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A disaggregated biodiversity offset accounting model to improve estimation of ecological equivalency and no net loss

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ABSTRACT

Biodiversity offsetting is a mechanism aimed at achieving biodiversity gains to compensate for the residual impacts of development activities on biodiversity. Estimating the ecological equivalence of biodiversity lost to development with that gained by the offset requires a currency that captures the biota of interest and an accounting model to evaluate the exchange. Ecologically robust, and user-friendly decision support tools improve the transparency of biodiversity offsetting and assist in the decision making process. Here we describe a tool developed for the New Zealand Department of Conservation that offers a mechanism to transparently design and evaluate biodiversity offsets intended to deliver no net loss. It is a relatively disaggregated accounting model that balances like-for-like biodiversity trades using a suite of area by condition currencies to calculate net present biodiversity value (NPBV) to account individually for each measured biodiversity element of interest. The NPBV is used to evaluate whether a no net loss exchange is likely for each biodiversity attribute. More disaggregated currencies have an advantage over aggregated currencies (which use composite metrics) in that they account for each itemised biodiversity element of concern. The Disaggregated Model we present can be used to account for a variety of biodiversity types in an offset exchange, and for different scales and complexities of development and impacts within both statutory and voluntary frameworks.

1. Introduction

Biodiversity is in decline globally (Butchart et al., 2010) and will remain under pressure as the world population and demand for resources increase (Brown, 2012). Continued biodiversity losses due to development provide wealth for some while eroding the wellbeing of others (Kumar, 2010). Biodiversity offsetting is an evolving mechanism that attempts to mitigate losses and manage associated risks (BBOP (Business and Biodiversity Offsets Programme), 2013). The approach requires development-induced losses in one place and time (the impact site) to be addressed by delivering biodiversity gains at another place and time (the offset site) with the goal of achieving no net loss. The practice of biodiversity offsetting is becoming increasingly popular as a way to compensate for development impacts (Calvet et al., 2015; Gonçalves et al., 2015; Ives and Bekessy, 2015; Maron et al., 2016; Rainey et al., 2015).

Biodiversity offsetting is controversial because it has yet to establish a compelling track record of achievement of either implicit or explicit goals (Brown et al., 2014; Harper and Quigley, 2005; Maron et al., 2012; Matthews and Endress, 2008; Walker et al., 2009). The concept is often used by development advocates to promise 'win-win' outcomes, a claim which attracts scepticism and controversy (Gordon et al., 2015). Biodiversity offsetting relies on using techniques with uncertain outcomes (e.g. 'restoration' Hobbs et al., 2011) to generate future gains in biodiversity values, assumes there is sound scheme design, and that regulators and developers will honour offsetting agreements on behalf of the public who would bear the costs of any net biodiversity loss. Consequently offsetting is a polarising concept criticised for the risks to biodiversity (e.g. Maron et al., 2010; Spash, 2015; Walker, 2010; Walker et al.,

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2009) but supported for its potential to enhance biodiversity outcomes (e.g. Holmes et al., 2016; Norton, 2007; Norton and Warburton, 2014).

There is general agreement within this wider debate that sound offsetting requires as prerequisites: i) strict adherence to the mitigation hierarchy, whereby an offset arrangement is only applied to residual impacts after all other impacts on biodiversity have been avoided, minimized, and rehabilitated/restored on site and ii) a recognition that some elements of biodiversity are irreplaceable or vulnerable, limiting what can be offset. Key conditions that should also be met include: a) the technical feasibility and success of proposed restoration/management actions have been demonstrated, or uncertainty in the chance of success has been accounted for; b) anticipated gains are demonstrably adequate to compensate for the losses; c) time lags between losses and gains occurring are adequately addressed; d) all additional aspects of uncertainty beyond success of offset action are accounted for, and e) currencies used to describe and account for the biodiversity being traded are transparent and rely on defensibly measurable units (BBOP, 2013; Gardner et al., 2013; Maron et al., 2016; McKenney and Kiesecker, 2010).

