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RESEARCH ARTICLE

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

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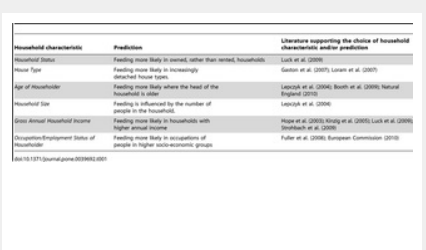
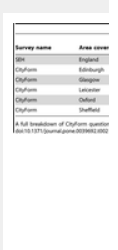
Figures





Abstract

Ameliorating pressures on the ecological condition of the wider lan
protected areas is a key focus of conservation initiatives in the dev
urbanized nations, domestic gardens can play a significant role in
biodiversity and facilitating human-wildlife interactions, which bene
societal health and well-being. The extent to which sociodemograp
factors are associated with engagement in wildlife gardening activi
unresolved. Using two household-level survey datasets gathered f
determine whether and how the socioeconomic background of a h
participation in food provision for wild birds, the most popular and w
human-wildlife interaction. A majority of households feed birds (64%
urban areas in England, and 53% within five British study cities). Ho
size and the age of the head of the household were all important pr
feeding, whereas gross annual household income, the occupation
household, and whether the house is owned or rented were not. In
prevalence of bird feeding rose as house type became more detac
the head of the household increased. A clear, consistent pattern be
varying size was less evident. When regularity of food provision wa
study cities, just 29% of households provided food at least once a w
households regularly feeding birds was positively related to the ag
household, but declined with gross annual income. As concerns gr
engagement between people and the natural environment, such fi
conservation organizations are successfully to promote public part
gardening specifically and environmentally beneficial behaviour in
generally.

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Introduction

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

A variety of strategies have been suggested to ameliorate pressure
condition of residential environments. These include creating green
corridors [24]–[25], developing urban forests [26]–[27], improving th
public parks (e.g., [28]–[29]), and encouraging householders to par
gardening' activities (e.g., [30]). Wildlife gardening can be broadly d
conducted in a domestic garden intended to increase its suitability
the provision of a diversity of resources (e.g., food, breeding and ov
One of the attractions of such an approach has been the potential
by individual households; gardens are intensively managed habita
landowners may invest substantial amounts of both time and mone
garden retail market is currently worth £4.6 billion [32] and, in 2005,
survey revealed that 13% of adults engage in gardening, spending
minutes per day doing so [33].

Although gardens are managed by individual households, their imp
biodiversity conservation and ecosystem service provision through
recognized not only by the research community (e.g., [34]–[36]), but
[37]–[39]) and national (e.g., [40]–[42]) authorities. An understanding
in wildlife gardening activities may vary with the socioeconomic cha
individual households is important if conservation organizations ar
public engagement in wildlife gardening activities, and to develop s
awareness of environmentally beneficial behaviour in society more

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

In this paper, we develop *a priori* hypotheses regarding the relation sociodemographic and socioeconomic status of individual househo engaged in bird feeding activities and how regularly food was prov on previous research in related areas, we focus on six fundamenta characteristics, for which data are straightforward to obtain (thus a groups wishing to launch initiatives to increase public uptake of wil on the outcomes of this study), and determine whether they can be involvement in bird food provision. Although our hypotheses are inf primary literature, the majority of these studies examine correlative socioeconomic status and measures of biodiversity, rather than on participation in activities that could support biodiversity.

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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-wildlif

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

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

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

Older members of the public are more likely to engage in activities r
environment in general [60]. In a single region study, older househo
were more engaged in bird feeding [54], a trend that, although not
also been reported for the US as a whole. We therefore anticipate t
positively related to the age of the householder.

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

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

6. *Occupation/Employment Status of Householder*. Across Europe, the
who reported making personal efforts to protect biodiversity varied
occupation/employment status [64]. We thus predict that the occup
the household will influence whether or not food is provided for bird

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

Methods

We carried out this study using two household surveys. The first co
on participation in bird feeding activities gathered in England, cover
urban areas across the country, and the second examines food pro
five major British cities (Figure 1). Using these complementary datas
contrast households situated within urban areas specifically and th
as a whole.

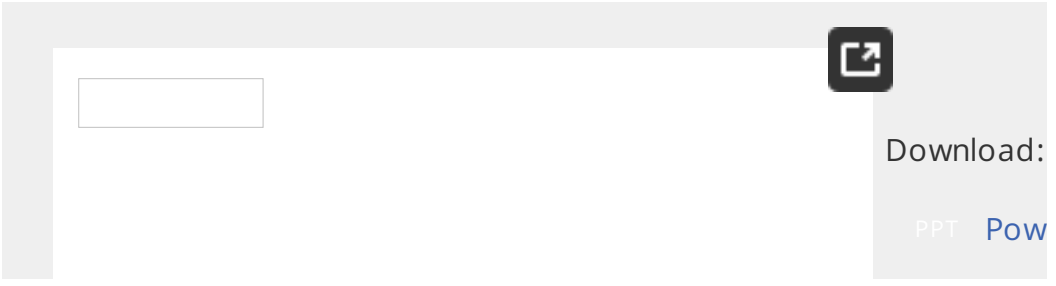

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Figure 1. The location of the five British cities (E, Edinburgh; G, Leicester; O, Oxford; S, Sheffield) sampled during the CityForm from which were subsequently used to investigate whether and socioeconomic and sociodemographic background of a household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

