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RESEARCH ARTICLE

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Tracking the cultural niches of North American birds through time

Justin G. Schuetz[1] | Alison Johnston[2]

[1]JGS Projects, Bath, ME, USA

[2]Cornell Lab of Ornithology, Ithaca, NY, USA

Correspondence
Alison Johnston
Email: aj327@cornell.edu

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Abstract

1. Conservation efforts are constrained by our poor grasp of changing relationships between humans and other species. We used internet query data describing relative public interest in different species of birds, and combined them with citizen science data describing relative encounter rates with those same taxa, to gain perspective on shifting relationships between people and birds in the United States.
2. National-level interest in birds increased an average of 12.6% across two sequential 5-year periods, while controlling for the volume of internet searches and changing encounter rates with species in the United States. Geographic alignment of state-level interest in birds and state-level encounters with birds increased by an average of 5.7% across species.
3. In multivariate multiple regression analysis, we found that species did not move uniformly through a 2D 'cultural niche space' between time periods. Shifts varied according to changes in federal protection afforded to species, by migratory strategy, whether species were native or introduced and by taxonomic Order.
4. Together, these results suggest that people in the United States became more inquisitive about birds over a relatively short period of time, that their growing curiosity was directed disproportionately towards local species, and that cultural labels and species characteristics continue to shape relationships between people and birds.
5. By tracking shifts in the cultural niches of birds over time, we provide quantitative perspective on general patterns of socio-ecological change. And by identifying factors associated with those shifts, our results also offer specific information that can be used to improve conservation efforts aimed at particular species or groups of birds.

KEYWORDS

birds, citizen science, conservation, culture, eBird, Google, internet, niche, public engagement, species traits

1 | INTRODUCTION

There is growing consensus that Earth is in the midst of a mass extinction crisis, one of only six in its history (Barnosky et al., 2011; Ceballos et al., 2017). While we continue to disentangle the proximate and ultimate causes of recent biodiversity losses, there is a clear need for conservation efforts focused on understanding and reshaping human values in relation to the rest of the natural world (Chan et al., 2016). Significant biodiversity losses may only be averted if human values—and actions that flow from those values—can be quickly aligned with the needs of other species.

Digital technologies are likely to play a central role in these conservation efforts because they both reflect and reinforce human values, and increasingly mediate our understanding of the natural world (Arts et al., 2015). The internet offers access to information about virtually any species—common and nearby, or rare and remote—and there is growing interest in using data derived from internet activity to characterize human perceptions of nature (Ladle et al., 2016, 2019; Toivonen et al., 2019). Web pages, internet searches and social media posts implicitly and explicitly manifest human priorities and, as a result, contain vast amounts of data with potential relevance to conservation efforts.

Researchers have started to probe these digital resources and have developed a variety of approaches for quantifying and contextualizing internet-derived data. For example, the numbers of web pages referencing species have been used as a measure of their cultural salience (Correia et al., 2017), Twitter and Wikipedia data have been used to index public awareness of species highlighted in natural history films (Fernández-Bellon & Kane, 2019), and social media data have been mined to probe the biodiversity preferences of park visitors (Hausmann et al., 2018). As humans spend more time online, and have more opportunities for creating and interacting with information about species through the internet, it will become increasingly important to understand the ways in which virtual engagement with species is connected to (or disconnected from) their biological realities (Courchamp et al., 2018).

In previous work, we used summaries of internet searches and direct observations of bird species to describe a 'cultural niche space' (Schuetz & Johnston, 2019). Like an ecological niche space which is useful for characterizing the environments that species occupy, we suggested a cultural niche space might be useful for characterizing parts of the human cultural environment that different bird species occupy. It is important to note that other researchers have used the term 'cultural niche' differently, either in reference to the ability of individuals or populations to construct suitable environments for themselves (Laland & O'Brien, 2011) or in reference to knowledge that is accumulated and shared through human culture (Boyd et al., 2011; Derex & Boyd, 2015).

We defined our cultural niche space in two dimensions: popularity and congruence (Schuetz & Johnston, 2019). The popularity dimension reflected how much more or less interest people expressed in species through internet searches than we expected based on encounter rates with species. The congruence dimension reflected the degree to which internet searches for species originated in states where people encountered those species. Together, estimates of popularity and congruence provided us perspective on the nature of relationships between people and birds across America (Schuetz & Johnston, 2019).

