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Evaluating Biodiversity Criteria in Green Building Rating Schemes: Toward 'Nature Positive' Development

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ABSTRACT

Aiming for a 'nature positive' future, built environment professionals increasingly adopt green building schemes as their roadmap. We review the most widely adopted green building rating schemes globally, focusing on evaluating their criteria for biodiversity action. We highlight key shortcomings in schemes, including that most do not specify biodiversity objectives (85%), lack monitoring plans (47%), lack ecological connectivity plans (76%) and allocate < 10% of available points to biodiversity (72%). Most schemes focus on mitigating harm (91%) or compensating unavoidable impacts via offsetting as the solution (3.4%) rather than rewarding positive, regenerative approaches that bring nature back into urban areas. These findings highlight critical gaps in how green building schemes address biodiversity, particularly given the call for regenerative approaches within the nature-positive agenda. We suggest re-evaluating and transforming specific aspects of green rating building schemes, including biodiversity objectives and monitoring strategies. These are critical improvements in the evolution toward nature-positive approaches.

1 | Introduction

In December 2022, the Kunming-Montreal Global Biodiversity Framework was signed at the 15th Conference of the Parties to the UN Convention on Biological Diversity (COP 15). The Framework included four long-term goals aligned with the 2050 vision of living in harmony with nature and 23 targets for urgent action by 2030. The Global Biodiversity Framework puts forth an aspiration to be 'Nature Positive' by 2050, a target that encompasses both policy formation and built environment implementations. This approach is a call for transformative change in the way humanity interacts with nature; a necessary goal of achieving 'net gain' for nature (Maron et al. 2024). Green building schemes offer benchmarks for best practice and therefore are an opportunity for driving the change needed for a nature-positive future.

The Kunming Montreal Global Biodiversity Framework introduced a target (Target 12) that aims to significantly enhance urban green and blue spaces to improve human well-being and biodiversity (Convention on Biological Diversity 2022). Target 12 focuses on increasing the quality and connectivity of these spaces in urban areas through biodiversity-inclusive urban planning and mainstreaming biodiversity in policies, thereby promoting healthier, more sustainable urban environments. Biodiversity-inclusive urban planning incorporates biodiversity considerations from the earliest planning stages through all phases of the design and construction process (Hernandez-Santin et al. 2022).

The built environment industry is widely recognised as one of the primary drivers behind environmental degradation and biodiversity loss, significantly impacting ecological systems worldwide (Irwin and Geschke 2023). The industry consumes a considerable share of global resources, including a third of all natural materials, 12% of freshwater supplies and 40% of energy (Ade and Rehm 2019; Doan et al. 2017; Rode, Burdett, and Goncalves 2011). The construction of cities, tailored primarily to human needs, typically overlooks the requirements of other species, resulting in uniformity in their environments (McKinney and McKinney 2006). For instance, the widespread use of mirrored or reflective glass panelling has led to a notable increase in bird collisions; well documented in the United States where over a billion birds have been reported to crash into these surfaces each year (Kim, Chae, and Koo 2007; Klem 2008). Land use changes, from rural to urban land, affect habitat structures, from soil compositions to loss of tree hollows (Beyer et al. 2001; Lindenmayer et al. 2013), while the proliferation of light and noise pollution disrupts the natural diurnal cycles of species (Dougherty, Parzer, and Morton 2024; Shannon et al. 2016).

As urbanisation is anticipated to continue, there is an urgent need to enhance the sustainability of development approaches. This need motivated the establishment of the Building Research Establishment Environmental Assessment Methodology (BREEAM) in the UK in the early 1990s. Today, it is estimated that there are over 600 green building rating schemes (GBRS) globally (Vierra 2016). GBRS are voluntary, third-party driven standards that assess the sustainability of building projects based on specific criteria (Doan et al. 2017). They aim to promote the highest standards of environmental and social best practices (Bernardi et al. 2017). These schemes are often tailored to their geographical context. Popular GBRSs include BREEAM, Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Built Environment Efficiency (CASBEE) and Green Building Council of Australia (Green Star) (Khese, Hedaoo, and Konnur 2016; Marchi, Antonini, and Politi 2021). The top evaluation criteria in GBRS are energy efficiency and indoor environmental quality (IEQ) (Tang, Foo, and Tan 2020). GBRS aims to encourage the highest standard of environmental and social sustainability and is often a costly endeavour (Ade and Rehm 2019; Geng et al. 2012). Each GBRS includes one or more manuals that detail how green ratings are achieved. Often these manuals are targeted at different features of the built environment such as new buildings, retrofits or master plans. Early schemes primarily focused on addressing the substantial energy consumption of buildings across development stages, from material extraction to assembly and ongoing usage (Ade and Rehm 2019). The methods of these schemes have been re-evaluated, updated and researched for decades (Ade and Rehm 2019; Doan et al. 2017) yet there is no existing literature examining the biodiversity-related criteria of GBRS, despite biodiversity being a well-established element of sustainability. Before the last decade, many GBRS did not include biodiversity as a consideration, despite the substantial negative impact the built environment can have on biodiversity (Ogden 2014).

