Contributed Paper

How economic contexts shape calculations of yield in biodiversity offsetting

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Abstract: *We examined and analyzed methods used to create numerical equivalence between sites affected by development and proposed conservation offset sites. Application of biodiversity offsetting metrics in development impact and mitigation assessments is thought to standardize biodiversity conservation outcomes, sometimes termed* yield *by those conducting these calculations. The youth of biodiversity offsetting in application, however, means little is known about how biodiversity valuations and offset contracts between development and offset sites are agreed on in practice or about long-term conservation outcomes. We examined how sites were made commensurable and how biodiversity gains or yields were calculated and negotiated for a specific offset contract in a government-led pilot study of biodiversity offsets in England. Over 24 months, we conducted participant observations of various stages in the negotiation of offset contracts through repeated visits to 3 (anonymized) biodiversity offset contract sites. We conducted 50 semistructured interviews of stakeholders in regional and local government, the private sector, and civil society. We used a qualitative data analysis software program (DEDOOSE) to textually analyze interview transcriptions. We also compared successive iterations of biodiversity-offsetting calculation spreadsheets and planning documents. A particular focus was the different iterations of a specific biodiversity impact assessment in which the biodiversity offsetting metric developed by the U.K.'s Department for Environment, Food and Rural Affairs was used. We highlight 3 main findings. First, biodiversity offsetting metrics were amended in creative ways as users adapted inputs to metric calculations to balance and negotiate conflicting requirements. Second, the practice of making different habitats equivalent to each other through the application of biodiversity offsetting metrics resulted in commensuration outcomes that may not provide projected conservation gains. Third, the pressure of creating value for money diminished projected conservation yields.*

Keywords: biodiversity yield, commensuration, conservation policy, English Biodiversity Offsetting Pilot, ethnography, value

Cómo los Contextos Económicos Dan Forma a los Cálculos del Rédito en la Compensación de la Biodiversidad

Resumen: *Examinamos y analizamos los métodos utilizados para crear equivalencias numéricas entre los sitios afectados por el desarrollo y propusimos sitios de compensación de la conservación. Se cree que la aplicación de las medidas compensadoras de la biodiversidad en el impacto del desarrollo y en las valoraciones de mitigación estandariza los resultados de la conservación de la biodiversidad, que a veces es denominada* rédito *por aquellos que realizan estos cálculos. Sin embargo, lo joven que es la compensación de la biodiversidad en la aplicación significa que se conoce poco sobre cómo las valoraciones de la biodiversidad y los contratos de compensaciones entre los sitios de desarrollo y compensación son acordados en la práctica, o sobre los resultados a largo plazo de la conservación. Examinamos cómo se hicieron equiparables los sitios y cómo las ganancias o el rédito de la biodiversidad fueron calculados y negociados para un contrato específico de compensación en un estudio piloto de la compensación de la biodiversidad dirigido por el gobierno en Inglaterra. A lo largo de 24 meses observamos a los participantes de varias etapas de la negociación de los contratos de compensación por medio de visitas (anónimas) repetidas a tres sitios de contrato de*

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compensación de la biodiversidad. Realizamos 50 entrevistas semi-estructuradas a los accionistas en el gobierno regional y local, al sector privado y a la sociedad civil. Utilizamos un programa de software de análisis cualitativo de datos (DEDOOSE) para analizar textualmente las transcripciones de las entrevistas. También comparamos las repeticiones sucesivas del cálculo de la compensación de la biodiversidad en las hojas de cálculo y en los documentos de planeación. Un enfoque particular fueron las repeticiones diferentes de la valoración de un impacto específico sobre la biodiversidad en el que se usó la medida compensadora de la biodiversidad desarrollado por el Departamento de Ambiente, Alimentos y Asuntos Rurales del Reino Unido. Tuvimos tres hallazgos principales. Primero, las medidas compensadoras de la biodiversidad fueron modificadas de formas creativas conforme los usuarios adaptaban los resultados a los cálculos de las medidas para balancear y negociar los requerimientos conflictivos. Segundo, la práctica de la elaboración de diferentes hábitats equivalentes a sí mismos por medio de la aplicación de las medidas compensadoras de la biodiversidad resultó en la equiparación de los resultados que podrían no proporcionar ganancias proyectadas de la conservación. Tercero, la presión por crear valor para el dinero disminuyó los réditos proyectados de la conservación.

Palabras Clave: equiparación, etnografía, Piloto Inglés de Compensación de la Biodiversidad, política de conservación, rédito de la biodiversidad, valor

Introduction

In recent years the mitigation practice of biodiversity offsetting (BDO) and associated conservation policy frameworks have expanded globally to secure conservation investment from infrastructure development (Carroll et al. 2008; Quintero & Mathur 2011; Benabou 2014). Preceded by wetland mitigation banking and species banking in the United States from the 1970s and 1990s respectively (e.g., Fox & Nino-Murcia, 2005; Robertson & Hayden 2008; Pawliczek & Sullivan 2011), BDO is a relatively new conservation technology. This means that there are few detailed case histories of offset implementation or of actual, as opposed to projected, conservation outcomes. We thus examined the application of BDO in England under a 2-year pilot study by the Department of Environment, Food and Rural Affairs (DEFRA) to assess the proposal that application of the DEFRA technical metric standardizes assessments of biodiversity value so as to offer robust numerical foundations on which to base planning for development and offset sites in England.

