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Received: 3 November 2023 | Accepted: 13 September 2024

DOI: 10.1002/pan3.10745

PEOPLE AND NATURE | BRITISH ECOLOGICAL SOCIETY

RESEARCH ARTICLE

How, why, where and when people feed birds?—Spatio-temporal changes in bird-feeding in Finland

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Funding information
Ella ja Georg Ehrnroothin Säätiö; Koneen Säätiö, Grant/Award Number: 201803079 and 201904974; Emil Aaltosen Säätiö; H2020 Marie Skłodowska-Curie Actions, Grant/Award Number: 101027534; Biotieteiden ja Ympäristön Tutkimuksen Toimikunta, Grant/Award Number: 323527, 329251, 333803 and 347478; Ministry of the Environment of Finland

Handling Editor: Masashi Soga

Abstract

1. Providing food to animals, especially birds, during winter is a common activity in many countries. While bird-feeding can increase connections between people and nature, there are increasing calls from researchers and the general public to limit this activity due to emerging knowledge of potential negative ecological impacts (e.g. biased competition and spread of pathogens). However, what motivates changes in bird-feeding habits remains largely unknown, despite the 'provisioners' perspective' being critical for designing and implementing policy that benefits both animals and people.
2. Here, we investigate changes in how and why people feed birds in urban and rural areas of Finland as a case study. We made use of two long-term annual bird monitoring data sets (the Winter bird census and Finnish bird feeder monitoring scheme) to investigate how the number of bird-feeding sites and the amount of food provisioned have changed since the 1980s. Additionally, we conducted an online questionnaire in 2021 (over 14,000 respondents) to examine reasons for the changes that we detected.
3. We find that, over 40 years, the annual amount of food provided has increased significantly in rural areas, while the number of bird-feeding sites has decreased and especially so in urban areas. Questionnaire answers indicated that this decline was likely due to changing regulations of local governments and housing organisations, with increased concerns of attracting pests leading to restrictions on providing food for birds. In rural areas, people who reduced feeding more often identified concerns over avian diseases and the effort required to access, clean and refill bird-feeding sites.
4. *Policy implications*: Our results highlight that provisioning food to wild animals involves complex decision-making depending on habitat, geography and economic

factors. Therefore, policies designed to curb (or promote) this activity should take into account its multifaceted nature.

KEYWORDS
Bird-feeding, Human–wildlife interaction, Long-term monitoring, Urban–rural patterns, Winter supplementary feeding

1 | INTRODUCTION

Supplementary provisioning of food to animals is a global phenomenon (Reynolds et al., 2017). In the case of endangered species (e.g. Eurasian eagle owl *Bubo bubo* [Pearson & Husby, 2021], Iberian lynx *Lynx pardinus* [López-Bao et al., 2010] and vultures [Cortés-Avizanda et al., 2016]) and conservation programmes, supplementary feeding is often used to maintain population size in times of food scarcity, to enable monitoring or to anchor individuals to a site after translocation (Ewen et al., 2015). Feeding can also be used to lure animals to certain locations, for example, for photography (Fennell & Yazdan panah, 2020; Newsome & Rodger, 2008; Orams, 2002), hunting (Knight, 2009), viewing birds in gardens and parks (Brock et al., 2017; Clark et al., 2019; Cox & Gaston, 2016) or simply because people wish to help birds by providing food (Clark et al., 2019). Despite its popularity, however, there are growing calls to reduce or modify how we feed animals (e.g. Ewen et al., 2015; Shutt & Lees, 2021) as it can have far-reaching consequences on both the intended recipients and the wider ecological community. Feeding can, for instance, increase competitors and predators of declining forest species (Wilman, 2023).

Food provisioning by humans to animals is especially widespread for birds (Shutt & Lees, 2021). In the United Kingdom alone, 150,000 tonnes of seeds are provided to birds in gardens (Pet Food Manufacturers Association, 2018), and in larger countries like the United States, this number increases to approximately 500,000 tonnes of seeds provisioned per year to birds (U.S. Fish Wildlife Service U.S. Census Bureau, 2011). Provisioning high-protein seeds and fat to birds in gardens can increase breeding success (e.g. Florida scrub jays *Aphelocoma coerulescens* [Schoech et al., 2008]) and may even select for morphological adaptations with concomitant genetic changes (Bosse et al., 2017). However, it can also cause reshuffling of bird communities (Prince & Zuckerberg, 2015). For example, the reliable availability of food over winter increases survival (e.g. crested tits *Lophophanes cristatus*; Jansson et al., 1981) and could be one reason why some bird species no longer migrate and instead overwinter at their breeding grounds (e.g. Eurasian blackcaps *Sylvia atricapilla*; Plummer et al., 2015). This could cause shifts in wintering ranges as well as affect species interactions through altered competition (Galbraith et al., 2015). Furthermore, feeding birds can also have wide ranging indirect effects, for example, (i) through non-targeted species in other taxonomic groups by supporting predator and competitor communities around the feeding site (e.g. rodents like squirrels *Sciurus* spp. and rats *Rattus* spp.; Plummer et al., 2013; Jokimäki et al., 2017; Shutt & Lees, 2021), (ii) spread of pathogens within and beyond avian community and (iii) land use changes needed to grow the food people provide to birds (Shutt & Lees, 2021).

A majority of research on the provisioning of food is focused on the impact on the birds, for example, how they make use of the resource and respond to its quantity and quality (e.g. Burt et al., 2021; Fuller et al., 2008). However, providing food to birds necessarily involves people. Therefore, here we focus on the provisioner's side in this interaction to gain a more comprehensive picture on the causes and consequences of bird-feeding, including changes in bird-feeding behaviour. Attracting birds and other animals to backyards and gardens through bird-feeding can help build a connection with nature that is being lost in urban centres (Soga & Gaston, 2016) and people providing food to birds report that they felt more relaxed and connected with nature (Cox & Gaston, 2016; Jones, 2018). These feelings of connection to nature are seen to strengthen when the provisioners can identify more species of birds in comparison to people who do not provision food (Cox & Gaston, 2016). Hence, in many countries across the globe, especially those with colder ambient temperatures, provisioning birds with supplementary food is often encouraged (Baverstock et al., 2019). Feeding birds is also viewed as empathic behaviour towards wildlife across cultures. For example, in Finland, there is a tradition of hanging grain outside houses on Christmas Day for birds. Similarly, in the 20th century, exceptionally harsh winters in the USA promoted bird-feeding after birds were found frozen in city streets (Goodwin, 1978). This means that calls to reduce bird-feeding could lead to biocultural conflicts (Torrents-Ticó et al., 2023), making it more challenging to enact policy change without a clear understanding of why people feed birds and what motivates changes in their behaviour.

