Ecological Economics 142 (2017) 185–193

Contents lists available at ScienceDirect

Ecological Economics

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

Analysis

Counterintuitive Proposals for Trans-boundary Ecological Compensation Under 'No Net Loss' Biodiversity Policy

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ARTICLE INFO

Article history:
Received 19 October 2016
Received in revised form 23 February 2017
Accepted 12 June 2017
Available online xxxx

Keywords:
Biodiversity offset
Counterfactual
Mitigation hierarchy
Multiplier

ABSTRACT

'No net loss' (NNL) policies involve quantifying biodiversity impacts associated with economic development, and implementing commensurate conservation gains to balance losses. Local stakeholders are often affected by NNL biodiversity trades. But to what extent are NNL principles intuitive to stakeholders when they are not experts? We surveyed 691 students with limited or no knowledge of NNL policy across three countries, eliciting perceptions of what constitutes sufficient ecological compensation for forest habitat losses from infrastructure development.

NNL policies assume that biodiversity compensation should be: close to development impacts; greater than losses; smaller, given a background trend of biodiversity decline; and, smaller when gains have co-benefits for biodiversity. However, survey participant proposals violated all four principles. Participants proposed substantial forest compensation abroad, did not always require commensurate compensation within their own country, and required more forest creation if background trends were for habitat decline or if forest creation had fauna co-benefits.

Our findings suggest that, under certain circumstances, international biodiversity trades could deserve consideration. The findings also support proposals to incorporate social considerations into compensation ratios for NNL. Wherever the rationale underlying NNL is discovered to be counterintuitive insofar as relevant stakeholders are concerned, careful communication of policy intentions is required.

1. Introduction

1.1. No Net Loss

Environmental policies and legislation that incorporate a 'no net loss' (NNL) of biodiversity objective have been widely adopted over recent decades (Maron et al., 2016). The theoretical assumption underlying all approaches to NNL is that if the negative biodiversity impacts associated with economic development are quantified, and commensurate biodiversity gains correspondingly achieved through additional conservation interventions, then losses and gains can be summed to demonstrate a neutral net outcome for nature (Bull et al., 2013a). Normally, when seeking NNL, it is required that the impacts predicted to occur as a result of a given development project are mitigated through a sequential 'mitigation hierarchy' of preferred measures. A widespread framing of the mitigation hierarchy is 'avoid, minimize, remediate, offset' i.e. predicted impacts are first avoided or minimized wherever possible, then remediated immediately if they are only temporary, and finally, all residual predicted impacts are compensated for through biodiversity offsets (Gardner et al., 2013; Bull et al., 2016).

The most controversial component of the mitigation hierarchy is biodiversity offsetting (Apostolopoulou and Adams, 2017; Maron et al., 2016). Biodiversity offsets (henceforth, offsets) involve the implementation of conservation actions, such as habitat creation, that provide quantified biodiversity gains which would not have been achieved otherwise – thereby fully and demonstrably compensating for any unavoidable impacts from the associated development project. Out of this simple premise, a large body of theoretical literature has emerged, detailing what form and magnitude the biodiversity gains that constitute offsets must take in order to ensure that the overarching NNL objective is met (Calvet et al., 2015). Widely held theoretical principles of good practice for biodiversity offsetting include that: offset gains should be realised in close proximity to development losses (Pilgrim et al., 2013); gains must be larger than losses by some factor, to account for restoration uncertainties and other considerations (Moilanen et al., 2009); and, NNL should be explicitly calculated against some counterfactual capturing background biodiversity trends (Bull et al., 2014). The first of these principles, the proximity requirement, can also be interpreted as meaning 'functional' proximity e.g. a wetland offset being implemented in the same watershed as the development for

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http://dx.doi.org/10.1016/j.ecolecon.2017.06.010
0921-8009/

which it compensates. In the case of either spatial or functional proximity, the assumed preference for proximity means that offsets in different countries to the associated development have not widely been countenanced.

Environmental policies involving trade-offs can be difficult to implement if local stakeholders do not view the trades favourably (Daw et al., 2015). Furthermore, in addition to technical requirements, the amount of ecological compensation necessary to achieve NNL is thought to require consideration as to what local stakeholders are willing to accept (Bull et al., 2017). For both reasons, the potential perception of biodiversity offsets held by laypeople should be an important consideration in NNL policy development. Survey methods have previously been employed to understand perspectives on the effectiveness of offsetting as a process from those involved in NNL trades (Coggan et al., 2013; Vaissière and Levrel, 2015), and to understand perceived offset needs from other local stakeholders (Burton et al., 2016; Kermagoret et al., 2016). However, to date, there has been no study that determines whether, or to what extent, basic principles underlying NNL are generally intuitive to those with little prior experience of the concept. Consequently, in this article, we focus upon stated choices for biodiversity compensation requirements from survey participants who are not NNL experts, and compare this with the logic underlying offsetting. In particular, we are interested in the application of NNL in a trans-boundary conservation context, how much compensation participants consider necessary, and how this amount is influenced by different background biodiversity trends.

