Is the focus on "ecosystems" a liability in the research on nature's services?

Health & Medicine

The services provided by nature to human populations have been the object of extensive research since WWII (e. g., Baveye et al., 2013). In the hundreds of articles, books, and reports published on the topic in the 1960s and 70s, terms like " environmental services," " environmental amenities," or " nature's services" (Westman, 1977 ; Baveye et al., 2013) were generally used to refer to benefits derived from nature. Westman (1977) , an ecologist by training, perceived nature through the lens of a broadly-defined concept of " ecosystem," but did not see the need to invoke this concept when referring to the benefits humans derive from nature. The alternative expression of " ecosystem services," apparently coined by Ehrllich and Ehrlich (1981) , gained little traction until 1997, but was then given significant prominence by Costanza et al. (1997) , Daily (1997) , and especially the publication of the Millenium Ecosystem Assessment (2005) . This terminology became the norm in the field, at least until recently. In the last couple of years, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) proposed what they viewed as a paradigm shift away from the concept of " ecosystem services" toward that of " nature's contributions to people" (NCP), perceived as significantly better in a number of respects (Díaz et al., 2015 ; Pascual et al., 2017). Nature's contributions to people are defined as " all the contributions, both positive and negative, of living nature (diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to people's quality of life" (Díaz et al., 2018). This proposal has rapidly stimulated an occasionally heated debate in which various protagonists (e. g., Braat, 2018 ; Faith, 2018 ; Peterson et al., 2018 ; see also the many e-letters posted at http://science.

sciencemag. org/content/359/6373/270/tab-e-letters) have tried to demonstrate the respective merits of the " ecosystem services" and NCP perspectives. One could argue at this stage that these relative merits, let alone the fundamental differences among the two terminologies, remain very fuzzy. At first glance, one would be tempted to say that a major difference is that the NCP terminology has eliminated any reliance on the notion of ecosystem, which would constitute a clear paradigm shift, but closer scrutiny shows that this is not the case; ecosystems still constitute implicitly the framework in which NCP are envisaged.

Yet, as we advocate in this short article, dropping the concept of ecosystem when assessing the functions or services of nature, at least in certain circumstances, might be a step in the right direction. Especially in an agricultural context, a number of obstacles are associated with the concept, and constitute as many compelling arguments, if not necessarily to adopt the controversial notion of Nature's Contributions to People, at least to move away from that of " ecosystem" services.

Criticisms of the concept of ecosystem among ecologists are not new. They have surfaced periodically over the last 30 years (e. g., Golley, 1991 ; Blew, 1996 ; Gignoux et al., 2012 ; Tassin, 2012 ; Silvertown, 2015). Several authors have criticized in particular the dichotomy between humans and nature that the notion of ecosystem implies (e. g., Berkes and Folke, 1998), and the hierarchical, scale-dependent structure of many ecosystems, which raises tricky methodological issues (Miller, 2008 ; Scholes, 2017). Various researchers have argued that, in its classical acception, the concept of ecosystem cannot be reconciled with the common observation of ecological

systems as metastable adaptive systems that usually operate far from equilibrium (e. g., Blandin and Bergandi, 2000 ; O' Neill, 2001), and new conceptualizations of ecosystems have emerged (e. g., Jørgensen et al., 2007).

Yet, the reasons for moving away from the classical concept of ecosystem when dealing with nature's services are different than those traditionally advocated by ecologists. There are basically three key reasons, namely that the ecosystem framework tends to limit unnecessarily the range of benefits to humans that are considered in practice, that it causes as yet unresolved difficulties for the measurement of ecosystem services, and that it makes it challenging to convince stakeholders to take nature's services into account in their decision making.

Restrictions on the Range of Functions/Services

A first type of restriction on the range of functions/services of nature that are considered in theory and practice is linked to a narrow interpretation of the concept of ecosystem. Barot et al. (2017) point out that, probably because the main goal of the " ecosystem services" approach was initially to foster nature conservation, there has been a strong tendency in the related literature to envision only the services provided by natural ecosystems, and to ignore those emanating from " anthropized" or " managed" ecosystems. For example, the recent global assessment of de Groot et al. (2012) excludes explicitly all cultivated and urban areas, because they are human-dominated ecosystems. This distinction between natural and human-dominated ecosystems may seem arbitrary since one might argue that all ecosystems

on earth are more or less impacted by human activities, that we want it or not. Therefore, a framework for the assessment of ecosystem services that is artificially restricted to " natural" ecosystems " is not fully adapted for the majority of ecosystems and may lead to misleading conclusions when [...] managed ecosystems with different intensit[ies] of anthropization or different types of management are compared." (Barot et al., 2017).

