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Research article

Conservation priorities for development: survey of UK public's views on brownfield sites and biodiversity

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Abstract

Policies prioritising the repurposing of abandoned land ('brownfield sites'), in order to spare undeveloped sites, are widely perceived to limit damage to biodiversity. However, brownfield sites can be of significant ecological value, providing scarce habitats, including as a source of greenspace in urbanised areas, and promoting ecological richness at landscape scales. Therefore, policies to promote brownfield site repurposing might do more harm than good in terms of preserving biodiversity, calling into question what the public understand by, and value in terms of, brownfield sites.

To examine public opinions relating to the prioritisation of biodiversity in the selection of sites for development, we undertook a survey of 2,247 respondents in the UK.

We found that a stigma exists against brownfield sites. Their ecological value is underappreciated, but those who associated brownfield sites with wildlife-related keywords viewed them more positively. Less importance was placed on a site's history of development (brownfield vs undeveloped) than on its actual value to wildlife when considering whether it should be repurposed, and to what use; repurposing to housing or renewable energy production were favoured when sites had little value to wildlife, regardless of whether they had previously been developed.

Overall, our results suggest that to best serve the preferences of local people, future planning decisions should consider the current biodiversity value of a site alongside its status as a brownfield site or otherwise. The existing stigma against brownfield sites could be alleviated by outreach and education about the value of such sites to nature.

Keywords: abandoned land, greenspace, landscape planning, public perception, repurposing.

Introduction

A key goal driving the redevelopment of 'brownfield' sites (here defined as abandoned land that has previously been developed), particularly for housing, is sustainability (Schulze Bäing & Wong, 2012). The repurposing of land already diverted from an assumed 'natural', or at least rural, state, is perceived to provide the social and economic benefit of reducing the blight of derelict land (Rizzo et al., 2015), whilst conferring the environmental benefit of preserving undeveloped land. For example, policies promoting brownfield regeneration may intend to relieve pressure to develop rural land (Dixon, 2006; Loures & Vaz, 2018), especially within 'green belts' immediately surrounding urban areas (Schulze Bäing, 2010). Besides housing, brownfield sites are often put forward for use in renewable energy production (Milbrandt et al., 2014) or can be brought into agricultural production (Hard et al., 2019). There are therefore multiple pressures for changes to land use with strong social and ostensibly, environmental, purposes. The potential benefits of bringing brownfield land back into use have been explored by policymakers internationally (for example, EU, Morar et al., 2021; USA, De Sousa et al., 2023; China, Gao, 2023). In the UK, the drivers for brownfield development are highlighted by changes to planning policy in 2020, promising 'fast track' planning permission for housing on brownfield sites (Town and Country Planning (*General Permitted Development) (England) (Amendment) (No. 3) Order 2020*).

Policies favouring brownfield development have inherent assumptions about the relative environmental value of different types of land-use. These are embedded into the planning system in the UK (Cox & Rodway-Dyer, 2023). However, the environmental goals of sustainable development can be at odds with brownfield regeneration (Dixon, 2006). Brownfield sites can have high ecological value, providing habitat for rare or threatened species (Eyre et al., 2003; Tropek et al., 2010; Kamp et al., 2015; Broughton et al., 2021), sometimes including water bodies (Preston et al., 2023), and the presence of such sites can enhance biodiversity at landscape scales (Macgregor et al., 2022). They can generate ecosystem services (Gardiner et al., 2013; Mathey et al., 2015), including cultural ecosystem services through provision of urban greenspace (Pueffel et al., 2018; De Valck et al., 2019; Masood & Russo, 2023). Concerns have therefore been raised that development on brownfield sites may have unintended negative consequences for biodiversity (Meehan et al., 2010; Fletcher et al., 2011; Broughton et al., 2021; Macgregor et al., 2022; Cox & Rodway-Dyer, 2023), and that rigid protection of green belts, in particular, can divert development onto brownfield sites that are ecologically more valuable (Amati & Yokohari, 2006). Given the biodiversity value of some brownfield sites, their protection and management as publicly accessible nature reserves could provide an alternative form of repurposing to redevelopment (Heatherington et al., 2019), which may be well received by local communities (Masood & Russo, 2023); the provision of public access in itself can improve locals' perception of such sites (Hofmann et al., 2012). Fast track approval carries the implication for reducing possibilities for local objections to planning applications; but consultation with communities around developments that relate to them is itself a sustainability goal.

Given the ongoing international drive to prioritise development on brownfield sites, especially linked to renewable energy production (Milbrandt et al., 2014) and housing (Schulze Bäing & Wong, 2012), it is important to consider local people's own prioritisation of different alternative land uses (Loures & Crawford, 2008), as well as the extent to which these are impacted by site type as a brownfield site or otherwise, and by site biodiversity value. Policies promoting the repurposing of brownfield sites often garner public support (Loures et al., 2016), probably due to a combination of idealised perceptions of rural land (Rust et al., 2021) and negative perceptions of brownfield sites

and their characteristics (Mathey et al., 2018), although deliberate regeneration of brownfield sites into urban greenspace can also be viewed positively (Masood & Russo, 2023). Whilst the ecological value of brownfields is increasingly well understood by scientists, conservationists, and to some extent planners (Loures & Vaz, 2018; but also see Cox & Rodway-Dyer, 2023), it is unclear to what extent this knowledge has permeated among the general public, or whether increased awareness of brownfield site biodiversity would lead to more positive perceptions of such sites. In particular, it is unclear whether knowledge about the actual biodiversity richness of candidate sites for redevelopment would alter public perceptions about whether sites should be repurposed, and if so, into what use; and whether this knowledge of biodiversity richness carries greater or lesser weight in the public's eyes than a site's status as a brownfield site (that is, its history of development). Recent studies have employed questionnaire-based public surveys to understand public preferences for land uses including agriculture (Rust et al., 2021) and urban greenspace (Tomitaka et al., 2022; Masood & Russo, 2023), including in relation to biodiversity conservation (Fischer et al., 2020), but this approach has not yet been applied to brownfield sites, except with restricted locations or contexts (Loures et al., 2016; Masood & Russo, 2023).

In this study, we conducted a survey of a sample of 2,247 adults living in Great Britain (namely, England, Wales, and Scotland; but not Northern Ireland), and analysed responses in order to analyse participants' opinions about brownfield sites and their repurposing, especially in the light of information about biodiversity value of such sites. Therefore, our study provides the first questionnaire-based assessment at a national (rather than regional or local) scale of public preferences for brownfield site use, incorporating a wide range of options for repurposing including use for nature, housing, industry and renewable energy. We hypothesised that: (i) awareness of the biodiversity value of brownfield sites would be associated with more positive opinions of such sites; (ii) both a site's status as a brownfield site and its biodiversity value would influence people's preferences for its repurposing. Under hypothesis ii, we expected redevelopment to be favoured on brownfield sites above undeveloped sites, but management as a nature reserve or remaining abandoned preferred by more people on sites which are richer in wildlife.

Methods

Survey questionnaire

In order to characterise public opinion at a national scale, we needed to access responses from a broad geographic area and across a wide section of the population. Thus, a questionnaire survey provided an efficient means to collect data from sufficient respondents to permit statistical analysis of the results (Rowley, 2014). Further research could adopt a more intensive approach, for example, based on interviews of a much smaller number of respondents in order to better understand their motivations; but at this stage, we sought an overview of public opinion, that is, an extensive approach in the terms of Sayer (2010). Data were gathered by means of an online survey, which was approved by the University of Hull Ethics Committee (reference no. FEC_2021_18). The survey was undertaken by YouGov in order to obtain a high number of responses in a short space of time, and all respondents consented to participation.

The survey was conducted in April 2021, using YouGov's GB Omnibus survey type (YouGov, 2021). A total of 2,247 unique responses were obtained from adults living in Great Britain, distributed broadly across a range of socio-demographic variables including age, gender, social grade, region, and employment status (Table 1). Socio-

demographic information was primarily drawn from data collected by YouGov about respondents during their sign-up process and were supplemented by four further questions covering local area settlement size, duration of occupancy in the settlement, duration of occupancy in the home, and affiliation with relevant stakeholder groups (for example, as employees, volunteers or supporters of conservation organizations).

The survey included 21 questions (Appendix 1, in Zenodo data archive). All questions were framed to prompt respondents to consider their opinions of brownfield or undeveloped sites 'in their local area'. The majority of questions were either multiple choice (commonly presented on a Likert scale, where respondents rate their agreement/disagreement with a statement on a five-point scale (Likert, 1932)), or arrays in which respondents ranked multiple options from most to least preferred. Some questions allowed open-ended follow-ups for respondents to provide more information about why they had responded in a particular way. The first question was preceded by a clear definition of what was meant by a 'brownfield site' in the context of the survey, which read: 'Brownfield sites are defined as "abandoned land that has previously been developed". They can include former mining or quarrying works, disused industrial sites, and closed landfill sites. In the UK, brownfield sites are prioritised for redevelopment: the government set a policy target in 2008 that over 60 per cent of newbuild housing should be built on brownfield sites, and this target is currently being exceeded'. Respondents were asked questions relating to:

(i) Whether they associated brownfield sites with a range of keywords which were expected to have positive, negative or ambiguous connotations (including keywords associated with biodiversity).

(ii) Whether their opinion about brownfield sites was positive or negative (and to explain their choice in their own words), and whether that opinion would change upon provision of information about wildlife on said sites.

(iii) What their opinion was of photographs of semi-natural habitats on four unspecified sites in rural locations (Figure 1 (a-d)), and whether they thought each photograph showed a brownfield site or an undeveloped site (in fact, the photographs depicted two brownfield and two undeveloped sites, all of which are currently managed as nature reserves by the Yorkshire Wildlife Trust, but respondents were not informed of this; see below).

(iv) Whether they agreed or disagreed with a range of key phrases, variously with positive or negative connotations, when shown a photograph of:

   a. a brownfield site;
   b. a nature reserve;
   c. an arable farm; and
   d. a renewable energy facility (solar farm) respectively (Figure 1 (e-h)).

(v) What their preferences (ranked from most preferred to least preferred) were for a variety of options for repurposing of sites, for each of four hypothetical sites which were respectively described as:

   a. a brownfield site, with little value to wildlife;
   b. a brownfield site, rich in wildlife;
   c. a previously undeveloped site, with little value to wildlife; and
   d. a previously undeveloped site, rich in wildlife'. A final open question allowed respondents to provide any other opinions or comments that they felt were relevant.