1.2. Trans-boundary Biodiversity Conservation

Nature conservation is always challenging across socio-political boundaries, and interventions must be designed in such a way as to acknowledge differences in societal values (Dallimer and Strange, 2015). It has been shown that people are generally willing to contribute more towards conservation in their own country than elsewhere (Dallimer et al., 2015). That finding has been replicated for NNL by Burton et al. (2016), who show that offsets implemented to compensate for development impacts are more acceptable the closer they are to the development site, and can become unacceptable if proposed for implementation in another country. We should therefore not be surprised if the public is less likely to accept NNL policies when the outcome of the policy is trans-boundary conservation interventions, and indeed, such an idea is controversial (Žydelis et al., 2009). But it has been shown that trans-boundary offsets might be necessary to achieve NNL in the case of some highly mobile biodiversity conservation targets e.g. migratory species (Wilcox and Donlan, 2007; Bull et al., 2013b). Therefore, it is important to clarify whether there are any conditions under which trans-boundary offsets might be considered acceptable, and by whom.

1.3. Multipliers and Counterfactuals

A fundamental component of NNL is deciding to what extent 'multipliers' are necessary. Multipliers are factors applied to predicted losses, to determine how large gains must be in order to ensure that NNL is achieved once restoration uncertainties and other technical considerations are accounted for (Pilgrim and Ekstrom, 2014). Beyond such standard uses, multipliers could feasibly be employed to incorporate social considerations such as human risk aversion into NNL schemes (Bull et al., 2017). However, there has been no previous empirical study that surveys people's perceptions as to how large a multiplier they would instinctively deem reasonable. Accounting purely for ecological considerations and time preferences, it is considered that achieving NNL always requires multipliers to be greater than or equal to unity, and often in the tens or hundreds (Moilanen et al., 2009; Overton et al., 2012; Laitila et al., 2014).

Achieving NNL also requires an understanding of the background biodiversity trends in the policy region, as these then act as one counterfactual against which any losses and gains can be evaluated. That is to say, biodiversity gains realised under NNL policy do not necessarily have to be absolute gains, but rather, gains against what would have happened in the absence of the NNL policy (Ferraro and Pattanayak, 2006; Bull et al., 2014; Maron et al., 2015). So, if the background biodiversity trend providing the counterfactual for evaluation is one of decline, then a smaller absolute conservation gain can be considered to have achieved NNL than the case in which the trend is for stability (so-called 'averted losses'; Maron et al., 2015). Counterfactuals are not a straightforward concept, and no one has yet explored how the layperson might vary their stated compensation requirements under different counterfactual biodiversity change scenarios.

1.4. Non-expert Perception of No Net Loss

Here, we use the results of an international study conducted across three countries (Denmark, Ghana, and Spain) to explore perceptions of what might constitute NNL on the part of certain 'non-experts'. We consider an NNL expert to be someone who has either published peer-reviewed literature on NNL, or who has specifically worked on delivering NNL projects on the ground. Anyone else, including experienced or even highly educated ecologists, is unlikely to have much technical understanding of delivering NNL. Since our survey respondent group was almost entirely undergraduate students (see Sections 2, 3), we assume likely to have included very few, if any, NNL experts. Consequently, we did not expect participants to consider compensation requirements for NNL on technical grounds. Rather, the survey was employed to elicit stated choices as to the amount of ecological gains considered appropriate to compensate for development impacts (from which we could calculate the implicit multiplier), where these should be implemented, and the influence upon offset requirements of different background habitat trends (i.e. counterfactual scenarios). In the survey itself, we made no mention of the phrases "biodiversity offset" or "no net loss" to avoid priming participants, as such phrases can be highly loaded (e.g. Apostolopoulou and Adams, 2017; Bull et al., 2016).

The survey left open to participants the possibility of proposing offsets in different countries, allowing us to consider whether and when trans-boundary offsets might be deemed reasonable. The main scenarios investigated were those in which losses and gains were achieved in terms of forest cover (an important habitat for nature conservation activities). We also included a scenario in which forest creation could provide incidental benefits for a migratory bird species, allowing us to consider how conservation preferences might change if offset gains explicitly benefitted more than one component of biodiversity and therefore had greater conservation value. Finally, we link the elicited conservation offsets to preferences of risk, trust, collaboration, and other beliefs of the participants about the other countries named in the survey.

Given the context discussed throughout Section 1, our hypotheses are that:

1. Participants will on average overwhelmingly prefer compensation (in the form of absolute area of proposed forest creation) in their own country, rather than abroad;
2. Proposed multipliers, constituting an average gain:loss ratio in forest area, will be equal to or greater than unity, for losses and gains within the participant's own country;
3. Participants will require equal or less compensation if the background trend in forest habitat cover trend is one of decline, than if it is stable or increasing; and,
4. Participants will require less compensation if forest creation provide incidental benefits for other components of biodiversity.

2. Materials and Methods

2.1. Survey Methodology

We designed and implemented a survey simultaneously at universities in Denmark, Spain and Ghana, as part of a broader series of economic experiments conducted in these countries from April to May 2016. The inclusion of these three countries in our study was arbitrary and based upon the availability of experimental resources, rather than due to the countries having any specific type of NNL policy framework. Although Denmark and Spain are covered by European Directives featuring an NNL objective, none of the three countries are considered to have well-established offset policies (Maron et al., 2016). This was beneficial from our perspective: our focus here was not upon the finer details of NNL legislation, but upon general perceptions of what constitutes sufficient biodiversity compensation from respondents with little prior experience of NNL policy. Survey participants in Denmark and Spain were recruited at random using the ORSEE software (a web-based online recruitment system, containing a database of students voluntarily willing to participate in economic experiments and surveys; Greiner, 2015) whilst voluntary participants in Ghana were recruited using flyers and in-class advertisements. All survey participants signed a consent form (Appendix A). These experiments were conducted at the University of Copenhagen (Denmark), Pompeu Fabra University (Spain), and the University of Ghana (Ghana). All participants were undergraduate students from these universities, and they were all national citizens of the country for which they were answering the survey. Whilst the use of student respondents in economic experiments could feasibly deliver findings that generally representative (Exadaktylos et al., 2013), we consider our results here to relate to students as a subset of NNL non-experts only.

