Rural children know cavity-nesting birds of the Atlantic Forest but may underappreciate their critical habitat

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ABSTRACT
Cavity-nesting birds are a diverse and charismatic community, with a common need for tree cavities that makes them vulnerable to land management by humans. However, little research has formally integrated human social aspects into management recommendations for the conservation of cavity-nesting birds. In agroecosystems, people's management decisions modify and define the habitat availability for native cavity-nesting species. These behaviors during adulthood are related to people's worldviews and are shaped, in part, by childhood experiences. On-going forest loss may reduce opportunities for children to interact with and learn from cavity-nesting birds and their habitats. We used a social-ecological framework to assess rural children's knowledge and representations of native cavity-nesting birds and their habitats in agroecosystems of the threatened Atlantic Forest of Argentina. We employed "freelists" and "draw-and-explain" strategies with 235 children from 19 rural schools, and then compared results with a 4-yr dataset of trees (n = 328) and tree-cavity nests (n = 164) in the same study area. Children listed a high diversity (93 taxa) of native cavity-nesting birds, especially parrots (Psittacidae), toucans (Ramphastidae), and woodpeckers (Picidae), which they mostly recognized as cavity-nesters. However, children drew agricultural landscapes with few of the habitat features that these birds require (e.g., tree cavities, native forest). Exotic trees were overrepresented in drawings (40% of mentions) compared to our field dataset of nests (10%) and trees on farms (15%). Although children mentioned and depicted a high diversity of native cavity-nesting birds, our results may reveal a problematic extinction of experience regarding how these birds interact with their habitat. To strengthen children's contextualized knowledge and promote their long-term commitment to the conservation of cavity-nesting species, we recommend fostering meaningful experiences for children to interact with native cavity-nesting birds and recognize their habitat needs. A version of this article translated into Spanish is available in the Supplementary Material 1.

Keywords: cavity-nesting birds, conservation in agroecosystems, extinction of experience, freelists, draw-and-explain method, rural children, social-ecological systems

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LAY SUMMARY

- Cavity-nesting birds are a diverse and charismatic community, susceptible to how people manage agroecosystems, yet how cavity-nesting birds are perceived is poorly understood.
- Perceptions form during childhood and influence adults' management behaviors.
- We investigated the knowledge and shared understanding of rural children about cavity-nesting birds and their habitats in agroecosystems of the Argentine Atlantic Forest.
- We used freelisting and draw-and-explain activities in rural schools and compared the results to field data on birds, nest trees, and random trees.
- Children listed a high diversity of native cavity-nesting birds, but under-represented the habitat elements they require, such as native trees.
- Although cavity-nesting birds were salient in children's shared understanding, the under-representation of key habitat features may indicate an ongoing extinction of experience.
- We recommend opportunities for children to interact meaningfully with native birds and their habitats, to enrich their contextualized knowledge and foster long-term commitment to the conservation of cavity-nesting communities.

Los niños de zonas rurales conocen a las aves que anidan en cavidades de la selva Atlántica, pero pueden infravalorar su hábitat crítico

RESUMEN
Las aves que anidan en cavidades son una comunidad diversa y carismática, con una necesidad común de cavidades en árboles que las hace vulnerables al manejo del paisaje por parte de los humanos. Sin embargo, pocas investigaciones han integrado formalmente las dimensiones humanas en las recomendaciones de gestión para la conservación de las aves que anidan en cavidades. En los agroecosistemas, las decisiones de manejo de las personas modifican y definen la disponibilidad de hábitat para las especies nativas que anidan en cavidades. Estos comportamientos durante la adultez están relacionados con la visión del mundo que tienen las personas y están moldeados, en parte, por experiencias durante la infancia. La pérdida de bosques puede reducir las oportunidades que tienen los niños para interactuar y aprender sobre las aves que anidan en cavidades y sus hábitats. Utilizamos un marco socioecológico para evaluar el conocimiento y las representaciones de niños rurales sobre las aves nativas que anidan en cavidades y sus hábitats en agroecosistemas de la amenazada selva Atlántica de Argentina. Empleamos “listados libres” y estrategias de “dibujar y explicar” con 235 niños de 19 escuelas rurales, y luego comparamos los resultados con un conjunto de datos de 4 años de árboles al azar (n = 328) y árboles nido (n = 164) en la misma área de estudio. Los niños enumeraron una gran diversidad (93 taxones) de aves nativas que anidan en cavidades, especialmente loros (Psittacidae), tucanes (Ramphastidae) y pájaros carpinteros (Picidae), a los que identificaron mayoritariamente como aves anidadoras en cavidades. Sin embargo, los niños dibujaron paisajes agrícolas con pocas de las características de hábitat que requieren estas aves (por ejemplo, cavidades en los árboles, selva nativa). Los árboles exóticos fueron sobrerrepresentados en los dibujos (40% de las menciones) en comparación con nuestro conjunto de datos de campo de árboles nido (10%) y al azar en agroecosistemas (15%). Aunque los niños mencionaron y representaron una gran diversidad de aves nativas que anidan en cavidades, nuestros resultados pueden revelar una preocupante extinción de la experiencia respecto a cómo estas aves interactúan con su hábitat. Para reforzar el conocimiento contextualizado de los niños y promover su compromiso a largo plazo con la conservación de las especies que anidan en cavidades, recomendamos fomentar experiencias significativas para que los niños interactúen con las aves nativas que anidan en cavidades y reconozcan sus necesidades de hábitat. Una versión de este artículo traducida al español está disponible en el Material suplementario 1.

Palabras clave: Aves que anidan en cavidades; Conservación en agroecosistemas; Extinción de la experiencia; Listas libres; Método dibuja y explica; Niños rurales; Sistemas socioecológicos

INTRODUCTION

Globally, >1,800 bird species nest in tree cavities and ~13% are endangered (van der Hoek et al. 2017), including charismatic and culturally important birds, such as parrots, toucans, woodpeckers, hornbills, and quetzals (Bennett et al. 1997, Arango et al. 2007, Borgerhoff Mulder et al. 2008, Anderson 2017). Cavity-nesting birds have a broad range of habitat requirements due to the diverse nature of this guild. They inhabit a wide range of environments, from deserts and savannas to forests and urban areas. Although many cavity nesters can inhabit agroecosystems, their breeding depends on the presence of excavation substrates or available cavities.

Numerous cavity-nesting bird species use agroecosystems for breeding (e.g., Marsden and Pilgrim 2003, Monterrubio-Rico et al. 2009, Cockle et al. 2015), but intensive land-use changes in agroecosystems reduce the current and future availability of cavity-bearing trees (van der Hoek et al. 2017). The availability of these trees is mostly defined by the management actions of landowners and managers, especially farmers. However, farmers' perceptions and attitudes towards cavity-nesting birds have been poorly studied or only targeted to particular species (Arango et al. 2007, Sánchez-Mercado et al. 2020). By learning how farmers perceive cavity-nesting birds and their habitats, conservationists can help generate and promote practices that draw on the positive effects of birds for agricultural production (such as pest control or pollination), while increasing the conservation value of agroecosystems.

Assessing people's perception of native habitats and species is an important first step in understanding their behavioral intentions (Clucas and Marzluff 2012) and, ultimately, their potential to participate in conservation initiatives (Paloniemi et al. 2017). For example, a person's attitudes toward a particular species are related to the willingness to adopt specific behaviors that help conserve that species (St John et al. 2010). Farmers' perceptions influence their behavioral intentions toward conservation of native species on their land and, along with external factors such as markets and policies, ultimately shape the types of management they undertake (St John et al. 2010, Silva-Andrade et al. 2016, Lutter et al. 2019).

In particular, it is important to understand the worldview and “common imaginary” of children because adult behavioral intentions are largely influenced by childhood experiences (Kidd and Kidd 1989, Wells and Lekies 2006). The common or social imaginaries are sets of dynamic schemes, meanings, symbols, and values that guide our perceptions, enable our explanations, and make our interventions possible, thereby structuring social life and human practices (Castoriadis 1975, Pintos 2014). These shared imaginaries are manifested in the institutions, norms, and practices of a given society, providing meaning and orientation to the actions of individuals within that society, including our management actions (Castoriadis 1975). People living in agroecosystem landscapes learn from daily practices and beliefs during their youth; these practices and beliefs contribute to their attitudes and shared, common imaginary, influencing their relationship with the environment and their future behaviors toward conservation (Sobel 2008, Soga and Gaston 2016). A first step in assessing children's common imaginary about native species and the forest is to investigate their view of their immediate environment and identify the elements most often evoked and familiar to them (Sobel 2008, Barreau et al. 2016).

