Biological Conservation 192 (2015) 522–532

Contents lists available at ScienceDirect

Biological Conservation

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

Categories of flexibility in biodiversity offsetting, and their implications for conservation

J.W. Bull [a,*], M.J. Hardy [b], A. Moilanen [c], A. Gordon [b]

[a] Department of Life Sciences, Imperial College London, Silwood Park campus, Ascot SL5 7PY, UK
[b] School of Global Urban and Social Studies, RMIT University, GPO Box 2476, Melbourne 3001, Australia
[c] Department of Biosciences, P.O. Box 65 (Viikinkaari 1), FI-00014 University of Helsinki, Finland

ARTICLE INFO

Article history:
Received 23 February 2015
Received in revised form 3 July 2015
Accepted 2 August 2015
Available online 4 September 2015

Keywords:
Conservation policy
No net loss
Fungibility
Substitutability
Interchangeability

ABSTRACT

Biodiversity offsets ('offsets') are an increasingly widespread conservation tool. Often, offset policies have a like-for-like requirement, whereby permitted biodiversity losses must be offset by gains in similar ecosystem components. It has been suggested that some flexibility might improve offset outcomes — such as out-of-kind offsets, which channel compensation towards priority species. But there has been little formal exploration of other types of flexibility, and the possible ecological consequences.

Building upon an existing framework for analysing conservation interventions, we first categorise the types of flexibility relevant to offsetting. We then explore ecological outcomes under two types of flexibility in offsetting, using a model which tracks biodiversity value (via the surrogate of '*habitat condition*' × *area*) over time for multiple vegetation communities. We simulate offset policies that are flexible in time (i.e., offsets implemented before or after development) and flexible in type (i.e., losses in one habitat compensated for by gains in another). Our categorisation of flexibility identifies categories previously not explicitly considered during offset policy development. The simulation model showed that offsets that were flexible in time resulted in biodiversity declines happening sooner or later than they would otherwise — important, as conservation priorities change with time. Incorporating flexibility in type resulted in significantly different outcomes in value for each vegetation community modelled, including some counter-intuitive results.

We emphasize the importance of considering the full spectrum of flexibility in biodiversity offsets during policy development. As offset policies become increasingly prevalent, insufficient consideration of the consequences of flexibility could lead to undesirable biodiversity outcomes.

1. Introduction

1.1. Biodiversity offsetting

Biodiversity offsets (henceforth 'offsets') have emerged as an important tool in conservation practice worldwide (Madsen et al., 2011), and continue to form part of policy development in an increasing number of geographical regions (e.g., Tucker et al., 2013; Saenz et al., 2013). Offset policies fundamentally involve exchanging biodiversity losses for equivalent gains, with the objective that 'no net loss' of biodiversity is achieved overall alongside development. Whilst this premise might seem simple, it gives rise to a range of complications (Bull et al., 2013a). Not least of these is that 'biodiversity' is itself a vague concept, and any measure of biodiversity as a whole (which can be defined as the "sum total of all biotic variation from the level of genes to ecosystems") cannot be based upon a single number or metric (Purvis & Hector, 2000). Indeed, the concept of complementarity (Kukkala and Moilanen, 2013), central to systematic conservation planning, implies that all different components of biodiversity should be catered for individually. Thus, in creating policies that aim for no measurable net loss of biodiversity, and consequently developing metrics to evaluate success, we must accept that these metrics will not capture every element of biodiversity at a site and therefore, fundamentally, remain only surrogate measures for biodiversity as a whole.

Current best-practice recommendations for implementing offsets suggest that they should be "in-kind" (BBOP, 2012; IFC, 2012), meaning that the gains from the biodiversity offset are for the same or very similar biodiversity components to those impacted. In practice, no two components of biodiversity (e.g., individuals of a given species, areas of the same habitat type) are ever precisely equivalent and fungible (Salzman and Ruhl, 2000). Thus all offsets are technically "out-of-kind" to some degree (Moreno Mateos et al., 2015–in this issue). But the simplifying assumption is made that trades that can be shown to be similar enough in terms of either overall biological diversity, or in terms of associated ecosystem functions, can be treated as equivalent (Quétier and Lavorel, 2011).

* Corresponding author.
E-mail address: jwb@ifro.ku.dk (J.W. Bull).

http://dx.doi.org/10.1016/j.biocon.2015.08.003

1.2. Flexibility in biodiversity offsets

In some cases, out-of-kind offsets might be preferable, by allowing offsets to focus upon priority conservation species or communities within a region in a cost-effective manner — this is often labelled “trading-up” (Habib et al., 2013). To elaborate, Habib et al. (2013) found using a Canadian example that non-flexible offset policies required 2–17 times more funding to achieve the same conservation objectives as flexible offsets. Offsets that are out-of-kind in this way are an example of “flexible” offsets. Flexibility in offsetting could take other forms, e.g., offsets that were required to be very close in space to the development for which they compensate would be non-flexible, whereas allowing offsets to be implemented at a ranges of distances would make them flexible (e.g., Wilcox and Donlan, 2007). Here we define ‘flexibility’ more broadly as a measure of the degree to which biodiversity losses and gains are permitted to have dissimilar characteristics in the way they are implemented, including both spatially and temporally.