The importance of GBRS for achieving sustainability goals is clear. If LEED certification was applied to 95% of new construction and 75% of existing buildings, it would result in a 14% reduction in the USA's total carbon emissions in 2025 from a 2005 baseline (Kats, Braman, and James 2010). Numerous studies compare GBRS and their sustainability criteria. While GBRS shares some similarities in their macro sustainability categories, they vary in their criteria and evaluation strategies (Mattoni et al. 2018). (Lazar and Chithra 2019) compared GBRS against the three pillars of sustainability: environmental, social and economic, and found that environmental criteria are the most highly valued. Others have focused on comparing criteria, such as building material choice criteria (Rahardjati, Khamidi, and Idrus 2011), or comparing the indoor environmental quality (IEQ) of green buildings versus non-certified buildings (Allen et al. 2015). Amongst GBRS, energy is typically considered the most important criterion, with a combined average weight of 26% (Tang, Foo, and Tan 2020) and a consistent finding across numerous studies that energy holds the highest weighting among the criteria in GBRS (Illankoon et al. 2017; Shan et al. 2018; Varma and Palaniappan 2019). Indoor environmental quality (IEQ) is another well-studied topic in GBRS literature (Zhou et al. 2022). Wei, Ramalho, and Mandin (2015) compared 31 schemes, assessing how well they consider and respond to indoor environmental quality (IEQ), finding that the average weight in GBRS is 7.5%.

Substantial differences in approaches and priorities exist in GBRS, with recent calls for greater alignment and goals consistent with the new Levels European Union Initiative (Sánchez Cordero et al. 2020). (Sallam and Abdelaal 2016) proposed that no single GBRS tool can be universally applied with trustworthy results across different regions. Marchi, Antonini, and Politi (2021) provided a comparison of the most frequently used GBRS, including BREEAM (UK), LEED (USA), Comprehensive Assessment System for Built Environment Efficiency (CASBEE) (Japan) and Green Star (Australia), and found that despite some differences in approaches, they all follow a similar structure, which is to group the assessment schemes by topics such as Energy or Indoor environmental quality (IEQ) and create a set of measurable criteria. Bernardi et al. (2017) called for GBRS to improve the credit weighting system to be better supported by 'sound evidence' and Li et al. (2017) conducted a comprehensive global review of GBRS, highlighting the need for further research, particularly in the realm of detailed and specific criteria comparisons. While energy efficiency remains a focus, other aspects of sustainability, such as biodiversity, are underrepresented in the GBRS comparison literature. A review of GBRS and their consideration of biodiversity is urgently needed. Globally, urbanisation and infrastructure development have contributed significantly to habitat loss and ecosystem fragmentation, resulting in a significant loss of biodiversity (Grimm et al. 2008). While GBRS like LEED, BREEAM and Green Star have successfully addressed sustainability metrics such as energy and water efficiency, the integration of biodiversity remains understudied.

In this study, a global review of GBRSs is conducted, focusing on how biodiversity is integrated into their approaches. This review is constrained to GBRS from the Global North (The Bradt line) (Sallam and Abdelaal 2016) though we acknowledge the omission of the Global South as a significant gap. Some International schemes are included, as they originate from countries in the Global North. For example, the Living Building Challenge, and BREEAM, both offer international manuals designed for global application. Our primary objective is to understand how biodiversity actions are measured and considered in sustainability schemes that guide the design and construction industry. Our assessment of GBRS involved examining manuals to understand how biodiversity is integrated and to identify key shortcomings and areas for improvement.

2 | Method

Our review consisted of three stages: (1) scoping of the literature, (2) refining and locating relevant GBRS and (3) gathering data from identified manuals. Our review was limited to GBRS with manuals that are publicly available or accessible through an educational institution. This excluded GBRS where access to manuals was restricted to paid registered users or practitioners with a live project. Italy ITACA, The Czech Green Building Council and the Bulgaria Green Building Council are some examples of GBRS manuals not reviewed for this reason. Our study was also limited to the most recent manuals available online; superseded editions of manuals were not reviewed. The analysis of manuals took place within a 5-month time frame (April–June 2023).

3 | Methodological Framework

3.1 | Scoping of the Literature

GBRS were identified from the literature using Google Scholar to identify relevant papers. The search criteria included terms 'green building', 'standard', 'assessment', 'green building rating schemes', 'biodiversity' AND 'green building schemes' and 'rating', as well as specific GBRS titles such as 'BREEAM', 'LEED' and 'DGNB'. This stage focused on abstracts to eliminate papers not directly pertinent to GBRS comparison or biodiversity considerations. Papers were required to be published after the year 2000 and had to directly relate to GBRS, excluding those discussing green building concepts in general. For example, papers discussing green buildings without specifying GBRS were excluded. Compiling a list of GBRS and their comparative literature resulted in a final selection of papers and GBRS for review. Building on the literature review, a database of GBRSs was compiled and GBRS websites were explored to identify additional schemes and manuals. This literature primarily served to scope and locate GBRS; however, the resulting list was not exhaustive. Subsequent investigations expanded the GBRS introduced in the literature. For example, while the peer-reviewed literature identified the Green Building Council New Zealand (NZGBC), additional research on the NZGBC website revealed additional schemes such as Home Fit and Home Star.

3.2 | Refining and Locating Relevant GBRS

Three exclusion criteria determined the inclusion of GBRS manuals in this study. The total number of located GBRS and the number of assessed manuals is provided in Data S1.

Exclusion criteria 1: GBRS are broadly categorised into three areas: Systems, Tools or Standards (Díaz López et al. 2019). Systems are GBRS that assess and certify projects based on multiple sustainability criteria (environmental, economic and social). Tools are more specific in scope, and used to measure and evaluate an aspect of a project's sustainability (Díaz López et al. 2019). Standards are typically guidelines or rules that set requirements for sustainability, for example, the United Kingdom's Zero Carbon Building by the International Living Future Institute (Díaz López et al. 2019). Tools and standards were excluded from the search.

We also removed GBRS from the Global South, primarily due to the limited sample size and different regulatory environments. Global South countries often differ substantially from those in the Global North, making direct comparisons challenging.

