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Review

# Indicators of Cultural Ecosystem Services for urban planning: A review

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ABSTRACT

The concept of Ecosystem Services has gained traction on the scientific agenda and has found its way into research on urban environments. Cities and towns, like any other ecosystem, provide specific services to their inhabitants and communities and they are benefited by surrounding ecosystems as well. Among the different categories, typical Ecosystem Services categories such as food production and erosion control usually have a lesser importance within urban contexts. However, the very diverse range of land uses and ecosystems in urban contexts provide specific Cultural Ecosystem Services including recreational, cultural and educational values.

However, to date only limited attention has been given to the provision of Cultural Ecosystem Services (CES), especially considering the relevant benefits that communities and urban planning processes can derive from them. In this document we review existing approaches for the assessment of CES in urban contexts and provide a critical overview of how indicators are used to assess and measure CES. We first conduct a literature review on the indicators used for CES in urban contexts then the paper addresses some specific issues with reference to both operability and benefits of the use of CES indicators for urban planning and management.

Our results show that existing CES indicators have limited usability for urban planning and management. Moreover a lack of appropriate data use is a significant obstacle for proper CES assessment. This impacts the potential for sustainable decision-making concerning CES in urban contexts. These issues, together with fact that most identified indicators are proxy ones, identify an urgent need to develop proper assessment indicators for CES.



**Contents**



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## 1. Introduction

The concept of Ecosystem Services (ES) has gained traction on the scientific agenda and has found its way into research on urban environments. Cities and towns, like any other complex ecosystem, provide specific services to their inhabitants and communities (Bolund and Hunhammar, 1999; Gómez-baggethun and Barton, 2013; Haase et al., 2014) and they are benefited by surrounding ecosystems as well. In urban contexts, a diverse range of land uses and ecosystems provide different services including air filtration (gas regulation), micro-climate regulation, noise reduction (disturbance regulation), rainwater drainage (water regulation), sewage treatment (waste treatment), and recreational, cultural and educational values. Other services such as food production and erosion control usually have a lesser importance within urban boundaries, but may become relevant when looking at more extended contexts (i.e. metropolitan or regional areas), especially under the eventual pressures that climate change might exert on urbanised areas.

To date limited attention has been given to Cultural Ecosystem Service (CES) among different categories of ES, especially considering the relevant benefits that communities and urban planning processes can derive from them (Hernández-Morcillo et al., 2013; Tengberg et al., 2012). Widely accepted and used definitions of CES are provided by MEA (2005) or TEEB (2011) and define CES as non-material and/or socio-ecological benefits people obtain from a contact with ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. CES are directly experienced and appreciated by people through ecosystems, thus, unlike other services, CES cannot be replaced if degraded (MEA, 2005; Plieninger et al., 2013).

In a recent review, Milcu et al. (2013) highlighted five clusters of research regarding CES, dealing with general conceptualisations, case studies coming from different disciplines, social and participatory approaches, descriptive reviews and economic assessments. Even if CES can act to bridge gaps between different research areas (Milcu et al., 2013; Hernández-Morcillo et al., 2013) studies on CES still do not have an effect on decision-making processes and especially on planning (Gómez-baggethun and Barton, 2013; Steiner, 2014).

Assessing the benefits of cultural services is a complex and sometimes even controversial issue, as CES need multidisciplinary outcomes from several disciplines such as ecology, economics and social sciences (Milcu et al., 2013). The diversity of approaches to CES can indicate a wide interest on the topic and dynamism in the applied research but, at the same time, might also be related to a lack of solid common terminology and understanding.

There are several features of CES that make their assessment different to assessment of other ES. Firstly, the general dependence of CES to an individual's value systems makes their assessments less quantitative than other services (i.e. provisioning services) that can be quantified independently from the presence of humans (Nahuelhual et al., 2014). Another important issue is the difficult use of spatial geographical units for CES assessment (Abson and Termansen, 2011; Burkhard et al., 2012). The use of spatial units is often absent, is rather general (Norton et al., 2012; Klain and Chan, 2012) or is characterised by continental/country mapping exercises (Maes et al., 2012; Paracchini et al., 2014). Furthermore, when it comes to measurements and operationalisation of CES through specific indicators, there is also lack of conceptual clarity. An explicitly spatial-based assessment of CES thus presents many challenges and studies have mainly focused on mapping benefits rather than on CES provision itself (Milcu et al., 2013). All these issues can be a good starting point to improve current assessments of CES towards their inclusion in urban planning.

The economic concept of cultural capital has recently taken shape for assessing cultural services (Throsby, 2001; Cheng, 2006; Bucci and Segre, 2011). This is an effort to recognise the distinctive features of certain cultural goods as capital assets and thus to capture the ways in which cultural assets contribute to the production of further cultural goods and services, job creation and wellbeing of local communities (Licciardi and Amirtahmasebi, 2012). This economic assessment of CES has found robust theoretical development in urban economics, where the use of hedonic models has developed strongly during recent decades, with a tremendous number of applications and calculations, many of them suitable in principle for their use in the assessment of CES (e.g. Colombo et al., 2014; Sander and Haight, 2012).

However, due to the problems inherent in monetary evaluations and to avoid reductionism, many authors have adopted non-economic approaches such as the relationship between a specific cultural service and its user, including personal culture, experiences and preferences (Klain and Chan, 2012; Gee and Burkhard, 2010; Kumar and Kumar, 2008). Examples of these approaches include mapping of personal preferences (Klain and Chan, 2012; Sherrouse et al., 2014; Sherrouse and Semmens, 2014), photo-based (Sherren et al., 2010) or survey based methods (Plieninger et al., 2013; Bieling and Plieninger, 2013; Bieling et al., 2014).

As noted by Bossel (1999) "indicators represent valuable information" and are also an expression of different values. Even if some ambiguity and plural meanings are still present in the term "indicators" (Heink and Kowarik, 2010), their use in ES research has recently increased (Müller and Burkhard, 2012; Hernández-Morcillo et al., 2013). As suggested by Heink and Kowarik (2010), an all-encompassing definition of indicators in environmental science can be: "An indicator in ecology and environmental planning is a component or a measure of environmentally relevant phenomena used to depict or evaluate environmental conditions or changes or to set environmental goals" as put forward by the OECD (2003).

For CES, a recent study by Feld et al. (2009) showed that even taking into consideration all indicators used for other ES assessments, only 6% referred to CES categories. Similar results can be obtained from the Ecosystem Service Indicators Database, created by the World Resource Institute, where no indicators are reported both for the "cultural" ecosystem service type and "urban" ecosystems (ESID, 2012).

In urban systems, research about CES is even more poorly developed and its real applicability in planning is still a promise (Haase et al., 2014). This is due to two main reasons. First, mismatches between areas providing services and areas benefiting from services should be highlighted in the context of urbanised territories. ES flow from production sites to sites where they are consumed (Costanza, 2008) and this makes CES assessments and evaluation difficult (Maes et al., 2012). Moreover, in urban systems the concentration of beneficiaries of ES is usually high and might result in frequent and difficult to interpret overlaps between the spatial extent of research and the spatial scale of its applications.

**Table 1**
Keywords for the search in the academic databases.

| **Searched terms** |
|---|
| Q1: "ecosystem services" and "indicators" |
| Q2: "cultural ecosystem services" |
| Q3: "cultural ecosystem services" and "indicators" |
| Q4: **"cultural ecosystem services" and "indicators" and "urban"** |

However the situation changes when we refer to particular CES, such as those provided by monuments, architecture and other cultural items that are naturally concentrated in cities, and thus currently addressed in standard urban planning. Thus, the second of our reasons is that urban ecosystems are characterised by high complexity, requiring careful selection of research methods, approaches and indicators. Complexity in urban systems is indicated by many different aspects, such as the large number of different land-cover types and their high degree of spatial mixing. This makes CES assessment based on land-use information particularly challenging and it requires data with an appropriately high resolution that is not always available.

Finding a proper way to assess and measure CES can provide essential insights for urban planning, especially for specific urban contexts where culture, history, location and other related features play a central role for social identity, local heritage and cohesion.

In this document we review existing indicators for the assessment of Cultural Ecosystem Services in urban contexts and provide a critical overview of how indicators can be used for urban planning purposes. We first conduct a literature review on the indicators used for CES in urban contexts and then address some specific issues with reference to both operability and benefits of the use of CES indicators for urban planning and management. The central research questions read as follows:

- What kind of indicators are currently used for CES in urban contexts?
- Which particular issues aspects are discussed in current research concerning CES?
- What are the conceptual shortcomings concerning current CES assessments?
- Which are the most suitable measurement methods and calculation units for CES indicators in urban areas?
- How and at which extent the results of CES indicators can inform urban planning and management of urban systems?
- Are there some indicators more relevant and effective for urban planning?

