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RESEARCH ARTICLE

## Household Factors Influencing Participation in Bird Feeding Activity: A National Scale Analysis

Zoe G. Davies , Richard A. Fuller, Martin Dallimer, Alison Loram, Kevin J. Gaston

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### Figures

Household characteristic	Prediction	Literature supporting the choice of household characteristic and/or prediction
Household Status	Feeding more likely to occur, rather than nested, households	Lock et al. (2005)
House Type	Feeding more likely to increase by detached house type	Gaston et al. (2007), Loram et al. (2007)
Age of household	Feeding more likely where the head of the household is older	Lapchin et al. (2004), Booth et al. (2006), Natural England (2010)
Household Size	Feeding is influenced by the number of people in the household	Lapchin et al. (2004)
2010 Annual Household Income	Feeding more likely to households with higher annual income	Hope et al. (2003), King et al. (2005), Lock et al. (2005), Southwell et al. (2006)
Occupation/Employment Status of household	Feeding more likely in occupations of people in higher socio-economic groups	Fuller et al. (2008), European Commission (2010)

doi:10.1371/journal.pone.0039692.t001



Survey name	Area cover
2007	England
08/09	Edinburgh
09/10	Strasbourg
09/10	Leicester
09/10	Oxford
09/10	Stafford

A full breakdown of 08/09 survey locations is available at <https://doi.org/10.1371/journal.pone.0039692.t002>

# Abstract

Ameliorating pressures on the ecological condition of the wider landscape in protected areas is a key focus of conservation initiatives in the developed urbanized nations, domestic gardens can play a significant role in increasing biodiversity and facilitating human-wildlife interactions, which benefit societal health and well-being. The extent to which sociodemographic factors are associated with engagement in wildlife gardening activities remains unresolved. Using two household-level survey datasets gathered from five study cities, we determine whether and how the socioeconomic background of a household influences participation in food provision for wild birds, the most popular and visible human-wildlife interaction. A majority of households feed birds (64% in urban areas in England, and 53% within five British study cities). Household size and the age of the head of the household were all important predictors of bird feeding, whereas gross annual household income, the occupation of the head of household, and whether the house is owned or rented were not. In all study cities, the prevalence of bird feeding rose as house type became more detached and the age of the head of the household increased. A clear, consistent pattern between household size and bird feeding was less evident. When regularity of food provision was considered, in all study cities, just 29% of households provided food at least once a week. In all study cities, households regularly feeding birds was positively related to the age of the head of household, but declined with gross annual income. As concerns grow about the decline in engagement between people and the natural environment, such findings suggest that conservation organizations are successful to promote public participation in wildlife gardening specifically and environmentally beneficial behaviour in general.

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project). The funders had no role in study design, data collection decision to publish, or preparation of the manuscript.

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## Introduction

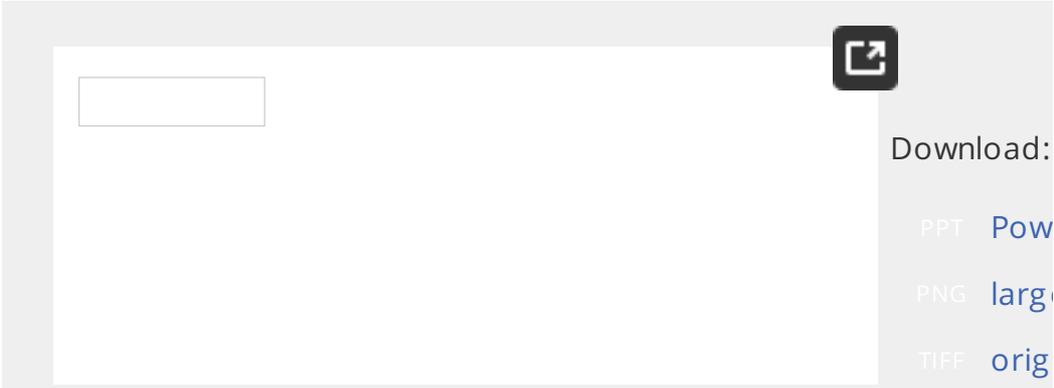
The prospects for maintaining large terrestrial land parcels for conservation that are relatively undisturbed by human activities have already been lost for many years [1]–[2]. Additional conservation measures are therefore being applied to rural landscape, outside of protected areas, in order to preserve species diversity. These measures have many added benefits including supporting ecosystem function, enhancing ecosystem service provision [4]–[5], and enhancing human health [6]. As a greater proportion of the world's human population comes to live in urban areas, the advantages of extending management to enhance biodiversity within residential areas are increasingly being recognized, not least given that the majority of the human population will experience interactions with nature in urbanized societies [9]–[10]. Indeed, evidence of the benefits to the human population of experiencing and interacting with wildlife and the natural world is accumulating [11]–[13]. The personal and societal gains are diverse, but include improved mental health when exercise is carried out in natural environments [14]–[15], improved reported general health [16]–[18], enhanced longevity [19], stress-reduction [20], mental fatigue [21], increased degree of social interaction [22] and improved quality of life [23].