Exclusion criteria 2: As defined by the (New Zealand Green Building Council 2005) GBRS are single-issue (such as energy or carbon-focused), multi-issue (only one or two issues, e.g., energy and carbon) or holistic (many different issues, e.g., energy and water and ecology and well-being). For this study, we only considered holistic GBRS. For example, GBRS concentrating solely on aspects like 'carbon reduction', was consequently excluded from the review.

Exclusion criteria 3: Accessibility criteria were established to ensure that the documents under examination were available for further reference and retrieval. While certain schemes like Italy's ITACA and Switzerland's DGNB by Swisss Building Council SGNI were relevant, their inaccessibility to the public excluded them from this study. Some schemes included manuals for two (or more) streams; for instance, UK BREEAM has a foundation route and a comprehensive route, which have different rules to follow. In such cases, each manual was assessed in our analysis.

The total number of GBRS found before exclusion criteria were applied was 144 GBRS (including Global North and South). After removing the global south and applying the three exclusion criteria the final list was 25 GBRS including 65 manuals from Australia, New Zealand, Europe, the United Kingdom, the United States and Canada, as well as international schemes that targeted a global audience.

3.3 | Gathering Data From Identified Manuals

To review the GBRS manuals, we employed a method as outlined in Figure 1. The first step involved determining whether the manuals were available in English. In instances where manuals were not available in English, manuals were translated using Google Translate. Google Translate allows documents up to 300 pages to be translated, hence manuals longer than 300 pages were broken into manageable segments before translating. After translation, manuals were reviewed. Read the translated version with regular consultation with the original text. The translation process can result in some graphics appearing disjointed or fragmented. A step-by-step reading methodology was applied to manuals. First, the contents page was reviewed to gain an overview of the manual's structure. This was followed by reading the introduction, some sections outlining 'How to' guides and glossary of terms pages. Particular attention was paid to terminology related to biodiversity, such as 'land use' and 'ecology', 'biodiversity', 'wildlife', 'birds' and 'ecology.' Particular attention was also paid to how these terms differ across contexts. For instance, in Australia (Green Star). The term Biodiversity was commonly used in reference to these sections, whereas in The United States (LEED), the term habitat anecdotally was more frequent. Or Italy's Green Building Code (Google translated), the term Nature was commonly referred to. We acknowledge that the use of Google Translate exposes the potential for information to be lost in translation. The document sections that feature

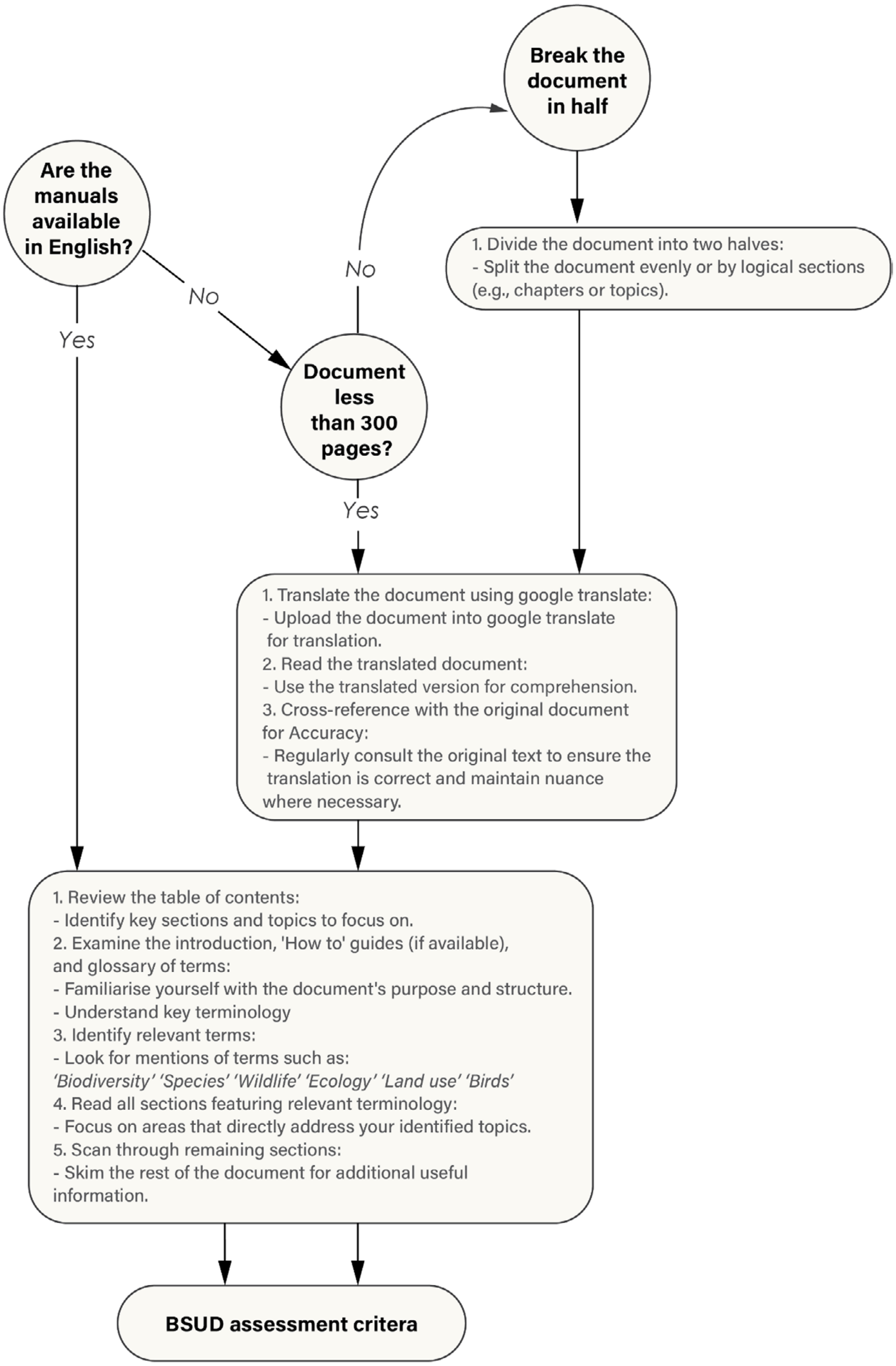

FIGURE 1 | Flow chart highlighting the process of locating and reviewing information in the GBRS manuals.