We suggested that, collectively, people in the United States had more intense relationships with popular species compared to unpopular species and more intimate relationships with species exhibiting high congruence compared to those exhibiting low congruence (Schuetz & Johnston, 2019). To make these distinctions easier to grasp, we also personified relationships between people and birds, classifying species in different quadrants of cultural niche space as 'celebrities' (low congruence, high popularity), 'friends or enemies' (high congruence, high popularity), 'neighbours' (high congruence, low popularity) or 'strangers' (low congruence, low popularity). By characterizing relationships in this way we hoped to expand discussion of the criteria used for making conservation decisions, which have traditionally been restricted to either intrinsic or instrumental values (Klain et al., 2017).

After describing the positions of species within a cultural niche space, we also quantified the degree to which different species traits (e.g. migratory strategy, size and coloration) and cultural labels assigned to species (e.g. 'federally protected' and 'introduced') explained the distribution of species with cultural niche space (Schuetz & Johnston, 2019). Many of the effects that we found echoed findings from a range of other studies (Clucas et al., 2008; Cox & Gaston, 2016; Ladle et al., 2019; Lišková & Frynta, 2013; Tisdell et al., 2007) and suggested that a variety of perceptual and cultural biases shape relationships with wildlife in Western cultural contexts. Since lasting conservation impacts may only be realized if we are able to change how other species are viewed, it is important to understand how flexible cultural niches are over time, and why some species may shift more easily through cultural niche space than others as a result of changing perceptual or cultural biases.

Here, we develop an approach for tracking the movements of individual species of birds through cultural niche space over time by quantifying changes in popularity and congruence between sequential 5-year periods. Then we explore whether certain groups of species move more than others by assessing whether species traits and cultural labels assigned to species are associated with movements through cultural niche space. The resulting analyses provide quantitative perspective on evolving relationships between people and birds in America and suggest different ways that observable characteristics of birds and ideas about birds, codified in cultural labels, may interact to determine their positions in contemporary American culture.

2 | METHODS

2.1 | Study species, study area and study periods

We gathered interest data (Google Trends data) and encounter rate data (eBird data) for 622 bird species within our study period

(1 January 2008–31 December 2017) and study area (United States). We partitioned our 10-year study period into two 5-year intervals (t_1 = 2008–2012; t_2 = 2013–2017) to investigate changes in relative public interest in birds and relative public exposure to birds over time.

2.2 | Interest data

Google Trends summarizes public interest in a topic based on the number of Google searches for that topic relative to the total number of Google searches. Two kinds of data summaries are available from Google Trends: 'Interest over time' data and 'Interest by subregion' data. We used these two sources of data to gain perspective on national-level and state-level interest in birds respectively.

'Interest over time' data describe the distribution of public interest in up to five topics, over a specified period of time, within a particular geography. We downloaded 'Interest over time' data for sets of five species from 2008 to 2017 within the United States. Google normalized interest estimates relative to the species-month combination with the highest ratio of topic searches to total searches. This reference species-month was assigned a value of 100 by Google and all other species-month combinations were assigned values proportionally.

To estimate changes in national-level interest over time, we summarized Google 'Interest over time' data across the United States for 622 bird species in t_1 and t_2. Interest data were averaged within each time period and were then all scaled relative to a value of 100 for Bald Eagle during t_1 (Figure S1). So, a species with a scaled value of 50 during t_1 or t_2 would have garnered half as much interest as Bald Eagle did during t_1.

'Interest by subregion' data describe the distribution of public interest in a topic over a specified set of geographies (e.g. states) within a particular period of time. We downloaded 'Interest by subregion' data separately for each study species in each time period. Data were available for 614 of our 622 study species in both t_1 and t_2. Google normalized interest estimates relative to the subregion with the highest ratio of topic searches to total searches. This reference subregion was assigned a value of 100 and values for all other subregions were defined in relation to the reference.

2.3 | Encounter rate data

eBird is a global citizen science initiative that collects bird observations in checklists and estimates the distribution and abundance of bird species through space and time (Sullivan et al., 2014). We used eBird complete checklists (i.e. reports of all birds that observers detected and could identify) to characterize the rates at which species were encountered by birdwatchers in each state and across the United States as a whole. We defined encounter rate as the proportion of complete checklists including a given species. Encounter rates provide useful indices of public exposure to birds because they integrate information about where people and birds co-occur, both at large spatial scales (e.g. among states) and small spatial scales (e.g. among urban and rural habitats) while also reflecting differences in the abundance and detectability of different species.

We downloaded seasonal histogram data files from the eBird website for all 50 states and the District of Columbia for both t_1 and t_2. Files contained counts of complete checklists submitted for each week of the year and the fraction of checklists that included each species. By pooling these seasonal data, we were able to calculate encounter rates for birds in all 50 states and the District of Columbia for t_1 and t_2.