The first step to understand this practice, and its implications for ecosystems and wildlife, is to quantify potential spatio-temporal changes in the feeding intensity and factors affecting bird-feeding. Long-term studies investigating the quality and quantity of provided food are particularly scarce, and knowledge of the spatial patterns of this behaviour is largely lacking. Studying spatial variation of bird-feeding practices is particularly relevant in light of earlier research unveiling a difference in the species using bird feeders between rural and urban areas (Tryjanowski et al., 2015) and the type of food provisioned (Tryjanowski et al., 2018). Social trends and norms can strongly affect the amount and type of food that is provisioned (Cox & Gaston, 2016; Davies et al., 2012). Understanding the quality and quantity of food provided by humans will also give us an insight into the nutrients that are provided and how these can affect wildlife.

Here, we investigate long-term patterns in bird-feeding at a large spatial scale in Finland. Located at 60–70° North, Finland has long and cold winters and so it is perhaps not surprising that there is also a long history of providing grains and fruits to birds once snow covers the ground typically November onwards (Vuorisalo et al., 2001). During the winter, there are also many differences between rural and urban areas in terms of the natural food resources available to birds (Fraixedas et al., 2015; Jokimäki et al., 2017; Lehikoinen et al., 2013) and how species are distributed among habitats (Deshpande et al., 2022). Finland is also experiencing rapid changes in bird communities, particularly among passerine birds which people like to see at garden feeding stations, for example, blackbirds *Turdus merula* are increasingly spending winters in Finland rather than migrating (Deshpande et al., 2022). Anecdotally, bird-feeding is undergoing rapid changes with urban by-laws and housing association rules banning the practice in some areas of Finland, but this trend is also seen in other parts of the world in response to avian-borne pathogens (Dayer et al., 2024). Therefore, Finland provides an ideal opportunity to investigate changes in bird-feeding behaviour. We used data from two separate long-term ecological monitoring schemes and an online questionnaire from Finland, to explore (1) the change in the number of bird-feeding sites since 1980s and patterns of these changes between rural and urban areas, (2) the change in the type of food that is commonly provisioned to birds in the winter (since the 1980s) and (3) how and why people have changed or stopped bird-feeding.

2 | METHODS

The data for this study were gathered across Finland, which spans over 1000 km in longitude with some regions more populated than others (Figure 1). As bird-feeding can be correlated with human density (Tryjanowski et al., 2015), throughout our study we have explored the differences in feeding habits between urban and rural areas. In all our data sets, participants or respondents self-reported if their feeding sites are in more rural or urban areas. Cities and urban areas were defined as more densely populated regions where buildings are situated close to each other, and the area can include parks, yards and gardens. Rural areas were defined as sparsely populated areas outside of the urban areas where houses are situated further from each other. We stress that even if the definition used here for rural and urban is not comprehensive, it clearly separates between densely populated urban areas from the rural areas and the sparsely populated areas around urban centres for the needs of this study. Most of the land area in Finland is sparsely populated rural areas (Figure 1). As the density of people also varies geographically, the country is more densely populated in the south as compared to the north, where possible we have included the latitude of the feeding sites in this study. For our online questionnaire, we divided responses into three regions: North (data from regions north of Tornio and Kuusamo), Central (data from regions between the Pori-Tampere-Mikkeli line to Tornio and Kuusamo) and South (data from regions south of the Pori-Tampere-Mikkeli line) as in Figure 1.

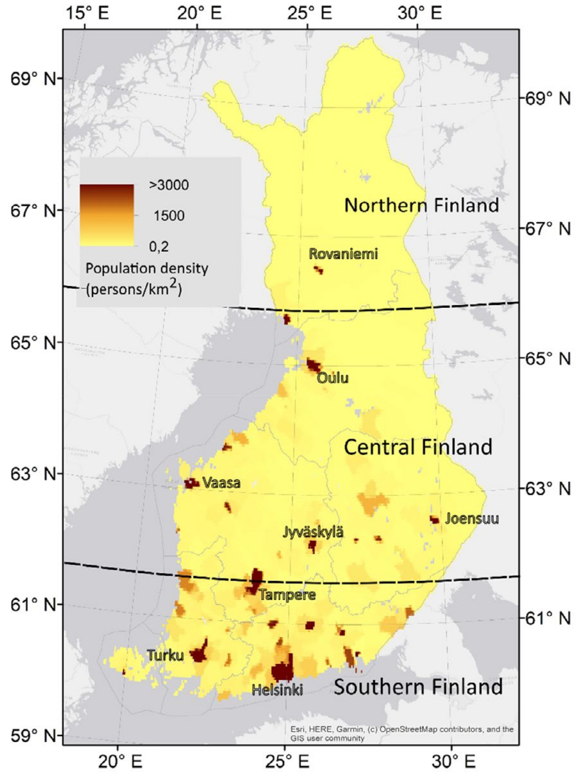

FIGURE 1 The map shows population density (persons per square kilometre) in the year 2000 across different parts of Finland, adjusted to match UN totals (NASA Socioeconomic Data and Applications Center (SEDAC), 2005). Darker red regions indicate more densely populated urban areas (where bird-feeding is more likely to take place according to the winter bird census data). Dark lines across the map show the borders of regions 'Northern Finland', 'Central Finland' and 'Southern Finland' used in the questionnaire part of this study. Largest cities are named.

The three data sets used here are: (i) Finnish winter bird survey, (ii) Finnish bird feeder monitoring scheme and (iii) our own online questionnaire. The first two data sets are long-term ecological monitoring data schemes from which we selected the longest possible time series available starting from the late 1980s. The questionnaire data represented a snapshot of bird-feeding habits (and changes within them) of people from 2021, where respondents were asked to reflect on their bird-feeding habits of the past 20 years. Also, to avoid responses that cover different locations, respondents were asked to fill the online questionnaire separately for each feeding site they have. We acknowledge that it is possible that multiple people from the same household could have replied to the survey but we expect these cases to be rare.

Below we detail, for each of the study questions, the data used, the data filtering steps as well as the statistical methods for each question. Under the guidelines of the Finnish Advisory Board on Research Integrity, this study did not require institutional ethical review.