these keywords are read in detail, while all other sections are scanned for potentially relevant insights. The data collected from GBRS manuals were analysed by a set of defined analysis criteria (Table 1). These criteria serve as the foundation for data collection, evaluation and assessment, most drawing inspiration from the Biodiversity Sensitive Urban Design framework (BSUD: Garrard et al. 2017). The BSUD framework includes five fundamental principles; the provision of habitats, mitigation of threats, promotion of ecological processes, connectivity in the landscape and facilitation of stewardship. The BSUD framework was applied for the analysis of GBRS with a mix of principles and steps (BSUD: Garrard et al. 2017). The framework was designed to generate on-site benefits for biodiversity and is adaptable to diverse urban development scenarios, regardless of type and density. The relevant manuals were read and data was recorded in a spreadsheet.

In addition to our assessment criteria, we calculated the proportion of credits allocated to 'biodiversity' within the overall score of each GBRS manual and compared this to 'energy'—a frequently used and well-studied category (Illankoon et al. 2017; Shan et al. 2018; Varma and Palaniappan 2019). While some schemes explicitly provided the weightings for biodiversity and energy points, others did not. Consequently,

TABLE 1 | Summary and definition of assessment criteria and BSUD framework adapted when reviewing the GBRS manuals.

	Assessment criteria	Definition	Response type	BSUD framework (BSUD: Garrard et al. 2017)
1	Ecological objectives	Ecological objectives are well-defined and clear ecological goals that are returned throughout the design and construction process (Garrard et al. 2017).	A binary response of 'yes' or 'no' indicates whether the GBRS considered the use of ecological objective-setting practices in the rating system. For example, Germany's DGNB—'Biodiversity strategy' states projects must have 'Vision; objectives (short, medium, long term); topics (flora, fauna)'.	BSUD step 2: 'Identify Biodiversity Objectives'—pg. 3
2	Ecological assessment	An ecological assessment evaluates a site's ecological state—surveying flora and fauna, habitats, connectivity and conditions before development (Simmonds et al. 2020)	A binary response of 'yes' or 'no' indicates whether the GBRS considered the use of ecological assessment practices in the rating system. For example, the 'Ecological Value' criteria in the New Zealand Green Building Scheme states that an ecological assessment must be carried out to establish a baseline for the project, consequently rewarding projects for 'targeting low ecological value sites'.	BSUD Step 1: Document Biodiversity Values—pg. 4
3	Criteria to minimise threats	Criteria to minimise threats aim to prevent harmful activities to biodiversity.	Binary response of 'yes' or 'no' indicating whether the GBRS includes criteria to minimise threats to biodiversity in the rating system. For example, light pollution measures minimise negative impacts on the movement of nocturnal species across landscapes at night time (Karan, Saraswat, and Anusha 2023).	BSUD principle 3: 'Minimise threats and anthropogenic disturbances'—pg. 3
4	Human and species interactions	Criteria recognising the importance of post-occupancy, positive interactions, between humans and other species (Garrard et al. 2017).	Binary response of 'yes' or 'no' indicating whether the GBRS includes criteria to foster positive interactions between humans and other species in the rating system. For example, Austria's BREEAM 'New Construction' suggests care packages with information on the management of species living on the site be provided to occupants of houses.	BSUD principle 5: 'Improve potential for positive human–nature interactions'—Pg. 4
5	Connectivity (Intra and Inter)	Ecological connectivity is the movement of species-both within the project site (intra-connectivity) and the larger surrounding natural areas (inter-connectivity) (Taylor et al. 1993; Kirk et al. 2023).	A binary response of 'yes' or 'no' indicates whether the GBRS includes criteria to support ecological connectivity. For example, in Norway's BREEAM-NR GBRS, 'Linear' habitats are specified in 'step 2: calculation of biodiversity' which requires 'the provision of shade, hiding and filtering nesting/sprawling sites, corridors, feeding sites, shelterbelts, growing areas'.	BSUD principle 2: 'Facilitate dispersal'—Pg. 3
6	Specified habitat solutions	Specified habitat solutions are design strategies targeted to provide resources to support species. (Cowan et al. 2021).	A binary response of 'yes' or 'no' indicates whether the GBRS considers habitat solutions. For example, Spain's BREEAM 'Commercial' includes criteria for projects to have habitat boxes at appropriate locations on or near the site such as bird boxes.	'Identify BSUD actions'—pg. 3

(Continues)

TABLE 1 | (Continued)

	Assessment criteria	Definition	Response type	BSUD framework (BSUD: Garrard et al. 2017)
7	Monitoring plan	Monitoring plans specify the methods to evaluate biodiversity improvements over time (Lindenmayer and Likens. 2010).	A binary response of 'yes' or 'no' indicates whether the GBRS includes biodiversity monitoring plans. For example, Spain BREEAM includes the option to develop a 5-year qualitative biodiversity monitoring plan.	'Assessing BSUD'—pg. 5
8	Offsetting	Offsetting practices compensate for on-site biodiversity loss from development by protecting or enhancing similar ecosystems in an offsite location (Ives and Bekessy. 2015).	Multivariable response of 'on-site', 'off-site', 'on and off-site' or 'none of the above'. For example, USA's LEED includes criteria for 'on and off-site' which equally incentivises schemes to take conservation action both on-site and offsite.	Not a recommended approach from BSUD.

our analysis of credit allocation only considered 45 of the 65 manuals reviewed. To assess the relative weight of energy and biodiversity categories, we calculated their value as a percentage of the total 100%. For example, in Austria's BREEAM, New-construction manual, the ecology category is weighted at 13% for non-residential projects and 18.36% for apartment buildings. However, since these weights appear within the same manual, the average of these values was calculated to provide a single representative figure per manual. In other instances, such as Ireland's HPI Technical Manual for new buildings, categories were aggregated where ecology or energy were distributed across multiple categories.

