Ecological Indicators 79 (2017) 63–72

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Original Articles

Expert-based ecosystem services capacity matrices: Dealing with scoring variability

Carole Sylvie Campagne[a,b,*], Philip Roche[a], Frédéric Gosselin[c], Léïta Tschanz[b], Thierry Tatoni[b]

[a] Irstea, UR RECOVER, 3275 route de Cézanne, CS 40061, 13182 Aix-en-Provence Cedex 5, France
[b] Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE), UMR 7263, Aix Marseille Université, CNRS, IRD, Avignon Université, FST St-Jérôme, 13397 Marseille, France
[c] Irstea, UR EFNO, Domaine des Barres, 45290 Nogent-Sur-Vernisson, France

ARTICLE INFO

Article history:
Received 31 January 2017
Received in revised form 10 March 2017
Accepted 23 March 2017
Available online 15 April 2017

Keywords:
Ecosystem services
Capacity matrix
Confidence index
Uncertainty
Expert panel size
Participatory assessment

ABSTRACT

Capacity matrices are widely used for assessment of ecosystems services, especially when based on participatory approaches. A capacity matrix is basically a look-up table that links land cover types to ecosystem services potentially provided. The method introduced by Burkhard et al. in 2009 has since been developed and applied in an array of case studies. Here we adress some of the criticisms on the use of capacity matrices such as expert panel size, expert confidence, and scoring variability.

Based on three case-study capacity matrices derived from expert participatory scoring, we used three different approaches to estimate the score means and standard errors: usual statistics, bootstrapping, and Bayesian models. Based on a resampling of the three capacity matrices, we show that central score stabilizes very quickly but that intersample variability shrinks after 10–15 experts while standard error of the scores continues to decrease as sample size increases. Compared to usual statistics, bootstrapping methods only reduce the estimated standard errors for small samples. The use of confidence scores expressed by experts and associated with their scores on ecosystem services does not change the mean scores but slightly increases the standard errors associated with the scores on ecosystem services. Here, computations considering the confidence scores marginally changed the final scores. Nevertheless, many participants felt it important to have a confidence score in the capacity matrix to let them express uncertainties on their own knowledge. This means that confidence scores could be considered as supplementary materials in a participatory approach but should not necessarily be used to compute final scores.

We compared usual statistics, bootstrapping and Bayesian models to estimate central scores and standard errors for a capacity matrix based on a panel of 30 experts, and found that the three methods give very similar results. This was interpreted as a consequence of having a panel size that counted twice the minimal number of experts needed. Bayesian models provided the lowest standard errors, whereas bootrapping with confidence scores provided the largest standard errors.

These conclusions prompt us to advocate when the panel size is small (less than 10 experts), to use bootstrapping to estimate final scores and their variability. If more than 15 experts are involved, the usual statistics are appropriate. Bayesian models are more complex to implement but can also provide more informative outputs to help analyze results.

1. Introduction

Ecosystem service (ES) is a popular and widely recognised concept (Burkhard et al., 2012; Fisher et al., 2009), and the term 'ecosystem services' has translated from scientific studies into the mainstream vocabulary of stakeholders and experts (Jacobs et al., 2014). Increasing demand from policymakers like the European Commission has prompted the development of an array of ES

Abbreviations: ES, ecosystem service; ET, ecosystem types; SD, standard deviation; SE, standard errors; CP, cut point; RNP, Regional Natural Park; RNPBP, "Les Baronnies Provençales" RNP; RNP-SE, "Scarpe-Escaut" RNP; RNP-SEwet, "Scarpe-Escaut RNP wetlands only".

* Corresponding author at: Irstea, UR RECOVER, 3275 route de Cézanne, CS 40061,13182 Aix-en-Provence Cedex 5, France.
E-mail addresses: sylvie.campagne@irstea.fr, sylviecampagne@gmail.com (C.S. Campagne), philip.roche@irstea.fr (P. Roche), frederic.gosselin@irstea.fr (F. Gosselin), l.tschanz@imbe.fr (L. Tschanz), t.tatoni@imbe.fr (T. Tatoni).

http://dx.doi.org/10.1016/j.ecolind.2017.03.043
1470-160X/

assessment and mapping methods (Martnez-Harms and Balvanera, 2012; Willemen et al., 2015).

One such method that is gaining ground is the "capacity matrix approach", which was even touted as "the most popular ES assessment technique today" (Jacobs et al., 2014). The capacity matrix is basically a look-up table that links land cover types to ecosystem services potentially provided (Burkhard et al., 2009).

Since the "matrix" first introduced by Burkhard et al. in 2009, the method has been developed and applied in an array of case studies (e.g. Hermann et al., 2013; Kroll et al., 2012; Stoll et al., 2014; Vihervaara et al., 2010; etc.). Based on experts' knowledge, it gives a quick assessment of ES potentially provided in an area (Vihervaara et al., 2012; Stoll et al., 2014). The ES concept makes the matrix method mobilize the ES concept in way that makes it easy for stakeholders to understand and appropriate. It is a pedagogical tool that has proven its utility by targeting priorities and highlighting management hotspots. The approach can be applied at different scales (e.g. Stoll et al., 2014 or Hermann et al., 2013). A lack of quantitative data and their spatial heterogeneity raises issues that can be bypassed by asking experts to estimate scores. Depending on the concertation process applied, data can be developed by consensus among the different experts of a territory. The method is also flexible enough to integrate all kinds of data—from models or measurements alike (Burkhard et al., 2014).

