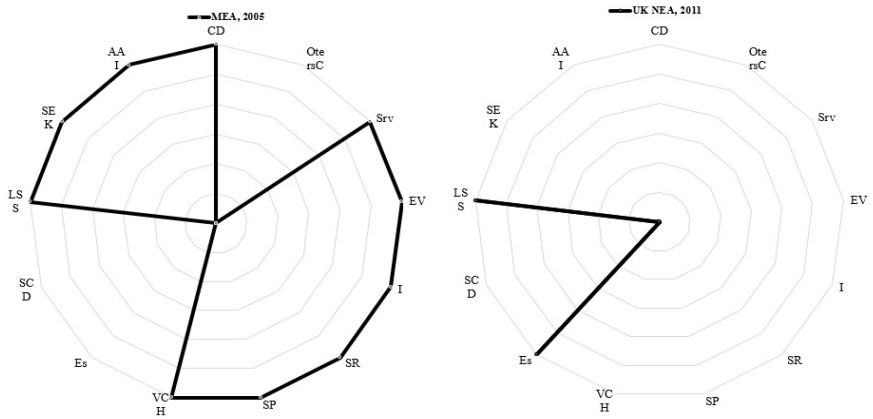
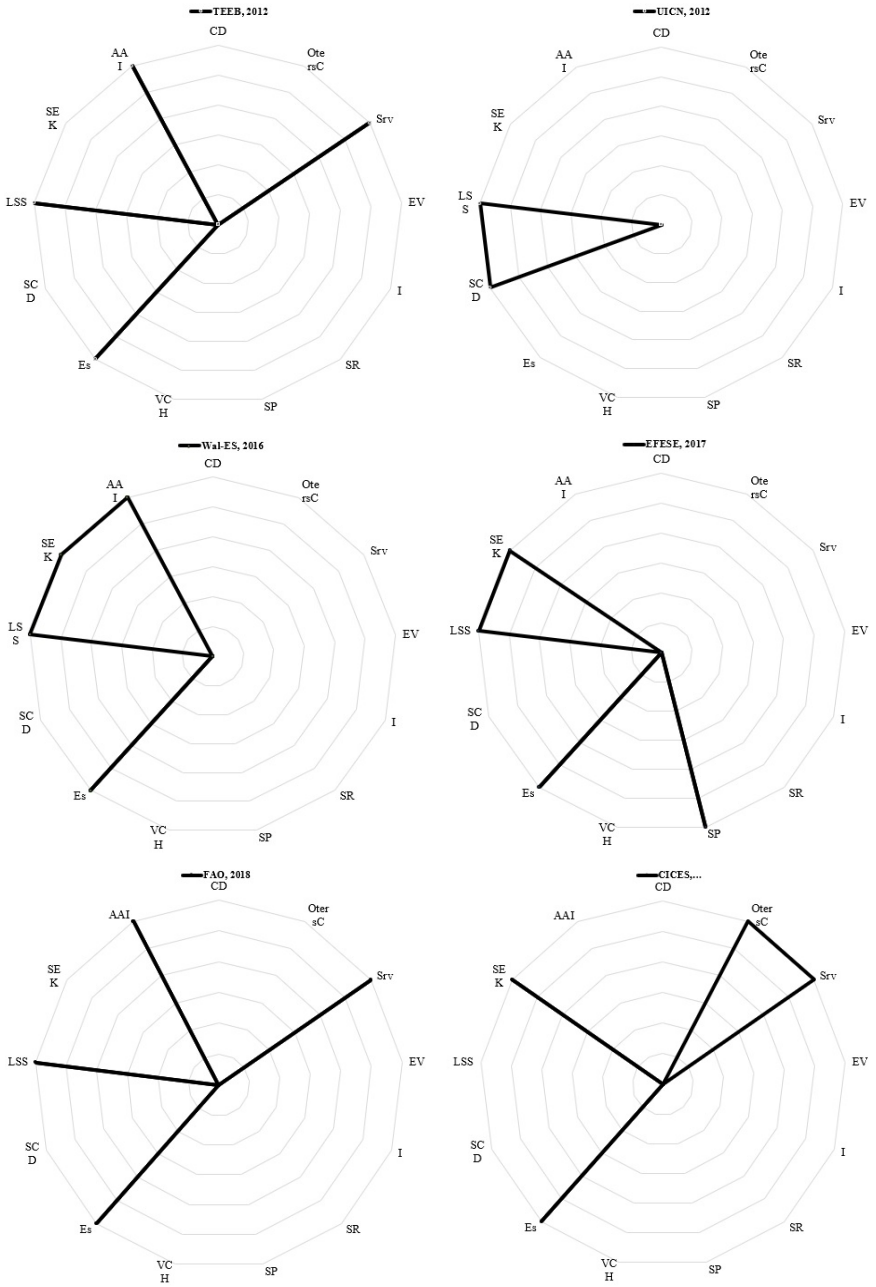


