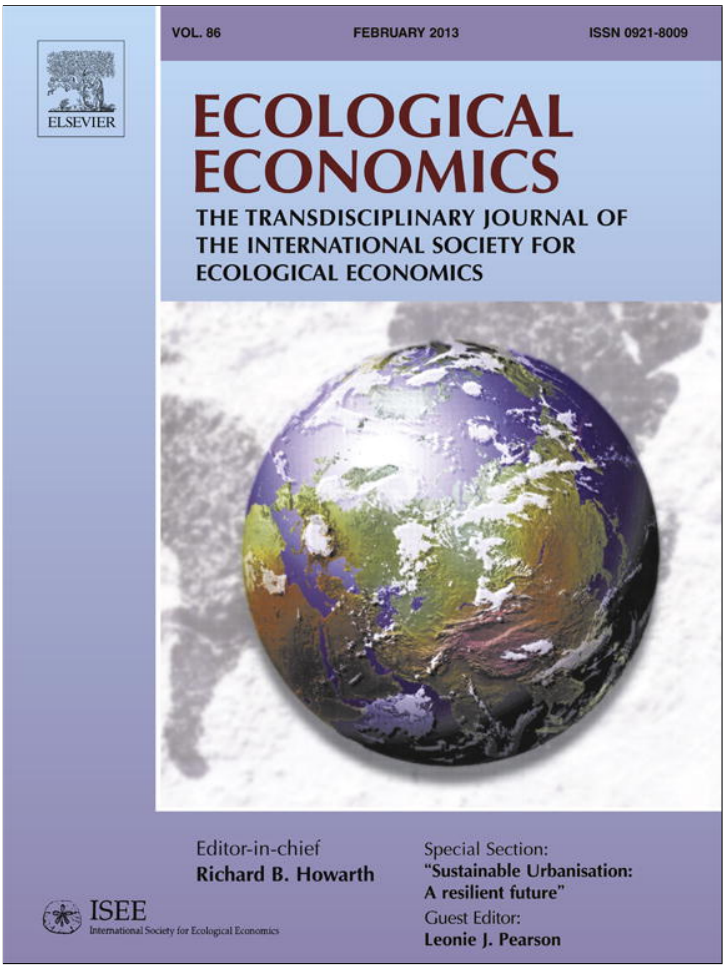

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Why garden for wildlife? Social and ecological drivers, motivations and barriers for biodiversity management in residential landscapes

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ABSTRACT

Residential landscapes with private gardens are major land covers in cities and their sustainable management is paramount for achieving a resilient urban future. Here we focus on the value of residential ecosystems for biodiversity conservation and explore the social and ecological factors that influence wildlife-friendly garden management. Using a stratified sampling design across the UK city of Leeds, this interdisciplinary study develops and applies a mixed method approach, including questionnaires, interviews and ecological surveys across multiple spatial scales. We quantify wildlife-friendly gardening using two measures: (i) the number of wildlife-friendly features within gardens (the wildlife resources index, WRI); and (ii) the frequency of winter bird feeding. Wildlife-friendly gardening is influenced by a combination of garden characteristics and management intensity, householder demographics, wider environmental activity and landscape context. Residents reveal a range of motivations for wildlife-friendly gardening, notably personal well-being and a moral responsibility to nature. Respondents expressed a duty to maintain neighbourhood standards, revealing that social norms are a considerable barrier to uptake of wildlife-friendly activities, but also provide an opportunity where neighbour mimicry results in diffusion of wildlife-friendly practices. Community-driven initiatives that engage, educate and empower residents are better placed to encourage wildlife-friendly gardening than top-down financial incentives.

1. Introduction

In a context of increasing urbanisation (United Nations, 2010) and declining biodiversity, there is concern that people living in cities are becoming disconnected from the natural world (Miller, 2005; Turner et al., 2004), resulting in apathy towards wider conservation objectives (Dunn et al., 2006). This disconnect from nature is particularly worrying in light of evidence that interactions with urban wildlife are important for human health and well-being (Fuller et al., 2007; Luck et al., 2011). Since private gardens are one of the primary settings for interactions with wildlife in cities, they offer great opportunity for personal engagement with the natural world (Dunnett and Qasim, 2000; Freeman et al., 2012; Power, 2005).

Private gardens are a major component of cities in both developed and developing world countries (e.g. Gonzalez-Garcia and Sal, 2008; Loram et al., 2007) and the manner in which householders manage these spaces has a substantial impact on the provision of urban biodiversity. The benefits of activities by householders to encourage biodiversity through wildlife-friendly gardening have been recognised by policymakers and conservation NGOs alike (Goddard et al., 2010b). Ecologists have recently attempted to quantify the extent of wildlife-friendly gardening across UK cities (e.g. Davies et al., 2009; Gaston et al., 2007) and found that feeding birds is the most popular activity carried out by an estimated 12.6 million (48%) households. Similar levels of bird feeding occur in both the United States and Australia (Jones and Reynolds, 2008; Lepczyk et al., 2012). Research suggests that supplementary feeding can benefit bird populations at multiple scales (Daniels and Kirkpatrick, 2006; Fuller et al., 2008), although others have highlighted the adverse impacts of bird feeding, such as disease transmission and increased predation pressure (Robb et al., 2008). In general, the cumulative actions of many householder activities can combine to benefit biodiversity (Cooper et al., 2007). Equally, these impacts can be negative, such as from the application of lawn chemicals (Robbins et al., 2001), predation by domestic cats (Sims et al., 2008), or the enhancement of biological invasions (Niinemets and Penuelas, 2008).

Residential landscapes are complex socio-ecological systems that are best understood within an interdisciplinary framework (Cook et al., 2011; Grove et al., 2006). Initial interdisciplinary studies have shown that patterns of urban biodiversity are inherently linked with social stratification (Warren et al., 2010). For example, there is evidence of a 'luxury effect', whereby wealthier neighbourhoods support greater levels of vegetation cover or higher plant diversity (e.g. Hope

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et al., 2003; Lubbe et al., 2010; Martin et al., 2004). Socio-economic status also correlates with the richness of various vertebrate taxa (Kinzig et al., 2005; Melles, 2005; Smallbone et al., 2011; Strohbach et al., 2009). At finer scales within neighbourhoods, householder landscaping decisions are influenced by the desire to conform to prevailing social or cultural norms (Kurz and Baudains, 2010; Marco et al., 2010; Nassauer et al., 2009). Research in Baltimore, US, has shown an 'ecology of prestige' whereby vegetation cover in private gardens is predicted by lifestyle behaviour and a need to show membership of a given lifestyle group (Grove et al., 2006; Troy et al., 2007). The presence of a shared social ideal often results in spatial autocorrelation of gardening practices in suburbia (Hunter and Brown, 2012; Warren et al., 2008; Zmyslony and Gagnon, 1998), although these findings are not universal (Kirkpatrick et al., 2009).

To maximise the contribution that householders make to the biodiversity of residential ecosystems, a greater understanding of the myriad ecological and social factors that underlie wildlife gardening practices is required (Goddard et al., 2010a; Kendal et al., 2010). There have been very few investigations into patterns of wildlife-friendly gardening, but preliminary research in US cities has explored some of the socioeconomic and demographic correlates of householder activities that influence birds (Lepczyk et al., 2004, 2012). UK urban ecology studies have examined the spatial variation in wildlife gardening and bird feeding and related this to neighbourhood-scale socio-economic status, population density and landscape context (Fuller et al., 2008; Fuller et al., 2012; Gaston et al., 2007). As yet, we know little about what drives people to engage in wildlife-friendly gardening. Studies of motivations for gardening in general have found that observing nature is highly valued by gardeners (Clayton, 2007; Fuller and Irvine, 2010). A body of social research from Australia and New Zealand has illustrated gardeners' attitudes and practice regarding native plants (e.g. Doody et al., 2010; Head and Muir, 2006; Zagorski et al., 2004), whilst researchers in environmental psychology have investigated the association between wider environmental values and ecological gardening practices and found contrasting results (e.g. Kiesling and Manning, 2010; Larson et al., 2010). Here, we use an integrated, interdisciplinary research design to simultaneously explore the social and ecological drivers, motivations and barriers for biodiversity management in residential landscapes at multiple scales. In particular, the study objectives are to: (1) examine the spatial variation in activities to encourage wildlife in gardens and relate this to landscape context, socio-economic status, householder demographics, environmental values and garden characteristics and management; (2) assess whether wildlife gardening activities are correlated with bird richness, diversity or abundance; (3) determine the range of influences on, and underlying motivations behind, wildlife gardening; and (4) explore the potential of various mechanisms for incentivising greater participation in wildlife-friendly gardening.

2. Methods

2.1. Study Area and Sampling Design

We develop and apply a mixed-methods research design that incorporates householder questionnaires and interviews with ecological surveys across a stratified sample of urban neighbourhoods in the UK city of Leeds, West Yorkshire (53° 47′ 59″ N, 1° 32′ 57″ W). With a human population approaching 790,000, Leeds is the third largest municipality in the UK. The Leeds metropolitan district covers an area of c. 550 km^2, of which around two-thirds is farmland. Here we define the Leeds study area as the extent of the contiguous Leeds and Bradford urban area that falls within the Leeds District (Fig. 1). This urban area covers 133 km^2 and is typical of cities in developed, temperate countries in containing a wide range of residential areas.

We used a hierarchical sampling design whereby study households were located within neighbourhoods that were in turn nested within wards. Wards are UK administrative areas and 27 fall within the Leeds urban boundary. Wards are further divided into Output Areas, OAs (hereafter termed neighbourhoods), that are the finest scale for which census data are available, typically classified based on tenure and dwelling type with a target size of 125 households (Office for National Statistics, 2011). We selected wards and neighbourhoods using stratified random sampling to capture the range of variation in landscape and socio-demographic characteristics. Six wards were selected: Roundhay, Morley South, Pudsey South, Whinmoor, Armley and Hunslet (Fig. 1). Three neighbourhoods were selected within each ward, giving a total of 18 study neighbourhoods (Fig. 1; Table 1). The hierarchical sampling design allows us to ascertain the relative contribution of household-scale factors compared to neighbourhood- and landscape-scale drivers affecting the biodiversity of private gardens.