The threatened Atlantic Forest is a complex of subtropical ecoregions that, in Argentina, is located in the province of Misiones. There, a large part of the rural human population lives in agroecosystems, carrying out subsistence family agriculture in landscapes with remnant patches of native cover (Furlán et al. 2015). By 2008, ~88% of the Atlantic Forest had been lost, mainly due to agricultural conversion (Ribeiro et al. 2009). The remaining forest patches are now largely fragmented and isolated, with almost all of them having been selectively logged (Izquierdo et al. 2008, Vancine et al. 2024). As in many other agricultural landscapes around the world, rural families manage small and medium agroecosystems (farms), directly influencing the presence of native trees, both living and dead (isolated or in forest patches). Their management, in turn, affects the availability of cavities and substrates for excavation, which ultimately allows the diverse community of cavity-nesting birds to nest and shelter in these agroecosystems (Silva-Andrade et al. 2016, Bonaparte et al. 2020). Although the conservation of cavity-nesting species and their habitat depends in part on the perception and ultimately the management actions that rural people make on their land, these dimensions have not yet been investigated in depth (Bonaparte et al. 2024).

Social-ecological systems are characterized by the dynamic relationships between people and their biocultural environment (Redman et al. 2004). In a context of continuous loss of native cover, people have limited possibilities of relating to and learning from native species, their interrelationships and habitats, especially in the case of younger generations (Barreau et al. 2016, Ibarra et al. 2020). Extinction of experience is defined as a process of progressive loss of interactions between people and the ecological components of their environment (Soga and Gaston 2016). This process can be caused by multiple factors, including urbanization, the predominance of a type of education based on activities detached from the direct environment, and the expulsion of communities from their ancestral lands (Barreau et al. 2016, Salinas 2020, Kokunda et al. 2023). Extinction of experience is likely when children in rural settings are unable to experience and learn about native species and their interaction in the forest and, instead, identify and learn more about common exotic species, cultivated species, or those they see in the media. For this reason, the present study investigates the common imaginary during childhood, and asks whether children that live in Atlantic Forest agroecosystems might be experiencing a process of extinction of experience (Soga and Gaston 2016).

In this article, we examined the salience of cavity-nesting birds in children's imaginaries and their knowledge of cavity-nesting taxa and their habitats, using a social-ecological systems framework to integrate social dimensions into the research and practice of cavity-nesting bird conservation in the Atlantic Forest. We asked: How salient are cavity-nesting birds and key habitat elements for their reproduction in agroecosystems (nest tree species, forest patches, cavities) in the common imaginary of rural children living in the Atlantic Forest of Argentina? The general objective of this study was to assess the knowledge and salience of native cavity-nesting birds and the representation of their habitats in small and medium-sized farms by children from rural elementary schools in San Pedro, Misiones, Argentina. Specifically, we aimed to (1) determine the salience of cavity-nesting taxa among all birds in the participants' common imaginary, (2) assess participants' knowledge of the cavity-nesting trait and evaluate which taxa they most frequently associate with this trait, (3) compare the cavity-nesting taxa mentioned by participants with the taxa present in the area, (4) describe the presence of cavity-nesting species and their habitats (cavities, native trees, dead trees, and native forests) in the participants’ visual representations of their farms, and (5) compare the species and status (live/dead) of the trees represented by the participants with the species and status of nest trees and random trees on farms in the area. As a first hypothesis, we postulated that children living in rural areas maintain a close relationship with the native species of their environment, making native birds an important component of their collective imaginary. In particular, we expected the community of cavity-nesting birds to be salient in their imaginary, as this community includes conspicuous and culturally important species (Arango et al. 2007, Borgerhoff Mulder et al. 2008, Rodríguez-Ramírez et al. 2017). Therefore, we predicted that the participating children would mention a representative sample of the birds found in the area, including cavity nesters. As a second hypothesis, we postulated that elements of native habitat important to birds are salient in the common imaginary of children, as some of these habitat elements, which remain in agroecosystem landscapes, may be shared by humans and the bird community (Rodríguez-Ramírez et al. 2017). We predicted that when making graphic representations of the agroecosystems in which they live, participants would include a broad representation of native ecosystem elements, especially key habitat elements for cavity-nesting birds, such as trees of native species that provide nesting cavities and patches of forest. As a third hypothesis, alternative to the previous two, we proposed that the conversion of native ecosystems for human use, along with other social-ecological changes, are leading to an extinction of experience in rural communities of the Atlantic Forest, alienating child inhabitants from knowing native bird species and their habitats (Soga and Gaston 2016). If this is the case, we predicted that participants would mention few native birds (including cavity-nesting birds) and their graphic representations would include scarce key habitat elements for cavity-nesting birds (native trees, forest cover, tree cavities).

METHODS

Study Area and Socioecological Context

We worked in high altitude terrain within the department of San Pedro, Misiones province (26°36'S, 54°01'W; 500–700 meters above sea level [m a.s.l.], 1,200–1,400 mm annual rainfall). The study area encompassed much of the remaining extent of Araucaria mixed rainforest in Argentina. This forest is composed of >100 tree species, including *Nectandra* spp. and *Ocotea* spp. (laureles), *Balfourodendron riedalianum* (guatambú) and *Araucaria angustifolia* (Paraná pine), a critically endangered species (Cabrera 1976, Kershaw and Wagstaff 2001, Thomas 2013). The study area covers two Important Bird Areas: San Pedro (AICA AR123) and Cruce Caballero Provincial Park (AICA AR122; Bodrati and Cockle 2005, Bodrati et al. 2005, Birdlife International 2019). Here, researchers have recorded at least 75 bird species in 21 families that are known or strongly suspected to nest in tree cavities (Bonaparte 2024). Twenty-four of these species are endemic to the Atlantic Forest and 7 are internationally threatened or near-threatened. In well-preserved Atlantic Forest, many cavity-nesting species select cavities in large, live, native trees for nesting (Cockle et al. 2011). However, in family agroecosystems, dead trees with cavities excavated by woodpeckers become increasingly important to the cavity-nesting community, probably because they replace the resource of large native trees with decay-formed cavities that are scarce in agroecosystems (Bonaparte et al. 2020).

The study area encompassed both public and private lands and comprised a mosaic of small and medium-sized family farms (mean ± SD = 36 ± 24 ha). This mosaic is characterized by patches and corridors of forest, as well as open paddocks, annual and perennial plantations, and both native and exotic tree plantations, interspersed with three provincial parks that have varying histories of selective logging and other land uses (Varns 2012). Scattered native and exotic trees are common in plantations, in pastures, and around residential areas. Those trees provide diverse ecosystem services to agricultural families, and constitute important habitat elements for many cavity-nesting bird species (Bonaparte et al. 2020). Traditionally, people that live and farm in rural areas of Misiones call themselves “colonos”, and the rural areas they inhabit are referred to as “colonia”. The “colono” families have varied origins (many are immigrants from Europe, Brazil, or Paraguay). In many cases, they arrived in Misiones during the 20th century with permits to occupy small plots on fiscal lands or as occupants of private lands. In our study area, 67% of the human population resides in rural areas (IPEC 2015) and their main productive activity is family agriculture, with no salaried labor (or little when it exists) and low accumulation potential (Baranger et al. 2008). Their production may be destined for family consumption, informal sales, and industry-oriented sales (Furlán et al. 2015).

Study Design and Participants

There are some difficulties in assessing children's ideas because they may lack the vocabulary they need to express themselves, or because they are sometimes shy and it is difficult for an unfamiliar person to access their opinion (Sullivan et al. 2018). However, there are several tools adapted for children of different ages that help researchers understand how they see and what they know about the landscape around them. A widely used tool in ethnobiology is the “freelisting” method, hereafter referred to as “freelists”. This method highlights elements within a given domain that are locally important or significant to respondents (Puri 2010). From freelist data (see below), researchers can calculate relative salience (a statistic that includes rank and frequency) of items within a given domain across all respondents (Quinlan 2005). Another tool used to assess children's representations and interpretations of their environment is the “draw-and-explain” method (Moseley et al. 2010), which seeks to access, in an easy and familiar way, children's ideas and visual representations of a given place (Barraza and Robottom 2008, Franquesa-Soler and Serio-Silva 2017). The combined assessment of these two activities constitutes a mixed approach that allowed us to obtain quantitative and qualitative information about children's knowledge, observations of their environment, and the most salient, important, and familiar elements of their surroundings.