2.1 | Change in the number of bird-feeding sites across habitats over time in Finland

Finnish Winter bird survey has been carried out annually since the 1950s. Volunteer birdwatchers have been counting birds on 1912 routes, where on average 544 (min 432 – max 660) of them have been surveyed annually. The same survey network has been used to calculate changes in winter bird populations (Deshpande et al., 2022; Fraixedas et al., 2015; Lehikoinen et al., 2016). Along with the number of birds, people also report the number of feeding sites encountered along survey routes has been counted in surveys since 1987. Note that summer feeding in Finland is rare (less than 3% of respondents based on our questionnaire). There are three census periods: early winter (1–15 November), mid-winter (25 December to 7 January) and late winter (21 February to 6 March). We only used the mid-winter surveys, because they have the best survey effort compared to the other periods (Lehikoinen et al., 2013). The volunteers estimated the length of the survey route in eight different habitat or land use categories (see below) and assigned the habitat type where each of the feeding sites has been observed. This allowed us to estimate differences in the number of feeding sites per habitat type and potential long-term changes between habitats. The habitat types surveyed were (a) dumping ground or fur farm (both include garbage); (b) urban settlement; (c) rural settlement; (d) arable land; (e) forest; (f) clear-cut area or stand of saplings; (g) reed-bed or shore scrub; and (h) other. We concentrated our analyses on urban settlements and rural settlements as there were very low densities of bird-feeding in other habitats (Jokimäki et al., 2017). We only used routes where the habitat segment covered at least 500 m of the habitats of interest to provide a sufficient sampling per route per habitat to avoid stochasticity in sampling. Due to this criterion, we had on average 468 routes surveyed annually (min 375 in 2003 to max 566 in 2022).

2.2 | Change in the type and quantity of bird feed across different habitat types over the years

The Finnish bird feeder monitoring scheme has been running since 1989. Under this scheme, volunteers survey the number of birds at the feeding sites as well as the estimated amount of provided food items of various food types per winter in kilograms (Väisänen, 2021). We used data from bird-feeding sites, which were either in urban or rural areas, and analysed trends for four categories of food: (a) sunflower seeds and other seed mixture (hereafter 'sunflower seeds'); (b) peanuts, almonds, cashew nuts and walnuts (hereafter 'nuts'); (c) oat and other cereals (hereafter 'cereals') and (d) fat.

2.3 | How and why have people changed their bird-feeding habits across habitats?

We designed a quasi-structured self-selected qualitative questionnaire which was promoted and circulated through social media (X [formerly known as Twitter], Facebook), emailing lists of birding societies and the main national news broadcasting company YLE on TV and radio from 28 January to 31 March 2021. The survey consisted of 12 questions which recorded data on the demographics of the respondents, the type and amount of food they provisioned during winter and the reasons for changing their bird-feeding habits. Through the Finnish bird feeder monitoring scheme, we had data on a larger temporal scale regarding the amount of food at bird-feeding sites and hence, for this study, we have only used the part of the questionnaire that deals with the change in bird-feeding habits and the reasons behind the same (Table S1) as these are seldom explored. The questionnaire included a description of the research project and respondents were asked to provide an informed consent, all replies were anonymised. The questionnaire was available in Finnish and Swedish (the second official language in Finland). It has not been described in any other publications.

2.4 | Statistical analysis

We conducted all the statistical analyses in R version 4.3.0 (R Core Team, 2022).

2.4.1 | Change in the number of bird-feeding sites across habitats over time in Finland

We built generalised linear mixed models (GLMMs) with negative binomial error distribution (to take overdispersion of the data into account) where the number of bird-feeding sites per habitat in a survey was the response variable, and fixed effect variables were year (standardised continuous variable), habitat (categorical variable: urban/rural), latitude (continuous) and longitude (continuous) and interactions between habitat and year and latitude and year to explore trends in time in the different habitats and geographical regions of the country. The log-transformed length of the survey in the particular habitat was an offset variable and survey route was a random factor as the routes were surveyed across multiple years. The log-transformation was done because the response variable is also log-transformed in negative binomial models. We examined the distribution of residuals of the models for their adherence to the model assumptions and found no violations.

2.4.2 | Change in the type and quantity of bird feed across different habitat types over the years

We built GLMMs with negative binomial error distribution where the amount of food (kg per year per site) was the response variable, and year (standardised continuous variable) and habitat (categorical variable: urban or rural) and their interaction as fixed effects. The bird-feeding site was a random factor, but we did not investigate spatial differences due to relatively small sample sizes in some parts of the country. The GLMMs for analysing both abundance of feeding sites and amount of provided food were constructed using glmmTMB function (Brooks et al., 2017). The residuals of the models were inspected for the presence of potential spatial autocorrelation using 'ncf' package in R (Bjornstad, 2016), but none was detected. We examined the distributions of residuals of the models to their adherence to the model assumptions and found no violations. We calculated the R^2 values for both above GLMM analysis using R function 'r.squaredGLMM' in package 'MuMIn' (Barton, 2022).

2.4.3 | How and why have people changed their bird-feeding habits across habitats?

How has bird-feeding changed?

To analyse whether people had changed their bird-feeding habits, we first filtered the data to exclude respondents who had chosen multiple answers for this question for ease of analysis. From the resulting data, we constructed ordinal logistic regressions using the MASS package (Venables & Ripley, 2002). We constructed two different models to account for the inherent differences in the categories pertaining to changing the amount of food versus starting and stopping feeding. In both models, 'no change' was given the value of 0. In the first model, 'stopped provisioning' was given a value of −1 and 'started provisioning 5 years ago' a value of 1. Similarly in the second model, 'provisioning less' was given a value of −1 and 'provisioning more' was given a value of 1. Habitat (categorical: urban or rural) and region (Categorical: Northern/Central/Southern Finland) and their interaction were added as independent variables. The cumulative probabilities of each of the responses for the different regions and habitats were then calculated with Bonferroni adjustment using the 'allEffects' functions of the effects package (Fox & Hong, 2009).

Next, we carried out pairwise comparisons (category 'no change' against the other four categories of responses to understand the changes in bird-feeding behaviour in more detail). For these, we constructed generalised linear models (GLMs) with binomial error distribution with the dependent variable as 'no change' with a value of zero against the other feeding category assigned the value of 1. As before, the interaction of habitat and region were added as independent variables. We also tested for bias due to multiple testing using the contrast function of the 'emmeans' package (Lenth, 2023) to make Bonferroni corrections (Simes, 1986).

Why has bird-feeding changed or stopped?