We reviewed studies of BDO, focusing on the development and application of metrics that create comparable measures of biodiversity so as to demonstrate measurable gains (or yields) in biodiversity value. In researching the BDO pilot in England (2012–2014), we focused on the application in practice of DEFRA's biodiversity offset metrics. Over 24 months, we documented negotiations and calculations that gave rise to a specific BDO contract, set within a broader data set of site visits, interviews, biodiversity impact calculations, and grey-literature planning documents for 6 DEFRA BDO pilot sites in England (data held by L.C.).

Shaping the Calculation of Biodiversity Yield

Biodiversity offsetting policy and best practice guidelines (BBOP 2009, 2012; DEFRA 2012*a*, 2012*b*, 2013; Gardner et al. 2013) are intended to support biodiversity conservation outcomes by providing methodologies for the technical calculation and apparent quantification of biodiversity values. Such methods aim to determine commensurable losses and gains in biodiversity at different sites, thereby creating the possibility of offset compensation. Biodiversity offsets inevitably pertain to 2 separate sites. They constitute quantitative biodiversity gains reflected as units or credits beyond a baseline over time at an offset site. These predicted biodiversity gains compensate for biodiversity unit losses at a development site and should be additional to a projected counter-factual scenario in the absence of compensation (Bull et al. 2014; Tucker et al. 2014). Following the wording of a respondent in our research, we use the term "biodiversity yield" to describe projected gains in calculated biodiversity values.

A variety of metrological approaches exist for calculating and creating equivalence between biodiversity losses and gains at different sites and temporal moments. In application, these are normally linked to the use of a standardized reference system for the classification of habitats or land cover (Quintero & Mathur 2011). In the United Kingdom, the basis for such calculations is the biodiversity offset metric developed by DEFRA (2012*b*), discussed in more detail below. Habib et al. (2013:1313–1314) state that "[e]xchanging dissimilar biodiversity elements requires assessment via a generalized metric" and the representation of biodiversity units by an appropriately fungible currency or system of credits. An aim of BDO is thus to standardize state and private-sector BDO auditing methods so as to improve and stabilize approaches considered ad hoc in practice (Gardner 2013: 1254). It is noticeable, however, that these standardizing assessment techniques and metrics are themselves proliferating, such that direct comparisons of offset quality between contexts becomes difficult. This phenomenon has also been observed for assessment methods in carbon accounting (Lohmann 2009; Lippert 2014). Tensions between ease

Table 1. Habitat scoring system for biodiversity offsetting in England.*

	Biodiversity distinctiveness		
Habitat condition	*low (2)*	*medium (4)*	*high (6)*
Good (3)	6	12	18
Moderate (2)	4	8	12
Poor (1)	2	4	6

* *Source: DEFRA (2012b).*

of compliance for development interests and robustness of conservation gain in terms of measurable biodiversity yield (Maron et al. 2012) make studies of applied BDO relevant for understanding how these tensions are worked out in practice.

English Biodiversity Offsetting Pilot

Along with the United States, Australia, South Africa, and Germany, England is considered at the forefront of developing BDO. In England, BDO has been enthusiastically endorsed at the ministerial level (DEFRA 2013) and in a number of recent environmental-policy documents and reports (e.g., Lawton et al. 2010; DEFRA 2011; NPPF 2012). A DEFRA BDO pilot project ran for 2 years from April 2012 to April 2014 and involved 6 local planning authorities (Devon, Doncaster, Essex, Greater Norwich, Nottinghamshire, and Coventry, Warwickshire, and Solihull) as well as private-sector organizations (e.g., DEFRA 2012*a*; Apostolopoulou & Adams 2015; Carver 2015).

Key to the DEFRA BDO pilot was the metric for numerically scoring the harm to biodiversity by a development and then scoring the possibilities for onsite and offsite mitigation of this harm (Table 1). These numerical scores enable the calculation of commensurable losses and gains of biodiversity in development and potential offset sites (DEFRA 2012*b*; Hannis & Sullivan 2012; Sullivan 2013). In applying the metric, development sites are first "mapped and divided into habitat parcels" (DEFRA 2012*b*: 7) and then classified according to the habitat designations of the Joint Nature Conservation Committee, a public body that advises the U.K. central and devolved governments on nature conservation (http://jncc.defra.gov.uk). These mapped and classified sites are then scored according to their observed condition and biodiversity distinctiveness with the scoring matrix of the BDO metric (Table 1). Distinctiveness is determined based on the guidelines in Treweek et al. (2010) and especially on species richness, diversity, rarity, and the unique potential for the area to support species rarely found elsewhere (DEFRA 2012*b*). The habitat condition grades are adapted from the Higher Level Agri-Environment Scheme (HLS) Farm Environment Plan Manual (FEP). A habitat type scored as in good condition (specific to habitat type within the FEP but usually based on percent cover of indicator species, for example, cover of undesirable species <5%) with high distinctiveness (incorporating rarity and endemism) would be assigned the highest numerical score. The metric thus aligns a numerical score for an area's ecological distinctiveness with a score for its condition. Scores for an area of habitat range from 2 (lowest distinctiveness and condition) to 18.

Table 2. Categories and subcategories (abbreviations in parentheses) of stakeholders interviewed regarding biodiversity offsetting in England.

