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Are diverse ecosystems more valuable? Economic value of biodiversity as result of uncertainty and spatial interactions in ecosystem service provision

Bartosz Bartkowski

Helmholtz Centre for Environmental Research – UFZ, Permoserstraße 15, D-04318 Leipzig, Germany

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ABSTRACT

Economic valuation mostly focuses on specific ecosystems, species or the services they provide. The diversity within ecosystems is viewed as a valuation object less frequently. In this paper, it is argued that the economic value of biodiversity highlights the relevance of the temporal and spatial dimensions in ecosystem service provision. A framework is presented in which the economic value of biodiversity is the result of uncertainty about the future, regarding both supply of and demand for ecosystem services, and of spatial interactions between ecosystems. Three sources of biodiversity's economic value are distinguished in this context: insurance value, option value and spill-over value. Furthermore, the paper introduces biodiversity-specific methodological challenges (importance of non-market ecosystem goods; uncertainty and subjectivity; complexity and abstractness) which can be used to identify suitable methods for the economic valuation of biodiversity.

1. Introduction

One of the most dramatic and detrimental consequences of the Anthropocene, i.e. the current 'human-dominated[...] geological epoch' (Crutzen, 2002; see also Lewis and Maslin, 2015), is the unprecedentedly fast pace at which biodiversity is being lost due to human activity (Barnosky et al., 2011; Pereira et al., 2012; Steffen et al., 2015). An important facet of this loss is the loss of ecosystem services (ES) (MEA, 2005), which is one of the main reasons why ES research has gained huge influence in conservation and many related discourses in recent years. However, exclusive focus on ES threatens to obscure the complexity of ecosystems and the potential relevance of the *diversity* in them for human well-being (Mainwaring, 2001; Norgaard, 2010). Biodiversity loss can be interpreted in terms of the identity of specific entities, processes and functions lost (ES), as well as in terms of their diversity (biodiversity stricto sensu). The latter perspective is much less pronounced in public debates and research. There exist many different perspectives on the relationship between biodiversity and ES (Jax and Heink, 2015). When it comes to the value of biodiversity, it is often seen as underpinning the provision of ES (via its contribution to ecosystem functions) or linked to cultural ES; sometimes, intrinsic value is attributed to it (Cardinale et al., 2012; Harrison et al., 2014; Mace et al., 2012; Schröter et al., 2014). In this paper, it will be argued that biodiversity has economic value going beyond these considerations.

One of the ways to highlight the seriousness of biodiversity loss is economic valuation (Kumar, 2010). Most valuation studies focus on specific entities – a given ES, a given species etc. Those that make biodiversity their valuation object are more scarce – and have been shown mostly not to capture its complexity (Bartkowski et al., 2015; Farnsworth et al., 2015); the overall picture drawn by available biodiversity valuation studies is rather inconsistent. It seems that there still 'is [...] not yet an established framework for valuing biological variety' (Nijkamp et al., 2008, p. 218), despite numerous improvements since this remark was made.

This paper aims at making a contribution in the tradition of ecological economics by pointing out that the economic value of biodiversity results above all from its mediation of uncertainty about the future and from spatial interactions between ecosystems in the context of ES provision. It is argued here that biodiversity contributes to human well-being in ways additional to the value of those ES, i.e. that the fact that an ecosystem is more or less biodiverse constitutes value-inducing effects additional to the value of ES. Specifically, biodiversity is the sole 'ecosystem-side' carrier of three categories of economic value (of course, these values are also influenced by human activities on the 'human side'):

E-mail address: bartosz.bartkowski@ufz.de

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- insurance value, which arises when biodiversity can reduce the uncertainty surrounding the provision of ES to risk-averse stakeholders;
- option value, which arises from biodiversity's being a portfolio of options that reduce the uncertainty surrounding future preferences towards ecosystems;
- spill-over value, which arises from the role of biodiversity in spatial interactions between ecosystems.

Each of these value categories is discussed in more detail below. Furthermore, the thus generated insights into what constitutes the economic value of biodiversity are used to identify valuation methods that are suitable for dealing with this valuation object.

2. Defining biodiversity

Since the term 'biodiversity' is often used very vaguely in both public and scientific discussions, all too often as a synonym of 'nature', it is essential to clearly define it before we can determine why it is economically valuable and how this value can be approached methodologically.

Despite being so popular, also in scientific discourses, biodiversity has no established definition (Meinard et al., 2014). Different definitions have been used in different contexts, which partly reflects the fact that the concept has evolved over time – for instance, the still highly influential CBD definition (CBD, 1992) does not mention functional diversity, simply because this concept, now considered very important, is of more recent origin. This paper is based on a combination of two definitions from the literature, which is both encompassing so as to account for the multidimensionality of biodiversity, and precise by not including non-biodiversity elements in it.

