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DATA ARTICLE

GIbase1.0: A database of green infrastructure plant species in England and Scotland

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Abstract

1. The contributions of constructed Green Infrastructure (GI) to biodiversity are often used to justify urban development projects, yet in many cases these contributions have been difficult to quantify.
2. As a result, a wide range of GI features are designed and implemented, often without knowledge of whether these features contribute meaningfully to biodiversity or if there are biosecurity risks presented by their design or procurement. Our understanding of design practices could be significantly improved if researchers and policymakers were able to draw upon a data resource that recorded the specifications used in development projects and facilitated easy access to them.
3. In the United Kingdom, planning Portals act as substantial and untapped repositories of grey literature, containing highly detailed data with a diverse spatial coverage, recording the diversity and extent of existing habitats and specifications for proposed species assemblages. However, they are difficult to navigate or query, making it challenging to use these resources to gain macro-level insights from the data held within the portals.
4. In this paper, we present GIbase 1.0, a new dataset that incorporates plant specifications from development projects across England and Scotland along with trait data associated with each species.
5. To demonstrate the utility of the dataset, in a separate exercise we tested whether these data could be used to inform policymakers and researchers about current procurement and planting practices. To this end, we assessed the proposed GI features that are submitted by developers to local planning authorities as part of the planning process and then carried out fieldwork to record the extent to which these specifications were delivered. The findings from this work are published separately (Karlsdottir et al., 2021).

KEYWORDS
biosecurity, Green Infrastructure, habitat creation, land-use change, landscape design, landscape planning, plant procurement

1 | INTRODUCTION

There are numerous, well-recognized threats to UK habitats, including urbanization (United Nations, 2016; Watkins et al., 2020), climate change (Burley et al., 2019; S. Roy et al., 2012) and biosecurity (Kemp et al., 2021; van Kleunen et al., 2018). Constructed Green Infrastructure (GI) is accepted as a means of minimizing, mitigating and adapting to these threats. To facilitate and measure GI delivery, targets are articulated in government policy (HMG, 2019) with schemes to assess GI benefits and efficacy (Building with Nature, 2020; Chudley & Greeno, 2020) and a growing body of guidance to inform best practice (Hirons & Sjöman, 2018). In this paper, we present a new dataset that contains information about the location, type and features of GI featured in development projects across England and Scotland, providing researchers and policymakers with a resource that can be queried and used to inform landscape management and future research.

GI features are typically created by developers as part of urban and peri-urban construction projects (e.g. for housing or infrastructure) with oversight from local planning authorities (LPAs) through the planning system. However, there is currently no easy way for researchers or policymakers to understand either the site-specific characteristics of particular GI projects or the cumulative impacts of these projects, making it difficult to develop effective policies or establish appropriate targets. Particularly pressing questions include (a) what effect guidance or policy targets are having on current GI practice, (b) what plants are being used to create GI features or in turn, (c) what risks UK landscapes are exposed to through the procurement routes for these plants, (d) the fitness of plants used in GI to their planting sites or (e)the extent or resilience of the ecosystem services that they are expected to provide.

Numerous initiatives and research exercises are being undertaken to try to address some aspects of these questions (Karlsdottir et al., 2021; Mills et al., 2011) but building a regional or national picture of trends and practice is proving difficult, principally due to the complexity of the development industry (Awwad et al., 2020). However, the professionals working in this industry (e.g. landscape architects, contractors, planners, developer clients) have for a long time been difficult to engage with (Watkins & Brace, 2018), a situation which may be exacerbated by the number of stakeholder engagement exercises being conducted in the recent past, leading to stakeholder fatigue. To assist with the challenges presented by this situation, we created GIbase using data derived from planning portals across England and Scotland.

The development industry in England and Scotland relies on complex design, procurement and management systems which are often subject to changing commercial objectives and team composition. Common to almost all projects, however, is a requirement for planning permission to be granted by the LPA before construction can begin; in order for planning permission to be granted, a developer is required to submit detailed design information about their project, detailing the types, quantities and design of materials that will be used in the project in a way that complies with the objectives of the LPA. As such, the details of every significant development project are handled by LPAs and access to these details is provided by planning portals which can be accessed by the public.