We note that these conditions are aspirational because acceptable thresholds of compliance are poorly defined (e.g. what is 'adequate' avoidance?). How to determine that compliance has been achieved, who makes this decision, and who bears the cost of noncompliance remain contentious. Despite this, there remains scope for improving biodiversity offsetting by developing tools and processes that address each of the problematic conditions. Here we present a decision support tool in the form of a disaggregated accounting model (herein the Disaggregated Model) for estimating ecological equivalency, which we suggest improves on more aggregated metrics by explicitly describing and measuring biodiversity elements of interest and thereby providing a more robust and transparent estimation of ecological equivalency demonstrated by offset proposals (condition *e* above). Our Disaggregated Model incorporates aspects of all the key conditions listed above, but its principal advantage is its use of disaggregated currencies. To fully appreciate this advantage, we first turn our attention to the importance of currencies in trading biodiversity and why (dis)aggregation matters.

Central to the concept of biodiversity offsetting is the requirement first to measure, quantify, and express as currencies the biodiversity lost to development and gained via the offset, and second, to balance this exchange to establish whether or not no net loss has been demonstrated. Currencies describe how much of what is exchanged in a biodiversity offset trade and have a substantial influence on the outcomes for biodiversity (Bull et al., 2014; Gonçalves et al., 2015; Strange et al., 2002). Therefore, a currency needs to capture what is important, both ecologically and to society, and should minimize exchanges of biodiversity elements not explicitly accounted for (Salzman and Ruhl, 2000).

Currencies can either aggregate measures of biodiversity into a composite unit or individually account for each measured biodiversity element of interest (i.e. more disaggregated currencies). However, it is misleading to perceive a strict dichotomy of aggregated or disaggregated currencies, and the concept is better expressed as a continuum along which specific characteristics are expressed to a greater or lesser degree (Table 1). For example, hollows in trees could be counted, or they could be described more finely before being measured. Reviews comparing offset policies and currencies across various jurisdictions which further illustrate the continuum have been well summarised elsewhere (e.g. Bull et al., 2014; McKenney and Kiesecker, 2010).

All currencies variously aggregate elements of biodiversity and so will result in some level of concealed trade. Concealed trades are exchanges of biodiversity elements that are not explicitly accounted for and which are either offset implicitly or lost in the exchange (e.g. different canopy tree species within the same vegetation type, or genes within species). Therefore, what is critical in designing a currency for biodiversity offsetting is that the elements of biodiversity for which no net loss is the desired outcome are not aggregated in such a way that unintended substitution can occur. The target biota for which no net loss is a specific goal are likely to be determined by a range of factors such as those required to meet conservation objectives, or provide required ecosystem services. For example, if maintaining critical components of a forest habitat is the goal and canopy cover is one of those components, it may be acceptable to aggregate canopy cover of functionally-similar species within a measure to represent canopy cover. This level of aggregation would not be appropriate if the level of interest was individual tree species that contribute to canopy cover, or if species of concern have a strong preference for particular tree species. Likewise, canopy and understory measures should not be aggregated into a single measure if both these things are individually of interest.

More aggregated currencies tend to be favoured in offset scheme designs because they reduce complexity (by virtue of having fewer

Table 1
Key characteristics of currencies used to evaluate biodiversity offset proposals related to the degree of aggregation within the currency.

Characteristic	More aggregated ⟵⟶	More disaggregated
Measure of biodiversity elements of concern	Composite or surrogate measure to describe many elements	Many and/or direct measures of all biodiversity elements of interest
Risk of concealed trades	Higher	Lower (occurs only below level of disaggregation)
Ability to substitute biodiversity elements	Higher	Lower (occurs only below level of disaggregation)
Transparency of what is being traded (ability to evaluate offset proposal, and to track performance of offset action)	Less transparent	More transparent
Opportunity for offset market	Wider (easier to find a match of a composite measure of biodiversity)	Narrower (more difficult to find a match across multiple elements of biodiversity, may require multiple offset sites)
Examples	Habitat hectares (Parkes et al., 2003); Quality hectares (Temple et al., 2012); UK pilot metric (2012) DEFRA (2012)	Disaggregated Model (this paper); Units of Global Distribution (Temple et al., 2012); Loss-gain calculator (Gibbons et al., 2015)