Stirling (2007) provides a general definition of diversity as the combination of three properties of systems: variety (number of items in a category; the more items, the higher diversity, ceteris paribus), balance (distribution of elements across items in a category; the more even the distribution, the higher diversity, ceteris paribus) and disparity (degree of difference between items in a category; the less similar the items, the higher diversity, ceteris paribus). Translated into ecological terminology, these three properties are richness, relative abundances (evenness) and phylogenetic distance (or a similar measure of dissimilarity).

Maier (2012) defines biodiversity as the multiplicity of kinds in biotic and biota-encompassing categories. This implicitly stresses three things: first, trivially, biodiversity is about biotic (living) elements of ecosystems. Second, it is concerned with the multiplicity of these items, not with their identity (see also Faith, 2017). This is important because in the context of economic valuation biodiversity is often wrongly approached by valuing particular species (Bartkowski et al., 2015). Third, biodiversity is multidimensional and cannot be sensibly reduced to e.g. species diversity (Lyashevska and Farnsworth, 2012).

By combination we acquire the definition of biodiversity that is underlying the present paper:

> Biodiversity is a property of ecosystems; it is the (i) variety, (ii) balance, and (iii) dissimilarity of kinds in biotic or biota-encompassing categories.

3. Sources of biodiversity's economic value: incorporating temporal and spatial considerations in ecosystem valuation

As mentioned in the Introduction, in the literature the value of biodiversity is often framed as: underpinning of ES provision; underlying some cultural ES, particularly those deriving from aesthetic appreciation of ecosystems; and intrinsic value (e.g. Harrison et al., 2014; Mace et al., 2012; Schröter et al., 2014). The first interpretation is only partly relevant from the point of view of economic valuation, namely, when it is linked to the concept of insurance value (see below); otherwise, its inclusion in economic valuation would amount to double-counting (Hamilton, 2013). The second interpretation, too, is only of limited relevance here, as the cultural ES 'supported' by diversity (such as aesthetic appreciation) are constituted by more factors than diversity alone, so it does not appear sensible to distil its relative contribution to them in practice. The third interpretation, while very common, seems to be wrong, as is compellingly argued by McShane (2017), who shows that none of the available interpretations of intrinsic value is compatible with biodiversity.

The basic, textbook perspective on the economic value of ecosystems is as follows: an ecosystem provides goods and services[1] to humans; furthermore, some ecosystems or their elements are valued simply because they exist (existence value[2]). To properly include biodiversity in this picture, one must broaden the perspective by including the temporal and spatial dimensions. Specifically, one must realise that (i) ecosystems are not static (temporal dimension 1); (ii) human preferences are not static as well (temporal dimension 2); and (iii) the provision of ecosystem goods and services does not take place in a vacuum, but is usually embedded in larger networks of interactions (spatial dimension). These considerations are depicted in Fig. 1 and discussed in more detail below. Each of the three categories of biodiversity's economic value that are this paper focuses on can be related in a different way to the dimensions of diversity identified by Stirling (2007). This shows that focusing on one dimension is not sufficient to capture the complexity of biodiversity.

In what follows, first each of the three sources of biodiversity's economic value will be introduced and discussed in more detail: insurance value and option value in Section 3.1, spill-over value in Section 3.2. In Section 3.3, their compatibility with the total economic value (TEV) framework will be briefly discussed.

3.1. Temporal dimension: ES provision and biodiversity in an uncertain world

Both the supply of and demand for ES can change over time. Supply changes result from changes in the ecosystem itself – ecosystems are dynamic, they evolve constantly. In addition to that, human activities increase the rate of change in ecosystems and make their future even more uncertain (Pereira et al., 2012). Changes in demand result from the dynamic nature of human preferences, changes in tastes, needs, technology etc. In fact, changes in ecosystems can trigger changes in needs/demand, e.g. as response to new pests. The two are connected. Together, this means that (i) a given ecosystem's capacity to provide ES in the future is uncertain and (ii) which ES will be demanded in the future is uncertain, too. Biodiversity is valuable because it can alleviate both sources of uncertainty: by stabilising the ecosystem it provides a 'natural insurance' (Baumgärtner, 2007) against fluctuations in the ecosystem's capacity to provide ES; at the same time, it is a pool of options to accommodate future changes in preferences and thus demand for ES.

3.1.1. Biodiversity and uncertainty of ES supply

There exists a large and long-standing literature on the relationships between biodiversity and ecosystem functioning (BEF). The

[1] Sometimes, a distinction is made between (final) ecosystem services and ecosystem goods (Boyd and Banzhaf, 2007; UK NEA, 2011). For the purposes of the present paper, this distinction is not relevant.

[2] Existence value is sometimes classified as an ES, e.g. in the influential Common International Classification of Ecosystem Services CICES (Haines-Young and Potschin, 2013). This, however, seems to overstretch the inherently instrumental meaning of the term 'service'.