Urban Ecosystems (2026) 29:99
https://doi.org/10.1007/s11252-026-01946-0

RESEARCH

Residents' attitudes toward diverse wildlife and implications for urban coexistence

Kelli L. Larson[1] · Susannah B. Lerman[2] · Carter Henry[3] · Jeffrey D. Haight[4] · Heather L. Bateman[5] · Paige Warren[6] · Mariah Beltran[3]

Received: 10 June 2025 / Accepted: 27 February 2026

Abstract

Human-wildlife research has frequently examined attitudes toward single species, especially carnivores and mammals in rural areas. Recent research has expanded in scope to evaluate urban residents' multifaceted attitudes toward multiple species or taxa. This paper presents a taxonomically inclusive examination of attitudes toward small mammals, birds, reptiles, and insects in metropolitan Phoenix, Arizona (USA) using survey measures that inform human-wildlife coexistence, specifically: tolerance of common wildlife, appreciation of different pollinators, and stewardship of iconic species in the region. Incorporating three theoretical sets of predictors, we ask: how do cognitive, environmental, and sociodemographic factors influence attitudes toward distinct types of wildlife? Coupling geolocated environmental variables with survey data, we found that pro-wildlife worldviews dominated explanations of attitudes broadly. However, environmental experiences—approximated by residents' proximity to and frequency of visiting desert preserves—significantly increased how comfortable people feel around wildlife (i.e., tolerance) and support for protection (i.e., stewardship), including for threatening and iconic wildlife. Meanwhile, socio-demographics most influenced tolerance and appreciation of pollinators, particularly bees and bats. Although white residents liked potentially threatening pollinators more than others, Latino residents tended to dislike bees/bats and exhibited less support for native wildlife stewardship than non-Latinos. Overall, our research advances a multi-species/taxa approach to human-wildlife coexistence by identifying distinct attitudes and underlying drivers that inform holistic management of urban landscapes for the wellbeing of diverse human and non-human biota. Understanding the perspectives of diverse residents is crucial to achieving social legitimacy in managing urban wildlife.

Keywords Human-wildlife coexistence · Environmental attitudes · Biological conservation · Urban ecology

✉ Kelli L. Larson
Kelli.Larson@asu.edu

Susannah B. Lerman
susannah.b.lerman@usda.gov

Carter Henry
cahenry5@asu.edu

Jeffrey D. Haight
jdhaight@asu.edu

Heather L. Bateman
Heather.L.Bateman@asu.edu

Paige Warren
pswarren@umass.edu

Mariah Beltran
mariahbeltran64@gmail.com

[1] School of Geographical Sciences and Urban Planning and School of Sustainability, Arizona State University, Tempe, AZ 85282-5302, USA

[2] U.S. Forest Service Northern Research Station, Amherst, MA 01003-9285, USA

[3] School of Life Sciences, Arizona State University, Tempe, AZ 85287-4601, USA

[4] Global Institute of Sustainability and Innovation, Arizona State University, Tempe, AZ 85281, USA

[5] College of Integrative Sciences and Arts, Arizona State University, Mesa, AZ 85212-6415, USA

[6] Department of Environmental Conservation, University of Massachusetts, Amherst, MA, USA

Published online: 30 March 2026

Introduction

Despite habitat loss in cities, urban greenspaces provide valuable habitat for diverse bird species, important pollinators such as bees, and urban-adapted mammals including coyotes and rabbits (Cocroft et al. 2024; Lerman et al. 2018; Zepeda et al. 2025). Research on urban wildlife has examined how land-use/cover configurations affect the distribution of specific taxa, with a focus on mammals (e.g., Grade et al. 2022; Haight et al. 2023a; Moll et al. 2025; Teixeira et al. 2015) and birds (e.g., Andrade et al. 2022; Aronson et al. 2014; Lerman et al. 2021). Ecological research broadly has favored mammals and birds, with an estimated 62–80% of journal articles in one study (Bonnet et al. 2002). By comparison, less research has focused on reptiles, insects, and small mammals despite their abundance (Clark and May 2002; Guénard et al. 2025; Roll et al. 2017; Troudet et al. 2017; Wierucka et al. 2023). The urban wildlife literature demonstrates similar taxonomic bias (Collins et al. 2021; Magle et al. 2019).

Research on people's attitudes toward urban wildlife has primarily focused on single species or taxa including birds, deer, coyotes, and bees (e.g., Andrade et al. 2022; Connors and Short 2023; Draheim et al. 2019; Larson et al. 2021). These studies are valuable for managing particular wildlife based on their unique traits and behaviors, as well as people's concerns and interactions with them. Meanwhile, fewer studies have assessed interactions with multiple taxa (e.g., Kansky et al. 2014; Liordos et al. 2020; Ngo et al. 2019). One notable example is Basak et al. (2023), which found an increase in public interactions with wildlife between 2010 and 2020 in Krakow, Poland. Specifically, a larger and more diverse set of conflicts emerged for 2020, for example, with property destruction linked to wild boar (*Sus scrofa*) and stone marten (*Martes foina*), anxiety and attacks on pets by red fox (*Vulpes vulpes*), and property damage and intrusions by roe deer (*Capreolus capreolus*). Broadly, multi-taxa studies can help agencies and organizations anticipate, prevent, and manage conflicts and other distinct interactions to propel urban human-wildlife coexistence (Liordos et al. 2020; Tan et al. 2020).

Although wildlife can pose problems for urban residents (Basak et al. 2023; Connors and Short 2023), such conflicts are less acute or problematic relative to rural areas (Larson et al. 2023; Soulsbury and White 2015). Broadly, scholars have shifted away from narrowly examining conflicts to more holistically evaluating human-wildlife interactions through the lens of coexistence, which is commonly defined as a dynamic state in which people and wildlife live in shared landscapes for the benefit of both (Carter and Linnell 2016, 2023; Glikman et al. 2021). This shift calls for research on an array of interactions and outcomes along a continuum, from physical harm, property damage, and milder nuisances to public enjoyment and stewardship of wildlife (Bhatia 2021; Nyhus 2016; Pooley et al. 2021). Depending on different types of interactions in shared landscapes, whether parks, neighborhoods, or other land use contexts, coexistence involves minimizing and managing conflicts between people and wildlife, as well as among different groups of people, in addition to fostering appreciation and stewardship to benefit human and non-human species. With people's problematic interactions with wildlife at the negative end of the spectrum and stewardship at the positive end, coexistence involves managing conflicts and stewardship actions that reflect conservation. Further, scholars argue that coexistence requires socially legitimate governance through management strategies that are accepted and supported by the public (Pooley et al. 2021), thereby underscoring the need for research on people's attitudes toward wildlife.

Along a continuum of coexistence, scholars have described human-wildlife interactions ranging from tolerance and acceptance to appreciation and stewardship (Bhatia et al. 2020; Frank and Glikman 2019). Tolerance involves acceptance of wildlife in the face of physical and economic harm or less severe annoyances (Bhatia 2021; Glikman et al. 2021; Pooley et al. 2021). People's tolerance of wildlife is significantly affected by perceived risks and fears, which affect how comfortable people feel living around wildlife (Hadidian 2015; Haight et al. 2023b). For example, people's tolerance and willingness to coexist with wildlife is greater for less problematic species such as tapir in Malayasia compared to tigers and elephants, which pose more severe risks (Tan et al. 2020). Meanwhile, positive perceptions and experiences increase tolerance and the potential for public enjoyment and appreciation of wildlife such as birds and coyotes (Andrade et al. 2022; Larson et al. 2023). Beyond tolerance and appreciation, behavioral intentions and actions related to stewardship signal the potential for coexistence (Bruskotter et al. 2015; Prévot et al. 2018). Support for conservation policies and collective actions are important since they are more likely to affect wildlife populations compared to human behaviors that impact individual animals (Bruskotter et al. 2015).