Respondents were allowed to select multiple options that applied to them from two different lists of options pertaining to reasons for changing and stopping their bird-feeding behaviour. The categories for changing bird-feeding habits were expense, change in timing of birds feeding (henceforth 'timing'), new location (moving the feeding site to a more accessible place due to old age of provisioner or local restrictions to birds-feeding, etc.), to attract more birds and no specific reason. We had provided respondents with many more categories to pick from to detail the reasons for stopping bird-feeding (see Table S1). This resulted in some of the categories being rarely reported. We grouped the responses from the original categories provided in the survey to the following: maintenance, forest mammals (e.g. squirrels, deer, hares), pets, neighbourhood rules, woodpeckers, rats, no snow and diseases (e.g. salmonella, trichomonas; Lehikoinen et al., 2013). To test for statistical significance of these patterns, we generated chi-square values using an asymptotic generalised Cochran–Mantel–Haenszel test in the 'coin' package (Hothorn et al., 2006).

3 | RESULTS

3.1 | Change in the number of bird-feeding sites across habitats over time in Finland

More bird-feeding sites (feeding sites per kilometre) were recorded during the winter bird survey in urban habitats as compared to rural habitats and there was in general a decreasing trend in the number of feeding sites with time (Table 1, Figure 2). The interaction between habitat and year showed that this decrease in the number of feeding sites with time was more in urban habitats compared to rural habitats. The interaction of latitude with year showed that there was a slight increase in the number of bird-feeding sites towards higher latitudes over time (Table 1; R^2 lognormal, marginal 0.022 and conditional 0.670).

TABLE 1 Results of GLMM with negative binomial error structure exploring the change in the number of provisioning sites (per kilometre) in urban and rural areas over the years.

	Estimate	Std. error	*Z*-value	*p*-value
Intercept	**0.255**	**0.030**	**8.429**	**<0.001**
Urban areas	**0.329**	**0.018**	**18.618**	**<0.001**
Year	**−0.004**	**0.001**	**−5.035**	**<0.001**
Latitude	−0.002	0.001	−1.684	0.092
Longitude	0.0003	0.003	0.108	0.913
Urban areas × Year	**−0.010**	**0.001**	**−8.088**	**<0.001**
Latitude × Year	**0.0001**	**0.0000**	**3.465**	**<0.001**

Note: Statistically significant results are highlighted in bold.

3.2 | Change in the type and quantity of bird feed across different habitat types over the years

There was a significant increasing trend in the amount of sunflower seeds provided per bird-feeding site with time. However, fewer sunflower seeds are provisioned in urban areas as compared to rural areas and this trend continues with time (Figure 3a; Table 2a, R^2 lognormal, marginal 0.083 and conditional 0.774).

There was no significant difference in the amount of nuts reported to be provided between rural and urban feeding sites. There was a significant increasing trend more recently in the amount of nuts provided per bird-feeding site (Figure 3b; Table 2b, R^2 lognormal, marginal 0.019 and conditional 0.827).

More cereal was reported to be provided per bird-feeding site in rural areas compared to urban areas. There was a significant decreasing trend in the amount of cereal per bird-feeding site in time and with the interaction of habitat and year, this decrease was significantly steeper in urban areas compared to rural areas (Figure 3c; Table 2c, R^2 lognormal, marginal 0.009 and conditional 0.886).

More fat was reported per bird-feeding site in rural areas compared to urban areas. There was a significant positive trend with time in the amount of fat per bird-feeding site and this increase was significantly steeper in urban areas compared to rural areas (Figure 3d; Table 2d, R^2 lognormal, marginal 0.086 and conditional 0.710).

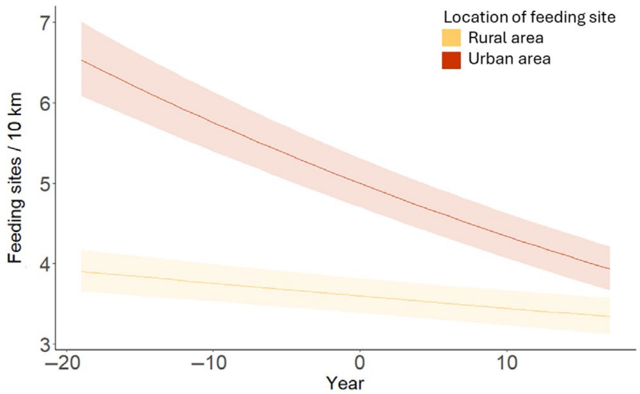

FIGURE 2 Model predictions how the number of bird-feeding sites per 10 km over time are varying in urban (red) and rural (yellow) areas. The lines show the predictions for numbers of feeding sites over time from a GLMM, with the 95% confidence intervals around each line. Year is shown in standardised values as used in the modelling approach.

3.3 | How and why have people changed their bird-feeding habits across habitats?

We obtained a wide response from the online questionnaire on the changes in bird-feeding practices of people. We received 14,592 responses, of which 14,127 had responses in the correct format (without contradictory answers for the same question). A majority of the respondents were from southern Finland ($n=8727$) and this was followed by central Finland ($n=4921$) and then northern Finland ($n=488$). We had nearly equal number of responses from urban ($n=7272$) and rural ($n=6855$) areas, and this is potentially an over-representation of rural respondents as 72% of Finns live in urban areas (Helminen et al., 2020). A majority of the respondents were of 51–70 years of age (60% of responses). Additionally, more women responded to our survey than men (66% of the respondents; $z=-57.508$, $p<0.001$).

3.3.1 | How has bird-feeding changed?

Overall, 4449 people reported that they had not made any changes to their bird-feeding behaviour, 4839 people reported that they had increased their provisioning, 2357 reported starting provisioning,