The survey questionnaire was originally written in English, translated to Danish and Spanish and then retranslated back to English, as is standard (Buchan et al., 2002). Anonymity for each survey participant is ensured: names were not collected, and participants were known only by Subject ID numbers. When answering the survey, participants in Denmark and Spain were divided by a partition, whilst participants in Ghana sat with two seats between them. Individuals conducting the surveys were nationals of the country they were assigned to, but all were trained in survey protocols together in Denmark. In total, we conducted 20 survey sessions in each country. Each survey session had 12 participants each. The relevant components of the survey forms were not completed by 7 participants in Denmark, by 5 participants in Spain, and by 17 participants in Ghana. One limitation of our method was that a specific opt-out question was not included, although those who did not complete our survey were assumed to have opted out. This left a total of 691 (of a maximum possible 720) survey participants who did not opt out: 233 from Denmark, 235 from Spain and 223 from Ghana.

The survey was composed of demographic questions (Appendix A), questions on beliefs and perceptions (Appendix B), and a stated preference survey to elicit respondent preferences for biodiversity offset requirements given a development scenario under NNL policy (Appendix C). In the questionnaire for beliefs and perceptions, we solicited participant beliefs regarding themselves, individuals with nationalities similar to theirs, and individuals with nationalities different to theirs. We measured risk, like/dislike, trust, cooperativeness, care for nature, desire for environmental conservation, desire to protect the habitat of migratory birds, wealth, and whether others care for the participant and the participant's country. All metrics were measured on a Likert Scale, from 1 to 10 for individual risk preferences and from 1 to 4 for everything else.

2.2. Scenarios

We outlined a hypothetical scenario in which a road development was planned, involving the clearance of 100 ha of existing forest in the participants' own country. We then asked what area of biodiversity compensation (in this case, the creation of a new area of forest) participants would consider reasonable, as compensation for the impacts of the road. There was no constraint upon in which of the three countries the compensatory forest could be planted, nor upon how large an area of compensation could be selected. Whilst, as discussed, we avoided priming the participants with controversial phrases such as "biodiversity offset", we did specify that developers were required to plant at least 100 ha of new forest, ensuring that the survey implied an overall NNL objective.

This same question was asked to each respondent for four different scenarios. In the first, forest habitat in all countries was considered stable in condition over time. In the second scenario, forest cover was decreasing in the participant's own country, and stable or increasing in the other two countries. The third scenario reflected the actual situation in the three countries with regards to current trends in forest cover (increasing in Denmark and Spain, decreasing in Ghana). Finally, we asked participants to respond to the first scenario again, but this time they were told that blackcap *Sylvia atricapilla* populations would also be impacted by the development, and benefits to blackcaps would be larger (per hectare of new forest created) in Africa than in Europe. Blackcaps were chosen for the study despite being of low conservation concern, because they met our criteria of being: migratory birds; present across all three countries; and, dependent upon forest habitat. The proposed scenario that the benefits of conservation action for blackcaps would be larger in Africa than Europe was purely hypothetical, but participants were not informed that this was the case.

The four scenarios are summarized below.

Scenario 1: forest cover stable in all three countries;
Scenario 2: forest cover decreasing in the participant's country, but stable or increasing in the other two countries;
Scenario 3: forest cover increasing in Denmark and Spain, decreasing in Ghana;
Scenario 4: as for Scenario 1. In addition, blackcap populations would benefit more from forest creation in Ghana than in Spain and Denmark.

Scenario 1 was used to test Hypotheses 1 and 2, Scenarios 2 and 3 were used to test Hypothesis 3, and Scenario 4 was used to test Hypothesis 4 (see Section 1).

2.3. Test Statistics

We analysed all data using two standard data analysis techniques: Student's *t*-test and ordinary least squares (OLS) regression (note that throughout Section 2.3, we draw from Wooldridge, 2002; Moffat, 2016). The Student's *t*-test is a commonly used technique for testing a hypothesis concerning the difference between sample means. It determines a probability that two populations are the same with respect to the variable being tested. In our case, 'populations' are countries of origin, and the test variable is the amount of reforestation an individual required to offset forest loss. Our data satisfy the assumptions underlying the Student's *t*-test: (1) the scale is continuous and ordinal; (2) data were collected from a randomly selected portion of the student population in the surveyed universities; (3) by the central limit theorem and given that the sample sizes in each our three countries are >50, our means approach a normal distribution regardless of the distribution of the population; and, (4) our dataset is reasonably large, containing 200+ observations per population.

We ran the OLS regression in order to identify the magnitude and direction of the above effect, and determine whether this remained consistent when controlling for possibly confounding socio-demographic factors. An OLS regression describes the linear relationship between the dependent variable (hectares of forest) and the independent variable (country of origin). Whilst the only assumption needed to obtain an estimator in OLS regression is (1) for explanatory variables not to be perfectly collinear with one another, there are four other assumptions that make the OLS estimator the best linear unbiased estimator: (2) linearity in parameters; (3) random sampling of observations; (4) conditional mean is zero; and, (5) homoskedasticity. Our data satisfy all 5 assumptions. None of our dependent variables are perfectly collinear with our independent variables. If they were, our coefficient would be 1 and we would not have been able to derive standard errors and p-values. Since we thought it likely that our errors were heteroskedastic given the sample size, we used robust standard errors.