In this study we used a mixed methods approach composed of 2 steps. The first step consisted of 2 independent activities, specially adapted for rural students in the last 3 grades of formal primary education in Argentina (10 to 13 years of age). The activities developed with the participant students consisted of a freelisting method (Puri 2010) and a drawing activity (“draw-and-explain” method; Moseley et al. 2010), carried out at school. The second step consisted of comparing the results obtained from the activities with the participants with field data on the cavity-nesting bird community in the area and the characteristics and species of trees they use for nesting (e.g., tree species used as nest trees).

Prior to starting the data collection at each school, we held a private, in-person meeting with the principal or teacher in charge. During these 15- to 30-min meetings, we provided a formal letter describing our objectives, methodology, scope of the study, and expected forms of disseminating results. We then verbally described the details written in the letter, explained the planned activities, and answered questions about the research and logistics. Finally, we verbally requested their free, prior, and informed consent to carry out the activities (Newing 2010), and agreed on a date to visit the school and perform the activities.

During April and May 2019, we visited 19 rural schools. Previously, we visited one additional school as a pilot to test and adjust the activities with 18 students; the results of the activities in the pilot school are not presented here. All schools visited were rural public schools with 12 to 120 students each. Participants were 236 students aged 10 to 13 years (mean ± SD = 11.6 ± 0.8; 9% 10-years-old, 37% 11-years-old, 43% 12-years-old, and 11% 13-years-old), in the last 3 years of formal primary education in Argentina. We decided not to gather data on the gender of study participants because our research was not focused on gender-related questions (Radi 2021). Collecting these data a posteriori based on participants' first names leads to misgendering and reinforces harmful cisnormative constructs. We consider the participant group in this study, students of public rural primary schools, to be representative because there are no private schools in the area and we did not observe gender bias in the groups of students attending classes.

Description of Methodologies at Each School

Upon arrival in the classroom, we conducted a playful icebreaker and gave a brief introductory talk (Barreau et al. 2016). During the introductory talk, we described in a general but clear way our objectives and the activities we would conduct with the participants, trying not to bias their upcoming answers. We asked the participants to complete the activities individually. Additionally, we informed them that our proposal was neither a school assignment nor mandatory, so they could opt out of the activities if they wished.

The first activity we developed at each school was the freelist to assess the salience and knowledge of native birds. For this, we provided each participant with a pencil and a sheet of paper with spaces to write their name, age, and grade, followed by ten numbered rows to write the names of bird species. We instructed the children to complete their personal information and then to write down the 10 species of native birds they knew that lived in the wild on farms that first came to mind. If they did not know up to 10 species, they could write down as many as they could and, if they could name more than 10, they had the option to continue writing on the back of the paper. During the development of the freelist and drawing activities, two coordinators (EBB and MHS) were present answering students' questions and encouraging them to perform the tasks individually. After writing down all the species they remembered, participants received a highlighter and we asked them to highlight only the species on their lists that they considered to nest in tree cavities. This entire activity took 10–20 min and then the lists were collected.

Following the freelists, we used a drawing assessment method, adapted from the Draw-an-environment Test Rubric (DAET-R; Moseley et al. 2010). To perform the drawing activity, each participant received a white sheet of paper and colored pencils. We asked them to close their eyes and imagine the landscape of their farm, especially a place they liked. If they did not have a farm they could think of a relative's farm. Then, we instructed them to represent that mental image in a drawing. When each participant finished their drawing, one of the coordinators asked them individually to describe the landscape in their drawing, naming all the species and other elements that they drew. The coordinator wrote down on the drawing each name given to each element or group of elements. This entire activity took 30–60 min and then the drawings were collected.

Nest Trees and Random Trees in Family Agroecosystems and Protected Areas

We compared the representation of trees in the drawings with information about nest trees and randomly selected trees that we collected from protected forest and family agroecosystems for a case-control study of nest-site selection (Bonaparte et al. 2020). We found nests from 2015 to 2018 by observing adult birds, listening for nestlings, inspecting cavities, and rechecking the contents of cavities used in previous years. Each nest was confirmed if it contained eggs or nestlings, or if adults exhibited nesting behavior. For each nest tree, we randomly selected 2 additional trees, in a random direction, at a distance of 20 to 100 m (Bonaparte et al. 2020). Here we use information about the condition of the tree (dead or alive) and its species for each nest tree and random tree.

Evaluation of Activities and Statistical Analyses

All statistical analyses were performed using R 3.6.1 (R Core Team 2021). In this article, we will refer to a "taxon" (and "taxa" in plural) as a unified group of birds that, for taxonomic classifications, can correspond to a species, genus, family, or order. We use this term when regrouping various common names provided by participants which do not always correspond to a single species. To analyze the freelists, we identified (1) the most specific taxa we were able to assign to the common name listed (species, genus, or family; for updated scientific names we used Remsen et al. 2024), (2) family to which each taxon belongs, (3) whether each taxon was native to the study area, (4) which taxa were highlighted with highlighter, and (5) which taxa listed included cavity-nesting birds. We assigned each taxon to a habitat (forest in good conservation status, secondary or selectively logged forest in agroecosystems, and/or other modified habitats such as crops and pastures) following Stotz et al. (1996) and Bodrati et al. (2010). To analyze the freelists we used two functions in the *AnthroTools* package (Purzycki and Jamieson-Lane 2017). Using the *CalculateSalience* function we calculated the salience of each item in each list, as:

$$\frac{n+1-k}{n}$$

where n is the total number of birds listed and k is the rank order in which an item was listed. Then, for each taxon mentioned, we used the *SalienceByCode* function to calculate the Smith salience (sum of the salience of each taxon divided by the total number of lists) and the average salience (sum of the salience of each taxon divided by the number of lists in which it was included; Purzycki and Jamieson-Lane 2017). Finally, we used the same package to calculate the frequency of mentions for each taxon.

To analyze the content of the drawings, we identified in each the presence, number, and identity of (1) native and exotic birds, (2) cavity-nesting birds, (3) native and exotic trees, and (4) dead trees. We also determined the presence of (5) tree cavities, (6) bird nests, and (7) native forest. We developed the content assessment of the representations using an iterative method with a group of drawings to capture all relevant information. First, we randomly selected 100 drawings (43%). EBB and KLC scored these 100 drawings independently, and we calculated the intraclass correlation coefficient, which measures inter-rater reliability for interval data (ICC; Hallgren 2012). Using the icc command of the *irr* package (Gamer et al. 2019), we obtained an ICC of 0.92, which is considered excellent inter-rater reliability (Hallgren 2012). Thus, EBB scored the remaining drawings and we based our analysis on her scores alone.

To compare the tree taxa mentioned in the drawings with nest trees and random trees in protected forest and agroecosystems, we used a rarefaction method to statistically contrast the species accumulation curve (using the rarefy function in the *vegan* package in R), and a dissimilarity index to compare the taxonomic composition of the 3 groups (Morisita index, using the *vegdist* function in the *vegan* package; Oksanen et al. 2020). We used a standardized rarefaction method using an individual approach (Gotelli and Colwell 2001). Each mention of a species in the drawings was counted as a sampled individual of that species. For the field data, each nest tree or random tree was counted as a sampled individual. To evaluate the similarity of the samples we used the Morisita index, which is a non-parametric index that evaluates differences in the abundance of species found in different samples. This index is sensitive to common species, handles unequal sample sizes, and varies from 0 (completely equal sample) to 1 (completely different sample; Wolda 1981, Oksanen et al. 2020).

RESULTS

Birds in Freelists: Salience, Frequency, and Cavity-nesting Trait

In their freelists, participants mentioned 93 bird taxa belonging to 41 families. The 10 most salient taxa were Ramphastidae (toucans), Columbidae (pigeons), Psittacidae (parrots), Cathartidae (vultures), *Cyanocorax chrysops* (Plush-crested Jay), Picidae (woodpeckers), Trochilidae (hummingbirds), *Amazona vinacea* (Vinaceous-breasted Parrot), Strigidae or Tytonidae (owls), and *Vanellus chilensis* (Southern Lapwing; Supplementary Material 2 Table S1). The 41 mentioned families included 16 that contain at least 1 cavity-nesting species in our study area (hereafter “cavity-nesting families”; Figure 1). The 3 cavity-nesting families most frequently mentioned by participants were Psittacidae, Ramphastidae, and Picidae. Across all freelists, the frequency of mentions was 96% for Psittacidae, 89% for Ramphastidae, and 73% for Picidae (Table 1). Within those mentions, Picidae was the family that participants most frequently associated with the cavity nesting habit. Eighty-nine percent of the times that participants mentioned a Picidae, they highlighted it as a cavity nesting taxon. For Ramphastidae, 57% of the participants that mentioned it highlighted it as a cavity nester, and 52% for Psittacidae (Figure 1).

