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Wildlife gardening initiates a feedback loop to reverse the "extinction of experience"

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Urbanization can cause the "extinction of experience", a feedback loop in which people who have little interaction with nature are less likely to protect it. This cycle could result in a continual erosion of biodiversity and fewer opportunities for people to experience nature. Alternatively, a sustainable version of this loop may occur which incorporates environmental engagement, or "noticing nature." Here we combine ecological and social data to provide the first empirical test of the full extinction of experience/noticing nature loop, using birds as a focal taxon. Our study included 815 urban residents from 25 neighborhoods near Chicago, IL (USA). Residents were asked about their yard management and perceptions of birds in their neighborhoods. A researcher also documented the neighborhood bird communities. The social and ecological data were incorporated into a structural equation model to test the existence of a feedback loop. Our data confirm the existence of a loop but indicate that the relationship between people and birds is indirect rather than direct, suggesting that biodiversity changes are less important in the loop than residents' impressions of biodiversity. This is promising for urban conservation, because it suggests the cycle may continue even when the scale of management in an individual yard does not match the scale necessary for an immediate impact on wildlife. We therefore suggest that small wildlife-friendly changes to residential yards, in the aggregate, have the potential to reverse the extinction of experience and promote long-term increases in biodiversity.

1. Introduction

Modern humans are more removed from nature than ever before. More than half of the world's population lives in cities (United Nations, Department of Economic and Social Affairs, Population Division, 2019) and most adults spend >22 h a day indoors (Diffey, 2011). These conditions can lead to the "extinction of experience", a feedback loop in which people who have little interaction with nature are less likely to protect it, resulting in less nature to interact with (Pyle, 1993; Pyle, 1978). Although this concept was first introduced 45 years ago, we still know relatively little about this hypothesized feedback loop, if or how it plays out on the ground, and how it might be reversed in our urbanizing world. It is increasingly important to fill this knowledge gap because many of today's environmental problems could be improved with small behavior changes by large numbers of people (Reddy et al., 2017).

Researchers have argued that the extinction of experience has two root causes: loss of opportunity to experience nature and loss of emotional affinity with nature (Soga and Gaston, 2016). These losses could potentially result in declining pro-environmental attitudes and behaviors (Mackay and Schmitt, 2019). For example, a reduced connection with nature can lead people to be less engaged in behaviors such as recycling, supporting conservation organizations, or wildlife-friendly yard practices (Whitburn et al., 2020; Zaradic et al., 2009), which in turn leads to environmental degradation more broadly. Over

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time, these behaviors may lead to a self-reinforcing cycle of deteriorating environmental conditions, a loss of biodiversity, and less opportunity to experience nature. However, there are opportunities to reverse this detrimental cycle and generate a more environmentally sustainable feedback loop – one that generates positive connections between people and nature (Barragan-Jason et al., 2022) and leads to broader implementation of pro-environmental behaviors and conservation strategies.

Residential yards and gardens are an important system for understanding the "extinction of experience" concept, particularly in urban areas. Yards and gardens comprise a substantial portion of green space in many cities (e.g. Mathieu et al., 2007; Minor et al., 2017; Ossola et al., 2019), and are a primary place for many urban residents to interact with nature. Furthermore, yards are places where urban residents make decisions and take actions that directly impact local biodiversity (Goddard et al., 2017; Padullés Cubino et al., 2020). The vegetation management and design choices that urban residents make in their yards are complex (Cook et al., 2012), but residents who value nature may be more likely to create wildlife-friendly yards (Belaire et al., 2015; Goddard et al., 2013). In turn, wildlife-friendly yards with more vegetation and other resources tend to attract more wildlife (Belaire et al., 2014; Daniels and Kirkpatrick, 2006; Smith et al., 2006). For example, native landscaping increased the presence and breeding activity of Carolina chickadees (*Poecile carolinensis*; Narango et al., 2017), and the richness, abundance, and foraging of non-breeding birds (Smallwood and Wood, 2023) in residential yards in the United States. Thus wildlife-friendly yards can increase opportunities for humans to interact and connect with nature and generate a sustainable version of the feedback loop.

Wildlife gardening has the potential to reverse the extinction of experience feedback loop in several ways. For example, wildlife gardening can engage residents to *notice nature* in the spaces where they live. The increased wildlife habitat on a gardener's property can make them more aware and appreciative of wildlife, which leads them to engage in more and different "wildscape" or pro-environmental behaviors such as planting native plants or minimizing pesticide use (Jones et al., 2021). This phenomenon was called the "noticing nature model" by Hamlin and Richardson (2022). Furthermore, wildlife gardening can lead to an *increase in wildlife* visiting a yard, increasing human-wildlife interactions and connections. Goddard et al. (2013) described a positive feedback in which gardeners were motivated to continue wildlife gardening when their activities were rewarded by visits of birds and other wildlife to their gardens.