In our study, we address the question: how do positive and negative attitudes toward different types of wildlife affect the potential for urban coexistence? Specifically, we examined the extent of positive and negative attitudes toward a diverse array of wildlife—including small mammals, ground-dwelling birds, reptiles, and pollinators—in metropolitan Phoenix, AZ in the southwestern U.S. Using data from a survey of residents coupled with geolocated environmental data, we analyzed multidimensional attitudes—which reflect tolerance, appreciation, and stewardship of different wildlife—in relation to three sets of explanatory factors: value-based cognitive judgements, environmental conditions and experiences, and sociodemographic attributes of residents (Fig. 1). Respectively, and as discussed below, the theoretical explanations draw from the cognitive hierarchy framework (Whittaker et al. 2006; Manfredo 2008), risk perception theory (Slovic 1987; Jenkins et al. 2024), and notions of social heterogeneity and differentiation (Grove and Burch 1997; Machlis et al. 1997).

Cognitive hierarchy theory posits that relatively broad-based values, beliefs, and attitudes affect more specific attitudes (Larson and Clark 2023; Manfredo 2008; Whittaker et al. 2006). For example, wildlife value orientations (WVOs) capture commonly held worldviews, including biocentric protectionism and anthropocentric domination, which strongly influence attitudes toward wildlife (Fulton et al. 1996; Manfredo et al. 2009; Teel and Manfredo 2010). An individual's affinity for a particular place or local ecosystem (e.g., deserts) may further affect their views of native wildlife (Anderson and Fulton 2008; Fulton et al. 1996). In addition, political orientations may affect attitudes toward wildlife and their management, especially those involving politically contentious government actions and regulatory policies (Dietsch et al. 2019; Manfredo et al. 2020). Accordingly, we hypothesized that individuals' WVOs would widely affect attitudes toward wildlife; affinity for desert ecosystems would especially affect stewardship of unique native wildlife; and liberal political identities would increase support for protecting wildlife.

Risk perception theory highlights how public views of environmental hazards and other threats depend on the characteristics of risks (e.g., whether they are catastrophic and controllable), personal experiences with them, and various social filters such as media and peer groups (Slovic 1987; Kasperson et al. 1988). Thus, a myriad of factors affect the willingness to accept risks, and perceptions often diverge from expert assessments based on the statistical likelihood of outcomes. While personal, social, cultural, and contextual factors combine to influence perceived risks, familiarity with a threat also tends to dampen them (Slovic 1987; Jenkins et al. 2024). While this may not be the case when people's lives and livelihoods are threatened by wildlife attacks, we expected the familiarity thesis may apply to urban wildlife. The familiarity thesis posits that increased experiences with wildlife could increase tolerance, with empirical support in recent studies of diverse wildlife including small mammals, snakes, and insects (Haight et al. 2023b; Larson et al. 2024; Liordos et al. 2020; Ngo et al. 2019; Zsido et al. 2022). Relatedly, nature experiences such as visiting parks increase awareness of wildlife and associated recreational activities (Hayes Hursh et al. 2024; Ngo et al. 2019). Hence, we hypothesized that environmental and personal factors that increase exposure to urban wildlife, such as park visitation and tenure of residency, may increase tolerance of potential wildlife threats while fostering attitudes conducive to coexistence.

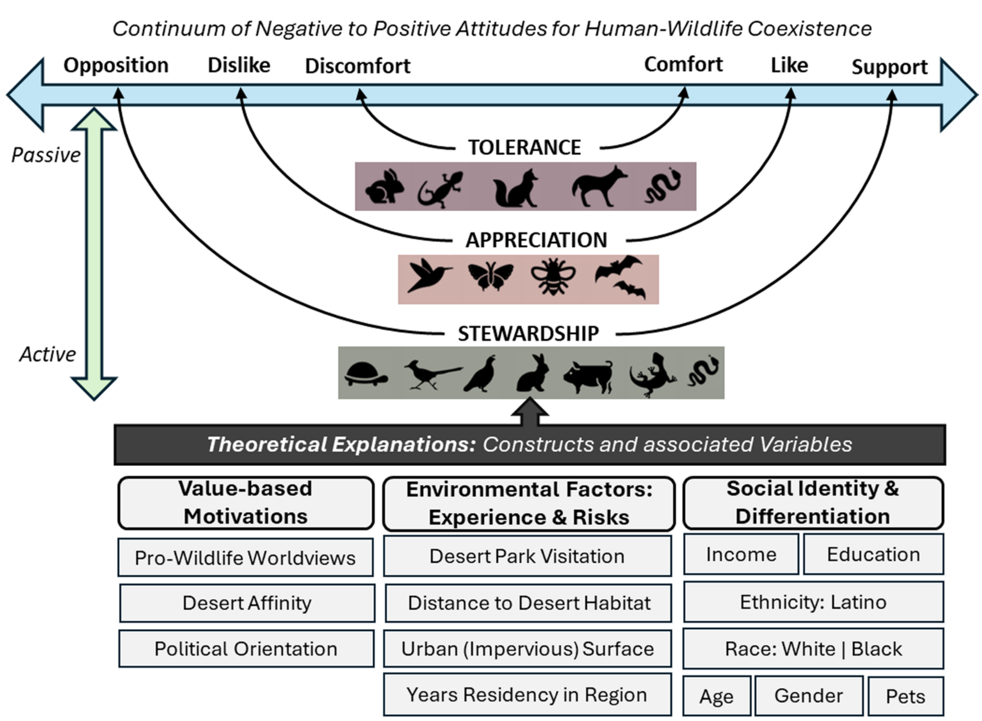

Fig. 1 Conceptual overview of the multivariate models analyzing multifaceted attitudes and underlying drivers for human-wildlife coexistence. The top of the graph depicts the negative-to-positive attitudes we analyzed (i.e., as dependent variables) reflecting tolerance, appreciation, and stewardship of distinct wildlife. The lower part highlights the three sets of theoretical predictors with variables specified in boxes.

As indicated above, social identity and differentiation mediate how people perceive and respond to environmental risks and benefits (Grove and Burch 1997; Machlis et al. 1997). Applied to wildlife, sociodemographics (such as age, gender, education) have been significantly associated with attitudes toward wildlife (Liordos et al. 2020; Ngo et al. 2019; Zsido et al. 2022). Thus, we expected that attitudes will differ by racial and ethnic backgrounds, socioeconomic levels, gender, and life stage or lifestyle factors that affect people's experiences and views of distinct types of wildlife. This hypothesis is consistent with risk perception theory, which emphasizes how people's subjective views vary based on personal characteristics and socialization (Kasperson et al. 1988; Jenkins et al. 2024). Rather than testing specific hypotheses about socio-demographic factors, we examined how varied personal and social attributes of residents differentially influence attitudes toward wildlife. In addition to standard socio-demographics including age, gender, education, income, race and ethnicity, we examined pet ownership since attacks on dogs and cats is a main threat that wildlife pose for urban dwellers (Larson et al. 2023; Soulsbury and White 2015). Alternatively, despite potential threats to residents, caring for pets might signal biophilic care and concern for wildlife such that pet-owners exhibit more positive attitudes toward wildlife compared to others (Haight et al. 2023b; Larson et al. 2021; Liordos et al. 2020).

Methods

Study area

In the Sonoran Desert of central Arizona, metropolitan Phoenix is home to more than five million residents in a warm, semi-arid climate. The urban region is expansive with low-density, sprawling development interspersed with mountainous parks of remnant desert vegetation (Fig. 2), which provide significant habitat for native wildlife (Haight et al. 2023b; Cocroft et al. 2024). These desert preserves punctuate "the Valley" of the Salt, Verde, and Gila Rivers. Water flows in these perennial and intermittent rivers are highly regulated via diversions and upstream water storage in dams; however, their channels and canals serve as habitat and corridors for wildlife (Bateman et al. 2015).