The GIbase dataset provides details about the plants specified by developers (or more commonly, their agents) in GI features, including a wide range of habitats such as street trees, buffer plantings, swales, herbaceous beds and meadows. The dataset allows users to summarize the quantity and diversity of species used, the formats in which they are specified, the types of projects that they are used in and the location of the projects. Building on the recommendation made in a recent meta-analysis of GI (Filazzola et al., 2019), we also include functional trait assessments of the plants so that the contributions of GI to nature could be better quantified. Users should note, however, that the dataset does not record whether or not the plants were actually planted and to identify the extent to which this may or may not present issues, we carried out fieldwork on a subset of the sites identified in this research and present the findings of this fieldwork here.

2 | METHODS AND MATERIALS

A pilot study was carried out to develop the methodology and identify potential challenges in the assembly and quality of the data that could be gathered (McLinden et al., 2019). In this pilot study, keyword searches of the Sheffield City Council and Birmingham City Council planning portals were carried out to identify projects with a landscaping component. Searches were conducted using the terms 'soft landscape', 'landscape', 'general arrangement', 'layout plan' and 'green infrastructure'. Planning applications returned by the search that met these criteria were recorded. Projects were coded according to development objective (e.g. housing, education, infrastructure) and those that had been approved within the previous 5 years (i.e. 2014–2019 inclusive) were selected for inclusion within the study and checked to ensure that the detailed soft landscape specifications were held in the planning portal data repository. To extend the scope of planning applications returned by this search, projects known from personal knowledge of these areas were also searched in the planning portals and filtered in the same way. In total, 22 sites met these criteria and the planting specifications for all projects were entered in the database, recording the plant species, quantity, plant type, project type and project location. To assess the extent to which soft landscape specifications were implemented accurately, 14 projects were randomly selected for field-based validation. Six publicly accessible quadrats measuring 2×2 m were identified at each site prior to the fieldwork. These quadrats were studied in July 2019, comparing the plant specifications in the approved drawings with the plants that could be observed on the ground. Six criteria were evaluated when studying the quadrats: (i) whether the planting area had been created, (ii) whether the planting area was the correct size, (iii) whether the plant forms (e.g. tree, shrub, herbaceous plant) matched the original specification, (iv) the percentage of correct species, according to the original specification, (v) the percentage of ground with weed establishment and (vi) the missing species (according to the specification) and their replacement.

Assessment of the pilot study revealed a number of issues both with the study design and also the apparent practice of GI, principally that the scope of the study would need to be extended across a wide spatial extent, the number of matches returned by the keyword search was too constrained to return a wide range of results and that the range of project types included within the study would need to be refined. To address these issues, we revised the search methodology to include LPAs across England and Scotland and complemented the keyword search by randomly selecting 30 landscape architecture practices from the 'LI Member Directory' resource hosted by the Landscape Institute (https://my.landscapeinstitute.org/directory), then randomly selecting up to three projects advertised that met the criteria above by each practice on their own websites. Using the same filtering process, we recorded a total of 81 sites across England and Scotland (including those from the pilot study) and transcribed the plant specifications in each project.

In a separate exercise, we extended the fieldwork that was carried out in the pilot study. Eighteen sites in Scotland were selected, making a total of 32 sites from the database that were validated through the fieldwork (i.e. 14 sites from Sheffield and Birmingham, and 18 from across Scotland; Figure 1). To protect the identity of the developers at the sites selected for fieldwork, the results of the fieldwork are not included within the dataset, although the results are published separately (Karlsdottir et al., 2021).