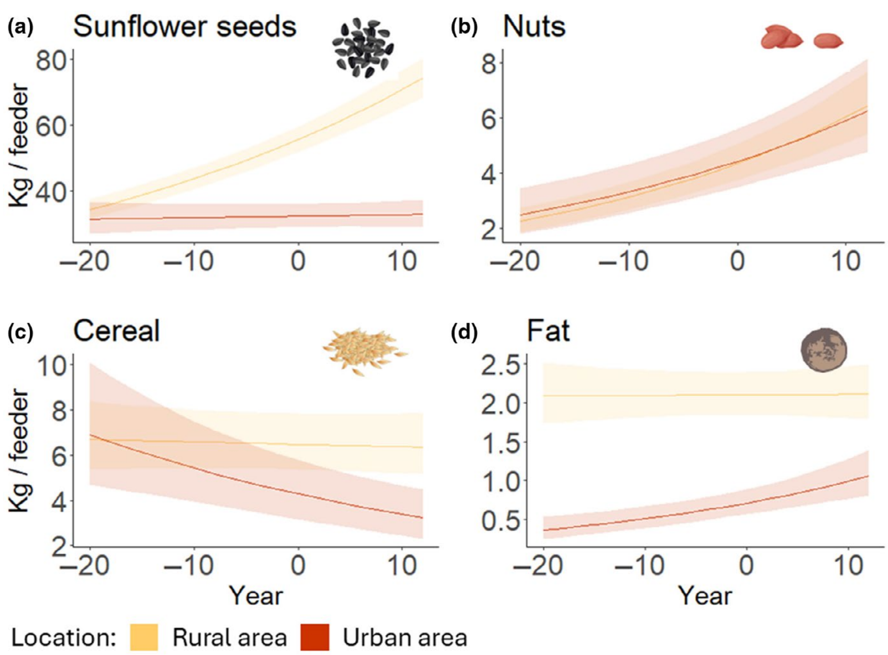

FIGURE 3 Model predictions how the amounts of food ([a] sunflower seeds, [b] nuts, [c] cereals and [d] fat) in kilograms per feeding site vary over time in urban (red) and rural (yellow) areas. The lines show the predictions for amount of food over time, with the 95% confidence intervals around each line. Year is shown in standardised values as used in the modelling approach.

TABLE 2 Results of GLMM with negative binomial error structure. Here, the amount of different food types is the dependent variable ([a] sunflowers, [b] nuts, [c] cereals and [d] fat).

	Estimate	Std. error	Z-value	p-value
(a)				
Intercept	**4.018**	**0.035**	**114.12**	**<0.001**
Year	**0.0240**	**0.001**	**16.159**	**<0.001**
Urban areas	**−0.542**	**6.114**	**0.066**	**<0.001**
Year × Urban areas	**−0.023**	**0.003**	**−7.426**	**<0.001**
(b)				
Intercept	**1.468**	**0.077**	**19.096**	**<0.001**
Year	**0.033**	**0.003**	**9.969**	**<0.001**
Urban areas	0.017	0.142	0.123	0.902
Year × Urban areas	−0.004	0.007	−0.638	0.523
(c)				
Intercept	**1.868**	**0.096**	**19.384**	**<0.001**
Year	−0.002	0.003	−0.490	0.624
Urban areas	**−0.414**	**0.180**	**−2.301**	**0.021**
Year × Urban areas	**−0.022**	**0.007**	**−3.246**	**0.001**
(d)				
Intercept	**0.744**	**0.067**	**11.074**	**<0.001**
Year	0.0004	0.004	0.098	0.922
Urban areas	**−1.085**	**0.130**	**−8.366**	**<0.001**
Year × Urban areas	**0.033**	**0.008**	**4.054**	**<0.001**

Note: Year and habitat (categorical variable rural and urban, and rural is the intercept) were added as independent variables and the provisioning site ID was added as a random factor. Values in bold indicate statistically significant results.

1234 reported stopping provisioning and 755 reported provisioning less than before.

Significantly more people reported that they are provisioning less food as compared to not changing provisioning habits (Figure 4; Table 3). However, this did not vary by region or degree of urbanisation (Figure 4; Table 3a, cumulative probabilities: Table S2a, Figure S1a).

When we compared if people were more likely to stop or start feeding with respect to the ones that have reported no change, we found that respondents from urban parts of Southern Finland were statistically more likely to report stopping provisioning as compared to those from Northern Finland (Figure 4; Table 3b, Cumulative probability of stopping provisioning, Southern urban: 0.192, Northern urban: 0.095; Table S2b, Figure S1b).

When we explored the patterns in pairwise comparisons between habitat and region, we found that more people reported that they have stopped provisioning in urban areas of the southern parts of the country. (R^2: 0.061, Table S3a). When compared with no change in provisioning, we did not find statistically significant changes in the categories of starting provisioning, provisioning more or provisioning in the different regions and habitats (Table S3b–d). We found a trend approaching significance that more people in the urban south of the country reported provisioning less as compared to the respondents from urban areas of the north (Table S3c).

3.3.2 | Why has bird-feeding changed or stopped?

Respondents from various habitats and regions differed in the reasons they reported for changing provisioning. An asymptotic generalised Cochran–Mantel–Haenszel test showed that the various reasons for changing bird-feeding among habitats stratified by region of the country were statistically significant (Figure 5a, $\chi^2=9.835$, df$=4$, $p=0.043$). The largest proportion of respondents across the different habitats and regions reported changing their provisioning to attract more birds. More respondents in rural northern and central Finland reported attracting more birds as a reason to change provisioning, while people in urban northern and central Finland and rural southern Finland were less likely to report this as a reason. Respondents from rural parts of northern and central Finland and urban parts of southern Finland were also more likely to report changing the location of provisioning (e.g. moving home). In southern urban areas, more respondents reported that they have changed their timing of provisioning, while in urban areas of central Finland, people have not reported such changes. More people reported no reason for changing provisioning in the urban areas of the south than other regions (Figure 5a).

The proportions of the different reasons for changing provisioning were similar across different regions of the country and habitats. However, the proportions of reports of stopping provisioning varied more by habitat and region. An asymptotic generalised Cochran–Mantel–Haenszel test showed that there was a statistically significant difference between the region and habitats with respect to the proportion of people reporting a change in bird-feeding behaviour (Figure 5b, $\chi^2=114.06$, df$=8$, $p<0.001$). Rats followed by neighbour/rules formed the largest fraction of the responses in the southern region for stopping provisioning. However, more people from urban areas in the south reported these reasons for stopping than respondents from rural areas. In northern regions of the country, people from urban areas were less likely to report rats as a reason for stopping as compared to the other regions. [Correction added on 27 January 2025, after first online publication: 'In central regions' has been corrected to 'In nothern regions'.] Difficulties associated with maintaining provisioning sites (which concerned travelling to bird-feeding sites to add food in feeding sites, cleaning the feeding sites, etc.) were reported as a reason for stopping provisioning in rural areas from all the three regions. This pattern was not observed in urban areas, with respondents from urban areas in the south less likely to report this as a reason for stopping as compared to other regions and habitat. Concern surrounding avian diseases was the reason for stopping in rural parts of central and northern regions of the country but not in the south. Finally, the presence of pets near provisioning sites was reported as a reason for stopping in the different regions, but it was only higher in the urban parts of northern Finland as compared to other regions (Figure 5b). [Correction added on 27 January 2025, after first online publication: 'in the rural parts of central Finland' has been corrected to ' in the urban parts of northern Finland'.]