Bird Taxa Mentioned vs. Taxa Present in the Area

Eighty-seven percent of the taxa named were native to the department of San Pedro and 38% of them were taxa with at least 1 cavity-nesting species. We were able to categorize 52 of 93 taxa to species level. Of these 52 species, 92% were native and 28% were cavity nesters. Five cavity-nesting families were present in the study area (Bonaparte 2024) but not named in the freelists (Table 1): Bucconidae (1 species of cavity nester), Apodidae (2 species), Grallaridae (1 species), Formicariidae (2 species), and Tityridae (2 species). Participants listed ten taxa that do not occur in the area (macaw, quetzal, Andean Condor, gulls, rhea, flamingo, stork, ostrich, and quail), in 0.8 to 6.4 % of the freelists (Supplementary Material 2 Table S1).

Evaluation of Drawings: Visual Representations of Bird Habitat in Agroecosystems

Forty-seven percent of drawings represented at least one bird (n = 123 drawings; Figure 2). The birds represented in the drawings were mostly native species (43% of the drawings contained native bird taxa; n = 117 drawings), while chickens, Laridae (gulls), and *Vultur gryphus* (the Andean Condor) were exotic species included in 3% of the drawings (n = 7 drawings). Cavity-nesting species were depicted in 21% of the drawings (47% of the birds drawn were cavity nesters; n = 57 drawings), and the most common taxa depicted that included at least 1 cavity-nesting species were Cathartidae (vultures, n = 11 drawings), Anatidae (ducks, n = 12 drawings), and *Amazona vinacea* (n = 11 drawings).

The drawings showed various landscape features (houses, pastures, various crops, streams, and rivers), but only 21% of the participants drew native forest (n = 56 drawings; Figure 2). Trees with cavities and bird nests were represented in 7% and 8% of the drawings (20 and 22 drawings), respectively. Participants mentioned 44 taxa from 22 tree families in their drawings (Supplementary Material 2 Table S2) and 19% of the tree taxa mentioned were exotic (Table 2). Most of the trees depicted were alive; 5% of the tree mentions showed dead individuals, almost the same proportion of dead trees as was found among random trees on farms (4%) and in protected forest (8%), but less than the proportion of nest trees that were dead (28% in protected forest and 42% on farms).

When comparing the taxa and condition of the trees represented by the students with the trees on farms and in protected areas, we found that the children represented a rich diversity of trees. The richness represented by children was comparable to the species richness of nests and random trees (Figure 3). However, dissimilarity indices were very high (Table 3). The highest dissimilarity was between tree taxa represented in drawings and random and nest tree species in protected forest areas, and nest trees on farms; the composition of trees mentioned in drawings was slightly more similar to random trees on farms (Table 3). Six of the 10 most represented trees in the drawings were exotic taxa that were not found in the protected forest, and only 2 of them were used for nesting by birds in cavities on farms (Table 3, Supplementary Material 2 Table S2). The most common nest tree taxa present in the area were *Apuleia leiocarpa* (grapia, Fabaceae), *Nectandra* spp. and *Ocotea* spp. (canelas or laurels, Lauraceae), and *Cabralea canjerana* (cancharana, Meliaceae) in protected forest, and *Nectandra* spp. and *Ocotea* spp. on farms (Supplementary Material 2 Table S2).

DISCUSSION

In this article, we explore the knowledge and salience of native cavity-nesting birds and the key elements of their habitats in the common imaginary of rural students in the Atlantic Forest of Argentina. In total, participants mentioned or represented 91 native bird taxa, 29 of which included cavity-nesting birds (facultative and obligate cavity nesters). Participants drew agroecosystem landscapes with few of the habitat elements that are important for cavity-nesting birds (native forest, cavities), a diverse representation of native birds (but less diverse than the birds in the freelists and less diverse than the bird community in the area), and an overrepresentation of exotic tree taxa (compared to the species composition of nest trees and random trees). Taken together, these results indicate that children possess a broad (but not species-level) knowledge of birds, and their common imaginary includes a high salience of cavity-nesting birds but a low representation of the elements that these birds require in agroecosystems.

As we predicted from our first hypothesis, participants mentioned a high percentage of native birds in their freelists and agroecosystem representations. Eighty-seven percent of the taxa listed and depicted in the drawings (93 and 27 taxa, respectively) were native to the study area. These results show a similar proportion of mentions of native animal taxa as reported for participants from an urban elementary school in the Brazilian Atlantic Forest region (Schwarz et al. 2012), but a higher proportion compared to studies from other regions of the world (Lindemann-Matthies 2005, Campos et al. 2012, Bermudez et al. 2017). In our study, participants rarely mentioned exotic bird taxa or taxa that do not occur in the study area (between 0.8 and 6.4% of the freelists). In contrast, in the Atlantic Forest region of Brazil, 33% of the animals mentioned by urban students as “forest animals” were exotic, especially large African mammals (Schwarz et al. 2012). In both investigations, children are probably aware of these exotic species because of their prevalence in educational materials and the media. For example, in elementary schools in our study area it is very common to see paper alphabets pasted on the walls for pedagogical purposes, which in many cases have exotic animals to represent each letter (e.g., quetzal for the letter Q or flamenco [flamingo] for the letter F; E. B. Bonaparte personal observation).

Although many bird taxa included in the freelists and represented by the participants are generalists, common in open agroecosystems of Misiones, many other taxa present in their collective imaginary are also inhabitants of closed forests or forests in relatively good conservation status. Twenty-seven percent of bird species in well-preserved Atlantic Forest nest in cavities (included in 18 bird families; Cockle et al. 2019a), and cavity nesters showed a similar level of representation among the taxa named by participants in freelists (28% cavity nesters; 15 families). Picidae, Psittacidae, and Ramphastidae families were the most salient taxa related to the habit of nesting in tree cavities, and may therefore be good candidates for use as flagship species in conservation initiatives for cavity-nesting birds (Borgerhoff Mulder et al. 2008, Millican 2023). Considering the order in which the activities were carried out, the freelist's instruction to highlight cavity-nesting species might have biased the children to draw more birds and trees with cavities in the subsequent draw-and-explain activity. However, the children drew a much lower diversity of cavity-nesting birds (vs. in their freelists), and few trees with cavities or nests in their farm drawings. This suggests that, although their common imaginary includes cavity-nesting birds, it scarcely includes the relationship between these species and cavity-bearing trees (a key habitat feature for these birds) on their farms.

Contrary to the predictions of our second hypothesis, the participants scarcely represented in their drawings key habitat elements for cavity-nesting birds (native tree species, cavities, native forest). The trees depicted in the drawings comprise a diverse set of taxa, but only 5 of the 10 most depicted tree taxa in the drawings have been reported as providing cavities used by birds in the study area (Bonaparte et al. 2020). The most frequently drawn native tree taxa (*Araucaria angustifolia*, *Syagrus romanzoffiana*, *Nectandra* spp., *Ocotea* spp., *Parapiptadenia rigida*) are common on the farms. All these native taxa were used by birds to nest in cavities, both in protected forest in good conservation status and on Atlantic Forest farms (Prestes et al. 2014, Cockle et al. 2019b, Bonaparte et al. 2020). On the other hand, the drawings included exotic and fruit species in higher proportions than the nest trees and random trees surveyed. Of the exotic species most frequently mentioned by the participants, only *Melia azedarach* was recorded being used by a bird to nest in a cavity (Bonaparte et al. 2020). Exotic and fruiting species rarely provide nests for cavity-nesting birds in either well-preserved forest or agroecosystems in the area. Excavated cavities have been recorded in dead *Pinus* sp. in the study area, but rarely do these species reach the size and decay stage necessary to provide cavities (EBB personal observation). Whereas children often mentioned native trees under the general term “forest trees”, they identified all exotic trees to genus or species level.

Our results partially support the predictions of our third hypothesis: participants mentioned a large percentage of native cavity-nesting birds but scarcely represented key habitat elements for this community. This may represent an extinction of experience that could explain the dissimilarity in tree species mentioned by children vs. surveyed in the field (Soga and Gaston 2016). Children represented native timber trees (such as *Apuleia leiocarpa* or *Myrocarpus frondosus*) in very low frequencies. These trees, with high utilitarian value, have been overexploited and are now scarce in agroecosystems. The participants in our study, aged between 10 and 13 years, were born after the decades of greatest deforestation pressure in the area (Izquierdo et al. 2008), and they are likely to have witnessed and experienced much less of the native flora and fauna of the forest than their parents and other older relatives. Therefore, they had little opportunity to recognize and learn about these valuable timber species or understand their ecological interactions and possible uses. This lack of learning opportunities can result in a scarcity of elements of well-preserved ecosystems in the children's common imaginary, and their replacement by anthropized elements.