Figure 7 Distribution of cultural services in lists of MEA, UK NEA, TEEB, UICN, Wal-ES, EFESE, FAO, CICES (continued)

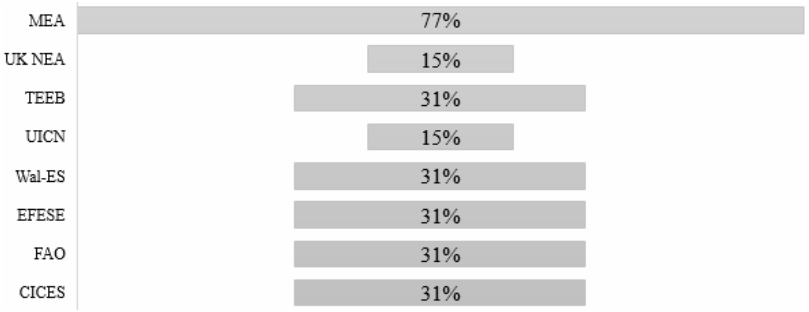


In this category, the lists of TEEB and FAO are faithful to each other, as in most case and are practically the only ones. All the other services are really scattered (no common point for the five lists) and no crossing is envisaged an absolute. Each organisation offers its own categorisation of cultural services and appropriates nominations differently. Even

the reference list does not seem to have any effect on the proposals. The latter has also focused on the retail strategy with several services recorded and precise and pointed titles. While the inspired lists sometimes chose the synthesis (in the form of categories) especially IUCN and UK NEA with an abstention to two groups of cultural services.

Regarding the texture of the lists of cultural services, none of lists has as many services as reference's list; scoring a record 77% of the included items (see Figure 8). Proportional size and greatly reduced lists do not exceed 31% outside the UK NEA and IUCN lists that do not exceed the 15% threshold (which makes them the shortest lists).

Figure 8 Sizes of the study cultural services lists



It is clear that the reference list has been retouched and indeed changed for a will of best use. However, faced with the rare crosses observed, it is clear, the rate of divergence is high within this selection. This also appears in the combination between lists like illuminated in Table 7.

Table 7 Level of ownership among the eight cultural services classes in the study

	MEA	*UK NEA*	*TEEB*	*UICN*	*WAL-ES*	*EFESE*	*FAO*	*CICES*
MEA	*1.00*	0.10	0.30	0.10	0.30	0.30	0.30	0.20
UK NEA	0.50	*1.00*	1.00	0.50	1.00	1.00	1.00	0.50
TEEB	0.75	0.50	*1.00*	0.25	0.75	0.50	1.00	0.50
UICN	0.50	0.50	0.50	*1.00*	0.50	0.50	0.50	0.00
WAL-ES	0.75	0.50	0.75	0.25	*1.00*	0.75	0.75	0.50
EFESE	0.75	0.50	0.50	0.25	0.75	*1.00*	0.50	0.50
FAO	0.75	0.50	1.00	0.25	0.75	0.50	*1.00*	0.50
CICES	0.50	0.25	0.50	0.00	0.50	0.50	0.50	*1.00*

Membership level shows that the MEA services are not widely shared with the rest of the classifications. Apart from this list, the others overlap with each other, with some exceptions (the CICES does not share anything in common with the IUCN list). Therefore, cross-listing leads to many single-list services, mostly from the MEA list; but not only. The maximum branching possible under this category is the service belonging to families of seven lists and entitled: "environmental settings (recreation, tourism, spiritual/religious)/environment of everyday/direct in-situ and outdoor interactions with living systems that depend on presence in the environmental setting."

Table 8 Fixed and variable cultural services after crossing the lists

Fixed cultural services	Environmental settings
	Leisure-sized services
Variable cultural services	Cultural diversity
	Other abiotic characteristics of nature that have cultural significance
	Spiritual and religious values/indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting
	Educational values
	Inspiration
	Social relations
	Sense of place
	Values of cultural heritage
	Services with a cultural dimension
	Sources of experience and knowledge
	Aesthetic awareness and inspiration in culture, art and design
	… (other)

This service is large enough and allows the inclusion of several sub-services. Given this observation, the outcome of this analysis leads to two fixed cultural services and 11 variables services (they are listed in Table 8).