3. Results

All survey participants were at least 18 years of age at the time of the survey. Average participant age in Denmark was 24 (max = 53); average participant age in Spain was 21 (max = 56); and average participant age in Ghana was 22, (max = 29). 46%, 34% and 73% of our participants in Denmark, Spain and Ghana, respectively, were males. Most participants were unmarried, with no children.

Risk aversion can be linked to the desire for nature conservation (Hummel et al., 2009) and rejection of offsetting (Bull et al., 2017), so we noted propensity for risk-taking among participants. On average, we found that participants in Ghana were more willing to take risks compared to participants in Denmark and Spain, and this level of risk-taking was correlated with their desire to conserve the environment. We also found a statistically significant bias for participants liking individuals from their own nationalities, believing that individuals from their own nationality were more cooperative, and that individuals from their own nationality were less likely to protect the habitats of migratory birds. Interestingly, only 25.8% of Danes, but 56.6% of Spaniards, and 46.6% of Ghanaians thought that Danes cared more for nature. Spanish participants trusted Danes the most, whilst the other two nationalities trusted individuals from their own nationalities more. We included questions on perception of national wealth, since we considered it likely that perceived relative national wealth would strongly influence a participant's likelihood to support nature conservation activities in another country. Perceptions of wealth corresponded to each country's per capita gross domestic product: Danes believed that they are wealthier than Spaniards and Ghanaians. Spaniards and Ghanaians believed that the Danes are wealthier than them. Both Spaniards and Ghanaians also believed that Spaniards were wealthier than Ghanaians. These perceptions of wealth were statistically significant. A summary of these statistics can be found in Appendix E.

3.1. Patriotic Conservation

Under Scenario 1, participants on average required the greatest area of forest creation in their own country, as a biodiversity offset for the hypothetical road development (Table 1). This preference for seemingly patriotic conservation was statistically significant. Columns (1), (3) and (5) of Table 2 show that Danish participants tended to allocate 34–40 ha more forest creation in Denmark compared to Spain and Ghana, Spanish participants tended to allocate 24 ha more of forest creation in Spain compared to Denmark and Ghana, and Ghanaian participants tended to allocate 95 ha more of forest creation in Ghana compared to Denmark and Spain. Even after controlling for gender, risk preferences, and perceptions of trust, cooperativeness, care for nature and migratory birds, and wealth, we consistently found these results, with higher magnitudes for Denmark and Spain and lower magnitude for Ghana (see Columns (2), (4) and (6) of Table 2). However, participants proposed a substantial proportion of the overall compensation they proposed in other countries – which suggests that, whilst there is clear evidence of patriotic conservation, we can reject Hypothesis 1 (Section 1).

3.2. Size of Implied Multipliers

Unexpectedly, participants in Denmark and Spain required <100 ha of forest to be planted on average in their own respective country i.e. an implicit national multiplier < 1.0 (Table 1). This was not the case for Ghanaian participants, who required almost twice the area of forest to be recreated in Ghana alone. As such, we can reject Hypothesis 2 for Danish and Spanish participants, but not Ghanaian participants. Moving on to total compensation for the road development summed across all three countries, the average response in all three countries was always to require >100 ha of forest (as suggested by the survey guidelines), i.e. on average, participants implicitly required a NNL multiplier > 1.0 to be applied to development losses (t-test: Denmark, $p < 0.001$; Spain, $p < 0.0001$; Ghana, $p < 0.0001$).

The multipliers varied by country and by Scenario (Table 3). Participants in Denmark required significantly more forest creation across all countries if forest cover in Denmark was declining (Scenarios 1 and 2), but not if cover was declining elsewhere (Scenario 3). They also required significantly more forest creation if it had co-benefits for blackcaps (Scenario 4). Participants in Ghana required the greatest area of forest creation, although with almost no significant variation between scenarios (Scenarios 1, 2 and 4). Curiously, although Scenarios 2 and 3 were identical from the Ghanaian participant's perspective, in Scenario 3 participants in Ghana required a significantly smaller multiplier overall. The Spanish participants were the most consistent, requiring significantly more forest creation when forest area was declining at home or abroad (Scenarios 2 and 3) and when there were co-benefits for blackcaps (Scenario 4), compared to the base case (Scenario 1).

3.3. Compensation Requirements Against Different Counterfactuals

In all three countries, participants required a greater area of forest creation on average as offsets for road development in their own country under Scenario 2 than under Scenario 1. That is, if forest in their own country was declining (it was clearly specified that forest cover "will disappear within a few decades" in the participants' country), the participants considered the compensation requirement to be greater. Table 2 shows regressions results for Scenario 2. In Columns (7), (9) and (11), we see statistically significant effects for own-country allocations. In Denmark, the marginal effect was 116.69 ha; in Spain, the marginal effect was 95.32 ha; and in Ghana, the marginal effect was 88.92 ha. All three coefficients were higher than the coefficients for the same variable under Scenario 1. Participants in Spain reacted particularly strongly to the change in background trend. In fact, when we ran t-tests on own-country contributions between Scenario 1 and 2, we found that own-country contributions in Scenario 2 were statistically

Table 1
Proposed area of forest creation in each country.