Besides our hypothesis about the extinction of experience, biocultural homogenization could also explain the overrepresentation of exotic and fruit tree species in children's common imaginary (Rozzi 2018). Biocultural homogenization manifests as an erosion and extinction of local ecological and cultural relationships (Rozzi 2018). It can be a cause and a consequence of people adopting globalized practices and forms of production (habits and habitats; Rozzi 2018, Méndez-Herranz et al. 2023) from which children learn on a daily basis. Biocultural homogeneity can be expressed in the species (co-inhabitants) mentioned by participants and their perceptions about their environments (habitats; Méndez-Herranz et al. 2023). As in our study, participants in Chile mentioned native species and some biocultural peculiarities of the region, but many characteristics they perceive of their environment are linked to ideas and preconceptions that are not native to their region, suggesting a process of biocultural homogenization (Méndez-Herranz et al. 2023). In the present study, in addition to overrepresenting exotic trees cultivated and used by their families, children depicted apple trees in 9.9% of drawings. The fourth most mentioned tree in drawings, apple trees are completely absent in the San Pedro landscape (EBB personal observation). To understand the causes and consequences of the extinction of experience and biocultural homogenization across all environments (rural, urban and forests) and communities (urban, farmers, Indigenous Peoples) researchers should compare the perceptions, attitudes, knowledge and behaviors of people from different regions and ages. Advancing knowledge of these processes will inform and improve locally meaningful actions for the conservation of cavity-nesting birds and the habitats they co-inhabit with human communities.

Although positive and useful results were obtained by using freelist and drawing methods, we must point out limitations that we found especially with the drawing method. While drawing methodologies are considered accessible to children, there was evidence of social pressure in the schools we visited for students to "draw well". Sometimes such conditioning limited the children's drawings, which tended to represent easy figures (e.g., houses, palms), perhaps avoiding complex colorful elements (e.g., some bird species, forest) because they believed they could not achieve a "good drawing" (Backett-Milburn and McKie 1999). This could have limited the representation of the farms in the drawings and could explain that the birds mentioned in the freelists were much more diverse than the birds that were drawn.

Today, many children are accustomed to seeing and experiencing landscapes without well-preserved native ecosystems. When people have less first-hand knowledge and understanding of the complex systems they co-inhabit with native species, they are less aware of the impacts their activities have on those communities and their habitats (Silva-Andrade et al. 2016). There are some initiatives in South America that seek to rescue biocultural memory and knowledge about native species, their habitats and their relationships within socioecological systems. Their results indicate that community experiences, with playful and artistic methodologies, increase the recognition and appreciation of native ecosystems, and enhance the transmission of biocultural memory (Baranzelli et al. 2015, Ibarra et al. 2020). As Collado et al. (2015) point out, for children who live (and work, in many cases) in agricultural landscapes, it is important to develop experiences that are not only first-hand but also gratifying and adapted to their needs, to help promote pro-environmental behaviors. Building on these proposals and experiences, we encourage conservationists and ornithologists to promote and participate in community-based initiatives, to listen and learn from people's worldviews, and to recognize the relationships among people, cavity-nesting birds, and the habitats they share. We can vastly enrich our research and conservation initiatives by considering the intrinsic relations between local communities, their culture and worldviews, and the native species that share their ecosystems (Snively and Williams 2016, Salinas 2020, Sánchez-Mercado et al. 2020).

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Ethic statement
We follow the Ethical regulations for research in Social and Human Sciences of the Science and Technology Secretary of the National University of Córdoba, and the Guidelines for the Use of Wild Birds in Research of the Ornithological Council.

Conflict of interest statement
The authors declare that they have no conflicts of interest.

Author contributions
E.B.B. and K.L.C. conceived the idea and managed the resources, E.B.B., K.L.C. and J.T.I. designed the methods, E.B.B. and M.H.S. collected the data, E.B.B. analyzed the data with substantial support from K.L.C., M.H.S., J.T.I. and A.K.L., E.B.B. wrote the manuscript with substantial contributions from K.L.C., J.T.I. and A.K.L.

Data availability
Analyses reported in this article can be reproduced using the data provided by Bonaparte et al. (2024).

REFLEXIVITY STATEMENT
(Ruelas Inzunza et al. 2023)

Did members of the local community/country participate in the study design?
Yes, EBB is Argentinean and recently completed her PhD at a public university in Argentina, and MHS is an Argentinean technical assistant. Both have been living in the study area for more than 8 years.

How will research products be shared to address local needs?
We will carry out: (a) local language version of the manuscript, (b) educational activities adapted for students in the area to be carried out in the framework of the conservation education campaigns that have been carried out for more than 15 years in the area, (c) dissemination materials in social media that reinforce knowledge about the importance of the native forest and the knowledge of birds.

Are researchers within the region (particularly women, gender minorities, and early career researchers) included as authors?
Yes. EBB identifies as a brown cis female, she conceived, developed and led this work that was part of her doctoral thesis. MHS identifies himself as a brown cis male, he has never been part of the authorship of a scientific article before and his contribution was key to the field work of this article.

Did the authors search for relevant publications in regional journals, including those in languages other than English?
Yes, we searched for and cited studies mainly from Latin American researchers, which served to inform methodologies and discuss the results of this manuscript.

If the study includes researchers from high income countries, how has the project developed their capacity to work collaboratively and equitably with colleagues within the region of study?
KLC (Canadian affiliated in Argentina/Canada) and JTI (Chilean affiliated in Chile) mentored EBB in the development, implementation, and interpretation of the research. AKL (German affiliated in Germany) was invited by EBB to help frame, interpret and communicate the results. KLC, JTI and AKL all had recent PhDs from institutions in high income countries when they began work on the project; the project strengthened their mentorship skills and their capacity to work in transdisciplinary international research collaborations led by students affiliated in Latin America. This project made it possible to work collaboratively, advance in mentoring among researchers in the region and begin to create more horizontal collaborations among researchers from neighboring South American countries

How has the project influenced the means and ability of the researchers from within the region to implement their research agenda?
This article was framed within the work of Selva de Pino Paraná Project (www.pinoparana.org) that brings together people from different backgrounds within Argentina and is the first paper to be published that comes from their work in conservation education in rural schools. The research helped Argentinean authors and collaborators to propose a solid research in a little explored area which is the studies of social-ecological systems in the Atlantic Forest with focus on conservation in rural areas of the province of Misiones.

LITERATURE CITED

Anderson, E. N. (2017). Birds in Maya imagination: A historical ethno-ornithology. *Journal of Ethnobiology* 37:621.

Arango, X., R. Rozzi, F. Massardo, C. B. Anderson, and T. Ibarra (2007). Descubrimiento e implantación del pájaro carpintero gigante (*Campephilus magellanicus*) como especie carismática: Una aproximación biocutural para la conservación en la Reserva de Biósfera Cabo de Hornos. *Magallania* 35:71–88.

Backett-Milburn, K., and L. McKie (1999). A critical appraisal of the draw and write technique. *Health Education Research* 14:387–398.

Baranger, D., F. Niño, and E. Simonetti (2008). Construcción de una tipología de los ocupantes de las tierras privadas en Misiones. In *Desarrollo y estudios rurales en Misiones* (L. J. Bartolomé and G. Schiavoni, Editors). Fundación Centro de Integración, Comunicación, Cultura y Sociedad - CICCUS, Buenos Aires, Argentina.

Baranzelli, M., S. Córdoba, G. Ferreiro, E. Glinos, C. Maubecin, V. Paiaro, and M. Renny (2015). Who lives there? About native and nxotic trees. An educational proposal to know the ecological importance of native forests and the problem of biological invasions. *Revista de Educación en Biología* 18:50–64.

Barraza, L., and I. Robottom (2008). Gaining representations of children's and adults' constructions of sustainability issues. *International Journal of Environmental & Science Education* 3:179–191.

Barreau, A., J. T. Ibarra, F. S. Wyndham, A. Rojas, and R. A. Kozak (2016). How can we teach our children if we cannot access the forest? Generational change in Mapuche knowledge of wild edible plants in Andean temperate ecosystems of Chile. *Journal of Ethnobiology* 36:412–432.

Bennett, E. L., A. J. Nyaoi, and J. Sompud (1997). Hornbills *Buceros* spp. and culture in northern Borneo: Can they continue to co-exist? *Biological Conservation* 82:41–46.

Bermudez, G. M. A., L. V Batistón, M. C. García Capocasa, and A. L. De Longhi (2017). Sociocultural variables that impact high school students' perceptions of native fauna: A study on the species component of the biodiversity concept. *Research in Science Education* 4:203–235.