The extent to which an actual change in wildlife abundance or diversity in response to yard management is a necessary part of the cycle, as opposed to people simply noticing the wildlife that are already present in their yards, is currently unclear. This link is particularly uncertain in part because people are notoriously inaccurate at estimating the biodiversity around them (e.g. Shwartz et al., 2014). However, understanding the role of wildlife in the cycle is essential to understanding whether wildlife gardening has the potential to directly and immediately impact biodiversity in cities. Here, we slightly modify and extend the model of Hamlin and Richardson (2022) to describe a "noticing nature cycle" as an ecologically sustainable version of the extinction of experience feedback loop, and explicitly include a change in biodiversity as part of the cycle to test its importance (Fig. 1).

If wildlife response is an integral part of the noticing nature cycle, the size of the yard and the particular wildlife species in question will affect the scale at which the cycle operates. For the cycle to be sustainable in a single isolated yard, the yard would need to be similar in size or larger than the home range of the focal species. If the size of the home range exceeded the size of the yard, the cycle would either break down or rely on interactions with neighbors. In many urban areas, individual yards are much smaller than the home range size required by many species of wildlife, especially for highly mobile organisms like birds (Goddard et al., 2010). If an individual created a small oasis of habitat within an otherwise unsuitable neighborhood, there may not be enough habitat to support birds or increase the individual's interactions with birds. However, wildlife with smaller home ranges (e.g. some small native rodent species) may respond well to changes in a single yard, allowing the noticing nature cycle to persist.

At the neighborhood scale, interactions among neighbors and their yards could also be important to sustaining the cycle. For example, the wildlife gardening activity of an individual may expose their neighbors to wildlife, which may in turn prompt those neighbors to engage in their own wildlife-friendly activities (Jones et al., 2021). Alternatively, social interactions or norms may cause neighbors to mimic each others' yard design (Locke et al., 2022; Minor et al., 2023), potentially creating larger

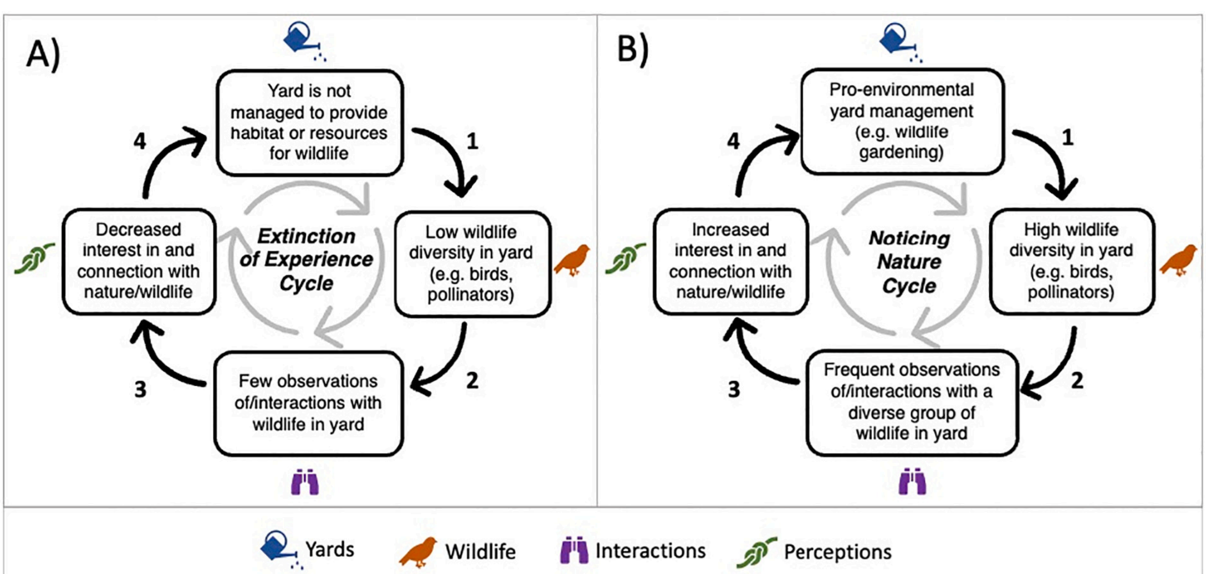

Fig. 1. Examples of how a feedback loop may play out in two different ways in residential yards and gardens, leading to either a decrease (A) or increase (B) in urban biodiversity over time. In panel A, the extinction of experience leads to urban residents becoming more disconnected from nature and a concurrent decrease in urban biodiversity. Panel B shows the hypothesized *noticing nature cycle*, a reversal of the extinction of experience in which urban biodiversity and residents' connections with nature increase as part of an ecologically sustainable feedback loop. Numbered arrows refer to individual relationships that comprise the feedback loop, which we test with a structural equation model.

