The multiple benefits delivered by hedgerows: Where is the evidence and does it meet current knowledge needs?

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RESEARCH ARTICLE

The multiple benefits delivered by hedgerows: Where is the evidence and does it meet current knowledge needs?

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Abstract

1. Hedges and hedgerows are a familiar feature in many global landscapes and can support a wide range of benefits. These range from environmental to societal, including habitat for wildlife, provision of pollination and pest control services, shade and shelter for crops and livestock, and heritage and aesthetic benefits connecting people to nature in rural and urban areas.
2. This study sought to explore perspectives on hedgerow benefits and research priorities. It also explored the knowledge needs of a range of stakeholders involved with planting, maintaining, educating and developing policy in relation to hedges and hedgerows. Stakeholders' needs were investigated through a series of workshops and surveys; they were compared with the findings from a systematic review of the literature to understand whether sufficient research and guidance is currently available.
3. Stakeholders valued the benefits hedges and hedgerows provided to wildlife, nature-based services, such as provision of pollination and pest control, climate change mitigation and adaptation, and flooding alleviation in both rural and urban environments.
4. The review of the literature identified gaps in the geographical coverage of hedgerow research as well as a disconnect between some benefits valued by stakeholders, such as flooding alleviation and climate change mitigation, and the availability of evidence on managing and planting hedges and hedgerows to maximise these benefits.
5. Priority areas for future research and dissemination of research on hedgerows are highlighted, including targeting locations, contexts and regions where there is currently a lack of available evidence, supporting research on understudied factors or benefits, and finally implementing research that tests and compares hedge characteristics and management approaches in order to underpin practical management and policy.

KEYWORDS
climate change, ecosystem services, environmental benefits, flooding alleviation, hedge, hedgerow, stakeholder perspectives, wildlife habitat

1 | INTRODUCTION

Hedgerows and hedges are a part of both urban and rural ecosystems across the globe and can take a wide range of forms and structures, from Devon hedgebanks in the South West of England where an earth bank is topped with woody vegetation (Wright, 2016), to the French Bocage (Montgomery et al., 2020) and native grass strips in China (Fan et al., 2015). Hedges may also have particular roles and structures in agricultural landscapes, for example alley cropping (Kanzler et al., 2021) and windbreaks (Smith et al., 2021). By providing a relatively undisturbed habitat containing often diverse and permanent plant species as well as connecting habitats across landscapes, hedgerows have the potential to play a key role in meeting biodiversity and climate targets (Montgomery et al., 2020) and help bring people closer to nature (Oreszczyn & Lane, 2000). Indeed, Brady (2006) argues that hedges provide an important aesthetic component of the agricultural landscape and hedge management 'enables an interaction with the environment that can deepen our ties to it and increase our understanding of both ourselves and the natural world'.

1.1 | The benefits of hedges and hedgerows

Recent reviews have considered the benefits and nature-based solutions (NbS) that hedgerows or hedges (used interchangeably in this study) and other linear woody features can provide in the landscape, for example from containing livestock and marking field and property boundaries (Drexler et al., 2021; Moreno et al., 2018; Smith et al., 2021) to providing a habitat for wildlife and reducing flood risk (Collier, 2021; Wolton et al., 2014). Using the well-established ecosystem services framework (Montgomery et al., 2020), these benefits can be broken down into three broad categories: provisioning, regulating/supporting and cultural. Provisioning services could include sheltering crops (Montgomery et al., 2020), shading livestock or providing livestock fodder and providing wood for fuel (Chambers et al., 2015). Hedgerows also provide food and habitat for wildlife (Staley et al., 2015) and the opportunity for people to forage (Wright, 2016). Regulating and supporting services could include sequestering and storing carbon in both the biomass and the soil (Axe et al., 2017; Biffi et al., 2023; Ford et al., 2021), supporting beneficial insects (such as pollinators and natural enemies for pest control) (Garratt et al., 2017; Van Vooren et al., 2017) and reducing air and noise pollution in towns and cities (Barwise & Kumar, 2020; Kumar et al., 2022). Hedges can also mitigate localised flooding and reduce rainfall run-off (Blanuša & Hadley, 2019) and support biodiversity through connecting habitats on a landscape scale (Atkins, 2019; Blanuša et al., 2019).

Finally, hedgerows also have aesthetic, cultural and historical significance, providing privacy, screening buildings, and they are a key component of the 'traditional' patchwork countryside often associated with agricultural landscapes (Moreno et al., 2018); they can even play a role in regional and national heritage and identity (Oreszczyn & Lane, 2000). Cultural services could also include educational benefits and awareness raising of the key role that hedgerows can have in both urban and rural settings in connecting people with nature and the natural world (Gosling et al., 2016).

Yet, there is also the need to consider the potential negative impacts or dis-benefits of hedgerows. Hedgerows can reduce visibility (Evensen et al., 2021), and in an agricultural setting, can reduce crop yields through shading and reducing soil moisture (Van Vooren et al., 2017). The range of benefits and dis-benefits provided by hedgerows will depend upon the context (e.g. farmland, urban), stakeholders involved (e.g. farmers, conservation mangers and public), and benefits and dis-benefits may change with the type of management applied. Furthermore, there may be some synergies where sets of benefits are positively associated, for example, reduction of gaseous pollution and flood alleviation (via stomatal control of gas exchange and removal of water from the soil via evapo-transpiration), or there may be trade-offs where the provision of one benefit co-occurs with the loss of another, such as livestock control and aesthetics.

Despite the benefits they can bring, hedgerows are being removed. The Countryside Survey of Great Britain showed that between 1984 and 1990 there was an estimated reduction of 23% in managed hedgerow length (Barr & Gillespie, 2000) and a further reduction of 6.2% between 1998 and 2007 (Carey et al., 2008). Surveys between 2016 and 2021 show 390,000 km of hedgerows now exist around field boundaries in England (Broughton et al., 2024) and there is evidence from the latest Countryside Survey in 2022/23 that there has been no significant decline in the extent of managed hedgerows and lines of trees since 2007 (Norton et al., 2024). Urban hedges are less often measured and recorded (Gosling et al., 2016) making it difficult to gauge change or loss; however, it was estimated that across Great Britain in 2016 there was approximately 43,100 km of urban hedgerow (Forestry Commission, 2017). Across Europe, hedgerows now cover approximately 1.78 million hectares (around 0.42% of the EU), with the largest extent in France (598,000 ha) the UK (240,000 ha) and Italy (168,000 ha) (den Herder et al., 2016), but it has been estimated that 50%–80% of the original hedgerows in Europe have been lost since 1950 (Reif et al., 2001).