		Proposed area of forest creation (hectares)				
		Denmark	Spain	Ghana	TOTAL	Effective multiplier
Country hosting road development	Denmark	73.5 ± 39.5	34.1 ± 46.0	39.2 ± 76.1	~150	~1.5
	Spain	66.6 ± 115.5	89.7 ± 120.8	79.5 ± 186.1	~240	~2.4
	Ghana	91.5 ± 124.2	93.0 ± 130.5	187.1 ± 752.3	~370	~3.7

Average compensation proposed by nationality of participant with standard deviations, under Scenario 1.

Table 2
Effect of nationality on forest allocation under Scenarios 1, 2, 3 and 4 (full regression results presented in Appendices F, G).

Dependent Variable: Forest Creation, ha.

	Scenario 1						Scenario 2					
	Denmark		Spain		Ghana		Denmark		Spain		Ghana	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Allocate: Spain	−39.3691***	−40.1000***	23.1340***	23.9267***	1.5637	1.1382	−78.6159***	−79.3152***	95.3234***	97.5822***	−13.7892	−10.8387
	(3.5706)	(3.6576)	(2.9525)	(3.0981)	(2.0648)	(2.1654)	(9.8521)	(10.1561)	(13.0804)	(13.8253)	(11.0544)	(12.2973)
Allocate: Ghana	−34.2790***	−34.9870***	12.9404*	13.5911*	95.6395*	31.1215***	−47.7532	−48.05	0.3404	1.2889	88.9170***	99.6747***
	(5.4458)	(5.6063)	(7.3924)	(7.8702)	(48.6790)	(7.5722)	(39.2671)	(40.5528)	(1.7099)	(1.7186)	(18.0389)	(20.8645)
Constant	73.4686***	102.6922***	66.5621***	34.6347	91.4771***	287.6201**	116.6867***	161.9660**	64.2268***	0.8604	101.2108***	332.06
	(2.5919)	(27.3474)	(7.5463)	(50.1943)	(8.3294)	(137.4557)	(6.2065)	(77.1805)	(11.5327)	(74.9638)	(13.3262)	(243.1053)
Controls	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
R-squared	0.09	0.14	0	0.14	0.01	0.11	0.01	0.08	0.05	0.17	0.03	0.16
N	699	690	705	675	669	558	699	690	705	675	669	558

	Scenario 3						Scenario 4					
	Denmark		Spain		Ghana		Denmark		Spain		Ghana	
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Allocate: Spain	−20.1717***	−20.6522***	8.6766***	8.9733***	0.7085	1.9731	−21.2489***	−21.7435***	5.8511	6.6444	2.7265	8.2151
	(2.6764)	(2.7434)	(2.0607)	(2.0961)	(2.3333)	(2.3809)	(2.7617)	(2.8313)	(4.8614)	(5.1520)	(6.5090)	(6.1383)
Allocate: Ghana	49.9185**	49.8087**	84.5149***	87.0044***	81.3117***	77.8898***	20.5923*	20.6000*	41.6234***	41.0511***	65.5919***	52.2634***
	(21.5030)	(22.2074)	(19.6329)	(20.8813)	(11.1973)	(11.2197)	(11.1118)	(11.4753)	(6.3748)	(6.6567)	(19.6990)	(11.8550)
Constant	47.8868***	65.4548**	63.0936***	−3.7046	78.4283***	151.5297	61.9482***	115.6493**	78.6996***	31.1875	99.6955***	709.6359
	(2.6298)	(32.3091)	(8.7125)	(67.8190)	(6.6845)	(111.7468)	(4.4271)	(44.9770)	(11.7100)	(73.6148)	(10.9935)	(453.6187)
Controls	no	yes	no	yes	no	yes	no	yes	no	yes	no	yes
R-squared	0.02	0.07	0.02	0.09	0.07	0.17	0.02	0.09	0.01	0.12	0.01	0.12
N	699	690	705	675	669	558	699	690	705	675	669	558

Notes: OLS regressions with robust standard errors. The columns signify which country the survey participant is from. The variables "Allocate: Spain" and "Allocate: Ghana" are dummy variables that take on the value of 1 if a forest allocation is made to Spain and Ghana, respectively, and 0 otherwise. The baseline is an allocation towards Denmark. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$. For all evenly numbered columns, we controlled for gender, risk preferences, perceptions of trust, cooperativeness, care for nature and migratory birds, and wealth. The estimated R^2 is 0.0675 on average, which appears low, but according to Hensher et al. (2015 p. 338) is acceptable.

Table 3
Total multipliers implicitly proposed by participants.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Denmark	1.5 ± 0.1	2.2 ± 0.5	1.7 ± 0.2	1.9 ± 0.1
Spain	2.4 ± 0.2	2.9 ± 0.2	2.8 ± 0.3	2.8 ± 0.2
Ghana	3.7 ± 0.5	3.8 ± 0.3	3.2 ± 0.2	3.7 ± 0.3

'Implicitly proposed' multipliers are those that consider average proposed forest creation when summed across all three countries, for any one scenario, divided by 100. Includes standard error of the mean.

significantly higher for Denmark and Spain (Denmark, $p < 0.0001$; Spain, $p < 0.0001$; Ghana, $p = 0.4768$).