A variety of strategies have been suggested to ameliorate the pressures on the condition of residential environments. These include creating green spaces, green corridors [24]–[25], developing urban forests [26]–[27], improving the quality of public parks (e.g., [28]–[29]), and encouraging householders to participate in 'wildlife gardening' activities (e.g., [30]). Wildlife gardening can be broadly defined as being conducted in a domestic garden intended to increase its suitability for wildlife through the provision of a diversity of resources (e.g., food, breeding and overwintering sites). One of the attractions of such an approach has been the potential for widespread adoption by individual households; gardens are intensively managed habitats and householders may invest substantial amounts of both time and money in their care. The garden retail market is currently worth £4.6 billion [32] and, in 2005, a survey revealed that 13% of adults engage in gardening, spending an average of 15 minutes per day doing so [33].

Although gardens are managed by individual households, their impact on biodiversity conservation and ecosystem service provision through the provision of habitat is increasingly recognized not only by the research community (e.g., [34]–[36]), but also by local [37]–[39] and national (e.g., [40]–[42]) authorities. An understanding of the factors that influence participation in wildlife gardening activities may vary with the socioeconomic characteristics of individual households is important if conservation organizations are to develop effective public engagement in wildlife gardening activities, and to develop strategies to increase awareness of environmentally beneficial behaviour in society more generally.

In both the UK and US, the most popular wildlife gardening activity is [42]–[43]. Although a number of studies have explored both the positive effects of food provision on bird populations and communities (e.g. socioeconomic factors underpinning such human-wildlife interactions), gardens have seldom been investigated explicitly (but see [54] for a review and [50] for an analysis resolved only to the neighbourhood level).

In this paper, we develop *a priori* hypotheses regarding the relationship between sociodemographic and socioeconomic status of individual households engaged in bird feeding activities and how regularly food was provided. In line with previous research in related areas, we focus on six fundamental characteristics, for which data are straightforward to obtain (thus a useful starting point for groups wishing to launch initiatives to increase public uptake of wildlife gardening on the outcomes of this study), and determine whether they can be used to predict involvement in bird food provision. Although our hypotheses are informed by primary literature, the majority of these studies examine correlations between socioeconomic status and measures of biodiversity, rather than on participation in activities that could support biodiversity.



The image shows a screenshot of a document viewer. On the left, there is a large, empty rectangular box, likely representing a table or figure that failed to load. To the right of this box, there is a 'Download:' menu with three options: 'PPT', 'PNG', and 'TIFF'. The 'PPT' option is highlighted in blue, with the text 'PowerPoint' partially visible. The 'PNG' option is also highlighted in blue, with the text 'large' partially visible. The 'TIFF' option is highlighted in blue, with the text 'original' partially visible. Below the viewer, there is a caption for Table 1 and a DOI link.