Addressing the recommendation of Filazzola et al (2019), we used the TRY database (Kattge et al., 2020), to derive leaf economic data for all species in GIbase and ordinated species within competitor, stress-tolerator, ruderal space (CSR is a widely used theory for classifying plant functional strategies) using the StrateFy methodology developed by Pierce et al. (2017) for as many species as possible (Figure 2). The StrateFy tool describes variation in plant size and conservative versus acquisitive resource economics, calculating the C, S and R strategies of species based on easy-to-gather leaf traits, and was used on the basis that has been validated through replicated studies, allowing rapid ordination within the CSR scheme (Li & Shipley, 2017). To further explore the issue of species diversity, Simpson's index of diversity was calculated for each type of planting. Finally, to understand the potential to increase invasion debt within UK habitats, the list of species was checked against the Wildlife and Countryside Act (1981), the List of Invasive Alien Species of Union Concern (Regulation (EU) 1143/2014) and two horizon scanning research exercises (H. E. Roy et al., 2014, 2019).

2.1 | Usage notes

Users should note that the CSR ordinations in the dataset are derived from mean values for traits held in a large database that was not assembled for this purpose. These ordinations are therefore based on data that were gathered from both fieldwork and common garden experiments across a range of stages of maturity and using a range of trait data collection techniques. As a result, precise ordinations for species within UK climates may vary from those shown.

The GIbase dataset can be used in a number of ways. For example, landscape architects, horticulture nurseries or planners may wish to make use of the dataset to identify functional characteristics of the plants that they intend to specify, or as a resource to identify trends in either taxonomic or functional diversity according to landscape character, project type or spatial location. Researchers may wish to use the dataset to contextualize existing research initiatives, initiate new research projects based on hypotheses that emerge from preliminary investigations of the dataset or in education and outreach programmes. Policymakers, environmental accreditation schemes and industry bodies may find the dataset useful when developing GI targets or reviewing current practices.

2.2 | General patterns

Reviewing the species in the dataset reveals a number of important findings. Firstly, the diversity of species specified in GI projects by developers is relatively narrow, with a small number of species accounting for a significant proportion of the overall number of plants (Table 1). Secondly, the types of planting specified by developers appear to fall into two categories: those that are intended for biodiversity benefit, and those that are intended for ornamental purposes. This is a seemingly minor point, but the results of the assessment of Simpson's index of diversity (Figure 3) reveal that the consequences of these design decisions do not necessarily lead to consistently or significantly greater species diversity in 'biodiversity' planting schemes.

Assessing the diversity of plants from a functional perspective indicated that species tend to be clustered around the C/S area, suggesting that the habitats designed for GI projects may be dominated by slower growing plants. Whilst this is likely to confer a degree of tolerance of the stresses commonly found in urban environments, it is also likely that these habitats will be vulnerable to invasion by more competitive or ruderal plants. This finding is exacerbated by a summary of the diversity of plants shown in Table 1, which illustrates the narrow range of species that account for a significant proportion of plants specified in new projects. Checking the dataset against the current legislation and the horizon scans, approximately 57% of sites were found to include species that are regarded as either invasive or potentially invasive, such as *Euonymus fortunei* and *Crocosmia* × *crocosmiflora* which were the most frequently specified, occurring at 29% and 10% of sites, respectively.

It does not appear that plant species selection varies meaningfully in response to either location, project type, or landscape character. Further research will be needed to identify the extent to which statutory guidance such as Landscape Character Assessments is being used to inform detailed design. A preliminary assessment of the patterns of species specification revealed biases in the way that species are selected: Silver birch (*Betula pendula*), for example, was specified five times more frequently than the closely related downy birch