Common wildlife in metropolitan Phoenix include mammals such as coyotes (*Canis latrans*), gray foxes (*Urocyon cinereoargenteus*), collared peccary (*Pecari tajacu*; colloquially and heretofore known as javelina), desert cottontail (*Sylvilagus audubonii*), and black-tailed jackrabbit (*Lepus californicus*). Distinct native bird species include Gambel's quail (*Callipepla gambelii;* referred to throughout as quail), the greater roadrunner (*Geococcyx californianus;* referred to as roadrunner), and four species of hummingbirds. Pollinators include the monarch butterfly (*Danaus Plexippus*) and other butterfly species, as well as several species of bats

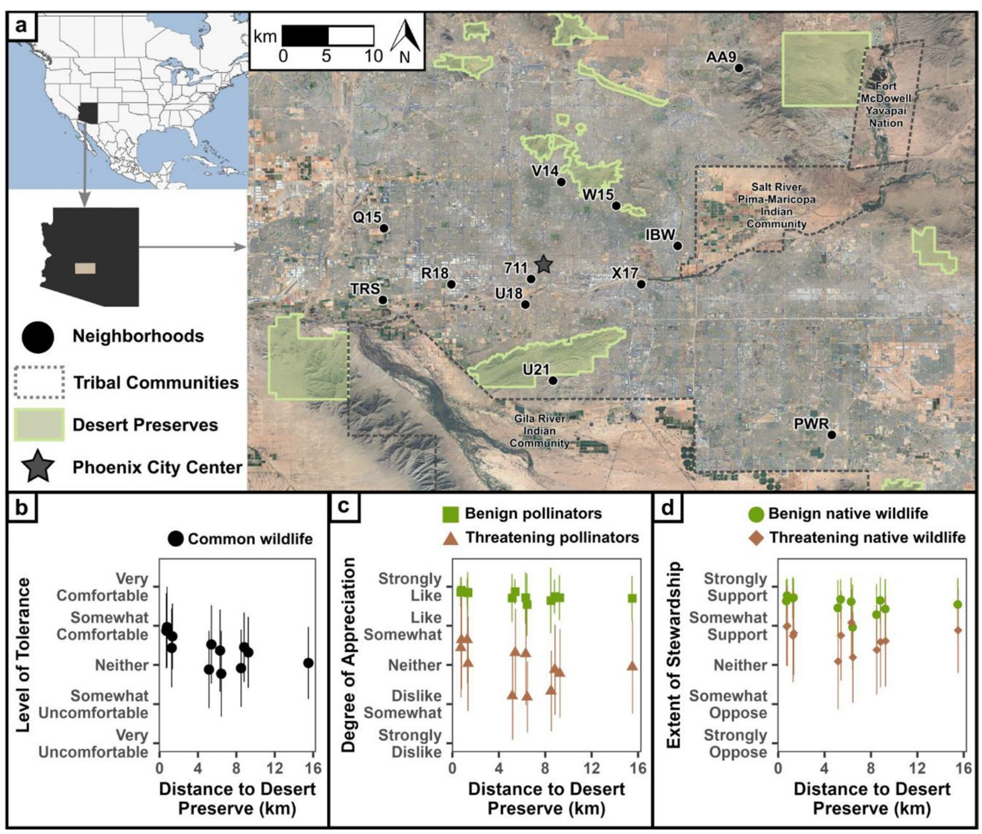

Fig. 2 The study area and mean attitudes by neighborhood relative to the nearest desert preserve in metro Phoenix, Arizona. (**a**) Location of surveyed neighborhoods relative to desert preserves and other landscape features, and neighborhood averages for attitudes based on proximity to preserves: (**b**) common wildlife (rabbits, lizards, foxes, coyotes, snakes), (**c**) benign (hummingbirds, butterflies) and threatening pollinators (bees, bats); and (**d**) benign native wildlife (desert tortoise, roadrunner, quail, jackrabbit), and threatening native wildlife (Gila monster, javelina, rattlesnake). Points and bars correspond to the mean +/- 1 standard deviation for all respondents in each neighborhood.

and bees. The Sonoran Desert is also home to several species of lizards and snakes, with venomous reptiles including six species of rattlesnakes (*Crotalus* sp.) and the distinctive Gila monster (*Heloderma suspectum*). The Sonoran Desert tortoise (*Gopherus morafkai*) is another iconic reptile in the region. According to the state of Arizona (Arizona Game and Fish Department 2025), "Species of Greatest Conservation Need" include: the Sonoran Desert tortoise and Gila monster as "tier 1" priorities; two venomous rattlesnake species and non-venomous reptiles (three snake and three lizard species) as "tier 2" priorities; and three hummingbird species (broad-billed, Costa's, and rufous) and several bat species (including the Mexican long-nosed bat) of varying priority levels.

Survey sampling and implementation

The data for this study were collected through a survey focused on human-environment dynamics in metropolitan Phoenix. With a random, stratified sampling design, the 2021 survey focused on twelve neighborhoods purposively chosen due to past and ongoing research in the area (see Fig. 2 for locations and areal coverage). Delineated by U.S. census tracts, the neighborhoods are diverse demographically (e.g. low to high income) and locationally (across urban, suburban, and fringe locations of the metro area).

The sampling frame included addresses ($n = 496$) from a previous (2017) survey, in addition to new addresses ($n = 1053$) randomly drawn from the U.S Postal Services Delivery Sequence Files within neighborhoods. We oversampled five neighborhoods with low participation in 2017, which were lower income areas, by randomly sampling 105 addresses, compared to 75 addresses from the other neighborhoods.

The multi-model survey was implemented through the internet and mail. To increase participation, five mailings began with an initial letter with a web address for the online survey starting in early May, followed by a survey booklet with pre-paid, self-addressed envelopes for their return, and then a postcard reminder. We followed up with non-respondents with two additional full survey packets (i.e., printed booklets with return envelopes) in June and July. The survey offered a $5 pre-completion incentive with the first survey packet and a post-completion $25 Visa gift card for respondents. Each full packet also included a postage card so participants could request a Spanish copy of the questionnaire, and a Spanish version of the survey was also sent in the third packet to households with Spanish surnames.

The response rate for the survey was 35.6% ($n = 509$). Although the sample was representative of the surveyed neighborhoods in terms of household income and average age of adults, the sample was more highly educated and underrepresented Latinos compared to the population. Due to the sample characteristics and neighborhood-based sampling design, we focus our interpretation of results on the patterns and relationships among attitudes and associated explanatory variables.

Data and variables

Dependent variables

To operationalize tolerance, appreciation, and stewardship as central concepts for coexistence, we evaluated three dimensions of residents' attitudes (i.e., as dependent variables, see Figs. 1 and 3; supplementary Table A). First, the *tolerance* measure represented levels of *dis/comfort* living around common wildlife in the study region and other urban areas: coyotes, foxes, rabbits, lizards, and snakes (Table A1). Specifically, we asked, "please tell us how comfortable or uncomfortable you would feel seeing [these] wildlife in and around where you live," with a five-point ordinal scale including: very uncomfortable (1), somewhat uncomfortable (2), neither uncomfortable nor comfortable (3), somewhat comfortable (4), and very comfortable (5).

Second, *appreciation* was captured as the extent of *dis/like* for diverse pollinators that are found in urban areas: bees, bats, hummingbirds, and butterflies (Table A2). We included these common pollinators since urban habitats can affect their populations and they provide important ecosystem services to society (Hall et al. 2017; Lerman et al. 2018). In particular, the survey asked: "to what extent do you dislike or like the following?" The response scale included: dislike a lot (1), dislike somewhat (2), neither dislike nor like (3), like somewhat (4), and like a lot (5).