**Table 1. A summary of the predicted relationship between each characteristic and the prevalence of food provision for wild bird findings of previous studies investigating various human-wildlife interactions.**  
<https://doi.org/10.1371/journal.pone.0039692.t001>

1. *Household Status*. At a neighbourhood-level, home ownership in the UK is positively correlated with abundance of nectar-rich plants and native trees, and is negatively associated with impervious surface cover [55]. The authors suggest that home owners are likely to have a greater attachment to their land and property, and are more prone to investing in garden maintenance that could be beneficial to wildlife. We hypothesize that home owners will be more likely to undertake bird feeding activities.

2. *House Type*. Garden area has been found to be positively correlated with bird feeding activity [46]. Given that housing type (in Britain, whether semi-detached, terraced or is a flat) is a reliable surrogate measure of garden area, we predict that the bird food provision will be greater as houses become more detached.

3. *Age of Householder*. There is concern among policy-makers [57] about the impact of human-wildlife interactions, especially amongst children and young people.

Older members of the public are more likely to engage in activities in their own backyards and gardens than in public spaces or the environment in general [60]. In a single region study, older householders were more engaged in bird feeding [54], a trend that, although not explicitly reported, has also been reported for the US as a whole. We therefore anticipate that bird feeding will be positively related to the age of the householder.

4. *Household Size*. In their study region, Lepczyk et al. [54] failed to find a significant relationship between the number of people in a household and participation in bird feeding activities. However, this does not preclude the possibility that larger households are more likely to undertake the provision of food for birds at a national-scale, if only on the grounds that larger households may be more likely to contain one or more individuals interested in undertaking such activities.

5. *Gross Annual Household Income*. Household income was positively related to measures of vegetation cover in Australia [55], while family income was negatively related to variation in plant diversity across different neighbourhoods in Phoenix, Arizona [56]. Similarly, in Germany, bird species richness was greater in neighbourhoods with a higher average income of residents was high [63]. In the UK, the proportion of households providing food for birds was negatively related to an index of socioeconomic deprivation [50]. As such, we hypothesize that the prevalence of bird feeding will be positively related to gross annual household income, not least because the cost of purchasing bird seed and feeding equipment may discourage lower income groups from undertaking such activity.

6. *Occupation/Employment Status of Householder*. Across Europe, the proportion of households who reported making personal efforts to protect biodiversity varied significantly with the householder's occupation/employment status [64]. We thus predict that the occupation/employment status of the householder will influence whether or not food is provided for birds.

In addition to testing these hypotheses, we also examine how the level of bird feeding varies for each household characteristic identified as a significant predictor of engagement. This is the first time that such trends at a national scale level have been formally assessed at a nationwide scale.

## Methods

We carried out this study using two household surveys. The first concerned participation in bird feeding activities gathered in England, covering both rural and urban areas across the country, and the second examines food provision in five major British cities (Figure 1). Using these complementary datasets, we will contrast households situated within urban areas specifically and those situated in rural areas as a whole.



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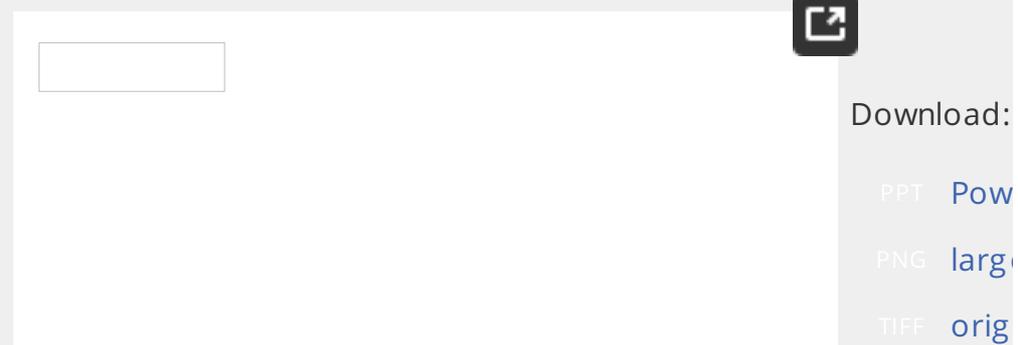
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**Figure 1. The location of the five British cities (E, Edinburgh; G, Glasgow; L, Leicester; O, Oxford; S, Sheffield) sampled during the CityForm survey from which were subsequently used to investigate whether and how the socioeconomic and sociodemographic background of a household affects participation in wild bird feeding activity.**

