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POLICY PERSPECTIVE

Exploring the ecological outcomes of mandatory biodiversity net gain using evidence from early-adopter jurisdictions in England

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Abstract

Net outcome-type biodiversity policies are proliferating globally as perceived mechanisms to reconcile economic development and conservation objectives. The UK government's Environment Bill will mandate that most new developments in England demonstrate that they deliver a biodiversity net gain (BNG) to receive planning permission, representing the most wide-ranging net outcome type policy globally. However, as with many nascent net-outcome policies, the likely outcomes of mandatory BNG have not been explored empirically. We assemble all BNG assessments (accounting for ~6% of England's annual housebuilding and other infrastructure) submitted from January 2020 to February 2021 in six early-adopter councils who are implementing mandatory no net loss or BNG requirements in advance of the national adoption of mandatory BNG, and analyze the aggregate habitat changes proposed. Our sample is associated with a 34% reduction in the area of nonurban habitats, generally compensated by commitments to deliver smaller areas of higher quality habitat years later in the development project cycle. Ninety-five percent of biodiversity units delivered in our sample come from habitats within or directly-adjacent to the development footprint managed by the developers. However, we find that these gains fall within a governance gap whereby they risk being unenforceable, a challenge that is shared with other net outcome type policies implemented internationally.

KEYWORDS
biodiversity net gain, biodiversity offsetting, ecological compensation, environmental governance, environmental policy, impact evaluation, impact mitigation, market-based instruments, nature conservation, no net loss

1 | THE CHALLENGE OF RECONCILING BIODIVERSITY CONSERVATION WITH INFRASTRUCTURE EXPANSION

Under the Sustainable Development Goals (SDGs), the global community has simultaneously committed to rapidly expanding built infrastructure networks (SDG 9), whilst ending biodiversity loss (SDGs 14 and 15). However, historically the unmitigated impacts of infrastructure have been a dominant driver of biodiversity loss, threatening one-third of IUCN Red List species (https://www.iucnredlist.org/). To reconcile the SDGs, fundamentally new approaches to infrastructure implementation are required (Thacker et al., 2019). A particular class of policies emerging globally to address this focus on achieving no net loss (NNL) or Net Positive biodiversity outcomes from new developments (Bull & Strange, 2018; Bull et al., 2020; Milner-Gulland et al., 2021). These are predicated on the concept that infrastructure and biodiversity conservation can theoretically go hand-in-hand if infrastructure is planned to avoid and minimize impacts, and residual impacts are compensated for through conservation actions. There is a wide variation in these policies' effectiveness (zu Ermgassen et al., 2019), with limited systematic understanding of when they work or fail. The most wide ranging of these policies globally is the proposal, outlined in the UK government's Environment Bill, for development under the Town and Country Planning Act (i.e., nearly all residential, commercial, and mining construction) in England to deliver a mandatory net gain in biodiversity (although this notably does not cover "Nationally Significant Infrastructure"; Defra, 2019a). The Environment Bill is expected to be ratified in 2021, with the mandatory requirement for biodiversity net gain (BNG) implemented after a 2-year transition period.

Like many densely populated wealthy nations, England faces interlocking socioecological policy challenges: it is ecologically impoverished, with ongoing wildlife declines (State of Nature Partnership, 2019). However, it has committed to building 300,000 new homes annually by the mid-2020s (Ministry of Housing, Communities & Local Government, 2018), and has promised heavy investments in new infrastructure through its post-Coronavirus recovery strategy (HM Treasury, 2020). Mandatory BNG might partially reconcile these challenges (Defra, 2018, p. 4), and is globally relevant in the context of finding policy solutions to mitigate the environmental impacts of the global infrastructure boom (zu Ermgassen et al., 2019).

