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Citizen science for assessing ecosystem services: Status, challenges and opportunities

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ABSTRACT

Citizen science approaches provide opportunities to support ecosystem service assessments. To evaluate the recent trends, challenges and opportunities of utilizing citizen science in ecosystem service studies we conducted a systematic literature and project review. We reviewed the range of ecosystem services and formats of participation in citizen science in 17 peer-reviewed scientific publications and 102 ongoing or finished citizen science projects, out of over 500 screened publications and over 1400 screened projects. We found that citizen science is predominantly applied in assessing regulating and cultural services. The assessments were often performed by using proxy indicators that only implicitly provide information on ecosystem services. Direct assessments of ecosystem services are still rare. Participation formats mostly comprise contributory citizen science projects that focus on volunteered data collection. However, there is potential to increase citizen involvement in comprehensive ecosystem service assessments, including the development of research questions, design, data analysis and dissemination of findings. Levels of involvement could be enhanced to strengthen strategic knowledge on the environment, scientific literacy and the empowerment of citizens in helping to inform and monitor policies and management efforts related to ecosystem services. We provide an outlook how to better operationalise citizen science approaches to assess ecosystem services.

Contents

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1. Introduction

The concept of ecosystem services (ES) bridges biodiversity science and society by assessing the benefits people derive from ecosystems for their well-being (Haines-Young and Potschin, 2010). Thereby, the concept integrates across different scientific disciplines of the natural and social sciences (Abson et al., 2014), aligns different sectors and stakeholders to discuss natural resource management (Reed et al., 2013) and attracts both biodiversity conservation and business interests (e.g., Goldman et al., 2008). Still, the integration of the ES concept in policy making and planning is not mainstream (Braat and de Groot, 2012) and related actors have concerns about the understanding and usefulness of the concept (Hansen et al., 2015; Kabisch, 2015).

The need for a better understanding of the state and trends of ES to safeguard and to enhance the benefits derived from them has been translated into global sustainability policies (Geijzendorffer et al., 2017) and the biodiversity strategy of the European Union. In particular, the EU member states are requested to map and assess ecosystems and ES in Target 2, Action 5 (European Commission, 2011). Science has taken up the challenge to develop suitable methods to assess ES, both driven by scientific endeavour (Crossman et al., 2013; Martínez-Harms and Balvanera, 2012; Schröter et al., 2015) and by the request for national and regional assessments (Albert et al., 2016; Maes et al., 2016; Schröter et al., 2016).

Overall, there is yet a bias towards assessing provisioning ES, for which suitable (trade) data and indicators are often available, and towards regulating ES, that can be modelled using mainly biophysical input data (Haase et al., 2014; Karp et al., 2015; Schröter et al., 2015). For assessments of cultural ES, such as the provision of recreational opportunities, aesthetic value of landscapes or cultural heritage (Chan et al., 2012; Daniel et al., 2012; Milcu et al., 2013; Plieninger et al., 2013) data availability is still limited. Specifically, the demand for and use of cultural ES is subject to individual preferences and perceptions of people. Hence, objective data collection and quantification of cultural ES can be difficult (Milcu et al., 2013). Studies that explore cultural ES are often based on assumed use-patterns (Raudsepp-Hearne et al., 2010; Schröter et al., 2014a), refer to perception and use of green spaces without directly linking to ES (Kabisch et al., 2015), or rely on land use and land cover data as proxies (Grêt-Regamey et al., 2015; Kabisch et al., 2014; Larondelle et al., 2014). However, some recent studies employ participatory methods (e.g., van Riper et al., 2017), and provide avenues for co-creating knowledge with affected ES beneficiaries.

In parallel to the interest in ES, citizen science has gained attention as an approach that aims to strengthen bonds between science and society by engaging citizens in research (Haklay, 2013; McKinley et al., 2015; Miller-Rushing et al., 2012). Citizen science is the voluntary, i.e. unpaid involvement of citizens in research activities (Cohn, 2008; Silvertown, 2009). Even though the term citizen science is relatively new (Kullenberg and Kasperowski, 2016), the practice of participatory research and volunteered science has a long tradition in a wide range of disciplines (Haklay, 2013) such as astronomy (Raddick et al. 2013), environmental monitoring (Pocock et al., 2017), natural history (Bonney et al., 2009a,b; Miller-Rushing et al., 2012), archaeology (Smith, 2014) and more recently also in life sciences (Den Broeder et al., 2016). High proportions of biodiversity data are collected by volunteers (Chandler et al., 2017; Schmeller et al., 2009), representing a vital source of information both for scientists and public authorities.

The meaning of the term citizen science varies within the scientific literature. Therefore, citizen science has not one definition or can be described as a replicable methodology. The concept of citizen science has developed from two origins, one in the social sciences and one in the natural sciences (Kullenberg and Kasperowski, 2016) and subsequently touching on issues of democratisation of science, public engagement itself (Irwin, 1995) and collection and analysis of large data sets through public participation (Bonney, 1996). Scholarly communication has mainly discussed the approach within natural sciences in the last 20 years but the discussion broadens with the spread of citizen science. For this article we refer to citizen science projects that mainly contribute to the monitoring of the environment and relate in any way to the assessment of ES.

The level of public participation in citizen science can vary (Shirk et al., 2012), and ranges from short-term data collection to intensive use of leisure time in order to delve deeper into a research topic together with or without scientists (Bonn et al., 2016). Citizens can participate in choosing or defining research questions, gather information and resources, develop explanations, design methods, collect samples and record data, analyse samples or data, interpret data and draw conclusions, disseminate results and discuss results and ask new scientific questions (Shirk et al., 2012). Common forms of citizen science participation comprise (i) contributory projects, led by scientists, involving volunteers mainly in the collection of data or samples, (ii) collaborative projects, that also include joint analysis of data or dissemination of results, (iii) co-created designs, i.e. the joint development of a study or (iv) citizen-led research or so-called collegial approaches where professional researchers are only involved secondarily, e.g. by being consulted for advice or specific analyses (Bonney et al., 2009a; Shirk et al., 2012).

Recent technological advances led to growth in popularity of citizen science by facilitating participation (Bonney et al., 2014; Newman et al., 2012; Silvertown, 2009). The internet helps projects to reach broad audiences by increasing visibility and allowing interested participants to find topics or projects. Further, the development of social media, mobile devices (incl. sensors), powerful (online) networks and computational facilities multiplies the capacity for data collection, storage, integration, analysis and dissemination (Pimm et al., 2015). Disseminating and applying new technologies such as intuitive mapping applications also allows for engaging previously not involved communities including indigenous people often hosting valuable traditional or local ecological knowledge (Drew, 2005; Liebenberg et al., 2017; Pimm et al., 2015). Beside technological advances, there is a rising awareness in the scientific community that citizen science can serve as a valuable tool to enhance the research design, to ease data acquisition and processing, to support science-policy-society communication and knowledge exchange and thus increase its social and