<https://doi.org/10.1371/journal.pone.0039692.g001>

## Survey of English Housing

The Survey of English Housing (SEH) is an annual interview-based survey of approximately 20,000 households (Table 2), conducted for the UK Government Department for Communities and Local Government by the National Centre for Social Research. All data were gathered in accordance with UK government data protection regulations and were fully anonymised prior to use. The main purpose of the survey is to gather reliable information on the characteristics of the household and the attitude of the respondent in relation to their personal and household circumstances. In its entirety, the survey consists of approximately 100 questions comprising a core of factual questions that remain largely unchanged over time (e.g., regarding factors such as whether the respondent owns or rents their home, costs and housing history), in addition to a set of questions on opinions and attitudes that are revised annually (see <http://www.esds.ac.uk/> for details). The households are chosen at random from within stratified groupings based on Office for National Statistics Regions and socioeconomic status.



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**Table 2. Response rates for the Survey of English Housing (SEH) questionnaire.**

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The 2001/02 survey [66] included a small set of questions investigating whether households participate in wildlife gardening activities. It represents the first national-level survey data pertaining to wildlife gardening, thereby enabling the investigation of the socioeconomic characteristics of households that participate in wildlife gardening activities (as opposed to previous neighbourhood-level analyses). Respondents were asked whether the household provided food for

bird feeder or table. Elsewhere in the questionnaire, respondents were asked whether they had access to a private, shared or communal garden, and the type of these. Over two-thirds of surveyed households completed the questionnaire.

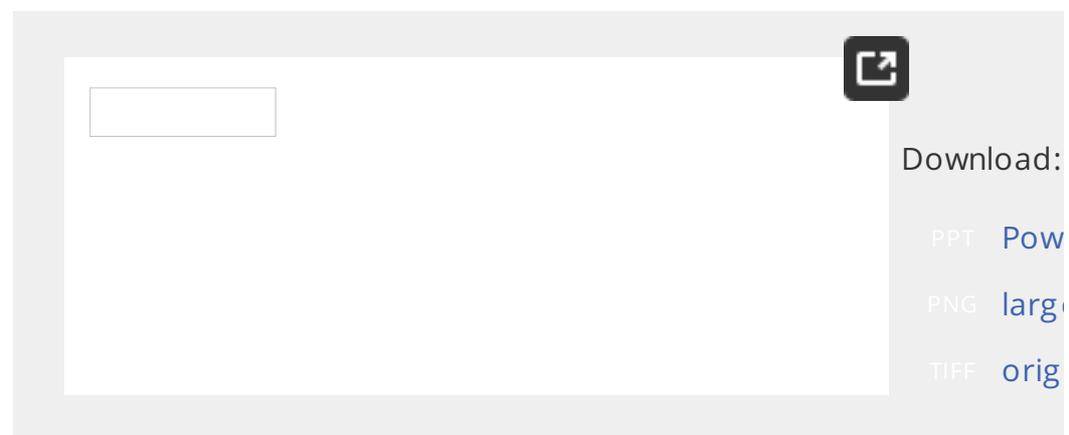
## CityForm Questionnaire

The CityForm questionnaire survey was conducted in 2005, as part of a larger research project investigating social, economic and environmental issues in urban areas (see [46], [67] for full details of the survey methodology, and Table 2 for details of the data). Data were collected from five cities across Britain: Edinburgh, Glasgow, Manchester and Sheffield (Figure 1). Within each city, addresses were selected to represent study sites representing a city centre location, an outer suburban location and a location in between the two. Sites were selected to represent the range of urban environments in each city; formal comparisons between cities are therefore not appropriate. Data from the CityForm survey are analyzed together. The questionnaire included questions relating to the aims of the wider consortium project, and questions on wildlife gardening used in this study formed only a small part of the survey. The structure minimized the potential biases associated with the level of wildlife gardening questionnaire recipients had in wildlife and/or gardening. All data from the survey were gathered and stored anonymously. Appropriate institutional ethics approval was followed.