The paper is structured as follow. In Section 2 we present results of the queries made in academic databases about the ongoing research on CES topics. Section 3 shows the results of the queries, highlighting some key issues about the use of CES in urban systems. In Section 4 we discuss the main findings of the review, addressing the above listed research questions and especially focusing on the use of CES for planning in urban contexts. Section 5 summarises the main conclusions of the work.

## 2. Method

Scopus (http://scopus.com) and all ISI Web of Knowledge (WoK) databases (https://webofknowledge.com) were used to perform a search for peer-reviewed papers or book chapters on Cultural Ecosystem Services in urban contexts. In order to understand the amount of ongoing research, different terms and combinations have been used, as shown in Table 1. The results obtained from the two databases were selected and merged to define a unique set of papers.

We decided to merge results from Scopus and WoK queries Q2 and Q3 in order to have a broader set of examples of CES that could have been evaluated. We then verified the relevance of these records by checking article titles, keywords and abstracts, ending up with a set of articles that specifically dealt with indicators for CES. We then analysed these papers to understand whether these studies contained examples of the use of indicators for CES.

As previously stated, the aim of the review was to obtain a refined list of CES indicators suitable for being used in urban planning. To assess the papers we used a system of double evaluation based on two sets of criteria.

In the first evaluation we first provide a general characterisation of the selected papers with relative indicators according to the following descriptive attributes:

- *Categories of CES evaluated*: categories of specific CES addressed by the paper (Aesthetic values, Sense of place, Recreation/amenity, Ecoturism, Inspirational values, Spiritual–religious value, Heritage, Educational values) are listed. We assigned a numeric code to every paper and to every CES category addressed;
- *Indicator(s)*: indicator(s) used in the paper. We assigned a reference code as a combination of the paper's number and the indicator's number;
- *Assessment method*: what kind of method was performed in the paper to evaluate the CES;
- *Measurement unit and calculation resolution*: the diverse kind of units (i.e. $, Hectares, etc.) and the minimum spatial unit used for the calculation of indicators;
- *Data and information used*: base spatial data or other information used in the assessment and calculations;
- *Geographical location*: the specific location and extension of the study area;
- *Spatial indicator(s)*: presence or not of spatially explicit indicators.

Each paper was reviewed according to the above-mentioned attributes. From the initial set, we selected those papers whose indicators might be used in urban contexts for planning purposes. Papers were considered pertinent if they used indicators that were spatially explicit.

Such papers were then used for the second further evaluation aimed at understanding the possible use of the indicators to inform planning processes in urban contexts. This second evaluation was based on an inclusive combination of two criteria: "**communicability**" and "**relevance of the urban context**" within the case studies presented in the papers.

"**Communicability**" was understood as the ability to transfer the results from indicators to policymaking. The following sub-criteria were used: (i) use of clear, theoretical framework for CES assessment, (ii) presence of the spatially explicit results of the study area (i.e. maps, tables, charts, etc.), (iii) reproducibility of the assessment method. Indicators used in the papers were considered to be communicable if all of the above sub-criteria were present.

We checked the "**relevance of the urban context**" for the use of indicators by evaluating the predominance of the urban context within the study area. We evaluated the relevance of the urban context using a qualitative scale of three grades A–C: (A) null or low relevance – in this case the study did not contain urban areas or they were insignificant such as the case of Grand County Colorado which has a population of only 11,000 inhabitants (Brown et al., 2012); (B) medium relevance: urban areas were more prevalent but not predominant, like in the case of Flanders in Belgium which is an area with significant levels of urbanisation but also has vast rural areas (Broekx et al., 2013); (C) high relevance: urban areas were predominant within the study area, like in the case of specific case study of cities like Tamar river estuary (Davis and Kidd, 2012) or the four cities in Florida (Escobedo et al., 2014).

**Table 2**
Combination of values of criteria of "communicability" and "relevance to urban context".

| Communicability | Relevance of urban contexts | Possibility of use in urban planning |
|---|---|---|
| Y | A | It can be used with **major** adjustments |
| Y | B | It can be used with **minor** adjustments |
| Y | C | It can be used **as it is** |
| N | A | It can be used with **major** adjustments |
| N | B | It can be used with **major** adjustments |
| N | C | It can be used with **minor** adjustments |

The combinations of the two criteria provided a qualitative evaluation of the possible use of the indicators for planning purposes in urban contexts. Those indicators fulfilling "communicability" sub-criteria and implemented in an area that has high relevance of urban context (C) were considered usable. Indicators fulfilling "communicability" sub-criteria, but implemented in an area that has a medium relevance of urban contexts (B) and indicators not fulfilling "communicability" sub-criteria and implemented in an area that has high relevance of urban contexts (C) are considered to be used with some minor adjustments (i.e. re-scaling, spatialising indicators or use of the same data in a more urban context). In all other possibilities, indicators might be used but with major adjustment (i.e. modification in calculation methods and/or type of data used). All these combination are summarised in Table 2.

Results from the literature review were analysed with VOSviewer, a freeware for creating, visualising, and exploring bibliometric maps of science (http://www.vosviewer.com/). The program uses a text mining and clustering functions to analyse co-occurrence of particular terms or data from citations (van Eck and Waltman, 2010). The software integrates a visualisation environment able to produce maps of analysed terms' occurrence. In our case we use as input to run the software the title, keywords and abstracts of papers obtained from queries Q2 and Q3.

Fig. 1 shows a graphical representation of the adopted approach for the review.

**Table 3**
Results from queries to SCOPUS and ISI Web of Knowledge (periods: all time).

| Searched terms | Occurrences | |
|---|---|---|
| | Scopus | ISI WoK |
| Q1: "ecosystem services" and "indicators" | 716 | 798 |
| Q2: "cultural ecosystem services" | 60 | 42 |
| Q3: "cultural ecosystem services" and "indicators" | 11 | 8 |
| Q4: **"cultural ecosystem services" and "indicators" and "urban"** | **1** | **0** |

## 3. Results

The results obtained from the SCOPUS and ISI WoK database in terms of resulted number of papers are reported in Table 3.

The combination of terms used in the search query highly affected the number of occurrences obtained (Table 3). Furthermore, the use of different and more specific terms in the queries allowed to better highlight the differences in the amount of researches about the topic. First, results from queries showed a limited set of papers dealing explicitly with CES (60 for Scopus, 42 for Wok) out of the total literature about ES and Indicators (716 for Scopus, 798 of WoK). Combining the terms "cultural ecosystem services" and "indicators" narrowed the results down further (11 for Scopus, 8 for WoK); and returned one solitary result when adding the term "urban" as a further attribute (1 for Scopus, 0 for WoK). These results clearly indicate how the real application of indicators for Cultural Ecosystem Services in urban contexts is still unexplored, even if urban contexts are places with a high density of CES.

Since 1 only occurrence resulted from the Q4 query, we used the a set of papers from merging occurrences from queries Q2 and Q3 in both Scopus and WoK (Annex 1). Those papers have been analysed according to the two evaluations presented in the Method.

Results from the analysis with VOSviewer software are reported in a map of the co-occurrence terms (Fig. 2). This map shows the most relevant of the analysed set of 2078 terms according to a "relevant score" calculated by VOSviewer. In the figure, each of the 53 most relevant terms is mapped with a circle, where the diameter of the circle and size of the relative label represent the frequency of the term, its proximity to another term indicates the degree of relatedness of the two terms and its colour represents the cluster to which it belongs. The term analysis showed as "indicator" (10