2 | IMPLEMENTATION OF THE MANDATORY BIODIVERSITY NET GAIN REQUIREMENT

Developers in England will have to demonstrate their proposals achieve a net gain in biodiversity (measured using a government-prescribed biodiversity metric) to receive planning permission from local planning authorities (LPAs), who ultimately assess all of the development plans associated with the site (which can include various economic, social and environmental impact assessments, construction plans, feasibility studies, etc.) and decide whether projects have the right to proceed. Currently, BNG assessments align with the ecological impact assessment (EcIA) process, taking information routinely collected during predevelopment ecological surveys and feeding this through an Excel-based biodiversity calculator tool, the "Biodiversity Metric 2.0" (Crosher et al., 2019; Treweek et al., 2010). The Metric is a multiplicative composite indicator converting inputs including the area, habitat condition, habitat distinctiveness, and various multipliers (capturing elements including the risk of project failure, the expected time taken for the proposed habitat to reach its desired condition level, and the landscape-scale ecological importance of the site) for each habitat patch within the development footprint into an overall biodiversity score measured in "biodiversity units" (Supporting information). The data required from the project site include quantitative data (the area of each habitat patch within the development site and in the proposed postdevelopment plan), qualitative judgments from ecological consultants regarding the habitats' condition and classification, and some landscape-scale information such as whether the project site lies within an area of landscape-scale importance to biodiversity. These data gathered at the project site are integrated in the Metric with other ecological information, which is preset for each habitat type and condition level based on expert judgment (e.g., each habitat is given a preset distinctiveness score within the Metric; preset values capture how long it takes for a given habitat to reach a given condition level under ecological management measures). It calculates the number of baseline biodiversity units within the development footprint plus (where applicable) associated compensation areas owned/managed by the developer, and compares this with predicted postdevelopment biodiversity units. The Metric also provides guidance on whether like-for-like trades should be required for the specific habitat types included in the assessment (e.g., for high distinctiveness habitats), or whether other trading rules are permitted (e.g., for low distinctiveness habitats). The mandatory BNG requirement necessitates that the

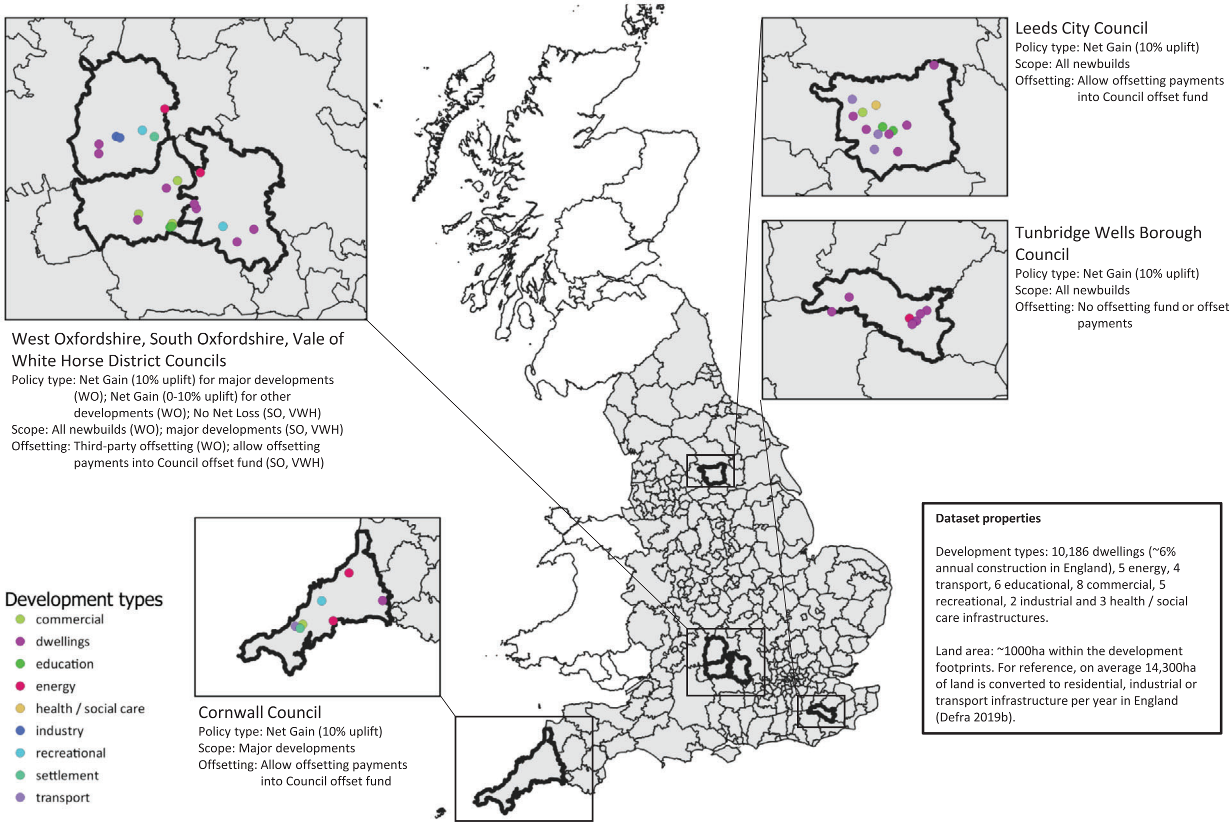

FIGURE 1 Summary of the BNG dataset, including the development types and locations and details of the six councils' BNG-equivalent policies