4 | Results

Our analysis included 65 GBRS manuals from across the globe which, in aggregate, captured current approaches for incorporating biodiversity in rating schemes for the built environment. GBRS manuals weighted energy more heavily than biodiversity. On average, energy credits accounted for 20% of the total points available, with some manuals allocating more than double this, while biodiversity accounted for a mean value of 7% (Figure 2). Notably, some manuals did not allocate any points to biodiversity.

When considering the distribution of ecological criteria in GBRS, the overwhelming majority of manuals (85%) did not provide biodiversity objectives (Figure 3). Plans for improving ecological connectivity and facilitating positive human–nature interactions were also poorly represented across GBRS (24% and 27%, respectively). The biodiversity criteria most commonly addressed in the manuals (91%) was minimising threats to biodiversity, indicating that GBRS that considered biodiversity criteria placed emphasis on mitigation tactics. More than half (56%) of GBRS manuals did not include any requirements for an ecological assessment. However, a similar proportion of GBRS

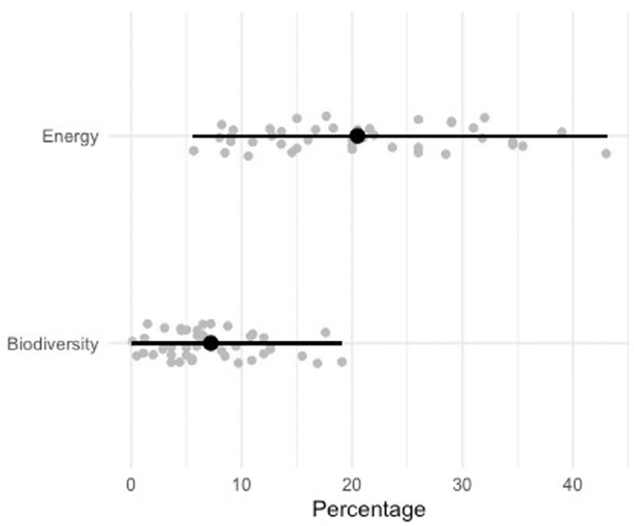

FIGURE 2 | Distribution of credit weightings for Biodiversity and Energy categories in GBRS manuals. Each grey dot represents the proportion of total possible points attributed to these categories in individual GBRS manuals, with the mean values highlighted by the large black points and the black bars represent the ranges of data.

manuals included requirements for specified habitat solutions (55%) and monitoring plans (53%). A small number (3.4%) of GBRS included offsetting.

4.1 | Ecological Objectives

Among the regions assessed, international GBRS manuals were the most likely to include ecological objectives, with 33% adherence, followed closely by the United Kingdom at 30% and Australia at 25% (Figure 4). Manuals for schemes in the United States, Canada and Europe tended not to specifically address or require articulated ecological objectives. Germany's DGNB required projects to include objectives for the site (short, medium and long term), specifying the need to consider both flora and fauna and a strong consideration of the local biodiversity of the site and surrounds in their Districts manual (2020) (DGNB 2007).

4.2 | Ecological Assessment

The United Kingdom led in this category, with 67% of GBRS manuals including a specification for an ecological assessment. Australia followed at 50%, with European and International schemes at 48% and 33%, respectively. The United States lagged behind with just 11% of manuals considering ecological assessment. The Netherlands BREEAM included a mandatory requirement for a 'Nature Report', which must be conducted by a certified ecologist, outlining the ecological value of the

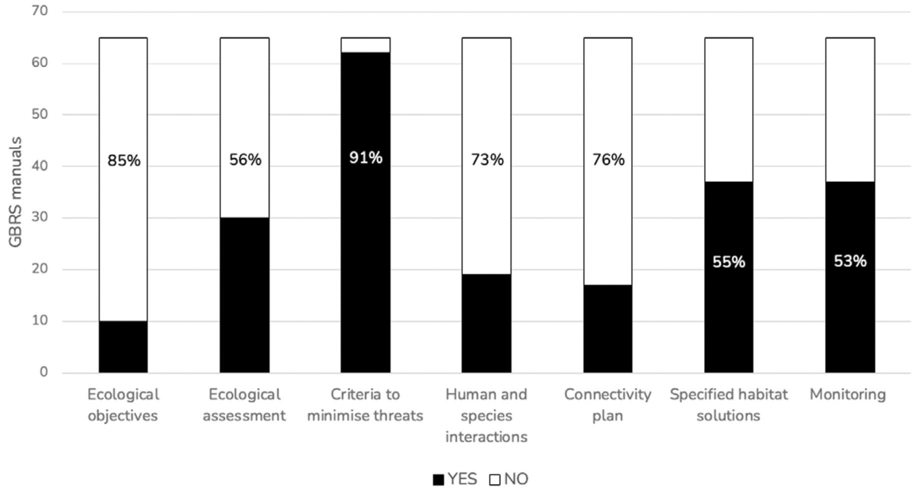

FIGURE 3 | The number and proportion of manuals that met ('yes', black) and did not meet ('no', white) assessed biodiversity criteria. Total number of manuals reviewed is 65. For each bar, the percentage is provided for the higher proportion.