We normalized eBird encounter rates across states to mirror values in Google Trends 'Interest by subregion' data. For each species and time period, all state-level encounter rates were divided by the maximum encounter rate for that species and then multiplied by 100. Thus, in t_1 and t_2, the state with the highest encounter rate for each species received a normalized value of 100 and encounter rates in all other states were adjusted proportionally. States in which a species was not encountered were assigned values of zero.

By pooling checklist data across all states, we generated national-level encounter rates for each species. Data in both t_1 and t_2 were normalized relative to the encounter rate for the species that appeared most frequently on checklists throughout the United States in t_1 (i.e. Mourning Dove).

2.4 | Analysis of national-level interest and encounter rates

Our a priori expectation was that people in the United States would express more interest in species that are encountered frequently but that some species would generate more (or less) public interest than others encountered at similar rates. So, we used linear regression to model the relationship between national-level interest and encounter rate data from t_1. Then, we calculated residuals from model predictions for data from both t_1 and t_2. These residuals indicated the relative popularity of each species in each time period relative to expectations generated during t_1. Positive values indicated species attracting more attention than expected after accounting for encounter rates. Negative values indicated species attracting less attention than expected.

2.5 | Analysis of state-level interest and encounter rates

We used linear regression to quantify the degree of geographic congruence between state-level interest and encounter rates for each study species in t_1 and t_2. Model slopes indicated the degree of congruence between interest and encounter rates. Slopes near 1 suggested a high degree of geographic congruence (i.e. Google searches for a species and encounters with a species aligned perfectly). Slopes near 0 suggested a low degree of geographic congruence

(i.e. Google searches for a species and encounters with a species showed no relationship).

2.6 | Analysis of shifts in cultural niche positions

We used popularity and congruence metrics to describe a 2D cultural niche space (Schuetz & Johnston, 2019). Then, because we possessed metrics for both t_1 and t_2 for 614 taxa, we were able to analyse shifts in species' cultural niche positions over time.

We used multivariate multiple regression to explore whether species traits (i.e. migratory strategy, mass, colour, feeder association, head plumage) and cultural labels assigned to species ('federally protected', 'change in federal protection', 'team mascot', 'introduced species', 'game bird') were associated with the direction and magnitude of shifts through cultural niche space between t_1 and t_2 (Table 1). To account for taxonomic effects that might not be reflected by our list of species traits and cultural labels, we also included Order as a predictor. Change in popularity and congruence metrics were specified as the two response variables. After constructing a global model including all covariates, we used backwards variable selection to eliminate non-significant covariates.

To further probe potential causes of niche shifts over time, we used multiple linear regression to assess whether changes in popularity between t_1 and t_2 were associated with the percent change in national-level interest in species between t_1 and t_2, percent change in national-level encounter rates and/or their interaction. This allowed us to assess whether changes in popularity over time were driven primarily by increases in interest (i.e. the rate of internet searches), as a by-product of decreases in encounters with species, or as a result of their interaction. We also used multiple linear regression to understand whether differences in congruence between t_1 and t_2 were associated with differences in state-level interest between t_1 and t_2, differences in state-level encounter rates, and/or their interaction. Again, this allowed us to assess the degree to which changes in congruence emerged from changes in the spatial distribution of interest, changes in the spatial distribution of encounters with species or as a result of their interaction.

3 | RESULTS

3.1 | Cultural niche shifts

Overall, 421 of 622 study species (68%) increased in popularity between t_1 and t_2. Popularity increased an average of 0.052 units across all species, which reflected a 12.6% increase in interest in birds while controlling for encounter rates (Figure 1). In addition, 360 of 614 taxa (59%) showed increases in congruence of state-level interest and encounter rates between t_1 and t_2. Congruence increased an average of 0.025 units across all species, which reflected a 5.7% average increase in the slopes of state-level species-specific regressions (Figure 2).

Species positioned in different parts of the 2D cultural niche space shifted by different amounts and in different directions (Figure 3). The least popular species in t_1 tended to increase the most in popularity. Similarly, species that showed the lowest congruence between state-level interest and encounter rates in t_1 tended to

TABLE 1 Description of species traits and cultural labels used in multivariate multiple regression analyses. Additional details are available in Data S1

Covariate	Description
Migratory strategy	Description of whether a species is primarily a migrant or resident throughout its range
Mass	Log_{10}-transformed average body mass of each species
Colour	An index describing the distinctiveness of species' plumages based on crowd-sourced perceptions of colour (0–100)
Feeder association	An index describing how frequently species are associated with bird feeders based on crowd-sourced descriptions of bird habitat (0–100)
Head plumage	Description of whether a species possesses a distinctive crest or ornamental feathers around its head (none, short, long)
Federally protected	Description of whether a species, or at least one of its subspecies, is protected under the Endangered Species Act (ESA) in the United States
Change in federal protection	Description of a change to the level of ESA protection during study period (decrease, none, increase)
Team mascot	Description of whether a species serves as a mascot for a professional sports team in MLB, NFL or NBA
Introduced species	Description of whether a species has been introduced to the United States
Game bird	Description of whether a species is hunted in the United States
Order	Taxonomic Order of each species