patches of habitat that span multiple yards. In these ways, positive interactions with either wildlife or human neighbors could both potentially lead to the creation of more habitat that supports a variety of wildlife species. Thus, understanding the relative importance within the cycle of the actual presence of wildlife versus social phenomena such as noticing nature or yard mimicry is critical. If social factors alone are sufficient to sustain the cycle, the cycle may not actually lead to the increase of biodiversity, or at least not in a single isolated yard. In contrast, if the presence or increase of wildlife is a necessary component of the cycle, then the cycle can lead to changes in biodiversity over time.

The extinction of experience, and the opportunities to reverse it, are theoretically driven by a series of interconnected relationships between people, their behaviors, and the environment (i.e., the numbered arrows in Fig. 1). Each of these relationships has been examined individually by numerous researchers. In a first attempt to empirically test the extinction of experience, Colléony et al. (2020) used structural equation modeling to analyze a survey of 523 urban residents about their opportunities to experience nature, their connections with nature, and their pro-environmental attitudes and behaviors. They found that connection with nature predicted visits to green spaces, which in turn predicted behaviors such as recycling and enhancement of wildlife habitat; connection with nature was also a predictor of environmental attitudes, which further predicted conservation behaviors. They concluded that strengthening people's connections with nature may avert the extinction of experience. Their research provided partial support for the theoretical framework but did not directly assess the ecological outcomes of the feedback loop (the "Wildlife" box in Fig. 1). In this paper, we combine both social and ecological data to conduct the first empirical test of the full "extinction of experience"/"noticing nature" loop.

Here we combine in a novel way three datasets that were previously published in separate papers. The datasets were collected in 25 suburban residential neighborhoods near Chicago, IL (USA). The first dataset, collected with ecological surveys, describes bird communities breeding in these neighborhoods, including the number of native species recorded by researchers at each location (Belaire et al., 2014; Fig. 1 "Wildlife"). The second dataset, collected with social surveys, describes the human residents of these neighborhoods, their socio-economic characteristics, their estimations of local bird diversity, and their perceptions of birds (Belaire et al., 2015; Fig. 1 "Interactions" and "Perceptions/Connection"). The final dataset, also collected via social surveys, describes the yards that are managed by the human residents, including the ecological resources within those yards (Belaire et al., 2016; Fig. 1 "Yards"). Whereas our previous research examined the relationships in Fig. 1 in isolation from one another, our goal with this new analysis was to integrate the full dataset to test the noticing nature cycle. By combining these three datasets for the first time, we test whether wildlife gardening can reverse the extinction of experience through an increase in noticing nature, an increase in wildlife, or both.

2. Methods

2.1. Study area

This study took place in residential neighborhoods in Cook County, Illinois (USA). Cook County contains the city of Chicago, and is the second most populous county in the United States, with a population of approximately 5.2 million residents. Approximately 85 % of the county is considered "developed land" (e.g., residential, transportation, industrial, etc.), but the county also owns and manages over 200 km^2 of

