Ecological Economics 113 (2015) 1–14

Contents lists available at ScienceDirect

Ecological Economics

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

Analysis

Capturing the complexity of biodiversity: A critical review of economic valuation studies of biological diversity

Bartosz Bartkowski *, Nele Lienhoop, Bernd Hansjürgens

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

ARTICLE INFO

Article history:
Received 30 June 2014
Received in revised form 18 December 2014
Accepted 23 February 2015
Available online 4 March 2015

Keywords:
Biodiversity
Economic valuation
Literature review
Biodiversity proxies
Multi-attribute valuation

ABSTRACT

Biodiversity is a highly complex and abstract ecological concept. Even though it is not one physical entity, it influences human well-being in multiple ways, mostly indirectly. While considerable research effort has been spent on the economic valuation of biodiversity, it remains to be a particularly challenging 'valuation object'. Valuation practitioners therefore have to use proxies for biodiversity, many of which are very simple (single species, habitats). This paper presents a comprehensive and critical review of biodiversity valuation studies with special emphasis on bio*diversity* valuation in order to depict the state-of-the-art in this research field. It develops evaluation criteria so as to identify best-practice applications and shows that the field of biodiversity valuation studies is rather heterogeneous regarding both valuation objects and valuation methods. On the basis of our evaluation criteria and best-practice studies we suggest that to account for the complexity and abstractness of biodiversity, multi-attribute approaches with encompassing information provision should be used that emphasise the roles biodiversity plays for human well-being.

1. Introduction

The term biodiversity has experienced a rarely seen rise in recent decades. Coined in 1986 by Walter Rosen, in 1992 it was included in the title of one major outcome of the Rio Earth Summit—the Convention on Biological Diversity. Another 10 years later it was an essential part of the Millennium Ecosystem Assessment framework. Since then, it has been becoming ever more popular both in policy and scientific debates. In 2008, the TEEB (The Economics of Ecosystems and Biodiversity) process was initiated. In 2013, the IPBES, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services was launched, a UN funded body that is hoped to mimic the success and influence the IPCC has had in the area of climate change.

Despite its obvious success, or maybe just because of it, the concept of biodiversity has remained vague and thus controversial. Also, its diffusion from scientific discourse into public awareness has been only partial—according to public opinion polls, many people around the world do not know the term, and even fewer are able to define it (DEFRA, 2007; UEBT, 2013). This is not surprising given that biodiversity is a complex, multi-level concept, which includes genetic, species, functional, molecular and phylogenetic diversity, among others. Accordingly, there are many different approaches to the measurement of biodiversity, which reflect various perspectives and specific research needs.

As indicated by the explicit inclusion of the concept in the name of the major study of the state of the art in environmental economics, the first TEEB report on 'Ecological and Economic Foundations' (Kumar, 2010), biodiversity is by no means a new concept for economists. On the contrary, economists have made significant contributions to the topic, including, among other things, the design of diversity indices (Solow et al., 1993; Weitzman, 1992; see also Baumgärtner, 2007), models of optimal conservation strategies (Figge, 2004; Weitzman, 1998), analysis of biodiversity as insurance (Weitzman, 2000) and of the socio-economic drivers of biodiversity loss (Swanson, 1998), as well as economic valuation of biodiversity (Heal, 2000; Kumar, 2010; Pearce and Moran, 1994). However, just as in the political discourse, the use of the word 'biodiversity' has not always been precise in the economic literature. Often the term is used just as a synonym for 'nature' or 'life on Earth', which is the *broad meaning* of the word. In its *narrower, more specific meaning*, however, 'bio*diversity*' emphasises the diversity or variety of all the biotic components the ecosphere consists of (Swingland, 2013), rather than the components as such. There is a need to distinguish between the two interpretations of the term.

In the case of valuation, the issue of the term's interpretation might be even more problematic. In fact, economic valuation of nature is mostly based on the ecosystem services approach (Daily, 1997). There are many different frameworks, classifications and definitions of ecosystem services in the valuation context (see, e.g., de Groot et al., 2002, 2010),

* Corresponding author.
E-mail addresses: bartosz.bartkowski@ufz.de (B. Bartkowski), nele.lienhoop@ufz.de (N. Lienhoop), bernd.hansjuergens@ufz.de (B. Hansjürgens).

http://dx.doi.org/10.1016/j.ecolecon.2015.02.023
0921-8009/

and no consensus on a common framework has yet been reached (Nahlik et al., 2012). Within the ecosystem service framework(s), the role of biodiversity is at best unclear, allowing for many contesting interpretations, e.g., in respect to the question whether biodiversity is regarded as the source of ecosystem services or not (Atkinson et al., 2012; Elmqvist et al., 2010; Mace et al., 2012). As it is a complex concept rather than a single physical entity, biodiversity cannot be captured 'directly', but only by use of proxies or indicators. Accordingly, economic valuation studies that aim to assign a value to bio*diversity* choose very diverging approaches and use different proxies to approximate this inherently abstract and complex concept (Meinard and Grill, 2011).

Already in the early stages of biodiversity valuation research, Pearce (2001) complained that most valuation studies claiming to provide value estimates of biodiversity actually had valued biological resources, not their *diversity* (see also Turner et al., 2003; Christie et al., 2006). Nunes et al. (2003) and Christie et al. (2004) have reached similar conclusions in their overview of suitable valuation approaches and monetary value estimates for different aspects of biodiversity (genetic and species diversity, single species, multiple species, natural habitats, biological resources, ecosystem functions and services).