1.2 | Hedgerow management

The management of a hedge impacts the benefits it can offer; for example, different management techniques are required to increase berry provision for birds and other wildlife (Staley et al., 2015) compared with the optimal management for insect pollinators, which

focuses on maximising pollen/nectar provision (Garratt et al., 2017). How a hedge is managed can impact its potential to store carbon (Axe et al., 2017; Black et al., 2023), and a gappy, infrequently managed or excessively cut hedge may provide a different range of, or potentially fewer benefits, to one that has been well managed and maintained. For example, Staley et al. (2015) explore how different hedgerow management and rejuvenation techniques can increase the habitat value of hedgerows for a variety of animal species. Graham et al. (2018) highlight the need for plant diversity and heterogeneity in structural condition to benefit a diverse range of flora and fauna. Hedgerow 'quality' also impacts the benefits it provides; unbroken hedges containing a diverse range of woody species and a rich floral understorey can be more valuable to some pollinators and natural enemies (Garratt et al., 2017). Ultimately, hedges should be managed to allow them to progress slowly through their natural growth cycle; across a landscape, hedges should be at different stages within this cycle to provide maximal benefits (Adams, 2014).

1.3 | Policies, stakeholders and management practices

Hedgerows in a policy context have the potential to support NbS and meet targets on biodiversity and climate change. Taking England as an example, the UK Government Environmental Improvement Plan 2023 (Defra, 2023) pledged to 'Support farmers to create or restore 30,000 miles of hedgerows a year by 2037 and 45,000 miles of hedgerows a year by 2050, returning hedgerow lengths in England to 10% above the 1984 peak (360,000 miles)'. Legislation introduced in England in 2024 (Rural Payments Agency, 2024) focusing on hedgerow management and buffer strips in agricultural settings highlights their benefits to biodiversity and land management in these settings, and puts in place rules intended to improve hedgerow condition and more effectively manage hedgerows to support these benefits, while reversing the recent shift from managed hedges to lines of trees due to a lack of long-term management (Norton et al., 2024).

Within the European Union (EU), the CAP (Common Agricultural Policy) Eco-schemes include agroforestry and natural cover in agricultural settings (European Commission, 2021), and hedgerows form a specific part of several EU members CAP strategic plans. While these policies focus predominantly on rural areas, there is potential for urban hedgerows to support a wide range of NbS and biodiversity targets while benefiting urban environments and communities.

Given the wide range of stakeholders involved with managing and/or using hedgerows, from farmers, agricultural contractors and landowners in rural contexts (Britt et al., 2000; CPRE, 2022) to those working in urban parks, gardens and public spaces (Gosling et al., 2016; Oreszczyn & Lane, 2000), relevant and accessible evidence is needed to meet the diverse requirements of these stakeholders if policy targets are to be met and the benefits of hedgerows maximised. This could include information on when and where to plant hedgerows, which species to plant to deliver particular services, and how to manage a hedgerow optimally. These ambitious targets for hedgerow increases (such as the target of creating or restoring 30,000 miles of hedgerow in England by 2037) require policy makers to understand the benefits and disservices of hedgerows in different contexts to inform policy and practitioners to be engaged in hedgerow planting and effective management in a range of environments.

Hedgerows can deliver a wide range of benefits and be used as a tool to meet environmental, social and economic targets for different stakeholders. They are also a familiar and often historical feature of many landscapes, both in urban and rural settings, connecting people with the natural world. However, we need to know how different stakeholders value hedgerows in different contexts, whether sufficient evidence exists to help them understand how hedgerows can meet their differing priorities, and if this evidence is available to them. The aims of this study were to (i) identify and survey different stakeholder groups to quantify which benefits delivered by hedgerows they consider a priority; (ii) systematically review available evidence on the benefits provided by hedgerows; (iii) explore to what extent the available evidence meets the needs of different stakeholders; and (iv) highlight evidence gaps and future research priorities.

2 | METHODS

This project involved first characterising the potential benefits delivered by hedgerows from the scientific literature. At stakeholder workshops, these benefits were then presented to different groups who ranked benefits based on their own priorities in their particular contexts. A systematic literature review was then carried out to examine where the weight of evidence lies regarding hedgerows, including benefits considered, geographical and temporal coverage, biome considered and management. We then used comparative analysis to explore the extent to which the evidence base meets the knowledge needs of different stakeholder groups.

2.1 | Characterising hedgerow benefits

A list of hedgerow benefits and disservices was developed and used as a basis for the following work. An initial search of Web of Science (WoS) (http://www.webofscience.com/wos/) for recent studies on hedgerows and consideration of recent review articles and reports focusing on the benefits of hedgerows, including Wolton (2018), Montgomery et al. (2020) and Dover (2019) was used to generate a global list of hedgerow benefits. The research team, with the support of the Hedgelink network of experts (https://hedgelink.org.uk/), then refined the list of benefits into distinct categories which covered all initial benefits. The 12 categories identified were as follows: Accessibility; Aesthetics; Climate change; Flooding alleviation; Functional biodiversity; Heritage; Livestock; Pollution control; Shelter; Soils; Wildlife; and Wood products. A full list of hedgerow benefits is available in Appendix S1.

2.2 | Stakeholder workshops

A map of key stakeholders was created through discussions with members of the UK-based 'Close the Gap' project (https://hedgelink.org.uk/news/close-the-gap-hedgerows-project/), and included groups or organisations involved with planting, maintaining, managing or using hedgerows and who may have an interest in hedgerows in a variety of contexts. These were then grouped into four overarching groups to form the basis of our workshops.

The four stakeholder groups were:

	Those active in *Rural* areas including Farmers, representatives of farming groups, for example National Farmers Union (NFU), The Farming and Wildlife Advisory Group (FWAG) and Hedge layers. (14 participants)
	Those active in *Urban* areas including ecologists, representatives of Network Rail and Water authorities and urban conservationists. (8 participants)
	*Educators and Enthusiasts* including Community groups, Conservation groups and environmental educators. (12 participants)
	*Ecologists, Researchers and Conservationists* including representatives of conservation and research groups, for example Royal Society for the Protection of Birds (RSPB), Centre for Ecology and Hydrology (CEH), and other academic researchers with an interest in hedgerows. (15 participants)