For the questions in which respondents were asked to give their opinion of photographs, we intended to show respondents four similar photographs of similar sites,

in order that their opinion of the site was as likely to be influenced by any biases relating to brownfield sites as the actual character of the sites in question, or of the photographs of those sites. To this end, we selected four sites that were visually similar, all of which comprised areas of semi-natural habitat managed by the same nature conservation organisation. Two out of the four sites were brownfield sites (a former quarry and a former landfill site), whilst the other two had no prior history of industrial use. Photographs were taken of each site (Figure 1a–d) that were deliberately intended to be compositionally similar, with open areas in the foreground, some trees in the background, and an approximately equal proportion of the photograph consisting of sky. Not all photographs were taken at the same time of year, but all photographs were taken in relatively bright weather conditions. As far as possible, we avoided showing man-made features in any photograph as we felt respondents might naturally assume the site in question was a brownfield site based on this feature, without assessing the holistic character of the site; however, the photograph of site 'Brownfield_1' did include some farm buildings located outside the site boundary. Photographs shown to respondents in connection with their response to a selection of key phrases (Figure 1e–h) were purely illustrative, and intended to show features of a 'typical' site in each category, including: unmanaged semi-natural habitat and some man-made structures (brownfield site, Figure 1e), managed wetland habitat (nature reserve, Figure 1f), crops (arable farm, Figure 1g), and an array of solar panels (renewable energy facility, Figure 1h).

Figure 1: Photographs shown to respondents

Note: (a–d) Respondents were asked to give their opinion of four photographs of undefined sites in rural locations. Unknown to respondents, the photographs depicted four nature reserves (NR) managed by the Yorkshire Wildlife Trust, of which two occupied brownfield sites and two occupied previously undeveloped sites, as follows: (a) Kiplingcotes Chalk Pits NR, labelled 'Brownfield_1' in analyses and figures; (b) Barlow Common NR, 'Brownfield_2'; (c) Ledsham Bank NR,

'Undeveloped_1'; (d) Townclose Hills NR, 'Undeveloped_2'. (e–h) Respondents were shown four photographs of sites in different land uses and asked whether they agreed with key phrases in association with each depicted site. Sites depicted were (e) a brownfield site; (f) a nature reserve; (g) an arable farm; and (h) a renewable energy facility (solar farm).

Table 1: Breakdown of survey respondents (out of 2247 total) across various socio-demographic variables

Variable	Number of respondents (percentage of total)
Gender	
Male	1059 (47.1%)
Female	1188 (52.9%)
Age	
0-17	0 (0%)
18-24	168 (7.5%)
25-34	373 (16.6%)
35-44	381 (17.0%)
45-54	391 (17.4%)
55+	934 (41.6%)
Social grade	
ABC1	1368 (60.9%)
C2DE	879 (39.1%)
Region	
England, North	516 (23.0%)
England, Midlands	378 (16.8%)
England, East	222 (9.9%)
London	277 (12.3%)
England, South	546 (24.3%)
Wales	103 (4.6%)
Scotland	205 (9.1%)
Employment status	
Working full time	945 (42.1%)
Working part time	306 (13.6%)
Full time student	93 (4.1%)
Retired	603 (26.8%)
Unemployed	114 (5.1%)
Not working/other	186 (8.3%)
Children at home	
0	1676 (74.6%)

Variable	Number of respondents (percentage of total)
1	251 (11.2%)
2	200 (8.9%)
3+	87 (3.9%)
(Information refused)	33 (1.5%)
Parent/guardian status	
Not parent/guardian	982 (43.7%)
4 years and under	172 (7.7%)
5 to 11 years	247 (11.0%)
12 to 16 years	196 (8.7%)
17 to 18 years	79 (3.5%)
Over 18 years	830 (36.9%)
Dog ownership	
Dog owned	562 (25.0%)
Other pets	1046 (46.6%)
No pets	1096 (48.8%)
Settlement size	
City (centre)	214 (9.5%)
City (suburbs)	577 (25.7%)
Town	835 (37.2%)
Village	452 (20.1%)
Hamlet	41 (1.8%)
Countryside	115 (5.1%)
Prefer not to say	13 (0.6%)
Settlement tenure	
Less than a year	101 (4.5%)
1-2 years	159 (7.1%)
3-5 years	286 (12.7%)
6-10 years	268 (11.9%)
10+ years	1307 (58.2%)
Prefer not to say	7 (0.3%)
Home ownership	
Own - outright	760 (33.8%)
Own - with a mortgage	655 (29.1%)
Own - through shared ownership	22 (1.0%)

Variable	Number of respondents (percentage of total)
Rent - from a private landlord	357 (15.9%)
Rent - from a local authority	95 (4.2%)
Rent - from a housing association	141 (6.3%)
Live with friends/relatives and pay rent	106 (4.7%)
Live with friends/relatives rent-free	75 (3.3%)
Other	36 (1.6%)
Home tenure	
Less than a year	181 (8.1%)
1-2 years	266 (11.8%)
3-5 years	374 (16.6%)
6-10 years	306 (13.6%)
10+ years	1097 (48.8%)
Prefer not to say	23 (1.0%)
Affiliation	
Conservation organisation (member of staff)	9 (0.4%)
Conservation organisation (volunteer)	45 (2.0%)
Conservation organisation (member or supporter)	291 (13.0%)
Local authority (for example, councillor)	33 (1.5%)
Community organisation (for example, Neighbourhood Watch)	90 (4.0%)
Farmer (or agriculture-related business)	12 (0.5%)
Renewable energy industry	18 (0.8%)
Other relevant stakeholder group	23 (1.0%)
None of the above	1749 (77.8%)
Don't know/can't recall	74 (3.3%)

Note: Breaks may not total to 2247 in cases where respondents could belong to more than one category simultaneously, or where some respondents did not provide answers.

Statistical analysis

Statistical analyses were conducted in R version 4.0.3 (R Core Team, 2024), using a range of packages of which the most important were lme4 (Bates et al., 2015) for constructing and testing generalized linear mixed-effects models (GLMMs), and ggplot2 (Wickham, 2009) for data visualization. R scripts are archived on Zenodo (doi: 10.5281/zenodo.11313478).

To assess whether the two hypotheses described above are supported, we interrogated survey responses with a series of questions, combining responses to multiple survey questions where appropriate, as follows:

1. What keywords did respondents associate most with brownfield sites?
2. What opinion did respondents have of the idea of a brownfield site in their local area, did opinions differ between different socio-demographic categories, and did opinions correspond to the connotations of respondents' chosen keywords?
3. Would provision of information about wildlife on a brownfield site affect respondents' opinion of that site?
4. Did respondents give more positive opinions about photographs of undeveloped sites than photographs of brownfield sites?
5. Did respondents give more positive opinions about photographs of sites when they believed them to be undeveloped sites?
6. Did respondents agree with key phrases (describing potential benefits/disbenefits of sites) more or less when applied to brownfield sites than to other types of site?
7. Did respondents prefer certain options for repurposing sites to others, and were their preferences affected by (a) site type ('brownfield' vs 'undeveloped') and (b) wildlife value ('little value to wildlife' vs 'rich in wildlife')?

In some cases where questions in the original survey were answered on a Likert scale, responses were assessed qualitatively by comparing percentages of respondents giving each possible response (questions 1-3 above). However, in order to facilitate quantitative statistical testing of hypotheses, qualitative answers were simplified to binary formats wherever appropriate, representing either 'agree/disagree', or 'agree/do not agree' in cases where a neutral response was available (in the latter case, 'neutral' was considered to indicate an implicit lack of agreement). Additionally, we generated a 'keyword score' for each respondent, using respondents' answers to a question in which they selected, from a list of provided keywords, which terms they associated with brownfield sites. Specifically, we assigned each keyword to have either clear positive connotations (n = 4, for example, 'Birdsong'), clear negative connotations (n = 4, for example, 'Pollution'), or ambiguous connotations (n = 3, for example, 'Boundary fencing'). Positive and negative keywords were assigned weights of +1 and -1 respectively (ambiguous keywords, and additional keywords written in by respondents who had selected 'other', were not used in the generation of keyword scores). The keyword score for each respondent was the sum of the weights for all keywords they had selected, and therefore ranged from -4 (respondent selected all available negative and no positive keywords) to 4 (respondent selected all available positive and no negative keywords). We also counted the number of wildlife-related keywords selected by each respondent, out of four in total: ('Birdsong', 'Bees and butterflies', 'Wild flowers', and 'Ponds/lakes').

We used a mixture of generalised linear models (GLMs), generalised linear mixed-effects models (GLMMs) and simpler statistical tests to test the questions listed below. For all GLMs and GLMMs, model fit was validated by visual inspection of plotted model residuals.

To test whether respondents' opinions of brownfield sites were related to a range of socio-demographic variables (question 2; gender, age, social grade, geographic/governmental region, employment status, children living at home, parent/guardianship status, dog/pet ownership, settlement size, duration of settlement tenure, home ownership status, and duration of home tenure), we constructed and tested GLMs with Gaussian error distributions, with each socio-demographic variable in

turn as the independent variable and respondents' opinions on a Likert scale (1–5, with respondents who answered 'Don't know' excluded) as the dependent variable. The significance of each overall model was tested using an F-test, and where models were deemed significant, significance of between-category differences was tested using a post-hoc Tukey test.

To test whether respondents who indicated more positive opinions of brownfield sites also selected more positive keywords and more wildlife-related keywords (question 2), we constructed two GLMs with a Gaussian error distribution, with opinion (on a Likert scale) as the independent variable, and keyword score and number of wildlife-related keywords respectively as dependent variables. The significance of overall models and between-category differences was tested as above.

To investigate whether respondents' opinions of sites in photographs were affected by actual or perceived site type (questions 4-5), we conducted Pearson's chi-squared tests. To test the effect of actual site type, we compared the frequency of each response on the Likert scale between photographs of brownfield sites and photographs of undeveloped sites. To test the effect of perceived site type, we split the dataset to separate responses to photographs of brownfield sites and responses to photographs of undeveloped sites, and for each site type, compared the frequency of each response on the Likert scale between cases where the respondent had guessed the photograph depicted a brownfield site, and those where they guessed an undeveloped site was depicted. We additionally tested whether respondents were better than chance at identifying whether sites were brownfields or undeveloped from photographs by conducting exact binomial tests on the proportion of correct guesses; and whether the likelihood of a correct guess was affected by a respondent's opinion of brownfield sites, by constructing a GLM with a binomial error distribution, with opinion as the independent variable and guess (correct/incorrect) as a binomial dependent variable. Model significance was tested using a Likelihood Ratio Test (LRT).

To test whether respondents associated various key phrases more with some site types than others (question 6), we constructed a GLMM for each key phrase separately. Models had a binomial error distribution, with site type and response (agree/do not agree) as the independent and dependent variable respectively, and respondent identifier as a random effect. In each case, overall model significance was tested using an LRT, and significance of between-category differences was tested using a post-hoc Tukey test.