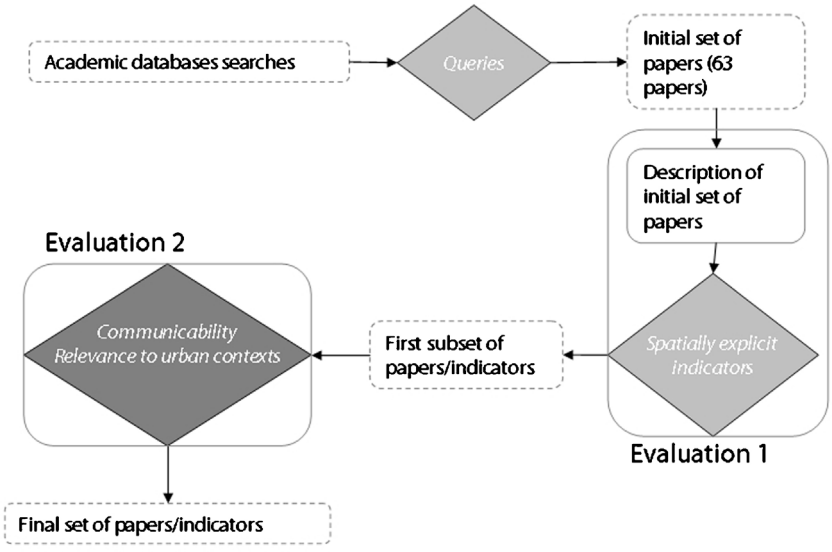


**Fig. 1.** Graphical outline of the adopted approach for the review.

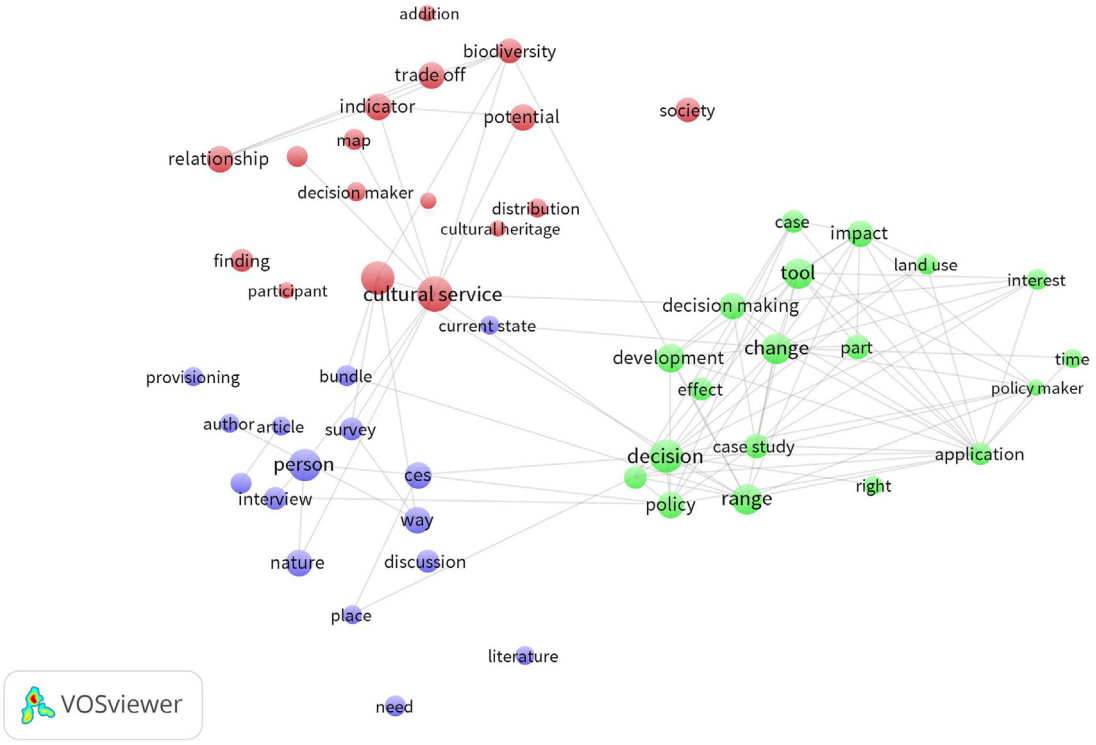


**Fig. 2.** Results from the analysis of VOSviewer software.

occurrences) was not the most frequent or relevant term and other keyword of our review such as "planning" or "urban" were absent.

### 3.1. First evaluation of papers

Table 4 shows the papers and their descriptive attributes after the first set evaluation was applied. An extended version of Table 4, with all the descriptive attributes introduced in the Method section can be found in the appendix (Annex 1).

#### 3.1.1. Categories of CES

Most frequently evaluated category of CES was "recreational and ecotourism", which was referred to 29 times. Within this category, other terms such as "forest recreation" (Raudsepp-Hearne et al., 2010), "recreational fisheries" (Van Poorten et al., 2011), "freshwater recreational fishing" (Villamagna et al., 2014) or related categories like "leisure-activities" (Norton et al., 2012) are included. The second most referred to CES category (22 references) is "aesthetic values" services, sometimes specifically named "landscape aesthetic" (Brandt et al., 2014; Frank et al., 2014) and "scenic quality" (Sander and Haight, 2012).

Other CES categories referring to MEA framework (2005) are reported in Table 5.

Some of the CES categories are described in very general way as "social values" (Sherrouse et al., 2014), "constituents of wellbeing" (Russell et al., 2013), "public goods" (Swallow, 2013) or "contribution of peri-urban woodlands to wellbeing" (O'Brien et al., 2014).

#### 3.1.2. Assessment methods of CES

The papers we analysed used different assessment methods. Almost a third – 21 out of 63 studies (33%) – were based on interviews with different stakeholders. This has been the most common approach. Delphi method (Nahuelhual et al., 2013) and hedonic models (Escobedo et al., 2014; Sander and Haight, 2012) were also used. Other methods included foresight assessments like "scenario simulation" (Frank et al., 2014) and stakeholder workshops (Fletcher et al., 2014), GIS based mapping (e.g. Raudsepp-Hearne et al., 2010), participatory mapping (Van Berkel and Verburg, 2014), field observations, expert-based scoring (Moore and Hunt, 2012), Lindahl framework (Swallow, 2013) and narratives (O'Brien et al., 2014). Most of these assessment methods were GIS-based, including GIS tools developed appositely for the purpose (Plieninger et al., 2012; Sherrouse et al., 2014; Sherrouse and Semmens, 2014) and web applications (Liekens et al., 2013).

#### 3.1.3. Type of data

Type of data used in the papers had diverse sources and nature, according to assessment method used. As stated above, 33% of the analysed manuscripts used data obtained directly from interviews. Methods based on interviews were: online, phone-based and face-to-face surveys. Some were described as "semi-structured cultural scoping interviews" (Fletcher et al., 2014). Some other surveys were based on different images or photographs (Casalegno et al., 2013; Frank et al., 2013). Thirteen papers (21%) used spatial data about land use/land cover like Corine Land Cover (e.g. Burkhard et al., 2012; Maes et al., 2012; Paracchini et al., 2014).

Some studies used detailed data available from different local public and private institutions (e.g. Ripoll-Bosch et al., 2013; Sander and Haight, 2012), site-specific publications and reports (e.g. Ripoll-Bosch et al., 2013), or historical photos and maps (e.g. Davis and Kidd, 2012).

#### 3.1.4. Geographic location and spatial extent

Most of the papers (46) presented case studies located in the Americas, 15 papers were located in Europe, 1 in Australia and 1 in Africa. One manuscript discussed two case studies, one located in Europe and one in Africa (Tengberg et al., 2012).

In most cases, papers dealt with very large geographical areas (e.g. Paracchini et al., 2014). Other papers focused on a particular geographical location, such as the coastline (Fletcher et al., 2014; Klain and Chan, 2012). It is worth mentioning that 17 papers (27%)