Stakeholders were approached and invited to attend the workshops via the Tree Council and Hedgelink and through contacting key individuals who were actively discussing hedgerows on social media. The groups were balanced in terms of organisational or sector affiliation, where possible, to ensure representation of the range of stakeholders with an interest in (or who are influenced by) hedgerows and their management. The workshops were all subject to ethics approval (University of Reading reference 1616D) and took place online using Microsoft Teams. Written, informed consent was received from all participants before attending the workshops, with participants completing a consent form outlining the workshop process and how their contributions would be recorded and used within the project. Prior to attending the workshop, attendees were asked to score the list of 12 hedgerow benefits from 0 to 5 (with 0 = not valued to 5 = highly valued) based on those they considered most important in their context. Stakeholders were provided with a list of the 12 benefits (Accessibility; Aesthetics; Climate change; Flooding alleviation; Functional biodiversity; Heritage; Livestock; Pollution control; Shelter; Soils; Wildlife; and Wood products) with definitions of, and examples of those benefits in a variety of contexts prior to the workshops. During the workshops attendees were then presented the initial scores and were given the opportunity to re-score these 12 identified hedgerow benefits. Interactive scoring was undertaken using Mentimeter (https://www.mentimeter.com/). Stakeholder rankings collected during workshops were collated and mean ranking ± standard error (SE) calculated for each benefit in each workshop. The mean and SE was plotted and rankings visually compared. Participants attending the Rural, Urban and Educators and Enthusiasts workshops were also asked for 'Three phrases or key words that highlight your key knowledge needs with regards to establishing and managing hedgerows'. Participants in the Ecologists and Researchers workshop were asked for 'Three phrases that best capture what research is needed to address any knowledge/evidence gaps'. These responses were collated and presented as wordclouds to highlight knowledge and research needs and gaps identified by each group.

2.3 | Literature review

We performed a review of available hedgerow literature to compare the extent to which existing research considers different hedgerow benefits. For each of our 12 benefit categories, a list of all search strings and terms was developed. The full list of terms is available in Appendix S2. Hedge and hedgerow are often used interchangeably within the literature; in this review, we used the term 'hedgerow' for the systematic searches, as using the term 'hedge' resulted in substantial numbers of unrelated items. The WoS Core collection was searched in March 2021. Following discussions, it was noted that in some literature focusing on hedges and hedgerows in urban environments 'hedge' is used in preference to 'hedgerow'. Additional simple searches (Hedge AND pollution, Hedge AND wildlife, Hedge AND aesthetics, Hedge AND biodiversity) were undertaken in WoS to capture any additional items that were not identified from the initial searches. The additional simple searches, using the terms described above, were undertaken in January 2022.

To supplement the systematic search, an additional assessment of the 'grey literature' was carried out. Websites of organisations and groups known to undertake and fund research into hedgerows in the UK were searched; see Data Sources for the full list. Further items were identified from: citations in review papers, recommendations from experts and workshop attendees. A search was also conducted on Google Scholar with broad search terms (e.g. hedgerow AND wildlife) and the first 10 pages of results scanned. Full details of the search are presented in a PRISMA diagram (Appendix S3).

For all items generated by the literature search, the title and abstract (if available) were initially reviewed, and a decision to retain or remove based on relevance was made. A review of the full text was then undertaken. Items were excluded if: the hedgerow in the study was not described or defined; it was part of an alley cropping or orchard scheme; or it was composed solely of herbaceous species or solely of trees with no scrub or herbaceous layer. Hedges

or hedgerows were defined, for the purpose of this study, as linear structures, in rural or urban settings, comprising solely woody or a mixture of woody and herbaceous species.

Each item was then reviewed and information on the following was extracted: (i) the benefits category the research considered, (ii) the geographic location, (iii) the habitat or biome and (iv) whether hedgerow management approaches were tested and management recommendations given. For biome, one of seven different categories was assigned: Rural, Urban, Mixed, Arable, Lowland, Pasture, Uplands. Rural studies encompassed those which did not specify a particular (non-urban) habitat or biome in which the study took place and 'Mixed' included studies which took place in both rural and urban hedgerows, such as those looking at the impact of hedgerows along an urban to rural gradient. The full list of information extracted is available in Appendix S4.

2.4 | Comparative analysis

To explore whether the availability of evidence matched the priorities held by stakeholders, a comparative analysis was carried out. Stakeholder rankings were compared with the available evidence for each benefit using radar plots for each stakeholder group. The value placed on each benefit was compared with the relative number of papers related to that benefit. The most valued benefit was furthest from the centre, plotted against the ranked number of instances of a benefit being highlighted in the literature review. The benefit with the most items is furthest from the centre. This highlighted disparities in what stakeholders value and the availability of research evidence.

3 | RESULTS

3.1 | What benefits do stakeholders consider a priority in relation to hedges and hedgerows?

All groups of stakeholders valued the benefits to wildlife highly, although for those in the Urban group it was not the highest-ranking benefit. Accessibility (hedgerows engaging the public through e.g. volunteer schemes, conservation groups, citizen science, education, their role in recreation, well-being, leisure and tourism) was ranked highly by both the Urban and Educators and Enthusiasts' groups; wood products were the lowest ranked benefit for every group. Pollution control was ranked the highest by the Urban group and accessibility was the lowest ranking among the Rural group (Figure 1).

3.2 | Literature review

The WoS search yielded 5092 items and an additional 151 items were included from searches of the grey literature and through recommendations. Eight hundred twenty-six of these items were reviewed and from which information was extracted. This included 684 primary research studies and 60 reviews (including 12 systematic reviews of the literature and 4 meta-analyses), 38 reports and 22 books and book chapters. Of these, 725 were peer-reviewed.

Of the 826 items, 81 tested interventions (e.g. implementing different cutting regimes) as opposed to undertaking an observational study. A small number (11) considered new hedges and hedgerows, and 30 considered both new and established hedges and hedgerows. Just under a third of all items (29%) provided management recommendations for hedges and hedgerows.

3.2.1 | Benefits considered

There was considerable variation in the number of items which considered each benefit category (Figure 2). Wildlife was the most highly researched category, with 70% of items considering benefits to Wildlife, followed by Functional Biodiversity with 21% and Soils with 14%. The benefits considered were also tracked over time, with a focus on items considering the benefits of hedgerows to wildlife consistent over a long period (Figure 2). The four benefits considered in this study, which could be viewed as the major NbS offered by hedges and hedgerows, climate change mitigation, flooding alleviation, functional biodiversity (e.g. provision of pollinators or pest control) and pollution control, all show more recent increases in the number of peer-reviewed items, particularly climate change mitigation, which moves from a very low number in the 2000s to a more steady year-on-year increase in the 2010s.