Category	*Subcategory*
Regional and local government	1. local planning authority (LPA)
	2. natural England (NE)
Private sector	3. developer (DEV)
	4. consultant ecologist (CE)
	5. planning consultant (PC)
Civil society	7. conservation and wildlife NGO (NGO)
	8. local resident (LR)
	9. landowning offset provider (OP)

Methods

We observed how biodiversity calculations and valuations were made for a 2-year pilot study of BDO led by DEFRA from 2012 to 2014. Field research followed three phases and was based primarily on repeat site visits to DEFRA pilot and voluntary offset sites as well as analysis and comparisons of associated policy and planning texts and successive biodiversity impact assessment (BIA) spreadsheets. We conducted 50 semistructured interviews with 30 key actors, organized into three stakeholder categories (regional and local government, the private sector and civil society) and nine subcategories (see Table 2) (see Supporting Information for interview questions). In referring to interview transcripts below, stakeholder categories for the DEFRA pilot sites are numbered 1 to 5 (as a sample of the 6 local planning authorities [LPA] that took part in the pilot), and the complementary voluntary pilot offsetting site is denoted by a "comp" prefix. Sequential codes for interviewees follow the format of stakeholder category, followed by site number, the individual within that site, and date of interview (e.g., LPA2.3 130515 means the third individual interviewed within the LPA stakeholder category at pilot site 2, on May 13, 2015). We conducted structured textual analysis of interview transcripts with DEDOOSE, a cloud-based qualitative data-analysis program that facilitates deductive and inductive coding of text excerpts to enable assessment of overarching themes and perspectives (Sullivan & Hannis 2015). All respondents and offsetting cases were anonymized.

From June 2013 to January 2014, we interviewed individuals from the ecology or green infrastructure departments of county or district councils where pilot sites had been established (see Supporting Information for interview questions). Following interviews, we selected 2 of the DEFRA pilot sites for the compilation of detailed case studies. Our selection was based on the availability of biodiversity impact as well as receptor site biodiversity unit calculations (in this case study) and on the treatment of protected species (in the second selected case study) (Carver forthcoming). An additional private-sector DEFRA pilot offset site was also selected for comparison with a developer-led voluntary biodiversity offset initiative. From January 2014 to January 2016, we made repeated site visits to observe BDO-related scoring activities and negotiations at the 3 sites, conducted semistructured interviews, and examined planning documents and BIAs. This triad of methods formed the basis of our 3 detailed case histories that tracked the design and development of offset contracts in England from 2013 to the present (data held by L.C.). A third and ongoing research phase entailed textual analysis of documents connected with BDO policy in England, interviews of participants in other local government, nongovernmental, and private-sector offset efforts (i.e., projects not part of the DEFRA pilot study). These interviews were categorized by stakeholder type and analyzed as for interviews of stakeholders in the DEFRA pilot study. The scope and depth of these case studies and space limitations mean that, while drawing on perspectives and findings derived from the broader data set, for this paper we focused on the negotiated calculations of development and offset locations that led to one particular BDO contract.

We examined the process used to make biodiversity calculations so that biodiversity values could be referred to in terms of losses or gains (or yields) and prices could be assigned to different sites in the offset agreement for a particular offset contract. These values and prices were negotiated over 32 months from March 2013 to December 2015. We drew on our multiple sources of data to describe the development site and to present in detail the metric calculations in the BIA applied to the development and offset sites. We focused on the negotiation process that ensued regarding the levels of mitigation and compensation payments required and on the biodiversity yields projected to arise from these transactions. The original format of the BIA Excel spreadsheet (version 17.4) is in Supporting Information. At the time of writing, local government ecologists were using version 18 of the BIA. The different iterations of the BIA affected the scores of values arising from its application independently of the biophysical dimensions of the areas being assessed.

Results

The Development Case

A planning application was submitted for delivery of 200 residential properties, a sports stadium, and playing fields across 13 ha of mostly agricultural fields. Under the guidance of the DEFRA BDO pilot and with the assistance of a private offsetting brokerage firm, the development became subject to BDO compensation payments in line with the calculated value of affected biodiversity at the development site. The proposed development site consisted largely of amenity grassland, improved grassland, hedgerows, scattered tall ruderal vegetation, and 4 ponds, one with great crested newts (*Triturus cristatus*), which are protected under the Conservation of Habitats and Species Regulations 2010. The site formed the southwestern fringe of a small medieval market town and was bordered to the north by an industrial and residential development and to the west and east by roads with open countryside beyond. The planning application was submitted in March 2013 by the property owners, the local football and bowls clubs, and a large residential developer who would oversee the bulk of the planning process and build, market, and sell the residential properties. Under new requirements shaped by the DEFRA BDO pilot study, the local planning authority asked the developer to apply the DEFRA metric, in the form of a BIA, to guide the biodiversity mitigation and compensation measures required to offset the development.

The Biodiversity Impact Assessment (BIA)

The developer's consultant ecologists completed site surveys and used existing records to provide information on the condition and distinctiveness of the habitats considered represented at the development site. These records formed the basis of an ecological impact assessment report for the planning application. Subsequently, to establish the site's biodiversity unit baseline and mitigation values in the format necessary for BDO under the DEFRA pilot, the contents of the ecological impact assessment report were translated into a BIA by an LPA ecologist and the offset broker assisting the LPA with the contract. The ecological condition and proposed mitigation actions at the development site were determined by entering the existing (i.e., pre-development) habitat scores into the BIA produced by the County Council planning-authority ecologist. The BIA spreadsheet operationalized the DEFRA BDO metric to yield biodiversity unit scores for each habitat type on the development site.