As with the SEH, respondents were asked to indicate whether they had a private garden, shared/communal garden, patio or yard, roof terrace/large balcony, or none of these. Respondents were then asked to indicate how regularly food was provided for birds by household members, choosing one option from the following: daily, weekly, monthly, less than monthly, or never.

## Data Extraction and Standardisation

We extracted data from both surveys relevant to the six hypotheses. From the SEH, we extracted whether the household was owned or rented (*Household Status*), the type of housing (e.g. flat, house), the age of the head of the household (*Age of Householder*), the number of people living in the property (*Household Size*), gross annual income for the household (*Household Income*) and the nature of employment of the head of the household (*Occupation of Householder* for the SEH, and *Employment Status of Household* for the CityForm questionnaire). The information was then re-coded into categories which were comparable between the SEH and CityForm questionnaire.



**Table 3. The probability ( $k$ ) of each household characteristic being a better predictor (i.e., better than random; highlighted in bold) of the level of participation in bird food provision, for three datasets collected as part of the Housing (SEH) and CityForm questionnaire.**

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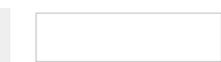
## Statistical Analyses

Prior to conducting the statistical analyses, we removed households that were located in an outside space from both the SEH and CityForm datasets, as they would not be able to participate in bird feeding activity regardless of their socioeconomic background. The data obtained in the CityForm survey of households that provided bird food were consolidated into binomial responses to allow for direct comparison with the SEH findings. In addition, we collapsed the CityForm dataset by grouping the data pertaining to how regularly households feed birds into two response categories: regularly (households feeding birds on a monthly or more than monthly basis) and irregularly (households feeding birds on a monthly or less than monthly basis). This allowed us to adopt a statistical approach to investigate the relationship between household characteristics and regularity of food provision. All statistical analyses were carried out using R (version 2.10.1 [68]).

For each of the three datasets, multiple colinearity between the household characteristics was investigated and found to be within accepted norms [69]. Correlation analysis showed that the relationships between the household characteristics and the response variable explained a maximum of 15% of the variation in the data unexplained (with a maximum  $r^2$  recorded of 0.15). Inflation Factors (VIFs) among all six variables were not sufficient to indicate a problem with the analysis.

To determine which of the six household characteristics were important predictors (i.e., better than random) of the level of participation in bird feeding activity, we used the Information Theoretic approach [70]. All possible combinations of household characteristics were modelled using logistic regression, with the response to bird feeding as the dependent variable (yes or no for SEH, and regularly or irregularly for CityForm). For each individual model within the set (which consisted of 64 models in total), we calculated the Akaike's Information Criterion (AIC) and the Akaike weight ( $w_i$ ). The best fitting model was defined as the model with the lowest AIC. The probability of each household characteristic appearing in the best fitting model ( $k$ ) could then be estimated. However, as poor predictor variables had selection probabilities close to zero, a single randomly generated explanatory variable model set was subsequently generated and  $k$  was estimated for this model. Household characteristics that were important predictors of participation in bird feeding activity had a value for  $k$  which fell outside the 95% confidence intervals for the random explanatory variable.





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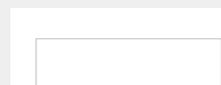
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**Table 4. Analysis of deviance models (GLM with binomial errors function) used to detect differences between the proportions of providing food for birds across household characteristic categories in the Survey for English Housing (SEH) and CityForm questionnaire.**  
<https://doi.org/10.1371/journal.pone.0039692.t004>

Mixed models were also developed that included UK government region as a random factor for the SEH and CityForm datasets respectively. For the SEH dataset, including city led to an increase in AICc compared to the fixed effect only model. For the CityForm dataset, including region as a random factor led to the mixed model being more parsimonious (lower AICc). However, there was no change in the form of the relationship between the explanatory and response variables and only minimal differences in parameter estimates. In order to retain a consistent analytical approach across both datasets, we therefore present results from the fixed effect only models.