Dis-benefits were also noted, with 97 items recording a dis-benefit of hedges; these included:

- Hedgerows are an unsuitable habitat for some species, such as grassland passerine bird species (Besnard & Secondi, 2014).
- Aspects of hedgerow structure or composition leading to unsuitable habitat provision for some species (Dover & Sparks, 2000).
- Hedgerows providing, or being perceived to provide, a habitat for pests and invasive species (Gonthier et al., 2019; Hansford et al., 2017).
- Hedgerows potentially decrease crop production (Van Voren et al., 2017).
- Making access for agricultural equipment more difficult or damaging agricultural equipment (Blanco et al., 2020).
- The cost of hedgerow management, both time and money, is associated with this, the cost of disposal of waste resulting from management (Britt et al., 2000).

3.2.2 | Geographical coverage

The UK had the highest number of studies either wholly or partly (i.e. the hedgerows were either wholly in the UK or in both the UK and other countries); 35% specifically took place in or considered the UK,

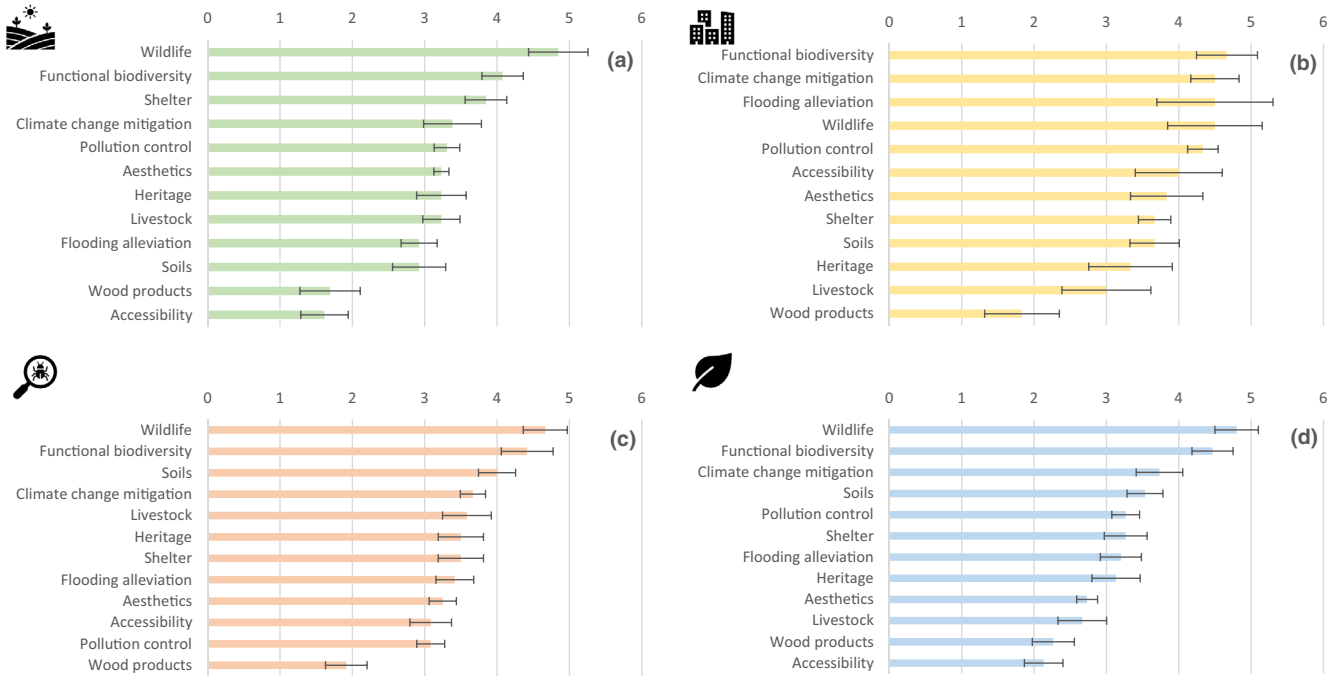

FIGURE 1 Ranking of hedgerow benefits by stakeholder group, N.B. not all stakeholders attending the workshops participated in the ranking exercise. (a) Rural stakeholders—13 participants, (b) Urban stakeholders—6 participants, (c) Educators and Enthusiasts—12 participants and (d) Ecologists and Researchers—15 participants. Mean ranking and ± SE shown, 5 = highly valued to 0 = not valued.

