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Research

People think there's no nature in cities, but they want to know more

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ABSTRACT. We surveyed urban residents to study their knowledge, engagement, perception, and curiosity of bird biodiversity in four Peruvian cities in two different ecosystems (Lima and Huacho in the Pacific desert, and Nauta and Iquitos in the western Amazon). Surveys also included questions on social variables such as age, gender, education, outdoor activities, and years residing in the area. Bird point counts were carried out in the same sites where residents were surveyed. These sites were also visually assessed for greenspace cover and distance to nearest landmarks. Exploratory analyses (principal components analyses and factor analysis of mixed data) were carried out on environmental and survey data to summarize and select correlated variables for multivariate linear models. Amazonian city residents had higher "knowledge" and "engagement" scores than residents in the desert cities. Best performing models predicting "knowledge" scores suggested that urban residents learned about birds outside of the formal education sphere, although there were no strong common patterns among cities or in the full dataset. "Engagement" scores in the desert cities seemed to be linked to local and neighborhood greenspace and education, suggesting socioeconomic class plays a role. The overwhelming majority of all four cities' respondents scored highly in "perception" and "curiosity" measures, implying that orientation toward nature is not lost in these four cities and that finding and promoting the human–nature connection in urban areas is a matter of asking the right questions and promoting existing nature practices and perspectives.

Key Words: *extinction of experience; human–nature connection; mixed methods; Peru; urban avian biodiversity*

INTRODUCTION

Cities are full of people who can promote or subvert conservation and environmental priorities depending on their political and economic participation, attitudes, and connections with nature (Sanderson et al. 2018). When cities subvert conservation and environmental priorities, they encroach on arable land and natural habitat (e.g., Ewing 1997), support a human population with a higher demand for meat and other energy-intensive goods (e.g., de Haen et al. 2003), and negatively disrupt nitrogen cycling and microbial communities (e.g., Wang et al. 2017). By contrast, when they promote conservation and environmental priorities, cities have less energy use per capita than rural areas (Güneralp et al. 2017), house more people at a higher standard of living (Addanki and Venkataraman 2017), and present the opportunity to lay down a foundation for a smaller future impact on biodiversity (Sanderson et al. 2018). Thus, as the global population urbanizes, the human–nature connections of urban residents are a starting point toward understanding how humans lead the cities they live in on paths away from or toward sustainability.

Human connections with nature are influenced by the varied ways people relate to and value it (Chan et al. 2016). In cities, green spaces can provide direct benefits by promoting exercise (Wolch et al. 2014), providing new economic opportunities (Wolch et al. 2014), and serving as the setting for urban agriculture (Azunre et al. 2019). Cities also have trees mitigating the increased temperatures caused by urbanization (Derkzen et al. 2017, Lin and Gou 2017), wetlands purifying water for use as tap water (de Groot et al. 2002), and biodiversity decreasing the chance of human infection by a generalist pathogen (Hassel et al. 2017). The aesthetic quality of nature has promoted scientific literacy through natural history activities (Wood et al. 2011), and both green and blue (water) spaces have facilitated community development through mental well-being and social cohesion (Wolch et al. 2014, Corburn 2017).

However, many cities are concrete canyons, not urban forests. In these gray spaces, scholars have theorized that humans lose their connection to nature, thus the desire to conserve it, through "the extinction of experience" (Pyle 1978, as cited in Pyle 2003). This process states that as the species richness to which humans are exposed decreases, the power of nature to incite humans into action is lost (Pyle 2003). Research into what causes extinction of experience has been conducted in the United States, Japan, Spain, Hong Kong, and the United Kingdom, among other countries (Botzat et al. 2016, Soga and Gaston 2016). Most of this literature is restricted to experiences from the Global North, yet cities in the Global South are some of the fastest growing and are located in highly biodiverse areas (Pyle 2003). Whether the same patterns of loss of interest in nature by urban residents occur across the Global South has not been characterized in peer-reviewed literature but must be identified to provide pathways for peoples' participation in nature conservation and resource management (Castillo et al. 2006).

In this study, we asked: How do urban residents' knowledge, engagement, perception, and curiosity (KEPC) toward birds vary in four Peruvian cities and what factors may explain these variations? We chose birds as a study group because they are noticeable, hold aesthetic and cultural value, and can indicate environmental health (Ogden et al. 2014, Robinson 2019). Given the theory of extinction of experience, we hypothesized that bigger cities, particularly those in deserts, would have the lowest measures across all response variables. Within cities, we hypothesized that respondents who live in places with more greenspace and higher bird diversity would score higher on all response variables.

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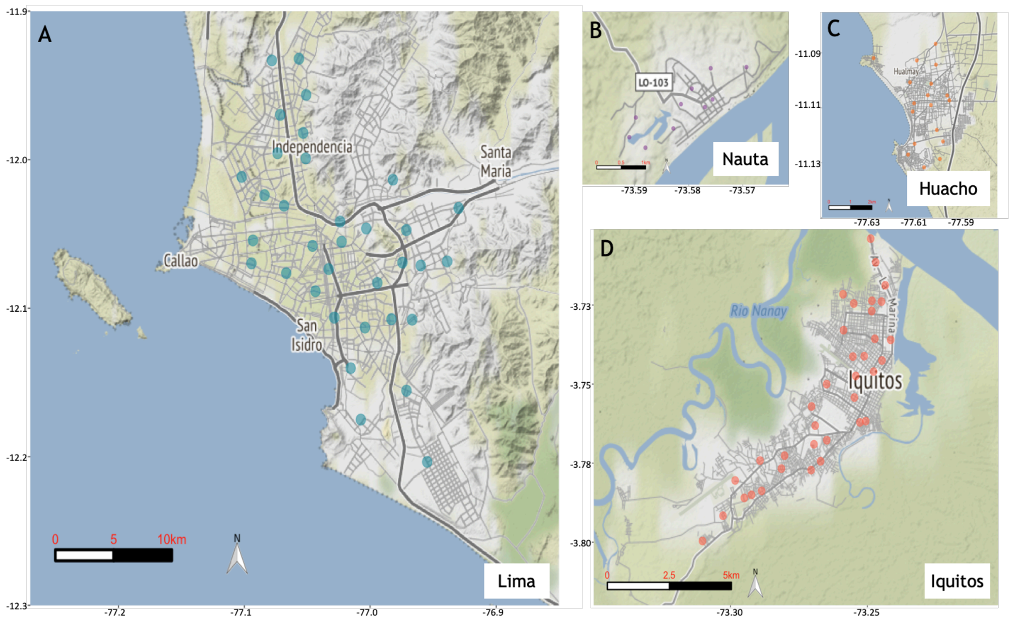
Fig. 1. Maps of study sites: (A) Lima (scale bar 10 km); (B) Nauta (scale bar 1 km); (C) Huacho (scale bar 2 km); and (D) Iquitos (scale bar 5 km). Maps constructed using R 4.0 in RStudio (R Core Team 2020, RStudio Team 2020) using the packages ggmap and ggsn (Kahle and Wickham 2013, Santos Baquero 2019).



METHODS

To assess urban residents' KEPC and potential predictive factors, we collected environmental and bird diversity data at a site level, and socio-demographic data at an individual level.

City and site selection

We first chose the largest city (both in territory and population) in two Peruvian ecosystems (Lima in the Pacific Coastal Desert, and Iquitos in the Western Amazon), and then a smaller city about 3 hours away from each large city by highway (Huacho in the Pacific Coastal Desert, and Nauta in the Western Amazon; see Table 1 for general characteristics). This distance assured separation between cities, but proximity and inclusion in the same ecosystem. Difference in sizes gave another axis of comparison. Sites within cities were selected with the following criteria: > 200 m from any other site, < 500 m above sea level, easily accessible by car, and, together, spanning the expanse of the city. Number of sites per city differed on account of the difference in size of cities. The distance between sites assured separation, whereas the inclusion within the same elevational range (< 500 m asl) assured that the bird communities were influenced by the city landscape rather than by different elevations (see Fig. 1 for city maps).

Environmental and bird diversity data

Following Piland (2020), we classified each site visually using satellite images acquired from Google Earth to characterize both a local (radius = 100 m around site coordinates) and a neighborhood measurement (radius = 500 m) of greenspace and grayspace cover for each site (satellite images copyrighted to CNES/Airbus between 2016-2018, and accessed in 2019, Google Earth V.7.3.2.5776). Distance from nearest landmark (park, center of city, and water) edge to site coordinates was measured using the Google Earth distance tool on these same images. Satellite images processed were those available on Google Earth closest to bird point counts in 2017 and survey implementation in 2018. Bird point counts were conducted at every site coordinate in January–April 2017 as part of a related project (Grández et al., *unpublished data*). For this study, we used the following resulting

Table 1. Study cities' characteristics. Population from citypopulation.de (in turn, from INEI 2017), except for Iquitos, for which we used the Maynas Province 2007 population estimate. This is because the estimate for the Iquitos metropolitan area (Brinkhoff 2020) is unofficial. Population growth calculated from the difference between the 2017 population estimate to the 2007 population estimate. Surface area for Lima and Huacho obtained from the Global Human Settlement Database (Florczyk et al. 2019). Surface area for Nauta and Iquitos calculated on Google Earth as described in Piland (2020). Density calculated by dividing population by surface area.

City	Environment	Population	Pop. Growth	Surface Area (km²)	Density (ppl./km²)
Lima	Pacific coastal desert	10,209,275	16.91%	876	11,654.42
Huacho	Pacific coastal desert	141,395	2.55%	31	4,561.13
Iquitos	Western Amazon	404,545	1.58%	36.3	11,144.49
Nauta	Western Amazon	20,716	3.53%	7.5	2,762.13

diversity metrics: total species richness (number of species seen at each site), average number of individuals (number of individual birds seen at each site averaged across visits), and Simpson evenness (a measure of species equitability based on number of individuals at site, where 1 means that species all occur at the same frequency). There were 97 sites assessed for environmental and bird diversity data.

Survey construction

The knowledge, perception, and attitude (KPA) protocol, first developed for public and community health social diagnostics (Gumucio et al. 2011), was adapted to assess urban residents' perception, knowledge, and attitudes toward bird diversity in their neighborhood (inspired by Celis-Diez et al. 2017). Four classes of response variables were chosen (KEPC) in order to capture more than just knowledge under the Western science paradigm, in an attempt to measure multiple ways of connecting with nature (Dickinson 2013). Knowledge was approximated by the ability to identify illustrations of abundant birds in the city by common, scientific, or popular name, with popular names determined by the sample's most popular response (Appendix 1: Question 15 and Figs. A1.1–4; see also methods in Celis-Diez et al. 2017). Selection of birds to identify for each city was determined by the most abundant birds observed during the bird point counts (see above). Engagement with nature was assessed through ownership of pets and gardens (Appendix 1: Questions 9 and 10), following literature that suggests a higher appreciation of surrounding nature given a requirement to engage with non-human life outside (Bjerke et al. 2015). Perception of bird diversity was approximated by questions focused on a respondent's assessment of their neighborhood's bird community (Appendix 1: Questions 11–14). Curiosity was assessed by asking questions related to a respondent's interest in learning more about birds in their neighborhood (Appendix 1: Questions 16–17).

