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Thoughts of a travelling ecologist 14.

Structure-function conflation in environmental risk assessment and monitoring

Gábor L. LÖVEI

Institute of Applied Ecology, Fujian Agriculture and Forestry University, Fuzhou, Fujian 350002, *China & Department of Agroecology, Aarhus University, Flakkebjerg Research Centre, DK*-4200 *Slagelse, Denmark*

Recently, I attended a conference organised by the European Food Safety Authority in the beautiful and prosperous Italian city of Parma. The overall topic of the conference was risk assessment, and the program included a section on aspects of environmental risk assessment. In various areas, including the evaluation of the effects of pesticide applications, invasive organisms or genetically modified plants (Arpaia *et al.*, 2014) preparing an environmental risk assessment is an obviously relevant exercise. Actually, I prefer if it were called an environmental *impact* assessment, which would help to save us from seeing "risks" everywhere. Additionally, this can easily lead to a patronising attitude, as if "the general public" were unhelpful children, to be guided through the various risks by (usually self-appointed) Wise Guardians. However, this is a sideline, and not the core of my story.

The current conceptual framework for environmental risk assessment, judged from the frequency of hearing the term at the conference, is that of ecosystem services (ESs). ESs as a concept emerged ca. 50 years ago, gained momentum during the famous Millennium Ecosystem Assessment exercise (MEA, 2005), and rapidly spread into the policy arena, culminating in the establishment of an Inter-governmental Panel on Biodiversity and Ecosystem Services, (IPBES), which started to issue periodic assessments. Actually, due to a recently suggested change in terminology, ecosystem services are now called "Nature´s contributions to people" (NCP), which can be classified as material, non-material or regulatory (Diaz *et al.*, 2018). Damage to ESs is to be avoided, and the environmental impact of various xenobiotics, GMOs and invasive organisms are to be evaluated by judging, modelling or examining their effects on various ESs. Monitoring is also recommended by tracking the status of various ESs.

However, when we get to the "how to do it", I see a conflation of structure and function. Sometimes the ES is characterised by a parameter that is functional. For example, carbon sequestration by a forest is routinely characterised by the amount of wood growth per area per year. In other cases, there is a mix of structure and function: decomposition is sometimes characterised by actually measuring the decomposition rate by using some simple test, like the tea-bag test (www.teatime4science.org). However, other times the same is characterised by changes in the density of a chosen "service providing unit", for example springtails (Collembola). Yet for others, such as natural

Corresponding address: G. L. Lövei, Department of Agroecology, Aarhus University, Flakkebjerg Research Centre, Forsoegsvej 1, DK-4200 Slagelse, Denmark. E-mail: gabor.lovei@agro.au.dk

pest control, the most frequent characteristic chosen is the density, or even diversity of natural enemies, usually of arthropods. At the extreme, density changes of a single species (for example, of the common European ground beetle, *Harpalus rufipes*, Lee & Albajes, 2016) are supposed to tell us all that is needed to know about the changes in several important ESs. This is hardly a credible approach.

None of these are obviously faulty (except the last example). However, we may run into serious problems if there is no clear distinction between structure and function, and a careful justification of the chosen parameter. There is no obvious, simple relationship between ecological structure and ecological function, although some important pointers emerged form analyses of field experiments (Isbell *et al.*, 2015). I reckon that when we use the ES conceptual framework, we are interested in the outcome of an ecological process. Characterising changes in this may be, in some cases, be characterised by changes in the "service providers", but this link is neither obvious nor necessarily simple. Biological control of a pest may legitimately be considered a service, and is provided by one or (usually) more species of natural enemies. Aphids as plant pests are prey or food for ground beetles, rove beetles, ladybird beetles, lacewings, spiders, parasitoids, fungi, and several other organisms. Clearly, density changes in one of them do not correlate with density changes in others, unless a drastic and usually negative impact occurs. However, if we monitor the densities of all of the above, we are not necessarily closer to judging changes in the level of pest control as an ES. This is because these organisms also interact, for example through competition or intraguild predation (Heimpel & Mills, 2017). If we register twice more ladybird beetles, the level of pest control did not automatically double. If, for example, they choose to feed on parasitised aphids, then an increase in coccinellid density may harm the control by parasitoids (Snyder & Ives, 2003). It would be an error to assume that because there are now more coccinellids, pest control proportionally increased. However, this is precisely the conclusion often drawn from monitoring population densities. There is a solid link between natural enemy density and pest control, but this is not always a simple arithmetic relationship. Conflation of these two, structure and function, does not serve our purpose well. There should be a careful consideration when is it more practical, and more informative, to try to track the changes in the intensity of the function, rather than monitoring structure. True, ecology has a long tradition and a well-developed toolkit of monitoring changes in density of various invertebrates (Henderson & Southwood, 2016) although the evaluation methods are often set this to Italics, and precise quantification of seasonal activity changes, or changes in density, are not common (Fazekas *et al.*, 1997, Lövei *et al.*, 2018). However, there also exist well-tried methods for tracking changes in various ecological functions (for predation, see Lövei & Ferrante, 2017) and guidelines (Meyer *et al.*, 2015) as well as examples of tracking multiple ESs (Leidinger *et al.*, 2017). Monitoring ecological functions is therefore not impossible any more.

There is a varied toolkit of ecological methods available to be used for environmental monitoring, and substantial methodological challenges do not stand in the way of choosing appropriate methods to monitor structure or function. Convenience is one important aspect when one selects methods for impact assessment or monitoring, but it is clear that mere convenience cannot be the overriding factor when deciding about methods to use. Conceptual clarity is necessary- and this is especially important when one declared aim of our activities is to guide the world to an ecologically sustainable future.

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