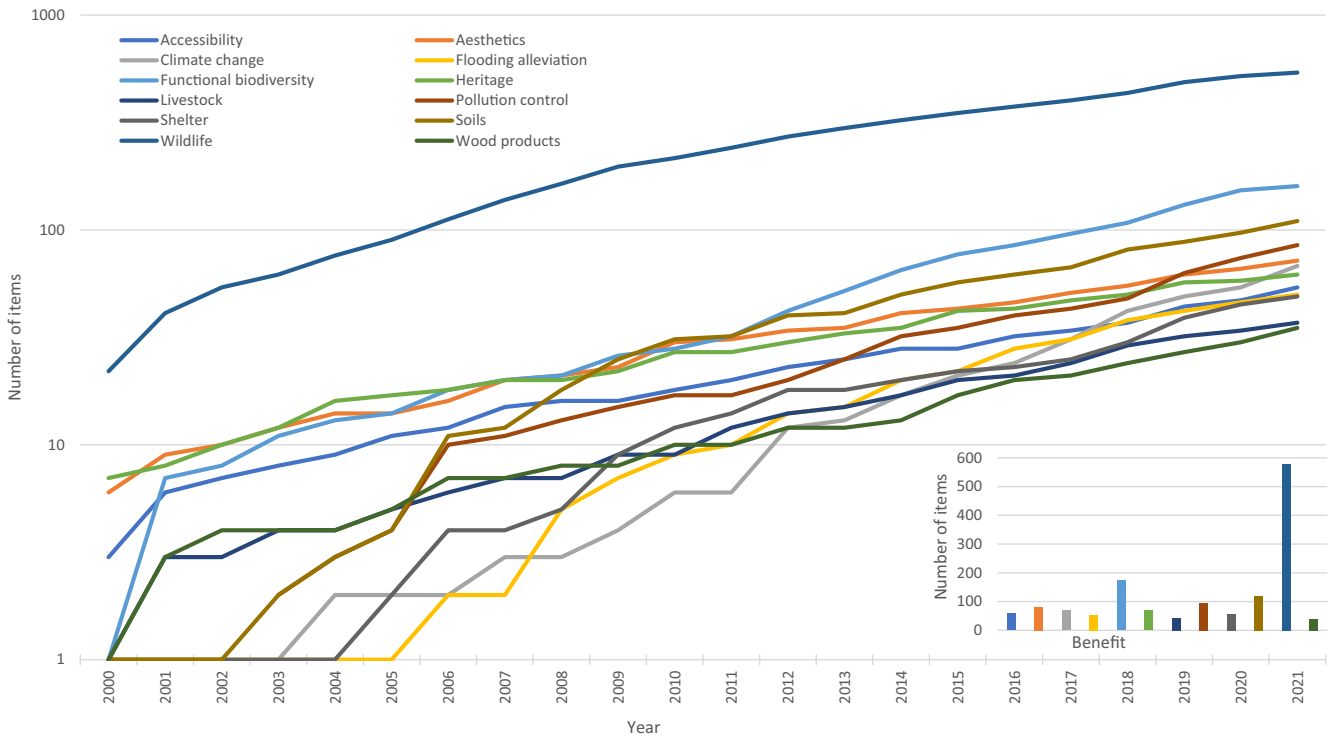

FIGURE 2 Cumulative number of peer-reviewed published papers covering the 12 hedgerow benefit categories in the period 2000 to 2022 (note logarithmic scale). Inset figure shows the number of items considering each benefit category; N.B. items could consider single or multiple benefits.

followed by France (14%), Italy (8%), the United States and Canada (both 6%). Over 80% took place in Europe and 94% in Europe and North America combined.

Some did not specify a country; some considered hedges and hedgerows across multiple countries, for example, multiple European countries. There were 15 items which focused on Europe but did not specify countries, and 50, predominantly reviews, which had a global spread. In addition, five were based around modelling, with no detail about the generation or gathering of data relating to either a specific country or global region.

Across those undertaken in the UK, the highest number took place in the South East, South West and East of England and more focused on hedgerows in England, predominantly on hedgerows in the South of England. The North East of England was the location of a single item and Northern Ireland, while having a high density of hedgerows (Spaans et al., 2018), was the focus of, or part of, only nine items, in contrast to the South East of England, with 85. In total, the South East and South West regions of England accounted for 45% of UK focused items.

3.2.3 | Habitat or biome

The majority of items, 89%, focused on hedges and hedgerows in rural areas, with mixed and urban biomes accounting for 6% and 5%, respectively (Figure 3).

Most studies undertaken on rural hedges and hedgerows were categorised as 'unspecified'. In these instances, the item did not specify a particular rural biome or may have been conducted on hedgerows in a range of biomes, for example one which covered several farms with a mixture of arable and pasture (Holden et al., 2019), or covered hedgerows across a region in a wide range of locations (Carey et al., 2008; Moreno et al., 2018).

3.3 | Comparative analysis

Comparing the importance stakeholders placed on the benefits provided by hedgerows with the literature available on those benefits highlighted some matches but also disparities (Figure 4).

Wildlife was a highly ranked benefit by all groups and also has a large number of items referring to it as a benefit. Functional biodiversity was also highly ranked as a benefit by stakeholders and was considered by a high number of items. Several mismatches between the benefits valued by stakeholders and the availability of literature or research were noted. For the Urban stakeholders, flooding alleviation benefits were ranked highly, but fewer items research or refer to flooding alleviation as a benefit of hedgerows. Similarly, Urban stakeholders and Educators and Enthusiasts ranked accessibility benefits highly; however, there are relatively few items which explore this. Rural stakeholders and Ecologists and Researchers ranked shelter highly; however, again there are few items focusing on or considering shelter as a

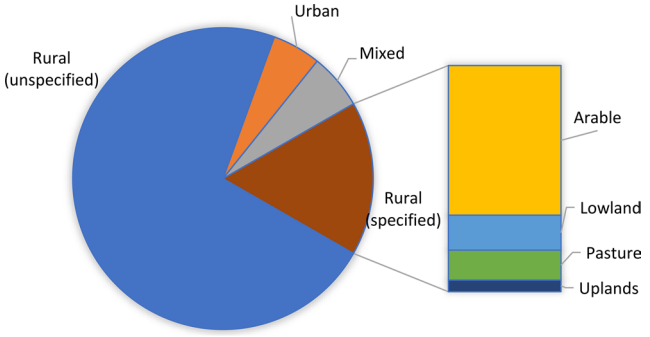

FIGURE 3 Distribution of biomes in which hedgerow studies were undertaken. 'Rural' includes those which did not specify a particular (non-urban) habitat or biome. 'Mixed' includes those which took place in both rural and urban hedgerows.

benefit of hedgerows. Within all groups, climate change mitigation was ranked highly as a benefit, but this did not correspond with the ranking for the number of items considering climate change mitigation, which was ranked 7th overall; although the amount of research being generated in this area is increasing.

3.4 | Knowledge and research needs

For the Rural, Urban and Educators and Enthusiasts groups, knowledge needs around effective management or maintenance of hedgerows, and the need for more information and awareness of the benefits of hedgerows, both for themselves and the communities they were part of, were highlighted frequently (Figure 5). What species to plant in hedgerows, the establishment of hedgerows and how to rejuvenate them were common themes. Their knowledge needs also considered specific benefits, such as benefits to wildlife (one of the benefits rated most highly by all groups) and connectivity, well-being and biodiversity.

Research associated with climate change, such as carbon capture and sequestration and flood alleviation and connectivity, was highlighted as areas where research was particularly required (Figure 6). The Rural, Urban and Educators and Enthusiasts stakeholders noted their need for knowledge in management and establishment, species to plant in hedgerows, and the value of hedgerows. The Ecologists and Researchers highlighted various aspects of hedgerow management as areas where further research is needed.

4 | DISCUSSION

This is the first study to systematically review the evidence on the multiple benefits and dis-benefits of hedgerows and compare this to the priority values placed upon these by stakeholders, in order to identify areas of convergence and areas where there is a shortfall in current available evidence to inform stakeholder decision-making. Potential differences and biases in areas of research into the benefits