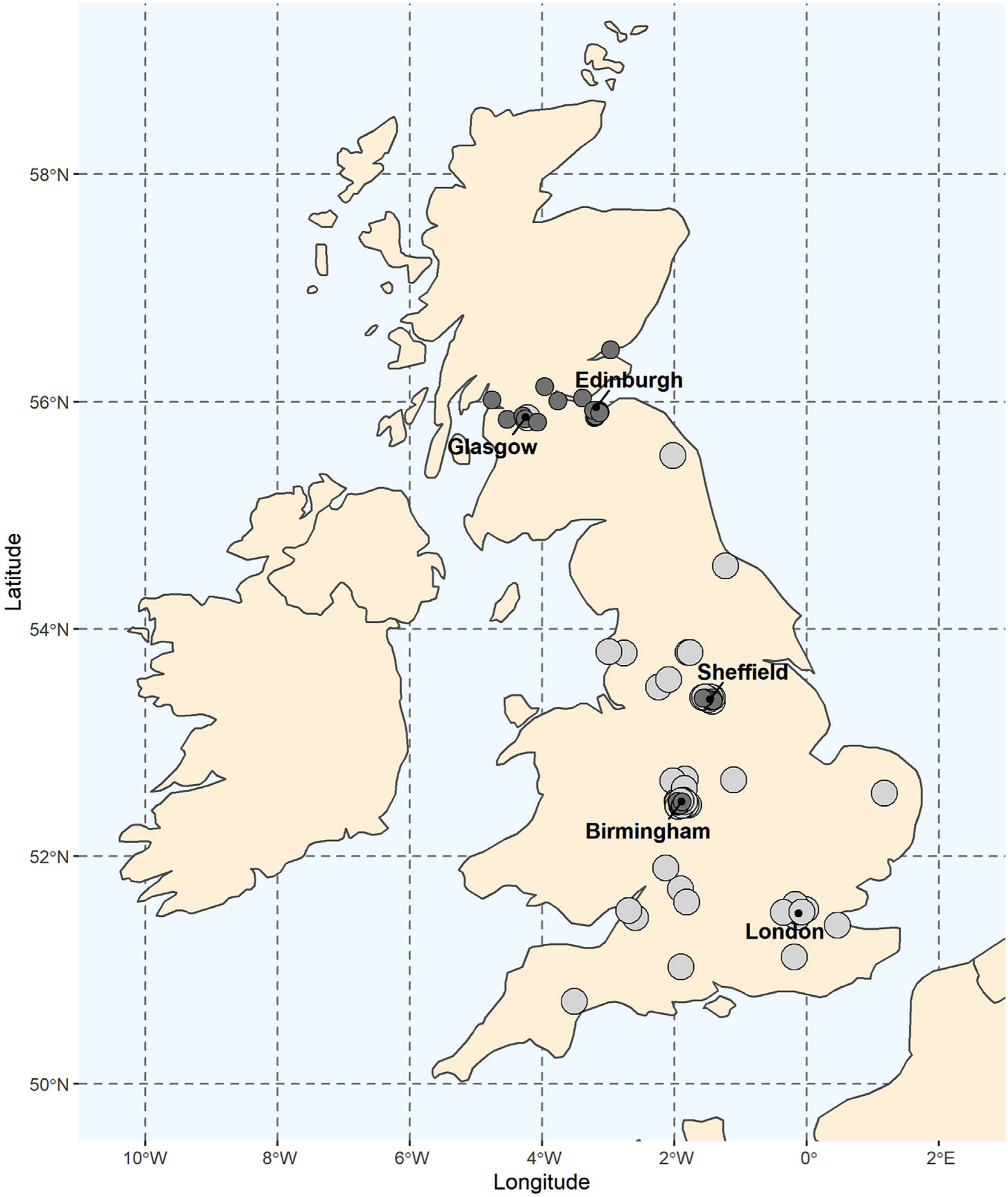

FIGURE 1 The location of 81 study sites in England and Scotland (sites where fieldwork was carried out are shown in dark grey)

(*Betula pubescens*). It is not clear what informs these decisions, but it is possible that commercial factors such as cost or availability, or behavioural factors such as familiarity or habit, may be driving species selection more than site characteristics. Further research is required to understand these dynamics.