2.2. Household Questionnaire

A questionnaire was delivered by hand to all households in the 18 neighbourhoods. To maximise response rate we implemented several of the methods recommended by the Tailored Design Method (Dillman et al., 2009), such as the inclusion of a stamped return envelope and personalising correspondence by using a hand-addressed envelope along with a personally signed covering letter explaining the purpose of the survey. 2198 questionnaires were delivered and 533 were completed (24% response rate). There was a response bias across neighbourhoods, with the most affluent neighbourhood (R1) having a 49% response rate, compared to 14% in the least affluent neighbourhood (H3). An exploratory analysis that controlled for the effect of response rate using linear models showed that it had no significant effect on model fit, so was subsequently dropped from analyses as it indicated response rate did not affect the results.

The questionnaire was the most comprehensive survey of garden management and wildlife gardening practices to have been undertaken in a UK city. It contained 30 questions that covered main themes of: (i) garden use and management; (ii) current wildlife gardening practices and wildlife observations; and (iii) house and garden characteristics (e.g. house type, garden size) (Appendix A). In addition, respondents were asked socio-demographic questions relating to age, presence of young children, housing tenure, length of residency, occupation and education. Respondents' level of wider environmental commitment was assessed by asking about participation in other environmental activities and membership of garden or wildlife organisations/charities. Finally, respondents were asked how important they deemed six global environmental issues by scoring them on a Likert scale from 1 (not important) to 5 (very important). Four indices were calculated for data analysis based on questionnaire responses (Table 2). The wildlife resources index (WRI) was used as one of two response variables, and the management intensity index, environmental activity index and environmental concern index were used as explanatory variables. Ground-truthing was used to verify the accuracy of the WRI during garden ecological surveys (Goddard, 2012) and correlation between respondent-assessed WRI and that recorded by MG in a subset of 90 gardens was moderately high ($r_s = 0.72$).

Questionnaire responses were excluded from data analysis if the householder failed to complete the appropriate questionnaire section, or if ≤3 questions were answered in the management intensity index or environmental concern index. Where respondents failed to answer ≤2 questions in the above indices, missing values were imputed based on responses to other questions in the same index (after Luck et al., 2011). For the WRI and environmental activity index, where respondents were asked to tick boxes to indicate the presence of features or participation in activities respectively, blanks were interpreted as negative because it was deemed relatively easy

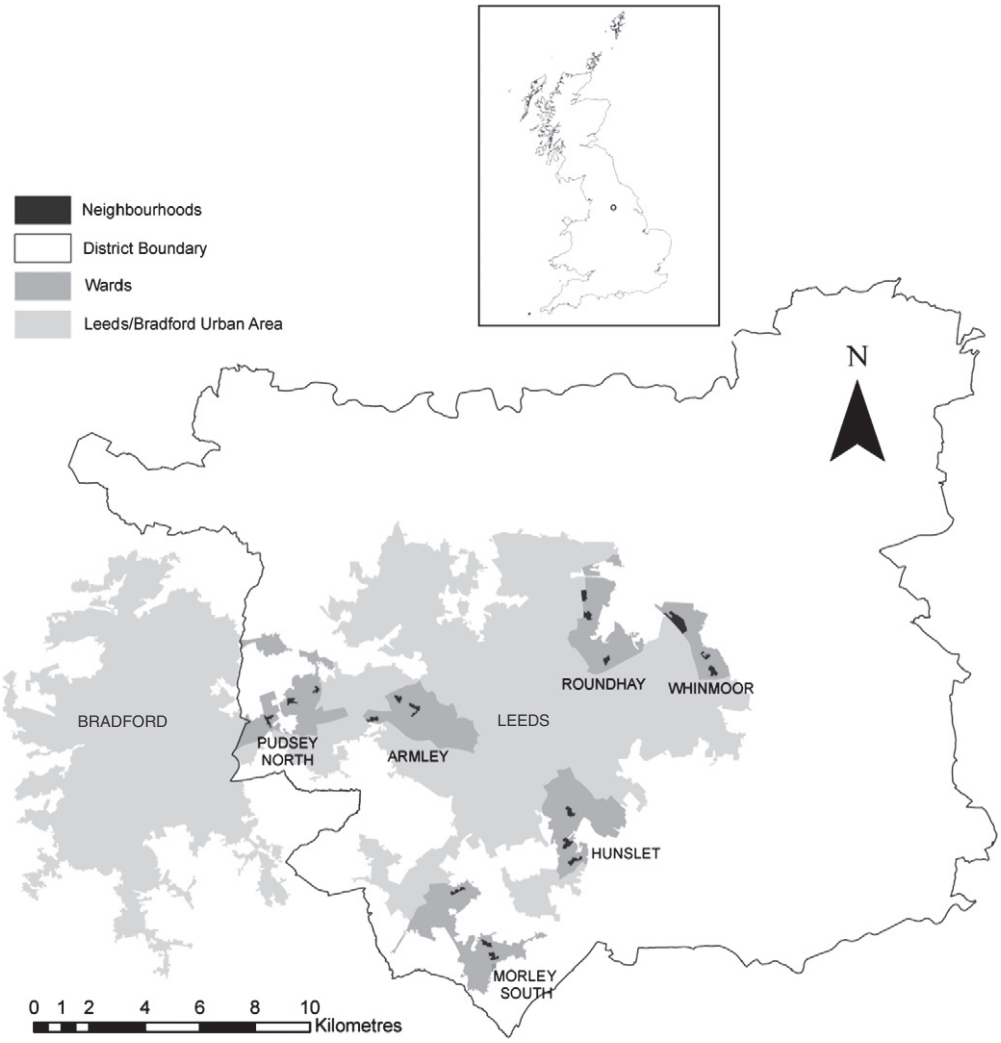

Fig. 1. The extent of the study area in relation to Leeds District and the Leeds/Bradford Urban Area. The location of the six study wards and 18 neighbourhoods is also shown. EDINA.

Table 1
Socio-demographic characteristics of the 18 study neighbourhoods. The mean values of the two response variables are also shown (wildlife resources index, WRI, and the percentage of households who feed the birds frequently in winter).

Ward	OA code (00DA..)	Study ID	% H'hold spaces detached	% H'hold spaces terraced	% 16–74 Unemployed	% 16–74 Retired	% 16–74 Higher education qualifications	% 16–74 Managerial/ professional occupations	% Owner occupied	Pop'n density (no. people/ha)	WRI	% Bird feeding
Roundhay	GD0060	R1	22.9	0	1.8	14.9	56.0	53.0	85.4	37.9	6.7	54.8
	GD0054	R2	15.3	0	2.3	7.6	41.3	47.2	91.1	57.0	5.1	42.9
	GD0046	R3	0	2.4	3.4	15.2	19.4	21.2	89.4	73.1	6.0	66.7
Morley South	FW0048	MS1	70.5	0	1.2	4.1	13.7	26.3	97.6	66.0	5.5	50.0
	FW0024	MS2	54.0	0	1.6	10.6	13.0	23.2	72.4	62.5	5.7	57.1
	FW0093	MS3	7.5	2.8	4.5	5.5	4.5	7.1	20.0	68.7	5.0	50.0
Pudsey North	FZ0074	PN1	41.4	45.2	0	9.4	22.2	30.6	97.0	75.3	4.2	47.1
	FZ0041	PN2	2.4	0	2.0	14.5	18.1	26.9	87.7	60.6	5.3	45.5
	FZ0025	PN3	11.5	11.5	3.3	16.0	7.5	19.4	64.6	62.5	4.7	57.7
Whinmoor	GJ0010	W1	12.6	0	2.1	11.0	18.5	25.0	97.6	14.8	6.9	70.2
	GJ0004	W2	0	25.9	3.9	20.6	3.0	7.6	26.4	51.3	3.9	57.7
	GJ0003	W3	2.2	87.4	2.2	14.8	4.9	7.1	30.0	94.8	3.2	57.1
Armley	FB0028	A1	2.4	0	0	24.9	9.0	22.2	100.0	51.2	5.0	56.3
	FB0016	A2	0	45.5	4.3	8.6	11.3	19.7	62.9	64.3	4.1	39.1
	FB0001	A3	3.6	22.2	6.9	11.9	9.6	11.1	36.8	68.3	4.2	45.5
Hunslet	FQ0001	H1	9.0	32.3	2.4	15.6	6.4	6.5	56.3	40.5	4.4	45.5
	FQ0044	H2	2.2	38.5	6.6	11.3	5.5	14.0	43.3	62.0	4.0	41.2
	FQ0007	H3	6.3	35.4	8.8	8.8	4.2	6.2	11.4	48.5	3.2	37.5

Table 2
Details on indices calculated from questionnaire responses.

Index name	How calculated	Components	Variable type
Wildlife resources index (WRI)	Sum of 13 wildlife-friendly garden features, scored as 0 (absent) or 1 (present)	1. Bird feeder/table; 2. Bird bath/water; 3. Bird nest box; 4. Other nest box (e.g. ladybird, bumblebee, bat); 5. Compost heap/leaf pile; 6. Pond; 7. Log pile; 8. Wild/uncultivated area; 9. Berry-bearing plants; 10. Flowering plants; 11. Hedge/shrubs; 12. Trees > 2 m in height; 13. Native plants	Response (continuous)
Management intensity index	Sum of frequency with which householders undertake seven garden management activities in spring and summer, scored as 0 (never)–5 (daily)	1. Mowing the lawn; 2. Planting flowers/ shrubs; 3. Dead-heading flowers[a]; 4. Watering lawn/ plants; 5. Weeding; 6. Applying chemical fertilisers; 7. Applying pesticides or herbicides	Explanatory (continuous)
Environmental activity index	The number of environmental activities participated in by householders (3 levels: none, one, more than one).	1. Household waste recycling; 2. Allotment gardening; 3. Practical conservation; 4. Wildlife surveys; 5. Other.	Explanatory (categorical)
Environmental concern index	The mean response to 6 questions asking householders to state their concern for global environmental issues, where 1 = not important and 5 = very important.	1. Climate change and global warming; 2. Pollution; 3. Food issues (e.g. organic farming, GM crops, food miles); 4. Conservation and wildlife; 5. Energy crisis (shortages of oil and gas); 6. Recycling and waste management	Explanatory (continuous)

[a] Dead-heading is the removal of flowers from plants when they are fading or dead to keep plants looking attractive and/or to encourage further flowering.

for respondents to omit to tick the 'none of the above' boxes (after Gaston et al., 2007). In total, the WRI was calculated for 527 households, the management intensity index for 526 households, the environmental activity index for 530 households and the environmental concern index for 525 households.