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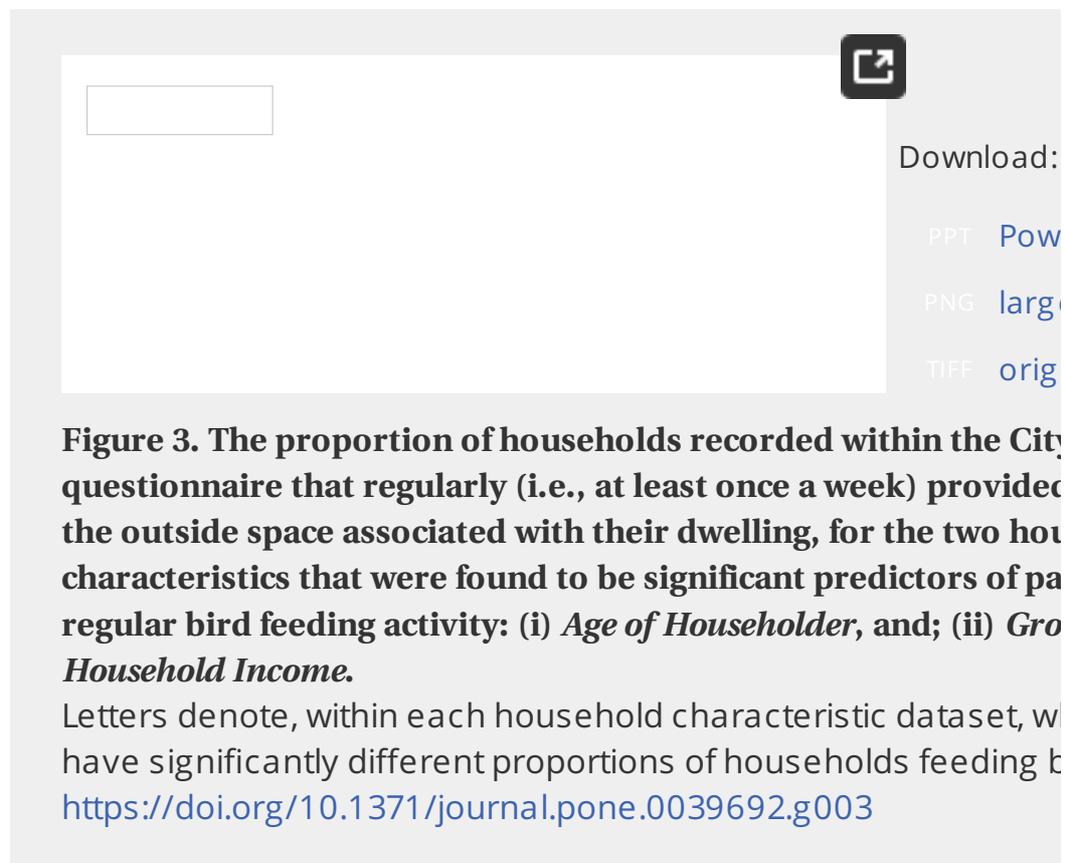
**Figure 2. The proportion of households recorded within the a) Survey for English Housing and b) CityForm questionnaire that participated in feeding birds in the outside space associated with their dwelling, for the characteristics that were found to be significant predictors of bird feeding: (i) *House Type*, (ii) *Age of Householder*, and; (iii) *Household Size*.**

Letters denote, within each household characteristic dataset, where we have significantly different proportions of households feeding birds. Letters with a significant difference in the proportion of households providing food for birds between the SEH (wider population) and CityForm (urban only) survey are highlighted in comparable categories.

<https://doi.org/10.1371/journal.pone.0039692.g002>

For every household characteristic identified as an important predictor of differences in the proportion of households engaged in bird feeding, we investigated between categories using a generalized linear model with binomial errors and logit link function. The resulting GLM was an analysis of variance (ANOVA) with household characteristic as the independent variable and the proportion of households feeding birds as the dependent variable.

an ANOVA, and post-hoc contrasts [72] were used to determine which significantly differed. Finally, we explored differences in the proportion providing food for birds for each household characteristic category and CityForm questionnaire datasets, using a 2-sample test for equality with continuity correction [72].