To investigate whether respondents ranked various options for repurposing sites as more or less preferred (question 7), we constructed and tested a GLMM as above, with land use option (one of eight) and ranking (1-8) as the independent and dependent variable respectively, and respondent identifier as a random effect. To test whether these rankings were affected by site type ('brownfield' vs 'undeveloped') and site wildlife value ('little value to wildlife' vs 'rich in wildlife'), we conducted a series of tests. For each of the eight repurposing options, we separately tested whether the option's ranking was affected by site type and by site wildlife value using both a paired t-test and a paired Wilcoxon signed-rank test. We conducted both types of test because the t-tests allowed us to obtain (and compare) effect sizes, but the non-parametric Wilcoxon tests gave us greater certainty about significance (or otherwise) of effects, given that for some repurposing options, the distribution of rankings was non-normal (for example, 'no change' had a bimodal distribution of rankings, tending to be ranked as either one of the most preferred options, or one of the least preferred, with respondents rarely placing it as an intermediate option). Nevertheless, both tests produced the same qualitative (significant vs non-significant) outcome in all cases. Rankings were paired both within respondent identifier and within-category for the non-focal variable, such that we compared each respondent's ranking of the same repurposing option for sites described

differently for the focal variable only (for example, 'a brownfield site, with little value to wildlife' compared to 'a brownfield site, rich in wildlife', and so on).

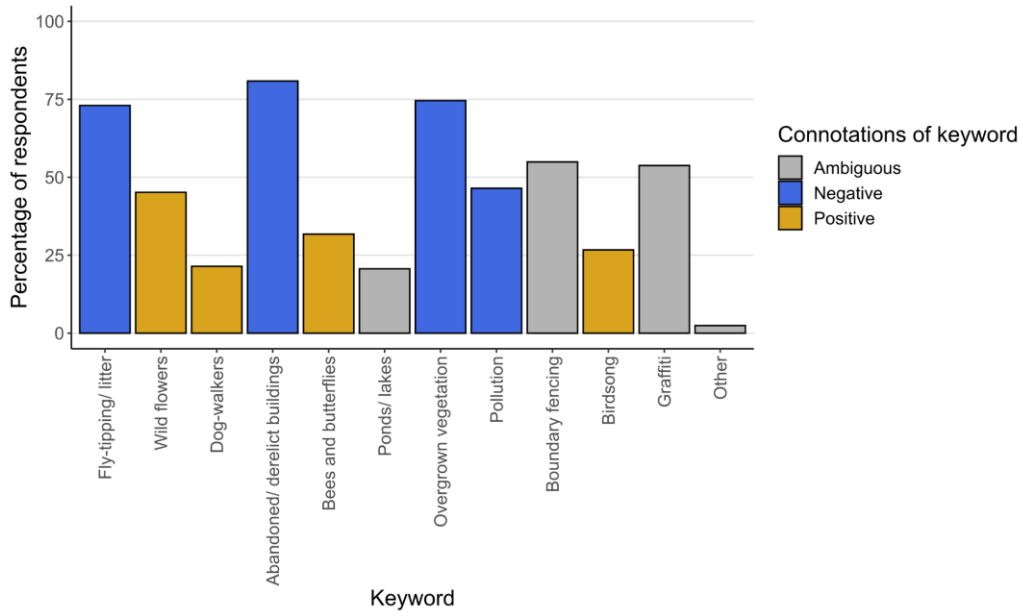
Results

This section is structured around the seven questions/themes through which we analysed the results.

General views of respondents on brownfield sites (questions 1-3)

Overall, the most selected keywords were 'Abandoned/derelict buildings' (selected by 80.9 per cent of respondents), 'Overgrown vegetation' (74.6 per cent) and 'Fly-tipping/litter' (73.0 per cent), all of which were expected to carry negative connotations. A much higher proportion of respondents selected keywords with negative connotations than positive connotations, whilst ambiguous keywords that could be interpreted as either positive or negative were generally intermediate in frequency of selection (Fig. 2). Respondents who selected 'other' described a range of negative features (for example, 'abandoned machinery and vehicles', 'broken ground', 'drug use paraphernalia', and 'hazardous material - chemicals'), and a smaller number of positive features, which were almost exclusively associated with biodiversity (for example, 'bats', 'invertebrates', and 'trees'), and occasionally indicated a significant level of knowledge about natural history (for example, 'often very rare flora - [especially] bryophytes').

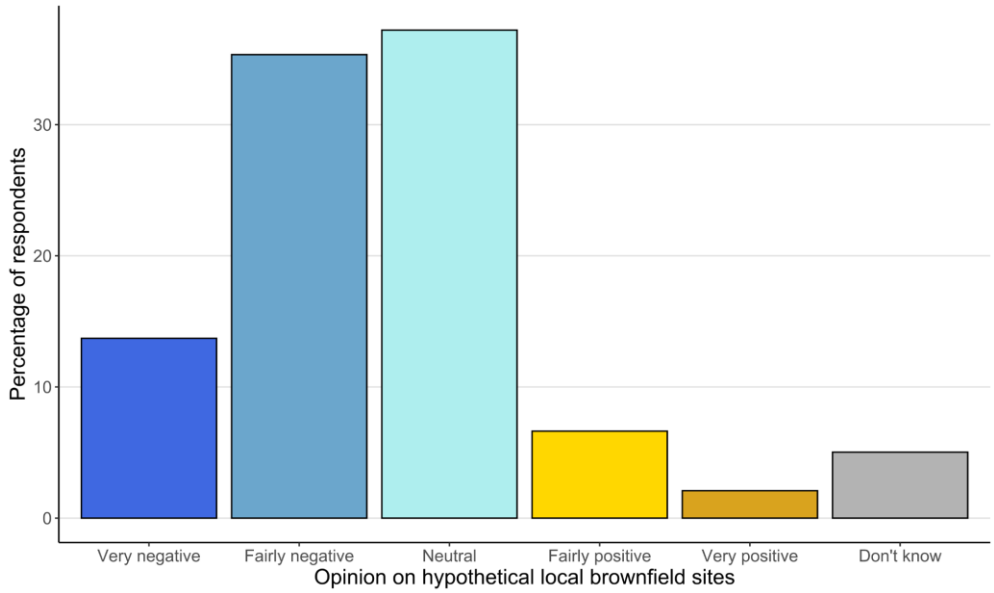
Figure 2: Selection of keywords with different connotations



Note: A greater percentage of respondents selected keywords with negative connotations (blue) to those with positive connotations (orange) to describe brownfield sites, with ambiguous keywords (grey) intermediate. Terms are organised in the same arbitrary order in which they were presented to respondents. Question asked: 'Based on [a definition of brownfield sites] above and your own knowledge, please picture a typical brownfield site. Which, if any, of the following features do you think this site has?'

Overall, the majority of respondents felt either 'Neutral' (37.2 per cent of respondents) or 'Fairly negative' (35.3 per cent) about the idea of having a brownfield site in their local area (Fig. 3), compared to less than ten per cent who felt either fairly or very positive. When asked why, respondents who felt negatively about brownfield sites cited concerns around their appearance (for example, 'eyesore', 'unsightly', 'ugly'; 43 per cent of the 1,094 respondents who felt 'Fairly negative' or 'Very negative'), utility (for example, 'waste of space', 'unused land', 'could be redeveloped'; 31 per cent), or facilitation of undesirable activities (for example, 'crime', 'antisocial behaviour'; 18 per cent). Respondents who felt positively about brownfield sites were evenly split between those who cited the biodiversity value of such sites (for example, 'provides natural habitat', 'wildlife', 'return to nature'; 27 per cent of the 192 respondents who felt 'Fairly positive' or 'Very positive') and those who instead viewed such sites as providing opportunities for future development (for example, 'waste land put to good use', 'regeneration', 'improvement'; 25 per cent). Biodiversity value was also the most commonly cited factor amongst those who felt 'Neutral' (for example, 'consideration for nature', 'wildlife', 'good for environment', 'nature takes over'; 14 per cent of 831 respondents).

Figure 3: Respondents' opinions on hypothetical local brownfield sites

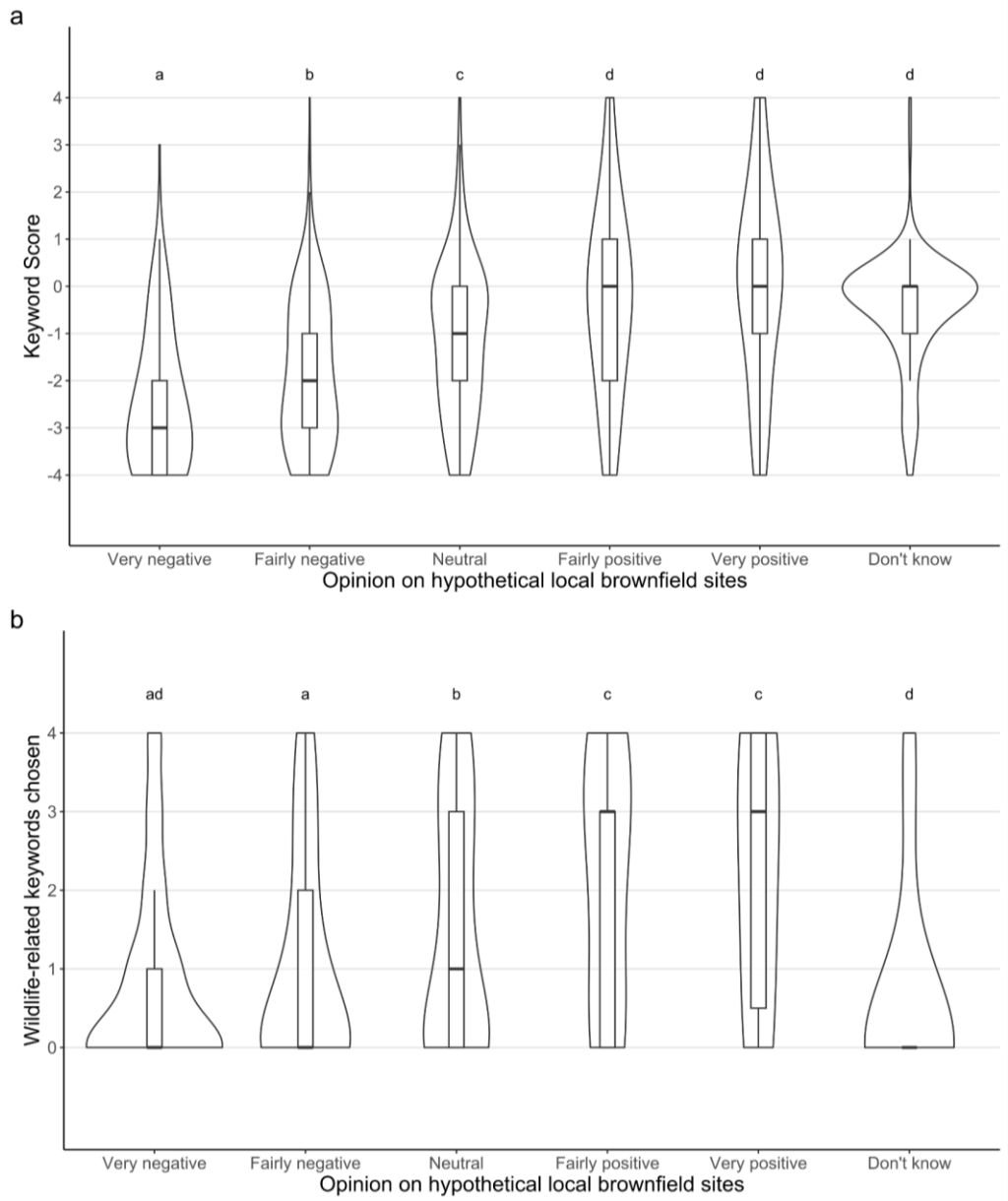


Note: The vast majority of respondents rated their opinion as either 'Neutral' or 'Fairly negative' about the idea of a brownfield site in their local area. Question asked: 'In general, how positive or negative would/do you personally feel about the presence of a site like this in your local area?'.