Fieldwork results reported in Karlsdottir et al. (2021) found that it was relatively rare for specifications to be delivered exactly as approved: only 27% of samples studied ($N = 117$) had exactly the right species in a planting area that was the right size. Fifty percent of sample planting areas were the correct size but included species that had been

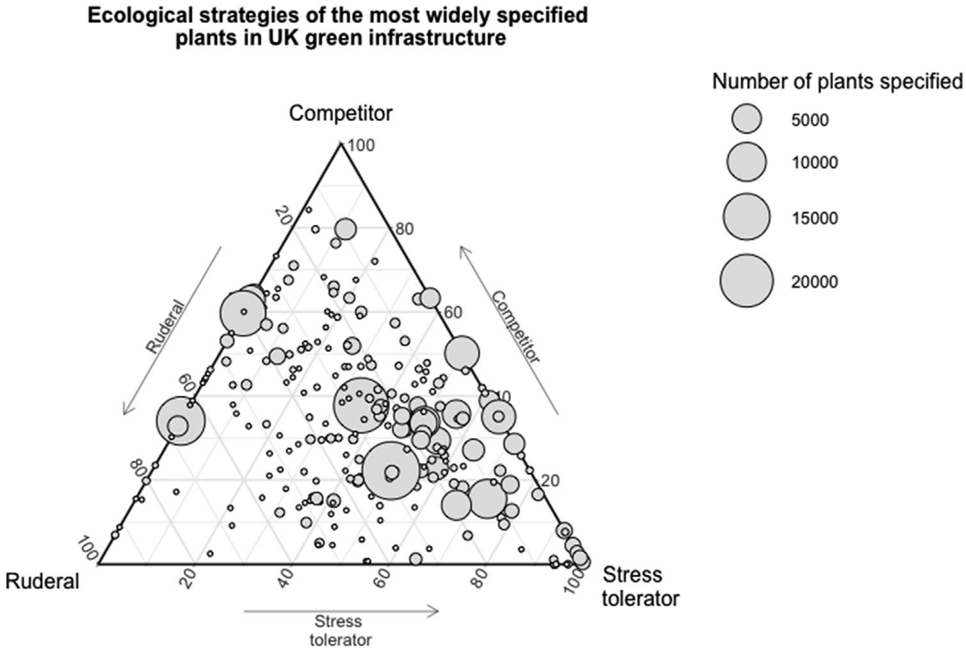

FIGURE 2 The species diversity of plants used in GI schemes in England and Scotland

TABLE 1 The most frequently specified plants in England and Scotland

Shrub and herbaceous planting		Hedges		Trees	
Species	**%**	**Species**	**%**	**Species**	**%**
Pachysandra terminalis	2.79	*Carpinus betulus*	32.84	*Fagus sylvatica*	21.95
Lavandula angustifolia 'Hidcote'	2.54	*Fagus sylvatica*	16.55	*Crataegus monogyna*	10.78
Sarcococca confusa	2.45	*Ilex aquifolium*	9.01	*Betula pendula*	9.24
Prunus laurocerasus 'Otto Luyken'	2.27	*Prunus spinosa*	7.45	*Corylus avellana*	8.98
Mahonia aquifolium	2.16	*Crataegus monogyna*	6.25	*Carpinus betulus*	6.22
Cornus sanguinea 'Midwinter FIre'	1.77	*Photinia x fraseri* 'Red Robin'	3.23	*Sorbus aucuparia*	4.17
Hedera helix	1.4	*Acer campestre*	3.21	*Alnus glutinosa*	4.05
Hakonechloa macra 'Alboaurea'	1.2	*Fagus sylvatica* 'Atropurpurea Group'	2.47	*Ilex aquifolium*	3.6
Liriope muscari 'Monroe White'	1.16	*Escallonia* 'CF Ball'	2.34	*Quercus petraea*	3.17
Viburnum tinus 'Eve Price'	1.09	*Rosa canina*	1.75	*Prunus avium*	2.82

substituted for those approved by the LPA, whilst 24% of the sample areas were not created in the first place. The results of this fieldwork suggest that there is a considerable cognitive bias in the delivery of GI against the plans that are approved through the planning process, meriting further research and policy consideration.