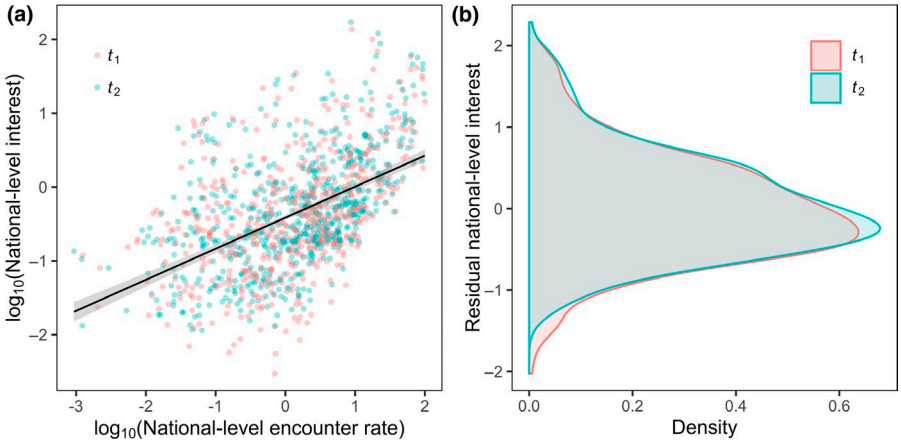

FIGURE 1 (a) National-level interest in birds as a function of national-level encounter rates with birds. Each point represents a species (t_1: $N = 622$ species, t_2: $N = 622$ species). The regression line is fitted to data for species from t_1 and then residuals are calculated for species in both t_1 and t_2. (b) Distribution of residuals (i.e. popularity estimates) for bird species in each time period