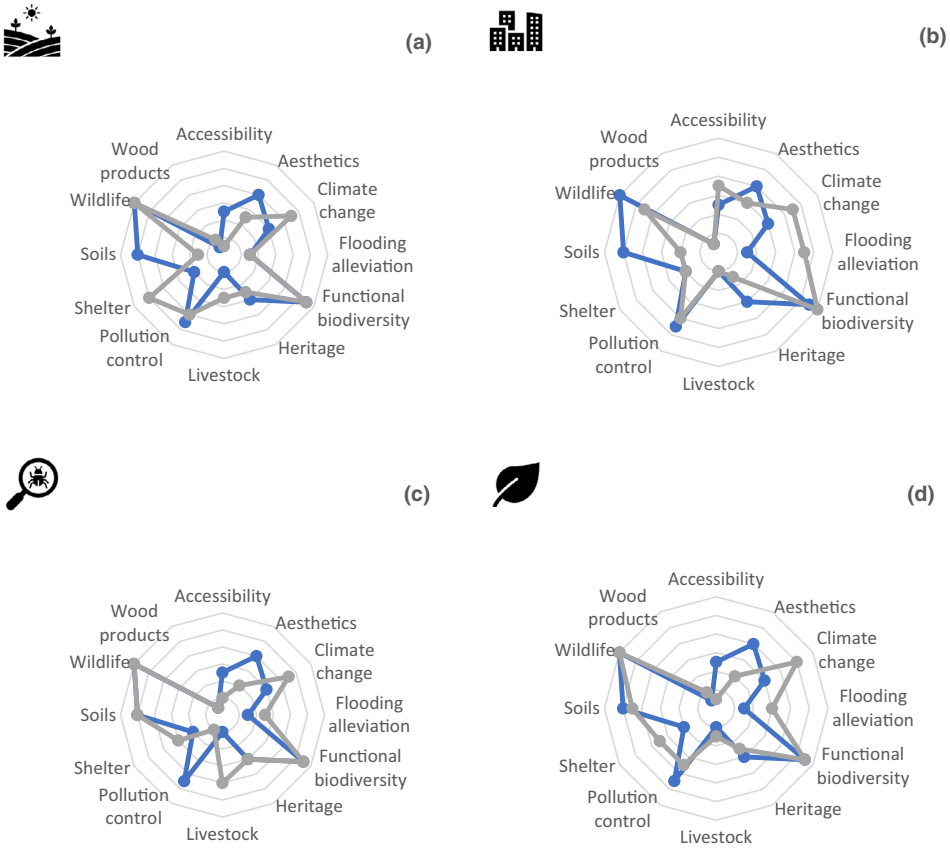

FIGURE 4 Comparing stakeholder priorities and literature available, the centre point of the radar diagram is 1 (lowest ranked) and the outer axis is 12 (highest ranked). The blue line shows ranked number of papers, wildlife benefits with the highest number of papers is ranked '12', wood products with the lowest is ranked '1'. The light grey line shows the priority placed on each benefit by the stakeholder group, including (a) Rural, (b) Urban, (c) Educators and Enthusiasts and (d) Ecologists and Researchers, with the highest priority benefit ranked '12' and the lowest priority benefit ranked '1'.

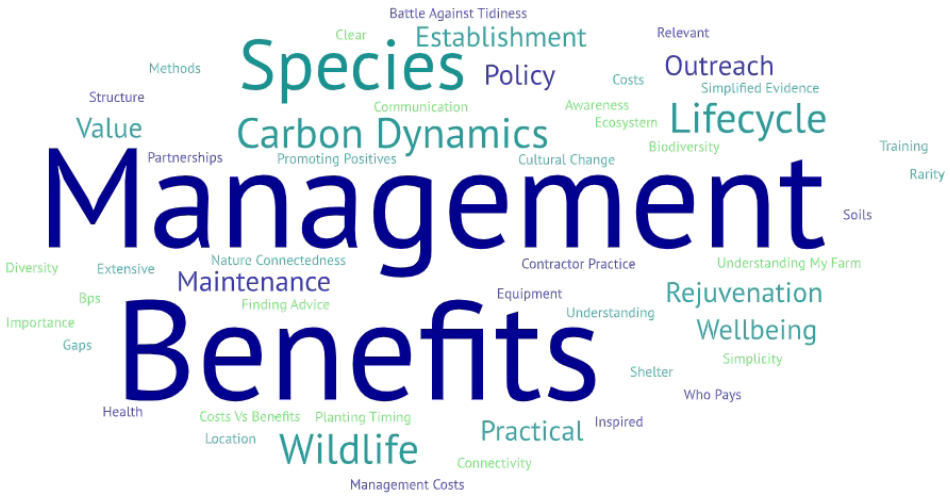

FIGURE 5 Words and key phrases from the Urban, Educators and Enthusiasts and Rural stakeholders highlighting key knowledge needs. Larger font indicates higher use.

of hedges and hedgerows, including biases in the subject, location and biome of study, were explored, and stakeholder interests and requirements were found to be met for some elements and areas of hedgerow research and knowledge, but not for others.

4.1 | Hedgerow benefits

All stakeholder groups valued the wildlife benefits of hedges highly; functional biodiversity also ranked highly among all stakeholder

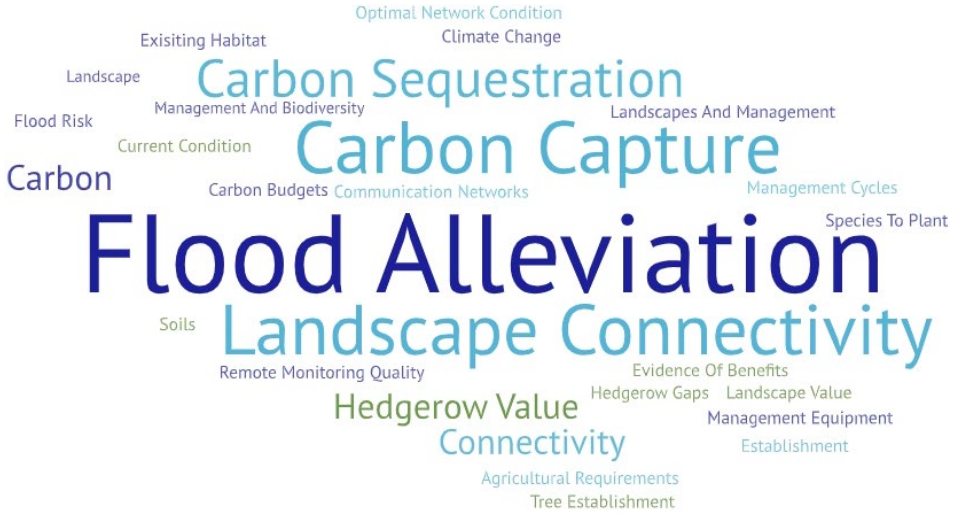

FIGURE 6 Words and key phrases from Ecologists and Researchers workshop participants highlighting knowledge and evidence gaps. Larger font indicates higher use.

groups. This was matched by the literature, as the majority focused on or referred to the benefits of hedgerows to wildlife (70% of items). These benefits could include providing food, shelter, nesting sites or connectivity within landscapes. The species considered were wide-ranging, including insects, birds, mammals and plants. There was also some cross-over with items considering aspects of functional biodiversity, which brought together the second largest number of items (21%), with a wide range of pollinators (including bees and hoverflies) and natural enemies (such as spiders and carabids) considered. That there is a strong match here between the priorities of stakeholders and available evidence is positive. This can provide a solid evidence base for the role of hedges in schemes, such as Biodiversity Net Gain (BNG) (Defra, 2024), and these policy initiatives can use this extensive evidence to put in place the necessary specifications to protect existing hedgerows or the placement of new hedges to deliver for biodiversity. Hedgerows are already a recognised biodiversity unit within the BNG scheme (Defra, 2025).