2.3. Neighbourhood Description

The 18 study neighbourhoods were selected to maximise socio-economic and demographic variation (Table 1). Further neighbourhood-scale variables (Table 3) were obtained from three sources: (i) population density and median household income from the UK census; (ii) landscape composition metrics computed using GIS and (iii) vegetation characteristics from garden and street bird surveys, comprising land cover and vegetation structure variables. The latter comprised 14 correlated variables and PCA was used for data reduction prior to analysis (Table 3).

2.4. Bird Surveys

Birds were recorded in the 18 study neighbourhoods using two complementary methods: (i) stationary point counts within five gardens per neighbourhood (15 min duration); and (ii) 100 m line transects along three streets within each neighbourhood. All bird species were identified using sight and/or call. Individuals flying over the garden or transect route above the height of the tallest stratum (i.e. house or tree) were not considered to be utilising the area and were ignored. Each garden and street was visited on three occasions (once in early-mid April, once in early-mid May and once in early-mid June 2009) and the data pooled across all sites and visits per neighbourhood for analysis.

2.5. Data Analysis

Analysis focused on two response variables at the household scale: the WRI and the frequency of bird feeding. The frequency of bird feeding in winter is a binomial variable scored as frequent (daily or weekly) or infrequent (monthly or less, including never). Explanatory variables were included at two spatial scales: the garden/householder scale and the neighbourhood scale (Table 3). Collinearity in explanatory variables was assessed using variance inflation factors (VIF) using a threshold of VIF = 3, above which variables were excluded from analyses (Zuur et al., 2007). Covariates were standardised prior to model fitting so they had a mean of zero and standard deviation of one.

Generalised linear models (GLMs) were fitted using a Poisson error distribution for the WRI and binomial for the frequency of bird feeding. The sample size for GLMs was 460 (households were excluded where data were missing for any of the explanatory variables). Residual diagnostics and goodness of fit (via the dispersion parameter) were used to assess model suitability. There was no significant residual spatial autocorrelation, and fitting mixed models to the data gave quantitatively the same parameter estimates with the random factors (neighbourhood and ward) explaining very little variation. Thus, we report GLM results for simplicity.

Model selection involved ranking models based on Akaike's second order Information Criterion (AICc) due to small sample size. All combinations of models were calculated using the 'dredge' function in the R package MuMIn (Barton, 2011). We used multimodel inference based on ΔAICc and Akaike weights (w_i) to rank alternative candidate models (Burnham and Anderson, 2002). The Akaike weights (w_i) sum to 1 and represent the relative likelihood that model i is the best model in the candidate set considered (Burnham and Anderson, 2002). Parameter estimates were averaged across all well-supported candidate models with ΔAICc < 2. Model selection and model averaging were completed using the R package AICcmodavg (Mazerolle, 2011). Model predictions were visualised using partial residual plots that show the relationship between the response and the explanatory variable while controlling for the effect of other explanatory variables in the model. They plot on the x-axis the explanatory variable of interest (xi), and on the y-axis they plot the residuals of the full model + regression coefficient of xi ∗ xi (Faraway, 2006).

2.6. Semi-structured Interviews

20 householders were selected from the 90 who had allowed access to their gardens for ecological survey. Householders spanned variation in: (i) garden size; (ii) socio-economic status; (iii) current level of wildlife-friendly gardening; and (iv) location within the city. We also included some householders who garden in a manner that is atypical for their neighbourhood (e.g. had a small garden in a neighbourhood of lower socio-economic status but a keen interest in wildlife-friendly gardening).

The semi-structured interview was split into three sections (Appendix B). Section A explored the range of influences on garden practices, including the importance of neighbourhood standards and the role of surrounding green space management. Section B focused on current practices for encouraging wildlife in the garden and underlying motives. Section C explored the variety mechanisms for encouraging greater participation in wildlife-friendly gardening (including bottom-up initiatives and top-down incentives), as well as barriers limiting greater uptake.

Table 3
Details of the household- and neighbourhood-scale explanatory variables included in models predicting the WRI and frequency of bird feeding.

Variable (range)	Description/categories	Source
Household scale		
Management intensity index (0–22)	The frequency with which householders undertook garden management activities (Table 2).	Questionnaire
Environmental activity index (categorical)	The degree of householder participation in environmental activities outside of the garden (Table 2).	Questionnaire
Environmental concern index (1–5)	The degree of householder concern for global environmental issues (Table 2).	Questionnaire
House age (categorical)	Late Victorian/Edwardian (1870–1914); World War 1–WW2 (1914–1945); Post War (1945–1964); Sixties/seventies (1964–1979); Recent (1979–current)	Questionnaire
Garden size (categorical)[a]	Small (up to 10 m×10 m); Medium (10 m×20 m, e.g. a tennis court); Large (clearly larger than a tennis court); Very large (>2 tennis courts)	Questionnaire
Householder age (categorical)[b]	18–25; 26–35; 36–45; 46–55; 56–65; >65 years old	Questionnaire
Children (categorical)	Presence of young children (12 or under) in the household (yes/no)	Questionnaire
House type (categorical)	Terraced; Semi-detached; Detached	Questionnaire
Tenure (categorical)	Owner-occupied; Rented	Questionnaire
Length of residency (categorical)[c]	Number of years the respondent has lived in the house (<1 year; 1–2 years; 3–5 years; 6–10 years; >10 years)	Questionnaire
Employment status (categorical)	Employment status of main earner in household (Full-time; part-time; not working; retired)	Questionnaire
Education level (categorical)	Highest level of education achieved by an adult in the household (Secondary school or below; Further education; Undergraduate degree; Postgraduate degree)	Questionnaire
Neighbourhood scale		
Population density (14.8–94.8)	The number of people per hectare	Census
Income (£18,675–52,710)	Median household income for the lower layer super output area (LSOA) in which the neighbourhood falls	Census
Garden PLAND	The percentage of the landscape (PLAND) composed of private gardens within a 500 m radius buffer	GIS
Green space PLAND	The percentage of the landscape (PLAND) composed of green space (i.e. grassland and agriculture) within a 500 m radius buffer	GIS
Woodland PLAND	The percentage of the landscape (PLAND) composed of woodland and scrub within a 500 m radius buffer	GIS
Vegetation PC1[d]	Principal component 1 of a PCA of 14 neighbourhood vegetation variables representing the mean scores from vegetation assessments of front gardens along three street transects plus five rear gardens per neighbourhood. PC1 described 59.0% of the variance, and the variable loading most positively is the % garden unmanaged, and variables loading negatively are the height of the tallest stratum and the % of the garden covered by vegetation 2–3 m in height.	Field survey
Vegetation PC2	Principal component 2 of the above PCA, describing 14.9% of the variance. The variable loading positively on PC2 is the % garden covered by artificial surfaces, and the variable loading negatively is % garden covered by lawn.	Field survey

[a] Garden size categories 'large' and 'very large' were pooled for analyses to equalise sample sizes.
[b] Respondent age categories '18–25' and '26–35' were pooled for analyses to equalise sample sizes.
[c] Length of residency categories '<1 year' and '1–2 years' were pooled for analyses to equalise sample sizes.
[d] Vegetation PC1 was excluded from analyses as it was highly correlated with income (based on VIF).

All interviews were conducted in the houses or gardens of interviewees and were recorded and transcribed verbatim. Interview transcripts were imported into the qualitative data analysis programme NVivo for coding. A series of *a priori* themes or nodes were identified on the basis of the original interview questions (e.g. the contribution of garden wildlife to quality of life; the influence of neighbourhood standards on garden management; barriers to wildlife-friendly gardening), with new nodes created where new ideas emerged.

3. Results

3.1. Wildlife-friendly Gardening

3.1.1. Garden Use and Management

The aesthetic appearance of the garden was most valued by householders, with 344 respondents (65%) scoring enjoyment of plants and flowers as '4' or '5' on a 5-point Likert scale of important garden uses. Relaxation was also a popular garden activity, with 329 respondents (62%) deeming it important. Watching or attracting wildlife was considered important by 217 respondents (41%), equivalent to both recreation (228 respondents; 43%) and entertainment (217 respondents; 41%). Indeed, 306 respondents (58%) stated that they actively spent time watching wildlife in their garden on a daily or weekly basis. The most frequently undertaken gardening activity in summer was watering, being performed daily or weekly by 330 respondents (63%), followed by mowing (305 respondents; 58%), weeding (237 respondents; 45%) and dead-heading of flowering plants (226 respondents; 43%). Fertilisers or chemicals were applied to the garden by just over half of householders (267 respondents; 51%).

3.1.2. Wildlife Resources Index

The mean number of wildlife-friendly garden features across all households (i.e. mean WRI) was 5.1 (±2.7). WRI varied considerably across the city (Table 1) and there were significant differences between neighbourhoods (Poisson GLM, $\chi^2 = 96.2$, d.f. = 17, $p < 0.001$) and wards (Poisson GLM, $\chi^2 = 34.2$, d.f. = 5, $p < 0.001$). Interestingly, the two most contrasting neighbourhoods were within the same ward of Whinmoor, where the WRI was more than twice as high in W1 (mean 6.9 ± 2.5) than W3 (3.2 ± 2.7). Across all gardens, standard habitat features were most common, with flowering plants recorded in 453 gardens (86%), followed by hedge/shrubs (416 gardens; 79%) and trees (348 gardens; 66%). Amongst the more specialised wildlife-friendly features, bird feeders were the most prevalent (279 gardens; 53%). 137 respondents (26%) indicated that they deliberately included native plants in their garden.

The WRI was influenced by both socio-demographic and ecological factors operating at household and neighbourhood scales. There were 19 models with ΔAICc <2 and the best model was not well supported

Table 4
Results of selection of models of the WRI and frequency of bird feeding at the household scale ($n = 460$). Models shown include the best model (lowest AICc), global and null models. Other models with ΔAICc <2 are not shown but were included in the calculation of Akaike weights (w_i). Parameters in bold were included in all models with ΔAICc<2.