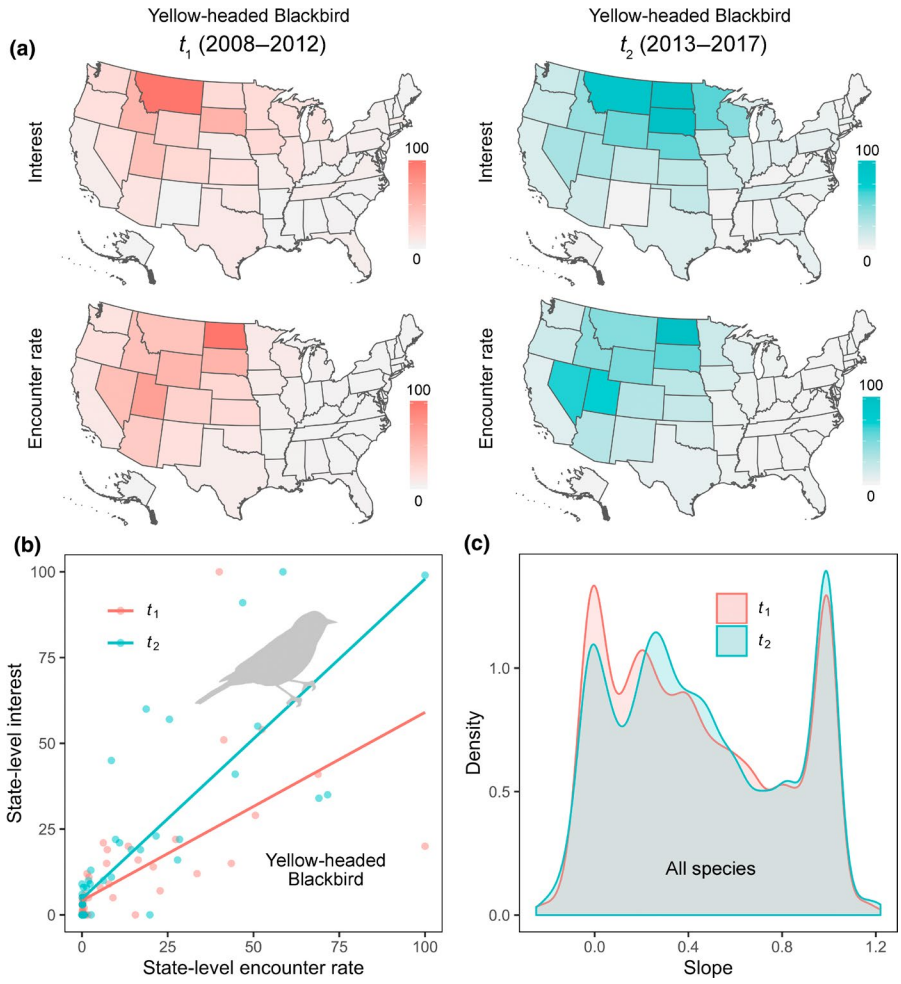

FIGURE 2 (a) Distribution of state-level interest and encounter rates for a sample species, yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), in t_1 and t_2. (b) Linear regressions describing relationships between state-level interest and encounter rates for yellow-headed Blackbird. Each point represents data for a state. (c) Distribution of regression slopes (i.e. congruence estimates) across study species. (t_1: $N = 615$ species, t_2: $N = 621$ species). Sample sizes differ between time periods because Google Trends 'Interest by subregion' data were unavailable for some species in either t_1 or t_2

show the greatest increases in congruence over time. The resulting pattern suggests general movement of species upwards and to the right within cultural niche space.

3.2 | Correlates of cultural niche shifts

In multivariate multiple regression analyses, only one of the ecological traits we explored (migratory strategy) was associated with movements through cultural niche space; migratory species grew more in popularity between periods than resident species (Table 2; Tables S2 and S3). There were no effects of mass, colour, head plumage or association with bird feeders on changes in popularity or congruence.

Two of the cultural labels that we explored (change in federal protection and introduced species) were associated with species' movements through cultural niche space. Species that gained federal protection during the study period showed greater increases in

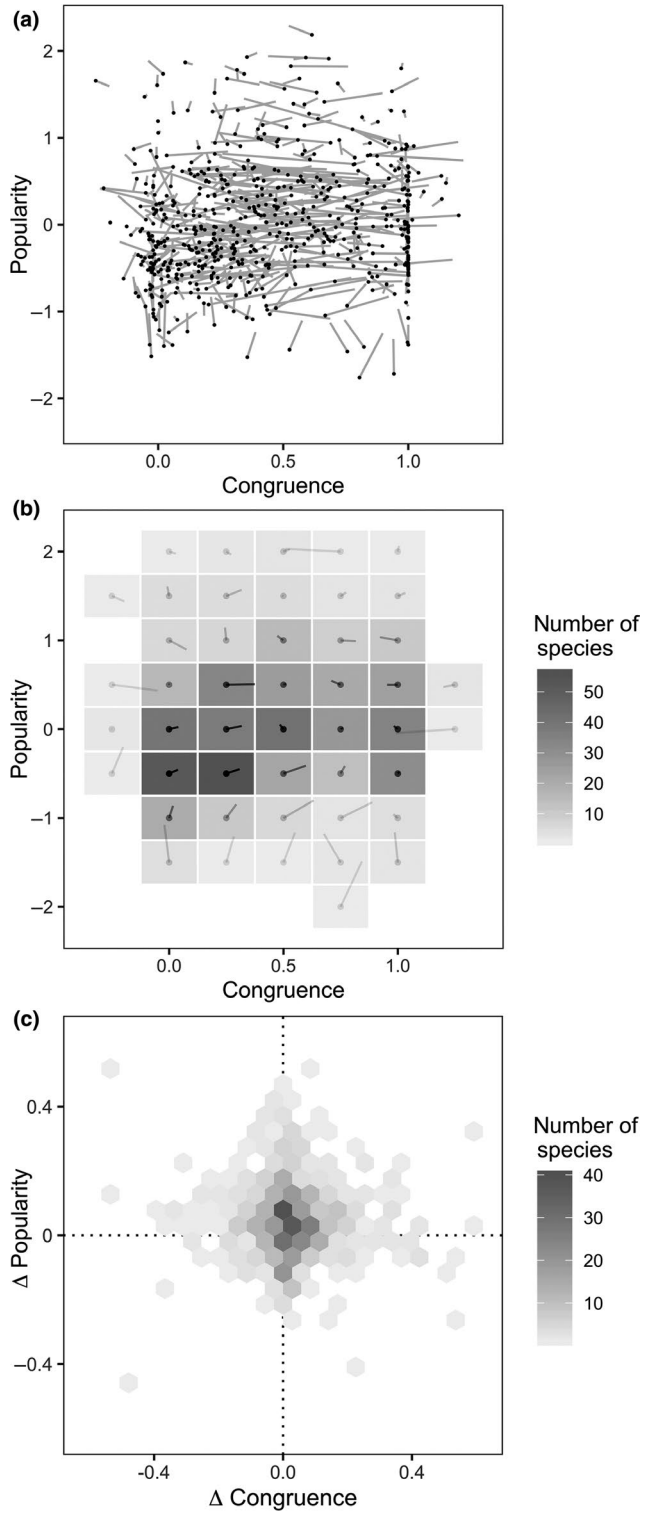

FIGURE 3 (a) Movements of 614 individual bird species through cultural niche space between periods. Lines indicate changes in congruence and popularity from t_1 (black dots) to t_2. (b) Movements of groups of species occupying different sections of cultural niche space. Lines indicate average changes in congruence and popularity. Black dots are centred in cells and do not reflect mean values for species in those cells. Tones indicate the number of species in each cell during t_1. (c) Numbers of species exhibiting similar changes in congruence and popularity. Tones indicate the number of species in each cell. Four outliers were cropped from the plot