For all stakeholder groups, the benefits of hedgerows with respect to climate change and flooding alleviation were ranked relatively highly; however, this did not necessarily correspond to the availability of research. This was particularly notable in the Urban stakeholders group, who placed a high value on the benefits of hedges in flooding alleviation when little research appears to have been undertaken in this area, particularly in urban settings. From 2010 onwards, there has been growth in the number of studies looking at the benefits of hedgerows in relation to climate change mitigation (particularly carbon capture), pollution control and flooding alleviation. Although the number of studies is low, there appears to have been a steady increase. This could be due to a growing interest in the role hedgerows can play in NbS (Collier, 2021) or a growing awareness of the benefits of hedgerows in a variety of environments.

In general, previous studies have noted a range of gaps in the literature in relation to the benefits of hedgerows. Haddaway et al. (2018) systematic review of vegetated strips, including hedgerows, notes the highest number of studies around biodiversity benefits and a lack around cultural, aesthetic and educational aspects. There are fewer studies associated with the benefits of urban hedges (Gosling et al., 2016; Irfan et al., 2018), and Holden et al. (2019) notes the lack of studies around hedgerow soils, although recent studies, including Biffi et al. (2023) and Drexler et al. (2023) are addressing this, particularly in relation to carbon sequestration in hedgerow soils.

4.2 | Geographical coverage and biome

While a greater extent of hedgerows is found in rural areas there are still a wide range of stakeholders who have associations with hedges or responsibilities for managing hedges in an urban or peri-urban context, and our workshop outlined key priorities urban based stakeholders have when it comes to understanding and managing hedges. Yet our review identified a clear disparity between research on hedges in urban and rural settings. The majority of items (731) focused on rural hedgerows. Although there is a growing interest in the benefits of green spaces and nature in urban settings and how urban green spaces connect people and nature, there has been less focus on hedges and hedgerows, and less study of urban hedges (Gosling et al., 2016). Urban hedges, while making up a smaller proportion of hedgerows, still provide valuable opportunities for wildlife and people and for connecting people and nature. Surveys of hedgerow density and coverage often focus on rural or agricultural hedgerows, in urban and peri-urban environments interactions with hedgerows, for both people and wildlife, can be a very different experience. Hedgerows as 'mini nature reserves' could arguably provide a wider range of benefits to a greater number of people. Local, urban hedges are appreciated, particularly for wildlife (Oreszczyn & Lane, 2000) and can provide opportunities for

education and awareness raising about the benefits of hedgerows both locally and on a landscape scale.

Stakeholders are working with hedgerows and hedged landscapes across the world; however, we found a considerable bias in the location on which hedgerow research focused. The global distribution of studies on hedgerows and the bias in this distribution has been noted in previous reviews. Haddaway et al. (2018) undertook a systematic review of vegetated strips, which included hedgerows surrounding agricultural fields. The highest number of studies was from the United States, UK, France and Canada, and they noted a particular lack of studies in South America and Russia. We found a similar global bias in research. Within the UK, we found a potential bias towards research on hedgerows in the South of England (149 items). Although these areas do have a high density of hedgerows (Broughton et al., 2024), high densities of hedgerows have also been recorded in Northern Ireland (Spaans et al., 2018), which had relatively few items (9). The north of England (North East, North West and Yorkshire and the Humber regions), while having a low density of hedgerows, appears under-represented with 22 items. While planting and management techniques can be transferable between regions, there are likely nuances relevant to different hedges in different regions. Hedgerows in different regions grow in different soils and provide habitat to different species, both plant and animal. Some studies note the importance of native species in hedgerows for pest control (Morandin et al., 2014) and disease resilience (Jones et al., 2001). Clearly, some regions have better knowledge provision and available evidence than others, and this should be addressed through targeted research. This targeted research could also focus on the opportunities for hedgerow planting and management to support targets in climate change mitigation.

4.3 | Management

Stakeholders showed a clear interest and need for information on hedgerow management, maintenance and establishment, and research which tests contrasting management approaches or provides management recommendations. Just under a third of items gave recommendations; however, they often appeared to be 'buried' and explicit recommendations for, for example, species to plant and effective management techniques were not routinely given. Management recommendations were more often found in the grey literature. Of 826 identified items, 243 (29%) gave management recommendations. Of these, 50 were grey literature (such as non-peer-reviewed reports, books and case studies); grey literature provided 21% of the items with recommendations while forming 12% of the items reviewed.

Some recommended planting more hedges (e.g. in order to support carbon capture) but gave no guidance on species to plant or where to plant. Some called for agri-environmental schemes to change focus or emphasis to encourage and enable hedge planting and management (Staley et al., 2023). The changing EU CAP strategic plans and in the UK the ELMS (Environmental Land Management Scheme) could be used to better locate and manage hedges and hedgerows in rural settings. There is also potential for changes in UK policy around planning and biodiversity to have an impact on urban hedges. With an estimated 43,100 km of urban hedgerow in Great Britain (Forestry Commission, 2017) just under 40% of UK domestic gardens having hedges (Blanuša et al., 2021), and considering the hedges surrounding public buildings, alongside urban roads, railways and waterways, there is huge potential for hedges to benefit urban environments. Urban settings can also provide opportunities to reach and impact large numbers of people, with hedges and hedgerows forming a very visible link to the natural world in urban and peri-urban environments.

In considering management recommendations for hedges and hedgerows, there could be value in stakeholders looking at proxies. For example, benefits to wildlife were highly scored by stakeholders, and a large proportion of the literature focuses on wildlife, but management of hedgerows for wildlife may also support other benefits. A well-managed hedge containing a variety of woody species that provides diverse habitat for wildlife, including food and shelter, will also enable other benefits, for example diverse floral spread to support pollinators (Graham et al., 2018), a dense woody structure to promote carbon capture (Axe et al., 2017) and reducing airborne particulate pollutants and noise (Wolton et al., 2014). A mix of plant species and a focus on native species may be more aesthetically pleasing and fit with societal, heritage and historical ideas of what a hedgerow should be (Wright, 2016). The extent or density of hedgerows at larger scales is likely to influence the benefits they provide. However, there was a lack of items considering a whole farm or area (e.g. urban housing estates or conservation areas) where different management or staggered management, such as cutting hedgerows in rotation every 2 or 3 years, might provide benefits (Staley et al., 2015).