overall postdevelopment biodiversity score is ≥10% higher than the baseline. If not, the developer must either alter their project plan appropriately or deliver the unit shortfall by offsetting through a payment to the council or a third party (e.g., habitat bank), which is then liable for delivering biodiversity gains elsewhere. If no compensation sites are available within the LPA where the development is planned, then compensation is permitted in other local authorities; but this triggers a spatial multiplier within the Metric, which increases the compensatory units required. As a last resort, developers will be able to purchase biodiversity credits from the national government.

The mandatory BNG requirement is expected to deliver conservation benefits by providing a punitive tax like disincentive from harming biodiversity initially: developers will incur costs if their project inflicts damage on habitats ("internalizing the externalities"; zu Ermgassen et al., 2020). Additionally, where developers are unable to meet biodiversity obligations themselves, the requirement to purchase "biodiversity units" is viewed as an opportunity to stimulate private sector investment in nature regeneration. There are widespread hopes that this will create a market in "biodiversity units", attracting private landholders into for-profit biodiversity unit generation (Defra, 2019b).

However, the potential impacts of the mandatory BNG requirement have not been empirically evaluated. We collected all the BNG assessments accompanying planning applications submitted from January 2020 to February 2021 (the Metric was essentially finalized in December 2019) in six councils that have adopted BNG-equivalent policies in advance of its national rollout (Table S1) into a new database. BNG assessments tend to be provided either as chapters within the proposed project's preliminary ecological appraisal, EcIA, or as stand-alone documents, and they contain as a minimum copies of the outputs of the Biodiversity Metric Excel tool (at best, they contain habitat plans and descriptions for the site at baseline and postdevelopment). We identified appropriate councils via engagement with representatives from Defra, councils, and industry associations. The database is live, with more councils added when identified. In total, 16 potential councils were identified, but only the six councils included in our database have BNG-equivalent policies (Figure 1). We define these as BNG-equivalent as they all ask applicants to submit BNG assessments utilizing the Metric alongside other planning information, and mandate that a net outcome type target is achieved for each project (either NNL or 10% net gain) like the proposed national policy. We identified 90 projects referencing BNG assessments, of which 55 provided sufficient information for inclusion. We then removed one outlier project (a dwelling overseeing a 30-ha estate implementing landscape-scale ecological restoration) as it was evidently not a policy-driven outcome, and six applications that were rejected by the planning authorities. Our sample spans 1000.3 ha of development footprint, of which created or enhanced compensatory nonurban habitats comprise 468 ha. The previous best academic estimate of England's entire implemented offset area was 53 ha (Bull & Strange, 2018), demonstrating the upscaling of ecological compensation represented by the mandatory requirement. By comparing the baseline and proposed future biodiversity assessments for developments in our sample, we explore which land cover changes are likely to be driven by BNG, what role off-site biodiversity offsetting will play, and their implications for conservation.

3 | EARLY SIGNS THAT THE BIODIVERSITY UNIT MARKET MAY BE SMALLER THAN EXPECTED

The first finding is that demand for biodiversity units delivered through council offset funds or the biodiversity unit market in our sample is low (4.5% of total units); 95% of biodiversity units are to be delivered through the creation and enhancement of habitats within the development footprint or directly-adjacent developer-owned compensation areas. This contrasts with the government's net gain impact assessment, which used a central estimate (based on anecdotal responses to the government's net gain consultation) for units purchased off-site of 25% (although they model scenarios including 0%; Defra, 2019b). The government has highlighted that developers paying for the off-site delivery of biodiversity units could be an important source of funding for investments within the local nature recovery networks for each LPA (Defra, 2018, p. 9). The funding provided by these off-site payments might either be collected by the LPAs themselves and invested in a portfolio of biodiversity projects (e.g., enhancement of council-owned land; purchase of private land and its addition to the council's conservation estate) selected by the LPA, or collected by private brokers and invested in habitat banks. Our preliminary results raise doubts about the size of the biodiversity unit market. However, only five of our LPAs provide offsetting options, and the habitat creation market is still immature, so the desirability of purchasing biodiversity units may rise over time.