Birdlife International (2019). Important Bird Areas factsheet: San Pedro. http://datazone.birdlife.org/site/factsheet/san-pedro-iba-argentina.

Bodrati, A., and K. L. Cockle (2005). Parque Provincial Cruce Caballero. In *Áreas importantes para la conservación de las aves en la Argentina: Sitios prioritarios para la conservación de la biodiversidad (No. 5).* (A. S. Di Giacomo, Editor). Aves Argentinas. Asociación Ornitológica del Plata, Buenos Aires, Argentina.

Bodrati, A., K. L. Cockle, and G. Capuzzi (2005). San Pedro. In *Áreas importantes para la conservación de las aves en la Argentina: Sitios prioritarios para la conservación de la biodiversidad (No. 5).* (A. S. Di Giacomo, Editor). Aves Argentinas. Asociación Ornitológica del Plata, Buenos Aires, Argentina.

Bodrati, A., K. L. Cockle, J. M. Segovia, I. Roesler, J. I. Areta, and E. Jordan (2010). La avifauna del Parque Provincial Cruce Caballero, Provincia de Misiones, Argentina. *Cotinga* 32:41–64.

Bonaparte, E. B. (2024). Factores ecológicos y sociales que influyen en la conservación de aves que anidan en cavidades de árboles en la selva Atlántica de Argentina. Ph.D. dissertation, Universidad Nacional de Córdoba, Córdoba, Argentina.

Bonaparte, E. B., C. Cuatianquiz Lima, H. D. Ferreira-Xavier, J. S. d. H. Barros, F. G. Di Sallo, F. G. López, K. L. Cockle, and M. G. Núñez Montellano (2024). Ecology and conservation of cavity-nesting birds in the Neotropics: Recent advances, future directions, and contributions to ornithology. *Ornithological Applications* 126:duae042.

Bonaparte, E. B., J. T. Ibarra, and K. L. Cockle (2020). Conserving nest trees used by cavity-nesting birds from endangered primary Atlantic forest to open farmland: Increased relevance of excavated cavities in large dead trees on farms. *Forest Ecology and Management* 475:118440.

Borgerhoff Mulder, M., R. Schacht, T. Caro, J. Schacht, and B. Caro (2008). Knowledge and attitudes of children of the Rupununi: Implications for conservation in Guyana. *Biological Conservation* 142:879–887.

Cabrera, Á. L. (1976). Enciclopedia argentina de agricultura y jardinería. Tomo II. Fascículo I. Editorial Acme S.A.C.I., Buenos Aires, Argentina.

Campos, C. M., S. Greco, J. J. Ciarlante, M. Balangione, J. B. Bender, and J. Nates (2012). Students' familiarity and initial contact with species in the Monte desert (Mendoza, Argentina). *Journal of Arid Environments* 82:98–105.

Castoriadis, C. (1975). *The Imaginary Institution of Society*. Polity Press, Cambridge, UK.

Clucas, B., and J. M. Marzluff (2012). Attitudes and actions toward birds in urban areas: Human cultural differences influence bird behavior. *The Auk* 129:8–16.

Cockle, K. L., A. Bodrati, M. Lammertink, and K. Martin (2015). Cavity characteristics, but not habitat, influence nest survival of cavity-nesting birds along a gradient of human impact in the subtropical Atlantic Forest. *Biological Conservation* 184:193–200.

Cockle, K. L., J. T. Ibarra, T. A. Altamirano, and K. Martin (2019b). Interspecific networks of cavity-nesting vertebrates reveal a critical role of broadleaf trees in endangered Araucaria mixed forests of South America. *Biodiversity and Conservation* 28:3371–3386.

Cockle, K. L., K. Martin, and K. Wiebe (2011). Selection of nest trees by cavity-nesting birds in the Neotropical Atlantic forest. *Biotropica* 43:228–236.

Cockle, K. L., M. K. Trzcinski, K. L. Wiebe, A. B. Edworthy, and K. Martin (2019a). Lifetime productivity of tree cavities used by cavity-nesting animals in temperate and subtropical forests. *Ecological Applications* 29:e01916.

Collado, S., J. A. Corraliza, H. Staats, and M. Ruíz (2015). Effect of frequency and mode of contact with nature on children's self-reported ecological behaviors. *Journal of Environmental Psychology* 41:65–3.

Franquesa-Soler, M., and J. C. Serio-Silva (2017). Through the eyes of children: Drawings as an evaluation tool for children's understanding about endangered Mexican primates. *American Journal of Primatology* 79:e22723.

Furlán, V., L. Cariola, D. García, and N. Hilgert (2015). Caracterización de los sistemas agroforestales familiares y estrategias de uso del ambiente en el bosque Atlántico argentino. *Gaia Scientia* 9:69–81.

Gamer, M., J. Lemon, I. Fellows, and P. Singh (2019). Package 'irr'. Various coefficients of interrater reliability and agreement. R package version 0.84.1. https://cran.r-project.org/package=irr.

Gotelli, N. J., and R. K. Colwell (2001). Quantifying biodiversity: Procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* 4:379–381.

Hallgren, K. A. (2012). Computing inter-rater reliability for observational data: An overview and tutorial. *Tutorials in Quantitative Methods for Psychology* 8:23–34.

van der Hoek, Y., G. V. Gaona, and K. Martin (2017). The diversity, distribution and conservation status of the tree-cavity-nesting birds of the world. *Diversity and Distributions* 23:1120–1131.

Ibarra, J. T., A. Barreau, J. Caviedes, N. Pessa, J. Valenzuela, S. Navarro-Manquilef, C. Monterrubio-Solíz, A. Ried, and J. C. Pizarro (2020). Listening to elders: Birds and forests as intergenerational links for nurturing biocultural memory in the southern Andes. In *Transnational Children and Youth: Experiences of Nature and Place, Culture and Care Across the Americas* (V. Derr and Y. Corona, Editors). Routledge, Abingdon, UK.

IPEC (2015). Gran Atlas de Misiones. https://www.ipec.misiones.gov.ar/

Izquierdo, A. E., C. D. De Angelo, and T. M. Aide (2008). Thirty years of human demography and land-use change in the Atlantic Forest of Misiones, Argentina: An evaluation of the forest transition model. *Ecology and Society* 13:3.

Kershaw, P., and B. Wagstaff (2001). The southern conifer family Araucariaceae: History, status, and value for paleoenvironmental reconstruction. *Annual Review of Ecology and Systematics* 32:397–414.

Kidd, A. H., and R. M. Kidd (1989). Factors in adults' attitudes toward pets. *Psychological Reports* 65:903–910.

Kokunda, S., H. Nahabwe, J. Nahamya, S. Niwamanya, R. Mazirwe, S. Gougsa, E. Kemigisha, and N. Redvers (2023). Batwa Indigenous Peoples forced eviction for "Conservation": A qualitative examination on community impacts. *PLOS Global Public Health* 3:e0002129.

Lindemann-Matthies, P. (2005). 'Loveable' mammals and 'lifeless' plants: How children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education* 27:655–677.

Lutter, S. H., A. A. Dayer, A. D. Rodewald, D. J. Mcneil, and J. L. Larkin (2019). Early successional forest management on private lands as a coupled human and natural system. *Forests* 10:499.

Marsden, S. J., and J. D. Pilgrim (2003). Factors influencing the abundance of parrots and hornbills in pristine and disturbed forests on New Britain, PNG. *Ibis* 145:45–53.

Méndez-Herranz, M., J. T. Ibarra, R. Rozzi, and G. Marini (2023). Biocultural homogenization in elementary education degree students from contrasting ecoregions of Chile. *Ecology and Society* 28:18.

Millican, D. M. (2023). Trees, birds, and people: Resource use and interespecific interactions in a Namibian cavity-nesting guild. Ph.D. dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA.

Monterrubio-Rico, T. C., J. M. Ortega-Rodríguez, M. C. Marín-Togo, A. Salinas-Melgoza, and K. Renton (2009). Nesting Habitat of the Lilac-crowned Parrot in a Modified Landscape in Mexico. *Biotropica* 41:361–368.

Moseley, C., B. Desjean-Perrotta, and J. Utley (2010). The Draw-An-Environment Test Rubric (DAET- R): Exploring pre-service teachers' mental models of the environment. *Environmental Education Research* 16:189–208.

Newing, H. (2010). Preparing for fieldwork and collecting and managing data in the field. In *Conducting Research in Conservation: Social Science Methods and Practice* (H. Newing, Editor). Routledge, London, UK.

Oksanen, J., F. G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P. R. Minchin, R. B. O'Hara, G. L. Simpson, P. Solymos, H. H. Stevens, et al. (2020). vegan: Community Ecology Package. https://cran.r-project.org/package=vegan.