A second type of restriction of the discourse concerns a zeroing in only on services that somehow involve living organisms. This is consistent with the fact that the concept of ecosystem, generally defined as " a community made up of living organisms and non-living components such as air, water and mineral soil" (e. g., Smith and Smith, 2012), explicitly requires the presence of something living, be it a plant, animal, or microorganism. This perception goes all the way back to Tansley, for whom an ecosystem was necessarily " organism centered" (Blew, 1996). And the focus on organisms (besides humans) also makes sense if the purpose of considering ecosystem services consists of making decision-makers aware of the importance of preserving biodiversity in nature. Unfortunately, the constraint of necessarily including organisms is problematic in the broader picture of the preservation of important natural resources, because for a number of benefits that humans derive from nature, one would be hard pressed to envisage a significant role for any living being (other of course than the humans at the receiving end). For example, in the use of soil as a building material by the countless populations around the world that still rely on soil to construct their dwellings, one would be hard pressed to identify a key role for living organisms. It would be equally tough to identify a key biotic component in a

wide range of other processes, like when soil erosion occurs on fields that are bare of any crop, or during the movement of engineered nanoparticles in soils toward groundwater supplies. One could of course decide, as some authors have done (e. g., de Groot et al., 2002 ; Dominati et al., 2014 ; McBratney et al., 2014) that for the provision of raw materials to be considered an ecosystem service, the raw materials in question have to be renewable and biotic, whereas non-renewable, abiotic resources like sand or clay cannot be included. This decision seems arbitrary to many stakeholders (Haines-Young and Potschin, 2018). It also implies that human-induced changes that have some of the most dramatic impact on nature, for example the choice to build a parking lot or a road on soil with a good agricultural potential, are partially beyond the scope of ecosystem services, when interpreted with such blinders. In addition, one could argue that an undue focus by ecologists on the role of living organisms in nature's services makes it very difficult for specialists of other disciplines, e. g., sociologists and anthropologists, interested in cultural services, to take part in ongoing discussions. Clearly, this type of interdisciplinary exchange of views is always fraught with difficulties, at a number of different levels, and is hindered by countless financial and administrative constraints (e. g., Baveye et al., 2014). In that context, a strong emphasis on living organisms (again, other than the human populations that are the beneficiaries of the functions/services) may ultimately heighten the risk that the field of ecosystem services lose some of its appeal to resolve issues of great societal concern, like urban sprawl, and may hinder the interdisciplinary efforts that are required to make headways.

Things have begun to change in this regard. Several recent classifications of ecosystem services, like the FEGS and NESCS tools of the U. S. Environmental Protection Agency, include abiotic components in their list of ecosystem services (Landers and Nahlik, 2013). In line with the soil science literature on soil functions, Dominati et al. (2010) , as do also Baveye et al. (2016) , include in the list of soil services they consider a number of strictly abiotic ones, like the physical support to infrastructures, and the supply of raw materials. Van der Meulen et al. (2016) argue that the inclusion of abiotic flows makes application of the ecosystem services concept more holistic and consistent. User community feedback to the group producing the Common International Classification of Ecosystem Services (CICES) led very recently to the inclusion of abiotic outputs in its most recent classification (Haines-Young and Potschin, 2018). Nevertheless, version 5. 1 of CICES, like the MEA, still " focuses on defining final ecosystem services that depend on living systems" and emphasizes " the fundamental contribution that biodiversity makes to human well-being," so that for example, services of an extractive nature (for sand, clay, groundwater) are still not included explicitly, nor is the function of soils as support to infrastructure.