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Survey of English Housing

The Survey of English Housing (SEH) is an annual interview-based s approximately 20,000 households (Table 2), conducted for the UK g Department for Communities and Local Government by the Nationa Research. All data were gathered in accordance with UK governme data protection regulations and were fully anonymised prior to use main purpose of the survey is to gather reliable information on the household and the attitude of the respondent in relation to their pe circumstances. In its entirety, the survey consists of approximately comprising a core of factual questions that remain largely unchang (e.g., regarding factors such as whether the respondent owns or re costs and housing history), in addition to a set of questions on opin that are revised annually (see http://www.esds.ac.uk/for details). Th households are chosen at random from within stratified groupings Office 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 investiga which households participate in wildlife gardening activities. It repre national-level survey data pertaining to wildlife gardening, thereby investigation of the socioeconomic characteristics of households th feeding activities (as opposed to previous neighbourhood-level an Respondents were asked whether the household provided food fo

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

CityForm Questionnaire

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

As with the SEH, respondents were asked to indicate whether they
garden, shared/communal garden, patio or yard, roof terrace/large
these. Respondents were then asked to indicate how regularly food
birds by household members, choosing one option from the followi
weekly, monthly, less than monthly, or never.

Data Extraction and Standardisation

We extracted data from both surveys relevant to the six hypothese
household was owned or rented (*Household Status*), the type of hou
age of the head of the household (*Age of Householder*), the number
the property (*Household Size*), gross annual income for the household
Household Income) and the nature of employment of the head of the
(*Occupation of Householder* for the SEH, and *Employment Status of H*
CityForm questionnaire). The information was then re-coded into ca
which were comparable between the SEH and CityForm questionna

Table 3. The probability (*k*) of each household characteristic bei predictor (i.e., better than random; highlighted in bold) of the l 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 household to an outside space from both the SEH and CityForm datasets, as th not be able to participate in bird feeding activity regardless of their socioeconomic background. The data obtained in the CityForm surv households provided bird food were consolidated into binomial res allow for direct comparison with the SEH findings. In addition, we co dataset by grouping the CityForm data pertaining to how regularly f birds into two response categories: regularly (households feeding and thus providing significant levels of food) and irregularly (house food on a monthly or less than monthly basis). This allowed us to ac statistical approach to investigate the relationship between househ and regularity of food provision. All statistical analyses were carried version 2.10.1 [68]).

For each of the three datasets, multiple colinearity between the hou was investigated and found to be within accepted norms [69]. Corre showed that the relationships between the household characterist variation in the data unexplained (with a maximum r_S recorded of 0. Inflation Factors (VIFs) among all six variables were not sufficient to analysis.

To determine which of the six household characteristics were impo better than random) of the level of participation in bird feeding activ dataset, we used the Information Theoretic approach [70]. All possi household characteristics were modelled using logistic regression, response to bird feeding as the dependent variable (yes or no for S regularly or irregularly for CityForm). For each individual model withi (which consisted of 64 models in total), we calculated the Akaike's In (AIC) and the Akaike weight (w_i). The best fitting model was defined AIC. The probability of each household characteristic appearing in t (k) could then be estimated. However, as poor predictor variables d selection probabilities close to zero, a single randomly generated e unrelated to the response variable, was added to the existing datas model sets were subsequently generated and k was estimated for explanatory variable. Household characteristics that were importan participation in bird feeding activity had a value for k which fell outs confidence intervals for the random explanatory variable.

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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 categor Survey for English Housing (SEH) and CityForm questionnaire.

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Mixed models were also developed that included UK government re random factor for the SEH and CityForm datasets respectively. For th including city led to an increase in AICc compared to the fixed effec SEH models, including region as a random factor led to the mixed m parsimonious (lower AICc). However, there was no change in the fo between the explanatory and response variables and only minimal parameter estimates. In order to retain a consistent analytical appr datasets, we therefore present results from the fixed effect only mo

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Figure 2. The proportion of households recorded within the a) S Housing and b) CityForm questionnaire that participated in foo birds in the outside space associated with their dwelling, for the characteristics that were found to be significant predictors of bi (i) *House Type*, (ii) *Age of Householder*, and; (iii) *Household Size*. Letters denote, within each household characteristic dataset, wh have significantly different proportions of households feeding b a significant difference in the proportion of households providin between the SEH (wider population) and CityForm (urban only) s comparable categories.