It should be noted that what we call flexibility here has been called other names elsewhere. For example, consider the terms ‘strong’ and ‘weak’ sustainability, which have been used in ecological economics and green accounting (Gowdy, 2000; Dietz and Neumayer, 2007). In biodiversity offsetting, these terms have been used to indicate the degree to which different biodiversity components can be exchanged — e.g., levels of ‘sustainability’ (i.e., flexibility) permitted in the newly developed ‘RobOff’ software range from treating different biodiversity components as completely fungible (i.e., weak sustainability) through to requiring no loss in any one biodiversity component (i.e., strong sustainability) (Pouzols and Moilanen, 2013). The terms ‘substitutability’, ‘interchangeability’, ‘replaceability’, and ‘fungibility’ also link to flexibility, and have been used in various contexts (Parris and Kates, 2003; Dietz and Neumayer, 2007).

From a policy perspective, offsets are considered flexible in relation to a number of different policy characteristics. Offsets could involve the trade of one component or kind of biodiversity for a different type (i.e., flexibility by type), or, for offset sites that are distant in space from the development for which they provide compensation (i.e., flexibility in space). Flexibility in time is also commonly discussed – e.g., by allowing time lags between development impacts and gains from associated offsets — although this is not always explicitly recognized as a form of flexibility, and is allowed by many policies. Flexibility in type, space and time have previously been highlighted as relevant to offset trades (Wissel and Wätzold, 2010), but other categories exist which are only considered implicitly, as we discuss below.

Further, there has been limited exploration in the literature as to what the outcomes of flexible offsetting might be from an ecological perspective, i.e., the potential responses of a given ecosystem in absorbing internal exchange between different biodiversity components. Whilst mentioned by Habib et al. (2013), they focus rather on economic efficiency and a static analysis of flexible offsetting — so the ecological outcomes in relation to ecosystem dynamics are not considered. Others consider offsets in the context of a dynamic landscape, exploring trade-offs between different landscape attributes, but primarily focusing on the types of attributes that make non-flexible offsets viable in terms of e.g., species persistence (Johst et al., 2011) or genetic diversity (Bruggeman et al., 2009). Van Teeffelen et al. (2014) go further, suggesting not only that flexible offsets may be desirable in the case of certain habitats and fauna species, but also that restraining offset trades to one ecosystem type might be economically unfavourable. But the degree to which existing problems with any biodiversity offset scheme are further complicated by allowing flexibility have yet to be fully understood (e.g., required longevity in the face of ecosystem change, the existence of ecological thresholds, potential for reversibility, complications around time lags and extinction debt; Bull et al., 2013a). In terms of conservation science and the acceptability of flexible offsets to different stakeholders, such considerations are open to exploration.

A comprehensive categorization of flexibility in offsets would be useful for developing and implementing biodiversity offset policies, in terms of both identifying and managing the different forms of flexibility that might arise. Here, we attempt to summarize the various ways in which offsets can be flexible. To date, the only empirical assessments of the ecological implications of a spatially flexible offsetting policy have been at the landscape scale and implemented using the Marxan conservation planning software to prioritize offset locations (Kiesecker et al., 2009; Habib et al., 2013). Here, building upon our categorisation of flexibility in offsets, we consider the ecological implications of a flexible policy through time. To do so, we extend an existing theoretical biodiversity offset model (developed by Bull et al., 2014a), and so explore some of the categories of flexible offsetting identified.

2. Material and methods

In order to explore the application of a flexible offsetting policy, we first classify different types of flexibility that could theoretically arise in offset policies, using a framework based upon a top-down literature synthesis (Moilanen et al., 2014; see below). Then, we explore the consequences of allowing flexibility by adapting the simulation model originally created for evaluation of biodiversity offset projects against different counterfactuals — the trajectory that an ecosystem would have followed under different management scenarios to the one implemented (Bull et al., 2014a; Fig. 1).

2.1. Different types of flexibility

A framework recently developed for the structured analysis of conservation strategies, amongst other things, specifies questions that can be answered to summarize the properties of such strategies (Moilanen et al., 2014). We utilise this framework to categorise flexibility in offsets. This involved the creation of two tables: the first table concerns nine “basic properties” of offsetting as a strategy (e.g., ‘why’ offsets are used, ‘what’ they involve). We considered the ways in which flexibility could arise in each of these basic categories. The second table draws upon the first and upon simulation model outcomes, relating to a set of topics that capture “fundamental properties” of conservation strategies (e.g., what are their major underlying assumptions, risks). In the discussion, we explore how feasible flexible offsetting is as an approach given these properties.

In order to evaluate how these various properties manifest themselves as forms of flexibility in actual biodiversity offset policies, we draw upon recent assessments in the literature, concerning the global development of biodiversity offset policies.

2.2. Theoretical biodiversity offset model

The theoretical offset model (henceforth the ‘model’) is based on a model originally developed to explore issues around evaluation of offset performance (Bull et al., 2014a). Here, we extend this model to consider multiple different biodiversity sub-components that together constitute the total biodiversity in a region, which in turn allows the modelling of different types of flexible offset trades (see Section 2.3). The model is based on analytic equations and is deterministic and non-spatial. It simulates the evolution of the total hypothetical biodiversity value in a region over time, which is broken down into biodiversity impacted by development, biodiversity managed as an offset, and the remaining biodiversity (which is assumed unmanaged). Conceptually, we considered our biodiversity surrogate to be a metric that measures the condition and area of different vegetation communities, as this is a common metric used in biodiversity offset policies (Quétier and Lavorel, 2011). For example in Victoria (Australia), the Habitat Hectares metric used to measure *condition* × *area* of vegetation, where condition is measured relative to a pristine example of that vegetation community (Parkes et al., 2003). As an illustration of the consequences of flexible offsets,