TABLE 2 Statistical significance of multivariate multiple regression effects. Significance tests account for covariance of effects in two-dimensional cultural niche space

	df	Pillai test statistic	~*F*	ndf	ddf	Pr(>*F*)
Order	22	0.1063	1.50	44	1,174	0.020
Migratory strategy	1	0.0107	3.17	2	586	0.043
Introduced species	1	0.0179	5.35	2	586	0.005
Change in federal protection	2	0.0230	3.42	4	1,174	0.009

popularity compared to species that did not experience any change in federal protection; they also showed reduced congruence of state-level interest and encounter rates. Species that had federal protections removed during the study period tended to become less popular. Introduced species showed decreased congruence of state-level interest and encounter rates between periods. Being a team mascot or a game bird did not influence movements through cultural niche space (Table 2; Tables S2 and S3).

The Order to which species belonged was a significant predictor of differential movements through cultural niche space (Tables S2 and S3; Figure 4). After accounting for effects of introduced species, migratory strategy and changes in federal protection, ducks and geese (Anseriformes), doves and pigeons (Columbiformes), and hummingbirds and nightjars (Caprimulgiformes) increased most in popularity while rails and cranes (Gruiformes), and gannets and cormorants (Suliformes) tended to decrease in popularity. Congruence of state-level interest and encounter rates increased most in rails and cranes and decreased most in cuckoos (Cuculiformes). Several Orders of birds with fewer than five species showed larger changes in popularity and congruence (Tables S2 and S3).

On average, encounter rates with species decreased between t_1 and t_2; however, multiple regression analyses showed that changes in popularity were driven primarily by changes in the amount of public interest in birds rather than changes in encounter rates with birds (Figure S2; Table S3). Similarly, changes in congruence of state-level interest and encounter rates were driven primarily by changes in the geographic distribution of public interest rather than changes in the geographic distribution of encounters with birds (Figure S3; Table S4).

The tighter spatial alignment of state-level interest and encounter rates that we described may have been affected by changes to Google Trends methods. Congruence increased significantly from 2008–2010 to 2011–2013—time periods that were separated by a change to Google's geographic assignment methods—but not from 2011–2013 to 2014–2016 (Figure S4; Table S5). Changes to the Google Trends data collection system did not appear to systematically affect national-level interest data, nor, by extension, our estimates of changes in species' popularity (Figure S5).