Only three studies have reviewed the biodiversity valuation literature (Bakhtiari et al., 2014; Christie et al., 2004; Nunes and van den Bergh, 2001), which differ from the review presented here. Due to their specific focus, the existing reviews explicitly do not include all biodiversity valuation studies available at the time of publication (Christie et al., 2004; Nunes and van den Bergh, 2001) or they focus on a specific class of valuation methods, namely choice experiments (Bakhtiari et al., 2014). In our review we provide an update of existing biodiversity valuation studies and include the entire range of valuation methods used. Also, Nunes and van den Bergh's categorisation of biodiversity studies was based on the values they ascribed to biodiversity. Conversely, our approach is more bottom-up, in that our biodiversity proxies (see Section 3) are derived from the studies reviewed here. Furthermore, earlier reviews do not clearly distinguish between biodiversity and biological resources. Here, we argue that this distinction is crucial and assess the accumulated body of valuation research focusing on biodiversity as valuation object. For this purpose, we conducted a comprehensive, exhaustive and critical review of all biodiversity valuation literature available through October 2014 and identified all studies that value diversity.

The specific objectives of the review are:

- to identify and critically discuss the suitability of proxies for biodiversity used in valuation studies;
- to explore common patterns and differences in the relevant body of applied literature;
- to pinpoint strengths and limitations of existing approaches and identify best-practice studies;
- to present criteria for a proper valuation of biodiversity;
- to offer an orientation as to how biodiversity should be valued.

The remainder of our article is structured as follows: in Section 2, an overview of the relevant ecological concepts regarding the definition and measurement of biodiversity is offered. The third section discusses the materials and methods used to conduct the actual literature review. We present the categories of biodiversity proxies derived from our review and used to group the approaches found in the studies reviewed. In the fourth section, we outline our understanding of the term 'biodiversity' and delineate it from related valuation objects, and we derive criteria for proper economic valuation of biodiversity. In the fifth section, key results of the review are presented. Section 6 contains an evaluation of the approaches identified in the review in accordance with the criteria proposed in Section 4, and the identification and presentation of best-practice approaches. The last, concluding section offers an orientation towards a more consistent framework for the valuation of bio*diversity* and recommendations for future research.

2. Definitions and Measures of Biodiversity

There exist many different definitions of biodiversity (DeLong, 1996). The term was coined by Walter Rosen in 1986 in the context of the National Forum on BioDiversity (Takacs, 1996). However, its full form, biological diversity, has been in use since at least 1980 (Swingland, 2013). According to critics, the term is not scientific, but advocative (Takacs, 1996), and represents a very vague, "pseudocognate"[1] concept (Gaston, 1996a; see also Kahn et al., 2001). Accordingly, the most widely-used definition of biodiversity, adopted by the Convention on Biological Diversity (CBD, 1992), is not very specific.

> "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems.

It has been argued, however, that this vagueness is insurmountable, and that for pragmatic reasons it is actually necessary, since the concept is used in many different contexts (Mace et al., 2012; Koricheva and Siipi, 2004). In the end, biodiversity may be viewed as a broad social concept in need for more concrete sub-concepts to be used as proxies when it comes to specific applications.

As a consequence of the term's complexity, abstractness and the insurmountable difficulty to provide an unambiguous definition of it, there exist a vast number of biodiversity measures and indicators (CBD, 2011; Pereira et al., 2013). For every biodiversity level (intraspecies, interspecies, between ecosystems), many different measures are available (see Table 1).

The design and use of biodiversity indices face essential data constraints (Mace, 2014; Pereira et al., 2013), which may be the reason why in applications species richness and related measures are by far the most popular. Often, less direct indicators of biodiversity (change) are used, including Red List data, habitat amount, water quality for aquatic biodiversity and so-called indicator species (Butchart et al., 2010).

3. Materials and Methods

To make the present literature review as comprehensive and exhaustive as possible, all relevant sources have been examined. The following databases were searched for peer-reviewed articles published through October 2014 using a range of alternative search terms for both "biodiversity" and "economic valuation": 1) the Web of Science database, 2) the TEEB Valuation Database (Van der Ploeg and de Groot, 2010), and 3) Carson's contingent valuation bibliography (Carson, 2011).[2]

As is clear from the introductory sections, the measurement and operationalisation of biodiversity are all but trivial tasks. Since there is no single 'right' indicator of biodiversity and since data constraints abound, economists who have aimed at valuing it have used various different proxies for biodiversity. In what follows, we would like to offer a classification of the attributes valuation practitioners used as proxies.[3] The classification was specifically designed for the purposes of the review. It has been inspired by classifications proposed by Nunes et al. (2003) and Pearce (2001), but it deviates from them, first, in that it is based on a more rigorous definition of biodiversity (see Section 4), and second, it was adapted during the process of reviewing the valuation studies so as to enable the full attribution of all studies to the

[1] "Pseudocognate" terms are observed to be implicitly treated as if everyone understood them equally, even though no clear definition exists.

[2] A more detailed description of the search process can be found in Appendix A.

[3] We deliberately use the word "proxies" instead of "indicators", as the proxies used by valuation practitioners are not always identical with the indicators ecologists use in biodiversity research (see also Section 6.2).