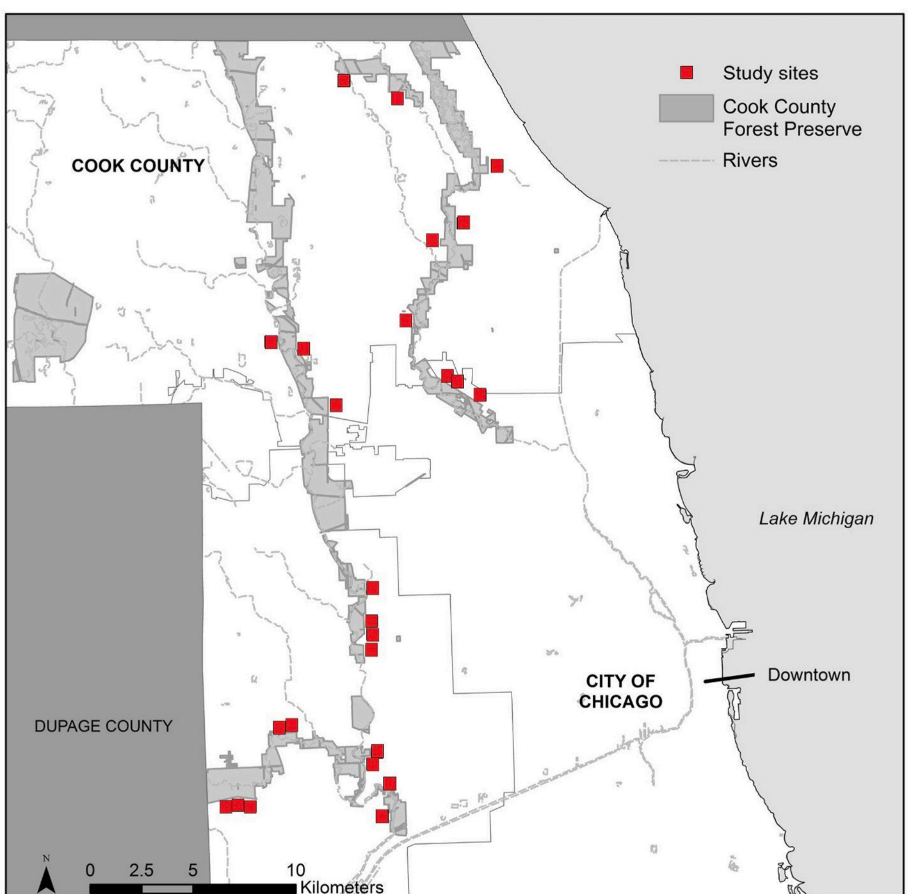

Fig. 2. Map of the 25 neighborhoods included in this study. All neighborhoods are located in Cook County, Illinois, USA.

nature preserves, mostly forests and prairies (Prairie Research Institute, 2014). The climate is classified as humid continental by Köppen climate classification, and the region experiences four distinct seasons each year.

In summer 2012, we selected 25 neighborhoods for our study (Fig. 2). We selected neighborhoods that were dominated by single-family homes and located adjacent to linear riparian forest preserves along the North Branch of the Chicago River, the DesPlaines River, and their tributaries, to minimize differences in landscape context. Each neighborhood was at least 500 m away from other neighborhoods in the study. Neighborhoods varied in terms of housing density (16–77 homes along the 1 km transect), tree canopy cover (20 % - 46 %), and median household income ($45,000 - $191,000 per year). More information about neighborhood environmental and socioeconomic characteristics can be found in Belaire et al. (2014) and Belaire et al. (2016), respectively.

2.2. Data collection and measured variables

In each neighborhood, 1-km transects were extended along residential streets that ran roughly perpendicular to a forest preserve. Each transect began 100 m from the edge of a forest preserve and extended 1 km outward into the adjacent neighborhood. The same transects were used to study birds, human residents, and their yards.

Birds were surveyed twice along the transect between 4 June and 6 July 2012. We used 5-min point counts, conducted between sunrise and 10:00 am, at designated points every 100 m along each transect. All birds seen and heard within 50 m of each point were recorded. In total, we recorded 36 bird species across all the transects, 32 of which were native species. We include only native bird species in the current analysis, as they were more likely to be correlated with wildlife-friendly yard characteristics (Belaire et al., 2014).

We also developed a social survey (following the guidelines of Dillman et al., 2008) to learn about the residents themselves, their yards and gardens, and their observations of and perceptions of birds. Social surveys were disseminated to all single-family residences adjacent to each transect (n = 1751) during July–September 2012, and we invited an adult with responsibility for yard decision-making to complete the survey. We used the "drop-off/pick-up" method (Allred and Ross-Davis, 2011; Steele et al., 2001), which involves knocking on doors to forge connections with study participants; this method helps to eliminate barriers associated with completing and returning the survey and leads to increased response rate. A $1 token financial incentive was included with the survey to further increase response rate.

The survey had three parts. In the first part, we asked residents about the composition of their yards (e.g., whether their yard contained certain kinds of vegetation and wildlife resources). In the second part, we asked residents about their observations and perceptions of neighborhood birds; those questions were adapted from previous survey research examining the benefits and annoyances of trees (Schroeder and Ruffolo, 1996; Sommer et al., 1990). This portion of the survey asked residents to estimate the number of bird species on their block. It also included positive statements and negative statements about birds, and residents indicated their level of agreement with each statement. For example, respondents indicated their level of agreement with positive statements about birds such as "I value birds in my neighborhood because they are pleasing to the eye," as well as negative statements such as, "I find birds in my neighborhood to be annoying or problematic because their droppings make a mess on my outdoor furniture, car, etc." The third part of the survey asked about residents' socioeconomic characteristics, such as their age, income, and education. We received responses from 924 residents (52.7 % response rate). Two checks for nonresponse bias indicated that respondents did not differ significantly from non-respondents in terms of income or yard composition (Belaire et al., 2016). The full survey is provided in the supplementary material.