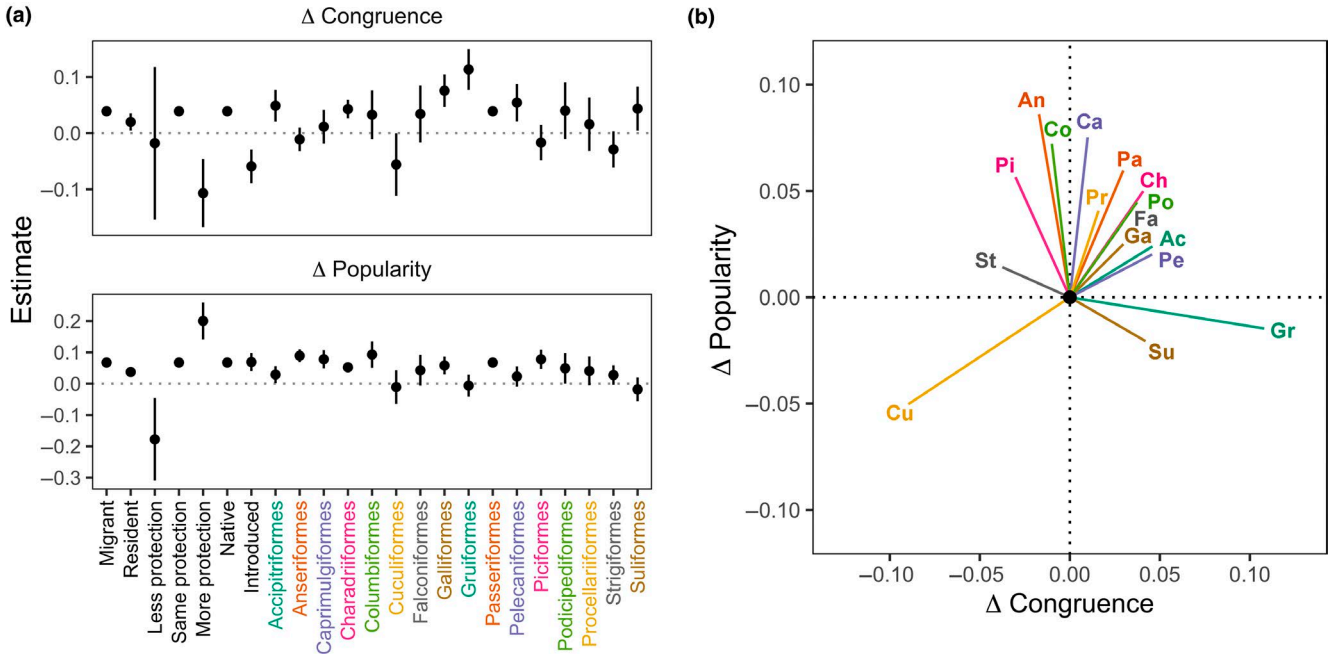

FIGURE 4 Correlates of cultural niche shifts. (a) Effects of species traits and cultural labels on changes in congruence and popularity between t_1 and t_2. Lines indicate standard errors. (b) Modelled changes in popularity and congruence between t_1 (black dot) and t_2 for an average species in each Order. Colours indicate different taxonomic Orders in both plots. Only Orders containing five or more species are shown in either plot

4 | DISCUSSION

We used Google Trends data and eBird checklist data to show that a majority of birds in North American increased in popularity between t_1 and t_2 and that, on average, national-level interest in birds increased by 12.6% after controlling for the rates at which species were encountered. This result could not be accounted for by increasing use of Google between time periods since Google Trends data reflect searches for particular topics (e.g. bird species) relative to all searches. Our analyses also suggested that congruence of state-level interest and encounter rates increased for a majority of species, by an average of 5.7%, indicating that growing curiosity about birds was focused more towards local species. Interpretation of this second result is complicated, however, by changes to Google Trends geographic assignment methods early in the study period.

Results of our analyses align qualitatively with results from surveys of wildlife-associated recreation conducted every 5 years by the US Fish & Wildlife Service and US Census Bureau (USFWS & USCB, 2011, 2016). Between 2011 and 2016, researchers estimated a 20% increase in the number of US adults who identified as wildlife watchers. After accounting for changes in the US population during that interval (USFWS & USCB, 2011, 2016), their results suggested a 12.6% increase in the probability of adults watching wildlife. Our estimate of a 12.6% increase in encounter-calibrated interest across bird species was remarkably similar in magnitude, despite having been estimated with wholly independent methods and data.

The same US Fish & Wildlife Service and US Census Bureau surveys showed that wildlife watching activities were increasingly focused near peoples' homes (rather than away from their homes; USFWS & USCB, 2011, 2016). Evidence for growing public engagement with local wildlife also mirrors results from our analyses, which describe closer geographic alignment of state-level interest and encounter rates in t_2 compared to t_1. People in the United States seem to be more frequently searching for information about species they have encountered (or might encounter) near their homes, but a longer study period during which Google Trends geographic assignment methods remain constant will be needed to confirm this interpretation.

While both popularity and congruence metrics increased on average, not all species shifted in the same way through cultural niche space. Species that acquired federal protection under the Endangered Species Act during the study period increased in popularity and exhibited decreased congruence of state-level interest and encounter rates relative to species that experienced no change in protection. Species that had federal protections removed experienced declines in popularity. Both of these results underscore a potential causal relationship between federal protections and cultural niche positions suggested by previous work (Schuetz & Johnston, 2019) and highlight the implications of formally recognizing the conservation needs of species through legislation.

Different life histories were also associated with different movements through cultural niche space. Migratory species increased in popularity more than resident species. In recent years, the technologies used to track individual birds during migration have advanced rapidly, enabling safer collection of more accurate data (McKinnon

& Love, 2018). At the same time, analyses of citizen science observations and weather radar data have revealed more details about the migratory patterns of bird populations (Fink et al., 2020) and communities (Lin et al., 2019). These advances in data collection and analysis have sparked an increase in migration research, but have also enabled members of the public to engage with bird migration in ways that were not previously possible (Cornell Lab of Ornithology, 2020). We speculate that these technological and scientific advances may have generated proportionally greater public interest in migratory taxa between t_1 and t_2.