To arrive at these scores the development site was first categorized by the LPA ecologist into habitat types entered on separate rows of the BIA spreadsheet, each with a code, description, size, and numerical score for habitat distinctiveness and condition (Table 3 & Supporting Information). The spreadsheet allowed 3 sets of calculations. The first (see Table 3 rows 15–28) generated a habitat impact score (HIS) for the total scored habitat on site prior to the development (46.68 biodiversity units, cell O53).

Table 3. Spreadsheet (version17.4, draft 1) used in biodiversity impact assessments to calculate the residual losses of biodiversity from development impacts at a specific site.[a]

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
11															
12			*Existing habitats on site*			*Habitat distinctiveness*		*Habitat condition*		*Habitats to be retained with no change within development*		*Habitats to be retained and restored within development*		*Habitats to be lost within development*	
13		*T.note[b]*	*habitat code*	*phase I habitat description*	*Habitat area (ha)*	*distinctiveness*	*score*	*condition*	*score*	*area (ha)*	*existing value*	*area (ha)*	*existing value*	*Area (ha)*	*existing value*
14				direct impacts and retained habitats			A		B	C	A × B × C = D	E	A × B × E = F	G	A × B × G = H
15		F1	B4	grassland: improved grassland	1.78	low	2	moderate	2					1.78	7.12
16		P1	G1	wetland: standing water	0.01	high	6	good	3					0.01	0.14
17		P1	B4	grassland: improved grassland	3.10	low	2	moderate	2					3.10	12.40
18		F2	C31	grassland: amenity grassland	0.18	low	2	moderate	2					0.18	0.70
19		Bowling green	J12	grassland: amenity grassland	0.12	low	2	poor	1					0.12	0.24
20		F6	J12	grassland: amenity grassland	0.97	low	2	poor	1					0.97	1.94
21		West of football grid	B4	grassland: improved grassland	0.08	low	2	good	3					0.08	0.48
25			n/a	built environment: buildings/ hardstanding	0.32	none	0	poor	1					0.32	0.00
26		F3	B4	grassland: improved grassland	4.88	low	2	moderate	2					4.88	19.52
27		Slurry pit	G1	wetland: standing water	0.01	high	6	poor	1					0.01	0.05
28		Part of F4 and F5	B4	grassland: improved grassland	1.52	low	2	moderate	2					1.52	6.08
45		Total			12.96				Total	0.00	0.00	0.00	0.00	12.96	48.68
46															ΣD+ΣF +ΣH
47												site habitat biodiversity value		46.68	J
48	Indirect impacts, including offsite habitats				K					value of loss from indirect impacts[c]					
49	Before or after impact									K × A × B = Li, Lii	Li- Lii				
50	Before														
51	After														
52		total			0.00					M	0.00				HIS = J + M
53													habitat impact score (HIS)		46.68

Continued

Table 3. Continued.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
11															
12			*Existing habitats on site*			*Habitat distinctiveness*		*Habitat condition*		*Habitats to be retained with no change within development*		*Habitats to be retained and restored within development*		*Habitats to be lost within development*	
13		*T.note*[b]	*habitat code*	*phase I habitat description*	*Habitat area (ha)*	*distinctiveness*	*score*	*condition*	*score*	*area (ha)*	*existing value*	*area (ha)*	*existing value*	*Area (ha)*	*existing value*
54	Caution: Destruction of habitats of high distinctiveness, e.g. lowland meadow or ancient woodland, may be against local policy. Has the mitigation hierarchy been followed, can impact to these habitats be avoided? Any unavoidable loss of habitats of high distinctiveness must be replaced like for like.														
55															
56			Proposed habitats on site (on-site mitigation)	Target habitat distinctiveness	Target habitat condition		Time till target condition	Difficulty of creation or restoration	Habitat bio-diversity value						
57				phase I habitat description	habitat area (ha)	distinctiveness	score	condition	score		time	score	difficulty	score	
58				habitat creation	N		O		P			Q		R	(N × O × P)/ Q/R
59		F1 and F6	n/a	Built environment: buildings or hardstanding	2.27	none	0	poor	1		5 years	1.2	low	1	0.00
60		F1 & F6	n/a	built environment garden (lawn and planting)	0.76	low	2	poor	1		5 years	1.2	low	1	1.27
61		F2, F3, F4	n/a	built environment: buildings or hardstanding	4.02	none	0	poor	1		5 years	1.2	low	1	0.00
62		F2, F3, F4	n/a	built environment: gardens (lawn and planting)	1.34	low	2	poor	1		5 years	1.2	low	1	2.23
63			J12	grassland: amenity grassland	2.44	low	2	poor	1		5 years	1.2	low	1	4.07
64		Area 4	B22	grassland: semi-improved neutral grassland	0.76	medium	4	good	3		15 years	1.7	medium	1.5	3.58
65		Area 3	G1	wetland: standing water	0.13	high	6	good	3		15 years	1.7	medium	1.5	0.92
66		Area 1	B22	grassland: semi-improved neutral grassland	0.16	medium	4	good	3		15 years	1.7	medium	1.5	0.75
67			G1	wetland: standing water	0.05	high	6	good	3		15 years	1.7	medium	1.5	0.35