From the data collected during bird and social surveys, we developed nine variables that describe each resident, their perceptions of birds, their own yard and neighboring yards, and the bird communities near their home (Table 1). Based on our previous research (Belaire et al., 2016; Belaire et al., 2015; Belaire et al., 2014), we expected these nine variables to be important components in reversing the extinction of experience and generating a more ecologically sustainable feedback loop.

2.3. Structural equation modeling

We used a structural equation model to test the hypothesized feedback loop. Structural equation modeling is a type of causal modeling in which complex relationships, including indirect relationships and feedbacks, can be modeled between one or more independent variables and one or more dependent variables. Variables can be either measured variables or theoretical constructs that are difficult to measure directly (called "latent" variables). Relationships between these variables can be represented by a path diagram, providing an intuitive understanding of the hypotheses being tested. We modeled relationships among the various social and ecological components of our system using the lavaan package (Rosseel, 2012) in R version 4.2.1 (R Core Team, 2022).

Based on our previous research in this system (Belaire et al., 2016; Belaire et al., 2015; Belaire et al., 2014), we created our initial structural equation model to examine the full feedback that includes people, their yards, and birds. Specifically, we created the model to examine the *feedback loop of linkages among* the relationships shown as numbered arrows in Fig. 1:

(1) Yards and gardens contain vegetation and other food and habitat resources that, in part, explain the measured bird richness in residential neighborhoods
(2) Bird richness in neighborhoods affects residents' observations of birds and their estimated bird species richness
(3) Estimated species richness of birds is positively correlated with residents' perceptions of birds and the extent to which they agree or disagree with positive and negative statements about birds
(4) Residents' perceptions of birds predict their approach to yard management and thus the food and habitat resources they provide in their yards, which supports a continuation of the feedback loop

Our initial structural equation model (Fig. 3A) included "perceptions of birds" as a latent variable that is summarized by two indicator values: the bird benefit score and the bird annoyance score (both described in Table 1). We also added age, income, and education of residents as predictors of perceptions of birds and of the wildlife friendly index of a resident's yard, as these were important in our previous research (Belaire et al., 2016; Belaire et al., 2015). Finally, the wildlife friendly index of neighbors' yards was added as a predictor of both bird richness and the wildlife friendly index of a resident's yard (Belaire et al., 2016; Belaire et al., 2014). The unit of analysis was the survey respondent, and we only retained surveys that did not have missing data for any of the endogenous (response) variables (n = 815). We log-transformed perceived bird richness to improve normality; we then centered and scaled (z-score) all variables.

We refined our initial model following the general approach of Grace et al. (2010). First, we assessed model fit using several indices, including a chi-square test, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean squared residual (SRMR, Grace, 2006; Kline, 2016). We then added missing links that would greatly improve model fit as indicated by modification indices. Finally, we sequentially removed the least influential measured variables or links as determined by p-values. We continued until the p-values for all of the regressions were statistically significant at α=0.05, and model fit as indicated by the above measures no longer improved.

Table 1
Variables used in the structural equation model. These data were previously analyzed separately and published in Belaire et al., 2014, 2015, and Belaire et al., 2016.