		WRI				Frequency of bird feeding			
Model	Parameters	*K*	AICc	ΔAICc	w_i	*K*	AICc	ΔAICc	w_i
Best (WRI)	Age + children[a] + education level + environmental activity index + garden PLAND + garden size + green space PLAND + income[a] + management intensity Index + population density + woodland PLAND	19	20013.7	0	0.10				
Best (bird feeding)	Age + education level[a] + environmental activity index + management intensity index + population density[a] + vegetation PC2[a]					13	554.0	0	0.06
Global	Age + children + education Level + employment status + Environmental activity index + environmental concern index + garden PLAND + garden size + green space PLAND + house age + house type + income + length residency + management intensity Index + population density + tenure + vegetation PC2 + woodland PLAND	34	2030.6	16.9	<0.01	34	585.3	31.3	<0.01
Null	Intercept	1	2230.5	216.8	<0.01	1	639.3	85.2	<0.01

[a] Indicates variable was included in the best model but was not significant at the 5% level.

($w_i = 0.10$; Table 4) indicating considerable model uncertainty. Eleven parameters were included in the best model, nine were significant at the 5% level in the best GLM, and seven were included in all of the 19 models with ΔAICc <2 (Table 4). Of the nine variables significant in the best GLM (Fig. 2), two related to householder demographics (age and education level), two to garden characteristics (garden size and management intensity), one to householder attitudes (environmental activity index) and four to neighbourhood-scale factors (garden, green space and woodland PLAND, and population density). WRI increased with both householder age (peaking at 56–65), and education level (Fig. 2). WRI was highest in large gardens and lowest in small gardens, and was positively associated with the management intensity index (Fig. 2). Householders who participated in more than one environmental activity had a higher WRI than those who participated in one or none (Fig. 2), but wider environmental values (as quantified by the environmental concern index) had no influence on the WRI. The availability of habitat in the surrounding landscape was an important influence on WRI, with garden, green space and woodland PLAND all having a small but positive effect on WRI (Fig. 2). In contrast, population density was negatively associated with WRI (Fig. 2).

3.1.3. Frequency of Bird Feeding

Three-quarters of households ($n = 398$) provided food for birds in their garden. Of those householders participating in bird feeding, 69% ($n = 273$) were found to be doing so frequently in winter (i.e. at least once a week). Although the prevalence of frequent winter bird feeding varied across the city (Table 1), neither neighbourhood (binomial GLM, $\chi^2 = 19.0$, d.f. = 17, p = 0.33) nor ward (binomial GLM, $\chi^2 = 10.41$, d.f. = 5, p = 0.06) were found to have a significant effect on the frequency of winter bird feeding.

The frequency of winter bird feeding was best explained by householder and garden characteristics, with neighbourhood-scale predictors less important than for the WRI. Model uncertainty was high — there were 32 models with ΔAICc <2 and consequently the best model had little support ($w_i = 0.06$; Table 4). Four parameters were included in all of the models with ΔAICc <2 (Table 4), and three of

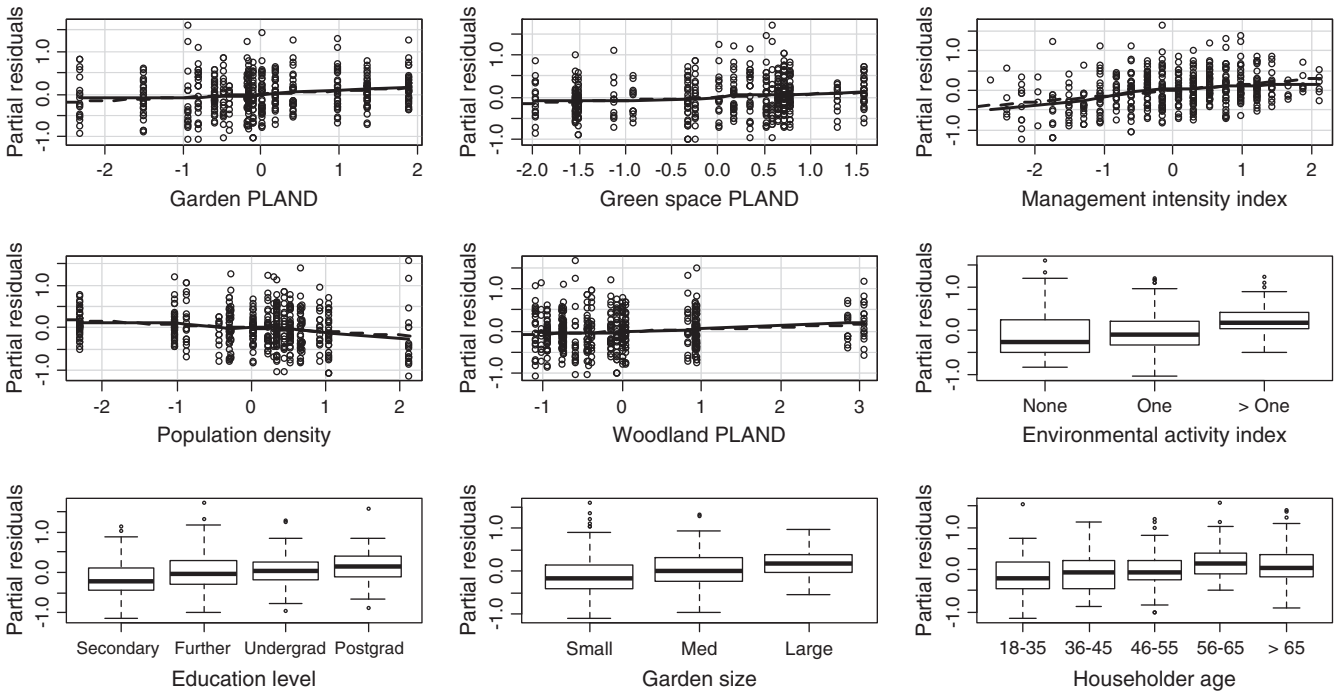

Fig. 2. Partial residual plots showing the relationship between the WRI and each term significant at the 5% level in the best GLM. For continuous variables, the solid line represents the nonparametric-regression (lowess) line, and the dashed line is the least-squares line.

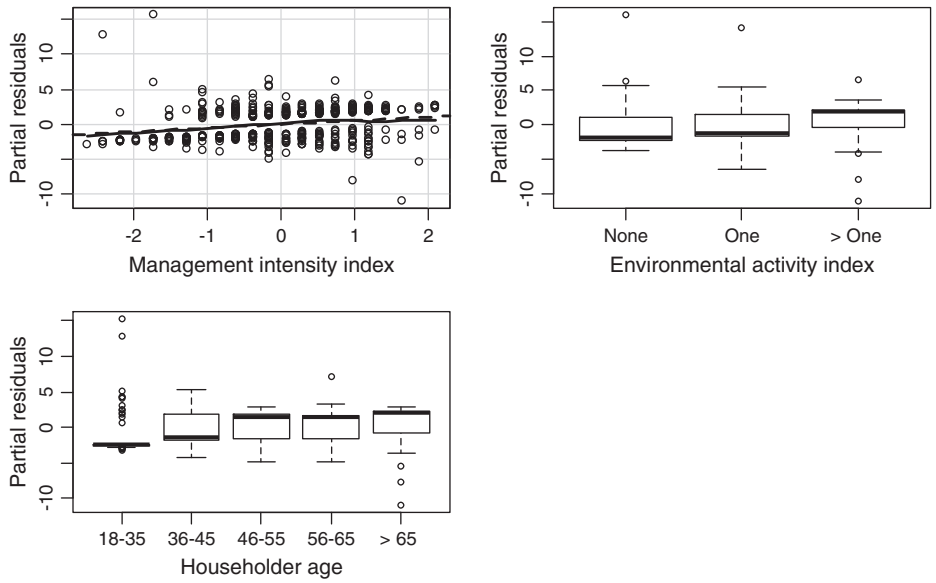

Fig. 3. Partial residual plots showing the relationship between the frequency of bird feeding in winter and each term significant at the 5% level in the best GLM. For the management intensity index, the solid line represents the nonparametric-regression (lowess) line, and the dashed line is the least-squares line.

these were significant at the 5% level in best model (Fig. 3). Frequency of bird feeding increased with each ascending householder age category, peaking with the over 65 s (Fig. 3). Environmental activity outside of the garden influenced bird feeding in a similar way to the WRI, with respondents who participated in more than one activity feeding birds more frequently (Fig. 3). Whilst garden size was not an important predictor, the intensity of garden management remained a strong positive influence (Fig. 3). The only neighbourhood-scale parameter included in the best GLM was vegetation PC2 (Table 4). Exchanging vegetation PC2 with the proportion of artificial surfaces (one of the original variables that loaded strongly on this component) improved model fit and revealed artificial surfaces to have a small but negative effect on the frequency of bird feeding. Education level was the only variable to have a contrasting influence on the two measures of wildlife-friendly gardening, with the frequency of winter bird feeding the highest amongst householders with secondary and further qualifications and lowest amongst those with postgraduate qualifications.

3.2. Neighbourhood-scale Correlates of Bird Species Richness, Abundance and Diversity

Mean WRI at the neighbourhood scale ($n = 18$) was positively correlated with both bird species richness ($r_s = 0.45$, $p = 0.06$) and Simpson's diversity of neighbourhoods ($r_s = 0.64$, $p = 0.004$) (Fig. 4), but not with bird abundance. The proportion of households feeding the birds frequently in winter was unrelated to all three of the neighbourhood-scale measures of bird diversity. Householders' observations of birds in their gardens increased significantly with neighbourhood-level species richness ($r_s = 0.58$, $p = 0.01$) and diversity ($r_s = 0.61$, $p = 0.008$), but not with bird abundance (Fig. 4).

3.3. Motivations and Barriers for Wildlife Gardening

3.3.1. Personal Motives

Respondents received a great deal of satisfaction from attracting wildlife in their gardens, often centred on a sense of wonderment for the natural world. Seeing wildlife in their garden had a positive impact on quality of life or emotional well-being for 85% (17/20) respondents. For Diane (46–55), this is manifested as a sense of pride that wildlife "chooses" her garden, whilst Jackie (56–65) describes feeling "reflective" and Carol (56–65) finds it "peaceful" and "restful" to sit and watch the birds. Householders were also motivated through a process of positive feedback, whereby their wildlife gardening activities were rewarded by evidence of success. Another common motive was "a duty to protect and preserve" wildlife (Sylvia, age 46–55) reflecting concern with biodiversity loss. Householders sought to encourage declining species such as house sparrows in an attempt to "do your bit" to mitigate declines and maintain a "natural balance or order" (Jackie, 56–65). Gardens are also shown to be significant places for overcoming the 'disconnect' between people living in cities and the natural world. For example, Sandy (36–45) realises that "if you never get a chance to go out to the countryside" then the garden "might be the only interaction you get with wildlife".