Surveys also included questions about a respondent's age, gender, level of education, employment, length of residence, their most recent previous residence (if applicable), time spent outside, and types of activities performed outside (Appendix 1: Questions 1–8). These variables, in conjunction with the environmental variables, were potential predictive factors of urban residents' attitude toward their surrounding nature. Once written, the survey was edited and commented on by three social scientists (Andrea Ugarte Villalobos, Department of Psychology, Pontificia Universidad Católica del Perú; Daniela Ugarte Villalobos, Department of Sociology, State University of New York-Albany; and Dr. Alaka Wali, Anthropologist at the Field Museum of Natural History), and approved by the University of Chicago Biological Sciences Division Institutional Review Board (Protocol #IRB18-0045). See Appendix 1 for survey materials, including illustrated birds and consent language.

Survey implementation

Between January and April 2018, we implemented the human surveys at the bird point count sites (a total of 96 sites; one site did not have residential buildings) by going door-to-door or asking people on the street if they lived nearby. Survey respondents consisted of people who live at or near the bird observation site and spend time there during the day. This audience allowed us to relate the survey responses to the site's environmental information. A survey took an average of five minutes. There were six surveyors for all four cities, with NCP interviewing in all four cities, whereas the other five were split with three in Iquitos and Nauta (XV, EV, and Claudia Pezo), and two in Lima and Huacho (MC and CP). Ten people were surveyed at every site with three exceptions: one in Lima where we surveyed nine respondents, another in Lima where we surveyed 11 respondents, and one in Nauta where we surveyed 11 respondents. Surveys were carried out between 9:00 AM and 6:00 PM every day of the week. Surveyors were trained in the study's aim and objectives, as well as how to ask questions. Respondents were informed of the study's objective and asked if they consented to taking part. Questions not about birds were asked first (Appendix 1: Questions 1–10), whereas questions on birds (Appendix 1: Questions 10–17) were asked in the same order and last. If there was a lack of clarity in the question, the question was explained using words not on the survey. In some cases, interviewers wrote down their interpretation of a respondent's gender rather than asking how they self-identify, and as such, all discussion of gender from here on out will be presumed to represent interpretation of gender by surveyor, rather than true gender.

Coding variables

As many questions in the survey were open-ended, responses required coding for analysis. Employment (Appendix 1: Question 4) was coded using the North American Industry Classification System (United States 2017) where the response was categorized into an "industry" variable. Information about the respondent's last residency change (Appendix 1: Question 6) was coded based on where their last residence was in relation to their current residence ("movement"). Activities outside (Appendix 1: Question 7) were classed into the following: "recreation" (main objective: to pass time, enjoy the outdoors, or socialize), "exercise" (main objective: to promote physical health), "extractive" (main objective: to consume), "work" (main objective: to produce), and "other" (main objective: outside the prior categories or where the respondent did not elaborate). In cases where people listed more than one activity, both were counted. In the analysis, dummy variables were created for each answer. Respondents were asked to specify topics of interest in regards to birds (Appendix 1: Question 17) and these were categorized broadly by whether the topic was centered on the bird or the human, and whether it related to that focus directly, indirectly, aesthetically, recreationally, or intrinsically. These categorizations are inspired by the human valuation of nature paradigm where nature's value to human society is relative to direct harm or benefit (Direct), indirect ecosystem services (Indirect), aesthetic/cultural meaning (Aesthetic), recreational opportunities (Recreational), or existence (Intrinsic; Primack 2014).

Data analysis

All analyses were conducted in R 4.0 and RStudio, using the tidyverse R packages for data wrangling and visualization (Wickham et al. 2019, R Core Team 2020, RStudio Team 2020). Descriptive statistics (minimum, maximum, median, mean, and standard deviation for numeric variables or frequency in percentage for factor variables) were calculated for the full dataset and for each individual city using R package summarytools (Comtois 2020).

Exploratory analyses
Principal component analysis (PCA) was used to explicitly summarize relationships between environmental and bird diversity variables in the full dataset and identify the dimension best characterizing the urban typology. The score on this dimension was used to describe each site (from here on, "greenspace score") in the models. Factor analysis of mixed data (FAMD) was used to summarize and visualize dimensions of attitudes on bird diversity by urban residents. Individuals were visualized on FAMD dimensions 1–4. All PCAs and FAMDs were run using the R package FactoMineR and visualized using factoextra (Lê 2008, Kassambara and Mundt 2020).

Model construction
Multivariate linear regression models were conducted using each FAMD dimension 1–4 score as a function of the following variables: age, gender, education, work, outdoor activities, weekly hours outside, residency length, last move, observed species richness, average number of individual birds, greenspace score, and Simpson evenness. Site was not included as a random factor, because the site variables (observed species richness, average number of individual birds, greenspace score, and Simpson evenness) deconstruct the site and are hypothesized to be potential factors in determining respondents' KEPC. Outlier respondents, i.e., those with unique categorical score, were excluded from the models. Three sites from Iquitos were excluded because their Simpson evenness bird scores were significantly higher than the rest: 0.1–0.4, whereas the mean of the rest of the sites was 0.04 with a standard deviation of 0.01. This pattern seems to be driven in two sites by the lack of *Brotogeris* spp. flocks, resulting in a more even species abundance distribution, and in the third site a low species diversity (n = 3) also resulting in a more even distribution of individuals. Full dataset models were run with and without the City variable as an independent variable. Models were also run on subsets of the dataset by city. All models used a 10-fold cross-validation as the resampling technique, and stepwise selection. Best performing models within each run were chosen based on the lowest value of root-mean-square-error (RMSE). These analyses were conducted using the caret and leaps R packages (Kuhn 2020, Lumley 2020).

RESULTS

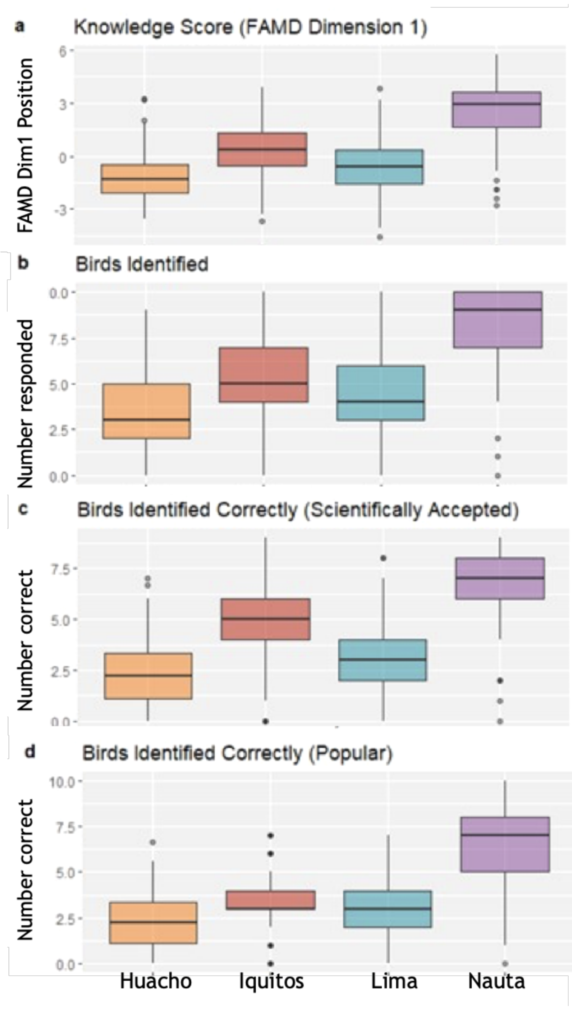
Descriptive statistics
Full descriptive statistics are included in Appendix 2. There were 961 respondents in the four cities of Iquitos (n = 350), Nauta (n = 101), Huacho (n = 180), and Lima (n = 330). Of these respondents, 52.8% were recorded as women, 46.1% were recorded as men, and 1.1% had no record of gender. The age distribution for all four cities was comparable (mean ± sd for each city: Huacho 41.3 ± 19.3; Lima 43.3 ± 19.4; Iquitos 40.8 ± 18.5; and Nauta 41.4 ± 16.1), with a combined mean of 41.8 years old and standard deviation of 18.7 years. Respondents in Lima had more formal education than those in the other three cities, with 52% having completed university, whereas in the other three cities 15–18% completed university. Although half of respondents in each city worked in "other services" (mainly domestic labor) or were students, the occupation of the other half differed according to city size: Huacho's, Lima's, and Iquitos' respondents worked mainly in retail (9.4%, 10.3%, 17.7%, respectively), were retired (7.8%, 8.7%, 2.9%), or worked freelance (Huacho and Iquitos; 6.7% and 10.6%, respectively) or in administration and support (Lima, 6.6%). In Nauta, the workforce of respondents was further made up of educators (15.8%) and those who worked in agriculture, forestry, fishing, and hunting (14.9%). Lima's respondents work more frequently in market-based jobs (retail and administration and support) than those in the other three cities. Nauta's respondent workforce reflects the local economy, which revolves around agriculture, hunting, and fishing, and the fact that the city has schools from primary to post-secondary levels, with a higher proportion of educators and people who work directly with natural resources (Ministerio de Transportes y Comunicaciones 2008).

These differences between cities are also reflected in the nature of the activities done outside. Although in Huacho, Lima, and Iquitos respondents rarely worked outside (7.8%, 3.3%, 7.4% respectively), 14.9% of Nauta respondents reported working outside. Nauta also seems to be a more transient city with respondents' average residency length being 15.1 years, whereas in the other cities average residency length for respondents was between 18 and 20 years. The most common movement respondents in Nauta experienced was moving from rural to urban areas (35.6%), whereas in the other three cities it was within the same city (35% in Huacho, 37% in Lima, and 52.9% in Iquitos). Mobility within Nauta for respondents was relatively low (26.7% in city and 2% in the same neighborhood) and this may reflect the relatively recent growth given that it positions itself as an important port and connector to Iquitos from the rest of the country (Ministerio de Transportes y Comunicaciones 2008, Figallo and Vergara 2014; Table 1). Lima is the only study city whose respondents reported international moves (2.4%).

Respondents from the Amazonian cities, Iquitos and Nauta, gave more responses for the bird identification exercise, and on average identified more illustrations correctly than those of the coastal desert cities (Fig. 2b–d). These cities also had more respondents with gardens and had a higher average number of reported species in their garden than those of the desert cities (Fig. 3c–d). Both large cities, Lima and Iquitos, had a higher fraction of pet owners than their smaller counterparts (Fig. 3b). Despite these differences, over 90% of respondents had noticed birds in their neighborhoods (Fig. 4b). Over half of respondents (64.1%, with individual cities ranging from 53.2% to 73.6%) believed the bird diversity in their neighborhoods to be low and, on average, estimated that about four different types of birds occurred in their neighborhood (species richness based on bird surveys varied from three to 35 in 87 sites, averaging at about 17 species/site; Fig. 4c–d). Over 70% of total respondents in each of the four cities wanted to know more about birds (Fig. 5b). The most popular category of subject matter people wanted to know about birds was "birds intrinsic," a category consisting of information about the birds themselves, e.g., identification, habitats, behavior, migration, and evolution.