Under Scenario 3, in which background trends in Denmark and Spain were for forest cover to be increasing, participants in those countries correspondingly chose a smaller area of forest creation in their own country (Fig. 1). In fact, Columns (15) and (16) of Table 2 show that although own-country allocation in Spain remains positive, it was no longer statistically significant. Allocations to Ghana, which had been statistically insignificant or significantly lower for our Danish and Spanish population in Scenarios 1 and 2, had now become higher and statistically significant.

In Ghana, there was no significant difference concerning the area of forest creation considered necessary in Ghana itself between Scenario 1 and 2 (*t*-Test: Scenario 1 > Scenario 2, $p = 0.5232$; Scenario 1 < Scenario 2, $p = 0.4768$), but much closer agreement among Ghanaian participants on requirements for Scenario 2 (i.e. a lower standard error). However, under Scenario 3, the Ghanaians proposed significantly less forest compensation within Ghana (where forest cover was decreasing) and significantly more in Denmark and Spain (where cover was increasing) (Fig. 1). In Ghana, the area of forest creation considered necessary in Ghana itself was higher in Scenario 2 than in Scenario 3 (*t*-Test: $p = 0.0583$). Ghanaians also allocated less forest in Scenario 3 compared to Scenario 2 in both Denmark and Spain. This decrease was statistically significant for Denmark (*t*-Test: $p = 0.0239$) but not for Spain (*t*-Test: $p = 0.2022$).

In combination, these results suggest that we can reject Hypothesis 3 for Denmark and Ghana, but not necessarily for Spain.

3.4. Co-benefits for Blackcaps

Under Scenario 4, where the benefits to blackcap populations from new forests were said to be greater in Africa than Europe (Appendix A), the focus upon blackcaps in Ghana results in responses similar to those under Scenario 3 (Fig. 1). All countries allocate forest compensation in Ghana, but to a lesser degree than the marginal allocations in Scenario 3. The Danish average allocation to Ghana of 97.8 ha of forest under Scenario 3 decreased to 82.5 ha under Scenario 4 (*t*-Test: $p = 0.0907$). We saw a similar trend for Spain. Average forest allocation to Ghana declined from 147.6 ha in Scenario 3 to 120.3 ha in Scenario 4 (*t*-Test: $p = 0.0710$). In Ghana, average own-country allocation increased from an average of 159.7 ha to 165.2 ha. This increase was not statistically significantly different, but allows us to reject Hypothesis 4.

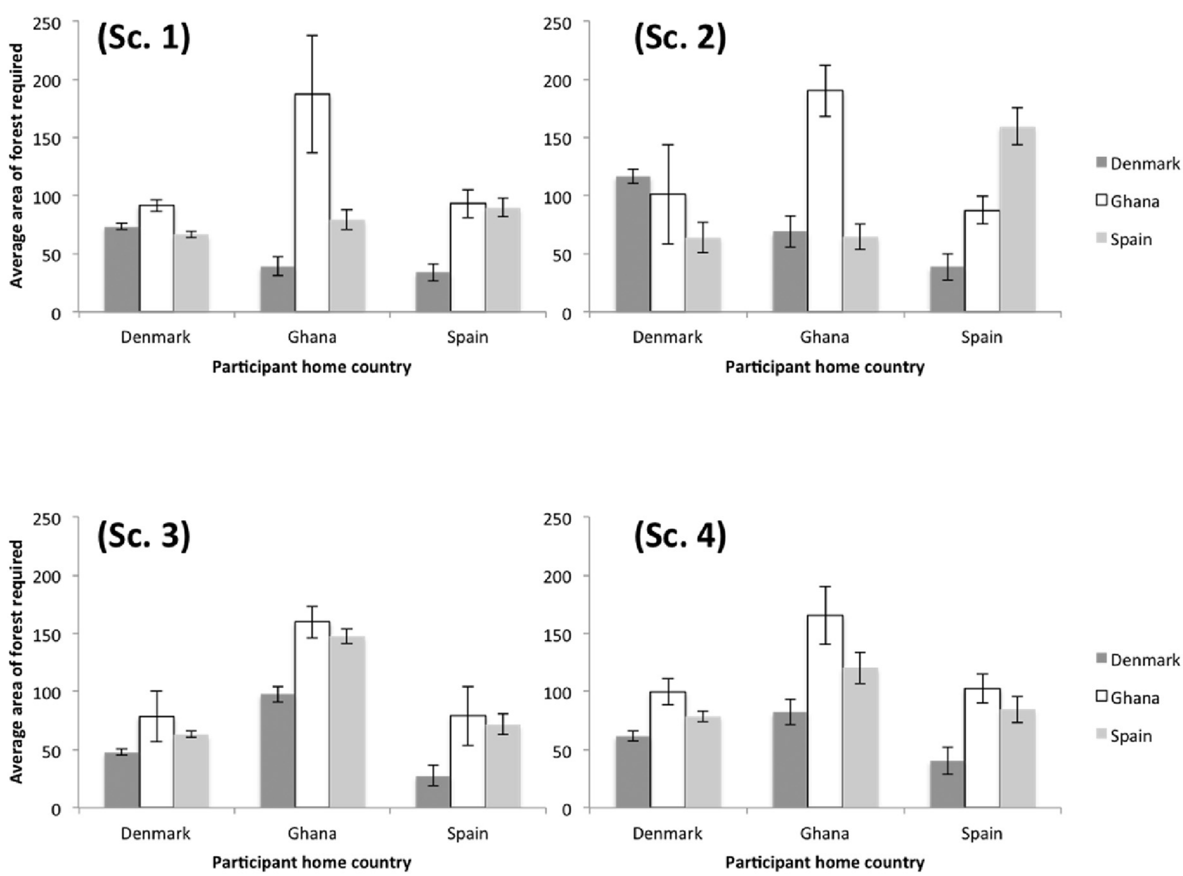

Fig. 1. Average area of forest creation proposed under each scenario (Sc.). Forest creation proposed by participants across all countries (participant located in the country on the x-axis). Error bars are standard error in the mean. Scenarios Sc.1 – Sc.4 as per the main text.