Third, stewardship was operationalized as *support/opposition* for protecting iconic native wildlife: javelinas, Gila monsters, desert tortoises, jackrabbits, quail, roadrunners, and rattlesnakes (Table A3). The five-point response scale was: strongly oppose (1), somewhat oppose (2), neither oppose or support (3), somewhat support (4), and strongly support (5). We chose this set of wildlife to represent iconic species in the Sonoran Desert since they might serve as relatively unique conservation ambassadors for the study region (Larson and Clark 2023; Macdonald et al. 2017).

For all wildlife, we used colloquial wording (e.g., javelina versus collared peccary) and commonly used terminology for animals (i.e., rather than the names of species) to ensure survey respondents recognized the wildlife, and therefore, could express attitudes toward them (rather than selecting "don't know"). Using three different sets of species for each of our three attitudinal measures (tolerance, appreciation, and stewardship) allowed us to simultaneously

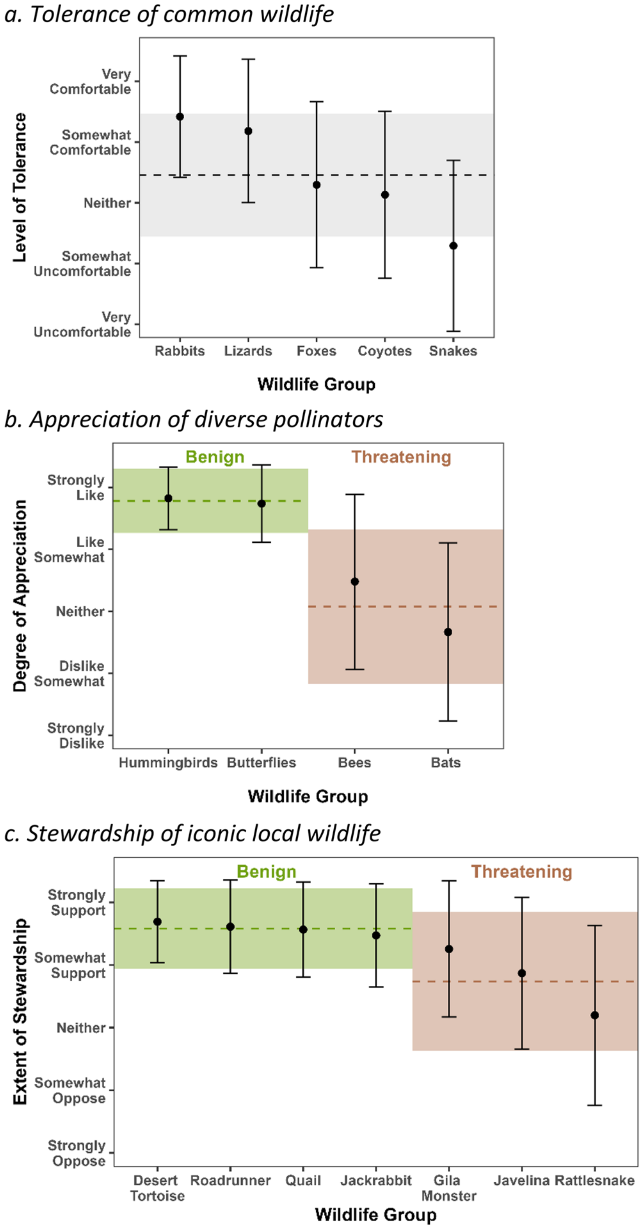

Fig. 3 The dependent variables: attitudes for tolerance (**a**), appreciation (**b**), and stewardship (**c**) of diverse wildlife. Points and bars correspond to the means +/- 1 standard deviation for individual attitude variables, and for the composite survey scales, the shaded areas and dotted lines indicate these descriptive statistics (see supplementary Table A1-3 for details)

assess multiple kinds of human-wildlife interactions while keeping the survey brief to increase response rates.

Explanatory variables

First, we measured wildlife value orientations with nine statements including three each for wildlife protectionism and human domination (Manfredo et al. 2009) and residential wildlife experiences (Fulton et al. 1996). The human domination variables were reverse coded, and a composite scale (Cronbach's alpha = 0.78) was created as the average of all nine variables. Measured on a five-point dis/agree scale with a neutral option in the middle, the average response was 3.9, indicating moderately pro-wildlife orientations among the sample. Also measured on a five-point dis/agree scale, desert affinity was a composite scale (Cronbach's alpha = 0.87) calculated as the mean of three variables (i.e., the desert is beautiful, a very special place, and a nice place to spend time; Andrade et al. 2019). With an average response of 4.0, the survey participants were somewhat positive about the desert. Political orientation was measured on a seven-point scale ranging from very, somewhat, and slightly (1–3) conservative or liberal (5–7) with a moderate option (4) in the middle; an average of 4 for the sample indicated moderate views overall.

Second, as proxies for potential environmental experience and familiarity with native wildlife, we evaluated four factors that included two survey variables—i.e., reported visitation of regional desert parks and length of residence in the study region, in addition to two variables calculated in GIS based on the location of the residents' home: distance to the nearest desert preserve and the amount of impervious surface around residents' home. Survey respondents indicated the frequency with which they had visited desert parks and open spaces in the metro area over the previous year using the following five-point scale: never (1), less than monthly (2), about monthly (3), more than once a month but not weekly (4), and at least once weekly (5). A mean response of 3 indicated monthly visits to desert preserves for the sample. Respondents also reported the number of years lived in the Phoenix region, with an average of 18 years. For the non-survey variables, we used R version 4.0.4 (R Core Team 2021) and QGIS version 3.16.16 (QGIS Development Team 2021) to capture the environmental context of people's homes. For proximity to desert preserves, which provide crucial habitat to the region's wildlife, we calculated the distance from the centroid of each respondents' parcel to the nearest desert preserve (Brown et al. 2021), with an average distance of 5.3 km and a range of 0.05–16 km. Based on data from the 2019 National Land Cover Database (Dewitz 2021), we estimated the percent of impervious surface within one kilometer of residents' homes (the mean was 42% with a range of 11–67%).

Third, survey measures captured socio-demographic variables including income and education, race and ethnicity, and age, gender, and pet ownership. We measured income on an eleven-point scale of $20,000 increments that ranged from $20,000 or less (1) to more than $200,000 (11). We also asked residents to report their highest level of education on a six-point scale: grades 1–8 (1), 9–11 (2), high school diploma (3), some college or vocational training (4), a bachelor's degree (5), and graduate school (6). The average income for the sample was 5.9, or roughly $100,000, and the average educational level was 4.6, equating to some college or a bachelor's degree (Table 1). For race and ethnicity, survey respondents could check all that apply from standard options included in census reports. More than two-thirds of the sample identified as white, about a fifth as Hispanic or Latino (heretofore called Latino), and 6% as black, with a small number of Latinos self-identifying as white ($n=9$) or black ($n=2$). Calculated from the reported year that participants were born, the average age of survey respondents was 54 years. More than half (63%) identified as women, which included two non-binary participants, and the rest identified as men. Lastly, more than half (58%) of respondents had at least one cat or dog.

Statistical analysis

Statistical analysis was conducted in the Statistical Package for Social Sciences (SPSS), version 27. We ran descriptive statistics for the (16) individual attitudes for distinct wildlife representing residents' levels of tolerance (5), appreciation (4), and stewardship (7). Next, factor analysis with principal components extraction and Direct Oblimin (Kaiser) rotation examined the dimensionality in the three sets of attitudes. The factor analysis informed the creation of composite survey scales that comprise the dependent variables in our multivariate models (supplementary Table A1-3).

Table 1 Descriptive statistics for explanatory variables. *For binary variables, the percentage and mode are presented instead of the mean and media, respectively.