Measurement Issues

A second argument in favor of taking some distance from the ecosystem paradigm when considering nature's services, is that this concept complicates drastically the measurement and quantitative prediction of a number of the services, which several authors have argued recently constitute key challenges facing research in this field (e. g., Grêt-Regamey et al., 2014 ; Andersson et al., 2015 ; Baveye et al., 2016 ; Baveye, 2017). A

forest is arguably one of the simplest examples of an ecosystem whose geographical boundaries can be readily identified, and for which it is possible to measure some services, like the production of wood. However, a forest does not necessarily lend itself at all to physical or hydrological measurements, e. g., of the dynamics of groundwater storage, the filtering out of potentially toxic agrochemicals (like pesticides), or the amount of soil that is retained in place and does not end up as sediment load in streams (Baveye, 2017). To be able to measure these services, the boundaries of the forest would have to correspond closely to the limits of a region, like a watershed, where one could monitor closely what enters the system and what goes out of it. In a natural forest ecosystem, unaffected by human influence, there may be a close connection between the limits of a forest and the boundaries of watersheds or areas occupied by specific soil types with distinct characteristics, and this may make it possible to come up with ways to measure services and not just “ guesstimate” them. However, in managed forest ecosystems, this close connection with the physical world (geotope) may no longer exist, which raises very significant experimental issues. If a forest is large enough to intersect several watersheds or alternatively is not large enough to fill a subcatchment, the task of measuring some of its functions or services poses daunting challenges, which to this day have yet to be addressed, and will need to be resolved for the analysis of nature's services to become quantitative and objective (Baveye, 2017). Once measurements will be available, it will be possible to develop reliable estimation techniques, which then in principle will be applicable to regions of

any extent, but we are not at that stage yet, by a far shot (e. g., discussion in Baveye et al., 2016).

Lack of Correspondence With Stakeholders' Concerns

The last argument against linking the concept of ecosystem too closely to an analysis of nature's services, is that stakeholders, whom we need to have on board (Bennett, 2017), tend not to associate the concept readily with their day-to-day reality. Except for wealthy landowners who may own an entire forest, very few individuals actually own or manage whole ecosystems, and even fewer would probably describe their property in those terms. For example, farmers, at least in Europe, do not routinely talk about owning or managing agroecosystems. They may own or rent several cadastral units of land, which may not be contiguous, and to which they apply specific agricultural practices in order to preserve the integrity and productivity of the land in the long run. To make the field of nature's services relevant to these farmers, the discourse would have to be at the scale of cadastral units that is relevant to them, and would have to deal with issues, often focused on soils, about which they are directly concerned. In that context, one could argue that the " mismatch between legal units and ecological phenomena" (Vejre et al., 2015) that characterizes much of the literature in the field, may be one of the root causes of the documented slow progression from theory to practice in the economic valuation and management of ecosystem services (Laurans et al., 2013 ; Laurans and Mermet, 2014). That there is enormous room for improvement in this respect is underscored particularly clearly by the recently published research of Watson and Newton (2018) . These authors conducted a survey of business dependencies on 26 different

ecosystem services in the English county of Dorset, " where the environment supports a significant portion of the local economy." Among the 212 businesses that responded to the questionnaire, an astounding 50% of them on average claimed no dependence on ecosystem service flows. Of course, multiple reasons may account for this somewhat shocking observation, but it is very tempting to see in it a result of a lack of understanding of what the concept of ecosystem, and therefore also that of ecosystem service, really represent.

Conclusion

The key conclusion we draw from these various arguments is that, at this stage, the question contained in the title of this article should probably be answered in the affirmative. The concept of ecosystem can be viewed as a liability not only in the research on nature's services, but especially in its application to the type of situations encountered locally by land managers and decision makers. In this context, researchers dealing with the benefits humans derive from nature have three options to move forward. The first is to return to Westman's (1977 ; 1985) terminology of " nature's functions and services," which does not make reference explicitly to ecosystems. Option 2 consists of making the concept of " ecosystem service" evolve so that it be either less focused on the notion of ecosystem or based on a broader perspective on ecosystems, as in Westman (1977) . The third option is to likewise broaden the recently proposed NCP framework to loosen its dependence on the notion of ecosystem. Options 2 and 3 run the risk of generating significant confusion in the field, with people using the same terms to mean different things, so that after a while, nobody will know

clearly what is talked about, and to what extent ecosystems are still part of the picture. Therefore, our recommendation is that it would be best to return to Westman's (1977) terminology, and to put us back on an " ecosystem-light" track that one could argue the field should perhaps never have left. Such a perspective is adopted by Baveye et al. (2016) , who consider the functions of soils (in the sense commonly used in the soil science literature since the 60s) and their services (or disservices) to humans. This shift in terminology offers many benefits but clearly, there are still sizeable challenges along that road, as the requirement of measurability of functions/services and of relevance to local practical issues pull us in what, at least initially, appears to be potentially conflicting directions. Nevertheless, if a healthy debate develops around the issues raised here, it might be possible to find workable solutions.

Author Contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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