Continued

Table 3. Continued.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
11															
12			*Existing habitats on site*			*Habitat distinctiveness*		*Habitat condition*		*Habitats to be retained with no change within development*		*Habitats to be retained and restored within development*		*Habitats to be lost within development*	
13		*T.note*[b]	*habitat code*	*phase I habitat description*	*Habitat area (ha)*	*distinctiveness*	*score*	*condition*	*score*	*area (ha)*	*existing value*	*area (ha)*	*existing value*	*Area (ha)*	*existing value*
68		Landscape	A112	woodland: broadleaved plantation	0.16	medium	4	good	3		32+ years	3	medium	1.5	0.43
69		Area 2	B22	grassland: semi-improved neutral grassland	0.19	medium	4	good	3		15 years	1.7	medium	1.5	0.89
70			B22	grassland: semi-improved neutral grassland	0.73	medium	4	moderate	2		15 years	1.7	medium	1.5	2.29
71		Total			13.01	ERROR: total area of habitats created must equal total area of habitats lost									
72		Habitat restoration									existing value S (= F)		((N × O × P)- S)/ Q/ R		
88				Total								trading down correction value			0.00
89												habitat mitigation score (HMS)			16.78
90															HBIS- HMS = HIS
91												habitat biodiversity impact score			−31.90
92												percentage of biodiversity impact loss			65.53

[a]*Numbers across rows 15–28 are multiplied to produce the habitat biodiversity value for each coded area subject to development. Numbers are rounded to 2 decimal places and as such if calculated manually here may produce different results. The sum of the values in column O for rows 15–28 (shown in cell O53) is the biodiversity baseline of the habitat impact score (HIS). In rows 59–70 numbers across rows are multiplied to produce the habitat-mitigation score (HMS) (cell O89), which is the value of habitats that will be restored or created on site so as to mitigate or minimize projected biodiversity losses. The original spreadsheet is in Supporting Information.*
[b]*Target area as habitat parcels subject to impacts coded on the development site maps (see Fig. 1a).*
[c]*Left empty on original BIA.*

The second set of calculations (Table 3 rows 59–70) yielded a habitat-mitigation score (HMS) for the total number of biodiversity units to be restored or created on site so as to mitigate or minimize projected biodiversity losses (16.78 units, cell O89). A notable feature of this HMS is that almost 40% of on-site mitigation was projected to be delivered through creation of a number of football pitches of different sizes. The spreadsheet showed the football pitches contributed substantial amounts of on-site biodiversity unit value and had the largest spatial habitat value of all mitigation activities. This mitigation value was to be achieved by attributing biodiversity value to the amenity grassland of the pitches themselves (cell O63) and by allowing the perimeter surface area of the proposed grassy margins to grow unmowed and thereby to provide 0.73 ha of semi-improved grassland (cell O70). Although receiving low habitat scores for both distinctiveness (2) and habitat condition (1), the size of the football pitches amenity grassland meant that in 5 years this aggregate spatial area was calculated to contribute 4.07 units (Fig. 1). After 15 years, the grassy margins would contribute a further 2.29 units cell. In total, then, the football pitches would eventually make up 6.36 units of biodiversity value of 16.78 units of total on-site mitigation and habitat creation.

The third set of calculations, through comparison of scores from the first and second calculation sets, yielded the residual biodiversity net loss. This value indicated how many biodiversity units would need to be purchased for mitigation purposes if an additional off-site offset were needed. This net loss or gain value was the habitat biodiversity impact score (HBIS) generated by subtracting HIS from HMS. The HBIS was calculated as an overall loss of 31.90 biodiversity units (Table 3, cell O91). It is this calculated biodiversity value that required an off-site offset to satisfy planning requirements for mitigation of on-site development impacts on biodiversity.

The Offset Site

Interviews showed that established conservation nongovernmental organizations (NGOs) and Wildlife Trusts were typically perceived as possessing the "experience and expertise to ensure delivery" (LPA2.1 020714) of offsets, and as being familiar and experienced with contracted management and improvement of habitat. The offset site identified by the council for the supply of scored offset units comparable to the HBIS score above was a 5-ha grassland meadow 5 km northeast of the development, acquired by a local wildlife and conservation NGO in 2013. The site consisted of a meadow of species-rich, semi-improved grassland in close proximity to a local site of special scientific interest (SSSI). The site supported 5 orchid species, including the largest population of greater butterfly orchid (*Plantanthera chlorantha*) in the county. It also supported 4 of the county's 6 rare farmland butterflies, 3 of which (grizzled skipper [*Pyrgus malvae*], dingy skipper [*Erynnis tages*], and white-letter hairstreak [*Satyrium w-album*]) are designated as biodiversity priority species under the 2007 U.K. Biodiversity Action Plan. At the time of assessment the NGO was not investing in much active management of the site due to limited funding, despite the site's excellent ecological enhancement potential (NGO5.1 241114).

A BIA was conducted for the offset site to calculate its baseline and projected biodiversity values. This BIA indicated the NGO had intended to bring the grassland to a moderate condition but with the offset payments from the developer would be able to fully restore the site and thus provide a lowland meadow of national importance (Fig. 1). These improvements would thereby demonstrate conservation additionality (NGO5.1 Offset Site Draft Management Plan 112013). It was hoped that with appropriate interventions 2 other rare farmland butterflies, also designated nationally as biodiversity priority species, would establish colonies on the site (NGO 5.1 Offset Site Draft Management Plan November 2013).