4. Discussion

4.1. Multiplier Values Implied by Participants

Theoretical development of multipliers necessary to achieve NNL find that multipliers in the tens or hundreds might be necessary to achieve NNL on development projects (Moilanen et al., 2009; Laitila et al., 2014). More recently, it has been proposed that these analyses do not allow for multipliers that incorporate sufficient social or ethical considerations, which would result in multipliers being even larger (Bull et al., 2017). At the same time, there is evidence that multipliers are rarely larger than ten in practice (Gibbons et al., 2015; Bull et al., 2017). Here, we effectively showed that participants would implicitly deem overall multipliers between one and four to be reasonable, on average (Table 1). These multipliers were sometimes constituted of multipliers less than one in their own country (i.e. the country in which the development itself occurred). The effective national multiplier varied widely across countries, as those in Ghana required almost twice as much forest to be created by way of compensation (implicitly, offsets) within their own country than the area removed for development (i.e. a multiplier approaching two). It had been expected that a multiplier equal to unity or greater would be required for forest creation within country, by most participants.

We do not consider our findings to suggest that small multipliers are generally acceptable. Again, since participants had not specifically been trained in NNL policies, they would not be expected to consider compensation requirements for NNL on technical grounds (e.g. Moilanen et al., 2009), and the multipliers implied here are likely more related to social considerations (Bull et al., 2017). Rather, the findings should provide a note of caution. When low multipliers are deemed reasonable by untrained stakeholders, then there may be little resistance to the size of proposed compensation dropping that low during the planning negotiation process, even if technical considerations necessitate larger multipliers for NNL. If such concerns had been articulated to respondents, higher multipliers may well have been specified.

Multipliers were generally higher (i.e. more forest creation was proposed) for both Danish and Spanish participants when forest creation would have co-benefits for blackcap populations, than the multipliers implied in the base case (Scenario 1). Existing NNL theory might suggest that if the conservation value of gains were higher than losses, due to multiple benefits, then less forest creation would be required to deliver NNL. However, this finding suggests that those participants required *more* forest creation. Whilst the latter is logical from the perspective of seeking nature conservation gains, it is not logical from the perspective of compensating for negative impacts (the objective of NNL policy). NNL policy principles apparently do not necessarily entirely map onto stakeholder intuition regarding necessary compensation for impacts.

4.2. Biodiversity Offset Requirements Against Different Counterfactuals

Knowledge of background trends significantly influences perceptions of the amount of compensation required under NNL trades. This finding provides additional empirical justification for counterfactuals to be better integrated into the development of NNL policy, echoing previous calls in the literature (Gordon et al., 2011; Bull et al., 2014; Maron et al., 2015). Participants tended to be supportive of forest conservation (Appendix D), and their responses here suggest they would be willing to accept at least some offsetting into other countries. Under these assumptions, if forest cover in a participant's own country were declining, and it was known that the forest would disappear in the near future (Scenario 2), then it would have arguably been logical to propose more compensation in other countries (where forests were safeguarded) than at home, as per our hypotheses. Otherwise, biodiversity compensation might have no positive outcomes in the long term. However, this is not what was seen in the results for Denmark, Spain and Ghana. Instead, all three groups of participants chose substantially more compensation within their own country when it was disappearing. Equally, if forest cover in participants' countries were stable or increasing (as was the case for Denmark and Spain, under Scenario 3), then one might logically expect a greater proportion of forest creation efforts to be directed within their own country than in Scenario 1, as those created forests would, again, be better safeguarded. But participants required the opposite i.e. less forest creation in their own country as compared to Scenario 1. Furthermore, participants reacted less strongly (in terms of the change in proposed forest creation) if forest cover in their own country was increasing than if it was decreasing.

It is not immediately clear why people who support nature conservation would want to create more of a declining habitat that was going to disappear in any case, than if it was stable. There are at least two plausible explanations: (i) participants did not take the logical step (which we did not mention when outlining the hypothetical scenarios in the survey) that planting more forest might be futile if all forest was disappearing in that country; and (ii) nature conservation is judged in terms of relative actions based upon trends of loss and gain, rather than in terms of absolute outcomes. In the case of explanation (i), this would suggest in turn that people understand the importance of counterfactuals as we have shown, but do not necessarily intuitively grasp the conservation implications. In the case of explanation (ii), this would be consistent with conservation being seen as a product of risk aversion (e.g. Hummel et al., 2009), and that people weight biodiversity losses more highly than gains (Bull and Maron, 2016). This explanation would potentially also offer a new perspective upon 'shifting baseline syndrome' (Pauly, 1995; Papworth et al., 2009); that is, if conservation outcomes are judged relative to an individual's personal baseline, it may not matter to them how much information they have about wider absolute trends. These two explanations are not necessarily exclusive, but further research would be needed to establish whether either was valid here. Nonetheless, the fact that NNL policy logic (with regards to compensation requirements under different counterfactual scenarios) is at odds with the compensation needs under those scenarios as perceived by participants, similarly to the point concerning multipliers, suggests that the rationale behind NNL policy is not entirely intuitive. Either way, there are potentially deep implications for the way NNL trades are designed.