Exploratory analyses
The full environmental PCA to identify an appropriate dimension to characterize greenspace and grayspace was performed on 97 sites using the following log-transformed traits: percent land cover, at both local and neighborhood scales, of trees, buildings, grass, asphalt, and dirt; distance to nearest landmarks of park, water, and center of city; average number of individual birds;

Fig. 2. Results for "knowledge" response variables: (a) Boxplots for factor analysis of mixed data (FAMD) Dimension 1 score by city; (b) Number of birds responded on bird identification survey by city; (c) Birds identified correctly when graded according to either an "accepted" common name or a scientific name; (d) Birds identified correctly when graded according to the most popular name given; and (e) Best performing models for each dataset (Huacho, Iquitos, Lima, Nauta, and the full combined dataset) with variable coefficients and quality measurements (root-mean-square-error [RMSE], R², and Bayesian information criterion [BIC]).



e Best Multivariate Models for Each Dataset (Response = Knowledge Score)

City	Variable Coefficients	Quality Measures
Huacho	0.96 (Work: Admin & Support) 0.25 (Gender: Masculine) 0.17 (Work: Arts & Entertain.) 0.16 (Work: Education) 0.02 (Age) -0.21 (Work: Agriculture)	RMSE = 1.2224 R^2 = 0.1267 BIC = -13.4238
Iquitos	1.73 (Work: Agriculture) 1.64 (Work: Education) 1.26 (Work: Science & Tech) 1.23 (Work: Arts & Entertain.) 0.97 (Work: Freelance) 0.74 (Unemployed) 0.65 (Work: Retail) 0.38 (Work: Other) 0.38 (Moved w/in City) 0.35 (Regular # Hrs. Outside) 0.30 (Exercise Outside) 0.02 (Species Richness) -0.01 (Years in Residency) -0.14 (Level of Education) -0.51 (Work Outside)	RMSE = 1.3655 R^2 = 0.1195 BIC = -23.3147
Lima	0.11 (Work: Admin & Support) 0.10 (Gender: Masculine) 0.00 (Age) 0.00 (Level of Education)	RMSE = 1.3879 R^2 = 0.0487 BIC = 5.0238
Nauta	0.49 (Level of Education) 0.04 (Age) 0.03 (Years in Residency) -1.88 (Work: Retail)	RMSE = 1.5024 R^2 = 0.3124 BIC = -12.0405
Full	3.23 (City: Nauta) 1.29 (City: Iquitos) 1.18 (Work: Education) 0.62 (Work: Freelance) 0.43 (City: Lima) 0.29 (Regular # Hrs Outside) 0.02 (Species Richness) 0.01 (Age)	RMSE = 1.3676 R^2 = 0.4167 BIC = -439.9493

Simpson evenness; and species richness. Percent land cover at both scales of water and wetlands were excluded because they did not show normal distributions. Dimension 1 (PC1; "greenspace score") demonstrated an urban gradient, where higher numbers were associated with greenspace and trees and lower numbers with buildings and asphalt. Cities showed a progression along the urban gradient with sites in Huacho and Lima tending toward negative PC1 values and more urban characteristics (for example, higher % of building cover), Iquitos sites spread out on the middle of the axis, and Nauta tending toward positive PC1 values and more tree-heavy or grass-heavy sites. Observed species richness is most strongly associated with dimension 1 (less urban, more birds). Simpson evenness is also associated with dimension 1 (less urban, less evenness). The average number of individual birds at a site was positively associated with dimensions 1 and 2 (less urban, more birds). Interpretation of other dimensions and PCA loadings are included in Appendix 3.

The FAMD for all respondents resulted in a first dimension that summarized "knowledge" variables (explaining 23.98% of variance), a second dimension that summarized "curiosity" (12.82%), a third dimension that summarized "engagement" (11.31%), and a fourth dimension that summarized "perception" (10.24%; Table 2). Individual respondents' survey responses were mapped onto these four dimensions with 95% confidence ellipses to assess visually whether any of the independent variables (human or environmental) display clustering. The only variable that displayed strong clustering was city membership (see Figs. 2–5 for differences in score distribution by city). Categories describing a respondent's interest were excluded from this analysis because the large number of potential answers overwhelmed the construction of dimensions. Outlier surveys (surveys whose contribution to the construction of dimensions singularly defined it) were excluded and the FAMD was re-run. The final FAMD included 956 surveys.

Table 2. Final factor analysis of mixed data (FAMD) loadings (rounded to two decimal places) for each survey response variable. In parentheses, the percent of variance explained by the respective dimension.

Survey Response Variable	Dim. 1 (23.98%)	Dim. 2 (12.82%)	Dim. 3 (11.31%)	Dim. 4 (10.24%)
# of Responses (ID)	0.44	0.03	0.05	0.00
Score on ID (Taxonomic)	0.47	0.03	0.05	0.00
Score on ID (Popular)	0.42	0.03	0.06	0.00
Number of categories	0.03	0.48	0.01	0.10
Interested in more info	0.03	0.44	0.03	0.11
Species in garden	0.19	0.00	0.34	0.00
Pet ownership	0.02	0.05	0.18	0.00
Garden ownership	0.12	0.00	0.44	0.00
Subjective level of biodiversity	0.01	0.10	0.01	0.33
Estimated bird species	0.03	0.06	0.00	0.17
Perception of birds	0.00	0.06	0.03	0.39

Best-performing models

The best performing multivariate linear models were constructed using a dataset that excluded outlier individuals (total respondents included in models = 911; 320 in Iquitos, 101 in Nauta, 317 in Lima, and 173 in Huacho; compared to the 961 total respondents). For each set of models constructed for each response variable, the model with the lowest RMSE was selected for interpretation. Of these, the model with the lowest Bayesian information criterion (BIC) score (-439.94) was the full model, including the city variable, with the response variable as the first FAMD dimension ("knowledge"; see Fig. 2e), and the model with the lowest RMSE was the model for Iquitos where the response variable is the fourth FAMD dimension ("perception"; see Fig. 4e). RMSE variation was low amongst all models presented, and R^2 values never surpassed 0.42, with the majority remaining below 0.15 (Figs. 2–5).

The best models for the response variable "knowledge" were quite different among cities (Fig. 2e). In Iquitos, a variety of work types most strongly affected the "knowledge" score (coefficients between 1 and 2), whereas working outside and a higher level of education were strong negative factors. Level of education in Lima also had a negative coefficient, although so small that it is likely not seriously affecting respondents' knowledge, whereas in Huacho and in Nauta, working in education was a strong indicator of knowledge about birds. In Huacho, working in agriculture had a negative influence on knowledge of birds. The strongest model for the knowledge dimension was the full dataset, including the city variable. In this model, residency in Nauta or in Iquitos alone was the best predictor of bird knowledge.

When assessing models with the response variable "curiosity" score, the strongest negative coefficients are found in work types that require time inside: e.g., in the Huacho model, working in manufacturing, or in the Iquitos model, working in administration and support, both with coefficients less than -1.0. The full dataset model is the strongest model if judged by BIC (BIC = -82.05) and no time spent outside has the strongest negative coefficient (-0.49). However, the distributions of scores and variables show that there are few strong differences in response variables across cities (Fig. 5a-c).

Factors predicting score of engagement, as measured by ownership of pets and gardens, and garden species richness, differed among cities (Fig. 3e). In Huacho and Lima, the most interpretable factor is the environmental dimension score: places with a higher "greenspace score", and thus more greenspace/trees, are more likely to have residents with pets and gardens. In Iquitos' best performing model, Simpson evenness had the largest coefficient. This coefficient was strongly negatively associated with the engagement score and may also be a stand-in for a greenspace score, where a higher Simpson evenness score suggests less species richness and a higher amount of grayspace. In Nauta, being a student made a respondent more likely to have a pet or a garden, although we do not know who in the family chose to have a pet or garden.

Finally, the best performing multivariate models for the fourth FAMD dimension score, "perception", at most explain 9.4% of the variance (see R^2 of the Lima model; Fig. 4e). The strongest coefficient was from Nauta where people working in the science and technology sector had a positive association (2.58). The strongest negative association was residency in Nauta in the full dataset. There were no common factors found between the five models.

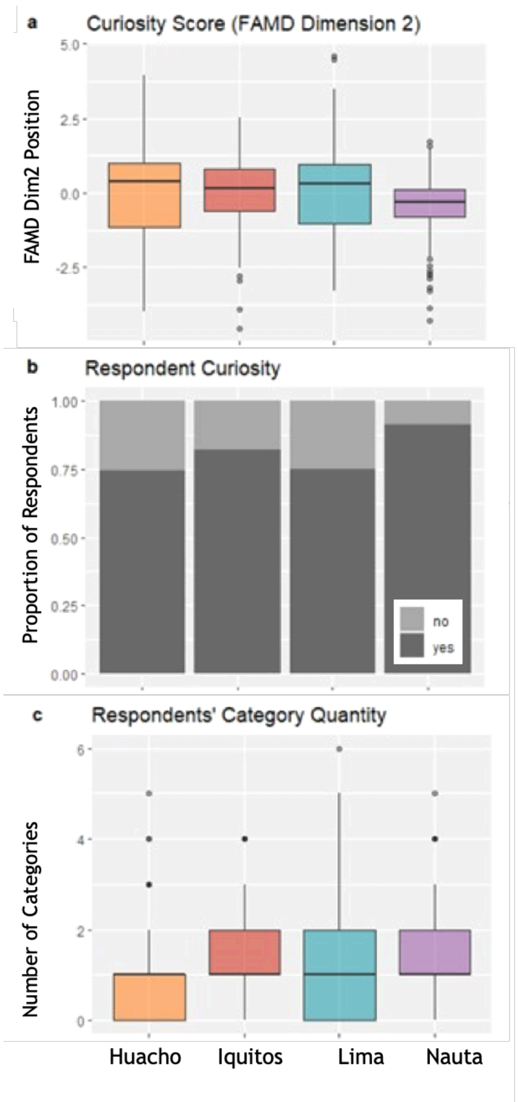
DISCUSSION

"Extinction of experience" leads us to believe that residents of big cities, regardless of where they are, have fewer opportunities to interact with nature, and thus have lower scores across measures of knowledge, engagement, perception, and curiosity (KEPC) toward nature. However, we show that urban residents' KEPC may depend more on the socio-environmental context of the city they reside in than on the size of it. Survey respondents in the Pacific coastal desert have lower "knowledge" scores than those in the western Amazon, yet the best models in each city differed. Likewise, respondents in the desert have lower "engagement" scores than those in the Amazon, but the scores for respondents in the desert seem tied to availability of greenspace. "Perception" scores are low across all four cities, although the Amazonian cities have lower scores, and "curiosity" scores are high across all four cities. Together, these results suggest a potential urban human–nature connection, grounded in the city in which people live.