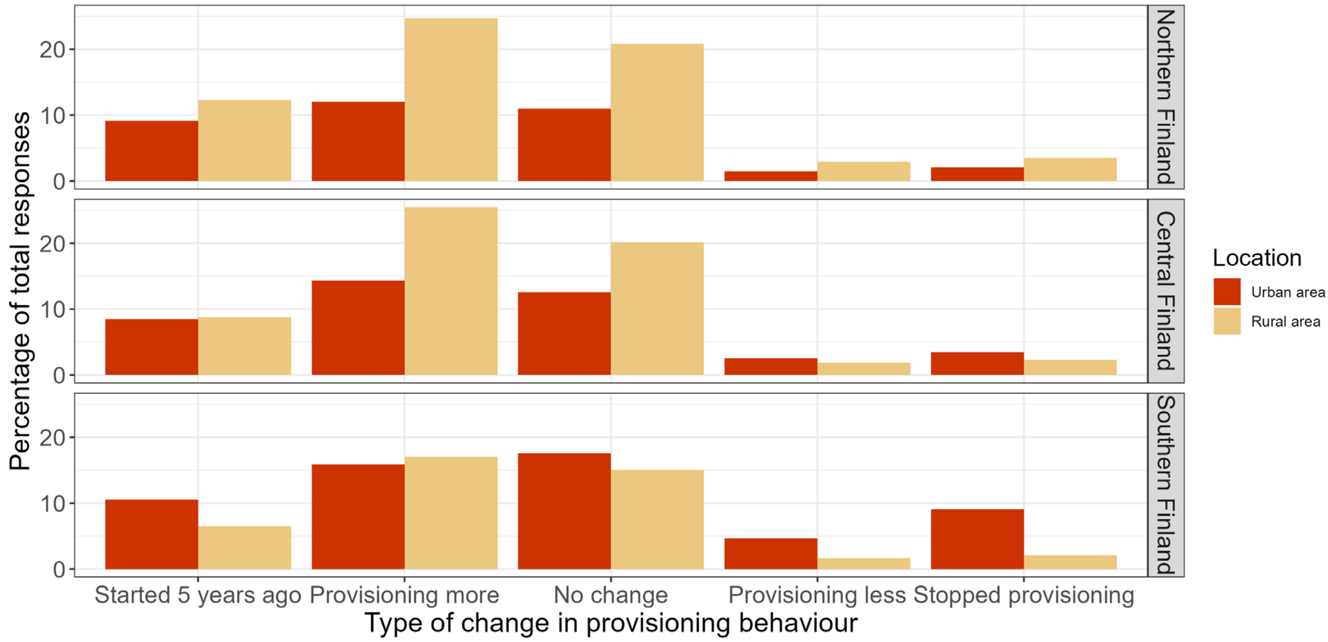

FIGURE 4 The bird-feeding behaviour reported by respondents in different regions (Southern, Central, Northern) of Finland split by habitat (urban/rural) based on an online questionnaire. Here, the *y*-axis represents the percentage of each of the response categories for the number of people that have given each answer. [Correction added on 27 January 2025, after first online publication: Figure 4 has been updated to correct the labels.]

TABLE 3 Results of ordered logistic regression on two scales of change in provisioning (a) provisioning more, less and no change reported ($n = 11,277$) and (b) starting provisioning, stopping provisioning or no change ($n = 8040$).

	Estimate	Std. error	*t*-value	*p*-value
(a)				
Rural areas	0.066	0.219	0.300	0.764
Southern Finland	**−0.387**	**0.181**	**−2.136**	**0.033**
Central Finland	−0.064	0.185	−0.346	0.729
Rural areas: Southern Finland	0.391	0.224	1.741	0.082
Rural areas: Central Finland	0.192	0.228	0.840	0.401
Provisioning less v/s no change	**−2.595**	**0.181**	**−14.346**	**<0.001**
No change v/s provisioning more	0.012	0.178	0.066	0.947
(b)				
Rural areas	0.256	0.235	1.089	0.276
Southern Finland	**0.822**	**0.190**	**4.335**	**<0.001**
Central Finland	0.335	0.195	1.721	0.085
Rural areas: Southern Finland	**−0.657**	**0.242**	**−2.717**	**0.007**
Rural areas: Central Finland	−0.222	0.246	−0.898	0.369
Started provisioning v/s no change	−0.356	0.186	−1.913	0.056
No change v/s stopped provisioning	**2.260**	**0.188**	**12.010**	**<0.001**

Note: The interaction of habitat and region of country was the independent effect in both the models. Here, urban areas and the northern part of the country are taken as the intercept. Statistically significant results are indicated in bold text.

4 | DISCUSSION

Feeding birds is a popular hobby across the world as it gives the provisioners an opportunity to feel close to nature and is also associated with positive feelings of compassions for other living things (Jones, 2018). However, what is less known are the motivations behind any changes in these habits. This information is critical since there are increasing calls for people to reduce feeding of birds. Here, we explored winter bird-feeding in Finland from the perspective of the provisioners to uncover the factors that may drive changes in behaviour. By taking advantage of long-term (40 years) data sets that use standardised methods to record the presence of