**Table 4**
Categories of CES and used for the indicators in the 63 reviewed papers.

| Paper no. | Source | Categories of CES evaluated | Indicator (s) | Spatial indicator/pertinence |
|---|---|---|---|---|
| 1 | Abson and Termansen (2011) | Essay | N | N |
| 2 | Barrena et al. (2014) | Agricultural heritage | 2.1. Willingness to pay | N |
| 3 | Bieling et al. (2014) | 1. Aesthetic values<br>2. Sense of place<br>3. Recreation and ecoturism<br>4. Inspirational values<br>5. Spiritual–religious values<br>6. Educational values | – | N |
| 4 | Bieling et al. (2014) | 1. Identity<br>2. Heritage<br>3. Spiritual–religious values<br>4. Inspiration<br>5. Aesthetic<br>6. Recreation | – | N |
| 5 | Bieling and Plieninger (2013) | 1. Identity<br>2. Heritage<br>3. Spiritual services<br>4. Aesthetic services<br>5. Recreation | 5.1. Benche<br>5.2. Hiking trails and signs<br>5.3. Recreational facilities<br>5.4. Subsistence gardens<br>5.5. Hunting facilities<br>5.6. Memorials, commemorations, historical sites | Y |
| 6 | Brancalion et al. (2014) | 1. Aesthetic values<br>2. Recreation and tourism values<br>3. Religious and psychological values<br>4. Educational values knowledge generation | – | N |
| 7 | Brandt et al. (2014) | 1. Aesthetic values<br>2. Recreational and ecotourism | 7.1. Landscape aesthetics proxy<br>7.2 Park visitation | Y |
| 8 | Broekx et al. (2013) | 1. Recreation, amenity,<br>2. Education<br>Bequest values | 8.1. Willingness to pay (WTP) | N |
| 9 | Brown et al. (2012) | 1. Recreation<br>2. Aesthetic<br>3. Social interaction<br>4. Science<br>5. Spiritual<br>Cultural | 9.1. Frequency distribution of Ecosystem Services | N |
| 10 | Burkhard and Gee (2012) | 1. Visual aesthetics<br>2. Seascape character<br>3. Sense of place<br>4. Cultural heritage<br>5. Habitat and species value<br>6. Regional image Inspiration<br>7. Informal education<br>8. Knowledge systems<br>9. Recreation | – | N |
| 11 | Burkhard et al. (2012) | 1. Recreation and tourism<br>2. Landscape aesthetics and inspiration<br>3. Knowledge systems<br>4. Religious and spiritual experience<br>5. Cultural heritage and cultural diversity<br>6. Natural heritage and natural diversity | – | N |
| 12 | Casalegno et al. (2013) | Aesthetic value | 12.1. Density of photographs | Y |
| 13 | Chan et al. (2012) | Review paper | – | N |
| 14 | Daniel et al. (2012) | 1. Landscape aesthetics,<br>2. Cultural heritage,<br>3. Outdoor recreation,<br>4. Spiritual significance | – | N |
| 15 | Davis and Kidd (2012) | 1. Recreational values<br>1. Aesthetic amenity (only mentioned, not measured) | – | N |
| 16 | Dominati et al. (2010) | Cultural services in general | – | N |
| 17 | Egoh et al. (2007) | Cultural services in general | – | N |
| 18 | Escobedo et al. (2014) | Cultural services in general | 18.1. Property value | N |
| 19 | Fletcher et al. (2014) | 1. Aesthetic information,<br>2. Recreation,<br>3. Inspiration for art and design,<br>4. Cultural heritage | 19.1. Frequency of terms | N |

Table 4 (*Continued*)

| Paper no. | Source | Categories of CES evaluated | Indicator (s) | Spatial indicator/pertinence |
|---|---|---|---|---|
| 20 | Frank et al. (2013) | Landscape aesthetics | 20.1. Shannon's Diversity Index (SHDI),<br>20.2. Shape Index (SHAPE)<br>20.3. Patch Density (PD) | Y |
| 21 | Frank et al. (2014) | Landscape aesthetics | 21.1. Shannon's Diversity Index (SHDI),<br>21.2. Shape Index (SHAPE)<br>21.2. Patch Density (PD) | Y |
| 22 | Gee and Burkhard (2010) | Cultural services in general | – | N |
| 23 | Hernández-Morcillo et al. (2013) | Review paper | – | N |
| 24 | Iverson et al. (2014) | Editorial | – | N |
| 25 | Jakubowski et al. (2010) | – | 25.1. Annual dry matter production | N |
| 26 | Kimmel and Mander (2010) | – | – | N |
| 27 | Kirchhoff (2012) | Letter | – | N |
| 28 | Klain and Chan (2012) | 1. Natural beauty<br>2. Cultural heritage site<br>3. Recreation<br>4. Unique natural feature<br>5. Ceremonial site<br>6. Stewardship activities<br>7. Scientific study site<br>8. Spiritual-inspiration<br>9. Education<br>10. Peace<br>11. Sense of place-home<br>12. Transformational<br>13. Intergenerational<br>14. Community identity<br>15. Existence | 28.1. Proxy of value of some ecosystem services<br>28.2. Proxy of threats to some ecosystem services | Y |
| 29 | Krasny et al. (2014) | – | – | N |
| 30 | Liekens et al. (2013) | 1. Recreation<br>2. Amenity<br>3. Nonuse value | 30.1. Willingness to pay | N |
| 31 | Lundy and Wade (2011) | 1. Spiritual value<br>2. Educational value<br>3. Aesthetics<br>4. Recreation | – | N |
| 32 | Maes et al. (2012) | Opportunities for recreation and tourism | 32.1. Recreation potential | Y |
| 33 | Mangi (2013) | Some CES cited together with data needed for their assessment | – | N |
| 34 | Milcu et al. (2013) | Review paper | – | N |
| 35 | Moleón et al. (2014) | – | – | N |
| 36 | Moore and Hunt (2012) | 1. Recreation (public accessibility, physical accessibility, and recreation infrastructure)<br>2. Education (proximity to schools or other educational centres, history of use for educational purposes, and the presence of educational infrastructure) | 36.1. Score criteria for the used categories of CES | N |
| 37 | Nahuelhual et al. (2014) | 1. Heritage value associated to Chiloé native potato as a culturally significant species;<br>2. Systems of knowledge;<br>3. Relations (or social networks) established in the agri-cultural society of Chiloé Island | 37.1. Agriculture Heritage (AH) as s spatial proxy of different dimensions that are spatialised with kernel density estimation | Y |
| 38 | Nahuelhual et al. (2013) | 1. Recreation<br>2. Tourism | 38.1. Recreation<br>38.2. EcoTourism | Y |
| 39 | Norton et al. (2012) | 1. History<br>2. Place<br>3. Inspiration<br>4. Calm<br>5. Leisure-Activities<br>6. Spiritual<br>7. Learning<br>8. Escape | 39.1. Cultural score (combination of LULC features with more qualitative landscape feature) | Y |
| 40 | O'Brien et al. (2014) | Contribution of per-urban woodlands to well being | – | N |
| 41 | Olschewski et al. (2010) | – | – | N |

Table 4 (*Continued*)

| Paper no. | Source | Categories of CES evaluated | Indicator (s) | Spatial indicator/pertinence |
|---|---|---|---|---|
| 42 | Paracchini et al. (2014) | Outdoor recreation | 42.1. Outdoor recreation | Y |
| 43 | Pleasant et al. (2014) | All according to MEA framework | – | N |
| 44 | Plieninger et al. (2013) | 1. Spiritual services<br>2. Educational values<br>3. Inspiration<br>4. Aesthetic values<br>5. Social relations<br>6. Sense of place<br>7. Cultural heritage values<br>8. Recreation and ecotourism<br>Disservices:<br>1. Unpleasantness<br>2. Scariness<br>3. Noisiness | 44.1. One indicator question per CES | Y |
| 45 | Plieninger et al. (2012) | 1. Aesthetics<br>2. Cultural heritage<br>3. Recreation<br>4. Sense of place<br>5. Spiritual | 45.1. CES as motivators for owning land | N |
| 46 | Raudsepp-Hearne et al. (2010) | 1. Deer hunting<br>2. Tourism<br>3. Nature appreciation<br>4. Summer cottages<br>5. Forest recreation | 46.1. Deer kills<br>46.2. Tourist attractions<br>46.3. Rare species<br>46.4. Tax value of cottages<br>46.5. Forested land | Y |
| 47 | Ripoll-Bosch et al. (2013) | In general CES | 47.1. Value of CES | Y |
| 48 | Ruiz-Frau et al. (2013) | Recreation services | 48.1. The average spent per person per day for each of the following activities: recreational scuba-divers, sea-kayakers, customers of wildlife viewing boat trips and seabird watchers | Y |
| 49 | Russell et al. (2013) | 10 constituents of well-being (connections between nature and human well-being): | – | N |
| 50 | Sander and Haight (2012) | (i) outdoor recreation,<br>(ii) scenic quality and tree cover<br>Used as a “mix” providing a series of cultural, supporting, regulating, and provisioning services, | (Variables)<br>50.1. Mean percent tree cover on the home's parcel [%],<br>50.2. Mean percent tree cover in neighbourhood<br>Land cover measured in home's viewshed:<br>50.3. Impervious land cover<br>50.4. Lawn<br>Area of short grass (lawn)<br>50.5. Area of maintained tall grassland cover<br>50.6. Area of forest<br>50.7. Area of shrub<br>50.8. Area of unmaintained grassland<br>50.9. Area of emergent vegetation<br>50.10. Area of open water<br>50.11. Area of woody wetland<br>50.12. Area of agricultural land | Y |
| 51 | Satz et al. (2013) | Perspective essay | – | N |
| 52 | Sherrouse and Semmens (2014) | 1. Aesthetic, recreation | 52.1. Social-value indicator | Y |
| 53 | Sherrouse et al. (2014) | Social values:<br>1. Aesthetic,<br>2. Biodiversity,<br>3. Cultural,<br>4. Economic,<br>5. Future,<br>6. Historic,<br>7. Intrinsic,<br>8. Learning,<br>9. Life sustaining,<br>10. Recreation,<br>11. Spiritual,<br>12. Subsistence,<br>13. Therapeutic | 53.1. Social-value indicator | Y |
| 54 | Swallow (2013) | Public goods | – | N |
| 55 | Tarolli et al. (2014) | Not specified | – | N |