To achieve this conservation additionality, the predicted biodiversity yield was quantified and the cost was estimated according to a management plan to be carried out by the offset provider. The BDO Draft Management Plan was written by the NGO conservation officer. Costs included NGO volunteer and paid staff and external contractor workforces, materials, and capital or lease payments for the land itself (NGO5.2 280115). The predicted budget for improvement and 30 years of management at the offset site totaled £204,076, of which £98,030 would come from the conservation NGO budget and £106,046 from the biodiversity offset payment made by the developers (NGO5.1 Offset Site Draft Management Plan 112013). The developer would pay a further 20% for brokerage fees (OB5.1 241114) and legal fees for arranging the contracts among parties (NGO5.2 280115).

Negotiating Biodiversity Calculations

Tracing successive calculations of HMS, HIS, and HBIS scores showed additionally that the costs arrived at above were also the outcome of negotiations between stakeholders. These negotiations frequently involved changing the numerical scores in the first BIA for the development site. Over the course of the planning process, the calculated baseline biodiversity value of the development site was reduced by almost 48% from 48.68 units in BIA draft 1 (Table 3 & Supporting Information) to 25.52 units in draft 2. This decrease in habitat value occurred through category changes to the condition of existing habitats.

Changes made to the condition values of the baseline habitats on site and identified through comparisons of drafts of the BIA excel sheets had dramatic effects on financial compensation requirements (Table 4). These changes included lowering the perceived condition of

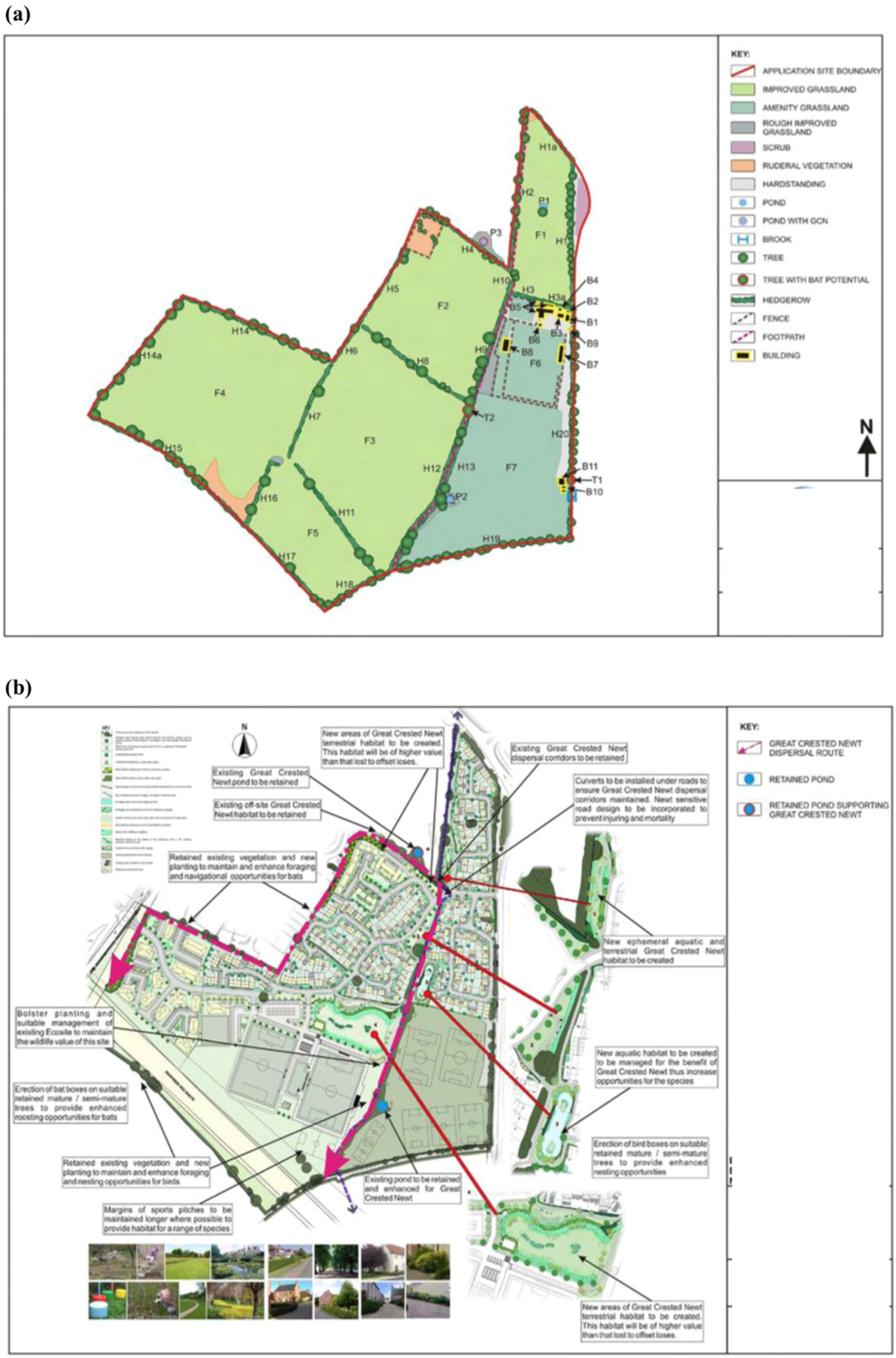

Figure 1. Map of development site in the United Kingdom (a) before and (b) after development.