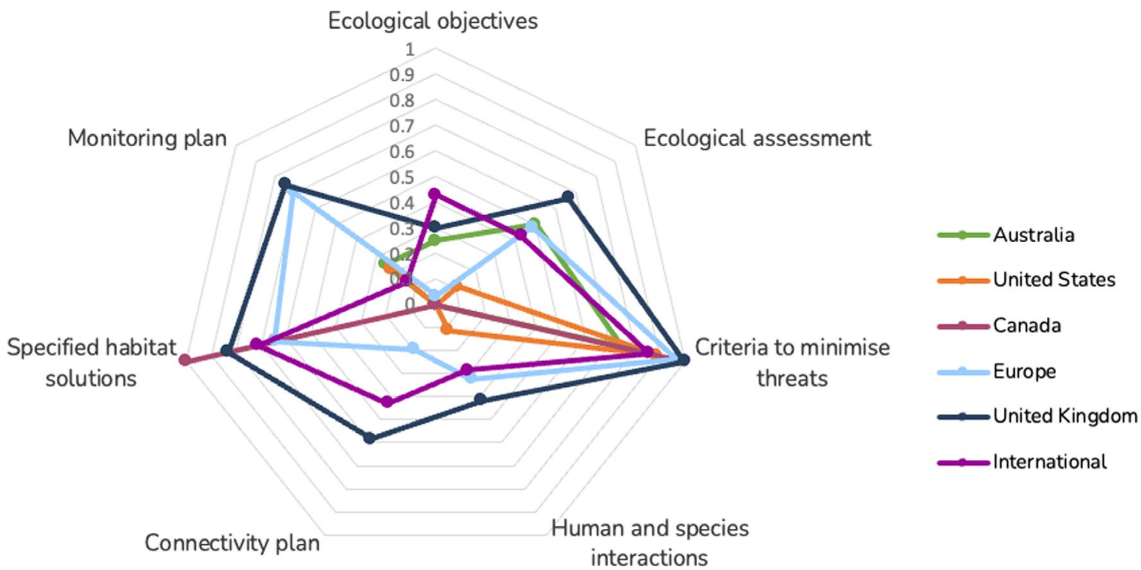

FIGURE 4 | The performance of GBRS from Australia, the United States, Europe, the United Kingdom and International schemes in addressing ecological criteria (as defined in Table 1). The axes represent different ecological criteria, with scores ranging from 0 to 1. A score of 1 indicates that all GBRS in that region addressed that criteria, while a score of 0.5 indicates that half of the GBRS in that region addressed that criteria. For instance, in the United Kingdom, all schemes ($n = 12$) reviewed included criteria to minimise threats. Conversely, in the United States, none of the GBRS reviewed require specification of ecological objectives. See numbers in Data S2.

site (flora and fauna) including any protected species or elements that may not be disturbed during the construction process (Building Research Establishment, Environmental Assessment, Methodology, and BREEAM 1990). The United Kingdom and Australia show higher inclusion rates of ecological assessments compared with the United States. This regional difference may impact the global uniformity and effectiveness of biodiversity considerations.

4.3 | Minimising Threats

Overall, this was the best-performing criterion (Figure 4). Exactly 100% of GBRS manuals from Canada and the United Kingdom met this criteria. Europe scored closely behind with a 97% adherence to criteria, while the United States and International GBRS reported 89% and 67%, respectively. Australia reported a 75% adherence rate. For example, the United States GBRS, Green Globes, placed an emphasis on reducing bird collisions. While such measures are commendable, a deeper dive into the GBRS manuals revealed guidelines that actively discourage birds from roosting on ledges, by providing criteria that specify keeping mullions and ledges < 1 inch (2.5 cm) deep. This example revealed conflicting objectives in schemes' capacity to both mitigate impacts and actively enhance ecological or 'nature positive' aspects.

4.4 | Improving Human and Species Interactions

Exactly 42% of GBRS manuals in the United Kingdom recognise the importance of encouraging positive human–species interactions. Manuals in Europe followed at 32%, while International GBRSs recorded a 22% adherence rate. Schemes such as in Denmark's DGNB, 'ensure a mutually beneficial interaction through the right care and mediation' by the inclusion of signage, fact sheets and information on care' in their Sustainability manual (2020) (DGNB 2007). In High-Quality Mark (HQM), UK residents are required to receive information on the long-term ecological management plan. LEED in The United States have an optional credit: 'Protect or Restore Habitat and also includes elements of human interaction' in their manual for Building Design and Construction (2019) (Leadership in Energy and and Environmental Design 2000).

4.5 | Connectivity Plan

Schemes within the United Kingdom were the most inclusive of connectivity criteria (58%) followed by international schemes (33%) and European schemes (19%). Germany's DGNB included ecological connectivity in their schemes by considering first how well the project is situated in terms of ecological connectivity ('interlinked with its surroundings'). If the project was considered to be an important element of a wider corridor, the project must incorporate 'steppingstone biotopes' New Construction manual (2020) (DGNB 2007). It is noted that even if a project is not a vital linkage in a wider system, projects still must articulate effort in improving broken or disturbed linkages—for example, if the site is near a busy and congested road, a 'frog tunnel' could be employed, if this is suited to the site. United Kingdom's BREEAM, offered clear guidance on determining the 'zone of influence' of the project site, including surrounding areas of conservation significance. Some GBRS made smaller inclusions of connectivity, such as Norway's Green Building Council (GBC) which refers to 'linear' habitats in their methodology for calculating biodiversity risk and opportunities.