There was some relationship between socio-demographic factors and these opinions, albeit with very small effect sizes. Specifically, those aged 55+ and retired people had slightly more negative opinions about brownfield sites than younger age groups and those in employment (effect of age: $F = 4.37$, $P = 0.0016$; effect of employment status: $F = 3.19$, $P = 0.0071$), and those in social grade ABC1 ('middle class', defined by the occupation of their household's chief income earner being managerial, administrative or professional) had slightly more negative opinions than those in social grade C2DE ('working class', chief income earner's occupation is skilled or unskilled manual or casual work; effect of social grade: $F = 3.89$, $P = 0.0488$). We found no significant effect of self-identifying with any of the key stakeholder groups investigated.

Respondents who had more positive opinions about brownfield sites also tended to select more wildlife-related keywords ($F = 34.44$, $P < 0.0001$), whereas respondents who had more negative opinions about brownfield sites selected more keywords with negative connotations ($F = 77.37$, $P < 0.0001$; Fig. 4).

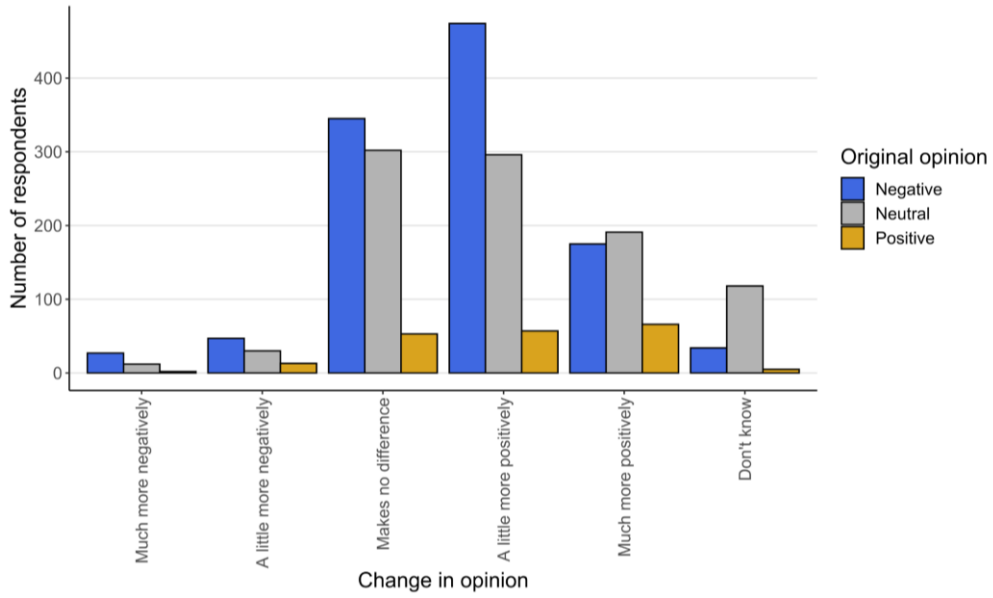
Figure 4: Associations between respondents' opinions on, and selected keywords to describe, brownfield sites



Note: Respondents who rated their opinion about brownfield sites more negatively on a Likert scale (Fig. 3) also tended to (a) have a more negative keyword score based on the keywords they selected to describe such sites (Fig. 2), and (b) select fewer keywords related to wildlife. Violin plots indicate the relative density of points. Box-and-whisker plots show the location of the median and quartiles. Letters indicate the significance of post-hoc Tukey tests comparing between categories; categories do not differ significantly from each other if they share a letter.

The majority of respondents answered that provision of information about wildlife that may be living on a brownfield site would make them feel either 'a little more positively' (36.8 per cent of respondents) or 'much more positively' (19.2 per cent) about the site (Fig. 5). Respondents' answers were significantly related to their originally stated opinion on the idea of a local brownfield site (X^2 = 131.92, d.f. = 10, P < 0.0001), with those who had previously expressed a negative opinion of brownfield sites being more likely to select 'a little more positively', and those who had previously expressed a positive opinion being more likely to select 'much more positively'.

Figure 5: Effect of wildlife information provision on opinion

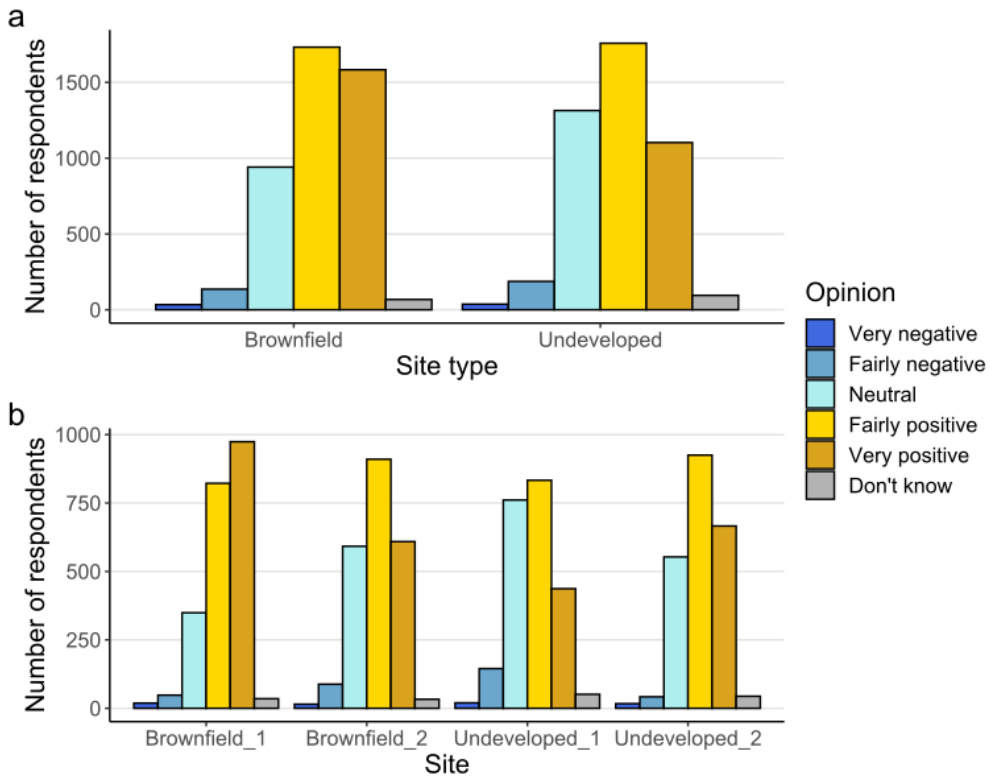


Note: The majority of respondents answered that provision of information about wildlife that is living on a brownfield site would make them feel more positively about that site. Question asked: 'How much more positively or negatively would you feel about the presence of a brownfield site in your local area, if information was provided about possible wildlife that may live within this site, or would it make no difference?'

Opinions of respondents on photographs of brownfield and undeveloped sites (questions 4-5)

Contrary to our expectations, respondents gave significantly more positive opinions about photographs of brownfield sites than photographs of undeveloped sites (Fig. 6; X^2 = 160.32, d.f. = 5, P < 0.0001). However, this effect appeared to be driven by particularly high rates of positive responses to one of the two brownfield sites in particular, rather than necessarily an overall effect (Fig. 6b).

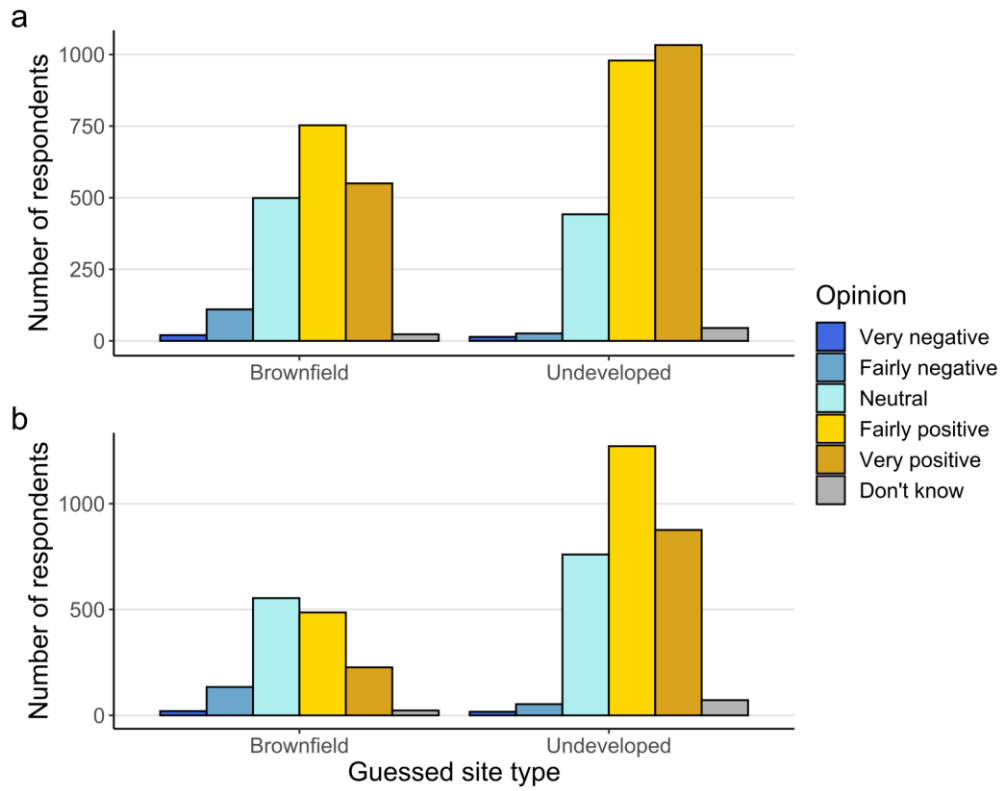
Figure 6: Respondents' opinions on photographs of brownfield and undeveloped sites



Note: (a) Respondents reacted more positively to photographs of brownfield sites than undeveloped sites, but (b) this effect was primarily driven by a high rate of positive responses to site 'Brownfield_1' and a relatively lower rate of positive responses to site 'Undeveloped_1' (Fig. 1). Question asked (each photograph shown in turn): 'How positive or negative would you feel about the presence of [the depicted] site in your local area?'