Some researchers have started to study the limits of this method, like Jacobs et al. (2014) who point out its poor methodological transparency, lack of reproducibility and lack of appropriate factoring on uncertainty. Hou et al. (2012) also discuss the uncertainties related to the matrix method. The uncertainty of experts judgements is often cited as a limit, but few have analyzed it or integrated it in ES studies (Seppelt et al., 2011; Hou et al., 2012; Vihervaara et al., 2012). Based on the combination of experts' judgments, the scoring in the capacity matrix may carry two sources of uncertainties:

- Variability among experts: variability of the expertise within the chosen experts and of more general knowledge (professional or personal knowledge depending on their experiences) (Hou et al., 2012).
- Variability of each expert: the confidence the expert has in his/her own scores (Jacobs et al., 2014).

The objective of our study is twofold. First, we aim to integrate the different variabilities in the final score of the capacity matrix and present and compare different approaches to computing them. Second, we aim to identify a minimal size of the expert pool needed to obtain a reliable estimate of the mean of the scores and a small SE of this mean.

In order to meet these objectives, we begin by defining our capacity matrices, the experts, and how the scoring was done. The confidence score we added on the capacity matrix is also detailled. In the second section, we present three sets of approaches to the final scores on a matrix: raw parametric approaches (mean and weighted mean), bootstrap models, and Bayesian models. For each approach, we have two calculations: means of scores that experts expressed, and means integrating a metric of the expert's confidence on his/her own scores. The final scores in the final matrix that incorporates all experts scores is thus estimated with 6 calculations. Most existing capacity matrices (e.g. Stoll et al., 2014) using expert knowledge are expressed as mean of scores of the expert panel, so we start by presenting the raw parametric approach. The bootstrap model enables to estimate different statistics by assuming an independent sampling from an unknown distribution and to integrate uncertainties. The Bayesian methods that we used are elaborate parametric statistical models that enable to integrate and estimate the different kinds of uncertainties in the statistical analysis. We restrict ourselves to these three sets of statistical methods. This work is the first comparison of three calculations applied on capacity matrix scores. We are not setting out to identify the best calculation of final score but to highlight the various possibilities and their related advantages and disadvantages. In the third section, we present the results of the three calcultations on one matrix and look at the final scores and their variabilities on three capacity matrices with a growing number of experts. Finaly, we conclude with recommandations on using the capacity matrix approach.

The data used in this paper came from three ES assessments: ES provided by land-cover types in the 'Baronnies Provençales' Regional Natural Park (RNP) (associated scores noted RNP-BP) and two ES assessments in the 'Scarpe-Escaut' RNP in northern France—one on ES provided by wetlands (associated scores noted RNP-SE*wet*) and another on ES provided by all land-cover types (associated scores noted RNP-SE*all*).

2. Data

2.1. Study sites

The Baronnies Provençales RNP (http://www.baronnies-provencales.fr/) is a sub-mountainous rural area in Southern France located at the crossroad between the Alps and Provence influences. Created in 2015, it is the latest RNP in France, taking the total to 51. The capacity matrix made in 2014 was based on the Park project of 2350 km^2 and 130 municipalities. This nature-preserve territory is recognised nationally for its unique landscapes, rich "terroir", built heritage (terraces in dry stone, hilltop villages) and agriculture (orchards, olive groves, linden, lavender, thyme, rosemary, and more), as well as its remarkable geology and biodiversity.

The Scarpe-Escaut RNP (http://www.pnr-scarpe-escaut.fr/en) in northern France, near the Belgian border, extends over 430 km^2 crossed by the Scarpe and the Escaut rivers with 55 municipalities. It is the oldest of the 51 French RNP. It is also the largest European park, as together with its Belgian neighbour, the Plaines de l'Escaut Natural Park, they form the Hainaut cross-border Nature Park. The Scarpe-Escaut RNP is especially marked by the wet lowland plain around the Scarpe and the Escaut rivers. As a peri-urban area, urban pressure is high (use of space) in a landscape formed by a mosaic of agricultural and natural environments (crops, grasslands, woodlands, marshes, ponds. . .) and urbanized areas. Water is everywhere, and man has been managing it for centuries to develop key activities (drainage, land use, channeling of rivers. . .). For decades, wetlands have been considered a less attractive landscape, and wet meadows have been declining under urban pressure or exploited as profitable sites for agricultural production such as livestock and as landscaped recreational ponds. Perceptions of wetlands today are either bad for certain local stakeholders or nonexistent for the wider community, despite their importance as ES provided to the territory. This perception deficit prompted a study of the ES provided by the wetland types in 2015. After the positive local feeback on the initiative, the method was applied in 2016 to all land cover types.

2.2. Data

2.2.1. The capacity matrices

We define ES as goods or services provided by ecosystems that directly or indirectly benefit humans (Millennium Ecosystem Assessment, 2005). For provisioning services and regulating services, the ES list has been based on the European CICES classification (Haines-Young and Potschin, 2013). We considered provisioning services, regulating services and cultural services.