## Results

### Household Access to a Garden

Of the 19913 households surveyed in the 2001/02 SEH, 91% (n=18000) had access to a shared or communal garden, yard or patio area. This result was also recorded by the CityForm questionnaire, which found that 87% (n=3000) of households that responded to the survey had a garden, yard or patio area associated with their dwelling.

### Household Participation in Bird Feeding Activity

In the SEH, over 64% (n=11620) of households provided food for birds using a bird feeder or table in their garden area. In contrast, only 53% (n=2027) of households that completed the CityForm questionnaire were participating in bird feeding in their outside space. For both the SEH and CityForm datasets, the same three household characteristics were better than random predictors of participation in bird feeding: *House Type*, *Age of Householder* and *Household Size* (Table 3).

We subsequently examined the differences between categories within each household characteristic (Table 4). The trends for *House Type* were

surveys, with significantly higher proportions of households feeding progressively more detached properties (Figure 2). In the SEH, the proportion of households providing food for birds increased significantly with each *Householder*, until 55 years and over. The results for the CityForm questionnaire were broadly similar, with a lower prevalence of bird feeding activity occurring in the youngest age categories; the proportion of households feeding birds increased significantly with successive age categories, before tailing off with the oldest age group. The patterns for *Household Size* were significant but less systematic between the two survey datasets. The only trend common to both the surveys was that households consisting of just a single individual were less likely to be engaged in bird feeding activity, relative to larger households.

## The Regularity of Food Provision by Households

When we investigated the regularity of food provision for birds using the SEH, only 64% (n=1291) of the 2027 households feeding birds were found to do so on a regular basis (i.e., at least once a week), which equates to 29% of all households with access to an outside space. *Age of Householder* and *Household Income* were the only two predictors of how regularly households provided food that were better than random (Table 3).

Significant differences between categories for both of these household characteristics were apparent (Table 4). For *Age of Householder*, the smallest proportions of households feeding birds on a regular basis were in the less than 44 year old age group, but the highest proportions in the 45 to 64 year old age groups were higher, but the proportion of households providing food for birds regularly was in the 65+ age group. The regularity of bird feeding decreased with increasing *Gross Annual Household Income*. Households with an income of less than £20,000 were more likely to feed birds at least once a week, than those households with an income of £20,000 and £49,999. The lowest proportions of households feeding at regularly were in the highest gross annual income in excess of £50,000 (Figure 3).

## Discussion

Across England, 64% of households with access to a domestic garden were feeding birds. Although the proportion of households engaging in food provision in a garden was smaller in the urban survey, approximately half of the households in five British cities were still participating in the activity. These estimates are robust as the households taking part in the surveys were selected from a representative population and were not necessarily bird enthusiasts (in contrast to monitoring schemes that collect data on food provision, such as the Ornithology's Garden BirdWatch [73]). Indeed, the questions pertaining to bird feeding comprised only a small fraction of the entire survey, for the CityForm questionnaires, ensuring that the probability of a household participating was independent of the head of the household's level of interest in garden biodiversity.

Of the six sociodemographic and socioeconomic household characteristics, we found that *House Type*, *Age of Householder* and *Household Size* were the most significant predictors of engagement in food provision, both across England and across cities. The patterns of household participation for each of these characteristics were broadly consistent between the SEH and the CityForm questionnaire.

In both the surveys, the proportion of households feeding birds increased with the age of the head of the household, becoming progressively more detached and as the age of the head of the household increased. In agreement with our findings, a study investigating land use along a rural-urban gradient in southeast Michigan [54] established that rural households were more likely to provide food for birds. Similarly, the prevalence of bird-feeding households was not related to the occupation of the head of the household. In contrast to our results, Lepczyk et al. [54] found that there was no significant relationship between the number of people living at a dwelling and whether householder fed birds or food out for wild birds.

Using the CityForm dataset, we found that 64% of the households feeding birds in urban garden areas did so on a frequent basis (i.e., at least once a week), compared to 29% of all households with access to an outside space. Cowie and colleagues [55] assessed patterns in bird feeding in suburban gardens in Cardiff and found that 64% of households provided food for birds during the winter, but just 56% provided food for birds during the summer months (52% provided food for birds on a daily basis). Likewise, during the summer months, 52% of households provided food for birds, yet 19% of this activity was only occasional. Therefore, bird feeding in urban garden areas is therefore an infrequent activity.