Urban residents in the western Amazon "know" more about birds

Formal education has been thought to predict scientific and natural history literacy (Luck et al. 2009, Celis-Diez et al. 2017), yet urban residents from the Pacific coastal desert consistently

Fig. 3. Results for “engagement” variables: (a) Boxplots for factor analysis of mixed data (FAMD) Dimension 3 score by city; (b) Proportion of residents who were pet owners by city; (c) Proportion of residents who were garden owners by city; (d) Number of species reported in their gardens by city; and (e) Best performing models for each dataset (Huacho, Iquitos, Lima, Nauta, and the full combined dataset) with variable coefficients and quality measurements (root-mean-square-error [RMSE], R^2, and Bayesian information criterion [BIC]).



e Best Multivariate Models for Each Dataset (Response = Curiosity Score)

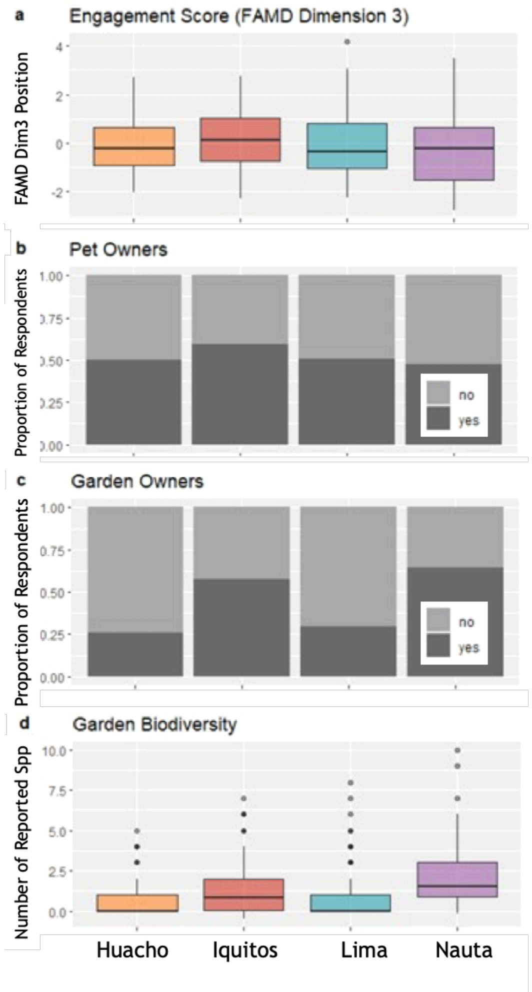
City	Variable Coefficients	Quality Measures
Huacho	0.26 (Level of Education) -0.03 (Age) -0.81 (Work: Retired) -1.71 (Work: Manufacturing)	RMSE = 1.2353 R^2 = 0.2266 BIC = 27.8812
Iquitos	0.50 (Exercise Outside) 0.20 (Level of Education) -0.01 (Age) -1.01 (Work: Admin & Support)	RMSE = 1.153 R^2 = 0.1302 BIC = -26.1836
Lima	0.67 (Student)	RMSE = 1.3202 R^2 = 0.0601 BIC = -0.1525
Nauta	0.03 (Age)	RMSE = 1.0214 R^2 = 0.1421 BIC = -4.3257
Full	0.56 (Work: Education) 0.14 (Level of Education) 0.01 (Average # Bird Individuals) -0.02 (Age) -0.46 (Moved w/in Neighborhood) -0.47 (City: Nauta) -0.49 (No Hours Outside)	RMSE = 1.217 R^2 = 0.121 BIC = -82.0451

scored lower along the “knowledge” axis and variables than urban residents from the western Amazon despite having more formal education (Fig. 2), suggesting that formal education, at least in the Pacific coastal desert, does not influence whether urban residents can identify local birds. The best model for the full dataset identified residence in Nauta or Iquitos as the strongest predictive factor for high “knowledge” score (Fig. 2e). Residents from these cities also consistently scored higher in the bird identification exercise, despite having less formal education than those of the desert cities. This points to a stronger extracurricular environmental awareness. The regional economy for Nauta and Iquitos, as with the rest of the Amazon, revolves around its natural resources, with birds providing an attractant for tourism, for which Iquitos and Nauta are points of access (Figallo and Vergara 2014). By contrast, in the region of Lima, the cities Huacho and Lima are industrial and commercial centers (Lazarte 2015). Results from these cities show similar knowledge results to those found in Santiago, Chile, another capital city in a similar, albeit higher elevation, ecosystem (Celis-Diez et al. 2017, where most respondents identified two to three birds correctly out of 10).

Urban residents’ ownership of gardens and pets is constrained by environment

“Engagement” scores for the Pacific coastal desert cities suggest that socioeconomic factors are more important for determining these scores than in the Amazonian cities, where residents had

Fig. 4. Results for "perception" variables: (a) Boxplots for factor analysis of mixed data (FAMD) Dimension 4 score by city; (b) Proportion of residents who had seen birds in their neighborhood; (c) Proportion of residents who perceived categories from low-high of biodiversity; (d) Number of species estimated in their neighborhoods; (e) Best performing models for each dataset (Huacho, Iquitos, Lima, Nauta, and the full combined dataset) with variable coefficients and quality measurements (root-mean-square-error [RMSE], R^2, and Bayesian information criterion [BIC]).



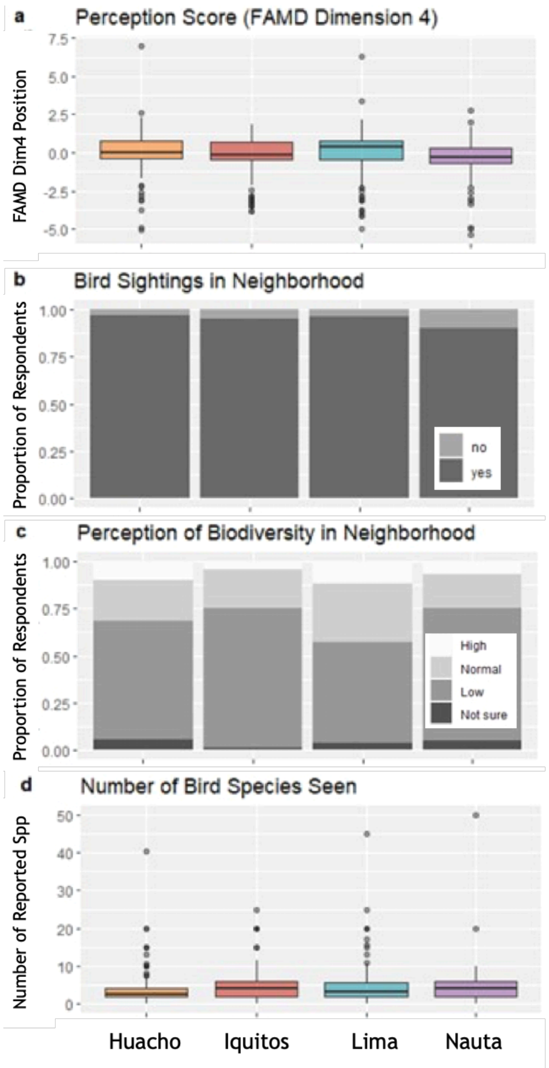
e Best Multivariate Models for Each Dataset (Response = Engagement Score)

City	Variable Coefficients	Quality Measures
Huacho	0.67 (No Activities Outside) 0.62 (Exercise Outside) 0.19 (Urban Score)	RMSE = 1.086 R^2 = 0.135 BIC = -8.246
Iquitos	0.36 (Gender: Masculine) -36.19 (Simpson Evenness)	RMSE = 1.1043 R^2 = 0.08 BIC = -1.8042
Lima	0.49 (Work: Education) 0.42 (Moved w/in Neighborhood) 0.09 (Urban Score) 0.01 (Years in Residency) 0.00 (Average # Individual Birds) -0.21 (Gender: Masculine) -0.37 (Work: Retail) -0.46 (Moved from Rural Area) -0.51 (Unemployed) -0.59 (Work: Admin & Support) -1.05 (Worked Outside)	RMSE = 1.2044 R^2 = 0.0911 BIC = 18.3608
Nauta	1.25 (Student)	RMSE = 1.3027 R^2 = 0.206 BIC = 0.8145
Full	0.37 (Moved w/in Neighborhood) 0.20 (Student) 0.12 (Urban Score) 0.01 (Years in Residency) -0.21 (Recreation Outside) -0.30 (Moved from Rural Area) -0.34 (Works Outside) -0.35 (Gender: Masculine) -0.52 (Work: Admin & Support) -0.73 (City: Nauta)	RMSE = 1.1818 R^2 = 0.0547 BIC = -10.6410

more gardens with more garden species more consistently (Fig. 3c–d). The overall model identified a high greenspace score as a positive factor in determining engagement score, yet the city-specific models differed in the role of the environment versus demographic factors (Fig. 3e). In Lima, the best model identified unemployment and moving from a rural area as negative factors —two factors that are indicative of low socioeconomic class in the capital. From a resources perspective, this makes sense: water access constrains the ability to have a garden, and water access (as well as more greenspace) is linked to higher socioeconomic levels (Ioris 2012, Bell 2015, Alata Ninapaytán et al. 2019). Water access for plants may not be as linked to higher socioeconomic levels in the Amazon where high levels of rain and the surrounding wetlands make water for gardens easily accessible. This is supported by the fact that non-environmental coefficients in the models for Iquitos and Nauta are low (Fig. 3e). Simpson evenness, however, had a very high coefficient in Iquitos and could function as a potential proxy for how urban a site is given that a higher Simpson evenness score suggests a lower species richness and a higher amount of grayspace, and thus less space or water for a garden or a pet.

However, these measures of quantifying "engagement" should be viewed with caution because the assumptions of what they measure come from another part of the world. What it means to have a garden or a pet is defined culturally and may vary from place to place. For example, some respondents said they did not have a pet, but then later mentioned feeding stray animals. Our questionnaire also used the word "*jardín*", connoting a flower garden, rather than "*huerta*", which suggests a vegetable or fruit garden. We quickly incorporated "*huerta*" into the conversation we had with respondents while implementing the survey; however, this may suggest that these percentages are underestimates of garden ownership in our study cities. Additionally, the concept of

Fig. 5. Results for "curiosity" response variables: (a) Boxplots for factor analysis of mixed data (FAMD) Dimension 2 score by city; (b) Proportion of residents interested in learning more about birds; (c) Number of categories respondents' answers on what they'd like to learn about birds fell into; and (e) Best performing models for each dataset (Huacho, Iquitos, Lima, Nauta, and the full combined dataset) with variable coefficients and quality measurements (root-mean-square-error [RMSE], R², and Bayesian information criterion [BIC]). (d) was skipped for ease of comparison across figures.



e Best Multivariate Models for Each Dataset (Response = Perception Score)

City	Variable Coefficients	Quality Measures
Huacho	0.87 (Work: Admin & Support) 0.20 (Gender: Masculine) 0.13 (Level of Education) 0.00 (Age) -0.36 (Work: Agriculture)	RMSE = 1.1801 R^2 = 0.0498 BIC = -4.6418
Iquitos	0.02 (Average # of Individual Birds)	RMSE = 0.9909 R^2 = 0.0577 BIC = -1.8088
Lima	0.67 (Work: Retired) 0.05 (Species Richness) 0.01 (Years in Residency)	RMSE = 1.1161 R^2 = 0.0939 BIC = -4.9335
Nauta	2.58 (Work: Science & Tech)	RMSE = 1.314 R^2 = 0.0623 BIC = 0.912
Full	0.21 (Regular # Hours Outside) 0.02 (Species Richness) 0.01 (Years in Residency) -0.21 (Moved from Rural Area) -0.41 (Never Moved) -0.37 (City: Iquitos) -0.77 (City: Nauta)	RMSE = 1.1277 R^2 = 0.0547 BIC = -3.22

having a home garden may be inapplicable to a context in which urban residents still tend to rural fields (*chacras*; Hecht et al. 2021), as may be the case in at least three of the four cities (Huacho, Iquitos, and Nauta). Anecdotally, there were some respondents, especially in Nauta, who would say they did not have gardens, but then told us about their *chacras*. This result highlights the need for more place-specific literature on this topic.