3.3.2. Neighbourhood-scale Drivers and Social Norms

The majority of householders (16/20) believed that they have a duty to maintain neighbourhood standards through their gardening. The presence of these standards was widely perceived to bring socio-economic benefits, in particular through elevated house prices. Even in estates where many of the properties are owned by the local authority, Wendy (46–55) suggests that the appearance of gardens makes people "proud of where they live and to respect it". When asked about their neighbours' reaction to reduced management in the front garden (e.g. leaving lawn grass longer), most respondents thought that neighbours would be concerned or disapproving. Four householders suggested that such action would elicit a comment or a note, whilst in the wealthiest neighbourhood such community enforcement is already apparent:

> *If somebody didn't maintain their garden the neighbourhood community would actually ask them to…when our hedge was going over onto the path…we were asked to trim it back by people up the street* (Jackie, 56–65).

Even where neighbourhood standards are not enforced, interviewees still expressed an innate or moral desire to keep the garden neat and tidy. The majority of residents (15/20) expressed a preference for neat gardens and this acts as a considerable barrier to wildlife friendly gardening. Amy (46–55) suggests that people transfer the "structured" mindset from the house to the garden and this

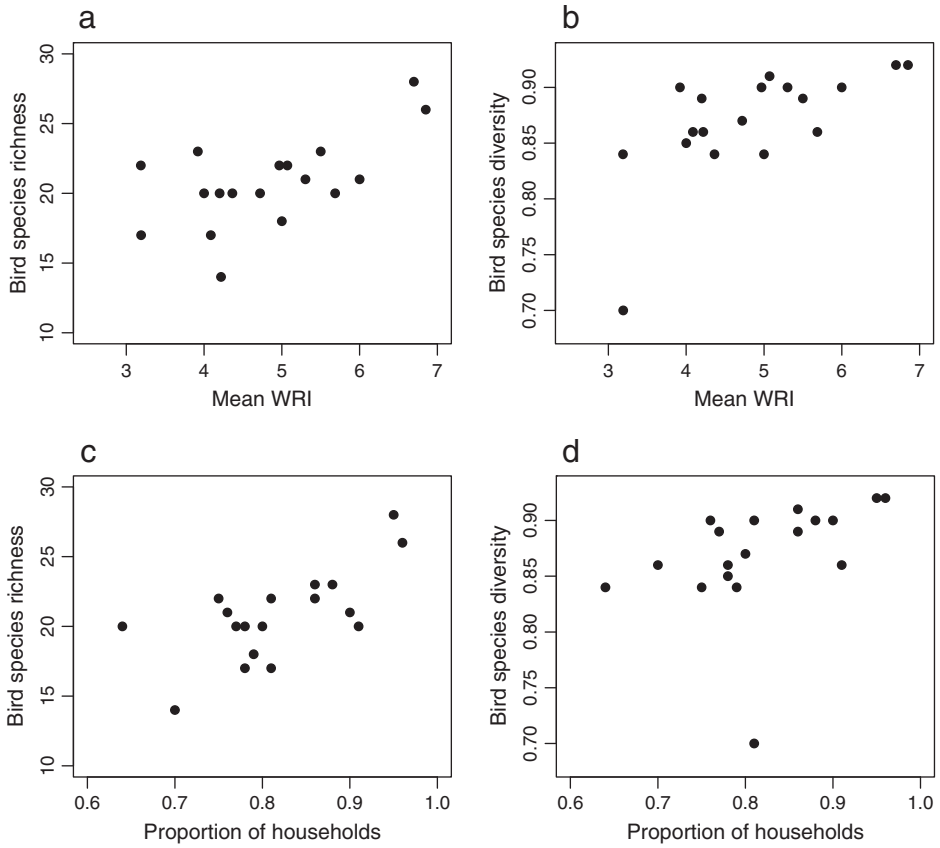

Fig. 4. Neighbourhood-scale correlates of bird species richness and diversity (N = 18). Graphs show the relationship between (a) mean WRI and bird species richness; (b) mean WRI and bird species diversity; (c) the proportion of householders who report seeing birds daily in the garden and bird species richness; and (d) the proportion of householders who report seeing birds daily in the garden and bird species diversity. Species diversity calculated using Simpson's index (1-*D* where *D* = *sum p_i^2* and *p_i* is the proportional abundance of species *i*).

process is especially prevalent in front gardens that are seen as 'public show' (Megan, 46–55). In contrast, the back garden tends to provide a greater opportunity for encouraging nature.

For those householders who are passionate about wildlife, even the social pressures to maintain a neat garden are not a barrier. Carol (56–65) is one such case who does not "consider [her]self answerable to neighbours" and has experimented with leaving islands of long grass in her front garden to provide habitat for butterflies and bees. Local wildlife champions, such as Carol, have the potential to lead change within their community. Neighbour mimicry is commonplace, with personal advice from friends, relatives and neighbours the most important influence on gardening amongst questionnaire respondents (40% scoring it as 4 or 5 on the Likert scale). Interviews corroborated this, with the majority of respondents (14/20) believing that friends or neighbours admire or imitate their garden, with the imitation stretching wildlife-friendly features. For instance, Heather (26–35) explains that the construction of her pond has "encouraged" and "inspired" her neighbours to follow suit, whilst Melanie (56–65) observes that "quite a few bird feeders have gone up since I put mine up". Local authority management practices are likewise mimicked by householders, with half of the interviewees believing that public green space management can influence gardening behaviour.

3.4. Incentivising Greater Uptake of Wildlife-friendly Gardening

3.4.1. Wildlife Garden Certification Scheme

The same social processes that cause spatial contagion in gardening and neighbour mimicry could be harnessed to spread wildlife gardening practices or awareness. For instance, 15/20 interviewees saw some utility in a wildlife gardening award scheme as currently implemented by a range of UK Wildlife Trusts and NGOs. Andrea (26–35) sees benefit in the "knowledge,…help and advice" that would be provided and sees a plaque as "making it a bit more official that people can have something to work towards", whilst for Megan (56–55) it's an "an excuse…to have a back garden that looks like a wilderness" and to inform neighbours about her motives.

3.4.2. Information and Financial Incentives

The majority of interviewees (13/20) thought that they did not have enough information on wildlife-friendly gardening. For most respondents this was manifested through a lack of awareness or understanding about specific features, such as bird feeders or bee 'hotels'. For others, ignorance about wildlife-friendly gardening was not an excuse and a common theme that emerged was that the information was available to householders but they have "got to want to know" (Sonia, 46–55). Information or passive incentives in isolation are unlikely to change attitudes or behaviour in unmotivated householders. For instance, when discussing the potential role of financial rewards for wildlife-friendly gardening, Mary (36–45) believes that "offering people money to actually care more is not going to make that much difference".

3.4.3. Education of Children

For respondents with young children or grandchildren, the education of children was a key reason for attracting wildlife in their gardens. Schools were also seen to have a key role in educating children about nature, whether it be through the establishment of a school garden, the re-instatement of traditional 'nature tables', or the provision of bird feeders on school grounds. Samantha (36–45) is an especially inspiring role-model who has empowered local children to create a

wildlife area in her local neighbourhood. Samantha is aware that if you "start with the kids… then the adults might follow", highlighting the potential for children to engage adults through pressure exerted on their parents. Respondents also recalled childhood activities in their gardens that have shaped their relationship with wildlife as adults.

3.4.4. Community Initiatives and Neighbour Collaboration

Beyond the individual garden, a diverse range of mechanisms for encouraging large-scale uptake of wildlife gardening practices were suggested. The majority of respondents thought that community projects would engage residents, with workshops, evening classes, in-bloom contests and 'Friends Of…' groups some of the initiatives mentioned. Underused or neglected local habitats were seen as particularly valuable opportunities for engaging residents in nature conservation:

> *We get a lot of people together to rejuvenate an area that's overgrown or that has a stream, little things like that I know can generate a lot more understanding, compassion…* (Heather, 26–35).

Nine participants saw potential in the idea of coordinating their gardening with neighbours to maximise habitat provision. In five instances such practice was already happening and for Jack it's a great excuse to reduce gardening effort:

> *…it sounds brilliant, a patch of garden that I don't need to do anything with, let it grow over and it's an ecosystem – yeah, brilliant!* (Jack, 18–25)

Laura's response to difficult growing conditions at the end of her garden due to flooding has been to talk "with a couple of the neighbours about maybe having a wildlife bit…that would grow in damp conditions". In addition to constraints imposed by housing tenure, some interviewees felt limited by the legacies of urban planning. For instance, Amy (46–55) suggests that "when they're building new developments…there are massive fences that tend to shut people in …and I think [they could] give a bit more thought to the back gardens and how they could all interlink".

4. Discussion

Collectively, the sustainable management of private gardens has huge potential to build ecological resilience in cities. Our study demonstrates that biodiversity management of residential landscapes is driven by a combination of ecological and social factors that interact across household- and neighbourhood-scales. We attempt to answer the question: 'Why garden for wildlife?' and suggest that householder decision-making is influenced by a range of personal motivations and social constraints.

4.1. Patterns and predictors of wildlife-friendly garden management

Our results corroborate previous research showing that the provision of resources for wildlife is a popular activity amongst urban householders, with the prevalence of wildlife features and the frequency of bird feeding in Leeds broadly consistent with other studies (Table 5). Gardens throughout Leeds are, on average, most comparable to the 'outer' suburbs of UK cities (Table 5), with lower wildlife gardening activity in the 'inner' and 'middle' urban neighbourhoods of other UK cities (Gaston et al., 2007). The relatively high prevalence of wildlife-friendly gardening in Leeds may in part reflect the low questionnaire response rate (24%), such that respondents were more likely to be interested in gardening and/or wildlife and not necessarily representative of the sample population. In addition, the higher response rate in wealthier neighbourhoods may have magnified the relationship between the WRI and ecological or socio-demographic variables that are associated with income, such as garden size and education level.

By considering a variety of explanatory variables across scales we find that uptake of wildlife-friendly gardening can be best explained by a combination of garden characteristics and management, householder demographics, wider environmental participation and neighbourhood landscape composition. The three variables found to be significant in the best model for both WRI and the frequency of bird feeding were all measured at the household scale, namely: the management intensity index, the environmental activity index and householder age. The

Table 5
A comparison of wildlife-friendly garden features and supplementary feeding levels between Leeds and other published studies. Responses are expressed as percentages of householders (rounded to nearest 1%).