The number of purchased biodiversity units is low in our sample because 95% of the proposed biodiversity units will be delivered on land owned/managed by the developers. Ninety-one percent of units will be delivered via habitats within the direct development footprints (e.g., recreational grassland areas, tree and scrub establishment along hedgerows and site margins, some projects have dedicated ecological enhancement zones). While small habitat patches within built environments can have ecological value, they are also threatened by high levels of human pressure. For example, 49% of the biodiversity units generated within residential developments in our sample come from on-site grasslands and scrub habitats, representing 27% of the total biodiversity units delivered in the dataset.

4 | BIODIVERSITY NET GAIN WILL TRADE LOSSES IN HABITAT AREA TODAY FOR PROMISES OF FUTURE GAINS IN HABITAT QUALITY

The dataset reveals a 34% reduction in the total area of open green space (defined as all nonurban habitats included within the Metric and excluding the units from as-yet-unspent offset funds), despite promising a 20.5% increase in biodiversity units across our sample. These losses in habitat area will be traded for habitats of higher distinctiveness and condition in the future (Figure 2). The pattern of change in habitats in our sample is consistent with a policy of "trading up," with less distinctive habitats replaced by more distinctive habitats or higher condition levels. The true biodiversity impact of these trends is unclear. Intuitively, the loss of 34% of nonurban habitat area is likely to lead to a reduction of real-world biodiversity, albeit much of this reduction comes from building on agricultural land. Improvements in the quality of habitats, which increase the ecological resources available to wildlife relative to the baseline state could counteract this. The relative strength of these two factors should be further explored through field validation of the Metric.

Our dataset demonstrates that mandatory BNG will generally trade biodiversity losses today for uncertain future gains, yielding a classic problem in the offsetting literature (Maron et al., 2012). It is widely recognized that compensating for losses today with promises of future biodiversity gains is risky (acknowledged in the Metric through restoration difficulty and temporal risk multipliers) as compensation measures are subject to implementation and restoration failure, and future political reversals (Bezombes et al., 2019; Maron et al., 2012; zu Ermgassen, et al., 2019). Therefore, conservationists typically prefer for compensation measures to be successfully implemented before associated biodiversity losses. These predevelopment gains are commonly delivered through habitat banks. However, when these proposed gains are delivered on-site, they cannot usually be secured in advance of development; here it