Variable	Description	Mean ± Std Deviation
Wildlife friendly index of resident's yard	The number of wildlife resources available in front and back yards on each residential parcel, as reported by residents on the survey. The index ranges from 0 to 11. Potential resources include deciduous trees, evergreen trees, shrubs, plants with fruits and berries, flowers/herbs/vegetables, vegetation intended to attract birds, native vegetation, bird feeders, bird houses, water features, and brush piles or open compost areas.	6.0 ± 2.1
Wildlife friendly index of neighbors' yards	The mean wildlife friendly index of yards within a 200 m radius of the focal home for which we have survey data, excluding the focal home itself.	5.9 ± 0.9
Bird benefit score	For each resident, their mean level of agreement with 11 positive statements about birds in their neighborhood, as reported in the social survey. This score ranges from 0 to 5, with higher scores indicating higher levels of agreement with positive statements about birds in their neighborhood.	4.1 ± 0.7
Bird annoyance score	For each resident, their mean level of agreement with 10 negative statements about birds in their neighborhood, as reported in the social survey. This score ranges from 0 to 5, with higher scores indicating higher levels of agreement with negative statements about birds.	1.9 ± 0.7
Age of resident	Age of resident, as self-reported in the social survey	54.6 ± 14.8
Education level of resident	Highest education achieved by resident, as self-reported in the social survey and converted to a scale of 1–5, with 1 representing no high school diploma and 5 representing a completed graduate degree.	3.4 ± 1.3
Household income	Household income of the resident, as self-reported in the social survey and converted to a scale of 1–5, with 1 representing less than $25,000/year and 5 representing more than $150,000/year	3.5 ± 1.2
Resident-estimated bird species richness in the neighborhood	The estimated number of bird species in the neighborhood as reported by residents on the social survey. This estimate was provided in response to the following question: "How many different types of birds (e.g., cardinals, robins, grackles, woodpeckers) would you guess live on your block?" When residents entered a range of values (e.g., 5–10), we retained their lowest estimate. Estimates were log transformed for analysis to correct a strong right-skewed distribution.	*Raw*: 9.6 ± 13.4 *Log*: 2.0 ± 0.7
Measured native bird species richness in the neighborhood	Total number of native bird species recorded by the researcher at the four point count locations nearest each home (~200 m around each home). This measure represents the bird community most likely experienced by a person around his or her home.	8.8 ± 2.2

3. Results

Our final, refined structural equation model is shown in Fig. 3B. This model fit the data well according to several metrics (χ^2 $p = 0.06$, CFI = 0.99, TLI = 0.72, RMSEA = 0.03, SRMR = 0.03). Modification indices suggested that we should remove the link in our initial model from the wildlife friendly index of the resident's yard to measured bird richness, and add a link to resident-estimated bird richness, to improve model fit. We also determined that income and education were not significant predictors of either perceptions of birds or yards, and we removed these variables completely from the model. All other relationships were significant at $p \leq 0.05$.

The feedback loop indicated by our final model shows that the wildlife friendly index of a resident's yard is positively related to the bird species richness that the resident estimates in their neighborhood (Fig. 3). Resident-estimated bird richness, in turn, is positively related to the residents' perceptions of birds; finally, these perceptions of birds are positively related to the wildlife friendly index of the resident's yard, which closes the loop. We also found that the link between measured and resident-estimated bird richness was fairly weak (standardized loading = 0.08).

4. Discussion

4.1. The feedback loop

Our findings confirm the existence of a feedback loop among people, their yards, and birds, although the feedback differed slightly from our original hypothesis. Specifically, we found that a resident's wildlife friendly yard index directly affected their *estimated* bird richness but not measured bird richness (Fig. 3B). Overall, our refined model suggests that people's perceptions of birds affect the decisions they make in their yards and gardens, which in turn affects the number of bird species they estimate to be around them. People who estimate more bird species have more positive perceptions of birds, thus completing the cycle. When wildlife gardening occurs in a neighborhood, the ecologically-sustainable noticing nature loop can override and reverse the extinction of experience loop.

Our results suggest that the feedback loop may be somewhat independent of actual biodiversity in a yard, and that the act of noticing nature may be more important than an actual change in yard wildlife diversity. Notably, the amount of "noticed nature" (i.e., resident-estimated species richness) was only weakly related to the measured bird diversity (as recorded by an ecologist). Furthermore, there isn't a direct link between the wildlife friendly index of a resident's yard and the actual (measured) bird richness. At first glance, these results may imply that the noticing nature feedback occurs only in the minds and behaviors of people and does not translate into benefits for birds. However, it is important to note that another aspect of "noticing nature" – residents' perceptions of the benefits of birds – has an outsized impact on their own yard decisions, and this deeper form of "noticing" nature may be a more important component of the feedback loop than resident-estimated species richness. Nevertheless, the fact that the feedback loop can continue for an individual regardless of whether the individual is rewarded by an actual increase in bird species richness is promising for urban conservation: after all, small actions by many individuals can have a large collective impact.