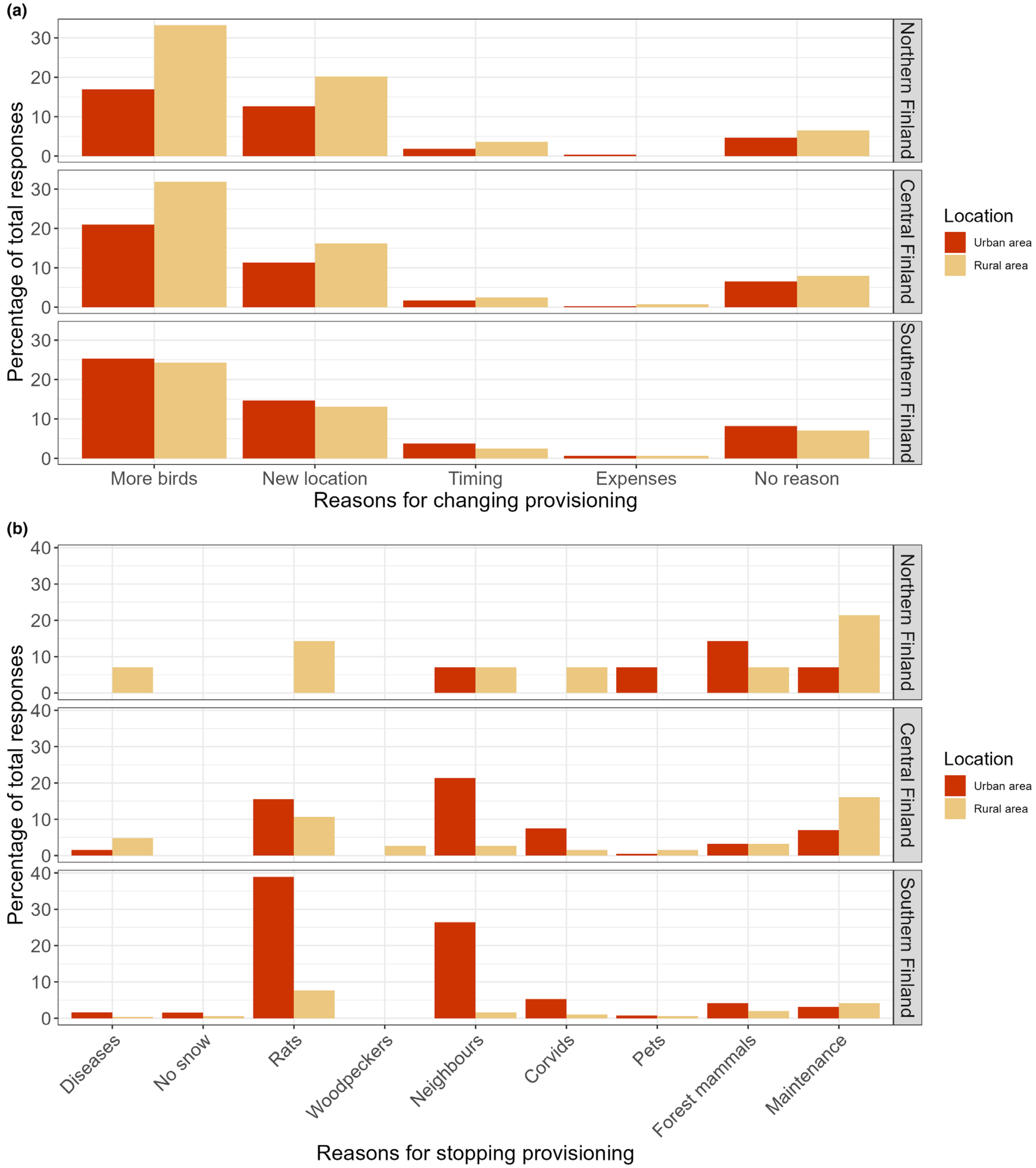

FIGURE 5 Responses for reasons for (a) changing bird-feeding and (b) stopping bird-feeding. The responses are shown as percentage of the responses from total responses in that region of Finland (Southern, Central, Northern) as there are vast differences in human density between the three regions (see Figure 1). [Correction added on 27 January 2025, after first online publication: Figure 5 has been updated to correct the labelling.]

feeding sites and types of food provided for birds across the country, we found that bird-feeding is declining, particularly in urban areas. However, at the same time, the amount of food provided per feeding site is increasing, especially in rural areas. The reasons for these changes in feeding habits (detected using an online questionnaire) also varied by habitat (urban vs. rural) and by geographic region (North, Central or South), suggesting that the motivations to feed birds are complex.

One of our main findings is that there is a difference in the patterns of feeding between urban and rural areas and that this varies over time. This difference between rural and urban areas has been recorded in other studies. For example, in Poland, Tryjanowski et al. (2015) found that there were more types of foods available in urban areas than rural areas in Poland. It is necessary to study the differences between urban and rural feeding sites, as in urban areas, natural food resources are depleted to a higher degree (Fuller & Irvine, 2010). Urban areas are predicted to grow in the foreseeable future (Seto et al., 2011) and with urban sprawl natural resources are lost, for example, urban areas are characterised by impervious surfaces which replace substrates that can provide food to birds. In such a scenario, feeding by humans can be an important resource to urban bird populations and can have major consequences for the structure of bird communities (Fuller et al., 2008; Galbraith et al., 2015). While Finland does not have as high rates of urban growth as some other countries (United Nations, 2019), internal migration to cities continues and it might be important from a global outlook on feeding to take into account the different bird-feeding behaviours by humans in urban and rural settings. As urban and rural areas differ widely in their cultural, social or institutional contexts, and feeding is modulated through these (Griffin & Ciuti, 2023), future studies on bird-feeding would benefit from exploring these feeding intensities along the urban–rural gradient.

In Finland, as would be expected due to the uneven distribution of the human population throughout the country, we found that there are more feeding sites in urban areas per survey kilometre. However, the data also show that these have been decreasing over the years as compared to rural areas. The decrease in the number of feeding sites was stronger in southern areas. According to our questionnaire, this pattern is likely driven by the presence of rats and private housing companies in urban centres prohibiting residents from feeding birds so as to not attract unwanted animals such as brown rats *Rattus norvegicus*. Humans also do not like rats in their surroundings, because they can cause damage to the households. In the larger cities of Finland, like Helsinki, it is now common that housing associations and companies prohibit their residents from feeding birds on their premises as this is thought to attract rats (Burt et al., 2021; Nygren & Aivelo, 2022). Rules and regulations were not a very highly reported reason in rural habitats and central and northern Finland where rats are perceived as a smaller problem (Nygren & Aivelo, 2022). However, it remains unclear if completely stopping feeding is the best solution and recent research is indicating that this might not benefit birds (Dayer et al., 2024). Our analyses show a contradiction as the surveys show a decline in the number of feeding sites, but the questionnaire has more answers from people who have started feeding compared to people who have stopped feeding. We assume that this is due to bias where it is more difficult to get answers from people who have stopped feeding birds, such as elderly people who have passed away.

Even though our results indicated that there are fewer feeding sites, the amount of imported food for wild birds to Finland has been increasing for some time. For instance, according to national statistic, 5.5–6.5 millions of kg of sunflower seeds and 1.1 million kg of peanuts were imported annually to Finland in 2007–2008, whereas it was 10.6–13.1 million and 2.3–2.7 million kg in 2019 and 2020, respectively (Finnish Food Authority, 2023). This decrease in the number of feeding sites and increase in the amount of imported food for wild animals can be explained by the fact that those that still keep feeding are providing more food than earlier. This is also supported by our feeding monitoring results, which shows that the amount of sunflower seeds and peanuts provided has increased over time. Overall, this means that while feeding sites have become scarcer (and possibly patchier) in recent times, existing feeding sites now provide a higher quantity of food.