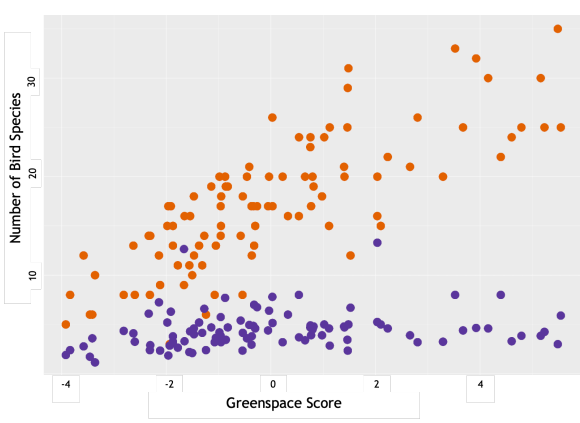
Despite these limitations, respondents in our Amazonian cities had much higher percentages of gardens (Iquitos 57.7% and Nauta 64.4%) than those in reported global North cities such as Stockholm, Sweden (16%), and Dunedin, New Zealand (19–27%), which were more similar to the percentages of reported garden ownership in Lima (29.5%) and Huacho (26.4%; Cox and Gaston 2018). Neither Dunedin nor Stockholm are in deserts, suggesting that although water access and environment may play a part in these differences, so does culture and socio-geographic position. Culture and socio-geographic position also influence how we interpret our results. For example, having property in both rural and urban areas can be a mark of a higher socioeconomic class in the global North, requiring enough wealth to purchase and manage two properties (Mendham and Curtis 2010, Stiman 2020). This is not necessarily the case in the global South, where there are still prevalent concepts of community ownership and family connectivity along the rural–urban gradient, land ownership can be acquired through settlement rather than purchase (including in urban areas), and property taxes are not high or enforced (Browder and Godfrey 1997, Padoch et al. 2014, Diep et al. 2019). Therefore, ownership of gardens or pets and whether it relates to engagement with nature depends on the city and where in that city you live.

Urban residents' perception of bird diversity in their city may also depend on ecosystem

Residents in all four cities perceived their neighborhood's bird diversity as low, yet the proportion of residents per city with this answer is higher in the Amazon than in the Pacific coastal desert (Fig. 4b–c), suggesting that how urban residents perceive their neighborhoods' bird diversity is a function of context. Cities are generally less biodiverse than their surroundings and cities' bird diversity measures are more similar to each other than to their surroundings (McKinley 2006, Aronson et al. 2014, Sol et al. 2020), but this does not mean that cities are completely devoid of bird diversity or that they are always less speciose than their surroundings (Piland 2020). In some cities, the input of energy and resources by humans supports more individual birds (Marzluff 2001), and this seems to be the case in Lima, where the average number of individual birds per site (41.07 ± 29.1) was higher than Huacho (35.72 ± 17.5) or Iquitos (34.5 ± 11.7). In Nauta, the average number of individual birds per site is 50.04 ± 23.8 and may still be relying on a mixture of urban and rural resources (a situation hypothesized with theoretical models; Anderies et al. 2007).

In the Amazon, cities' surroundings are some of the most bird speciose in the world; in comparison, the cities themselves are species-poor. In the Pacific coastal desert, the surroundings, although still speciose, harbor birds that live in patches or are harder to see. Thus, in comparison, the cities have a similar number of bird species and sometimes more (Piland 2020). In our study, we registered a range of three species in one site in Iquitos to 35 species in another site in Iquitos, and a mean species richness ranging from 11.5 species/site (Huacho) to 23.9 species/site (Nauta). When asked to quantify, residents on average said there were about four different species of birds regardless of how urban the site was or how many species were observed during point counts (Fig. 6). Yet, a higher proportion of people in Nauta and Iquitos categorized their neighborhood as having "low" bird diversity (Fig. 4c).

Fig. 6. Localities and their average number of species observed by point counts (orange) and average number of species estimated by residents (purple), organized by greenspace score.



Urban residents across the board want to know more about birds

In all four cities, over 75% wanted to know more about the birds in their neighborhoods (Fig. 5b). From the group of residents that were interested in learning more about the birds in their neighborhoods, the majority of respondents were interested in information about birds themselves. The second most popular general category of response differed by region: those of the coastal desert were most interested in information about how birds relate to humans directly, e.g., how to keep them as pets or raise them, whether they transmit diseases, etc. (about 16% for both cities), whereas in the lowland rainforest, respondents were interested in information about what supports or interacts with the birds, in particular, their habitat, their ecological relationships, etc. (~17% in Iquitos and ~13% in Nauta). After these three categories, the most popular category for all four cities was information for information's sake. Many respondents said they would be interested in learning more simply because it is always good to know more. This suggests that although urban areas may diminish the opportunity to spend time in places considered to be "natural", it does not diminish "orientation", that is, the ability to perceive, be interested in, and be motivated to interact with natural elements (in these cities, with birds). This aspect has been shown to be more important than "opportunity" in other cities (such as in Brisbane, Australia; Lin et al. 2014), and has been theorized to be another casualty of urbanization as a driver of "extinction of experience" (Soga and Akasaka 2019).

Many studies, when they ask about "orientation," "knowledge," or "connection," focus on specific types of these that may not be appropriate for all populations (Dickinson 2013). Connectedness to and willingness to act in the interest of nature have been measured in different ways: the Connectedness to Nature Scale (e.g., Mayer and Frantz 2004, Olivos et al. 2011); visits, hiking, and backpacking in parks (e.g., Zaradic et al. 2009, Wright and Matthews 2015); and knowledge of Linnaean classifications of wildlife (e.g., Cotterill 1995, Celis-Diez et al. 2017). Yet, the Connectedness to Nature Scale has been shown to be biased and ineffective (Perrin and Benassi 2009, Zhang et al. 2014). Asking about visits to protected parks in the United States prioritizes the experiences of those that established the protected parks or those like them, often those who are in more racially or economically privileged classes (Byrne and Wolch 2009, Wolch et al. 2014, O'Brien 2015, Mock 2017). Knowledge of Linnean classifications assesses only one type of identification of wildlife that has a history of being inaccessible to those outside groups of power, and glorifies an individual whose original classifications included racist characterizations of humans (Boster et al. 1986, Spickard et al. 1995, Dickinson 2013). In this study, we show a multi-pronged approach to assessing human–nature connection, and recommend in further studies the use of methodologies where participants have more control over how connections are characterized, for example, photovoice methodologies (Wang and Burris, 1997).

The possibility of an urban human–nature connection

Respondents in all four of our study cities perceived and were interested in birds across neighborhoods, with different socioeconomic, cultural, and racial histories (Figs. 4 and 5). The fact that urban residents are most interested in information about the birds themselves rather than how to capitalize on them shows that there are other non-monetary benefits that nature may provide for urban residents (for more information on potential benefits, see Masterson et al. 2019). Supporting these already existing orientations, while attempting to act more as a translator between different economies and politics rather than as a "change agent", can empower community participation in politics, self-determination, and, ultimately, environmental management and stewardship (Wali et al. 2017).

Additionally, our research runs counter to literature that prescribes a focus on children as a long-term investment to prevent the extinction of experience (Miller 2005), because children have the strongest possibilities in creating a connection to nature (Chawla 1999). During survey implementation, many survey respondents of all ages went on to engage in a conversation to suggest ideas on how to engage residents in noticing and learning about neighborhood birds. One respondent from Lima was very excited to think about ways to involve their child: they mentioned puppet shows about birds at the park, interactive activities at the park, and creating local field guides. Adult respondents in all four cities shared many thoughts and questions on birds that were hard to categorize within this context. Some of these questions included: "Why do we not have the lions and tigers that we see on TV? Why are the birds that we see here not on TV?"; "Do the birds sing because they're sad?". The focus on children is important, but children do not exist in a vacuum; they interact with adults who themselves can communicate their connection to nature (Schuttler et al. 2018). Harnessing the excitement of the parents and other adults is beneficial, not just in engaging in a larger conversation and answering questions together, but also for society. Limiting our scope to generational change artificially transfers responsibility to the next generation when we can start creating a more environmentally and socially just society now (Carruthers 2018).

CONCLUSION

The environmental movement's romanticization of wildness and pristine landscapes has painted nature as inaccessible for many urban residents and fomented the idea of extinction of experience in urban areas (Cronon 1995, Pyle 2003). Yet, these ideas of "wildness" and "pristine" are not well supported by experience or evidence. For example, most natural areas, such as the contiguous forests of the Amazon, are the settings in which humans have evolved and continue to evolve, and they have been formed by this relationship (Heckenberger et al. 2014). In *The Nature of Cities*, Marianne Krasny (Cornell University) writes of her surprise at the strength of the connection to nature she felt in the Lower East Side of Manhattan (Krasny 2015). Instead of feeling this connection from the sight of a pristine alpine landscape, or a wild oceanic wave, she feels it from meeting a family working a community garden. She continues to reflect that, in preventing "extinction of experience", it is necessary to define what the experience you're preserving is. We expected to see patterns of loss of KEPC and thus a growing indifference as cities and neighborhoods become more urban. However, although knowledge and engagement (garden and pet ownership) did generally decrease from smallest city to largest city, the complexity and diversity of the best performing models suggest interactions between cities' natural and social histories. Perception and curiosity measurements remained broadly constant across cities, underlining that the urban environment itself may not be a definitive factor in people's disconnection to nature. Respondents in these urban communities are noticing and are interested in nature, and could thus lead their communities toward sustainability. As conservation professionals, our role could lie in connecting residents to those who may support their initiatives financially, politically, or technologically, and, as residents, our role could lie in engaging with our own communities.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/13043

Author Contributions:

NCP took part in study design, data collection, data processing, data analysis, writing, and editing. EV took part in data collection, data processing, and editing. All other authors took part in data collection and editing.

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Data Availability:

Data/code available on request because of privacy/ethical restrictions The data/code that support the findings of this study are available on request from the corresponding author, NCP. None of the data/code are publicly available because the data are geo-referenced to individuals' residency and could compromise the privacy of research participants. Ethical approval for this research study was granted by the University of Chicago Biological Sciences Division Institutional Review Board (Protocol #IRB18-0045).