	Leeds	Sheffield[a]	UK inner[b]	UK middle[b]	UK outer[b]	UK total[c]	UK 5 cities[d]	Michigan urban[e]	Michigan suburban[e]	Phoenix[f]
Wildlife-friendly garden feature										
Trees>2 m in height	66	48[g]	–	–	–	54[g]	55[g]	–	–	–
Bird feeder	53	–	12	28	45	23	–	–	–	–
Bird bath	33	–	5	12	27	–	–	–	–	–
Compost heap	31[h]	29	6	23	30	–	33	–	–	–
Bird nest box	28	26	4	11	14	16	–	44	51	–
Wild area	19	–	–	–	–	–	43[i]	–	–	–
Pond	17	14	3	7	13	10	21	–	–	–
Frequency of bird feeding										
Total	64	–	23	46	67	–	–	65	67	41
Daily	31 (Wint) 21 (Sum)	–	8	14	29	–	–	–	–	–
Weekly	21 (Wint) 23 (Sum)	–	6	12	17	–	–	–	–	–
Monthly	12 (Wint) 10 (Sum)	–	3	6	6	–	–	–	–	–
Less than monthly	10 (Win) 12 (Sum)	–	6	14	15	–	–	–	–	–
Never	27 (Win) 34 (Sum)	–	67	54	23	–	–	–	–	–

[a] Telephone survey of 250 households, including those without gardens (Gaston et al., 2005);
[b] Questionnaire survey of ca. 4400 households in inner, middle and outer areas across 5 UK cities (Gaston et al., 2007);
[c] UK-wide extrapolations based on 12 datasets (Davies et al., 2009);
[d] Ecological surveys in 267 gardens across 5 UK cities (Loram et al., 2008);
[e] Questionnaire survey of 1694 householders across the rural–urban gradient in Michigan, US (Lepczyk et al., 2004);
[f] Comparative survey of ca. 3800 householders in Michigan and Phoenix, US (Lepczyk et al., 2012);
[g] Trees>3 m in height;
[h] Includes leaf piles in Leeds study;
[i] Comprises 34% uncultivated land and 9% unmown grass.

significance of conventional garden management suggests that, at least in terms of the provision of wildlife resources, gardening is inherently wildlife-friendly and that mechanisms for encouraging greater participation in gardening per se are likely to enhance urban biodiversity. However, many garden management activities are far from beneficial to urban wildlife. For example, nearly 60% of respondents mow the lawn at least weekly in summer, and over half apply chemical fertilisers, pesticides or herbicides. In addition to their detrimental ecological impact, these activities represent considerable monetary and energy expenditure, and initiatives for reducing the frequency with which they are undertaken will make an important contribution to urban sustainability more widely.

Participation in environmental activities outside the garden was significantly associated with the degree of wildlife-friendly gardening. There has been little research into the degree with which different pro-environmental behaviours predict each other, although evidence for spill-over effects has been reported in the UK and Denmark (Thøgersen and Ölander, 2006; Whitmarsh and O'Neill, 2010). UK policymakers have expressed an interest in the idea of 'catalyst behaviours' that may have a knock-on effect and cause wider behavioural change (Austin et al., 2011). The extent to which wildlife-friendly gardening can be a catalyst for other sustainable practices remains to be seen, but it is interesting that wider environmental values did not predict wildlife gardening. Environmental psychology studies in other residential settings have also found that environmental values do not align with ecologically-oriented landscaping decisions (Larson et al., 2009; Larson et al., 2010; Yabiku et al., 2008).

The extent of gardens and green space across scales makes a significant contribution to the number of wildlife-friendly features within gardens. Individual garden size was an important predictor of the WRI, in accordance with other UK research (Gaston et al., 2007; Loram et al., 2008; Loram et al., 2011; Smith et al., 2005). At the neighbourhood scale, we show that the extent of gardens, woodland and other green space in the surrounding landscape all had a positive influence on the WRI (Fig. 2), whilst the proportion of artificial surfaces within gardens was negatively associated with the frequency of bird feeding. Interviews with Australian gardeners have similarly shown that householders living adjacent to semi-natural bush land are more likely to encourage nature into their gardens (Trigger and Head, 2010). In contrast to Gaston et al. (2007), we found that population density had a negative effect on the provision of wildlife-friendly garden features, being negatively associated with the WRI (Fig. 2). Despite recent revisions to UK policy that have removed housing density targets (DCLG, 2011), new developments remain typically high-density with small gardens and are thus detrimental to the retention of biodiversity in residential landscapes (e.g. Tratalos et al., 2007). Nevertheless, population density had no effect on the frequency of bird feeding in Leeds since householders do not need a large garden (or even a garden at all) to feed birds. In fact, the density of bird feeders can be greater in the inner city than in the suburbs, underlining the importance of gardens for human-nature interactions in highly urbanised areas (Fuller et al., 2012).

Median householder income at the neighbourhood-scale had an inconsistent influence on wildlife gardening practices, being positively (albeit weakly) associated with the WRI but unrelated to the frequency of bird feeding (Table 4). Previous research in the UK and US has also found mixed results, with Gaston et al. (2007) and Lepczyk et al. (2012) showing that socio-economic status had little effect on the prevalence of wildlife-friendly gardening, whilst Fuller et al. (2012) found that the proportion of people feeding birds increased with householder income. Given the evidence that socio-economic status is positively correlated with plant and bird diversity in urban landscapes (e.g. Lerman and Warren, 2011; Warren et al., 2010), future studies should attempt to disaggregate the extent to which income per se is associated with the ability for householders to pay for wildlife-friendly landscaping from the effect of income-linked factors such as garden size, education level and age.

4.2. Correlations Between Wildlife-friendly Gardening and Bird Diversity

The importance of householder activities to encourage wildlife in their gardens is best gauged by the impact that these activities have on local biodiversity. The WRI, but not proportion of bird feeding, was positively correlated with bird species richness and diversity at the neighbourhood scale. However, when bird diversity is measured at the garden scale, supplementary feeding is an important predictor of avian species richness and abundance (Daniels and Kirkpatrick, 2006; Goddard, 2012). Other studies suggest that bird feeding may boost the abundance of some urban-adapted bird species in urban neighbourhoods (Fuller et al., 2012), although avian species richness is more likely to be dictated by the extent and quality of habitat in the surrounding landscape (Chamberlain et al., 2004). Thus, at a landscape scale, the cumulative provision of habitat resources in gardens across a neighbourhood (as quantified by the WRI) is of more significance to the conservation of birds than the density of bird feeding activities.

From the perspective of human-nature interactions, it is interesting to ask whether or not householders perceive differences in bird diversity in their neighbourhoods (Lerman and Warren, 2011). One might expect that bird abundance would be the most likely component of bird diversity to be perceived by residents, but our data suggest otherwise: householders are more likely to report seeing birds daily in their garden in neighbourhoods with high species richness and diversity, but not abundance of birds. Clergeau et al. (2001) similarly showed that perception of birds by people in Rennes, France, was more related to diversity than to abundance, indicating that householders' likelihood of noticing birds in their gardens may increase where they experience a greater variety of species. Indeed, interviewees described a process of "positive feedback" whereby they were more likely to persist with wildlife-friendly gardening where their activities were rewarded by encouraging more bird species into the garden.

4.3. Motivations for Wildlife-friendly Gardening

4.3.1. Human-nature Interactions and Personal Well-being

By interviewing a range of householders we have gained insight into the reasons why people undertake wildlife-friendly gardening. We reinforce the findings of previous studies that show gardens are significant places for interacting with nature (Bhatti and Church, 2004; Clayton, 2007; Gross and Lane, 2007; Power, 2005). The sorts of meaningful interactions between people and wildlife that take place in gardens demonstrate emotional engagement and are essential for encouraging long-term pro-environmental behaviour (Maiteny, 2002). In this way, wildlife-friendly gardening has substantial potential for stimulating the creation of sustainable urban communities.

4.3.2. Social Norms and the Diffusion of Wildlife Gardening Practices

Questionnaire results indicated that friends and neighbours are the most important influence on gardening, implying that garden management is likely to be governed by prevailing social norms. This is particularly the case in front gardens that are viewed as "public show" and very rarely include any purposeful wildlife habitat. The finding that private back gardens seems to be a more direct expression of personal preferences whereas front gardens reflect a display of social status recalls the work of Larsen and Harlan (2006) in Phoenix and supports the theory of ecological prestige (Grove et al., 2006).

Currently, the preference for tidy gardens acts as a considerable barrier to wildlife-friendly gardening. We identify two mechanisms by which the prevailing garden management mindset can be overcome, namely: (i) the mimicry of wildlife-friendly practices of neighbours or local authorities; and (ii) the actions of local champions. Our qualitative data shows for the first time that neighbour mimicry of planting and landscaping (Hunter and Brown, 2012; Zmyslony and Gagnon, 1998)

can extend to wildlife-friendly features such as ponds and bird feeders. As acknowledged by Warren et al. (2008), if the same social processes that currently limit sympathetic management of gardens can be harnessed to develop a conservation ethos then neighbours' attempts to keep up with each other could be beneficial to biodiversity. One tool that was widely supported by householders was a wildlife garden certification scheme. The award of a plaque to place in the garden would perform a range of functions, including: (i) encouraging competition amongst neighbours; (ii) acting as a label or status symbol showing that the householder acts in a pro-environmental way; and (iii) a way of demonstrating 'cues for care' to justify the perception of an unkempt garden (Nassauer, 1995). Wildlife-friendly gardening certification schemes have been widely adopted by conservation NGOs in the UK and US (see review by Goddard et al., 2010b). Policymakers have followed their lead, for example, the UK government has pledged support for the 'Big Wildlife Garden' scheme that seeks to promote sustainable wildlife-friendly management of gardens and community green spaces (HM Government, 2011). The process of neighbour imitation can also apply to the management of local green spaces in urban neighbourhoods; half of the householders interviewed believed that local authority management of parks and verges can influence gardening practices. Unkempt public green spaces are unlikely to garner public support, but given appropriate cues for care, for example by maintaining a short mown area around a longer patch of meadow, ecologically sensitive council management practices are more likely to be mimicked by householders and bring wide-ranging benefits to urban biodiversity (Hunter and Hunter, 2008).