When responding to photographs of the two brownfield sites, respondents rated their opinion as 'Very positive' significantly more often for photographs that they guessed showed an undeveloped site, and as 'Neutral' or 'Fairly negative' more often for photographs that they guessed showed a brownfield site (Fig. 7). This held true regardless of whether the photograph actually showed a brownfield site ($X^2 = 167.31$, d.f. = 5, $P < 0.0001$) or an undeveloped site ($X^2 = 289.19$, d.f. = 5, $P < 0.0001$).

Figure 7: Associations between respondents' opinions on photographs and guessed site types



Note: Respondents reacted more positively to photographs that they guessed depicted undeveloped sites than those that they guessed depicted brownfield sites, both for (a) photographs that actually depicted brownfield sites and (b) photographs that actually depicted undeveloped sites. Questions asked (each photograph shown in turn): (i) 'How positive or negative would you feel about the presence of the site in your local area?'; (ii) 'Still thinking about the image and the previous description of a 'Brownfield site', do you think this is a brownfield site?'

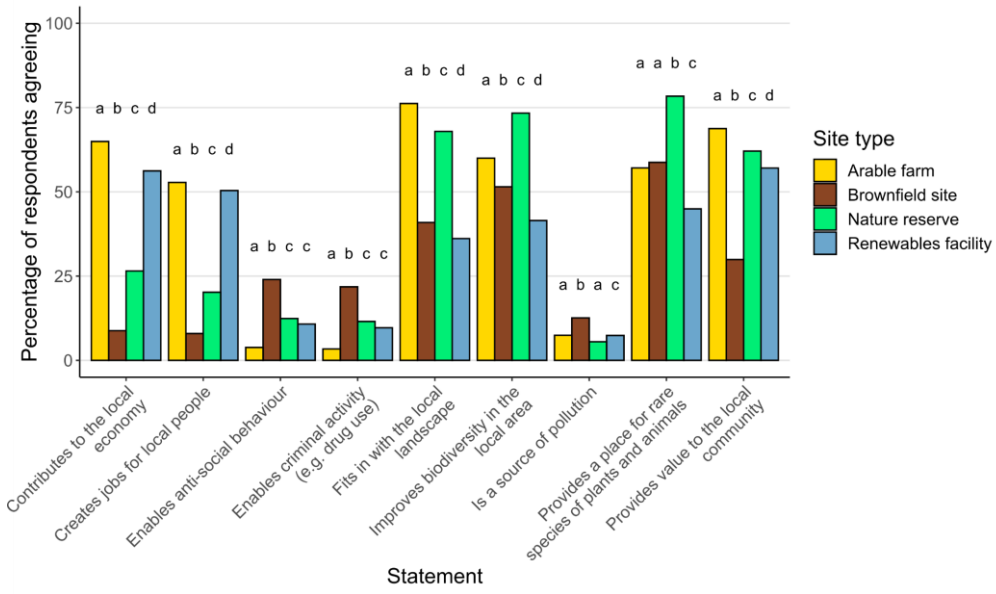
Overall, respondents performed marginally better than chance when asked to guess whether each of the four photographs depicted a brownfield site or an undeveloped site (Exact binomial test, *n* trials = 8988, *n* successes = 5005, $P < 0.0001$), but with a caveat. For all four sites, more than half of respondents identified the site as being undeveloped. For three out of four sites, including both brownfield sites, approximately 55-60 per cent of respondents guessed the site was undeveloped. The exception was site 'Undeveloped_2', which 79.0 per cent of respondents correctly identified as undeveloped. Excluding the latter site, respondents only guessed correctly in 47.9 per cent of cases, which was significantly *worse* than chance (Exact binomial test, *n* trials = 6741, *n* successes = 3229, $P = 0.0006$). Respondents' positive or negative opinion of brownfield sites had no influence on their chance of identifying such sites correctly ($X^2 = 2.592$, $P = 0.7626$).

Opinions of respondents on benefits/disbenefits of various site types (question 6)

For all nine available key phrases (see Fig. 8 legend), site type significantly affected the proportion of respondents who agreed with the statement (Fig. 8). In comparison to arable farms, nature reserves, and renewable energy facilities, brownfield sites were

considered by fewer respondents to contribute to the local economy, create jobs, and/or provide value to the local community; but by more respondents to enable anti-social behaviour and criminal activity, and create pollution. Brownfield sites were considered to fit into the landscape, improve biodiversity, and provide a place for rare species by more respondents than renewable energy facilities, but by fewer than nature reserves; in comparison to arable farms, brownfield sites were considered to fit into the landscape and improve biodiversity by fewer respondents, but to provide a place for rare species by an equal number.

Figure 8: Respondents' associations between key phrases and site types



Note: Respondents associated key phrases differently with brownfield sites than with other site types. Bars show the percentage of respondents who agreed with each key phrase when applied to one of four site types. Letters indicate the significance of post-hoc Tukey tests comparing between site types for the same key phrase; respondents agreed with the key phrase with equal frequency for two site types if they share a letter. Question asked (each photograph shown in turn): 'Below is a picture of a [site type]. Based on the image and imagining that this site was in your local area, to what extent do you agree or disagree with each of the following statements?'.

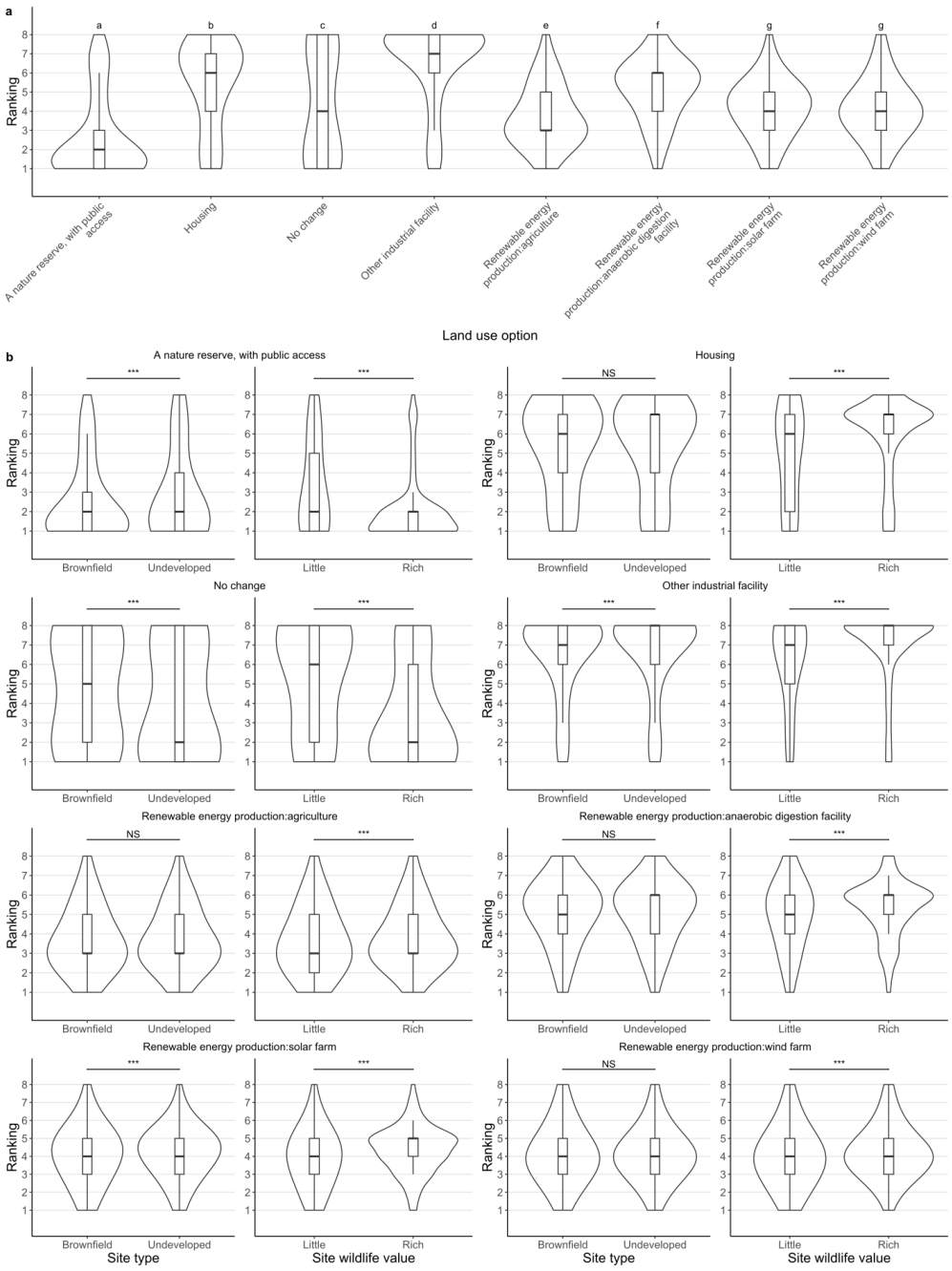
Preferences of respondents for repurposing sites, given site type and wildlife value (question 7)

When considering hypothetical repurposing of sites, on average, respondents ranked nature reserves as their most preferred option (Fig. 9a), followed by all four renewable energy options (with 'agriculture' most preferred of these). Industrial use was ranked lowest, whilst 'no change' (that is, leaving a site in its current unmanaged condition) was ranked at the extremes of the scale by most respondents, with few placing it as an intermediate choice.

However, rankings of different repurposing options were affected by both site type ('brownfield vs undeveloped') and site wildlife value ('little value to wildlife' vs 'rich in wildlife'). Perhaps surprisingly, respondents showed greater support for brownfield sites to be repurposed as nature reserves than undeveloped sites (Fig. 9b), and also ranked industrial uses and solar farms higher on brownfield sites than on undeveloped sites, whilst ranking 'no change' higher on undeveloped sites than on brownfield sites.

Respondents ranked nature reserves and 'no change' much higher on sites rich in wildlife compared to those with little value to wildlife, whereas all six options that involved site development were ranked higher on sites with less value to wildlife. Effect sizes (that is, average differences between rankings within each comparison) were much larger for the effect of rich vs poor in wildlife (site wildlife value) than the effect of brownfield vs undeveloped site (site type), indicating that the former variable invoked stronger changes in preference than the latter.