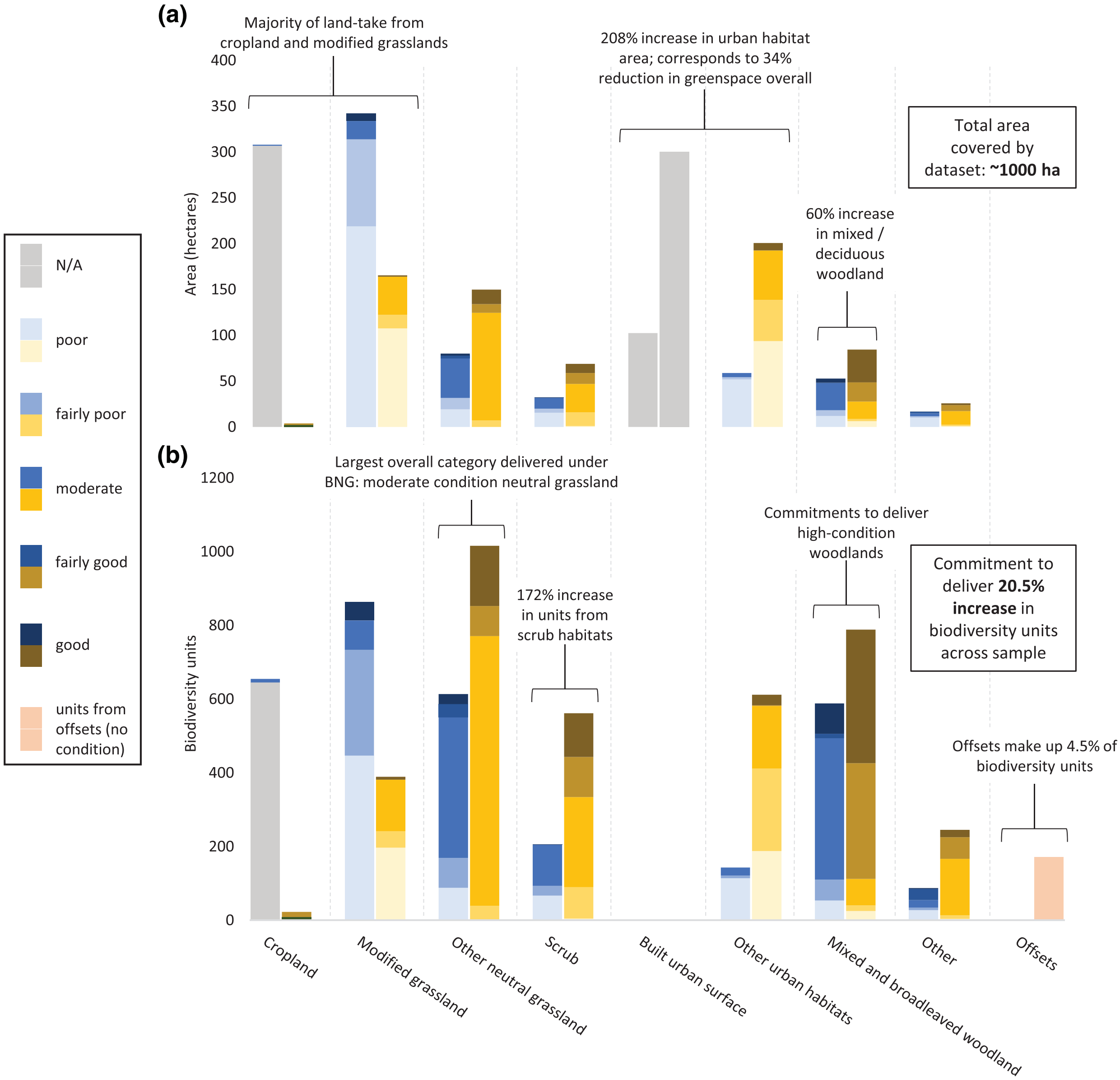

FIGURE 2 Aggregate ecological changes proposed in our sample of biodiversity net gain assessments, by habitat type and habitat condition

Note: Categories represent all of the relevant habitat types included in the Metric grouped together (e.g., "scrub" contains the sum of "mixed scrub", "bramble scrub", and other related habitats included in the Metric), while "modified grassland", and "other neutral grassland" each represent a single habitat category in the Metric. (a) total area devoted to different habitat types under the baseline (blue), and postdevelopment scenario (yellow/brown). (b) The total number of biodiversity units delivered under the baseline (blue), and postdevelopment scenario (yellow/brown). Annotations highlight key patterns in the dataset

is essential that appropriate governance exists to ensure promises of future habitat improvements are delivered (discussed next; Damiens et al., 2021). This requires that proposed future gains are ecologically realistic and that modeling of gains is unbiased, so if the specified ecological measures are actually implemented, these gains are likely to be achieved in reality. Second, it relies on the appropriate governance being in place for incentivizing and regulating real-world implementation.

5 | HOW ROBUST AND OPEN TO BIAS ARE HABITAT CONDITION ASSESSMENTS?

Like many EcIA processes, the Metric requires inputs based on subjective judgments of ecological consultants (although BNG guidance documents underpin these with some objective criteria to guide judgments). The Metric is most sensitive to the identification of habitat type (using the UK Habitats Classification system; https://ukhab.org/), which determines the "distinctiveness" score for each habitat, and its condition score. If there is substantial scope for error or bias in the Metric, then the number of units reportedly delivered through the BNG assessment process might be a poor reflection of their true ecological value. For example, under the baseline we find 342 ha of modified grassland, a "low distinctiveness" habitat (distinctiveness multiplier = 2). If that same grassland were classified as "other neutral grassland" ("medium distinctiveness", multiplier = 4), all else equal, it would require compensation by double the area of post-development habitats. This highlights the importance of EcIAs (and BNG assessments) being undertaken by suitably trained professionals, and subject to rigorous assessment by regulators. Leaving such an influential scope for judgments comes with risks, especially if ecological consultants lack sufficient training to conduct the relevant specialized ecological assessments (e.g., grassland assessments), or are implicitly pressurized to report a reduced biodiversity unit obligation by clients (Carver & Sullivan, 2017).