4.88 ha of improved grassland on the development site from moderate to poor condition such that the BIA F3 baseline value of 19.52 in Table 3 (cell O26) became 9.76 units. The adjustment to the condition score constituted a 50% reduction of baseline biodiversity value for this area. Because of this habitat parcel's size this single modification amounted to an almost 20% overall reduction to the baseline biodiversity unit value for the entire development site. The same process was applied to improved and amenity grasslands in different areas. Whether these modifications increased or decreased the final compensation costs of development-planning applications was built into the numerical adjustments that took place. Other iterations to the BIA over the course of the pilot study included adding category values to the BDO metric (Table 1) with the odd numbers 1, 3 and 5 for local habitat types that had greater regional than national distinctiveness and rarity (NGO5.1 241114), as well as extensive formatting changes and numerous editions to make the calculator more user friendly and manageable (OB5.2 050114).

One explanation for these modifications is that local planning authorities had a relatively limited ability to determine the exact condition of the habitats under consideration. Only a few habitats were visited and verified by a county ecologist (LPA5.2 241114) because of the widespread shortage of ecological expertise within local governments more generally (NGO 270116, NGOComp1 290116). Often the ecological data were assembled and cross-referenced remotely against data in the ecological assessment report and biological and historical data held by the council offices at the district council's Biological Records Centre. Indeed, the good quality and extensive scope of the ecological data held by the county council and the size of the county's ecological team were considered anomalous in this case (LPA5.2 241114).

Underlying the overall downward recalculation of the development site's baseline value from 48.68 to 25.52 units, however, was a view that the first BIA calculations would create too large a future compensation package, thereby threatening the financial viability of the development (DEV5.1 060315). The initial calculation for the biodiversity offset compensation package was £300,000. The developer and the local planning authority met and the baseline habitat condition assessments for many areas on site were adjusted downward to produce the new figure of 25.52 biodiversity units in the second draft (Table 4). Described as "... something we could live with" (DEV5.1 060315), the ensuing revised cost for the final compensation package was £120,000.

Discussion

Our case study provides an in-depth history of the assessments, calculations, and negotiations of biodiversity and financial values for a BDO compensation contract. This case illustrates several problems for biodiversity conservation predicted in the theoretical literature on BDO. We considered 3 problems in particular and focused on their broader implications for biodiversity conservation through the implementation of BDO.

First, evidence from repeat site visits to this and other pilot offsetting sites in England over 24 months (data held by L.C.) showed that making the DEFRA metric applicable to real-life planning cases is a process of constant iteration and trial and error. Our BDO case history illustrates in particular how metrics for deciding biodiversity values at development and off-site mitigation sites are being redesigned during application and are generating numerical values that are then further negotiated and adjusted. Instead of acting as technical means for the standardized production of impartial and objective calculations based on observed site characteristics, the new metrics associated with BDO design and recommendations are being used differently by different actors with competing interests in negotiations. Such differences in application may be appropriate in response to real-world complexities, but they conflict with the stated aims in BDO policy design for standardization and comparability. The nexus of competing development, conservation, and LPA interests meant that biodiversity values calculated through application of the metric were adjusted downward to facilitate a compensation package that was cheaper for developers. In a similar case at another development site, the development firm negotiated a reduction in biodiversity offset compensation from £300,000 to £90,000 (DEV5.1 060315) (also see the example in Sullivan [2013]). As predicted in theory (Walker et al. 2009; Hannis & Sullivan 2012), then, these case studies seem consistent with concerns that an emphasis on market values for biodiversity conservation and compensation will encourage developers, as purchasers of impact compensation, to push prices downward so as to lower their costs. In doing so, both the quality and quantity of conservation yield through BDO may also be reduced.

Second, our case shows how the commensuration process works in practice to make different habitats equivalent to each other through the application of BDO metrics (Tables 1 and 3). Numerical indicators form proxies for qualitatively different ecological assemblages, calculated with the aid of the DEFRA biodiversity metric as represented by the BIA Excel spreadsheet calculations. Sometimes these commensuration processes generated unintuitive outcomes. It was unclear, for example, how the sports pitches, with 6.36 units of biodiversity value, was equivalent to 6.36 units of high-quality grassland habitat that supports a range of biodiversity-action-plan species at the offset site. The proposed mitigation value of the sports pitches, determined to be habitats of low distinctiveness and poor condition, was achieved because they were the largest habitat type within the development.

Table 4. Negotiated changes in calculated biodiversity baseline unit values between biodiversity impact assessment (BIA) drafts 1 and 2. The habitat codes in the first column relate to the habitat codes in Fig. 1a.