Table 4 (*Continued*)

| Paper no. | Source | Categories of CES evaluated | Indicator (s) | Spatial indicator/pertinence |
|---|---|---|---|---|
| 56 | Tengberg et al. (2012) | 1. Heritage values<br>Identity | – | N |
| 57 | Turner (2012) | Briefing note | – | N |
| 58 | Urquhart and Acott (2014) | Sense of place | – | N |
| 59 | Van Berkel and Verburg (2014) | 1. Recreation,<br>2. Aesthetic<br>3. Beauty,<br>4. Cultural heritage,<br>5. Inspiration,<br>6. Spirituality | 59.1. Respondents' willingness to pay (WTP) for landscape maintenance,<br>59.2. Travel time-cost estimate | Y |
| 60 | Van Poorten et al. (2011) | Recreational fisheries | – | N |
| 61 | Villamagna et al. (2014) | Freshwater recreational fishing (key benefits: relaxation, communication with nature, spiritual renewal, social bonding) | Biophysical capacity<br>61.1. Surface water availability<br>61.2. Game-fish species richness<br>61.3. Water quality<br>61.4. Forested riparian areas<br>61.5. Boating access sites<br>Social capacity<br>61.6. Publicly accessible areas<br>61.7. Fishing spots<br>61.8. Fish stocking<br>Demand<br>61.9. Fishing licenses<br>Ecological pressure<br>61.10. Licensed anglers within 16.09 km of fishable waterbody | Y |
| 62 | Von Heland and Folke (2014) | Not specified | – | N |
| 63 | Weyland and Laterra (2014) | Recreation potential (such as: angling, hiking, trekking, cycling, horse-back riding and bird-watching) | 63.1. Campsite density as independent variable explained by landscape metrics (variables):<br>mean annual temperature, annual thermal amplitude, roughness, coastline density, Normalised Difference Vegetation Index (NDVI), Standard Deviation in NDVI (NDVI SD), tree cover, bare soil cover, crop area | Y |

were review papers, did not have a precise geographical context or study area or dealt with issues that were not spatial.

The papers analysed referred to different spatial extents. Thirty-five studies (56%) referred to regional case studies and seven (11%) referred to national or international case studies. Remaining 33% of the case studies did not have a precise geographical context. Most of the case studies dealt non-urban ecosystems like marine/coastal areas (Klain and Chan, 2012; Pleasant et al., 2014; Ruiz-Frau et al., 2013), inland waters (Lundy and Wade, 2011; Ripoll-Bosch et al., 2013) and forests (Sherrouse et al., 2014). As noted by MEA (2005) boundary limits for mapping of urban ecosystems are limited to "known human settlements with a population of 5000 or more, with boundaries delineated by observing persistent night-time lights or by inferring areal extent in the cases where such observations are absent". None of the case studies, as a whole, can be characterised as "urban ecosystems". More detailed assessment of the relevance of the urban context is provided in Table 6.

### 3.2. Second evaluation of papers

#### 3.2.1. Presence of spatial indicators and their pertinence for urban planning

As showed by the last column of Table 4, indicators were used in only 30 papers (48%). Of these papers, 21 manuscripts (33%) used spatial indicators and 58 different indicators were identified. These papers are reported in Table 6, together with the results of the second evaluation which was based on the criteria of "communicability" and "relevance of the urban context". Furthermore, Fig. 3 summarises the number of indicators with respect to their relevance to urban contexts.

Eighty-nine percent of the indicators included in Table 6 fulfilled the "communicability" criterion described in the Method. 66% pre-

**Table 5**
Categories of CES and relative number of papers.

| Categories of CES | # of papers referred | Other terms used |
|---|---|---|
| Recreational and ecotourism | 29 | – |
| Aesthetic values | 22 | – |
| Spiritual and religious values | 14 | "Spiritual significance" (Daniel et al., 2012), "Spiritual-inspiration" (Klain and Chan, 2012), "Spiritual value" (Lundy and Wade, 2011), |
| Cultural heritage | 12 | "Natural heritage" (Burkhard et al., 2012) |
| Educational values | 9 | "Informal education" (Burkhard and Gee, 2012), "social value learning" (Sherrouse et al., 2014) |
| Inspiration | 8 | – |
| Sense of place | 6 | – |
| Cultural diversity | 5 | "Cultural" (Brown et al., 2012, Sherrouse et al., 2014.), "Cultural services" (Dominati et al., 2010; Egoh et al., 2007; Escobedo et al., 2014) |
| Knowledge systems | 4 | "Knowledge generation" (Brancalion et al., 2014) |
| Social relations | 3 | "Social interaction" (Brown et al., 2012), "relations (or social networks)" (Nahuelhual et al., 2014) |

**Table 6**
Criteria for the usability of the indicators for urban planning.

| No | Source | Indicator(s) | Relevance of the urban context | Communicability | Possibility for using in urban planning |
|---|---|---|---|---|---|
| 5 | Bieling and Plieninger (2013) | 5.1. | A (Natural landscape context) | Y | Y, major adjustments |
| | | 5.2. | A (Natural landscape context) | Y | Y, major adjustments |
| | | 5.3. | A (Natural landscape context) | Y | Y, major adjustments |
| | | 5.4. | A (Natural landscape context) | Y | Y, major adjustments |
| | | 5.5. | A (Natural landscape context) | Y | Y, major adjustments |
| | | 5.6. | A (Natural landscape context) | Y | Y, major adjustments |
| 7 | Brandt et al. (2014) | 7.1 | B (urban context limited) | Y | Y, minor adjustment |
| | | 7.2 | B (urban context limited) | Y | Y, minor adjustment |
| 12 | Casalegno et al. (2013) | 12.1 | B (urban context limited) | Y | Y, minor adjustment |
| 20 | Frank et al. (2013) | 20.1. | A (Natural landscape context) | N | Y, major adjustment |
| | | 20.2. | A (Natural landscape context) | N | Y, major adjustment |
| | | 20.3. | A (Natural landscape context) | N | Y, major adjustment |
| 21 | Frank et al. (2014) | 21.1. | A (Natural landscape context) | N | Y, major adjustment |
| | | 21.2. | A (Natural landscape context) | N | Y, major adjustment |
| | | 21.3. | A (Natural landscape context) | N | Y, major adjustment |
| 28 | Klain and Chan (2012) | 28.1. | B (urban context limited) | Y | Y, minor adjustment |
| | | 28.2. | B (urban context limited) | Y | Y, minor adjustment |
| 32 | Maes et al. (2012) | 32.1. | A (European scale) | Y | Y, major adjustment |
| 37 | Nahuelhual et al. (2014) | 37.1. | B (Regional scale) | Y | Y, minor adjustment |
| 38 | Nahuelhual et al. (2013) | 38.1. | B (Regional scale) | Y | Y, minor adjustment |
| | | 38.2. | B (Regional scale) | Y | Y, minor adjustment |
| 39 | Norton et al. (2012) | 39.1. | A (Regional scale) | Y | Y, major adjustment |
| 42 | Paracchini et al. (2014) | 42.1. | A (Regional scale) | Y | Y, major adjustment |
| 44 | Plieninger et al. (2013) | 44.1. | A (Natural landscape context) | Y | Y, major adjustments |
| 46 | Raudsepp-Hearne et al. (2010) | 46.1 | A (different specificity of indicator) | Y | Y, major adjustments |
| | | 46.2 | B (National scale) | Y | Y, minor adjustment |
| | | 46.3 | B (National scale) | Y | Y, minor adjustment |
| | | 46.4 | B (National scale) | Y | Y, minor adjustment |
| | | 46.5 | B (National scale) | Y | Y, minor adjustment |
| 47 | Ripoll-Bosch et al. (2013) | 47.1. | A (natural landscape context) | Y | Y, major adjustments |
| 48 | Ruiz-Frau et al. (2013) | 48.1. | A (natural landscape context) | Y | Y, major adjustments |
| 50 | Sander and Haight (2012) | 50.1. | B (county scale) | Y | Y, minor adjustment |
| | | 50.2. | B (county scale) | Y | Y, minor adjustment |
| | | 50.3. | B (county scale) | Y | Y, minor adjustment |
| | | 50.4. | B (county scale) | Y | Y, minor adjustment |
| | | 50.5. | B (county scale) | Y | Y, minor adjustment |
| | | 50.6. | B (county scale) | Y | Y, minor adjustment |
| | | 50.7. | B (county scale) | Y | Y, minor adjustment |
| | | 50.8. | B (county scale) | Y | Y, minor adjustment |
| | | 50.9. | B (county scale) | Y | Y, minor adjustment |
| | | 50.10. | B (county scale) | Y | Y, minor adjustment |
| | | 50.11. | B (county scale) | Y | Y, minor adjustment |
| | | 50.12. | B (county scale) | Y | Y, minor adjustment |
| 52 | Sherrouse and Semmens (2014) | 52.1. | A (natural landscape context) | Y | Y, major adjustments |
| 53 | Sherrouse et al. (2014) | 53.1. | A (natural landscape context) | Y | Y, major adjustments |
| 59 | Van Berkel and Verburg (2014) | 59.1. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 59.2. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| 61 | Villamagna et al. (2014) | 61.1. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.2. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.3. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.4. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.5. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.6. | B (limited presence; landscape scale study) | Y | Y, minor adjustment |
| | | 61.7. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.8. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.9. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| | | 61.10. | B (limited presence in landscape scale study) | Y | Y, minor adjustment |
| 63 | Weyland and Laterra (2014) | 63.1. | B (National scale) | Y | Y, minor adjustment |