To investigate whether the Metric is open to judgment-based variability, we surveyed seven expert grassland ecologists (Supporting information). We provided them with all the publicly available grassland survey information used in the baseline calculation associated with a sample of five BNG assessments (N = 13 grassland patches), chosen to represent a range of survey qualities (Supporting information). We removed the final condition scores and habitat type classifications, and asked experts to propose the correct grassland type and condition score, given the information provided. Our specialized expert sample (which required expertise with a new condition assessment process and two habitat classification systems) is too small for statistical inference, but is indicative of whether experts broadly agree with judgments in BNG reports. Our expert sample agreed with both habitat type and condition assessments 31% of the time, habitat type alone 42%, and condition alone 64% of the time. There was no universal agreement among experts regarding the grassland type for any grasslands in our survey (Supporting information), which indicates that less specialized planners critiquing BNG assessments may find the habitat type and condition assessments challenging to scrutinize. Our survey findings indicate that boundaries between habitat categories are open to interpretation, and that the quality of information provided in BNG assessments is often insufficient to properly scrutinize.

6 | MAJOR GOVERNANCE GAPS RISK JEOPARDIZING THE OUTCOMES OF BIODIVERSITY NET GAIN

To assess whether appropriate governance is in place to ensure the delivery of promised biodiversity units (a complex challenge that is often unrecognized; Damiens et al., 2021), we reviewed the governance mechanisms proposed in all BNG-related government, parliamentary and industry documentation, highlighting the key points relating to skills, capacity building, monitoring, enforcement, financial arrangements, and legal arrangements (Table S4). The key finding is that, although there are ambitious commitments to monitoring and implementing offsetting measures delivered into the biodiversity unit market and via the government's stream of "statutory" biodiversity credits, little attention has been paid to ensuring the delivery of habitats within developer-owned land. Nearly all additional governance mechanisms proposed are aimed at securing 4.5% of the biodiversity delivered through mandatory BNG (although this may rise on implementation of national mandatory BNG). Experience from NNL-type policies around the world shows that governance and implementation issues are essential drivers of their outcomes—often more important than policy-design parameters (Evans, 2017; Quétier et al., 2014; Samuel, 2020).

The UK government has committed to resourcing mandatory BNG implementation and developing appropriate industry and regulator skills and capacity, which if implemented may address key problems highlighted in other NNL-type contexts (Quétier et al., 2014; Samuel, 2020). The government has committed to resourcing an additional 1.3 full time equivalent (FTE) employees for every higher tier LPA in England (the largest spatial unit of local government, with 152 across England) to implement mandatory BNG (Defra, 2019b; although these commitments were made prior to the Covid-19 recession, which has renewed the government's narrative regarding the need for fiscal prudence). This represents a large increase in capacity given approximately three-quarters of English LPAs currently have no in-house ecological expertise (ENDS Report, 2019). However, planning policy is often delivered by lower tier authorities (25 of the higher tier authorities across England covering > 50% of England's land area comprised 188 "lower tier" authorities), and we found no formal commitments to increase their resourcing. There are concerns that most councils currently lack the ecological expertise to evaluate net gain assessments (Knight-Lenihan, 2020). If unaddressed, this might lead to councils "accepting" BNG assessments which are ecologically unrealistic (i.e., overpromise on biodiversity units). Additionally, the government commits to resourcing 59 FTE employees across Defra and Natural England to facilitate BNG implementation, focusing on the delivery and monitoring of off-site biodiversity units and local nature recovery networks. The Environment Bill also lays down a policy framework for the delivery of off-site biodiversity units on private land via "conservation covenants" (Table S4).