Paloniemi, R., T. Hujala, S. Rantala, A. Harlio, A. Salomaa, E. Primmer, and S. Pynnönen (2017). Integrating social and ecological knowledge for targeting voluntary biodiversity conservation. *Conservation Letters* 10:1–10.

Pejchar, L., Y. Clough, J. Ekroos, K. A. Nicholas, O. Olsson, D. Ram, M. Tschumi, and H. G. Smith (2018). Net effects of birds in agroecosystems. *BioScience* 68:896–904.

Pintos, J. L. (2014). Algunas precisiones sobre el concepto de imaginarios sociales. *Revista Latina de Sociología* 4:1–11.

Prestes, N. P., J. Martinez, J. C. Kilpp, T. Batistela, A. Turkievicz, É. Rezende, and V. T. R. Gaboardi (2014). Ecologia e conservação de *Amazona vinacea* em áreas simpátricas com *Amazona pretre*i. *Ornithologia* 6:109–120.

Puri, R. K. (2010). Documenting local environmental knowledge and change. In *Conducting Research in Conservation: Social Science Methods and Practice* (H. Newing, Editor). Routledge, Abingdon, UK.

Purzycki, B. G., and A. Jamieson-Lane (2017). AnthroTools: An R package for cross-cultural ethnographic data analysis. *Cross-Cultural Research* 51:51–74.

Quinlan, M. (2005). Considerations for collecting freelists in the field: Examples from ethobotany. *Field Methods* 17:219–234.

R Core Team (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. http://www.r-project.org/

Radi, B. (2021). Las personas trans en la ontología social oficial: Políticas de números con perspectiva de género. *Revista Argentina de Ciencia Política* 1:26–49.

Redman, C. L., J. M. Grove, and L. H. Kuby (2004). Integrating social science into the long-term ecological research (LTER) network: Social dimensions of ecological change and ecological dimensions of social change. *Ecosystems* 7:161–171.

Remsen, J. V. J., J. I. Areta, S. Bonaccorso, S. Claramunt, G. Del-Rio, A. Jaramillo, D. F. Lane, M. B. Robbins, F. G. Stiles, and K. J. Zimmer (2024). A classification of the bird species of South America. Museum of Natural Science, Louisiana State University. http://www.museum.lsu.edu/~Remsen/SACCBaseline.htm.

Ribeiro, M. C., J. P. Metzger, A. C. Martensen, F. J. Ponzoni, and M. M. Hirota (2009). The Brazilian Atlantic forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142:1141–1153.

Rodríguez-Ramírez, M. del C., E. M. Aldasoro- Maya, C. B. Zamora-Lomelí, and J. J. Velasco-Orozco (2017). Conocimiento y percepción de la avifauna en niños de dos comunidades en la selva Lacandona, Chiapas, México: Hacia una conservación biocultural. *Nova Scientia* 9:56.

Rozzi, R. (2018). *Biocultural Homogenization: A Wicked Problem in the Anthopocene. From Biocultural Homogeneization to Biocultural Conservation*. Springer Nature Switzerland, Cham, Switzerland.

Salinas, C. (2020). The pedagogy of detachment and decolonial options: Reflections from a 'minoritized' point of view. *Nordic Journal of Comparative and International Education* 4:10–25.

Sánchez-Mercado, A., O. Blanco, B. Sucre-smith, J. M. Briceño-Linares, C. Peláez, and J. P. Rodríguez (2020). Using peoples' perceptions to improve conservation programs: The Yellow-shouldered Amazon in Venezuela. *Diversity* 12:342.

Schwarz, M. L., P. André, and L. Sevegnani (2012). Children's representations of the biological richness of the Mata Atlântica biome. *Ciência & Educação* 18:155–172.

Silva-Andrade, H. L., L. P. De Andrade, L. S. Muniz, W. R. Telino, U. P. Albuquerque, and R. M. Lyra-Neves (2016). Do farmers using conventional and non-conventional systems of agriculture have different perceptions of the diversity of wild birds? Implications for conservation. *PLoS One* 11:e0156307.

Snively, G., and W. L. Williams (2016). *Knowing Home: Braiding Indigenous Science with Western Science*. University of Victoria, Victoria, BC, Canada.

Sobel, D. T. (2008). *Childhood and Nature: Design Principles for Educators*. Angewandte Chemie International Edition. Stenhouse Publishers, Portland, Maine, USA.

Soga, M., and K. J. Gaston (2016). Extinction of experience: The loss of human-nature interactions. *Frontiers in Ecology and the Environment* 14:94–101.

St John, F. A. V, G. Edwards-Jones, and J. P. G. Jones (2010). Conservation and human behaviour: Lessons from social psychology. *Wildlife Research* 37:658–667.

Stotz, D. F., J. W. Fitzpatrick, T. A. Parker III, and D. K. Moskovits (1996). *Neotropical Birds: Ecology and Conservation*. University of Chicago Press, Chicago, USA.

Sullivan, A., A. Brewis, and A. Wutich (2018). Studying children's cultural knowledge and behaviors related to environment, health, and food: Methods for ethnoecological research with children. *Journal of Ethnobiology* 38:276–293.

Thomas, P. (2013). Araucaria angustifolia. In *The IUCN Red List of Threatened Species 2013: e.T32975A2829141*. https://www.iucnredlist.org/species/32975/2829141.

Vancine, H. M., R. L. Muylaert, B. B. Niebuhr, J. E. de F. Oshima, V. Tonneti, R. Bernardo, C. De Angelo, M. R. Rosa, C. H. Grohmann, and M. C. Ribeiro (2024). The Atlantic forest of south america: Spatiotemporal dynamics of the vegetation and implications for conservation. *Biological Conservation* 291:110499.

Varns, T. (2012). Constrained cultivation: Examining the drivers of forest use and conservation by smallholder farmers in a frontier colony of Northeast Argentina. Master's dissertation, Yale School of Forestry and Environmental Studies, New Haven, Connecticut, USA.

Wells, N. M., and K. S. Lekies (2006). Nature and the life course: Pathways from childhood nature experiences. *Children, Youth and Environments* 16:1–25.

Wolda, H. (1981). Similarity indices, sample size and diversity. *Oecologia* 50:296–302.

Table 1. The participating children mentioned several taxa of native birds, although on many occasions they did not identify cavity-nesting birds to species level (with exceptions in the families Psittacidae and Ramphastidae). The table shows orders/families of birds mentioned in freelists in decreasing order of salience. Smith's salience is the total salience of each family/order divided by the total number of participants. Mean salience is the total salience divided by the number of lists in which each order/family was mentioned. Frequency is the percentage of lists that included each family/order. The number of cavity-nesting species was based on the lists in Cockle et al. (2019a) and Bonaparte (2024). The cavity-nesting species column shows which species were mentioned within each family/order. Asterisks indicate exotic taxa.

	Family/Order	**Smith's Salience**	**Mean Salience (Frequency, %)**	**Number of cavity-nesting species in the area**	**Species mentioned that nest in cavities**
1	Psittacidae	0.758	0.8 (95.8)	5	*Pionopsitta pileata* (Pileated Parrot), *Pionus maximiliani* (Scaly-headed Parrot), *Amazona vinacea* (Vinaceous-breasted Parrot), *Pyrrhura frontalis* (Maroon-bellied Parakeet), *Psittacara leucophthalmus* (White-eyed Parakeet)
2	Ramphastidae	0.708	0.8 (88.6)	5	*Ramphastos toco* (Toco Toucan), *Ramphastos dicolorus* (Red-breasted Toucan), *Pteroglossus bailloni* (Saffron Toucanet)
3	Columbidae	0.604	0.7 (86.0)	0	
4	Cathartidae	0.355	0.6 (60.3)	1	None
5	Corvidae	0.324	0.6 (55.5)	0	
6	Picidae	0.316	0.4 (73.3)	11	*Celeus galeatus* (Helmeted Woodpecker)
7	Trochilidae	0.287	0.5 (57.2)	0	
8	Strigidae / Tytonidae	0.196	0.5 (41.8)	8	*Tyto alba* (Barn Owl)
9	Charadriidae	0.196	0.5 (43.2)	0	
10	Falconiformes	0.181	0.5 (39.4)	3	None
11	Furnariidae	0.177	0.4 (45.3)	10	None
12	Rallidae	0.176	0.5 (34.3)	0	
13	Unidentified Passeriforme	0.161	0.5 (29.2)	-	
14	Cuculidae	0.154	0.4 (34.3)	0	
15	Troglodytidae	0.125	0.6 (22.5)	1	*Troglodytes aedon* (House Wren)
16	Accipitridae	0.098	0.5 (18.2)	0	
17	Thraupidae	0.093	0.5 (18.2)	1	*Sicalis flaveola* (Saffron Finch)
18	Turdidae	0.09	0.5 (18.2)	0	
19	Unidentified Order	0.088	0.4 (22.5)		
20	Icteridae	0.086	0.4 (19.1)	1	*Gnorimopsar chopi* (Chopi Blackbird)
21	Ardeidae	0.062	0.4 (14.0)	0	
22	Tinamidae	0.061	0.4 (14.4)	0	
23	Tyrannidae	0.05	0.5 (9.3)	6	None
24	Trogonidae	0.038	0.5 (7.6)	2	None
25	Thamnophilidae	0.033	0.6 (5.9)	0	
26	Anatidae	0.027	0.3 (8.1)	1	None
27	Laridae*	0.025	0.4 (6.4)	0	