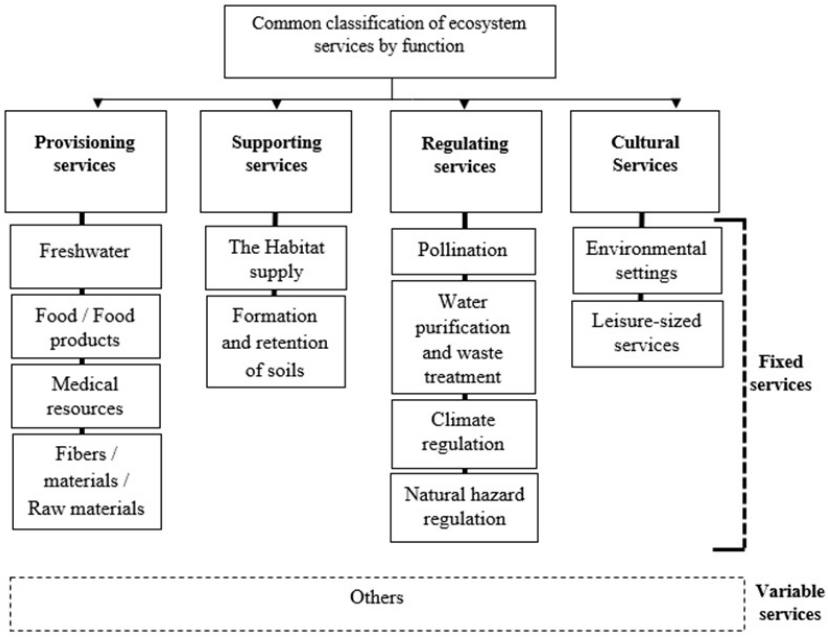
3.5 Towards a shared functional classification of ecosystem services

Apparently, the partial comparison indicates a remarkable divergence of the contents of the lists by function and mark convergences under the four distributions. Overall, when collect provisioning services that obtain only three identical lists out of the eight existing ones. In addition to supporting services capturing two totally identical lists only and two others very similar. Also, lists of regulating services very different from each other and cultural services not really shared by all and only at scale of two lists similar. Finally, the differences are channelled into the content of our respective lists.

The four function categories do not have the same ecosystem service components. Each organisation appropriates part of listing of environmental services. But, beyond this first observation, it is possible to retain interesting common points and through their prospection it is freeze a preliminary list to initiate a quantification. Crosses of ecosystem services from those lists have led to the development of a well-identified first classification. It is considerate here that from the moment when the majority of the eight organisations agree on certain points jointly; these positions are validated. Although they are not closed to opportunities to improve their nomination and identification. Of course, it is clear that discard all other wacky services that have made only a few appearances in rare classifications. This does not exclude them from use and does not mean their impertinence, but their use requires more scientific discussion and it is for this reason that they are grouped under the category of variable services.

Thus, to assist the initiation of any quantification exercise, or even the assessment of environmental flows, it is represented the following configuration of the classification of ecosystem services by function.

Figure 9 Common classification of ecosystem services by function after crossing lists of MEA, UK NEA, TEEB, UICN, Wal-ES, EFESE, FAO, CICES



Being a cross-certified classification performed in this comparative analysis, its use can help to encourage initiation into environmental reviews. Based on the fixed elements of this shared classification and with this non-exhaustive list of services of any kind, it would be possible to initiate an enumeration of the component into services of a natural space. Of course, the crossover has led to a theorisation of functional classification, but use remains to be adopted in the best of ways. Variable services are to be added as and when the specificity of the site in question. This contribution can be considered as a tool to help with quantification. It presents a model listing that can be readjusted and better adapted.

4 Conclusions

The concept of ecosystem services is today the appointment of the pivotal concept as it infiltrates virtually all disciplines. Highly coveted by environmental stakeholders, it has the merit of being better studied. Its use has evolved over a long period as it has become clear to include this concept in all environmental policies.

For this purpose, the success of the Millennium Ecosystem Assessment report has contributed to the spread of the method for classifying ecosystem services by function. The latter is known for its simplicity and fluidity to divide the services into several categories. In the continuity, other lists appeared over time and they have evolved and changed. In this comparative analysis, it was a question of following a strategy to check the gaps between the lists of references and other lists available in the literature; most of which are directly inspired by the original lists. However, the comparison of eight lists of global organisations, all using the same method, has shown very interesting results. We

can no longer speak today of a classification by function, but rather of the existence of several functional classifications.