However, the documentation reveals a gap with regard to biodiversity units delivered within developers' land. It suggests that existing planning enforcement without modifications is sufficient to secure developer-managed biodiversity delivery, although "significant" on-site biodiversity gains will need to be secured through a "suitable mechanism" (Defra, 2020, p. 179), which although not yet formalized could mean by conservation covenant or section 106 agreement. Given that 95% of biodiversity units in our sample are delivered through developer-managed land, this ambiguity and lack of commitment to enforcement creates risks. Compliance with on-site ecological mitigation and compensation measures in the United Kingdom is thought to be low (Drayson & Thompson, 2013), yielding concerns that long-term ecological management measures may be insufficiently implemented. Most importantly, the current reactive nature of English planning enforcement is poorly suited to guaranteeing the delivery of high-quality habitats within approved developments. Councils can only take action against known planning violations, with little financing currently available for routine monitoring. Failures of habitat types to reach specified condition levels are unlikely to be reported by the public (although Defra emphasize that they would like a transparent system for monitoring implementation of the mandatory requirement; Defra, 2019a). Furthermore, the logistical challenges of how to monitor and enforce whether habitats have reached their promised condition levels given that each development is associated with multiple habitats which each "mature" over different timescales have not yet been addressed (although we expect accelerating discussions about implementation issues as the national policy rollout draws closer). Industry best-practice guidance alludes to this issue by recommending that project proponents produce BNG Management and Monitoring Plans, which outline the long-term management and monitoring timetables for their development operations. These should include commitments to adaptive management if monitoring demonstrates that the compensatory habitats are not on track to meet their commitments, and potentially performance-based payment schedules (i.e., so ecological subcontractors would be paid only once given objectives were achieved; Baker et al., 2019). However, potential problems remain: the slowest maturing habitats in the Metric are assumed to reach their desired condition levels 32 years after project implementation, and assuming that councils will take enforcement action if those habitats fail to achieve their desired condition level decades after the project is constructed seems unrealistic.

Compounding this, even when planning violations are reported, local government guidelines outline that councils are encouraged to only take enforcement action in the case of "serious harm to a local public amenity" (House of Commons Library, 2019). The failure of a habitat to achieve the desired condition risks not satisfying this criterion, leaving them in essence unenforceable—identified as a key driver of failings of the Australian Environmental Protection and Biodiversity Conservation (EPBC) Act and French NNL policy (Evans, 2017; Quétier et al., 2014; Samuel, 2020). Therefore, local authorities must rely on developers to implement the actions that are approved in their development applications, but if these actions include costly long-term management measures, they are implicitly incentivized to underinvest in ecological management with little or no oversight, risking long-term biodiversity outcomes.

7 | LESSONS FOR RECONCILING INFRASTRUCTURE EXPANSION AND BIODIVERSITY CONSERVATION

The mandatory BNG requirement will join a growing number of national NNL-type policies (zu Ermgassen et al., 2019). The wide scope of development subject to mandatory BNG has the potential to make it a valuable template for other countries in the midst of international calls to change the functioning of our infrastructure systems in order to address ecological and climate emergencies (Thacker et al., 2019). However, this preliminary evaluation highlights that mandatory BNG as currently implemented at the local level risks poor outcomes for biodiversity when implemented nationally, unless key aspects receive additional attention. Many of these problems are paralleled by those in other biodiversity offsetting systems around the world (Table 1).

First, it is essential that the appropriate governance measures are in place if the policy is to continue to trade immediate biodiversity losses for uncertain future gains (Damiens et al., 2021); temporal multipliers cannot be relied upon alone (Bull et al., 2017). The governance of biodiversity units delivered through habitat banking and offsetting have received much attention. But if the majority of biodiversity units are likely to be delivered on site, current planning system mechanisms for monitoring and

TABLE 1 Problems with compensatory mitigation systems around the world, and the degree to which proposed governance measures for the implementation of the mandatory BNG requirement address these problems