sented a "medium relevance (B) of urban context" and no indicators were found to be of "high relevance of urban context". This implied none of the indicators could be used in urban planning without adjustments: 64% were considered usable after minor adjustments and 36% after major adjustments.

Papers rendered usable for urban planning after minor adjustments formed the final set of 37 indicators reported in Table 7, together with their features (name, measurement, calculation unit, remark for their use).

Table 8 and Fig. 4 report how the 37 selected indicators correspond to the MEA (2005) categories, showing huge differences in addressed categories: while almost all indicators referred to "Recreational and ecotourism", no indicator was related to "Cultural diversity" and "Knowledge systems" (Table 8). Almost

**Table 7**
Synthesis of spatial indicators suitable for urban planning.

| No | Source | Correspondence with CES category | Indicator(s) code | Indicator name | Proxy indicator | Measurement unit | Calculation resolution |
|---|---|---|---|---|---|---|---|
| 7 | Brandt et al. (2014) | Aesthetic values | 7.1 | Landscape aesthetics | Y | Spatial proxy | Unknown resolution grid |
| | | Recreational and ecotourism | 7.2 | Park visitation | Y | Spatial proxy | Unknown resolution grid |
| 12 | Casalegno et al. (2013) | Aesthetic value | 12.1 | Density of photographs | Y | # photographs per 1 km$^2$ | 1 km grid |
| 28 | Klain and Chan (2012) | Aesthetic values, cultural heritage, recreational and ecotourism, spiritual and religious values, inspiration, sense of place | 28.1. | Monetary value of marine ES | Y | Spatial proxy of the preference value of some ES | 500 m resolution grid |
| | | | 28.2. | Number of threats to marine ES | Y | Spatial proxy of perceived threats to some ecosystem services | 500 m resolution grid |
| 37 | Nahuelhual et al. (2014) | Cultural heritage, knowledge systems, social relations | 37.1 | Agriculture Heritage | Y | Spatial proxy of different dimensions that are spatially estimated with kernel density | 100 resolution grid |
| 38 | Nahuelhual et al. (2013) | Recreational and ecotourism | 38.1. | Recreation potential | Y | Spatial proxy of different aggregated variables | Different spatial resolutions |
| | | | 38.2. | EcoTourism potential | Y | Spatial proxy of different aggregated variables | Different spatial resolutions |
| 46 | Raudsepp-Hearne et al. (2010) | Recreational and ecotourism | 46.2. | Tourist attractions | Y | Number of tourist attractions in certain area (Tourist attractions/km$^2$) | Municipality |
| | | | 46.3. | Rare species | Y | Number of observations of rare species in certain area (Observations of rare species/km$^2$) | Municipality |
| | | | 46.4. | Tax value of cottages | Y | Tax value of cottages (Tax value of cottages/km$^2$) | Municipality |
| | | | 46.5. | Forested land | Y | Percent of land that is forested | Municipality |
| 50 | Sander and Haight (2012) | Recreational and ecotourism, aesthetic values | 50.1. | Mean percent tree cover on the home's parcel | Y | Mean percent of home's parcel that is forested | County |
| | | | 50.2. | Mean percent tree cover in neighbourhood land cover measured in home's viewshed | Y | Mean percent of land that is forested in neighbourhood limited by home's viewshed | County |
| | | | 50.3. | Impervious land cover | Y | Area of land that is covered with impervious surface (m$^2$) | County |
| | | | 50.4. | Lawn area of short grass | Y | Area of land that is covered with short grass (m$^2$) | County |
| | | | 50.5. | Area of maintained tall grassland cover | Y | Area of land that is covered with maintained tall grass (m$^2$) | County |
| | | | 50.6. | Area of forest | Y | Area of land that is forested (m$^2$) | County |
| | | | 50.7. | Area of shrub | Y | Area of land that is covered with shrub (m$^2$) | County |
| | | | 50.8. | Area of unmaintained grassland | Y | Area of land that is covered with unmaintained grassland (m$^2$) | County |
| | | | 50.9. | Area of emergent vegetation | Y | Area of land that is covered with emergent vegetation (m$^2$) | County |
| | | | 50.10. | Area of open water | Y | Area of land that is covered with open water (m$^2$) | County |
| | | | 50.11. | Area of woody wetland | Y | Area of land that is covered with woody wetland (m$^2$) | County |
| | | | 50.12. | Area of agricultural land | Y | Area of land that is used for agriculture purposes (m$^2$) | County |
| 59 | Van Berkel and Verburg (2014) | Recreational and ecotourism, aesthetic values, cultural heritage, inspiration, spiritual and religious values | 59.1. | Respondents' willingness to pay (WTP) for landscape maintenance | N | Estimation of the monetary value of environmental and cultural services (€) | Vector Landscape features (unknown resolution) |
| | | | 59.2. | Travel time-cost estimate | N | Calculation of estimated respondents' travel costs (€/km) | Vector Landscape features (unknown resolution) |

Table 7 (*Continued*)

| No | Source | Correspondence with CES category | Indicator(s) code | Indicator name | Proxy indicator | Measurement unit | Calculation resolution |
|---|---|---|---|---|---|---|---|
| 61 | Villamagna et al. (2014) | Recreational and ecotourism | 61.1. | Surface water availability | Y | Length/area of waterbodies | Hydrologic units |
| | | | 61.2. | Game-fish species richness | Y | Number of species found | |
| | | | 61.3. | Water quality | Y | Length/area impaired for aquatic life | |
| | | | 61.4. | Forested riparian areas | Y | Forested riparian area | |
| | | | 61.5. | Boating access sites | Y | Number of boat access sites | |
| | | | 61.6. | Publicly accessible areas | Y | Waterbody shoreline and length within public use area | |
| | | | 61.7. | Fishing spots | Y | Number of fishing spots | |
| | | | 61.8. | Fish stocking | Y | Number of stocked fish | |
| | | | 61.9. | Fishing licenses | Y | Number of licenses | |
| | | | 61.10. | Licensed anglers within 16.09 km of fishable waterbody | Y | Number of licenses | |
| 63 | Weyland and Laterra (2014) | Recreational and ecotourism | 63.1. | Campsite density with landscape metrics | N | Campsite density explained by landscape metrics (variables): | 32 km resolution grid |

all indicators (92%) were proxies. The final set of indicators included simple percentages of land covers types or their extension, number/density of particular features, monetary estimations or aggregated raster indices.

25 indicators (68%) were calculated by GIS, with different calculation units, spanning from different resolution raster grids (40%), to vector polygon unit (60%).

## 4. Discussion

In this section we explore the usability of CES indicators for planning in urban contexts, at the light of results of our review. We will focus the discussion on three main issues: (1) usability of analysed CES indicators for urban planning; (2) other emerging issues concerning CES in urban contexts that are poorly addressed in peer-review literature, namely CES disservices and CES within ES bundles; (3) criteria for the performed literature review, with relative pros and cons.