GIbase 1.0 presents a snapshot of the green infrastructure that is delivered through development projects and is possibly the first attempt to collate projects across England and Scotland so that landscape- and national-scale trends can be identified. Our intention is to add to the dataset over time, recording further projects so that increasingly robust assessments can be made and used to inform national policy development and future research initiatives.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHORS' CONTRIBUTIONS

The study was designed by HW, AM, SOH, MM, BK and CP. Data were collected by HW, AM, SOH, MM, BK and CP, and were transcribed by HW and EL. All authors contributed to the writing of the paper.

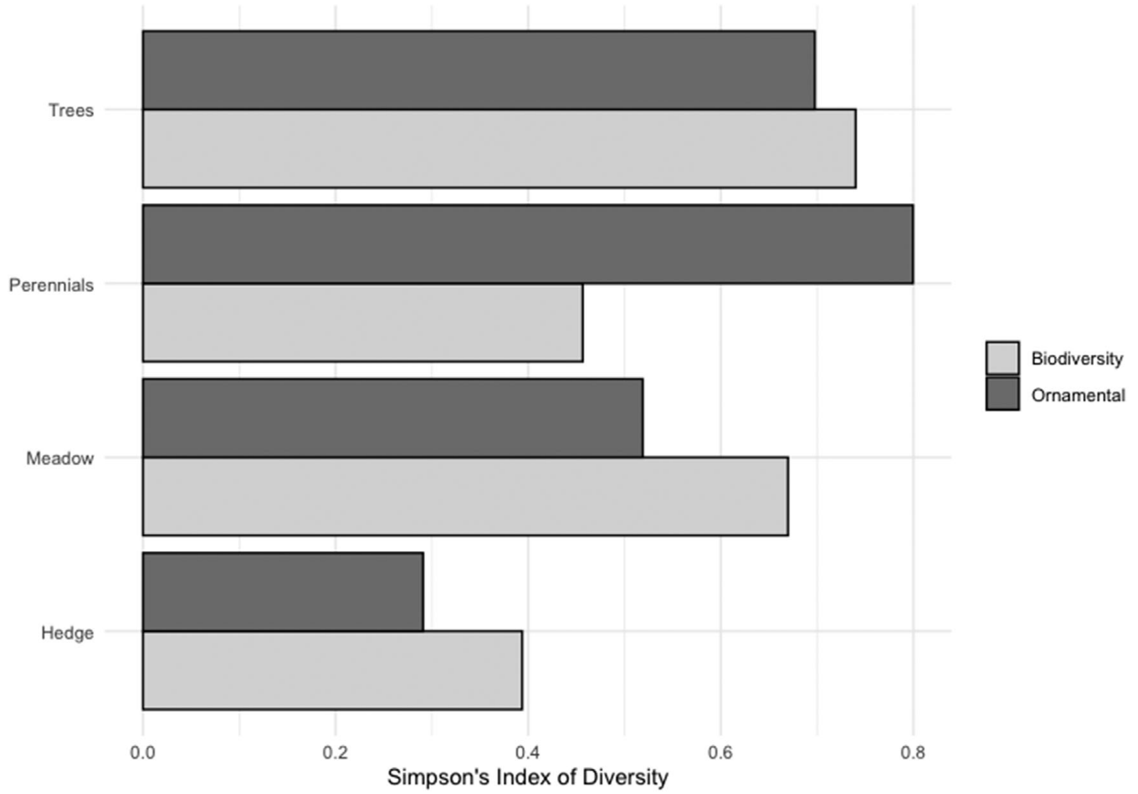

FIGURE 3 The difference in diversity between different types of green infrastructure planting in England and Scotland

DATA AVAILABILITY STATEMENT

The GIbase dataset is available on the Dryad data repository: https://doi.org/10.5061/dryad.0gb5mkm23 (Watkins, 2021). Future revisions will increase the scope and coverage of the dataset.

PEER REVIEW

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