4.6 | Specified Habitat Solutions

One-hundred percent of Canada's GBRS manuals included criteria specifying habitat solutions, followed closely by the United Kingdom with 83%, Europe with 65% and International schemes with 56%. Neither Australia nor the United States reported this criterion in their GBRS. BREEAM International exhibited this criterion by stating 'the masterplan enhances ecological value throughout the creation of appropriate new habitats or increase in the scale of existing habitats on-site' Communities manual (2012) (Building Research Establishment, Environmental Assessment, Methodology, and BREEAM 1990).

4.7 | Monitoring

Exactly 53% of GBRS manuals include a qualitative monitoring agreement (Figure 3). For example, High Quality Environment (HQE) in France, stipulated a maintenance program for landscapers or groundkeepers of the site—this was discussed in relation to keeping up appearances of the landscape design but without reference to ecological aspects. An example of a scheme that accepted qualitative monitoring of biodiversity is Italy's Green Building Council, stating that 'The plan must include biological objectives consistent with habitat and/or water resource conservation' Neighborhoods manual (LEED Italia, n.d.). Regionally, manuals in Europe had 71% qualitative monitoring plans, and the United Kingdom had 75%. Australia and the United States followed at 25% and 22%, respectively.

5 | Discussion

Through a global analysis of GBRS, our study identified strengths and critical areas for improvement with respect to the inclusion of biodiversity criteria. This is the first review that we know of relating to the consideration of biodiversity within such schemes. Our findings lead to three key recommendations: shifting from mitigation-focused strategies to nature-positive approaches, creating and implementing evidenced-based monitoring plans, and increasing the representation of biodiversity categories within GBRSs.

While it is promising that the vast majority of GBRS reviewed required threats to biodiversity to be minimised, a nature-positive agenda requires a shift from mitigation of biodiversity impacts toward strategies that yield a net benefit for nature (Maron et al. 2024; Milner-Gulland 2022). A discernible gap remains in GBRS' capacity to promote tailored biodiversity improvement strategies, which will require formal ecological assessment, the setting of clear biodiversity objectives and strategic planning to facilitate key ecological processes such as dispersal and monitoring programs to assess outcomes. We recommend the incorporation of flexible, context-specific criteria rather than adopting a one-size-fits-all approach. DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) in Germany includes criteria to address all critical life stages for species such as breeding/rearing, food/sleeping place, hibernation and courtship/mating phases as per the Animal- Aided Design method (Weisser and Hauck 2017). These criteria support existing species on-site and enhance biodiversity within or near the project; 'If animals become part of the draft design in this way, they not only inspire the design but also make it better' in their renovation of buildings manual (2022) (DGNB 2007). This case study from Melbourne, Australia provides an example of the application of nature-positive strategies. The project applied BSUD principles to an urban renewal initiative, demonstrating how such strategies can enhance biodiversity on a site with very little ecological value to start with (Kirk et al. 2021). Connectivity analyses for the Growling Grass Frog and Superb Fairy-wren revealed that the BSUD approach improved animal connectivity across the landscape (Kirk et al. 2021).

GBRS should ensure an ecologist is involved from the early design stages through to post-occupancy monitoring. Unfortunately, some GBRS apply options to opt out of an ecologist's opinion entirely. For example, projects in the United Kingdom, HQM are placed in two categories. Route 1 does not need an ecologist beyond deeming whether the site is of ecological insignificance, whereas Route 2 necessitates specialist advice as the site is deemed sensitive or complex (HQM. 2015). Recognising the ecological value of small land patches, as shown by Robinson and Lundholm (2012) and Wintle et al. (2018), can ensure even small sites contribute to biodiversity conservation. We found that some GBRS apply generic rule sets that categorise or rule out projects from considering biodiversity, based on non-ecological site conditions. For example, US Green Globes allow exemptions for ecology categories if a project occupies at least 80% of the site, allowing projects to bypass biodiversity considerations altogether. We recommend transforming these exemptions into incentives, similar to developers receiving height or density bonuses for delivering community or social housing (State Environmental Planning Policy (Housing) [NSW Government 2021], 2023).

GBRS are essential for advancing best practices in sustainability by continuously setting higher standards. However, these schemes are not solely responsible for driving change; policy and regulatory frameworks significantly shape GBRS criteria and direction. For example, international agreements like the UN Biodiversity Conference (COP15) Kunming-Montreal Global Biodiversity Framework inform sustainability standards, as seen in their influence on the recent Green Star report Nature Roadmap 2.0, which will likely impact updates to Green Star manuals (Convention on Biological Diversity 2022; Green Building Council of Australia 2023). Governments also incentivise sustainable building practices, for example, all government or social housing in Victoria, Australia is mandated to meet a minimum 5-star Green Star certification (Victoria, 2024). Industry bodies like the Property Council of Australia and the Green Building Council of Australia further support these efforts by advocating for 'sustainability-driven density bonuses' to encourage the development of high-performing green buildings (Every Building Counts, 2023). GBRS and policy therefore work in tandem to push improvements to sustainability practices.

We identified a moderate amount of GBRS including monitoring plans (71%). Monitoring plans are vital to the long-term success of biodiversity conservation efforts and ensure ecological benefits are sustained over time. (Lindenmayer and Likens 2010) highlight key components that make for a successful monitoring plan, including the frequency of the data collected from the site. Anecdotal evidence suggests that this approach is uncommon, with the majority of GBRS reviewed following a plan-only approach; allowing for projects to commit to a written agreement without quantitative evaluation informing decisions or maintaining standards. This issue is commonly referred to as the 'performance gap', a term coined to bring attention to the lack of incentive to maintain the high benchmarks set during green certification (Menezes et al. 2012; Zhou et al. 2022). The recommended monitoring approach follows a time-stamped, incentivised and evidence-based approach. The Living Building Challenge demonstrates this approach, in which accreditation is acquired 12 months after building occupancy. Such an approach ensures a level of adaptability and accountability.