Second, local wildlife champions have potential for inspiring behavioural change in neighbours via social or sustainability learning (McCarthy et al., 2011; Tàbara and Pahl-Wostl, 2007). Two potential candidates emerged from the interviews (Carol and Samantha) and it is of particular note that they live in two of the most deprived neighbourhoods. With appropriate training and expertise, potentially provided via conservation NGOs or local authorities, a local wildlife-gardening champion could be the impetus behind reaching the "threshold of cultural sustainability" that Nassauer et al. (2009) suggest is needed to ensure the long-term success of ecologically innovative management practices in residential neighbourhoods. The impacts of such wildlife champions are maximised when they are linked to strong community groups, such as those developed from gardening clubs or 'Friends of…' initiatives, that enable dissemination of their practices more widely. Opportunities linked to school initiatives and new social network media should be explored to enhance the sense of community-based urban natural resource management, building from the many successes of participation in rural conservation initiatives globally (Reed, 2008).

4.4. Top-down versus bottom-up initiatives for incentivising biodiversity management in residential landscapes

In addition to the presence of neighbourhood standards, another oft-cited barrier to wildlife-friendly gardening was a lack of information or knowledge. Although a range of methods for distributing information to householders were discussed, a common theme that emerged was that you have "got to want to know". This idea also extended to the use of financial incentives, striking a chord with the work of Maiteny (2002) who suggested that information or other passive incentives (including financial) are unlikely to engender sustainable behaviour in the long term. Similarly, studies have demonstrated the failure of top-down planning to incentivise behaviour change in residents of new 'green' or sustainable developments (Hostetler and Noiseux, 2010; Williams et al., 2010; Youngentob and Hostetler, 2005). Communicating information to the public is most successful when it involves a two way process of dialogue, as exemplified by researchers in Dunedin, New Zealand, who have successfully facilitated a shift towards environmentally-friendly gardening by tailoring advice to the individual householder (van Heezik et al., 2012). Likewise, participants in the current study were observed to have adopted more wildlife-friendly garden features following discussion and feedback from the researcher (M Goddard, personal observation).

A reason for the failure of top-down mechanisms to encourage pro-environmental behaviour is that they fail to implement change at the grass-roots. Education of children was considered of paramount importance and for most householders it was schools that had the greatest responsibility for encouraging first-hand experience of nature. The resurgence of the grow your own movement was also evident and sharing of locally grown produce and plants is likely to be increasing community cohesion and well-being, in addition to benefiting wildlife. The coordination of garden management with neighbours can also contribute to a sense of community. In the instances where such practice is already happening it represents an ideal opportunity to maximise wildlife habitat and highlights that gardens should not be ignored in urban planning attempts to promote connectivity in the green infrastructure of cities (Colding, 2007; Goddard et al., 2010b; Rudd et al., 2002). Collectively managed urban green spaces, such as allotment gardens, that empower residents to become local stewards can foster sustainable and resilient urban communities through the exchange of ecological knowledge (Barthel et al., 2010; Colding et al., 2006).

5. Conclusion

Understanding what drives householder decision-making for biodiversity management in residential landscapes is of paramount importance for achieving a more sustainable urban future (Cook et al., 2011) and for guiding on routes to social learning and greater community empowerment on wildlife gardening initiatives. We focused here on the provision of habitat for wildlife, but vegetation within private gardens also has potential for the delivery of wider ecosystem services in cities (Davies et al., 2011). Questionnaires and interviews in Leeds revealed that a combination of multi-scalar social and ecological factors motivate wildlife-friendly garden management. They also demonstrate the ecological outcomes of such practices, showing that the extent of wildlife-friendly features in urban neighbourhoods correlates with bird diversity. Mechanisms for increasing the uptake of wildlife gardening would benefit from harnessing existing social norms whereby ecological practices are spread by a process of neighbourhood diffusion. Such a process can be stimulated by sympathetic management of local green spaces, garden habitat certification schemes or through the enabling of local champions to educate and empower local communities. At coarser scales, urban planning that maximises the provision of gardens and green space and integrates natural habitat into residential neighbourhoods is imperative to provide a platform for sustainable and ecologically sound garden management.

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Appendix A. Householder Questionnaire

Gardens in Leeds — Survey instructions

If there is a main gardener in the household then they would be the best person to complete the questionnaire. However, if there is not a main gardener please continue whatever your level of interest in gardening.

The survey takes around 10 min to complete. It contains 30 questions and is divided into 4 sections:

A Garden use and management
B Garden wildlife
C House and garden characteristics
D Background information

Please answer the following questions by placing a tick in the appropriate box(es).

If you would prefer to complete the survey online, it can be found at: http://www.survey.leeds.ac.uk/gardens_a1.

A. Garden use and management

1. Which of the following descriptions best applies to you? (Please select one)
☐ Gardening enthusiast (I enjoy gardening all year round.)
☐ Fair weather gardener (I only do gardening in good weather or during spring/summer.)
☐ Gardener out of necessity (I only do what is absolutely necessary to keep the garden tidy.)
☐ Wildlife-friendly gardener (I garden mainly to provide food and shelter for wildlife.)
☐ Rent-a-gardener (I pay someone else to do the gardening.)
☐ Non-gardener (I do not do any gardening and I do not hire a gardener.)

2. On average, how long do you (or your gardener) spend gardening per week in the summer months?
☐ Less than 1 h ☐ 1–5 h ☐ 6–10 h
☐ 11–20 h ☐ More than 20 h

3. On average, how frequently do you (or your gardener) undertake the following gardening activities in the summer months?

	Never	Less than monthly	Monthly	Weekly	Daily
Mowing the lawn	☐	☐	☐	☐	☐
Planting flowers/shrubs	☐	☐	☐	☐	☐
Dead-heading flowers	☐	☐	☐	☐	☐
Watering the lawn or plants	☐	☐	☐	☐	☐
Weeding	☐	☐	☐	☐	☐
Applying chemical fertilisers	☐	☐	☐	☐	☐
Applying pesticides or herbicides	☐	☐	☐	☐	☐

4. How important are the following reasons for using your garden?
Please score each reason from 1 to 5 where 1 = not important, up to 5 = very important

	1	2	3	4	5
Enjoyment of plants/flowers	☐	☐	☐	☐	☐
Keeping fit	☐	☐	☐	☐	☐
Relaxation	☐	☐	☐	☐	☐
Recreation (e.g. for children, pets)	☐	☐	☐	☐	☐
Entertainment and outside dining (e.g. barbeques)	☐	☐	☐	☐	☐
Growing food	☐	☐	☐	☐	☐
Watching/attracting wildlife	☐	☐	☐	☐	☐

5. How important are the following sources of information for influencing your gardening?
Please score each source of information from 1 to 5 where 1 = not important, up to 5 = very important

	1	2	3	4	5
Personal advice (e.g. friends, relatives, neighbours)	☐	☐	☐	☐	☐
Books and media (e.g. magazines, websites, TV, internet)	☐	☐	☐	☐	☐
Design of public green spaces (e.g. parks etc.)	☐	☐	☐	☐	☐
Local events (e.g. stalls at community fun days)	☐	☐	☐	☐	☐
Expert talks/meetings at gardening clubs or associations	☐	☐	☐	☐	☐
Demonstration gardens (e.g. at flower shows)	☐	☐	☐	☐	☐

B. Garden wildlife

6. Please indicate which (if any) of the following features are present in your garden (please select all that are present):
☐ Bird feeder/table
☐ Bird bath
☐ Bird nest box
☐ Other nest box (e.g. bat, hedgehog, bumblebee, ladybird)
☐ Pond
☐ Compost heap/leaf pile
☐ Log pile
☐ Wild/undisturbed area (e.g. long grass, brambles)
☐ Plants with berries/fruits
☐ Flowering plants
☐ Hedge/shrubs
☐ Trees taller than 2 m (if yes, please select how many):
☐ 1 ☐ 2–5 ☐ 6–10 ☐ Over 10
☐ None of the above

7. Have you deliberately chosen to include any native plants in your garden (i.e. plants that grow naturally in the wild in Britain)?
☐ Yes ☐ No

8. On average, how frequently do you spend time watching wildlife in your garden?
☐ Never ☐ Less than monthly ☐ Monthly ☐ Weekly ☐ Daily

9. On average, how frequently do you see the following groups of wildlife in your garden in the summer months?

	Never	Less than monthly	Monthly	Weekly	Daily
Birds	☐	☐	☐	☐	☐
Butterflies	☐	☐	☐	☐	☐
Bees	☐	☐	☐	☐	☐
Dragonflies	☐	☐	☐	☐	☐
Frogs, toads and newts	☐	☐	☐	☐	☐
Snakes and lizards	☐	☐	☐	☐	☐
Bats	☐	☐	☐	☐	☐
Squirrels	☐	☐	☐	☐	☐
Mice and small mammals (e.g. voles, shrews, moles)	☐	☐	☐	☐	☐
Hedgehogs	☐	☐	☐	☐	☐
Foxes	☐	☐	☐	☐	☐
Badgers	☐	☐	☐	☐	☐

10. On average, how frequently do you feed the following groups of wildlife in your garden?

	Never	Less than monthly	Monthly	Weekly	Daily
Birds (in winter)	☐	☐	☐	☐	☐
Birds (in summer)	☐	☐	☐	☐	☐
Hedgehogs	☐	☐	☐	☐	☐
Foxes	☐	☐	☐	☐	☐
Badgers	☐	☐	☐	☐	☐

11. Do you consider any of the following animals to be unwelcome in your garden? (Please select all that apply)
☐ Rats ☐ Foxes ☐ Squirrels ☐ Moles ☐ Badgers ☐ Cats
Other(s), please state:

C. House and garden characteristics

12. House type (please select):
☐ Terraced ☐ Semi-detached ☐ Detached ☐ Flat

13. What is the approximate age of your house? (Please select)
☐ Historic–end Georgian (pre-1837) ☐ Post war (1945–1964)
☐ Early/middle Victorian (1837–1870) ☐ Sixties/seventies (1964–1979)
☐ Late Victorian/Edwardian (1870–1914) ☐ Recent (1979-current)
☐ World War 1–WW2 (1914–1945) ☐ Don't know

14. What is the approximate size of your back garden or yard? (Please select)
☐ Small (up to 10 m × 10 m, e.g. half a tennis court or less)
☐ Medium (up to 10 m × 20 m, e.g. a tennis court)
☐ Large (clearly larger than a tennis court)
☐ Very large (more than 2 tennis courts)
☐ Don't know

Please state size in metres if known: .....m×.....m

15. What is the main land cover type in your back garden or yard? (Please select one)
☐ Lawn ☐ Hard surface (e.g. patio, decking, gravel)
☐ Trees/shrubs ☐ Flower beds
☐ Vegetable plot ☐ Other (Please state)

16. How many cats and dogs do you own?

	0	1	2	3+
Cats	☐	☐	☐	☐
Dogs	☐	☐	☐	☐

4. Background Information

Please note that a number of questions in this section ask for details of the main earner in the household, which may not be the person completing the survey.