First, there is a large difference in the content of the ecosystem service lists. Some lists have shown the example of a ranking based on the choice of a panel of ecosystem services far from the original lists. This process is one of the phenomena that complicates the work of the evaluators. The volatility of information and the changing natures of public policies have a great impact on the quantification of ecosystem services.

Second, the divergence of terms attributed to services complicates their quantification. The problem lies in substance and in the components of the classifications. Based on the results of this comparative test, the use of function classification in its current form is not the effective solution for quantifying. It is not the lists that pose a problem, but rather their coherence. Currently, you have to make a choice between the different proposals. This can lead to controversy, where the legitimacy of the choice is questioned.

Fortunately, the analysis also demonstrated several points of convergence between the existing lists. To provide a precise methodological framework for the development of environmental treatment, these crossing points have been identified and valued. Thus, the use of the shared classification makes it possible to remove the evaluators from criticism due to the instability of the classification methods. Since in the absence of a standardised classification, negative discussions may result from such work. Proposals for the categorisation of services should be based on a benchmark list accepted by all. What it is propose in this article is a first version of a cross classification. It will support the launch of quantification and support tool for evaluation. Such an application necessarily requires future scientific improvement. We hope through this contribution open the field of discussions around this issue.

References

Bouwma, I., Schleyer, C., Primmer, E., Winkler, K.J., Berry, P., Young, J., Esther, C., Spulerovà, J., Bezàk, P., Preda, E. and Vadineanu, A. (2018) 'Adoption of the ecosystem services concept in EU policies', *Ecosystem Services*, Vol. 29, Part B, pp.213–222.

Boyd, J. and Banzhaf, S. (2007) 'What are ecosystem services? The need for standardized environmental accounting units', *Ecological Economics*, Vol. 63, Nos. 2–3, pp.616–626.

Chevassus-au-Louis, B. (2012) 'Les services écologiques des forêts: définition des concepts, origine et typologies', *Revue Forestière Française*, Vol. 64, No. 3, pp.213–224.

Costanza, R. and Daly, H.E. (1992) 'Natural capital and sustainable development', *Conservation Biology*, Vol. 6, No. 1, pp.37–46.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. (1997) 'The value of the world's ecosystem services and natural capital', *Nature*, Vol. 387, No. 6630, pp.253–260.

Daily, G.C. (1997) *Nature's Services*, Island Press, Washington, DC.

Daly, H.E. (1977) *Steady-State Economics: the Economics of Biophysical Equilibrium and Moral Growth*, W.H. Freeman, San Francisco.

Fisher, B. and Turner, R.K. (2008) 'Ecosystem services: classification for valuation', *Biological Conservation*, Vol. 141, No. 5, pp.1167–1169.

Fisher, B., Turner, R.K. and Morling, P. (2009) 'Defining and classifying ecosystem services for decision making', *Ecological Economics*, Vol. 68, No. 3, pp.643–653.

Food and Agriculture Organization of the United Nations (FAO) (2018) [online] http://www.fao.org/ecosystem-services-biodiversity (accessed 24 January 2019).

Groupe de travail de l'Étude sur l'importance de la nature pour les Canadiens (2017) *Completing and Using Ecosystem Service Assessment for Decision-Making: an Interdisciplinary Toolkit for Managers and Analysts*, Report En4-295/2016F-PDF, Environment and Climate Change, Canada, Centre de renseignements, Les gouvernements fédéral, provinciaux et territoriaux, Ottawa, ON [online] http://publications.gc.ca/collections/collection_2017/eccc/En4-295-2016-fra.pdf (accessed 1 February 2019).

Haines-Young, R. and Potschin, M. (2012) *Common International Classification of Ecosystem Services (CICES, Version 4.1)*, Centre for Environmental Management, University of Nottingham, Vol. 33, p.107 [online] https://cices.eu/content/uploads/sites/8/2012/09/CICES-V4_Final_26092012.pdf (accessed 24 January 2019).

Haines-Young, R. and Potschin, M.B. (2018) *Common International Classification of Ecosystem Services (CICES) V5. 1 and Guidance on the Application of the Revised Structure*, European Environment Agency (EEA) [online] https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf (accessed 1 February 2019).