In the UK and other countries, private landowners are frequently encouraged to provide food for birds, in order to enhance the survival of avian populations and the ecosystem services they provide (e.g., [36], [75]–[79]). Here we find that 64% of households in England with access to a domestic garden feed wild birds. In the US, 25% of citizens engage in bird feeding at home [45], and between 25 and 50% of households in Australia put out food for avian visitors [51]. Over \$3.4 billion is spent on bird seed in the US alone [45], and the global market for bird seed is growing at 5% per year [80].

Nonetheless, the ecological impacts of this particular wildlife garden management practice are controversial and are likely to vary between countries (see [51] for a review). [51] suggests that domestic gardens can play an important role in supporting wild bird populations by increasing the availability of food resources (e.g., [36] and feeding experiments have documented significant positive effects on the abundance, condition and productivity of specific species at various locations [47]–[48], [84]–[88]). However, opponents to food provision stress the potentially detrimental effects that are yet to be fully investigated. These include reliance on an unpredictable resource, a reduction in diet quality, loss of foraging behaviours [87], [89], the spread of disease [52], [90], loss of reproductive success and increased predation risk at feeders as a result of higher predator density [83]. Therefore, it is therefore required to understand better how the spatial distribution and quality of food provision for wild birds in domestic gardens may

conservation value of the activity. This is particularly important given that bird feeding is advocated by UK NGOs [91].

Here, we draw attention to socioeconomic characteristics that underpin the interactions between human society and biodiversity. Research in this area is infrequent in the literature, is of particular relevance to statutory agencies and governmental organizations that are currently involved in endorsing conservation actions to private landowners. For instance, the UK government Department for Environment, Food and Rural Affairs (Defra) has used the concept of 'households undertaking wildlife gardening' as one of their urban biodiversity initiatives in England [40]–[42]. The clear trends evident in this study could be used to help aim at raising awareness in the general public of the benefits of bird feeding within domestic gardens, by identifying key social groups to be targeted. Local councils and local authorities could use planning regulations and targets aimed towards particular income groups or housing types to increase participation in bird-friendly gardening activities [36]. Alternatively, as bird feeding cannot be mandated by government, a community-led approach could be taken by NGOs to encourage greater participation in food provision, under existing initiatives such as the "Homes for Wildlife" scheme in the UK or the USA National Wildlife Federation's Habitat Certification Scheme, which are increasingly targeted at private households in society. In following these strategies, we further propose two approaches to be adopted: (i) to focus on sociodemographic and socioeconomic groups where high proportions of households are undertaking such activities and, the impact could be made, or; (ii) to target sociodemographic and socioeconomic groups where high proportions of households participate in activities and where greater involvement may more readily be accomplished.

As the general public get progressively more disinterested in nature, identifying creative and pertinent mechanisms through which to promote the integration of conservation action into everyday life is vital in order to both support and enhance human health and well-being [43]–[44], [57]. An appreciation of the sociodemographic and socioeconomic background of the households within a campaign, as acquired by this study, will allow conservationists to give advice accordingly and communicate more effectively with their intended audience.

## Supporting Information

### **Table S1.**

Survey of English Housing questions pertaining to the six sociodemographic characteristics that were identified as those that may influence the likelihood of households providing supplementary food for birds. Superscript numbers indicate where data was re-categorized where applicable.

<https://doi.org/10.1371/journal.pone.0039692.s001>

(DOCX)

### **Table S2.**

CityForm survey questions pertaining to the six sociodemographic characteristics that were identified as those that may influence the households providing supplementary food for birds. Superscript numbers in the data was re-categorized where applicable.

<https://doi.org/10.1371/journal.pone.0039692.s002>

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## Author Contributions

Conceived and designed the experiments: ZGD RF MD AL KJG. Analyzed the data: ZGD RF MD AL KJG. Wrote the paper: ZGD RA MD KJG.

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