The stakeholders who took part in the workshops are part of this process to plant, grow and maintain hedgerows in a wide range of ecosystems and contexts. In order to plant and maintain hedgerows, or work with others to do so, they need access to the information in understandable formats relevant to their context. Those working in urban and peri-urban environments have different limitations to a landowner or farmer planting a hedgerow in a rural area with limited public access and so may need information on species to plant that would thrive and provide the widest range of benefits in an urban, as opposed to rural, setting. Through the systematic literature review, this study brought together a wide range of items focused on the benefits of hedgerows and identified studies which provided management recommendations. Discussions in the stakeholder workshops highlighted the knowledge gaps and needs of those working with hedgerows in a range of environments and also highlighted the interest in, and need for, accessible knowledge and evidence around the benefits of, and how to manage, hedges and hedgerows. This review forms part of the Close the Gap project (https://hedgelink.org.uk/news/close-the-gap-hedgerows-project/), which also developed a database of resources and guidance for those working with hedgerows, identifying and

bringing together practical guidance and information—the Hedge Hub (https://hedgelink.org.uk/hedge-hub/). The Hedge Hub also brings together the results of this systematic review, enabling stakeholders to search for research related to knowledge gaps, for research undertaken in their region and studies which look at management and offer management guidance. Practitioner-focused, user-friendly access to knowledge, such as this will serve to raise awareness of the potential of hedgerows and allow stakeholders to make more informed management decisions.

4.4 | Limitations

Our work with stakeholders focused on hedges and hedgerows within the UK context. Nonetheless, the workshops brought together a diverse group of stakeholders with a range of interests in hedgerows, from their use in an agricultural setting, their education potential, to their relevance to antisocial behaviour. Stakeholders were also from a range of UK regions and backgrounds, from central London to rural Wales. They were, however, all already interested and involved in planting, maintaining or educating the wider community about hedgerows. It would be informative to try and capture the views of those less engaged with hedgerows to explore what could encourage engagement.

The use of the term 'Hedgerow' for searching, while excluding large numbers of irrelevant studies, may have excluded items where 'Hedge' rather than hedgerow is used, potentially introducing a bias against studies undertaken in urban environments. We attempted to remedy that by carrying out additional focused searches using the word 'hedge' and several ecosystem services (see 'Literature Review' section in Methods). The low number of studies focusing on the benefits of hedges and hedgerows in urban environments could also be a reflection on the lower length of hedges in urban settings.

4.5 | Research priorities

4.5.1 | Supporting research on under studied factors or benefits

Highlighted by our comparative analysis, the available evidence does not always meet the needs of potential knowledge users. For example, there is considerable interest in the role of hedges for combating climate change and mitigating risks of flooding, where further research is needed. Our literature review demonstrated that some benefits have a far greater body of research associated with them than others. Therefore, more research should be carried out on the influence of hedgerows on little-studied factors, but those which we know are important for decision-making around hedgerows. For example, a better understanding of the social, cultural and heritage aspects of hedgerows and their influence on current and future hedgerow management is needed.

4.5.2 | Targeting research where there is currently a lack of available evidence

Future study should include regions where little research has already been done. From a global perspective, this includes countries and continents outside of Europe and North America. Similarly, at more local scales, there are hedgerow types and contexts where there is a lack of evidence. For example, there is a clear need for more work on urban hedges. Despite the smaller extent of the hedge 'resource' in urban areas, the multiple benefits hedges can provide, such as temperature regulation, pollution control, biodiversity and aesthetic and well-being benefits, could have a high impact in urban areas where they are 'experienced' by a greater number of people than in rural areas and offer a link to nature in areas with less green space.

4.5.3 | Research that tests and compares hedge characteristics and management approaches

Evidence-based advice on how hedgerows should be established and managed to maximise the benefits they can provide is of value to policy makers and practitioners. However, our review has demonstrated that only a minority of studies make specific management recommendations; fewer still (>10%) involve testing and comparing management interventions. As hedgerows fall increasingly under the spotlight as a tool to tackle climate change and support biodiversity, it is critical that optimal establishment and management approaches are undertaken to deliver the greatest benefits with what will inevitably be limited resources. More practical and applied research, which identifies optimal approaches in different contexts, is needed.

4.5.4 | Making research and knowledge more widely available

Research is needed to fill in the gaps noted, but knowledge, information and the outcomes of research do not always make it to stakeholders and those working to plant, manage and maintain hedgerows in an accessible format. Stakeholders' knowledge needs and gaps need to be understood, and relevant research and recommendations around establishing and managing hedgerows effectively disseminated. If hedgerow management is to be undertaken effectively to support the multiple benefits of hedges and hedgerows, stakeholders need to be able to access the information and gain relevant advice from it.

5 | CONCLUSIONS

This exercise has identified evidence gaps and key research priorities which can help better inform policy and management practice

decisions in the future. Effective management is key to enabling hedgerows to reach their full potential, connect people with nature and provide maximum benefits while improving the environment for all. However, to do this, those who work with hedgerows need research that considers their priorities and is relevant to the context in which they operate. In addition, policies need to be in place to protect hedgerows and the benefits they provide; in order to do this, policy makers need to be well informed with relevant research. We have identified key gaps in relation to the benefits, regions and biomes in which research was undertaken and information was available. Closing these gaps in hedgerow research, and disseminating this knowledge, could effectively support hedgerows to grow and thrive and increase the benefits they have the potential to provide.

AUTHOR CONTRIBUTIONS

Michael Garratt, Alice L. Mauchline, Michelle Felton, Simon Potts and Katherine Clark conceived the ideas, designed the methodology and collected and analysed the data. Katherine Clark led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

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CONFLICT OF INTEREST STATEMENT

No conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data are available from University of Reading, Dataset: https://doi.org/10.17864/1947.000371 (Clark et al., 2022).

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DATA SOURCES

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Gateway to Research, https://gtr.ukri.org/

Hedgelink, https://hedgelink.org.uk/

Natural England. https://www.gov.uk/government/organisations/natural-england

Woodland Trust. https://www.woodlandtrust.org.uk/

SUPPORTING INFORMATION

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

Appendix S1. Hedgerow benefits.

Appendix S2. Searches.

Appendix S3. PRISMA diagram showing search and review process.

Appendix S4. Information extracted.

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