4.3. Trans-boundary Trades in Biodiversity

The results support findings in the existing literature that people exhibit a degree of patriotism when it comes to biodiversity compensation, and are more likely to seek investment in conservation in their own country than in others (Dallimer et al., 2015; Burton et al., 2016). This finding is not novel, but the fact that it agrees with previous findings in the literature provides some confidence in relation to the more unexpected results obtained during our survey. For instance, there have been almost no suggestions in the literature that NNL policies could enable trade of biodiversity losses and gains across international borders, with the possible exception of measures related to highly mobile or migratory species (Wilcox and Donlan, 2007; Bull et al., 2013b). Indeed, it is often assumed by policymakers that this would be deemed unpalatable. Conversely, our participants readily proposed compensation in other countries, even when not proposing sufficient compensation to fully replace the forest habitat lost in their own (Table 1; Fig. 1). This finding does not necessarily suggest that international trades in biodiversity can be deemed acceptable, especially when others have found the opposite (Burton et al., 2016); rather, it suggests that policymakers should not assume international trades to be out of the question.

In the only comparable study in the literature, Burton et al. (2016) conversely found that their survey participants were generally unwilling to countenance offsets abroad. The crucial difference in our study is perhaps that forest creation in other countries was proposed alongside compensation nationally, meaning the offset was a mixture of national and international conservation activities ('direct' and 'indirect', respectively, to follow NNL terminology used by Burton et al., 2016). This discrepancy in findings could be due to other factors too: for instance, we allowed participants to propose compensation measures themselves with no constraints, and we did not use the term 'offset' (which can be a strongly value-laden term; e.g. Apostolopoulou and Adams, 2017).

Finally, again, participants proposed substantially more forest creation abroad if doing so would also result in benefits for blackcaps. Note that we did not specify in the survey whether those populations of blackcaps benefitting in Ghana were the same as those migrating back into Europe. This finding, building upon research which has shown that public stakeholders are variously supportive of offsetting dependent upon the type of biodiversity gains (Kermagoret et al., 2016), presents another condition under which stakeholders might consider trans-jurisdictional biodiversity trades acceptable under NNL policy. Previously, the idea of trading species or species habitat losses for far distant commensurate gains (e.g. Wilcox and Donlan, 2007; Kormos et al., 2014) has caused controversy (e.g. Žydelis et al., 2009). In our survey, we did not include the suggestions that species losses would occur, only gains, and the results suggest that the latter might be considered not only acceptable but desirable. So despite patriotic conservation demands, given sufficient nature conservation gains in multiple components of biodiversity (especially fauna, represented in our case by blackcaps), trans-boundary trades might in some cases even be encouraged.

5. Conclusions

We can draw several conclusions from this study. Firstly, given that those participating in the survey were assumed not to be technical experts and so would be unlikely to have knowledge of multiplier requirements in NNL, and yet still effectively proposed a multiplier, our findings support the contention that offsets require incorporation of multipliers based upon social considerations (e.g. risk aversion) as well as ecological considerations in order to genuinely deliver NNL (Bull et al., 2017). The size of the necessary 'social' multipliers appears to vary by country. Second, our analyses should further encourage decision-makers to explicitly incorporate consideration of background trends into the development of NNL projects and policies, as respondent perceptions were clearly influenced by background trends. However, it is also clear that stakeholders were more concerned with relative losses than absolute gains in biodiversity, so NNL policy must take this into account. Thirdly, under some circumstances, international offsets could be acceptable as part of NNL trades, which runs counter to prevailing assumptions in NNL policymaking. The option of international offsets therefore requires further academic exploration.

Finally, and most interestingly, several of the above findings point to the overarching conclusion that the layperson's perception of necessary ecological compensation requirements in response to development impacts may not exactly match the requirements proposed by NNL theory. Whether this conclusion suggests we should seek to better educate public stakeholders concerning the rationale and goals of NNL policy, or conversely that the logic behind NNL policy is somewhat flawed, is a discussion for another article. Either way, our research is highly relevant at a time when NNL policy is being designed and implemented by governments and large corporations worldwide. The outcomes here provide information on a crucial consideration for policymakers, that is, public perceptions as to what may or may not constitute 'no net loss'.

Funding

J.W.B. is funded by a Marie Skłodowska-Curie Action under the Horizon 2020 call H2020-MSCA-IF-2014 (grant number 655497). J.W.B., A.L.A. and N.S. acknowledge the Danish National Research Foundation for funding for the Center for Macroecology, Evolution and Climate (grant number DNRF96).

Acknowledgements

We thank Rosemarie Nagel, Wisdom Akpalu, Finn Tarp and Bo Jellesmark Thorsen for their organizational and logistical assistance and for enabling us to conduct our study on their university campuses. We are also grateful for extensive on-the-ground assistance and translation services from Elvira Rey Redondo, Gianluca Vassallo, Maria Ellemann Hansen, Mathilde Lund Holm, Isaac Ankamah-Yeboah, Josep Renard Segarra, Mathias Vodrup-Schmidt and Lea Skræp Svenningsen. Three anonymous reviewers provided extremely useful commentary on the manuscript.

Appendix A. Supplementary Data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2017.06.010.

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