Explanatory Variables	Mean (or Percent)*	Median (or Mode)*	St. Dev.	Range
Value-based Beliefs				
Pro-wildlife orientations	3.92	4.0	0.66	1–5
Desert affinity	4.06	4.0	0.92	1–5
Political orientation	3.95	4.0	1.65	1–7
Environmental Experience				
Desert visitation	3.09	3.0	1.33	1–5
Length of residency (years)	27.6	25.0	17.8	<1–81
Distance to preserve (km)	5.39	5.34	4.55	0.05–16.0.05.0
Impervious surface (%)	0.42	0.41	1.15	0.11–0.67
Demographic Attributes				
Income	5.87	5.0	3.34	1–11
Education	4.63	5.0	1.19	1–6
Race: white	67.0%	1	n.a.	0–1
Ethnicity: Latino	19.8%	0	n.a.	0–1
Race: black	5.9%	0	n.a.	0–1
Age (years)	54.3	56.0	17.4	18–100
Gender: women	62.7%	1	n.a.	0–1
Pet(s): cat/dog	58.2%	1	n.a.	0–1

As detailed below for the factor analysis, attitudes for both wildlife appreciation and stewardship were distinguished by benign versus potentially threatening animals. Thus, simple linear regression models analyzed predictors for five highly reliable and distinct attitudinal scales that reflect: (dis)comfort with common wildlife (i.e., tolerance), (dis)like of benign vs. threatening pollinators (i.e., appreciation), and support (vs. opposition) for protecting benign vs. threatening iconic wildlife (i.e., stewardship). With missing values replaced by the sample mean for the explanatory variables, all model fits were strong, and multicollinearity was not problematic based on common criteria for tolerance (above 0.2) and variance inflation factors (VIF below 2.5; Mansfield and Helms 1982). In the results, we report the adjusted R^2 values for each model while emphasizing variables significant at $p<0.05$ and interpret the standardized Betas (β) of explanatory variables (i.e., which involve different data types and numeric units) to compare their relative influence on each dependent variable. Moreover, β values indicate effect sizes across models, wherein 0.10–0.29 are small, 0.30–0.49 are medium, and >0.50 are large (Cohen 1988; Nieminen 2022).

To test the explanatory power of each set of theoretical predictors, we first ran partial models (supplementary Table B) with each set of variables (Fig. 1) to compare model fits and significant predictors for broad, value-based judgements, environmental factors that reflect potential wildlife risks and experiences, and socio-demographic attributes. We then present the final results for the full models of all predictors for each distinct attitudinal dimension (supplementary Table C), the results of which we underscore in the discussion.

Results

As a whole, residents' distinct attitudes toward wildlife were best explained by different explanatory factors (Fig. 4 and supplementary Tables B and C). Yet overall, value-based judgments, especially pro-wildlife worldviews, consistently and most strongly explained all five attitudes, followed by social differentiation based on race, ethnicity, and other sociodemographic attributes including gender, pet ownership, age, and income. Environmental factors explained the least amount of variation across the attitudinal dimensions we evaluated, although our hypotheses about nature experiences, specifically frequency of visiting desert preserves and proximity to them (Fig. 2), significantly explained specific attitudes reflecting tolerance and stewardship. Although our hypotheses regarding the three sets of predictors for attitudes were supported by the statistical models, a few

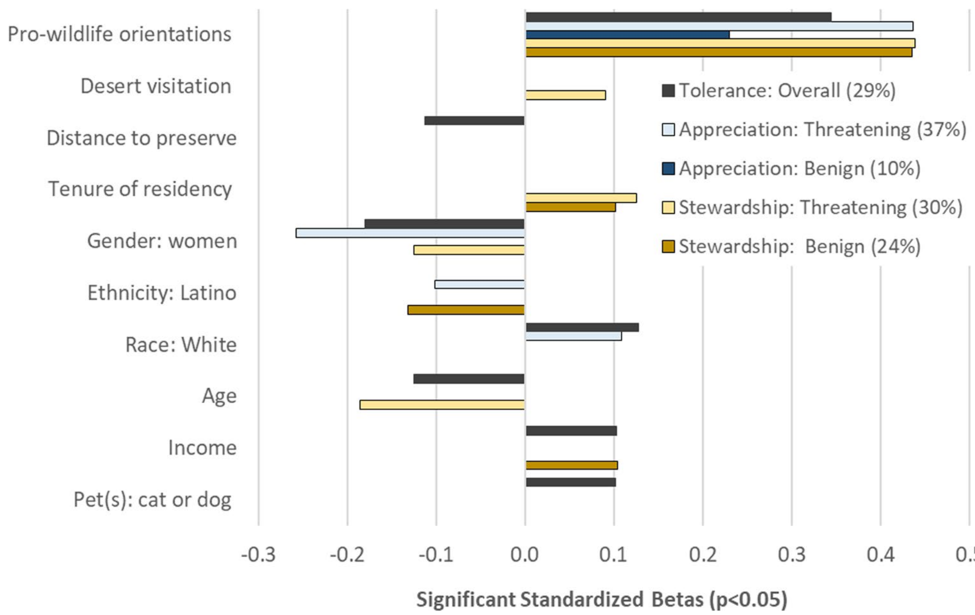

Fig. 4 Regression results explaining distinct attitudes toward wildlife (full models). Only significant variables are shown, with the percentage of variance explained based on adjusted R^2 values in parentheses for each dependent variable. Insignificant variables included desert affinity, pollical orientation, impervious surface, education, and race: black. See supplementary Table C for model details. For wildlife captured in the dependent variables, see Fig. 3

variables were insignificant in all models (i.e., education, political orientation, and impervious surface).

Multidimensional attitudes toward different wildlife

Regarding *tolerance*, more than three-fourths of survey respondents were either somewhat or very comfortable living near rabbits and lizards, whereas the percentages dropped to just below half for foxes and coyotes and only a quarter for snakes, which was the only wildlife toward which a majority of participants expressed discomfort (Fig. 3a; details in supplementary Table A1). On average, residents were "somewhat uncomfortable" living around snakes (mean = 2.3), relatively "neutral" about coyotes (3.1) and foxes (3.3), and "somewhat comfortable" with lizards (4.2) and rabbits (4.4). With decreasing levels of comfort, residents' attitudes exhibited greater variation around the means (Fig. 3a). Based on the factor analysis (Table A1), attitudes toward foxes, coyotes, lizards, rabbits, and snakes produced a single factor (loadings 0.71–87.71 and 63% of variance explained). As a composite scale (Cronbach's alpha = 0.85), the average of these five variables comprised the dependent variable for tolerance of wildlife.

For *appreciation* of pollinators, the vast majority (95–97%) of respondents reportedly like hummingbirds, in contrast to just over half for bees and only a third for bats (Fig. 3b; details in supplementary Table A2). Overall, the sample means indicated a strong appreciation of hummingbirds (4.8) and butterflies (4.7), lower appreciation of bees (3.5) and neutral attitudes to mild dislike of bats (2.7). With averages around the midpoint on the response scale, residents held more disparate views of bees and bats (Fig. 3b).

Regarding the factor analysis (Table A2), attitudes toward hummingbirds and butterflies accounted for 52% of the variance in the data (loadings > 0.9; Cronbach's alpha = 0.87), and appreciation of bats and bees accounted for 29% (loadings > 0.8; alpha = 0.81). Respectively, we labeled the two factors as benign and threatening pollinators since the latter dimension included bats, which are often associated with diseases such as rabies (Reidinger and Miller 2013) and bees, which may sting and cause allergic reactions (Turo and Gardiner 2019), whereas hummingbirds and butterflies are relatively non-threatening, or benign.