The wider ecological consequences of bird-feeding remain poorly understood. As the availability of feeding sites decreases due to constraints imposed on provisioners, the amount of food available to wild animals in the winter could drastically decrease, having potential trickle-down effects. This could also lead to more animals gathering at these more spatially aggregated feeding sites and lead to an increased risk of pathogen transmission (Aberle et al., 2020). It has been suggested that the improved food quality of the feeding has led to the strong increases in population sizes of Blue Tit *Cyanistes caeruleus*, Tree Sparrow *Passer montanus* and Greenfinch *Chloris chloris* in Finland since 1980s (Valkama et al., 2011). The Greenfinch numbers in Finland have recently started to decline because of a trichomonas parasite that is actively spreading at feeding sites (Lehikoinen et al., 2013). Furthermore, very little is known about the ecological consequences of cultivating seeds for feeding, as most of the provisioned food has been imported (e.g. 64% of sunflower seeds from Bulgaria and 52% of peanuts from Argentina in 2020; Finnish Food Authority, 2023). Agricultural areas used for growing bird feed can replace land that could be used for human agriculture and forestry. This can increase the habitat loss of natural habitats (Shutt & Lees, 2021).

Like other studies carried out in Europe and parts of North America, we also found that sunflower seeds are preferred by provisioners and the import of these is growing over time (Tryjanowski et al., 2018). Sunflowers are not native to Finland and native foods that were traditionally provisioned (and can be found in the region naturally) such as oats have been out of favour over the past decades. This could be attributed to the fact that peeled sunflower seeds are high in energy (Besser, 1978) and do not leave as much waste as some of the cereals. Leftover husks from cereals are seen to attract unwanted species, like rats, to the feeding sites. Hence, provisioners might be investing in sunflower seeds due to their low cost and in an effort to not attract other taxa. However, research has shown that harmful invasive species can spread through bird feed (Oseland et al., 2020). We also note an increase in provisioning of fat, especially in urban areas, in recent years. This could be due to the bird-feeding products available in the supermarkets. Provisioning in the form of fat balls that contain seeds might be popular as these can be provided to birds without investing in a separate feeding equipment. Earlier studies have shown that provisioning only fat negatively impacts the breeding success of birds in the coming season (Plummer et al., 2013). Further studies on the quality of the commonly provisioned foods and their impact on the birds' health and breeding success would help provisioners make more informed decisions about which products to purchase. Also, regulations could help prevent provisioning of harmful foods, in the case of clear future evidence on their harmfulness to bird populations.

In summary, birds have experienced significant spatio-temporal changes in bird-feeding in Finland since the 1980s. It is unlikely that Finland is the only country in the world that is experiencing such changes and the ecological consequences of these changes are poorly understood and hence can affect bird populations on a global scale. Feeding sites are known to be spatial hubs for birds, and the consistency of the feeding regime is seen to affect the bird communities that use the feeding site (Mady et al., 2021). The consistency and quality of feeding hence play a major role in the winter survival of birds. The effects of winter bird-feeding are seen in the next breeding season in terms of carryover physiological condition of the birds with spill-over impacts on their breeding success (Robb et al., 2008). Hence, the obstacles that the provisioners face are important to understand. More studies from the provisioners' perspective will help us to identify and overcome the challenges that provisioners face and inform better policy especially in urban areas where non-target taxa like rats pose a threat. Interactions of humans with nature are known to go through cycles of tolerance and conflict (Griffin & Ciuti, 2023). Our work highlights the dynamic nature of bird-feeding in terms of changes that can take place with regard to a food source for birds, for which the birds would not have many obvious cues based on which to change their foraging behaviour. Finally, research on the challenges that provisioners face would also result in identification of best practices for feeding in terms of the quality and quantity of the food provisioned. More research on the ecological consequences of bird-feeding in urban and rural areas will help us to make informed policy decisions that benefit both the birds and the provisioners.

AUTHOR CONTRIBUTIONS

Aleksi Lehikoinen and Rose Thorogood conceptualised the study. Tuomas Aivelo, Aleksi Lehikoinen, Rose Thorogood, Andea Santangeli, Katja Rönkä and Anna Haukka designed the survey. Anna Haukka and Katja Rönkä translated and organised the data from the online survey. Data analysis was carried out by Purabi Deshpande and Aleksi Lehikoinen. Purabi Deshpande wrote the manuscript with inputs from Anna Haukka, Andea Santangeli, Tuomas Aivelo, Katja Rönkä, Aleksi Lehikoinen and Rose Thorodood.

ACKNOWLEDGEMENTS

We thank the members of the Helsinki Lab of Ornithology, Informed Birds and Helsinki Urban Rat Project for their inputs at various parts of the project. We also thank the thousands of volunteers who take part in the different long-term monitoring schemes and the respondents of our online survey for their enthusiastic participation. This project was supported by various funders: Kone Foundation (P.D.: 201904974 and A.H.: 201803079) and Research Council of Finland (A.L.: 323527 and 329251, K.R.: 347478 and R.T.: 333803). T.A. received funding from Emil Aaltonen Foundation. K.R. also received funding from Ella and Georg Ehrnrooth Foundation. The present research was carried out within the framework of the activities of the Spanish Government through the 'Maria de Maeztu Centre of Excellence' accreditation to IMEDEA (CSIC-UIB) (CEX2021-001198). AS acknowledges support from the European Commission through the Horizon 2020 Marie Skłodowska-Curie Actions individual fellowships (grant no. 101027534). Finally, the winter bird counts have been supported by the Ministry of the Environment of Finland.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

One of the long-term monitoring data sets is free to access through GBIF (winter bird census: https://doi.org/10.15468/vmdzin). Data used here from the Finnish bird feeder monitoring scheme used here and data collected through the online questionnaire along with all the code used for the analyses are openly available at http://doi.org/10.5281/zenodo.13805256.

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SUPPORTING INFORMATION

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

Table S1. Details of the questions asked in the questionnaire to explore the provisioning habits of people and reasons for stopping or changing.

Table S2. Cumulative probabilities of reporting a particular response for a (a) provisioning less, no change and provisioning more across different regions and habitats and (b) stopping provisioning, no change and starting provisioning across different regions and habitats.

Table S3. Results of GLMs with binomial error distribution where we compare the categorical responses about change in provisioning as pairs.

Figure S1. Graphical representation of the cumulative probabilities of different reports for (a) provisioning less (−1), no change (0) and provisioning more (+1) and (b) stopping provisioning (−1), no change (0) and starting provisioning (+1).

How to cite this article: Deshpande, P., Haukka, A., Rönkä, K., Aivelo, T., Santangeli, A., Thorogood, R., & Lehikoinen, A. (2025). How, why, where and when people feed birds?—Spatio-temporal changes in bird-feeding in Finland. *People and Nature*, *7*, 360–372. https://doi.org/10.1002/pan3.10745