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Appendix 1. Survey materials

Lenguaje para pedir permiso
Por favor considere participar en esta encuesta voluntaria. La encuesta solo debe tomar 10 minutos para completar y los datos no estarán vinculados a su identidad. Como investigadores, estamos tratando de entender cómo la gente de esta ciudad interactúa con la naturaleza y cuánto conoce de las aves en su alrededor. Estos datos se usarán para la tesis de doctorado de la Biologa Natalia Piland. Puede contactarla con cualquier pregunta al correo: npiland@uchicago.edu

Encuesta
Nota para el/la encuestador/a: Esta encuesta se ha diseñado para entender algunos factores que podrían afectar cómo un/a ciudadan@ se relaciona con la naturaleza en su vecindario/barrio. Entre estos factores se encuentran edad, nivel de educación, duración en el barrio, origen, tiempo que se realiza y tipo de actividades realizados afuera. La relación que se percibe en esta encuesta con la naturaleza es conocimiento de aves y motivación en conocer más sobre las aves. Esto se correlacionará con información obtenida sobre cada localidad en cuanto a diversidad de aves observado y algunos factores ambientales cómo porcentaje de áreas verdes que se medirán a través del monitoreo remoto.

Localidad:

Fecha:

Encuestador/a:

Encuestad@ (Si se siente comod@):

¿Cuál es su fecha de nacimiento? ______________________

¿Cómo se identifica en cuanto a género? ____________________

¿Qué nivel de estudios tiene?
- Primaria Completa / Primaria Incompleta
- Secundaria Completa / Secundaria Incompleta
- Estudios técnicos completos / incompletos
- Universitario completo/ incompleto
- Posgrado completo/incompleto

¿A qué se dedica? ¿En qué trabaja? _____________________________________

¿Desde que año usted vive en este barrio? ___________________________

¿Dónde vivía antés de mudarse a este barrio? ___________________________

¿Qué tipo de actividades realiza afuera de su casa en el barrio?
- Sentarse a tomar sol/respirar aire fresco
- Caminar por el barrio/en un parque cercano
- Jugar deportes
- Otro: ____________________________________

¿Cuántas horas semanales pasa realizando esas actividades?
- Poco (1 hora/semana – 4 horas/semana)
- Regular (4 – 10 horas/semana)
- Mucho (10+ horas/semana)

¿Tiene mascotas?
- ¿Cuáles y cuántas?

¿Los deja salir afuera?

¿Tiene un jardín?

¿Qué tipos de plantas tiene en el jardín?

¿Ud. ha observado aves en el barrio? ________________

¿Aproximadamente cuántos diferentes tipos de aves estima que ha visto aquí?
____

¿Puede nombrar algunas de las aves que ha visto?
____

En su opinión, estima que la diversidad de aves que hay en este vecindario es:

Sólo hay pocos tipos de aves
Normal
Muchos diferentes tipos de aves
No sabe

¿Conoce el nombre de las siguientes aves? (*Enseñar lamina de aves*)

1 _______
2 _______
3 _______
4 _______
5 _______
6 _______
7 _______
8 _______
9 _______
10 _____

¿Le gustaría más información de las aves que se encuentran aquí? SÍ / NO

¿Qué tipo de información le gustaría obtener? ______________________

Comentarios sobre las láminas*:* Las láminas incluyen las diez especies que se encontraron ser más abundantes en cada ciudad de interés durante conteos de aves en el 2017. La lámina de Huacho tiene diez especies, pero solo nueve cuentan (hubo un fallo que no se percató hasta después de completar la mayoría de las encuestas). El nombre científico para cada ave se encuentra en la siguiente tabla. Las aves correspondientes se encuentran empezando por la ave en la esquina superior a la izquierda, siguiendo de izquierda a derecha y por file de arriba hacia abajo. Si la ave es introducida, se encuentra "(I)" después de su nombre científico. Las aves no están en orden de abundancia.

Table A1.1 Scientific names for birds in figures A1.1-4. | Nombres cientificos para las aves en figuras A1.1-4.

Iquitos (Fig. A1.1)	Nauta (Fig. A1.2)	Lima (Fig. A1.3)	Huacho (Fig. A1.4)
Columba livia (I)	*Columba livia* (I)	*Coereba flaveola*	*Cathartes aura*
Phalacrocorax brasilianus	*Ardea alba*	*Psittacara erythrogenys*	*Coragyps atratus*
Coragyps atratus	*Coragyps atratus*	*Coragyps atratus*	*Mimus longicaudatus*

Iquitos (Fig. A1.1)	Nauta (Fig. A1.2)	Lima (Fig. A1.3)	Huacho (Fig. A1.4)
Hirundo rustica	*Tachornis squamata*	*Pyrocephalus rubinus*	PAJARO EQUIVOCADO INCORRECT BIRD
Brotogeris cyanoptera	*Brotogeris cyanoptera*	*Pygochelidon cyanoleuca*	*Pygochelidon cyanoleuca*
Brotogeris versicolorus	*Brotogeris versicolorus*	*Molothrus bonariensis*	*Passer domesticus* (I)
Aratinga weddellii	*Graydidascalus brachyurus*	*Larus dominicanus*	*Columbina cruziana*
Thraupis episcopus	*Egretta thula*	*Columba livia* (I)	*Columba livia* (I)
Tyrannus melancholicus	*Thraupis episcopus*	*Zenaida meloda*	*Zenaida meloda*
Pitangus sulphuratus	*Cacicus cela*	*Columbina cruziana*	*Zenaida auriculata*

Translation for English Speakers

Consent Language

Please consider participating in our voluntary survey. The survey should only take 10 minutes to complete and the data will not be linked to your identity. As researchers, we are trying to understand how people in this city interact with nature and how well they know the birds in their surroundings. These data will be used for biologist Natalia Piland's doctoral thesis. If you would like to ask questions, please contact her at the email: npiland@uchicago.edu

Survey

Note for the surveyor: This survey is designed to understand some factors that may affect how a resident relates to nature in their neighborhood. These factors include age, education level, residency length, where they're from, how much time is spent on which activities outside. The human-nature relationship assessed in this survey is knowledge of birds and motivation in knowing more about birds. This will be correlated with information about each site, including birds observed and some environmental factors like percent of green areas (quantified through remote sensing).

Site:

Date:

Surveyer:

Surveyed (If they feel comfortable):

1. ¿What is your birth date? ______________________

2. ¿How do you identify in terms of gender? ____________________

3. ¿What is your highest level of education?
    Completed Primary / Incomplete Primary
    Completed Secondary / Incomplete Secondary
    Completed Technical Studies / Incomplete Technical Studies
    Completed University / Incomplete University
    Completed Post-graduate / Incomplete Post-graduate

4. ¿What's your profession? _____________________________________

5. ¿Since what year do you live in this neighborhood? ____________________________

6. ¿Where did you live before you moved to this neighborhood? ___________________________

7. ¿What type of activities do you engage in outside in your neighborhood?
   Sit to sunbathe and breathe fresh air
   Walk in the neighborhood/to a nearby park
   Play Sports
   Other: ____________________________________

8. ¿How many hours a week do you spend outside?
   Small amount (1 hour/week – 4 hours/week)
   Regular amount (4 – 10 hours/week)
   Large amount (10+ hours/week)

9. ¿Do you have pets?
   ¿Which and how many?
   ¿Are they allowed outside?

10. ¿Do you have a garden?
   ¿What types of plants do you have in the garden?

11. ¿Have you noticed birds in your neighborhood? __________________

12. ¿Approximately how many types of birds have you seen in your neighborhood? __________

13. ¿Can you name some of the birds you've seen?
____

14. In your opinion, do you estimate that the diversity of birds in this neighborhood is:
   There are only a few types of birds
   Normal
   There are many types of birds
   I don't know

15. ¿Do you know the name of these birds? (*Show laminated sheet with birds*)

   1 ________
   2 ________
   3 ________
   4 ________
   5 ________
   6 ________
   7 ________
   8 ________
   9 ________
   10 ______

16. ¿Would you like to know more about the birds you can find in this neighborhood? YES / NO

17. ¿What type of information would you like to learn? _________________________

***Commentary regarding the following figures**:* These laminated sheets (presented as figures) include the ten most abundant species according to the bird counts from 2017. The laminated sheet for Huacho has ten species, but only nine contributed to the analysis (there was a mistake that was not caught until the majority of surveys had been implemented). The scientific name for each bird is presented in table A1.1 seen above. The order to read the laminated sheets is from the uppermost left corner, going left to right, then going down each row. If the bird is introduced there is an “I” after the scientific name. The birds are not in order of abundance.

Figures A1.1-4. Bird identification sheets for: (1) Iquitos; (2) Nauta; (3) Lima; and (4) Huacho. Note that in Supp-1Cd (Huacho), everything was calculated out of nine rather than ten, because *Sporophila* sp. pictured does not occur in Huacho.

Fig. A1.1

Fig. A1.2

NAUTA

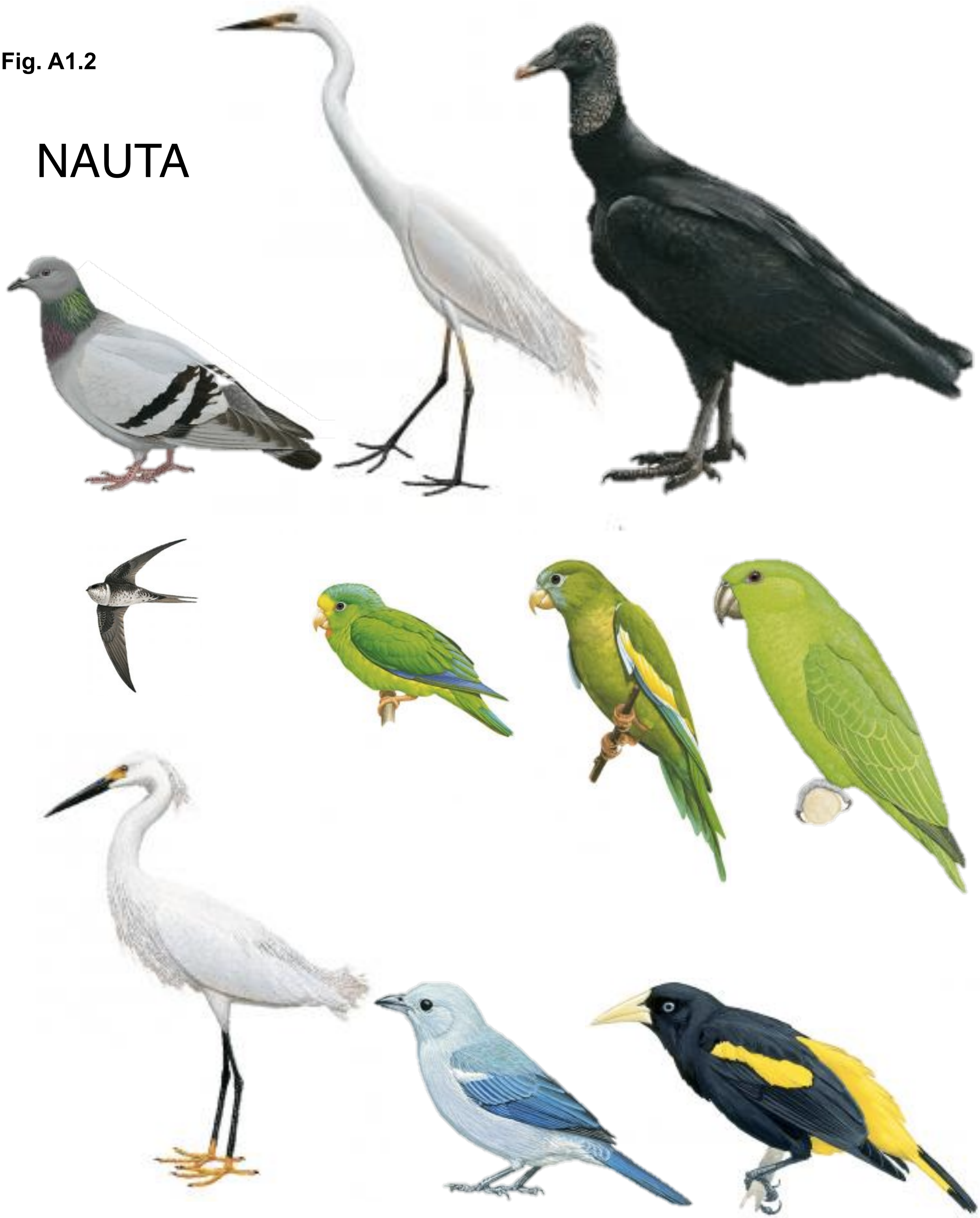

Fig. A1.3

LIMA

Fig. A1.4

HUACHO

Appendix 2.
Descriptive Statistics

Table A2.1. Table summarizing all independent variables from the survey by city, and then in total. For categorical variables raw numbers are presented with their proportion of the group in parenthesis. For quantitative variables, distribution parameters minimum, mean, standard deviation, median, and maximum are presented for each group. 963 individuals were surveyed in total.