Lastly, for *stewardship* attitudes, survey respondents overwhelmingly supported (either somewhat or strongly; 85–92%) protecting iconic wildlife including desert tortoises, greater roadrunners, Gambel's quail, and black-tailed jackrabbits (Fig. 3c; details in supplementary Table A3). In contrast, 45–78% supported protecting Gila monsters, javelinas, and rattlesnakes. On average (Fig. 3c), support for stewardship was strong for tortoises, roadrunners and quail (4.6 for both), and jackrabbits (means = 4.5–4.7) with more moderate support for Gila monsters (4.3) and javelinas (3.9). The sample was relatively split and neutral about rattlesnakes (mean = 3.2), with about one-third of respondents opposing their protection. Similar to appreciation of pollinators, *stewardship* attitudes were distinguished by two factors reflecting stronger support for relatively benign wildlife (loadings > 0.7–9.7; 57% of variance explained) compared to the potentially threatening wildlife (loadings > 0.7–9.7; 16% of variance explained; Table A3). The composite scales for these attitudinal dimensions were highly reliable for benign (Cronbach's alpha = 0.87) and threatening (alpha = 0.81) iconic wildlife.

Table 2 Regression results for ***partial*** models testing distinct theoretical predictors of wildlife attitudes. Standardized Betas presented at $p<0.01$***, $p<0.05$**, and $p<0.1$* levels, along with adjusted R^2 values. Missing values replaced by means. Bolded Beta values indicate significant variables in the full models at $p<0.05$ (Fig. 4 and Table B). See Supplementary Tables D for additional partial model details

Explanatory Variables: Partial Models	Comfort: Common Wildlife	Like: Pollinators Benign	Like: Pollinators Threatening	Support: Iconic Benign	Support: Iconic Threatening
Model 1: Value-based Beliefs	*R2 = 0.17 F = 35.3 p < 0.001*	*R2 = 0.07 F = 13.3 p < 0.001*	*R2 = 0.25 F = 58.0 p < 0.001*	*R2 = 0.21 F = 45.6 p < 0.001*	*R2 = 0.25 F = 56.5 p < 0.001*
Pro-wildlife values	**0.38*** **	**0.26*** **	**0.45*** **	**0.45*** **	**0.44*** **
Desert affinity	0.11**	0.05	0.10**	0.03	0.11**
Politically liberal	−0.04	−0.05	0.02	−0.01	0.04
Model 2: Environmental Experiences	*R2 = 0.07 F = 11.0 p < 0.001*	*R2 = 0.02 F = 3.6 p = 0.007*	*R2 = 0.06 F = 9.6 p < 0.001*	*R2 = 0.02 F = 4.0 p = 0.003*	*R2 = 0.04 F = 6.2 p < 0.001*
Desert visitation	0.13***	0.04	0.17***	0.10**	**0.21*** **
Years residency	0.02	0.11**	−0.02	**0.10** **	**0.07**
Distance to preserve	**−0.22*** **	−0.11**	−0.17***	−0.09**	−0.02
Impervious surface	−0.07	−0.02	0.05	0.01	−0.02
Model 3. Demographic Attributes	*R2 = 0.17 F = 11.5 p < 0.001*	*R2 = 0.06 F = 4.7 p < 0.001*	*R2 = 0.17 F = 13.3 p < 0.001*	*R2 = 0.06 F = 5.2 p < 0.001*	*R2 = 0.07 F = 5.6 p < 0.001*
Income	**0.14*** **	0.03	0.03	**0.08**	0.07
Education	−0.01	0.03	0.06	−0.04	0.03
Race: white	**0.20*** **	0.12**	**0.21*** **	0.14***	0.15**
Ethnicity: Latino	*−0.10**	−0.07	**−0.14*** **	**−0.13** **	−0.05
Race: black	−0.09**	−0.03	−0.05	−0.02	0.00
Age	**−0.07**	0.13***	−0.03	0.02	**−0.13** **
Gender	**−0.14*** **	**0.10** **	−0.22***	−0.02	*−0.08**
Pet(s): cat or dog	**0.13*** **	−0.01	0.10**	0.11**	0.12***

Explanations for multi-dimensional attitudes toward wildlife

Partial model results

Among the three sets of predictor variables, *value-based cognitive factors* best explained attitudes (7–25% of variation), particularly toward threatening and iconic wildlife (Table 2 and supplementary Table B). Specifically, the highest adjusted R^2 values for the partial models were for appreciation of the threatening pollinators ($R^2=0.25$) and stewardship support for threatening iconic wildlife ($R^2=0.25$), followed by benign iconic wildlife ($R^2=0.21$). The cognitive variables also explained variation in people's tolerance of common wildlife ($R^2=0.17$) and appreciation of benign pollinators ($R^2=0.07$). Based on standardized Betas ranging from 0.26 to 0.45, pro-wildlife worldviews most strongly yet moderately influenced all attitudes (Table 2). Additionally, desert affinity was significant, albeit with low effect sizes (β=0.10–0.11), for tolerance of common wildlife and stewardship support for both sets of iconic wildlife. Political orientation was insignificant in all five partial models.

Compared to both cognitive and socio-demographic factors, the partial models testing how *environmental* factors affect attitudes toward wildlife explained the least amount of variation (2–7%; Table 2 and supplementary Table B). The environmental variables best explained tolerance of common wildlife ($R^2=0.07$) and appreciation of threatening pollinators ($R^2=0.06$), followed by stewardship support for threatening iconic wildlife ($R^2=0.04$) and appreciation of benign pollinators (both $R^2=0.02$). While Betas were relatively small in these partial models, the strongest environmental variables (β values around 0.2; Table 2) were distance from desert preserves, which decreased tolerance of wildlife (Fig. 2), and desert visitation, which increased stewardship of threatening iconic wildlife. Desert visitation significantly explained four of the five attitudinal scales (β=0.13–0.21), with the exception being appreciation of benign pollinators. Distance from desert preserves was also significant in four models (β = −0.09 to −0.22), with the exception of stewardship support for threatening iconic wildlife. In addition, tenure of residency explained attitudes toward both groups of benign wildlife (β=0.10–0.11), but not threatening wildlife or tolerance of common wildlife. Impervious surface was insignificant across all partial models with the environmental variables.

Based on adjusted R^2 values, the *social differentiation* models explained a moderate amount of variation (6–17%) in attitudes compared to the above models. All socio-demographic variables except education were significant for at least one attitudinal dimension, although the standarized Beta values indicated small effects (Table 2; supplementary Table B). Socio-demographics best explained tolerance of common wildlife and appreciation of threatening pollinators (R^2=0.17 for both models), followed by support for protecting threatening (R^2=0.07) and benign (R^2=0.06) iconic wildlife and appreciation of benign pollinators (R^2=0.06). For all five models, white residents were significantly more positive about wildlife than others (β=0.14–0.21), with comparatively high Betas (~0.2) for tolerance of wildlife and appreciation of threatening pollinators. In contrast, Latino residents were more negative toward threatening pollinators and benign iconic wildlife (β = −0.14 and −0.13 respectively). Black residents were also less tolerant of wildlife (−0.09). Meanwhile, higher income residents were more tolerant of wildlife (β=0.14) than lower income residents. Additionally, women were less appreciative of threatening pollinators (β = −0.22) and less tolerant of wildlife (−0.14) than men; however, women expressed greater appreciation of benign pollinators (0.10). Similarly, age had varying effects on attitudes toward wildlife, with older people expressing greater appreciation of benign pollinators (β=0.13) but lower stewardship support for threatening iconic wildlife (−0.13). Lastly, pet ownership was significantly and positively related to four of the distinct attitudes (0.11–0.13), excluding appreciation of benign pollinators.

Full model results

With all three sets of explanatory variables, the full models (Fig. 4) best explained attitudes toward threatening pollinators (R^2=0.37) and iconic local wildlife (R^2=0.32), as well as comfort living near common wildlife (R^2=0.29). Stewardship support for benign wildlife was also relatively well explained by the full models (R^2=0.24) but less so for appreciation of benign pollinators (R^2=0.10). Wildlife value orientations was the only variable significant in all five models, with small to moderate effects; in particular, standardized Betas ranged from a low of 0.23 for appreciation of benign pollinators and 0.34 for tolerance for common wildlife to a high of 0.44 for appreciation of threatening pollinators and stewardship support for both threatening and benign iconic wildlife (details in supplementary Table C). Neither desert affinity nor political orientation were significant in any of the full models.