Question 17 asks for your street and house number. This information is optional and will only be used to help me identify the characteristics of your garden from aerial photographs and Ordnance Survey (OS) maps.

Please remember that all data collected in this survey will be held anonymously and securely.

17. Your house is located in Armley Sample Area 1. Please help me to improve the quality of my research by indicating your street and house number:
Street House number

18. Are you the main gardener in the household?
☐ Yes ☐ No ☐ I manage the garden jointly
☐ I hire a gardener

19. Gender: ☐ Female ☐ Male

20. Age: ☐ 18–25 years ☐ 26–35 years ☐ 36–45 years
☐ 46–55 years ☐ 56–65 years ☐ Over 65 years

21. How many people are there in your household?
☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ More than 5

22. Do you have any young children (12 years or under) in the house?
☐ Yes ☐ No

23. Tenure:
☐ Owner occupied
☐ Rented from private landlord
☐ Rented from local authority
☐ Other (Please state)

24. How long have you been living in your house?
☐ Less than 1 year ☐ 1–2 years ☐ 3–5 years ☐ 6–10 years ☐ More than 10 years

25. What is the employment status of the main earner in your household?
☐ Full-time ☐ Part-time ☐ Not working ☐ Retired ☐ Student

26. What is the occupation of the main earner in your household?
☐ Managerial/professional ☐ Service and sales
☐ Technician/associate professional ☐ Process and machine operator
☐ Administrative/secretarial ☐ Other occupation
☐ Skilled trades ☐ Not working

27. What is the highest level of academic qualification achieved by an adult in your household?
☐ Secondary school or below
☐ Further education college (e.g. A-Levels, GNVQs)
☐ Undergraduate degree (e.g. BA)
☐ Postgraduate degree or above (e.g. MA, PhD)

28. Do you participate in any of the following conservation or environmental activities outside of your garden? (Please select all that apply)
☐ Household waste recycling
☐ Practical conservation (e.g. tree planting, pond creation etc.)
☐ Allotment gardening
☐ Wildlife surveys
☐ None of the above
☐ Other (please state)

29. Are you a member of any garden or wildlife organisations or charities (e.g. Royal Horticultural Society (RHS), Wildlife Trust, RSPB)?
☐ Yes ☐ No
If so, please state which one(s)

30. How important do you consider the following environmental issues?
Please score from 1 to 5 where 1 = not important, up to 5 = very important

	1	2	3	4	5
Climate change and global warming	☐	☐	☐	☐	☐
Pollution	☐	☐	☐	☐	☐
Food issues (e.g. organic farming, GM crops, food miles)	☐	☐	☐	☐	☐
Conservation and wildlife	☐	☐	☐	☐	☐
Energy crisis (shortages of oil and gas)	☐	☐	☐	☐	☐
Recycling and waste management	☐	☐	☐	☐	☐

Thank you very much for taking the time to participate in this survey. Your answers are and will remain confidential.

One more thing…. Gardens needed for wildlife surveys!

A vital part of my project is to visit gardens in Leeds to record the wildlife in different neighbourhoods throughout the city (to find out more about my research please see: http://www.see.leeds.ac.uk/ebi/studentship-urban-gardens.htm). As a follow up to this questionnaire I am looking for volunteers to offer their gardens for ecological survey work. These garden surveys are planned for spring and summer 2009 and 2010 and will involve a series of short visits (around 30 min each) to record birds, insects and plants in your garden. You would not be required to assist with the survey — your only commitment would be to provide access to the garden. It is important that I survey different types of gardens in all areas of Leeds so it doesn't matter how big your garden is or how much wildlife you see in it.

If you are interested in offering your garden please fill in your contact details on the enclosed slip and return it to me with your completed questionnaire using the Freepost envelope provided. I will then get in touch with you to discuss this further. Alternatively please feel free to contact me directly via email (bsmag@leeds.ac.uk) or by telephone at the University (0113 343 3078). My research would not be possible without the generous cooperation of people in Leeds.

Many thanks again for your help.

Mark Goddard

Appendix B. Garden Interview Protocol

Introduction to research project

- As you know I'm a PhD student at the University of Leeds interested in the management of residential gardens.
- The purpose of this interview is to explore the range of influences on your gardening practices and your attitudes towards garden wildlife. We will also discuss ways for improving gardens as habitats for wildlife.

Some comments about the process

- There are 19 Qs and I expect the interview to take around an hour.
- I would like to record the interview so that I don't forget your answers! I won't let anyone else listen to the recording. Is that OK? (TURN ON RECORDER)
- The interview is confidential and you will not be named in any research report that I write, but I may use your words in the report. Is that OK?
- Try to ignore the recording and please take your time in answering.
- Please ask if you don't understand anything that I am asking.

A. Your garden and influences on your gardening

1. Tell me about your garden.

- What do you use it for?
- What do you most enjoy about your garden?
- What's the main benefit of your garden?

2. How much are you influenced by the appearance of other gardens in your neighbourhood?
- Do most people in the neighbourhood tend to garden in a similar way?
- Do you know what your neighbours think about your garden?

3. Do you feel that you have a duty to maintain neighbourhood standards and keep your garden neat and tidy?
- What activities in particular do you feel that you have a duty to do (e.g. mowing the lawn, tidying leaves)?
- Do you resent having to do this?
- Do you maintain your front and back gardens in the same way?
- What benefits do these neighbourhood standards bring to your street (e.g. increased property prices)?
- What would happen with your neighbours if you reduced the maintenance of your garden, e.g. if you let the grass grow long for a while?

4. Does the management and planting of public green spaces (e.g. road verges, parks etc.) influence your gardening?
- If the local green spaces were maintained less intensively (e.g. mowed less frequently) do you think this would alter your gardening?

B. Wildlife in and around your garden

5. Tell me about the wildlife that visits your garden.
- What species do you see?
- How often do they visit?
- Have you noticed any changes in the species or numbers of wildlife visiting your garden over the years?

6. What kinds of things do you do to encourage wildlife in your garden?
- Do you have any features in your garden with the main aim of attracting wildlife (e.g. feeding, shelter, water, nest sites)?
- Do you alter your gardening practices in any way to benefit wildlife, (e.g. mow less, avoid pruning in spring/summer, avoid chemical use, keep cats inside)?
- Why do you like/not like to encourage wildlife to your garden?
- Does seeing wildlife in your garden affect your quality of life?
- Do any of your neighbours like to encourage wildlife too?

7. Could you describe any ecological roles performed by animals in your garden?
- Rephrase: are there any important jobs done by animals in your garden?
- Prompt with particular example mentioned earlier (e.g. butterflies, birds)

8. Would you say that your garden is part of a wider ecosystem?
- Rephrase: how is your garden part of the larger community of plants and animals in the surrounding area?
- Can what you do in your garden have an effect on the wildlife in the surrounding area?
- Are there any places in the neighbourhood that are particularly important for wildlife (e.g. parks, woodlands, other gardens)?

9. Do you consider any plants or animals to be unwelcome in your garden?
- Why?
- Do you do anything to control or deter unwelcome wildlife?
- How do you feel about using chemicals in the garden such as fertilisers or pesticides?
- Can you think of any animals that could be 'natural enemies/predators' of garden pests?

10. Do you deliberately include native plant species in your garden?
- Prompt: plants that grow naturally in the wild in Britain
- Why or why not?

11. Are there any other environmental issues that you think about when gardening or buying garden products?
- Prompts: peat in compost, water conservation, origin of wood or stone

12. In general, do you think that we should try to encourage wildlife in towns and cities?
- Why or why not?
  - Do you think that urban areas can be important for wildlife compared to the countryside?

13. What are the main threats to wildlife in your neighbourhood?
- What impact do you think cats have on wildlife in your area?
- Any ideas for reducing the impact of cats?

C. Encouraging wildlife-friendly gardening

14. What would encourage you to garden in a more wildlife-friendly way?

15. What are the main things that stop you from gardening in a more wildlife-friendly way?
- Prompts: time, garden size, cost, e.g. garden size, cost, knowledge/information, neighbourhood standards/social pressures, appearance/aesthetics, cats
- How could you overcome these barriers?
- Do you have enough information about wildlife-friendly gardening?
- What more information could be provided and how could it be distributed?

16. Can you think of any ways to encourage wildlife-friendly gardening on a large scale by more people throughout your neighbourhood?
- Would you consider working together with your neighbours to increase the amount of habitat available to wildlife throughout your gardens or neighbourhood?
- Prompt: e.g. would you plant a continuous strip of trees across a group of gardens, or remove the fences to create a wildflower meadow?
- What would prevent this from working?

17. Would local community projects or initiatives encourage you to garden in more wildlife-friendly way?
  - Prompts: e.g. free-tree schemes, local fun-days
- What do you think of the idea of a 'wildlife-friendly' award for your garden or street?
- Do you think that a 'cats indoors campaign' could be successful in this area?
  - Are you aware of any similar nature conservation projects/environmental improvement schemes that have been implemented in your area?

18. Could financial incentives (e.g. grants, tax breaks) encourage you to garden in a more wildlife-friendly way?
- Prompts: e.g. grants, tax cuts for retaining/planting trees in your garden or building a pond
- Could you see such incentives be implemented by the city council?
  - Would you be willing to pay more council tax for enhancing the wildlife habitat in your neighbourhood?

19. Do you think that gardens and garden vegetation are sufficiently protected within the planning system?

- o E.g. regulation to reduce the loss of garden area for building new houses and extensions, or the removal of large trees
- o Are you aware of the Biodiversity Action Plan for Leeds?

Thank you very much for taking the time to help with my research

- Anything else you didn't get a chance to say or any questions about the interview?

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