Figure 9: Associations between site type and respondents' preferences for site use



Note: (a) Respondents ranked nature reserves highest and industrial use lowest overall when considering options for hypothetical repurposing of sites, but (b) respondents' preferences depended on both site type ('brownfield' vs 'undeveloped') and site wildlife value ('little value to wildlife' vs 'rich in wildlife'). Preferences were ranked from most preferred 1 to 8 where 1 is 'Most preferred' and 8 is 'Least preferred', so options with more responses at lower numbers were ranked as more preferred by respondents. Violin plots indicate the relative density of points. Box-and-whisker plots show the location of the median and quartiles. In panel (a), letters indicate the significance of post-hoc Tukey tests comparing between categories; categories do not differ significantly from each other if they share a letter. In panel (b), significance indicates the consensus outcome of both a paired t-test and a paired Wilcoxon signed-rank test comparing each respondents' ranking of the same repurposing option for sites described differently for the focal variable only. Question asked (four site descriptions, see methods): 'On a scale of 1 to 8, where '1' is 'Most preferred' and '8' is 'Least preferred', please rate what you think personally a [site description] should be used for?'.

Insights from open question

At the end of the survey, respondents were given the opportunity to 'let us know if there is anything else you would like to say about this topic (e.g. brownfield sites, undeveloped sites, use of the land in the UK, etc.)'. Approximately 1,000 respondents (out of 2,247, 45 per cent) gave a substantive response to this question (that is, answered more fully than 'don't know', 'n/a', and so on; albeit some answers referred to the survey structure or implementation rather than its topic). Answers given in response (archived alongside R code in Zenodo; doi: 10.5281/zenodo.11313478) to this provide a number of useful insights that reflect and reinforce our main findings, or highlight other areas for consideration. These are discussed in full in discussion, below.

Discussion

Perceptions of brownfield sites

Most respondents expressed negative, or at best neutral, opinions when asked to 'picture a typical brownfield site', and these opinions were reflected in their choices of keywords describing features they pictured on the site, which tended to include more negative than positive features. Analysis of socio-demographic variables revealed that negative opinions were marginally more prevalent in the 55+ age group, among retired people, and among social grade ABC1 than other groups. The former two variables are clearly correlated with each other, since most retirees are aged 55 and above, but why this group should feel more negatively about brownfield sites is uncertain. The more positive opinions among social grade C2DE are perhaps surprising, given that members of this group may be more likely to live in more deprived urban areas (Scott et al., 2007; Office for National Statistics, 2011), in closer proximity to brownfield sites. However, it is possible that under such circumstances, brownfield sites might represent a valuable urban resource of open space for exercise or recreation; this nature of brownfield site usage was raised by several respondents in answer to the final, open question (see 'Insights from open question', below). This research was conducted in a UK context, but social and cultural settings may influence people's priorities, so further work is necessary to establish to what extent our findings are applicable in other national contexts. Even within the UK, the introduction since our survey was conducted of a policy of Biodiversity Net Gain, whereby any development, whether on brownfield or undeveloped sites, needs to provide evidence to support a net positive influence on a statutory biodiversity metric (DEFRA, 2024), may have some influence on public thinking with regards to which sites should be developed first and in what way.

When shown photographs of areas of semi-natural habitat on both brownfield and undeveloped sites, respondents rated sites that they *guessed* were brownfield sites more negatively than those that they guessed were undeveloped sites, regardless of the sites' actual history of development. This is consistent with well-documented negative perceptions and depressed value of brownfield sites and contaminated land shown in previous research (for example, Eisen, 2015). Due to the order in which questions were presented to respondents (Appendix 1, in Zenodo data archive), it is more probable that this was due to respondents being more likely to guess a site was a brownfield site if they had previously rated it more negatively, as opposed to respondents being more likely to rate a site more negatively if they already suspected it was a brownfield site. Either way, these results indicate a clear stigma or negative bias against brownfield sites, such that respondents drew an association between the 'brownfield site' label and sites that they viewed less positively. Despite this, respondents tended to rank photographs of brownfield sites more positively than undeveloped sites, but it is not possible to draw robust conclusions directly from this finding, because respondents were only shown images of two brownfield and two undeveloped sites, all in rural locations and under management as nature reserves, and differing in a host of covariates (including weather conditions and time of year); indeed, reactions to sites 'Brownfield_2' and 'Undeveloped_2' were very similar (Fig. 6).

Survey results also suggested that this stigma might be linked to a general lack of awareness of the potential biodiversity value of brownfield sites. Three out of four keywords with positive connotations (Fig. 2), as well as the ambiguous 'Ponds/lakes', were connected to biodiversity, but these were among the least-selected by respondents, reflecting previous research that found brownfields to be associated with terms such as 'rubbish-strewn' (Mathey et al., 2018). By comparison to other site types, it was unsurprising that fewer respondents agreed that brownfield sites were beneficial to biodiversity than nature reserves (key phrases 'Improves biodiversity in the local area' and 'Provides a place for rare species of plants and animals'); but more unexpected that brownfield sites were outperformed by arable farms in this regard (fewer respondents selecting the former phrase, and a similar number selecting the latter). This appears to be an unfavourable comparison, given that brownfield sites are frequently acknowledged to be beneficial to ecological assemblages and communities as a whole (Eyre et al., 2003; Macgregor et al., 2022) and to conservation of certain rare species (for example, Tropek et al., 2010; Broughton et al., 2021), whereas intensive agricultural practices are frequently implicated in driving species declines (Benton et al., 2002; Ewald et al., 2015; Gilburn et al., 2015; Azam et al., 2016; Woodcock et al., 2016; Habel et al., 2019; Seibold et al., 2019) and often cited among the most important contemporary drivers of environmental change, both at the UK-scale and globally (Burns et al., 2016; IPBES, 2016; Vellend et al., 2017; Wagner, 2020). This result suggests that the policy of prioritising development of brownfield sites over agricultural land is in line with public opinion, albeit the latter may be out of touch with scientific evidence (Cox & Rodway-Dyer, 2023).

However, our results also suggest that public education on the benefits of brownfield sites to biodiversity could substantially reduce the bias against such sites. The majority of respondents indicated they would feel more positively about a brownfield site if information about the wildlife inhabiting it were made available (Fig. 5). In general, respondents who felt 'fairly positive' or 'very positive' about brownfield sites were much more likely to have indicated awareness of the ecological value of such sites through selection of wildlife-related keywords. Moreover, such respondents typically selected negative keywords as well (Fig. 4a; median keyword score = 0), suggesting that they felt the biodiversity value outweighed any downsides. Together, these results suggest that even limited awareness of the biodiversity value of brownfield sites can mitigate negative opinions (Fig. 4). Environmental education can improve attitudes towards nature in

general (for example, Sellmann & Bogner, 2013; Sousa et al., 2016), but future research could assess whether this is effective in the highly stigmatised context of brownfield sites.

Repurposing of brownfield sites

With regards to the prioritisation of different alternative land uses, our results showed that wildlife value had a much stronger impact on respondents' priorities than did site type (Fig. 9). In particular, wildlife value affected whether respondents felt sites should be developed at all (comparing the 'no change' option to others), with 'no change' ranking second on average (behind only 'nature reserve') for sites that were rich in wildlife, but second-last (to 'other industrial') for sites with little value to wildlife. Comparisons between responses for brownfield and undeveloped sites were associated with much smaller effect sizes, but on average respondents ranked industrial uses and solar farms higher on brownfield sites, but 'no change' higher on undeveloped sites. Nature reserves were much more strongly preferred on sites that were rich in wildlife and, surprisingly, marginally more preferred on brownfield sites than on undeveloped sites (perhaps indicating a trade-off between nature reserves and 'no change' that was influenced by each site's history of development). Despite being ranked close to least preferred on average, housing was the first preference of a sizeable minority of respondents, but primarily on sites with little value to wildlife, suggesting that many people would prefer more space for wildlife than more housing in their local area. Renewable energy production options were all preferred on average to housing and other industrial uses; among these options, most respondents preferred agriculture associated with renewables (for example, biocrops) to wind or solar farms, which in turn were preferred to anaerobic digestion facilities (Fig. 9a). This order of preferences, across all options and especially within the four renewable energy production options, appears to reflect a gradient from least to most industrialised. The general order of preference is similar to that identified in previous studies (Karlstrøm & Ryghaug, 2014; Bertsch et al., 2016; Masood & Russo, 2023), and reflects that variation in acceptance of renewable energy technology by local people is related to the degree of landscape modification required for each technology, or the extent to which a technology 'fits' within the landscape (Bergmann et al., 2008; Bertsch et al., 2016; Salak et al., 2021).

These findings indicate widespread support for measures that conserve biodiversity when making planning decisions (especially in light of our findings that people feel favourably towards, but are often unaware of, the biodiversity value of brownfield sites). Nature reserves were top-ranked on average in all site types (Fig. 9), but assuming development must take place somewhere, rankings for both these and the 'no change' option indicate that respondents would prefer land to be conserved based on its actual wildlife value, rather than simply because it has not previously been developed. The loss to development of wildlife-rich brownfield sites, on the basis of their history of development making them a priority for repurposing, would not necessarily be the preference of most people in Britain.

Insights from open question

Many respondents used the final open question to note the complexity of the issues under consideration; for example, 'The definition of a 'brownfield site' encompasses too large a range of possible attributes of an area of land to be useful in designating how land should be redeveloped, for e.g., setting a target on the number of brownfield sites to be redeveloped' and 'Brownfield sites are complex and each one is different', reflecting similar arguments made by experts in brownfield redevelopment (Loures & Vaz, 2018). Nonetheless, some specifically highlighted the distinction between urban

and rural brownfield sites as being crucial, but the direction of stated preferences was not consistent. Some saw urban brownfield sites as being more likely to have little value to wildlife; for example, 'Brownfield sites in cities and towns should be used before ones in more open areas where there is rich wildlife' and 'It seems sensible to develop urban brownfields especially for housing – but it is a different matter in the countryside'. Others argued that urban brownfield sites provide much-needed open space as a community resource; for example, 'Many brownfield sites, near large urban areas, would be better turned into green spaces to add nature and wildlife to heavily built up areas' and 'The last 12 months [referring to the COVID-19 pandemic] has shown how much people appreciate places to walk when they live in a highly populated area, and one of these places locally was a brownfield site'. This reflects studies showing a general desire for access to urban green space for recreational purposes (Loures et al., 2016; De Valck et al., 2019), which increased during and after the COVID-19 pandemic (Venter et al., 2021). The potential value of brownfield sites as community resources of open space was also raised more broadly; for example, 'I live in an area with many brownfield sites that have been turned into nature reserves and country parks. They are wonderful places and heavily used by the local communities'. Availability of urban green space is increasingly a priority for planners (Ahmadpoor & Shahab, 2021), and these comments reflect that cultural ecosystem services can be provided by brownfield sites as places to exercise and to interact with nature, both in rural and especially urban settings; these may be just as important as their value to biodiversity itself as an argument for preserving such sites.