The series of relationships we describe could result in two very different outcomes: continually increasing or continually decreasing biodiversity. Soga and Gaston (2016) argue that the main causes of the extinction of experience are loss of opportunity to experience nature and loss of emotional affinity with nature. But in a feedback loop, every major element is both a cause and an effect. Thus, our final model suggests that the outcome can potentially be changed by altering wildlife observations and interactions, human connections with nature, or garden management. Transformations of complex systems can be made

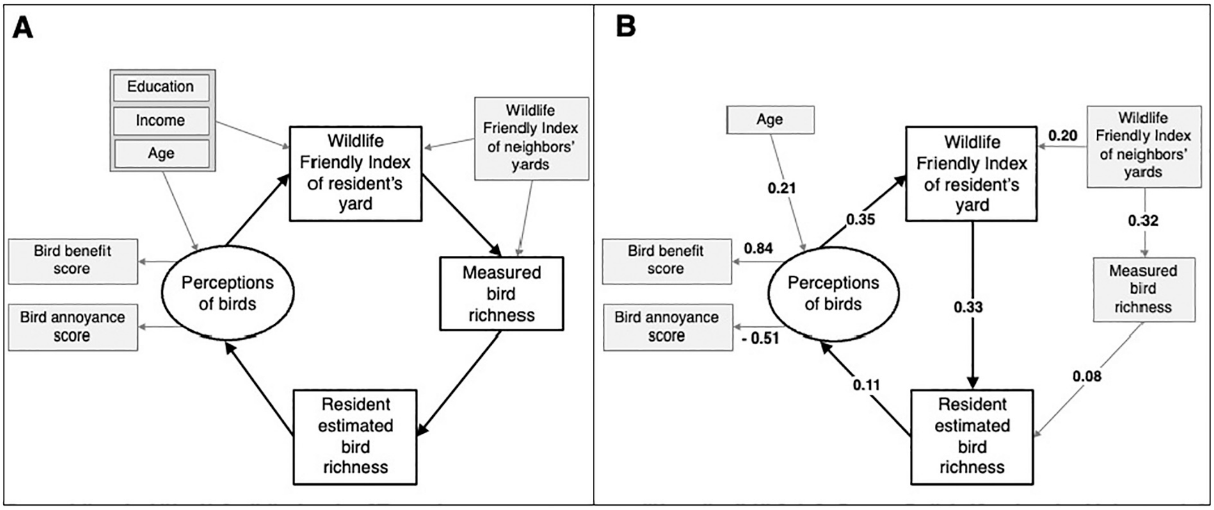

Fig. 3. Initial (A) and final (B) structural equation models of the noticing nature feedback loop. Measured variables are shown in rectangles; the latent variable, "perceptions of birds," is shown as an oval. Components of the feedback loop are in white boxes with black outlines while other variables are in gray boxes. In the final model (B), standardized loadings are shown on the path arrows and all arrows indicate statistically significant relationships ($p \leq 0.05$).

through "leverage points," where a small shift in one thing can lead to big changes in the whole system (Meadows, 1999). Leverage points can be shallow, which means that the interventions are easy but limited in their potential to bring about transformative change, or deep, which means that the interventions are difficult but have great potential to bring about transformative change (Fischer and Riechers, 2019). Ives et al. (2018) describe gardening as an activity that can simultaneously impact shallow and deep leverage points through environmental learning, nature connectedness, pro-environmental behaviors, and other numerous social activities. Our results suggest that wildlife-friendly gardening could be an important "leverage point" not only in the sense that it increases noticing nature, but also in that, in aggregate, it substantively changes the structure and provision of resources for wildlife within urban areas.

Our final structural equation model reinforces the importance of wildlife gardening as a key strategy in reversing the "extinction of experience" cycle, particularly because it seems to trigger increased attention by urban residents to nature in their yards and neighborhoods. Residents with more wildlife resources in their yards reported seeing a higher number of bird species, even though there was not a direct correlation between the wildlife friendly index of a yard and the nearby measured bird richness detected by researchers. Jones et al. (2021) also noticed a feedback loop in which the actions of "wildscape" gardeners led to a perceived increase in wildlife habitat on their property, which made them more aware and appreciative of wildlife — and subsequently engage in more wildscaping activities. This could be due to a sort of "field of dreams" fallacy in which the resident believes that because they have built it, the birds will come; or, it could be interpreted as a self-fulfilling prophecy in which residents who intentionally create wildlife friendly yards are simply "noticing nature" more than others (Hamlin and Richardson, 2022).

4.2. *The importance of scale*

As previous researchers of this feedback have not directly measured ecological components of their system, they could not assess whether gardeners' actions led to real increases in biodiversity. Our study provides some clarity about this issue. By including ecological data in our structural equation model, we can see the connections between a resident's yard, their neighbors' yards, and measured bird diversity. Studies show that gardeners' actions can and do lead to increases in real biodiversity (Belaire et al., 2023; Lerman et al., 2021). However, this relationship is indirect in our system, likely due to the scale mismatch between the environmental behaviors by individual residents (managing a small urban yard) and the ecological response (neighborhood bird diversity).