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

For every household characteristic identified as an important predi differences in the proportion of households engaged in bird feedin investigated between categories using a generalized linear model errors and logit link function. The resulting GLM was an analysis of

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

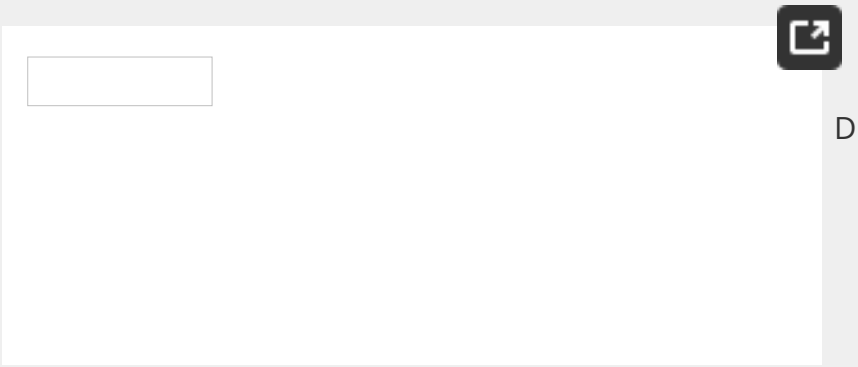

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Figure 3. The proportion of households recorded within the City questionnaire that regularly (i.e., at least once a week) provided the outside space associated with their dwelling, for the two hou characteristics that were found to be significant predictors of pa regular bird feeding activity: (i) *Age of Householder*, and; (ii) *Gro Household Income*.

Letters denote, within each household characteristic dataset, w have significantly different proportions of households feeding b

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Results

Household Access to a Garden

Of the 19913 households surveyed in the 2001/02 SEH, 91% (n=18 to a shared or communal garden, yard or patio area. This result wa recorded by the CityForm questionnaire, which found that 87% (n=3 households that responded to the survey had a garden, yard or pa dwelling.

Household Participation in Bird Feeding Activity

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

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

surveys, with significantly higher proportions of households feedin
progressively more detached properties (Figure 2). In the SEH, the p
households providing food for birds increased significantly with ea
Householder, until 55 years and over. The results for the CityForm qu
broadly similar, with a lower prevalence of bird feeding activity occu
youngest age categories; the proportion of households feeding bir
significantly with successive age categories, before tailing off with
The patterns for *Household Size* were significant but less systematic
between the two survey datasets. The only trend common to both t
surveys was that households consisting of just a single individual w
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 usin
only 64% (n=1291) of the 2027 households feeding birds were foun
regular basis (i.e., at least once a week), which equates to 29% of al
households with access to an outside space. *Age of Householder* an
Household Income were the only two predictors of how regularly ho
food that were better than random (Table 3).

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

Discussion

Across England, 64% of households with access to a domestic garde
birds. Although the proportion of households engaging in food prov
garden was smaller in the urban survey, approximately half of the h
five British cities were still participating in the activity. These estima
robust as the households taking part in the surveys were selected
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 pertain
bird feeding comprised only a small fraction of the entire survey, fo
CityForm questionnaires, ensuring that the probability of a household
independent of the head of the household's level of interest in garde
biodiversity.

Of the six sociodemographic and socioeconomic household charac
potential factors that may influence the likelihood of participation in
activity, we found that *House Type*, *Age of Householder* and *Household*
predictors of engagement in food provision, both across England a
cities. The patterns of household participation for each of these cha
broadly consistent between the SEH and the CityForm questionnair

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

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

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

Nonetheless, the ecological impacts of this particular wildlife garde
controversial and are likely to vary between countries (see [51] for
suggests that domestic gardens can play an important role in supp
populations by increasing the availability of food resources (e.g., [3
and feeding experiments have documented significant positive eff
abundance, condition and productivity of specific species at variou
[47]–[48], [84]–[88]). However, opponents to food provision stress t
potentially detrimental effects that are yet to be fully investigated. T
reliance on an unpredictable resource, a reduction in diet quality, lo
behaviours [87], [89], the spread of disease [52], [90], loss of reproc
increased predation risk at feeders as a result of higher predator d
increase in the number and abundance of exotic species [34], [83].
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 give
feeding is advocated by UK NGOs [91].

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

As the general public get progressively more disinterested in natur
creative and pertinent mechanisms through which to promote the i
conservation action into everyday life is vital in order to both suppo
enhance human health and well-being [43]–[44], [57]. An appreciati
sociodemographic and socioeconomic background of the household
within a campaign, as acquired by this study, will allow conservation
advice accordingly and communicate more effectively with their int

Supporting Information

Table S1.

Survey of English Housing questions pertaining to the six sociodem
characteristics that were identified as those that may influence the
households providing supplementary food for birds. Superscript nu
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 l
characteristics that were identified as those that may influence the
households providing supplementary food for birds. Superscript nu
data was re-categorized where applicable.
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Author Contributions

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

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