	City				
Variable	**Huacho**	**Lima**	**Iquitos**	**Nauta**	**Total**
Gender Presentation					
Feminine	96 (53.3%)	174 (52.7%)	193 (55.1%)	44 (43.6%)	507 (52.8%)
Masculine	79 (43.9%)	151 (45.8%)	156 (44.6%)	57 (56.4%)	443 (46.1%)
No Response	5 (2.8%)	5 (1.5%)	1 (0.3%)	0 (0.0%)	11 (1.15%)
Total	180	330	350	101	961
Age					
Mean (sd)	41.3 (19.3)	43.3 (19.4)	40.8 (18.5)	41.4 (16.1)	41.8 (18.7)
Minimum	7	7	4	12	4
Median	38	42	39	42	40
Maximum	86	92	86	78	92
No Response	3	9	1	0	13
Education					
None	0 (0%)	0 (0%)	4 (1.1%)	1 (1.0%)	5 (0.5%)
Primary - Incomplete	6 (3.3%	10 (3.0%)	24 (6.9%)	18 (17.8%)	58 (6.0%)
Primary - Complete	13 (7.2%)	21 (6.4%)	20 (5.7%)	10 (9.9%)	64 (6.7%)
Secondary - Incomplete	22 (12.2%)	27 (8.2%)	63 (18%)	19 (18.8%)	131 (13.7%)
Secondary - Complete	65 (36.1%)	0 (0%)	98 (28%)	21 (20.8%)	184 (19.1%)
Technical Studies - Incomplete	2 (1.1%)	14 (4.3%)	13 (3.7%)	1 (1.0%)	30 (3.1%)
Technical Studies - Complete	17 (9.4%)	45 (13.6%)	37 (10.6%)	10 (9.9%)	109 (11.3%)
University - Incomplete	15 (8.3%)	31 (9.4%)	38 (10.9%)	3 (3.0%)	87 (9.0%)
University - Complete	33 (18.3%)	172 (52.1%)	53 (15.1%)	17 (16.8%)	275 (28.6%)
Postgraduate	2 (1.1%)	4 (1.2%)	0 (0.0%)	1 (1.0%)	7 (0.7%)
No Response	5 (2.8%)	6 (1.8%)	0 (0.0%)	0 (0.0%)	11 (1.1%)
Total	180 (100%)	330 (100%)	350 (100%)	101 (100%	961 (100%)

Variable	City				Total
	Huacho	Lima	Iquitos	Nauta	
Work					
Accommodation and Food Services	5 (2.8%)	7 (2.1%)	5 (1.4%)	0 (0.0%)	17 (1.8%)
Administrative and Support Services	4 (2.2%)	22 (6.6%)	7 (2.0%)	0 (0.0%)	33 (3.4%)
Agriculture, Forestry, Fishing, and Hunting	7 (3.9%)	0 (0.0%)	3 (0.9%)	15 (14.9%)	25 (2.6%)
Arts, Entertainment, and Recreation	3 (1.7%)	7 (2.1%)	5 (1.4%)	1 (1.0%)	16 (1.7%)
Construction	5 (2.8%)	4 (1.2%)	9 (2.6%)	6 (5.9%)	24 (2.5%)
Educational Services	4 (2.2%)	9 (2.7%)	21 (6.0%)	16 15.8%)	50 (5.2%)
Finance and Insurance	1 (0.6%)	8 (2.4%)	0 (0.0%)	0 (0.0%)	9 (0.9%)
Freelance	12 (6.7%)	11 (3.3%)	37 (10.6%)	7 (6.9%)	67 (7.0%)
Health Care and Social Assistance	5 (2.8%)	10 (3.0%)	4 (1.1%)	1 (1.0%)	20 (2.1%)
Information	1 (0.6%)	2 (0.6%)	0 (0.0%)	0 (0.0%)	3 (0.3%)
Management of Companies and Enterprises	7 (3.9%)	9 (2.7%)	0 (0.0%)	0 (0.0%)	16 (1.7%)
Manufacturing	2 (1.1%)	4 (1.2%)	4 (1.1%)	0 (0.0%)	10 (1.0%)
Mining, Quarrying, Oil, and Gas Extraction	0 (0.0%)	1 (0.3%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
Other Services	45 (25.0%)	63 (19.0%)	79 (22.6%)	28 (27.7%)	215 (22.4%)
Professional, Scientific, and Technical Services	2 (1.1%)	12 (3.6%)	12 (3.4%)	2 (2.0%)	28 (2.9%)
Public Administration	3 (1.7%)	10 (3.0%)	9 (2.6%)	0 (0.0%)	22 (2.3%)
Retail Trade	17 (9.4%)	34 (10.3%)	62 (17.7%)	10 (9.9%)	123 (12.8%)
Retired	14 (7.8%)	29 (8.7%)	10 (2.9%)	0 (0.0%)	53 (5.6%)
Student	33 (18.3%)	51 (15.4%)	61 (17.4%)	11 (10.9%)	156 (16.2%)
Transportation and Warehousing	3 (1.7%)	7 (2.1%)	6 (1.7%)	2 (2.0%)	18 (1.9%)
Unemployed	0 (0.0%)	7 (2.1%)	16 (4.6%)	2 (2.0%)	25 (2.6%)
Utilities	1 (0.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
Wholesale Trade	0 (0.0%)	1 (0.3%)	0 (0.0%)	0 (0.0%)	1 (0.1%)
No Response	6 (3.3%)	22 (6.6%)	0 (0.0%)	0 (0.0%)	28 (2.9%)
Total	180 (100%)	330 (100%)	350 (100%)	101 (100%)	961 (100%)
Years in Current Residence					
Mean (sd)	19.8 (18.7)	19.8 (17.7)	18 (15.2)	15.1 (16)	18.7 (16.9)
Minimum	0	0	0	0	0
Median	15	16	15	10	15
Maximum	81	84	75	73	84
No Response	1	1	1	0	3

Variable	City				Total
	Huacho	Lima	Iquitos	Nauta	
Last Move					
Never moved	48 (26.7%)	75 (22.7%)	57 (16.3%)	13 (12.9%)	193 (20.1%)
Same Neighborhood	0 (0.0%)	35 (10.6%)	50 (14.3%)	2 (2%)	42 (4.4%)
Same City	63 (35%)	122 (37.0%)	185 (52.9%)	27 (26.7%)	397 (41.3%)
Urban to Urban	29 (16.1%)	36 (10.9%)	44 (12.6%)	21 (20.8%)	130 (13.5%)
Rural to Urban	27 (15%)	19 (5.8%)	51 (14.6%)	36 (35.6%)	133 (13.9%)
International	0 (0.0%)	8 (2.4%)	0 (0.0%)	0 (0.0%)	8 (00.8%)
No Response	13 (7.2%)	35 (10.6%)	8 (2.3%)	2 (2%)	58 (6.0%)
Total	180 (100%)	330 (100%)	350 (100%)	101 (100%)	961 (100%)
Activities Outside					
Exercise	32 (17.8%)	61 (18.4%)	100 (28.6%)	35 (34.7%)	228 (23.7%)
Extractive	5 (2.8%)	11 (3.3%)	6 (1.7%)	8 (7.9%)	30 (3.1%)
Recreation	102 (56.7%)	232 (70.3%)	199 (56.9%)	42 (41.6%)	575 (59.8%)
Work	14 (7.8%)	11 (3.3%)	26 (7.4%)	15 (14.9%)	66 (6.9%)
Other	0 (0.0%)	0 (0.0%)	1 (0.3%)	0 (0.0%)	1 (0.1%)
None	29 (16.1%)	36 (10.8%)	35 (10.0%)	8 (7.9%)	108 (11.2%)
No Response	9 (5.0%)	10 (3.0%)	0 (0.0%)	0 (0.0%)	19 (2%)
Total (Responses/Individuals)	191/180	361/330	367/350	108/101	1027/961
Hours Outside					
None	29 (16.1%)	36 (10.1%)	35 (10.0%)	8 (7.9%)	108 (11.2%)
Few (1-4)	72 (40%)	120 (36.4%)	163 (46.6%)	39 (38.6%)	394 (41%)
Regular (4-10)	34 (18.9%)	104 (31.5%)	104 (29.7%)	36 (35.6%)	278 (29%)
Many (10+)	40 (22.2%)	70 (21.1%)	46 (13.1%)	18 (17.8%)	174 (18.1%)
No Response	5 (2.8%)	0 (0.0%)	2 (0.6%)	0 (0.0%)	7 (0.7%)
Total	180 (100%)	330 (100%)	350 (100%)	101 (100%)	961 (100%)

Table A2.2. Table summarizing all response variables from the survey by city, and then in total. For categorical variables raw numbers are presented with their proportion of the group in parenthesis. For quantitative variables, distribution parameters minimum, mean, standard deviation, median, and maximum are presented for each group. 963 individuals were surveyed in total.