These results reinforce the important role of multiple yards, collectively, for urban biodiversity and reversing the "extinction of experience". The median single residential lot size in the greater Chicago metropolitan area is 0.08 ha (Pacheco, 2022), and the standard lot size in Chicago itself is only 0.03 ha—which includes the area taken up by the residence itself. In comparison, for instance, the home range of the American robin *Turdus migratorius*, a species commonly found in urban and suburban yards throughout the United States, is between 0.04 and 0.84 ha (Vanderhoff et al., 2020). While some bird species may respond to habitat features at the yard scale, others respond more strongly to features at the neighborhood scale (McCaffrey and Mannan, 2012). Therefore, one individual's wildlife friendly yard might not be sufficient to increase bird diversity on its own. Our model suggests that overall measured bird richness is linked to the aggregate wildlife friendly index of neighbors' yards.

Wildlife gardening in one yard can still be important, though, in that it may encourage other nearby neighbors to mimic similar wildlife-friendly practices in their own yards, leading to larger habitat "patches" within urban landscapes over time (Goddard et al., 2013). Our model suggests that the wildlife friendly index of a resident's yard is linked to the wildlife-friendly index of their neighbors' yards. From previous research, we know that wildscape gardeners often engage in advocacy related to wildscaping (Jones et al., 2021). Moreover, neighbors' yards tend to be similar to each other with respect to plant composition, presumably due to social interactions (Minor et al., 2023). Therefore, residents with a wildlife friendly yard might influence their neighbors to make their yards more wildlife friendly, and clusters of wildlife friendly yards *would* be sufficient to increase diversity of birds, and, presumably, other wildlife.

4.3. *How to increase the adoption of wildlife-friendly gardens*

Widespread adoption of wildlife-friendly gardens has the potential to substantially improve the sustainability of urban areas, although how best to achieve this is not always clear. Management of yards and gardens is influenced by a variety of personal motivations and social constraints (Goddard et al., 2013) as well as governance at larger spatial scales (Carr and Kramer, 2022; Larson et al., 2020). Furthermore, people's stated environmental values are not always reflected in the ways that they manage their yards (Beumer, 2018; Larson et al., 2022). Some barriers to increasing "wildness" in urban yards include the desire to conform to neighborhood norms and aesthetics (Carr and Kramer, 2022), the interpretation of wildness as a lack of care (Burr et al., 2021) or conversely requiring too much maintenance (Larson et al., 2022), and the desire to deter rather than encourage wildlife (Larson et al., 2022). A number of initiatives and certification programs encourage people to make their yards more sustainable and wildlife friendly, although their effectiveness has rarely been tested (Pham et al., 2022). In their study of six U.S. cities, Larson et al. (2022) found significant potential for expanding the adoption of wildlife-supporting landscapes. In particular, neighborhood organizations such as Homeowners' Associations (HOAs) can play a surprisingly positive role in the widespread adoption of wildlife friendly landscaping practices (Larson et al., 2022; Lerman et al., 2012). While HOAs may also create barriers to sustainable landscaping (Carr and Kramer, 2022), they should be considered as a potentially important avenue for improving wildlife habitat and human-nature connections across residential landscapes.

5. Conclusion

Our study highlights the importance of residential yards and gardens for reversing the extinction of experience. Gardens are potentially unique settings that offer the average person an easy opportunity to alter their experiences with nature and improve their own well-being (Hamlin and Richardson, 2022). Gardens also provide what Klaniecki et al. (2018) describe as an "equal interaction" opportunity, where human-nature connections (e.g., observations of wildlife) occur in the same space as the pro-environmental behaviors (e.g., garden management decisions). These fine grain, small extent connections may be the easiest human-nature connections to foster and may lead to the adoption of convenient pro-environmental behaviors, although Klaniecki et al. (2018) argue that these types of connections may not lead to deep transformational change. However, we are more optimistic. Small changes to gardens, in the aggregate, can lead to increases to urban biodiversity, an increase in urban residents "noticing nature" and, perhaps, to a more widespread and self-reinforcing sustainable mindset.

CRediT authorship contribution statement

Megan Garfinkel: Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Amy Belaire:** Conceptualization, Funding acquisition, Investigation, Writing – review & editing. **Christopher Whelan:** Conceptualization, Writing – review & editing. **Emily Minor:** Conceptualization, Funding acquisition, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2023.110400.

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