The environmental variables were most strongly linked to stewardship support (Fig. 4), wherein longer residency in the region and visitation of desert preserves (β=0.13 and 0.09 respectively) increased support for protecting threatening iconic wildlife. Tenure of residency was also significant (0.10) for protecting benign iconic wildlife. Meanwhile, distance to desert preserves explained comfort living near wildlife (β=−0.11), with residents closer to preserves exhibiting greater tolerance. As an indicator of urbanization, the impervious surface variable was insignificant in all models (Table C).

Similar to the partial models, sociodemographic factors exhibited complex relationships with attitudes toward wildlife, as no single explanatory variable was significant across all five attitudes (Fig. 4). Gender had the highest Beta values in absolute terms, with women expressing lower appreciation of threatening pollinators (β = −0.22), lower tolerance of common wildlife (−0.18), and lower stewardship of threatening iconic wildlife (−0.13) compared to men. Meanwhile, older people exhibited lower tolerance for living around common wildlife (β = −0.19) and lower levels of stewardship support for threatening iconic wildlife (−0.13). The white and Latino variables (β=0.11 and −0.10 respectively) were also significant for appreciation of threatening pollinators; moreover, white residents expressed greater tolerance of wildlife compared to other residents (0.13), and Latino residents expressed lower stewardship support for benign iconic wildlife (−0.10). Additionally, wealthier residents expressed greater tolerance around common wildlife (β=0.10) and greater stewardship support for benign desert species (0.10) compared to lower-income residents. Lastly, pet ownership was significant in one full model, such that people who have at least one dog or cat expressed more tolerance for living around wildlife compared to people without these pets (supplementary Table C).

Discussion

Aligning with past research (Fulton et al. 1996; Teel and Manfredo 2010), our study demonstrates that pro-wildlife views dominated explanations of varied attitudes. This finding confirms that value-based judgments substantially influence specific attitudes; however, affinity for the desert had minimal impact on select yet diverse attitudes (Table 2), and political orientations were not significant for stewardship attitudes (as hypothesized) or otherwise (Table C). Our hypotheses regarding environmental factors were partially supported, wherein factors reflecting local nature experiences explained tolerance of common wildlife and stewardship of iconic local wildlife, but not appreciation of pollinators. This finding validates past research that suggests nature experiences positively impact attitudes, including tolerance for relatively disliked wildlife such as snakes (Larson et al. 2024; Ngo et al. 2019). Meanwhile, despite the lower occurrence of wildlife in urbanized areas (Haight et al. 2023a), developed land (as measured by impervious surface) around residents' homes did not affect attitudes. Lastly, our hypothesis about attitudes varying by social identity and related demographic attributes was confirmed, with race and ethnicity, socioeconomic status, and age and gender influencing distinct attitudes in complex ways, thereby demonstrating the discriminant validity of the attitudinal dimensions we analyzed. As discussed further below, our analysis of multidimensional attitudes toward distinct wildlife underscores the need to tailor wildlife and land management in heterogenous cities to diverse people, places, and wildlife to achieve social legitimacy of coexistence through holistic yet stratified approaches (Larson and Clark 2023; Liordos et al. 2020; Tan et al. 2020).

Dominance of value-based judgments

The significance of wildlife values in explaining multifaceted attitudes in our study is consistent with the cognitive hierarchy model (e.g., Manfredo 2008; Teel and Manfredo 2010; Whittaker et al. 2006). Although not surprising or novel, this finding amplifies the importance of understanding value-based views and their implications for managing human-wildlife interactions, especially since attitudes and underlying values are difficult and slow to change (Heberlein 2012; Larson and Clark 2023; Manfredo 2008). Given the beliefs embodied in the pro-wildlife worldviews we evaluated, conservation messaging might emphasize mutualism, protectionism, and appreciation, which are values that have increased in the US in recent decades (Manfredo et al. 2020). Outreach aimed at coexistence could further emphasize anthropocentric benefits such as pest control, especially for undervalued wildlife such as snakes, which residents may be willing to protect despite negative attitudes (Larson et al. 2024). Our results also highlight the importance of controlling for worldviews to understand the effect of other factors—such as environmental experiences and socio-demographics—on attitudes toward different wildlife.

Role of nature experiences and environmental factors

Broadly, our results for environmental factors indicate that, similar to the familiarity thesis in risk perception research, residents' experiences with wildlife may attenuate perceptions of related risks and increase people's tolerance of wildlife (Jenkins et al. 2024; Kasperson et al. 1988; Lute et al. 2020; Slovic 1987). This finding is notable since (1) risk perception research has largely focused on natural and technological hazards; and (2) much of the human-wildlife research has demonstrated intolerance for wildlife among people who are most affected by threats (e.g., ranchers whose livestock is threatened by large carnivores; Lute and Gore 2019). In contrast, urban residents in our study who were more likely to encounter wildlife—that is, based on proximity to habitat, how often they had visited desert preserves, and how long they had lived in the Sonoran Desert of metro Phoenix, Arizona—exhibited higher tolerance for wildlife and greater support for stewardship of iconic wildlife. Importantly, positive attitudes extended to both tolerance and conservation support for potentially threatening wildlife including coyotes, javelina, and rattlesnakes.

Coupled with our finding that stewardship and other attitudes were not significantly influenced by political orientation, our results indicate that fostering experiences with nature and wildlife may enhance stewardship and conservation efforts in ways that can transcend partisan politics. Based on our findings and others (e.g., Liordos et al. 2020; Ngo et al. 2019), outreach activities that incorporate nature experiences–especially hands-on and field-based learning about wildlife (e.g., Larson et al. 2024; Prévot et al. 2018)—could increase positive attitudes toward wildlife and their protection. In addition, since childhood experiences are formative for conservation attitudes and behaviors (Larson et al. 2024; Ngo et al. 2019), youth-oriented programs are recommended, along with those targeted to communities underserved by nature experiences (Kuras et al. 2020; Rowland-Shea et al. 2020).

Socially heterogenous attitudes toward wildlife

Our findings for sociodemographic drivers of attitudes underscore how social heterogeneity and differentiation (Grove and Burch 1997; Machlis et al. 1997) affect multifaceted attitudes toward diverse wildlife (Liordos et al. 2020; Ngo et al. 2019; Zsido et al. 2022). In particular, we found that lower-income, non-white and Latino residents expressed lower tolerance and appreciation of wildlife, specifically in terms of feeling less comfortable around wildlife and disliking pollinators such as bats and bees more so than higher income and non-Latino residents. Latinos were also less supportive of protecting benign iconic wildlife including quail, jackrabbits, and reptiles. These findings may be due to lower access to natural areas among Latinos (Kuras et al. 2020; Rowland-Shea et al. 2020); however, more research is needed to fully understand how and why ethnoracial beliefs and experiences affect people's experiences with and attitudes toward wildlife (Dietsch et al. 2019; Lute and Gore 2019).

Since threats to pets are among the top risks that wildlife pose to urban residents (Soulsbury and White 2015), the biophilic effects of pet ownership in our study—as well as others (e.g., Haight et al. 2023b; Larson et al. 2021; Liordos et al. 2020)—suggest that risks to pets may be less of a problem for coexistence than intuitively assumed. Acknowledging potential harms to pets, however, could still include keeping pets indoors, supervised, or on leashes to keep them safe, especially given the negative impacts pets have on wildlife (Loss et al. 2013). The combined message of keeping both pets and wildlife safe could broadly appeal to diverse residents, rather than focusing on one message or the other.