### 4.1. Usability of CES indicators for urban planning

The review showed a lack of conceptual clarity and ambiguity in the use of CES categories for urban contexts. This makes selection of proper indicators difficult for certain CES categories. Several examples of indicators with unclear CES categories were identified: (i) "'seascape character", "habitat and species value" (Burkhard and Gee, 2012) (ii) "unique natural feature", "ceremonial site", "stewardship activities", "scientific study site", "peace", transformational", "integration", "community identity", "existence" (Klain and Chan, 2012); (iii) "amenity", "nonuse value" (Liekens et al., 2013), (iii) "history", "place", "calm", "escape" (Norton et al., 2012); (iv) "contribution of per-urban woodlands to well being" (O'Brien et al., 2014); (v) "deer hunting", "nature appreciation"," summer cottages"(Raudsepp-Hearne et al., 2010); (vi) different social values like "biodiversity", "economic", "future", "historic", "intrinsic", "life sustaining", "subsistence", "therapeutic" (Sherrouse et al., 2014); (vii) "identity" (Tengberg et al., 2012); (viii) "beauty" (Van Berkel

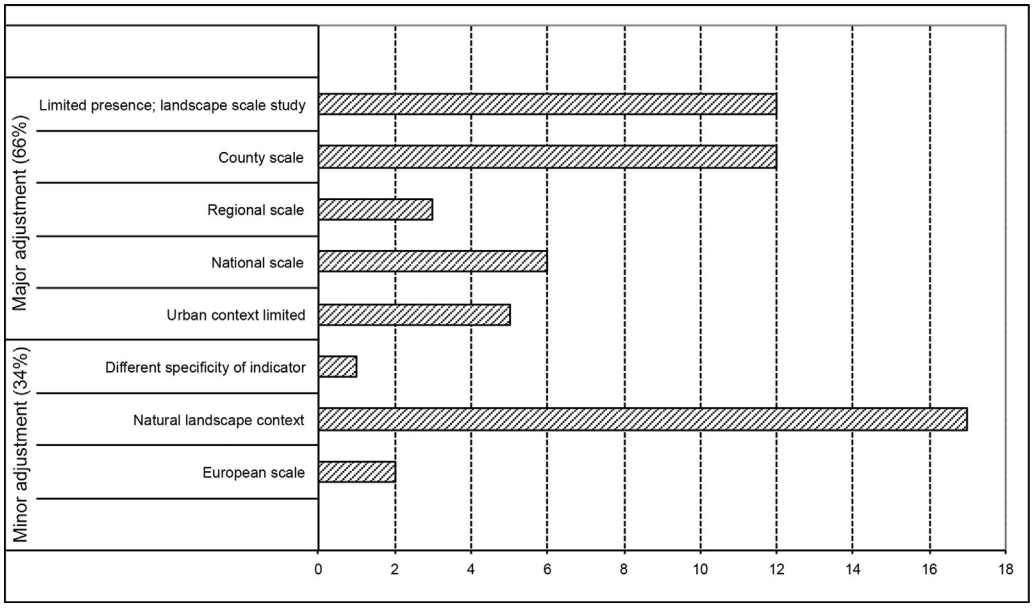


**Fig. 3.** Number of indicators that can be used for urban planning.

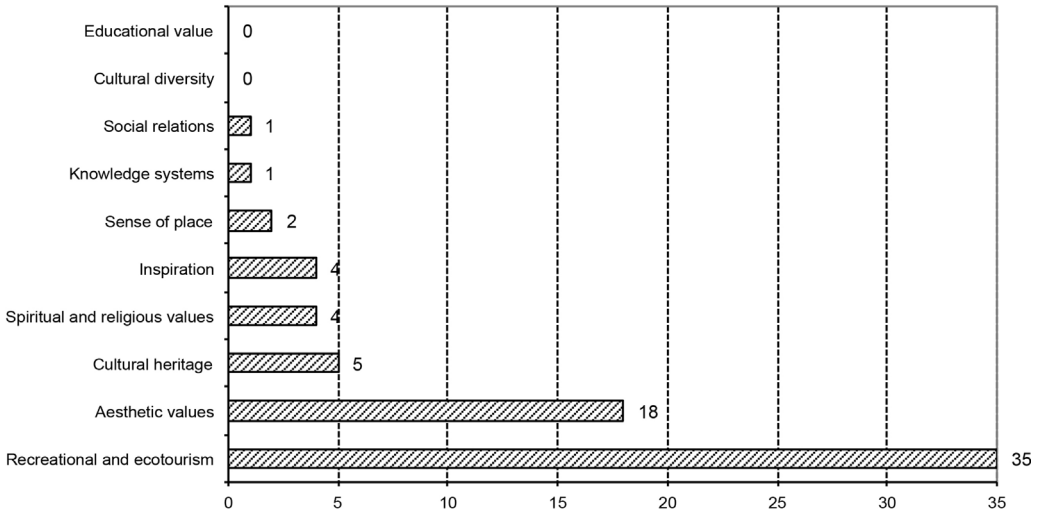


**Fig. 4.** Final selected indicators and relative categories.

and Verburg, 2014). Papers with above-mentioned CES categories were actually not included in research results, as these categories were used as theoretical references only, without specifying the nature of the indicators and their clear relation to the CES using MEA or another similar framework. A better operationalisation of CES categories is needed to simplify and better address the selection of more effective CES indicators for urban planning. This can be done by referring to the most prevalent CES categories like MEA (2005) or TEEB frameworks (Van der Ploeg et al., 2010) and using an appropriate urban scale able to display spatial distribution of CES.

However, in many cases the assessments end up as a nominal reference of the ES concept, aiming to prove the use of the framework but without conceptual clarity in terms of what the indicator specifically should measure in order to be a dimension of the specific CES under assessment.

"Recreational and ecotourism" and "aesthetic values" were the most often assessed categories in the papers we analysed, confirming other recent research about CES (e.g. Plieninger et al., 2013). For those categories not covered by the indicators selected in Table 7 ("cultural diversity" and "educational values") indicators like density or diversity of different types of cultural items could be easily used as proxies. As defined by World Resources Institute (ESID, 2012), a proxy indicator for Ecosystem Services is a "substitute measure used to provide insight into the area of interest when it is not possible to measure the issue directly. Proxy measures must behave reasonably in sync with a good direct measure".

An assessment method does not necessarily lead to a valuation where a specific value structure has already been put into play. Valuation is, in terms of urban planning, a matter of policy discussion on the basis of assessment and measurements already done. Some methods were clearly conceived to lead to specific types of valuation, like hedonic pricing or willingness to pay for landscape maintenance which gives prices as a valuation results (Klain and Chan, 2012; Sander and Haight, 2012; Van Berkel and Verburg, 2014), and others were neutral measurements like narratives assessments (e.g. Weyland and Laterra, 2014).

All the final 37 indicators were communicable to decision makers, thanks to a general use of related maps. This confirms the recent and well-developed stream of research into mapping of ES (Nahuelhual et al., 2013, 2014; Paracchini et al., 2014; Sherrouse et al., 2014; Plieninger et al., 2013).

Regarding which level of decision-making concerning CES is appropriate for urban planning purposes, Pleasant et al. (2014) noted that CES are generally managed at the state level, but the benefits that they generate are experienced both locally and internationally. For this reason, it is probably at the local level (i.e. municipal level) that planning decisions about CES might be more effective in improving the overall quality of the urban environment (Pleasant et al., 2014).

If land-use planning processes are aimed at the design and organisation of urban space both physically and socio-economically, they need to find appropriate measures to address problems in the management of urban complexity. For an indicator to really serve as a base for decision makers in urban planning contexts, there is the need to be spatially explicit (La Rosa et al., 2014). This would also allow producing choices that are spatially differentiated within the urban context under exam. With this in mind, scenarios about new land uses in urban contexts should be based on spatial configurations resulting from spatially differentiated indicators scores. Among the final 37 indicators selected in Table 7, 25 indicators produced spatially differentiated scores. However, urban areas were never the precise contexts of the indicators, that were mainly calculated for regional (i.e. Nahuelhual et al., 2014; Frank et al., 2014), national (Weyland and Laterra, 2014) or continent (i.e. Norton et al., 2012) level. Urban contexts were always present as a portion of a wider geographical context and their relevance was

**Table 8**
CES categories for the final selected indicators.

| Categories of CES | # indicators | Indicator code |
|---|---|---|
| Recreational and ecotourism | 35 (95%) | 7.2, 28.1, 28.2, 37.1,38.1, 38.2, 46.2, 46.3, 46.4, 46.5, 50.1, 50.2, 50.3, 50.4, 50.5, 50.6, 50.7, 50.8, 50.9, 50.10, 50.11, 50.12, 59.1, 59.2, 61.1, 61.2, 61.3, 61.4, 61.5, 61.6, 61.7, 61.8, 61.9, 61.10, 63.1 |
| Aesthetic values | 18 (53%) | 7.1, 12.1, 28.1, 28.2, 50.1, 50.2, 50.3, 50.4, 50.5, 50.6, 50.7, 50.8, 50.9, 50.10, 50.11, 50.12, 59.1, 59.2 |
| Spiritual and religious values | 4 (11%) | 28.1, 28.2, 59.1, 59.2 |
| Cultural heritage | 5 (13%) | 28.1, 28.2, 37.1, 59.1, 59.2 |
| Inspiration | 4 (11%) | 28.1, 28.2, 59.1, 59.2 |
| Sense of place | 2 (5%) | 28.1, 28.2 |
| Cultural diversity | – | – |
| Educational value | – | – |
| Knowledge systems | 1 (3%) | 37.1 |
| Social relations | 1 (3%) | 37.1 |

thus extremely limited for the choice and development of CES indicators. No specific indicator was found for which the urban context was of high relevance or predominant within the study area of the paper.