28	Hirundinidae	0.025	0.3 (7.6)	4	None
29	Rheidae*	0.023	0.4 (5.9)	0	
30	Alcedinidae	0.021	0.4 (5.5)	0	
31	Falconidae	0.02	0.5 (4.2)	0	
32	Bucconidae	0.017	0.5 (3.4)	0	
33	Cracidae	0.015	0.4 (3.8)	0	
34	Momotidae	0.015	0.4 (3.8)	0	
35	Mimidae	0.007	0.6 (1.3)	0	
36	Passeridae	0.007	0.4 (1.7)	1	*Passer domesticus* (House Sparrow)
37	Ciconiidae	0.005	0.4 (1.3)	0	
38	Odontophoridae	0.004	0.9 (0.4)	0	
39	Struthonidae*	0.004	0.4 (0.9)	0	
40	Phoenicopteridae*	0.002	0.6 (0.4)	0	
41	Phasianidae	0.002	0.2 (0.9)	0	
42	Cotingidae	0.001	0.4 (0.4)	0	
43	Nyctibiidae	0.001	0.2 (0.4)	0	

TABLE 2. The tree taxa represented in the "draw-and-explain" activity showed a high richness and a high percentage of exotic species, compared to nest trees and random trees in protected forest and agroecosystems. The number of mentions in the first column refers to the number of times the species was mentioned in different drawings (if a species was drawn more than once in the same drawing, it is counted as a single mention).

	Trees drawn (*n* = 529 mentions)	**Nest trees on farms (*n* = 50)**	**Random trees on farms (*n* = 100)**	**Nest trees in protected forest (*n* = 114)**	**Random trees in protected forest (*n* = 228)**
Total number of taxa	44	22	31	26	44
Number of exotic species	19	3	3	0	0
Exotic species as a percentage of mentions (in drawings) or individuals (nest or random)	41%	10%	15%	0%	0%

Table 3. Composition of tree taxa mentioned by children in their drawings showed high dissimilarity compared to nest trees and random trees in protected forest and agroecosystems. The Morisita index ranges from 0 (totally equal communities) to 1 (totally dissimilar communities).

	Taxa mentioned in drawings	**Nest trees in protected forest**	**Random trees in protected forest**	**Nest trees on farms**
Nest trees in protected forest	0.76	—	—	—
Random trees in protected forest	0.73	0.11	—	—
Nest trees on farms	0.74	0.45	0.27	—
Random trees on farms	0.53	0.38	0.24	0.16

FIGURE 1. Psittacidae, Ramphastidae and Picidae families included the most frequently mentioned bird taxa in freelists, and were also the most identified as cavity nesters. The figure displays the families mentioned in freelists, which include at least one cavity-nesting species. Bars indicate the total percentage of lists that included at least one taxon from each family, in decreasing total frequency. Black fill indicates the percentage of mentions where taxa were highlighted as cavity nesters on the freelists.

FIGURE 2. Examples of participants' drawings. The participants were students, between 10 and 13 years of age, from rural primary schools in Misiones, Argentina. (**A**) A drawing by a 10-year-old participant shows a cavity-nesting bird species (Vinaceous-breasted Parrot) perched beside its nest cavity, as well as two native tree species (Paraná pine and pindó *Syagrus romanzoffiana*) and an unidentified tree species. (**B**) A drawing by a 10-year-old participant shows four birds of two species: three pigeons (Columbidae), and a hawk (Falconiformes). It depicts eight trees: four exotic species (apple tree *Malus domestica*, mandarin *Citrus* sp., pine *Pinus* sp., eucalyptus *Eucalyptus* sp.) and one unidentified tree species. (**C**) A drawing by a 12-year-old participant shows a Vinaceous-breasted Parrot and 12 trees, mentioning two exotic species (orange *Citrus* sp. and mandarin), one native species (pindó), and at least one native species under the description "forest trees". (**D**) A drawing by a 12-year-old participant shows no birds and only one tree, the exotic lime (*Citrus* sp.).

FIGURE 3. The accumulation curve of tree taxa mentioned by children in their drawings (dotted black lines) was lower but comparable to the diversity of nest and random tree species in protected forest (dashed green lines) and agroecosystems (solid orange lines). The figure presents rarefaction curves for the number of species as a function of sample size (number of mentions in drawn trees or number of individuals sampled in nest trees and random trees), with associated confidence interval (shaded).

Figure 1

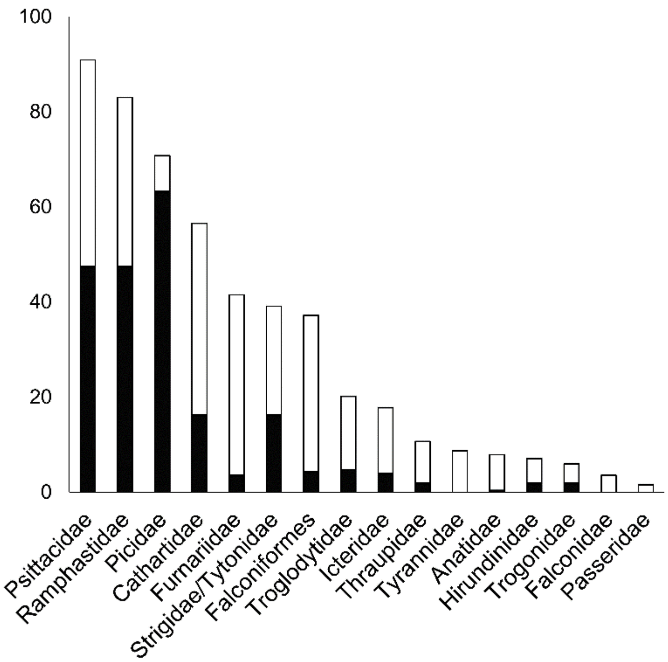
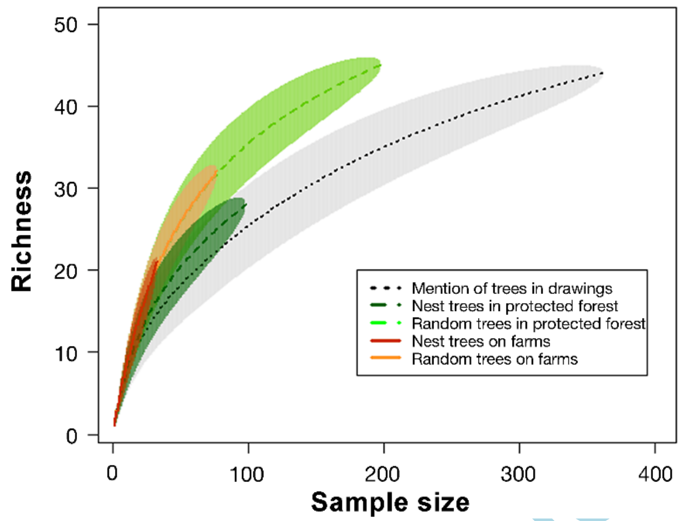

100
80
60
40
20
0
Psittacidae
Ramphastidae
Picidae
Cathartidae
Furnariidae
Strigidae/Tytonidae
Falconiformes
Troglodytidae
Icteridae
Thraupidae
Tyrannidae
Anatidae
Hirundinidae
Trogonidae
Falconidae
Passeridae

Figure 2


A
Arbol
Loro pecho vinoso
Nido de Loro
Camino
Arbol
B
Palomas
Manzanas
Pino
Eucalipto
C
Loro pecho vinoso
Naranja
Yerba
Mandarina
Arboles de Monte
Maíz
Coco
D
Potrero
Leña

Figure 3



Richness
50
40
30
20
10
0
0
100
200
300
400
Sample size
Mention of trees in drawings
Nest trees in protected forest
Random trees in protected forest
Nest trees on farms
Random trees on farms