	City				
Variable	**Huacho**	**Lima**	**Iquitos**	**Nauta**	**Total**
Engagement					
Has Pets	88 (49.4%)	167 (50.8%)	208 (59.4%)	48 (47.5%)	511 (53.3%)
No Pets	90 (50.6%)	162 (49.2%)	142 (40.6%)	53 (52.5%)	447 (46.7%)
Has Garden	47 (26.4%)	96 (29.5%)	202 (57.7%)	65 (64.4%)	410 (42.9%)
No Garden	131 (73.6%)	231 (70.5%)	148 (42.3%)	36 (35.6%)	546 (57.1%)
#Garden Species					
Mean (sd)	0.5 (1)	0.6 (1.3)	1.6 (1.6)	2.8 (2.1)	1.1 (1.6)
minimum	0	0	0	0	0
median	0	0	1	3	0
maximum	5	8	7	10	10
No response	2 (1.11%)	10 (3.01%)	148 (42.3%)	36 (35.6%)	196 (20.35%)
Perception					
Sees birds	173 (96.7%)	318 (96.1%)	332 (94.9%)	91 (90.1%)	914 (95.1%)
Does not see birds	6 (3.4%)	13 (3.9%)	18 (5.1%)	10 (9.9%)	47 (4.9%)
Not sure	10 (5.8%)	12 (3.7%)	5 (1.4%)	5 (5.0%)	32 (3.4%)
Low biodiversity	107 (61.5%)	173 (53.2%)	257 (73.6%)	71 (70.3%)	608 (64.1%)
Normal biodiversity	40 (23.0%)	101 (31.1%)	72 (20.6%)	18 (17.8%)	231 (24.3%)
High biodiversity	17 (9.8%)	39 (12.0%)	15 (4.3%)	7 (6.9%)	78 (8.2%)
No response	6 (3.3%)	7 (2.1%)	1 (0.29%)	0 (0%)	14 (1.45%)
#Estimated Species					
Mean (sd)	4.3 (8.5)	4.6 (6.7)	4.4 (3.5)	4.6 (5.5)	4.5 (6)
minimum	0	0	0	0	0
median	2.5	3	4	4	3.5
maximum	100	100	25	50	100
No response	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Variable	City Huacho	Lima	Iquitos	Nauta	Total
Knowledge					
#Responses					
Mean (sd)	3.6 (1.9)	4.2 (1.9)	5.4 (1.9)	7.9 (2.2)	4.9 (2.3)
minimum	0	0	0	0	0
median	4	4	5	9	5
maximum	9	10	10	10	10
No response	1 (0.6%)	1 (0.3%)	5 (1.4%)	0 (0%)	7 (0.7%)
#Correct (Lists)					
Mean (sd)	3 (2)	3 (2)	5 (2)	7 (2)	4 (2)
minimum	0	0	0	0	0
median	2	3	5	7	4
maximum	7	8	9	9	9
No response	11 (6.1%)	1 (0.3%)	5 (1.4%)	0 (0%)	7 (0.7%)
#Correct (Popular)					
Mean (sd)	2 (1)	3 (2)	5 (2)	6 (2)	3 (2)
minimum	0	0	0	0	0
median	2	3	5	7	3
maximum	7	7	9	9	10
No response	11 (6.1%)	1 (0.3%)	5 (1.4%)	0 (0%)	7 (0.7%)

Variable	City Huacho	Lima	Iquitos	Nauta	Total
Curiosity					
More Info - Yes	135 (75%)	246 (74.6%)	287 (82%)	92 (91.1%)	760 (79.1%)
More Info - No	45 (25%)	83 (25.4%)	63 (18%)	9 (8.9%)	200 (20.9%)
#Categories					
Mean (sd)	1.1 (0.9)	1.16 (1)	1.2 (1)	1.4 (1.1)	1.2 (1)
minimum	0	0	0	0	0
median	1	1	1	1	1
maximum	5	6	4	5	6
No response	0 (0%)	1 (0.3%)	0 (0%)	0 (0%)	1 (0.1%)
BirdIndirect	15 (8.3%)	26 (7.8%)	59 (16.9%)	13 (12.9%)	113 (11.7%)
BirdIntrinsic	86 (47.8%)	184 (55.8%)	222 (63.4%)	66 (65.3%)	558 (58%)
HumanAesthetic	1 (0.6%)	3 (0.9%)	3 (0.9%)	0 (0%)	7 (0.7%)
HumanDirect	30 (16.7%)	53 (16%)	19 (5.4%)	10 (9.9%)	112 (11.6%)
HumanIndirect	5 (2.8%)	6 (1.8%)	3 (0.9%)	8 (7.9%)	22 (2.3%)
HumanIntrinsic	15 (8.3%)	23 (7.0%)	20 (5.7%)	11 (10.9%)	69 (7.2%)
HumanRecreational	4 (2.2%)	6 (1.8%)	3 (0.9%)	2 (2%)	15 (1.6%)
No Response	47 (26.1%)	85 (25.8%)	84 (24%)	16 (15.8%)	232 (24.1%)
Responses/Individuals	207/180	386/330	413/350	126/101	1128/961

Table A2.3. Table summarizing all environmental variables from the survey by city, and then in total. Distribution parameters minimum, mean, standard deviation, median, and maximum are presented for each group. There were 97 sites in total.

	City				
Variable	**Huacho**	**Lima**	**Iquitos**	**Nauta**	**Total**
Land Cover Metrics					
Local Tree Cover					
Mean (sd)	7% (6%)	14% (15%)	13% (9%)	28% (10%)	10% (10%)
minimum	0%	1%	5%	10%	0%
median	5%	10%	10%	30%	10%
maximum	20%	70%	40%	40%	70%
Number of sites	18	34	35	10	97
Local Grass Cover					
Mean (sd)	5% (5%)	10% (7%)	14% (8%)	20% (8%)	10% (10%)
minimum	0%	0%	0%	10%	0%
median	4%	10%	15%	20%	10%
maximum	15%	20%	30%	35%	30%
Number of sites	18	34	35	10	97
Local Building Cover					
Mean (sd)	59% (16%)	59% (20%)	57% (17%)	29% (15%)	60% (20%)
minimum	30%	0%	20%	10%	0%
median	58%	62%	60%	25%	60%
maximum	85%	85%	85%	60%	80%
Number of sites	18	34	35	10	97
Neighborhood Tree Cover					
Mean (sd)	4% (3%)	8% (4%)	11% (6%)	24% (8%)	10% (10%)
minimum	0%	2%	1%	10%	0%
median	4%	5%	10%	25%	10%
maximum	10%	20%	25%	35%	30%
Number of sites	18	34	35	10	97
Neighborhood Grass Cover					
Mean (sd)	8% (6%	7% (3%)	16% (10%)	21% (8%)	10% (10%)
minimum	0%	0%	3%	10%	0%
median	6%	10%	15%	20%	10%

Variable	City Huacho	Lima	Iquitos	Nauta	Total
maximum	20%	10%	40%	35%	40%
Number of sites	18	34	35	10	97
Neighborhood Building Cover					
Mean (sd)	54% (17%)	66% (9%)	53% (16%)	25% (9%)	60% (20%)
minimum	30%	40%	15%	10%	10%
median	50%	66%	60%	28%	60%
maximum	80%	80%	80%	40%	80%
Number of sites	18	34	35	10	97
Nearest Landmark Metrics					
Distance to Park (m)					
Mean (sd)	121.21 (185)	77.89 (133)	109.22 (113)	52.36 (55)	94.6 (132.3)
minimum	0	0	6.1	6.1	0
median	21.34	12.5	64.9	26.55	33.8
maximum	708.11	627.64	439.4	142.6	708.1
Number of sites	18	34	35	10	97
Distance to City Center (m)					
Mean (sd)	1581.6 (795)	7901.69 (4049)	3564.1 (2194)	892.9 (622)	4441.2 (3854.6)
minimum	0	861	510.2	34.1	0
median	1641.53	7346.7	3057.8	789.35	3009.5
maximum	2639.32	199955.9	9221.5	1850.7	19955.9
Number of sites	18	34	35	10	97
Distance to Water (m)					
Mean (sd)	1027 (522)	2508.27 (1727)	819.17 (491)	157.69 (110)	1381.6 (1380.5)
minimum	52.43	191.72	71.9	17.1	17.1
median	1031.59	2349.64	804.5	130.6	976.9
maximum	1915.12	6035.04	2237	368.2	6035
Number of sites	18	34	35	10	97
Bird Biodiversity Metrics					
Species Richness					
Mean (sd)	11.5 (4.15)	14.44 (4.18)	21.03 (6.52)	23.9 (4.12)	17.2 (6.7)
minimum	5	6	3	17	3
median	11.5	14.5	20	24.5	17

Variable	City				Total
	Huacho	Lima	Iquitos	Nauta	
maximum	20	21	35	30	35
Number of sites	18	34	35	10	97
Simpson Evenness					
Mean (sd)	0.06 (0.02)	0.05 (0.01)	0.05 (0.07)	0.03 (0.01)	0.1 (0)
minimum	0.03	0.03	0.02	0.03	0
median	0.06	0.05	0.03	0.03	0
maximum	0.11	0.09	0.4	0.05	0.4
Number of sites	18	34	35	10	97
Average # of Individuals					
Mean (sd)	35.72 (17.5)	41.07 (29.1)	34.55 (11.7)	50.04 (23.8)	38.6 (21.7)
minimum	6.25	29.13	18.8	15.4	6.2
median	34.88	13.25	31	44.9	33
maximum	83.25	32	62.6	89	127.8
Number of sites	18	34	35	10	97

Appendix 3.

PCA results

Table A3.1. PCA loadings (rounded to 2 decimal places) for each environmental variable used. All shaded cells correspond to either the two highest or two lowest loadings for respective dimension. Those shaded in green indicate variables associated with "greenspace", in grey associated with “greyspace” or “concrete cover”, and in beige associated with “dirt.” In parentheses, the percent of variance explained by the respective dimension.

Environmental Variable	Dim. 1 (31.6%)	Dim. 2 (16.5%)	Dim. 3 (10%)	Dim. 4 (8.7%)
LOC_Tree	0.31	0.22	0.16	-0.13
LOC_Grass	0.31	0.22	0.14	0.08
LOC_Asphalt	-0.19	0.24	-0.12	-0.39
LOC_Building	-0.35	0.01	-0.28	0.31
LOC_Dirt	0.09	-0.47	0.29	-0.22
NEI_Tree	0.37	0.13	-0.04	0.02
NEI_Grass	0.35	0.03	-0.02	0.12
NEI_Asphalt	-0.23	0.35	0.10	-0.28
NEI_Building	-0.36	0.18	0.09	0.19
NEI_Dirt	0.032	-0.49	0.20	-0.30
Distance from Park	-0.01	-0.34	-0.27	0.43
Distance from Water	-0.22	0.13	0.54	0.14
Distance from Center	-0.02	0.09	0.53	0.32
Observed Species	0.33	0.15	-0.22	0.22
Simpson Evenness	-0.14	-0.08	0.01	-0.24
Avg. # Individual Birds	0.13	0.20	-0.26	-0.22

Interpretation of PCA results:

Dimension 2 (PC2) suggested a gradient of greenspace versus dirt open area. Dimensions 3 and 4 were less clearly interpreted, although they seem to be related to distance from the center of the city (PC3) and distance from the nearest park (PC4). The four cities displayed little differences along PC2, except for Huacho. The variables measured through bird surveys had less clear associations with the different dimensions. Observed species richness has relatively strong associations with dimensions 2, 3, and 4 (more dirt, less species; further away from center, less species; further away from nearest park, more species). Simpson evenness is associated with dimension 4 in the following manner: less urban, less evenness. Average number of individual birds is associated with dimension 2 such that less dirt, means more birds, and negatively associated with dimensions 3 and 4 (closer to center, more birds; in places closer to parks, more birds).