Hein, L., Van Koppen, K., De Groot, R.S. and Van Ierland, E.C. (2006) 'Spatial scales, stakeholders and the valuation of ecosystem services', *Ecological Economics*, Vol. 57, No. 2, pp.209–228.

Holland, J., Jeanneret, P., Herzog, F., Moonen, A.C., Rossing, W., van der Werf, W., Kiss, J., van Helden, M., Paracchini, M.L., Cresswell, J., Pointereau, P., Heijne, B., Veromann, E., Antichi, D., Entling, M. and Balázs, B. (2014) 'The QuESSA project: quantification of ecological services for sustainable agriculture', *Landscape Management for Functional Biodiversity*, Vol. 100 [online] https://www.researchgate.net/profile/John_Holland2/publication/262826769_The_QuESSA_Project_Quantification_of_Ecological_Services_for_Sustainable_Agriculture/links/02e7e538f368d9e20a000000.pdf (accessed 5 February 2019).

Kremen, C. (2005) 'Managing ecosystem services: what do we need to know about their ecology?', *Ecology Letters*, Vol. 8, No. 5, pp.468–479.

La Notte, A., D'Amato, D., Mäkinen, H., Paracchini, M.L., Liquete, C., Egoh, B., Geneletti, D. and Crossman, N.D. (2017) 'Classification des services écosystémiques: perspective de l'écologie des systèmes du cadre en cascade', *Indicateurs écologiques*, Vol. 74, pp.392–4023.

Landers, D.H. and Nahlik, A.M. (2013) *Final Ecosystem Goods and Services Classification System (FEGS-CS)*, Report Number EPA/600/R-13/ORD-004914, Anonymous EPA United States Environmental Protection Agency [online] https://gispub4.epa.gov/FEGS/FEGS-CS%20FINAL%20V.2.8a.pdf (accessed 12 December 2018).

Mace, G.M., Albon, S., Balmford, A., Brown, C., Church, A., Haines-Young, R., Pretty, J., Turner, K., Vira, B. and Winn, J. (2011) *Conceptual Framework and Methodology*, The UK National Ecosystem Assessment Technical Report, UK National Ecosystem Assessment, UNEP-WCMC, Cambridge [online] http://catalog.ipbes.net/system/assessment/1/references/files/7/original/Ch2ConceptualFramework.pdf?1346667949 (accessed 11 February 2019).

Millennium Ecosystem Assessment (MEA) (2005) *Écosystèmes et bien-êtrehumain*, Island Press, Washington, DC.

Neugarten, R.A., Langhammer, P.F., Osipova, E., Bagstad, K.J., Bhagabati, N., Butchart, S.H., Butchart, S., Dudley, N., Elliott, V., Gerber, L., Gutierrez Arrellano, C., Ivanic, K.Z., Kettunen, M., Mandle, L., Merriman, J.C., Mulligan, M., Peh, K., Raudsepp-Hearne, C., Semmens, D.J., Stolton, S. and Willcock, S. (2018) *Tools for Measuring, Modelling, and Valuing Ecosystem Services: Guidance for Key Biodiversity Areas, Natural World Heritage Sites, and Protected Areas*, Series Editor, Craig Groves [online] https://portals.iucn.org/library/sites/library/files/documents/PAG-028-En.pdf (accessed 2 February 2019).

Pagiola, S. and Platais, G. (2002) *Payments for Environmental Services, Environment*, Environment Strategy Notes Report No. 3, World Bank, Washington, DC [online] http://documents.worldbank.org/curated/en/983701468779667772/pdf/296710English0EnvStrategyNote302002.pdf (accessed 1 July 2010).

Patil, P., Lange, G-M., Jain, S., Mealey, E., Narain, U., Delos Angeles, M., Behrendt, H., Naikal, E., Cantrell, J. and Aguilar, G. (2012) *Moving Beyond GDP: how to Factor Natural Capital into Economic Decision Making*, World Bank, Washington, DC [online] http://documents.worldbank.org/curated/en/724461468157521765/pdf/696120WP0Movin00606020120Box369282B.pdf (accessed 24 March 2017).

Pesche, D. and Méral, P. (2016) *Les services écosystémiques: repenser les relations nature et société*, Quae ed., Paris, Versailles 78026, France.