Our analyses also show that, between t_1 and t_2, congruence of state-level interest and encounter rates decreased for introduced species, but not for native species. The result may reflect populations of introduced species being more dynamic than populations of native species, and public interest in introduced species not keeping pace with changes in their geographic distributions. Alternatively, it is possible that public interest in introduced species may be growing, and increasingly extending beyond their geographic distributions, thus creating a greater mismatch between state-level interest and state-level encounter rates for introduced taxa compared to residents. The popularity of introduced species did not increase any more than for native species, however, which suggests that public interest in introduced species is lagging behind—rather than anticipating—expansions in the geographic distributions of introduced species.

The significance of taxonomic (i.e. Order) effects in our multivariate multiple regression analysis indicated that public interest in different groups of birds did not change uniformly over time. It was not immediately obvious to us why different Orders of birds shifted differently through cultural niche space. Future analyses should aim to assess whether additional species traits and cultural labels tied to different Orders of birds contribute to their differential movements through contemporary American culture.

Surprisingly, variation in species' association with feeders was not linked to changes in either popularity or congruence. Rates of wildlife feeding across the United States increased over the course of our study period (USFWS & USCB, 2016), which could have impacted both encounter rates and interest in feeder species. The act of feeding birds may stimulate greater awareness of nature more broadly (Cox & Gaston, 2018; Dayer et al., 2019). So, it is feasible that people who started feeding birds during our study period became more attuned to feeder species and non-feeder species alike and sought information about both groups of birds on the internet.

Mapping changes in human relationships with birds (Schuetz & Johnston, 2019) based on the results of this study suggests several interesting shifts over a relatively short period of time. On the whole, relationships between people and birds increasingly moved towards 'friendships', as evidenced by increasing popularity and congruence metrics. Several groups of birds—those with increasing popularity and decreasing congruence metrics—were increasingly viewed as 'celebrities' (e.g. owls, ducks, doves and woodpeckers) while other Orders with decreasing popularity but increasing congruence were increasingly viewed as 'neighbours' (i.e. rails and gannets). Relatively few species (11.9%) from a range of Orders were increasingly viewed as 'strangers' (Data S1). Adding dimensions to our cultural niche space may allow for a more detailed understanding of how and why human relationships with birds change over time.

There is concern that people are becoming increasingly disconnected from nature (Pergams & Zaradic, 2006; Soga & Gaston, 2016) and that willingness to conserve nature may decline as a result (Rosa et al., 2018; Soga et al., 2016). Results of our analyses suggest that this general trend may not be true for people and birds in America. Even so, it is difficult to project how interest in different bird species translates to individual and collective notions of their value, or to conservation outcomes. There is often a gap between environmentally motivated intentions and actions (Kennedy et al., 2009) and it remains unclear whether technologies that enable different kinds of digital engagement with nature will close that gap—or widen it (Dorward et al., 2017; Fletcher, 2017).

It is also important to note that while our measures of popularity and congruence increased between time periods, we are not able to confirm with current data that those increases were driven by an increase in positive sentiments towards species. Changes in popularity and congruence metrics could also be driven by more negative (or conflicting) sentiments towards birds. More generally, it is important to keep in mind that the Google Trends and eBird data we used in our analyses do not represent the interests and activities of everyone in the United States. Rates of internet use and birding activity vary by geography, income, education and race—among other factors—and have likely changed at different rates across communities over time (Anderson et al., 2019; Sullivan et al., 2014; USFWS & USCB, 2016). This makes it difficult to determine if the changes we detected should be attributed to changing perspectives of the whole US population, or only to changing perspectives within a subset of the US population. However, strong alignment of our results with those from national surveys performed by the US Fish & Wildlife Service and US Census Bureau (USFWS & USCB, 2011, 2016) suggests that perceptions of birds have changed throughout the US population.

Despite uncertainty about the direction and magnitude of feedbacks between human interests and bird populations, we are cautiously optimistic about our findings from a conservation perspective. The rate at which people in the United States are seeking information about birds appears to be increasing. With that increase comes an opportunity for conservation organizations to communicate specific information about the challenges faced by birds and to recruit conservation advocates. By tracking relationships between people and birds, we provide further leverage for understanding patterns of socio-ecological change and enable informed adjustment of conservation strategies aimed at birds.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

J.G.S. designed the research; J.G.S. and A.J. performed the research, analysed the data and wrote the paper.

DATA AVAILABILITY STATEMENT

Data are deposited in the Dryad Digital Repository https://doi.org/10.5061/dryad.34tmpg4j3 (Schuetz & Johnston, 2020).

ORCID

Justin G. Schuetz https://orcid.org/0000-0002-6163-538X
Alison Johnston https://orcid.org/0000-0001-8221-013X

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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