The limited relevance of the urban context is also reflected by a lack of appropriate data used: most of the data used in the papers we reviewed had a very general level of detail not appropriate for capturing particular urban items like cultural objects, architectures, monuments, configurations of land uses, etc. Such features, as elements of the urban ecosystem, significantly influence ability of such urban ecosystem to provide CES.

Previous considerations indicate some difficulties implementing CES in urban planning and decision making, highlighting a mismatch between the potential of communicable information by spatial indicators so far developed for CES and their real usability in urban contexts. Results from our review showed the need for some adjustments for their applicability and use in urban contexts, such as the use of a different set of spatial data (density of cultural items/tourist places, data from geocoding services about urban features, etc.) or an increase in the spatial resolution of information used (i.e. land use/land cover datasets).

Furthermore, the review showed that almost all selected indicators useful for CES were proxies (Table 7), like the presence of particular physical features (Raudsepp-Hearne et al., 2010; Nahuelhual et al., 2013, 2014) or set of indicators used within hedonic pricing assessments (Sander and Haight, 2012).

Other indicators were used to assess CES only in a wider framework of multi-indicator approaches (Villamagna et al., 2014) or as spatial proxy to denote the preference of particular ES (Klain and Chan, 2012). The widespread use of proxies highlighted the complexity of transferring the concepts from the ES framework onto the cultural dimension in spatial terms, and the difficulty in finding quantitative indicators able to express the cultural dimension of specific ES in a spatially explicit way. This trend also shows that there is still space for new indicators addressing CES specificities (Hernández-Morcillo et al., 2013).

### 4.2. Emerging issues

As noted by Costanza (2008) ES "flow from sites where they are produced to sites where they are consumed". Thus, areas that benefit from ES are very often human dominated, characterised by relatively low biodiversity, like urban systems (Burkhard et al., 2012; Spyra, 2014). Therefore a better understanding of spatial locations of areas benefiting from a service and areas providing a service is necessary, as well as a careful assessment of the capacity of certain ecosystems to provide CES and other ecosystems to absorb CES. Such assessments can lead to better planning decisions concerning to urban environments in particular and other less anthropogenised environments in general.

CES are very often part of an ES bundle. Ecosystem service bundles are "sets of ecosystem services that repeatedly appear together across space or time"(Raudsepp-Hearne et al., 2010). According to CES, bundles are shaped by social and ecological processes (Raudsepp-Hearne et al., 2010; Ripoll-Bosch et al., 2013). Since within urban systems certain ecosystems provide cultural services beside or together with other services, CES have to be planned and managed in a bundle. CES are an ES directly responsible for the quality of life in urban systems and are directly experienced and appreciated by urban systems inhabitants and visitors (Plieninger et al., 2013). Both facts should be perceived as important motivators for CES sustainable management in urban systems ES bundles (Plieninger et al., 2012).

The potential effectiveness of managing CES through socio-economic policies remains unclear, probably because they are still unfamiliar concepts to "normative makers" or decision makers and not explicitly included in national, regional and local norms and regulations. Difficulties in monetary valuation of CES can lead to overlooking such services in a certain bundle or being marginalised as externalities (Chan et al., 2012; Urquhart and Acott, 2014). Particularly in urban contexts, this might lead to inappropriate planning decisions (Ruiz-Frau et al., 2013).

In the context of the applicability and usefulness of CES for urban planning, the presence of disservices is an important issue with increasing relevance. CES disservices have a negative impact on urban users by negatively affecting their activity (Piwowarczyk et al., 2012) and are understood as "functions of ecosystems that are perceived as negative for human wellbeing" (Lyytimäki and Sipilä, 2009, p. 311). CES disservices are very often effects of human activities in an urban environment (Plieninger et al., 2013) and suggest a trade-off between ecosystems and quality of life (Haase et al., 2014). In the review, only one of the papers analysed (Plieninger et al., 2013) dealt with disservices such as unpleasantness, scariness, and noisiness: indicators for CES disservices are still not widely enough discussed (Haase et al., 2014).

### 4.3. Criteria used for the literature review

The review was based on some specific terms used in the database queries. The results obtained were thus affected by the combination of terms used for the queries. The use of a broader scope of terms with a more "urban" or "spatial" meaning directly related to types of urban ecosystems providing certain services (e.g. "park", "urban forest", etc.) or particular parts of urban systems (e.g. "periphery", "urban fringe", "peri-urban", etc.) would have provided different results. Even though there might still be a set of papers that have not been targeted, due to this lack of an extended word search using CES terms specifically, we concentrate the search for peer-reviewed articles referring specifically and explicitly to the ES assessment framework (MEA, 2005; Van der Ploeg et al., 2010). We are aware that other papers might address some specific issues of CES without mentioning it in the title, abstract or keywords. But with our method we gain a clearer image of research published in peer-review journals which directly concerns CES by using or trying to use the ES framework.

However, to avoid narrowing the results of our query too much, we reviewed a set of papers dealing with indicators and cultural ecosystem services in general and not cultural urban ecosystem services, as we aimed to find elements about the use of CES in urban contexts from the existing research ongoing on CES in general. This approach was necessary because only one paper was found when using the keywords "cultural ecosystem services", "indicators" and "urban" (see Table 3).

Finally, it is worth pointing out differences of this work with previous reviews about CES. First, this paper investigates which are CES indicators that can be used for planning purposes and especially for urban planning. Other existing reviews have dealt with more general issues about CES (Haase et al., 2014; Milcu et al., 2013), without focusing on indicators and their possible use in decision making processes. Furthermore, the other review about CES indicators (Hernández-Morcillo et al., 2013) strongly differs from the structure of this review, in terms of objectives, methodology and reported results. A detailed investigation of articles dealing with CES in relation to urban planning is presented here, analysing in detail and discussing particular features of indicators (used data, scale, geographical units, reproducibility) that were not taken into account into previous studies.

## 5. Conclusions

CES are produced by human perceptions of a certain ecosystem, thus CES are the most "human made ES" (Raudsepp-Hearne

et al., 2010). Urban ecosystems are complex, adaptive and dynamic systems, which are shaped by interactions between human and biophysical agents (Alberti, 2008). Since urban ecosystems are the most anthropogenised among ecosystem types, the role of CES is significant for them. That indicates an urgent need for an adequate incorporation of CES within urban planning.

This paper presents a review of indicators for the assessment of CES, based on existing literature retrieved from academic databases. Papers resulting from database queries were evaluated, in order to obtain a list of CES indicators suitable for use in urban planning processes. Criteria of spatial features, communicability to planning and relevance of urban context were chosen as particular characteristics for indicators that should be used for urban planning.

The results showed that no indicator specifically addresses CES in an urban context and, on the contrary, urban environments seem to play a minor role within current ES assessments, although they are places with high density of CES. From the first set of papers we selected 37 indicators that might be used in urban context with some adjustments, according to the chosen criteria of evaluation.

This lack of an adequate urban concept can be easily observed in the scale of the assessments and in the non-urban nature of most indicators. Almost all the indicators found have problems when displayed at a proper urban scale, where the explicit evidence of spatial anisotropies is indispensable for an indicator to be useful for urban planning purposes. We have found a limited usefulness for indicators when the calculation refers to the entire area of municipalities. This implies the need for spatially differentiated indicator scores in order to enable planning tools to make effective use of the information they are providing. Identifying the spatial distribution of CES is a fundamental aspect to advance the inclusion of the ES framework into urban planning. Even though there are some suitable and potentially good indicators for planning purposes, most of them are borrowed from other sciences and disciplines. Furthermore, when looking in more detail at the indicators, it was found that most of them were proxies, thus having a tangential relationship with specific CES measurement. This indicates scope for developing new indicators addressing CES specificities. These results clearly indicate how the direct application of indicators for CES in urban context is still unexplored. Good quality of CES indicators will help to make wiser and ecologically focused decisions in urban planning processes (Daily et al., 2009; Xiang, 2014).

## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ecolind.2015.04.028

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