			Distinctiveness		*Condition*				
BIA habitat code	*Habitat description*	*Area (ha)*	*category change*	*score change*	*category change*	*score change*	*Original unit value draft 1*	*New unit value draft 2*	*Reduction in unit value (%)*
F1	improved grassland	1.78	none	none	moderate to poor	2 to 1	7.12	3.56	50
P1	wetland standing water	0.01	none	none	good to moderate	3 to 2	0.14	0.01	93
F2	improved grassland	3.10	none	none	moderate to poor	2 to 1	12.40	6.20	50
F2	tall ruderal	0.18	none	none	moderate to poor	2 to 1	0.70	0.35	50
Bowling green	amenity grassland	0.12	none	none	none	none	0.24	0.24	0
F6	amenity grassland	0.97	none	none	none	none	1.94	1.94	0
West of football grid	improved grassland	0.08	none	none	good to moderate	3 to 2	0.48	0.32	33
F3	improved grassland	4.88	none	none	moderate to poor	2 to 1	19.52	9.76	50
Slurry pit	standing water	0.01	high to low	6 to 2	none	none	0.05	0.02	60
Part of F4 and F5	improved grassland	1.52	none	none	moderate to poor	2 to 1	6.08	3.04	50
Total							48.68	25.52	48

Table 5. Biodiversity units calculated for football pitches as amenity grassland at the development site compared with an equivalent area of species-rich semi-improved grassland at the offset site.

	Development site	*Offset site*
Size (ha)	2.44 (3.8 full-size football pitches)	0.64
Habitat type (qualitative category)	amenity grassland	species-rich semi-improved grassland (lowland meadow)
Biodiversity units	4.07	5.48

This outcome shows how the numerical abstractions inherent in the English BDO process can lead to large areas of low value for biodiversity becoming commensurate with small, unique areas of high biodiversity value (Sullivan 2013; Carver 2015) (Table 5). The packaging of football pitches as habitat for on-site mitigation reduced the financial compensation value in the final offset calculations by decreasing offset unit requirements by an equivalent number of biodiversity units.

Finally, elements of these 2 problems suggest that the pressure to create value for money (i.e., more conservation gains for less money) in compensation strategies for conservation may be pushing BDO in directions that favor the growth of market values and exchanges for offset units, but that may work against the robust generation of conservation value (Hannis & Sullivan 2012; Dauguet 2015). Observations in our case study confirm this tendency. For example, although conservation NGOs were considered convenient offset providers by district councils (LPA5.1 010215),councils also recognized that to achieve market liquidity in offset units private landowners would have to play a significant role. Indeed, a barrier to the development of BDO in England has been a shortage of offset sites from which to purchase biodiversity offset credits, as confirmed in DEFRA's pilot evaluation report (Baker et al. 2014). The local authority in our case thus forged partnerships with organizations that could assist in stimulating and brokering a greater supply of offset credits and receptor sites through private landowners. High transaction costs for site identification and preparation and legal fees are fostering economies of scale by bringing offset provision together with the economically astute ways that large commercial landowners can manage their farms (OB5.2 020315 and as predicted by Sullivan and Hannis [2015]). This is expected to result in a better supply of offset credits from newly formed habitat banks. Emerging offset brokerage firms hope that a high supply of offset credits will improve credit-supply competition and result in cheaper prices for developers seeking compensation. It is this combination of commercial outlook, farmer experience, and land management that makes the corporate broker now partnering with the county council confident that with this approach they can produce a "good biodiversity yield per hectare" across multiple sites (OB5.2 020315). In doing so, BDO is becoming further aligned with commercial agricultural productivity agendas that emphasise efficiencies and scale of production (i.e., agricultural yield).

The case we examined was of a biodiversity offset to be provided directly by a conservation NGO to a local planning authority. Despite months of preparation and considerable staff costs, the developer eventually rejected the proposed offset site in favor of developing an offset arrangement with the farmer issuing the land for development in the first place (OB5.1 140116). The calculations and negotiations presented here are nonetheless valuable as a detailed example of how the DEFRA metric is being applied to biodiversity assessments at different sites. In tracking, documenting, and analyzing the calculations and negotiations in this and other cases, we observed that although BDO applies technical and apolitical practices to calculate equivalence and commensurability between sites of biodiversity damage and conservation investment, in practice the process is subject to frequent changes to the input values of the metrics and valuation criteria to balance these in order to meet the conflicting interests of stakeholders. As such, instead of confining the decision-making process to a neutral calculative and technical framework, the process opens up avenues through which stakeholders can negotiate, and sometimes struggle over, specific outcomes (Coralie et al. 2015; Sullivan & Hannis 2015). As suggested by Walker et al. (2009:149), the concern is that "biodiversity protection interests will fail to counter motivations for officials to resist and relax safeguards to facilitate exchanges and resource development at cost to biodiversity." Application of scoring practices that create numerical values may help stimulate greater compensation payments for biodiversity loss in the English planning system and elsewhere, thereby supporting greater biodiversity outcomes (although see Carver 2015). Obscured within these technical calculation practices, however, and as predicted by Salzman and Ruhl (2000), are additional value judgments and struggles over arriving at the perceived right numerical values that straddle competing demands such that they are economically palatable, politically pragmatic, and ecologically coherent. Whether or not biodiversity yields are achieved through these negotiations depends on the bargaining powers of stakeholders, beyond the application of standardized practices to calculate and commensurate biodiversity losses and gains.

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Supporting Information

The interview guide for semistructured interviews (Appendix S1) and the original development site BIA (version 17.4) of 27 June 2013 (Appendix S2) are available online. The authors are solely responsible for the content and functionality of this material. Queries (other than absence of the material) should be directed to the corresponding author. Appendix S2. Original development site Biodiversity Impact Assessment (BIA) v17.4, 27 June 2013 (Source: OB5.1 140714, reproduced with permission).

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