A substantial number of respondents expressed views that brownfields should always be developed as a priority in order to spare green belts and undeveloped sites, which matches current policy; for example, 'Brownfield sites should be the first to be redeveloped rather than building on green belt land which should be protected at all costs'. However, many others expressed views which more closely reflected our main finding, that wildlife value can carry more importance than brownfield status, and should be taken into account when considering a site's future; for example, 'Brownfield sites should be used sensitively with awareness of wildlife, flora and fauna. Research should be carefully undertaken before using such sites' and 'If the area is rich in wildlife, developed or not, it should be preserved for wildlife'. This suggests that the public would be open to more flexible policy targets that encouraged brownfield site repurposing, but considered each site on its own merits with respect to biodiversity and (cultural and other) ecosystem services; the new policy of Biodiversity Net Gain in the UK (DEFRA, 2024) may prove to be a mechanism towards achieving this goal. This raises the further question of whether other factors that might confer value on brownfield sites (for example, historical or cultural significance) might also influence public preferences around their future usage (Wheeler, 2014; Crane et al., 2017).

Our survey results also indicated that there is a stigma attached to brownfield sites, and a lack of awareness of their potential biodiversity value. Several respondents directly highlighted misconceptions or stereotypes that are often held about brownfield sites; for example, 'I wasn't aware that brownfield sites had often been repossessed by nature'. Others drew attention to the term 'brownfield' itself as problematic; for example, 'Some sites described as brownfield sites have been reclaimed by nature (e.g., old quarries) [so] perhaps the definition of 'brownfield' needs revising' and 'The name brownfield is misleading - brownfield [sites] can be green and greenfield sites brown!'. Related to this, some respondents specifically expressed surprise that none of the four photos they had been asked to give opinions on appeared to fit their vision of what a brownfield site looks like; for example, 'Sites where there are remnants of the original development (abandoned buildings, debris etc.)... cause most concern. None of the sites in the photos was an eyesore' and 'I am a supporter of developing brownfield sites in city centres, but the images tended to indicate more rural locations which I would be less supportive to

see turned into housing or an industrial estate'. These comments, combined with the wider results of our survey, indicate that education about the diversity of rural and urban brownfield sites and the potential benefits of many brownfield sites could alleviate the blanket stigma attached to sites labelled as brownfields, given that even small amounts of environmental education can lead to long-term improvements in attitudes towards nature (Sellmann & Bogner, 2013; Sousa et al., 2016). Potentially, this could lead to greater public support for determining planning decisions on a case-by-case basis rather than prioritising brownfield sites over others for development.

Conclusions

Overall, our results show that in a UK context, people with greater awareness of the biodiversity value of brownfield sites tend to feel more positively about them, indicating that education about the potential for such sites to support wildlife and provide ecosystem services might go some way towards rehabilitating brownfields in the court of public opinion. Even without such education, people placed much greater importance on a site's current value to wildlife than on its history of development when considering options for its repurposing; people preferred sites that are rich in wildlife to be left unchanged or managed as nature reserves rather than repurposed for housing, industry or renewable energy production, regardless of whether they were brownfield sites or not. A more nuanced understanding of the value of a brownfield site is needed - they should not be automatically considered as priorities for development, as the definition of brownfield sites is so broad that, in reality, they are far more diverse in character than is associated with the term 'brownfield site' by many members of the public. Planning decisions that focus on a site's status as a brownfield site, leading to development taking place on ecologically-valuable sites, are unlikely to meet the preferences of local people; meaningful community consultation may provide the necessary information for an informed decision. More broadly, policies focusing on the prioritised use of brownfield sites may need reconsideration, not just to protect biodiversity on such sites but also to find other locations for necessary redevelopment (incorporating both social and environmental priorities).

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Authors' contributions

This study was instigated and designed by all authors. The survey questions were written by C.J.M. in consultation with all authors and other collaborators. The statistical analysis was conducted by C.J.M., who also prepared the first draft of the paper. All authors contributed substantially to revising the paper.

Competing interests

The authors declare no competing interests. However, note that this work was completed prior to C.J.M.'s employment by the British Trust for Ornithology (BTO), which is an

impartial organisation. Therefore, any views on policy expressed in this manuscript should not be taken as the views of the BTO.

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References

Ahmadpoor, N., & Shahab, S. (2021). Urban form: Realising the value of green space: a planners' perspective on the COVID-19 pandemic. *Town Planning Review*, *92*(1), 49-55. https://doi.org/10.3828/tpr.2020.37

Amati, M., & Yokohari, M. (2006). Temporal changes and local variations in the functions of London's green belt. *Landscape and Urban Planning*, *75*(1-2), 125-142. https://doi.org/10.1016/j.landurbplan.2004.12.007

Azam, C., Le Viol, I., Julien, J.-F., Bas, Y., & Kerbiriou, C. (2016). Disentangling the relative effect of light pollution, impervious surfaces and intensive agriculture on bat activity with a national-scale monitoring program. *Landscape Ecology*, *31*, 2471-2483. https://doi.org/10.1007/s10980-016-0417-3

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1), 1-48.

Benton, T.G., Bryant, D.M., Cole, L., & Crick, H.Q.P. (2002). Linking agricultural practice to insect and bird populations: a historical study over three decades: Farming, insect and bird populations. *Journal of Applied Ecology*, *39*(4), 673-687. https://doi.org/10.1046/j.1365-2664.2002.00745.x

Bergmann, A., Colombo, S., & Hanley, N. (2008). Rural versus urban preferences for renewable energy developments. *Ecological Economics, 65*(3), 616-625. https://doi.org/10.1016/j.ecolecon.2007.08.011

Bertsch, V., Hall, M., Weinhardt, C., & Fichtner, W. (2016). Public acceptance and preferences related to renewable energy and grid expansion policy: Empirical insights for Germany. *Energy*, *114*, 465-477. https://doi.org/10.1016/j.energy.2016.08.022

Broughton, R.K., Parry, W., & Maziarz, M. (2021). Wilding of a post-industrial site provides a habitat refuge for an endangered woodland songbird, the British Willow Tit Poecile montanus kleinschmidti. *Bird study*, *67*(3), 269-278. https://doi.org/10.1080/00063657.2020.1863333

Burns, F., Eaton, M.A., Barlow, K.E., Beckmann, B.C., Brereton, T., Brooks, D.R., Brown, P.M.J., Al-Fulaij, N., Gent, T., Henderson, I., Noble, D.G., Parsons, M., Powney, G.D., Roy, H.E., Stroh, P., Walker, K., Wilkinson, J.W., Wotton, S.R., & Gregory, R.D. (2016) Agricultural Management and Climatic Change Are the Major Drivers of Biodiversity Change in the UK. *PloS one, 11*, e0151595. https://doi.org/10.1371/journal.pone.0151595

Cox, L., & Rodway-Dyer, S. (2023). The underappreciated value of brownfield sites: motivations and challenges associated with maintaining biodiversity. *Journal of Environmental Planning and Management, 66*(9), 2009-2027. https://doi.org/10.1080/09640568.2022.2050683

Crane, R.A., Sinnett, D.E., Cleall, P.J., & Sapsford, D.J. (2017). *Physicochemical composition of wastes and co-located environmental designations at legacy mine sites in the south west of England and Wales:* Implications *for their resource potential. Resources, Conservation and Recycling*, *123*, 117-134. https://doi.org/10.1016/j.resconrec.2016.08.009

DEFRA. (2024). *Understanding biodiversity net gain* [WWW Document]. GOV.UK. URL https://www.gov.uk/guidance/understanding-biodiversity-net-gain

De Sousa, C., Carroll, A.M.M., Whitehead, S., Coffin, S., Heberle, L., Hettiarachchi, G., Martin, S., Sullivan, K., & Van Der Kloot, J. (2023). A review of brownfields revitalisation and reuse research in the US over three decades. *Local Environment, 28*(12), 1629-1654. https://doi.org/10.1080/13549839.2023.2248625

De Valck, J., Beames, A., Liekens, I., Bettens, M., Seuntjens, P. & Broekx, S. (2019). Valuing urban ecosystem services in sustainable brownfield redevelopment. *Ecosystem Services, 35,* 139-149.

Dixon, T. (2006). Integrating sustainability into brownfield regeneration: Rhetoric or reality? – an analysis of the UK development industry. *Journal of Property Research, 23*, 237-267. https://doi.org/10.1080/09599910600933889

Eisen, J.B. (2015). Stigmatized sites and urban brownfield redevelopment. In J.M. Duke, & J. Wu (Eds.), *The Oxford Handbook of Land Economics* (p. 648). Oxford University Press, Oxford, UK.

Ewald, J.A., Wheatley, C.J., Aebischer, N.J., Moreby, S.J., Duffield, S.J., Crick, H.Q.P., & Morecroft, M.B. (2015). Influences of extreme weather, climate and pesticide use on invertebrates in cereal fields over 42 years. *Global Change Biology, 21*(11), 3931-3950. https://doi.org/10.1111/gcb.13026

Eyre, M.D., Luff, M.L., & Woodward, J.C. (2003). Beetles (Coleoptera) on brownfield sites in England: An important conservation resource? *Journal of Insect Conservation, 7*, 223-231. https://doi.org/10.1023/B:JICO.0000021020.66549.1e

Fischer, L.K., Neuenkamp, L., Lampinen, J., Tuomi, M., Alday, J.G., Bucharova, A., Cancellieri, L., Casado-Arzuaga, I., Čeplová, N., Cerveró, L., Deák, B., Eriksson, O., Fellowes, M.D.E., Fernández de Manuel, B., Filibeck, G., González-Guzmán, A., Hinojosa, M.B., Kowarik, I., Lumbierres, B., … Klaus, V.H. (2020). Public attitudes toward biodiversity-friendly greenspace management in Europe. *Conservation Letters, 13.* https://doi.org/10.1111/conl.12718

Fletcher, R.J., Jr, Robertson, B.A., Evans, J., Doran, P.J., Alavalapati, J.R.R., & Schemske, D.W. (2011). Biodiversity conservation in the era of biofuels: risks and opportunities. *Frontiers in Ecology and the Environment, 9*, 161-168. https://doi.org/10.1890/090091

Gao, J. (2023). Spatial restructuring and the logic of industrial land redevelopment in urban China: IV. A case study of jointly redevelopment by multi-actors. *Regional Sustainability, 4*(1), 44-53. https://doi.org/10.1016/j.regsus.2023.02.003