We recommend increasing the information provided to future residents and the broader public about the biodiversity values of the sites and designing 'cues to care' (Nassauer 1998) to encourage positive engagement. Despite the benefits of people engaging positively with nature being strongly linked to well-being and health benefits (Cox et al. 2017), fostering positive human–nature interactions is an overlooked criterion in GBRS. The 'cues to care' concept recognised that the individual is crucial to maintain and nurture the land after it has been designed and constructed. The French HQM scheme provides an information package to residents about the biodiversity found on the site, along with measures to preserve its ecological value (HQM., 2015). We recommend GBRS address this key missing piece in manuals, enabling end users of the site to understand the land they live on and learn ways to be sensitive to its ecosystem.

A further recommendation is to exclude biodiversity offsetting. A small number of GBRS included offsetting (3.4%). Offsetting aims to counteract the damage caused by development by creating or restoring habitats elsewhere (Maron et al. 2015). While theoretically, this exchange appears promising, the unique complexity of biodiversity includes place-based values, making biodiversity a very difficult commodity to trade (Ives and Bekessy 2015) The ecological outcomes of offsetting policies have, to date, been very poor (Zu Ermgassen et al. 2019). Biodiversity 'onsetting' has been suggested as an alternative, whereby the focus shifts to achieving on-site net gain for biodiversity, which is likely to be easier to monitor and evaluate (Bekessy et al., in review). We acknowledge that 'onsetting' is challenging; however, evidence shows that offsetting is largely unsuccessful in enhancing biodiversity (Bekessy et al., in review). The changes required to implement onsetting would, for example, mean that developing on sites with significant ecological value would no longer be viable. Instead, development would need to be directed toward areas that have already undergone substantial modification of their natural values.

Compared with other categories, we found a disproportionately small proportion of credits in GBRS allocated to biodiversity; significantly less than those allocated to energy categories. Responding to the global biodiversity crisis will require a much stronger emphasis on biodiversity in the design and construction sector, driving meaningful nature-positive outcomes (Irwine and Geschke., 2023). Currently, there are substantial gains to be had for projects that take on energy categories, as a large number of points incentivise action. We do not recommend changing this but rather call for increasing the allocation of biodiversity categories. There are already enticing performance-based monetary benefits for projects to use more sustainable energy approaches. Energy and biodiversity are not mutually exclusive—there will be win–wins; green roofs and walls deliver significant energy reductions and can also be designed to provide biodiversity benefits (Madre et al. 2015; Raji, Tenpierik, and van den Dobbelsteen 2015).

We aimed to review the most widely adopted GBRS and provide strong global representation, however, we acknowledge that we have not covered all GBRS available. Some manuals were not accessible for various reasons (access issues such as behind a paywall or not relevant scope). It is recommended that a more exhaustive review in the future to eliminate some of these omissions. GBRS are frequently updated and revised. The study therefore is limited to the manuals that were available at the time of review, meaning the findings may become quickly outdated as new versions inevitably come along. Additionally, the lack of representation from the Global South is recognised as a significant gap (Kahn et al., 2022), particularly given the high biodiversity value of regions such as the Amazon rainforest and the Congo Basin (Guayasamin et al. 2024) The omission of these regions limits the global applicability of our findings, as GBRS designed for the Global North do not account for the unique ecological and socio-economic challenges present in the Global South. We recommend that future reviews focus on integrating GBRS from these areas to provide a more comprehensive understanding of global biodiversity strategies.

The implications of this study are significant in raising awareness of biodiversity criteria in GBRS. This increased attention can help the built environment industry recognise the importance of integrating biodiversity into GBRS, and provide a pathway for them to contribute to a nature-positive future. The review also showcases best practices from manuals that have incorporated biodiversity considerations well, offering valuable examples for others to follow in their projects. Additionally, the study highlights how different regions are at varying stages of incorporating biodiversity objectives into GBRS, indicating that biodiversity remains a globally underrepresented area in GBRS. The novel insights gained from this study are timely, given the growing awareness of the importance of biodiversity in urban development and nature-positive approaches more generally. This review provides a current and relevant assessment of the key areas where biodiversity is becoming more prominent in GBRS.

Monitoring will be critical for realising the potential of GBRSs for biodiversity. Future research that focuses on tracking the long-term biodiversity outcomes of a real building project from concept to completion will provide valuable insights into how green building practices impact biodiversity over time. In the field of energy efficiency, monitoring case studies have helped refine assessment criteria by observing real-world applications and improvements, offering a model for biodiversity-focused research (Rastogi et al. 2017). Another potential avenue for research could involve analysing projects that have achieved high ratings from GBRS to assess how effectively they have integrated biodiversity considerations. Since GBRS are frequently updated, future studies could build on the analysis conducted in this study to compare how biodiversity criteria evolve over time, helping to identify improvements or gaps in future updates. Furthermore, the omission of the Global South from this study presents a potential avenue for future research.

Green building rating systems hold a pivotal role in driving the design and construction industry toward a more sustainable future. In our global review of GBRS, we found varying approaches to integrating ecological considerations into the building process. Whilst we found there to be a major, and commendable focus on minimising threats or harm to biodiversity, a shift from mitigation to positive gain is necessary to reverse the trajectory of biodiversity loss and achieve the nature-positive goals of the Global Biodiversity Framework. Through our review, we established that GBRS must incorporate biodiversity more substantially and explicitly, rewarding efforts that are regenerative for biodiversity as well as those that minimise impacts. We hope that our critical review and reflection will result in more substantive and nuanced treatments of biodiversity within GBRS in the future.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.