Puydarrieux, P., Beaufaron G., Bruley, E., Darses, O., Degeorges, P., Devaux, J., Fiorina, C., Kervinio, Y. and Sapijanskas, J. (2017) 'EFESE: l'évaluationfransaise des écosystèmes et des services écosystémiques: Cadre conceptuel', Ministèe de l'environenement, de l'énergie et de la mer, en charge des relations internationals sur le climat [online] https://www.ecologique-solidaire.gouv.fr/sites/default/files/Thema%20-%20Efese%20-%20Le%20cadre%20conceptuel.pdf.

Reid, W.V., Mooney, H.A., Cropper, A., Capistrano, D., Carpenter, S.R., Chopra, K., Dasgupta, P., Dietz, T., Duraiappah, A.K., Hassan, R., Kasperson, R., Leemans, R., May, R.M., McMichael, A.J., Pingali, P., Samper, C., Scholes, R., Watson, R.T., Zakri, A.H., Shidong, Z., Ash, N.J., Bennett, E., Kumar, P., Lee, M.J., Raudsepp-Hearne, C., Simons, H., Thonell, J. and Zurek, M.B. (2005) *Ecosystems and Human Well-Being – Synthesis: a Report of the Millennium Ecosystem Assessment*, p.137, Island Press, Washington DC, ISBN: 1597260401 [online] https://www.millenniumassessment.org/documents/document.356.aspx.pdf (accessed 02 June 2018).

Tallis, H., Mooney, H., Andelman, S., Balvanera, P., Cramer, W., Karp, D., Polasky, S., Reyers, B., Ricketts, T., Running, S., Thonicke, K., Tietjen, B. and Walz, A. (2012) 'A global system for monitoring ecosystem service change', *Bioscience*, Vol. 62, No. 11, pp.977–986.

The Economics of Ecosystems and Biodiversity (TEEB) (2012) [online] http://www.teebweb.org (accessed 29 January 2019).

The Ecosystem Services in Wallonie Project (2016) [online] http://webserver.wal-es.be (accessed 2 February 2019)

Therond, O., Tichit, M., Tibi, A., Accatino, F., Biju-Duval, L., Bockstaller, C., Bohan, D., Bonaudo, T., Boval, M., Cahuzac, E., Casellas, E., Chauvel, B., Choler, P., Constantin, J., Cousin, I., Daroussin, J., David, M., Delacote, P., Derocles, S., De Sousa, L., Domingues Santos, J.P., Dross, C., Duru, M., Eugène, M., Fontaine, C., Garcia, B., Geijzendorffer, I., Girardin, A., Graux, A-I., Jouven, M., Langlois, B., Le Bas, C., Le Bissonnais, Y., Lelièvre, V., Lifran, R., Maigné, E., Martin, G., Martin, R., Martin-Laurent, F., Martinet, V., McLaughlin, O., Meillet, A., Mignolet, C., Mouchet, M., Nozières-Petit, M-O., Ostermann, O.P., Paracchini, M.L., Pellerin, S., Peyraud, J-L., Petit-Michaut, S., Picaud, C., Plantureux, S., Poméon, T., Porcher, E., Puech, T., Puillet, L., Rambonilaza, T., Raynal, H., Resmond, R., Ripoche, D., Ruget, F., Rulleau, B., Rusch, A., Salles, J-M., Sauvant, D., Schott, C. and Tardieu, L. (2016) *Volet 'écosystèmes agricoles' de l'Evaluation Française des Ecosystèmes et des Services Ecosystémiques (EFESE)*, Rapport d'étude, Inra, France [online] https://inra-dam-front-resources-cdn.brainsonic.com/ressources/afile/419255-b2a7d-resource-efese-services-ecosystemiques-rendus-par-les-ecosystemes-agricoles-rapport-avant-propos.pdf (accessed 25 May 2018).

Union Internationale pour la Conservation de la Nature France (2012) *Panorama des services écologiques fournis par les milieux naturels en France*, Vol. 1, Contexte et enjeux, Paris, France [online] http://uicn.fr/wp-content/uploads/2016/09/Brochure_Panorama_des_services-vol1.pdf (accessed 22 January 2019).

United Nations, European Union, Food and Agriculture Organization of the United Nations, International Monetary Fund Organisation for Economic Co-operation and Development and The World Bank (2012a) *System of Environmental-Economic Accounting: Central Framework*, Document Symbol: ST/ESA/STAT/Ser.F/109, New York [online] https://unstats.un.org/unsd/envaccounting/seearev/seea_cf_final_en.pdf (accessed 5 February 2019).

Wallace, K.J. (2007) 'Classification of ecosystem services: problems and solutions', *Biological Conservation*, Vol. 139, Nos. 3–4, pp.235–246.