Gardiner, M.M., Burkman, C.E., & Prajzner, S.P. (2013). The value of urban vacant land to support arthropod biodiversity and ecosystem services. *Environmental Entomology, 42*(6), 1123-1136. https://doi.org/10.1603/en12275

Gilburn, A.S., Bunnefeld, N., Wilson, J.M., Botham, M.S., Brereton, T.M., Fox, R., & Goulson, D. (2015). Are neonicotinoid insecticides driving declines of widespread butterflies? *PeerJ, 3*, e1402. https://doi.org/10.7717/peerj.1402

Habel, J.C., Ulrich, W., Biburger, N., Seibold, S., & Schmitt, T. (2019). Agricultural intensification drives butterfly decline. *Insect Conservation and Diversity, 12*(4), 289-295. https://doi.org/10.1111/icad.12343

Hard, H.R., Brusseau, M., & Ramirez-Andreotta, M. (2019). Assessing the feasibility of using a closed landfill for agricultural graze land. *Environmental Monitoring and Assessment, 191*, 458. https://doi.org/10.1007/s10661-019-7579-9

Heatherington, C., Jorgensen, A., & Walker, S. (2019). Understanding landscape change in a former brownfield site. Landscape Research, 44(1), 19-34. https://doi.org/10.1080/01426397.2017.1374359

Hofmann, M., Westermann, J.R., Kowarik, I., & Meer, E. van der. (2012). Perceptions of parks and urban derelict land by landscape planners and residents. *Urban Forestry & Urban Greening, 11*(3), 303-312. https://doi.org/10.1016/j.ufug.2012.04.001

IPBES. (2016). *The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production.* Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Kamp, J., Pelster, A., Gaedicke, L., Karthäuser, J., Dieker, P., & Mantel, K. (2015). High nest survival and productivity of Northern Lapwings Vanellus vanellus breeding on urban brownfield sites. *Journal of Ornithology, 156*, 179-190. https://doi.org/10.1007/s10336-014-1114-0

Karlstrøm, H., & Ryghaug, M. (2014). Public attitudes towards renewable energy technologies in Norway. The role of party preferences. *Energy Policy, 67*, 656-663. https://doi.org/10.1016/j.enpol.2013.11.049

Likert, R. (1932). A technique for the measurement of attitudes. Archives of Psychology, 140, 1-55.

Loures, L., & Crawford, P. (2008). Democracy in progress: Using public participation in post-industrial landscape (re)-development. *WSEAS Transactions on Environment and Development, 4*(9), 794-803.

Loures, L., Panagopoulos, T., & Burley, J.B. (2016). Assessing user preferences on post-industrial redevelopment. *Environment and Planning. B, Planning & Design, 43*(5), 871-892. https://doi.org/10.1177/0265813515599981

Loures, L., & Vaz, E. (2018). Exploring expert perception towards brownfield redevelopment benefits according to their typology. *Habitat International, 72*, 66-76. https://doi.org/10.1016/j.habitatint.2016.11.003

Macgregor, C.J., Bunting, M.J., Deutz, P., Bourn, N.A.D., Roy, D.B., & Mayes, W.M. (2022). Brownfield sites promote biodiversity at a landscape scale. *The Science of The Total Environment, 804*, 150162. https://doi.org/10.1016/j.scitotenv.2021.150162

Masood, N., & Russo, A. (2023). Community perception of brownfield regeneration through urban rewilding. *Sustainability, 15*(4), 3842. https://doi.org/10.3390/su15043842

Mathey, J., Arndt, T., Banse, J., & Rink, D. (2018). Public perception of spontaneous vegetation on brownfields in urban areas—Results from surveys in Dresden and Leipzig (Germany). *Urban Forestry & Urban Greening, 29*, 384-392. https://doi.org/10.1016/j.ufug.2016.10.007

Mathey, J., Rößler, S., Banse, J., Lehmann, I., & Bräuer, A. (2015). Brownfields as an element of green infrastructure for implementing ecosystem services into urban areas. *Journal of Urban Planning and Development, 141*(3), A4015001. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000275

Meehan, T.D., Hurlbert, A.H., & Gratton, C. (2010). Bird communities in future bioenergy landscapes of the Upper Midwest. *Biological Sciences, 107*(43), 18533-18538. https://doi.org/10.1073/pnas.1008475107

Milbrandt, A.R., Heimiller, D.M., Perry, A.D., & Field, C.B. (2014). Renewable energy potential on marginal lands in the United States. *Renewable and Sustainable Energy Reviews, 29,* 473-481. https://doi.org/10.1016/j.rser.2013.08.079

Morar, C., Berman, L., Unkart, S., & Erdal, S. (2021). Sustainable Brownfields redevelopment in the European Union: An overview of policy and funding frameworks. *Journal of Environmental Health, 84*(4), 24-31.

Office for National Statistics. (2011). *Approximated Social Grade (UK Census 2011 data)*. https://www.nomisweb.co.uk/census/2011/qs611ew

Preston, P.D., Dunk, R.M., Smith, G.R., & Cavan, G. (2023). Not all brownfields are equal: A typological assessment reveals hidden green space in the city. *Landscape and Urban Planning, 229*, 104590. https://doi.org/10.1016/j.landurbplan.2022.104590

Pueffel, C., Haase, D., & Priess, J.A. (2018). Mapping ecosystem services on brownfields in Leipzig, Germany. *Ecosystem Services, 30*, 73-85. https://doi.org/10.1016/j.ecoser.2018.01.011

R Core Team. (2024). *R: A language and environment for statistical computing.* Vienna, Austria: R Foundation for Statistical Computing.

Rizzo, E., Pesce, M., Pizzol, L., Alexandrescu, F.M., Giubilato, E., Critto, A., Marcomini, A., & Bartke, S. (2015). Brownfield regeneration in Europe: Identifying stakeholder perceptions, concerns, attitudes and information needs. *Land Use Policy, 48*, 437-453. https://doi.org/10.1016/j.landusepol.2015.06.012

Rowley, J. (2014). Designing and using research questionnaires. *Management Research Review, 37*(3), 308-330. http://dx.doi.org/10.1108/MRR-02-2013-0027

Rust, N.A., Rehackova, L., Naab, F., Abrams, A., Hughes, C., Merkle, B.G., Clark, B., & Tindale, S. (2021). What does the UK public want farmland to look like? *Land Use Policy, 106,* 105445. https://doi.org/10.1016/j.landusepol.2021.105445

Salak, B., Lindberg, K., Kienast, F., & Hunziker, M. (2021). How landscape-technology fit affects public evaluations of renewable energy infrastructure scenarios. A hybrid choice model. *Renewable and Sustainable Energy Reviews, 143*, 110896. https://doi.org/10.1016/j.rser.2021.110896

Sayer, A. (2010). *Method in Social Science.* Revised 2nd Edition. London: Routledge.

Schulze Bäing, A. (2010). Containing Urban Sprawl? Comparing Brownfield Reuse Policies in England and Germany. *International Planning Studies, 15*(1), 25-35. https://doi.org/10.1080/13563471003736910

Schulze Bäing, A., & Wong, C. (2012). Brownfield Residential Development: What Happens to the Most Deprived Neighbourhoods in England? *Urban Studies, 49*(14), 2989-3008. https://doi.org/10.1177/0042098012439108

Scott, A., Gilbert, A., & Gelan, A. (2007). *The Urban-Rural Divide: Myth or Reality?* (No. 2). SERG Policy Brief Series. Macauley Institute.

Seibold, S., Gossner, M.M., Simons, N.K., Blüthgen, N., Müller, J., Ambarlı, D., Ammer, C., Bauhus, J., Fischer, M., Habel, J.C., Linsenmair, K.E., Nauss, T., Penone, C., Prati, D., Schall, P., Schulze, E-D., Vogt, J., Wöllauer, S., & Weisser, W.W. (2019). Arthropod decline in grasslands and forests is associated with landscape-level drivers. *Nature, 574*, 671-674.

Sellmann, D., & Bogner, F.X. (2013). Effects of a 1-day environmental education intervention on environmental attitudes and connectedness with nature. *European Journal of Psychology of Education, 28,* 1077-1086. https://doi.org/10.1007/s10212-012-0155-0

Sousa, E., Quintino, V., Palhas, J., Rodrigues, A.M., & Teixeira, J. (2016). Can environmental education actions change public attitudes? An example using the Pond habitat and associated biodiversity. *PloS one, 11*, e0154440. https://doi.org/10.1371/journal.pone.0154440

Tomitaka, M., Iwachido, Y., & Sasaki, T. (2022). Spatial scales and urban greenspace types influence public conservation preferences. *Land Use Policy, 123*, 106403. https://doi.org/10.1016/j.landusepol.2022.106403

Town and Country Planning (General Permitted Development) (England) (Amendment) (No. 3) Order 2020. (2020) https://www.legislation.gov.uk/uksi/2020/756/contents/made

Tropek, R., Kadlec, T., Karesova, P., Spitzer, L., Kocarek, P., Malenovsky, I., Banar P., Tuf I.H., Hejda M., & Konvicka M. (2010). Spontaneous succession in limestone quarries as an effective restoration tool for endangered arthropods and plants. *Journal of Applied Ecology, 47*, 139-147.

Vellend, M., Baeten, L., Becker-Scarpitta, A., Boucher-Lalonde, V., McCune, J.L., Messier, J., Myers-Smith, I.H., & Sax, D.F. (2017). Plant Biodiversity Change Across Scales During the Anthropocene. *Annual Review of Plant Biology, 68*, 563-586. https://doi.org/10.1146/annurev-arplant-042916-040949

Venter, Z.S., Barton, D.N., Gundersen, V., Figari, H., & Nowell, M.S. (2021). Back to nature: Norwegians sustain increased recreational use of urban green space

months after the COVID-19 outbreak. *Landscape and Urban Planning, 214,* 104175. https://doi.org/10.1016/j.landurbplan.2021.104175

Wagner, D.L. (2020). Insect Declines in the Anthropocene. *Annual Review of Entomology, 65*, 457-480. https://doi.org/10.1146/annurev-ento-011019-025151

Wheeler, R. (2014). Mining memories in a rural community: Landscape, temporality and place identity. *Journal of Rural Studies, 36,* 22-32. https://doi.org/10.1016/j.jrurstud.2014.06.005

Wickham, H. (2009). *ggplot2: elegant graphics for data analysis*. Springer, New York.

Woodcock, B.A., Isaac, N.J.B., Bullock, J.M., Roy, D.B., Garthwaite, D.G., Crowe, A., & Pywell, R.F. (2016). Impacts of neonicotinoid use on long-term population changes in wild bees in England. *Nature communications, 7,* 12459. https://doi.org/10.1038/ncomms12459

YouGov. (2021). *GB and UK Omnibus.* *https://business.yougov.com/product/realtime/gb-and-uk-omnibus*