Offsetting region	Problem	BNG susceptibility to problem—on-site	BNG susceptibility to problem—off-site
Australia (national policy), France	Capacity shortfalls and inability to enforce lack of compliance (Evans, 2017; Quétier et al., 2014; Samuel, 2020)	High susceptibility. Planning enforcement system poorly suited to incentivizing compliance, although significant investment committed to improving capacity.	Low susceptibility if all proposed governance measures implemented. Conservation covenants (contracts to protect private land designated for offset sites) expected to come with monitoring schedules and enforcement mechanisms.
Queensland	Inability to find appropriate projects to spend offset funds to generate biodiversity gains. Of the AUD$9.6 million paid into Queensland's offset fund as of February 2019, only AUD$1.5 million had been committed or spent on offsets (Queensland Government, 2019)	–	High susceptibility. Landholders often unwilling to commit to covenants, especially if there is policy uncertainty.
France	Failure to implement compensatory habitats (Bezombes et al., 2019)	High susceptibility. Planning enforcement system poorly suited to incentivizing compliance; compliance with ecological mitigation measures is in general imperfect (Drayson & Thompson, 2013)	Low susceptibility if all proposed governance measures implemented. Government has proposed an offset register, reporting annually.
Western Australia	Site-level condition assessments are inaccurate and cannot be replicated by independent evaluators (Thorn et al., 2018)	High susceptibility. Expert survey shows information routinely provided in BNG assessments insufficient to eliminate judgment-based variation in condition assessments.	High susceptibility. Expert survey shows information routinely provided in BNG assessments insufficient to eliminate judgment-based variation in condition assessments.
England (offsetting pilots)	Power imbalances between regulators and developers allow developers to argue for cost reductions to their proposed compensation measures (Carver & Sullivan, 2017)	Unknown susceptibility. Power imbalances were shown to influence the outcomes of biodiversity assessments for the offset pilots; mandatory BNG aims to address this by making biodiversity gains mandatory rather than negotiable.	Unknown susceptibility. Power imbalances were shown to influence the outcomes of biodiversity assessments for the offset pilots; mandatory BNG aims to address this by making biodiversity gains mandatory rather than negotiable.
Canada; globally	Low offset multipliers are a key predictor of offset failure (Quigley & Harper, 2006; zu Ermgassen, Baker, et al., 2019)	High susceptibility. BNG found to be delivering 34% loss of green space area, which if unaccompanied by significant improvements in vegetation condition postdevelopment will lead to a loss of biodiversity.	High susceptibility. BNG found to be delivering 34% loss of green space area, which if unaccompanied by significant improvements in vegetation condition postdevelopment will lead to a loss of biodiversity.

enforcing compliance are poorly suited for ensuring these materialize in reality.

Second, although the responses to the government consultation found broad support from across stakeholders for the majority of biodiversity units being delivered on-site (Defra, 2019a), our study suggests this urgently deserves further debate. Our dataset is associated with a 34% loss in open green space, coupled with indications that the total level of funding generated through mandatory BNG for off-site, strategic investments in the local nature recovery networks may be small. Biodiversity enhancements delivered within development footprints risk not materializing in reality, because of governance issues, and these locations being subject to high levels of human pressure and disturbance. Therefore as currently implemented, mandatory BNG risks not only delivering little for biodiversity, but also missing a major opportunity to finance investments in regional biodiversity priorities that can help restore biodiversity at a landscape scale. These risks could be addressed by potentially incentivizing the delivery of biodiversity offsite, such as through mandating that a certain percentage of the total biodiversity units delivered by a project must be invested in off-site regional biodiversity priorities or the local nature recovery network. Another mechanism might be capping how much urban land take is permitted by the policy. When the Metric was first designed, the authors recommended a 1:1 minimum area be established, so that a loss of habitat area could not solely be compensated for through promises of future condition increases (Treweek et al., 2010). On the other hand, a mandatory area target might disincentivize delivering higher condition habitats. It is also worth recognizing that a key policy aim of mandatory BNG is improving peoples' access to green space (Defra, 2019b), which can be used to justify on-site biodiversity enhancements being prioritized. However, this priority risks overwhelming the biodiversity goals of the policy, and potential trade-offs should be explicitly discussed.

Lastly, our study provides yet further evidence that designing governance mechanisms for reconciling infrastructure expansion with biodiversity conservation is deeply challenging. Even ambitious policies are subject to huge uncertainties that risk undermining their biodiversity benefits. The safest mechanism for reducing the biodiversity impact of infrastructure is to avoid impacts to biodiversity initially. In practice, this means redirecting development to previously degraded sites wherever possible. On a deeper level, given the need to transition to an economy that meets the needs of all within the constraints of the Earth system (O'Neill et al., 2018), we must rethink our bias toward finding environmentally damaging hard infrastructural solutions to societal challenges.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTION

Sophus O. S. E. zu Ermgassen, Sally Marsh, and Joseph W. Bull conceptualized the study. Sophus O. S. E. zu Ermgassen designed the study. All authors collected the data. Sophus O. S. E. zu Ermgassen conducted the analysis and led the drafting of the manuscript with inputs from all authors.

DATA AVAILABILITY STATEMENT

All data used in this study are available in the Supporting information.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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