Together, our novel findings regarding positive attitudes linked to both pet ownership and residents' proximity to nature preserves (i.e., as primary urban habitat) warrant deeper examination since both factors increase the potential threats of wildlife to people (Soulsbury and White 2015; Larson et al. 2023). In light of "Not in My Backyard" (NIMBY) opposition to environmental risks, including decreased tolerance of 'backyard wildlife' in some studies (e.g., Hamazaki and Tanno 2002; Scott et al. 2016), our findings are surprising and significant for coexistence since risk factors were linked to higher tolerance and support for stewardship. Future studies could further test our results through similar approaches that couple survey data with geolocated environmental variables, such as proximity to wildlife corridors and other habitat features. Additional research could also explore how fear or other factors underly perceived threats and tolerance of wildlife risks.

Research limitations and future research

We acknowledge several limitations to our study. First, we only evaluated certain dimensions of tolerance, appreciation, and stewardship for limited types of wildlife. Future research could build on this research by examining distinct attitudes under the coexistence framework, inclusive of small mammals, herpetofauna, invertebrates, and other understudied wildlife (Collins et al. 2021; Magle et al. 2019). Similar research can inform holistic approaches to managing wildlife in shared urban landscapes while complementing single-species or taxa research to identify varied public responses to different wildlife (Liordos et al. 2020; Tan et al. 2020). To this end, operationalizing attitudes and behaviors within the framework of coexistence is worthwhile for managing a range of passive-to-active interactions (from tolerance to stewardship; Fig. 1) and outcomes for both wildlife and people. Second, regarding our environmental measures for nature and residential experiences broadly, future studies could more precisely examine how specific experiences with wildlife uniquely affect different attitudes and behaviors. Third, given varied findings about sociodemographics within and across studies, as well as our limited focus on neighborhoods in metropolitan Phoenix, meta-analyses or systematic literature reviews (similar to Kansky et al. 2014) could compare how different socio-demographic attributes affect attitudes toward distinct wildlife across geographic contexts.

Lastly, we realize that the R^2 values for some of our models were small, as were the effect sizes for explanatory variables based on standardized Betas (Cohen 1988; Nieminen 2022). As noted above, improved measures for experiences with wildlife could increase the explanatory power of multivariate models, since our environmental models explained the least amount of variance in attitudes toward widllife. In general, since our goal was not to predict attitudes (Ozili 2023), but instead to compare explanations for multifaceted attitudes across distinct theoretical predictors for different dimensions of attitudes toward wildlife, the results of our research are nonetheless informative.

Implications for human-wildlife coexistence

Overall, heterogeneity in attitudes across different people and places (Figs. 2 and 3) calls for diverse strategies for human-wildlife coexistence, including those aimed at managing both human-wildlife interactions and human-to-human conflicts (Lute and Gore 2019; Pooley et al. 2021). For the latter, identifying attitudes that are negative or neutral, on average, and highly varied (e.g., for coyotes and bats; see Fig. 3) can help wildlife managers anticipate and plan for disagreement over contentious species. Moreover, when residents exhibit low tolerance and appreciation of wildlife (e.g., potentially threatening snakes and bats; Fig. 3), management efforts could focus on deterrence strategies to keep unwanted wildlife off private property. To increase their effectiveness while preventing harm to wildlife, evidence-based deterrence efforts (e.g., hazing; Sampson and Van Patter 2020) could be tailored to species such as coyotes or to neighborhoods with high occurrence of unwanted or potentially threatening wildlife (Haight et al. 2023a). As another example, removal of low-lying vegetation (e.g., lantana) and other landscape features (e.g., hose containers), which serve as places for snakes to shelter and forage, can prevent feared or unwelcomed wildlife on residential or other properties, as can snake-proof fencing (Bateman et al. 2021; Enloe et al. 2024). Whether through fencing, vegetation maintenance, or removal of attractants such as pets, food, and water (Reidinger and Miller 2013), deterrence strategies are important for coexistence in the face of negative attitudes toward particular wildlife. Considering that coexistence involves managing conflicts and intolerance toward wildlife (Bhatia 2021; Glikman et al. 2021; Pooley et al. 2021), promoting conflict-prevention strategies that keep people safe and reassured while also protecting wildlife populations are a crucial part of the management toolkit for coexistence.

Meanwhile, when public appreciation is high (e.g., for pollinators such as hummingbirds and butterflies) or stewardship support is widespread (e.g., for iconic wildlife such as desert tortoise and roadrunners), wildlife could serve as conservation ambassadors (Macdonald et al. 2017). Since desert tortoises, monarch butterflies, and some species of hummingbirds are imperiled in the state of Arizona, these species might be well-poised for garnering support conservation in the region. Given urban habitat particularly supports pollinators (Larson et al. 2021; Lerman et al. 2018), hummingbirds and butterflies represent promising wildlife to serve as ambassadors for stewardship programs such as the USA-based National Wildlife Federation's habitat certification program.

Conclusion

Overall, we found that residents' multifaceted attitudes toward wildlife reflect varying levels of positivity and agreement among residents linked to tolerating, appreciating, and stewarding urban wildlife. Since nature experiences appear to increase tolerance and positive attitudes, outreach activities could center experiential learning about undervalued wildlife or species that pose potential threats. Communities with more negative attitudes may require tailored outreach to increase their tolerance of wildlife, such as Latino residnets in this study. By examining a variety of cognitive, experiential, and socio-demographic influences on attitudes and behaviors, wildlife managers and land planners will be better equipped to manage human-wildlife interactions for coexistence and conservation. Moreover, tailoring various strategies to specific contexts can help achieve social legitimacy while improving management of heterogenous, shared landscapes in urban environments.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11252-026-01946-0.

Acknowledgements This material is based upon work supported by the National Science Foundation under grant numbers DEB-1832016 and DEB-2224662, Central Arizona-Phoenix Long-Term Ecological Research Program (CAP LTER). We thank Jeffrey A.G. Clark for his assistance with data collection, as well as Becky Ball for her leadership of the CAP LTER. We are also grateful for survey administration support by Kyle Endres, Mary Losch, and their team at the University of Northern Iowa. The findings and conclusions in this article are those of the authors and should not be construed to represent any official USDA or U.S. government determination or policy.

Author contributions KLL led the research as senior author, including the literature review, analysis, graphics, writing, and supervision; SBL assisted with writing throughout and served as the main editor; CH and MB assisted with the literature review and data analysis as undergraduate mentees, especially during early stages of this research; JDH assisted with the literature review, discussion, and graphics (especially Figs. 2 and 3); HLB and PW assisted with the literature review, graphics (especially Figure 1), and discussion. All authors assisted with editing.

Funding This work was supported by the U.S. National Science Foundation, as specified below.

Data availability The survey data are currently being prepared for online publication. The reference will be added before publication.

Declarations

Competing interests The authors declare no competing interests.

References

Anderson DH, Fulton DC (2008) Experience preferences as mediators of the wildlife-related recreation participation: place attachment relationship. Hum Dimens Wildl 13:73–88. https://doi.org/10.1080/10871200701669971

Andrade R, Larson KL, Franklin J et al (2022) Species traits explain public perceptions of human–bird interactions. Ecol Appl 32:e2676. https://doi.org/10.1002/eap.2676

Andrade R, Larson KL, Franklin J, Hondula D (2019) Social-spatial analyses of attitudes towards the desert in a Southwestern U.S. city. Ann Am Assoc Geogr 109(6):1845–1864. https://doi.org/10.1080/24694452.2019.1580498

Arizona Game and Fish Department (2025) Arizona's biodiversity. In: Arizona wildlife conservation strategy. https://awcs.azgfd.com/arizonas-biodiversity. Accessed 22 Dec 2025

Aronson MFJ, La Sorte FA, Nilon CH et al (2014) A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. Proc R Soc B: Biol Sci 281:1780. https://doi.org/10.1098/rspb.2013.3330

Basak SM, Hossain MS, O'Mahony DT, Okarma H, Widera E, Wierzbowska IA (2023) Public perceptions and attitudes toward urban wildlife encounters–a decade of change. Sci Total Environ 834:155603

Bateman HL, Brown JA, Larson KL, Andrade R, Hughes B (2021) Unwanted residential wildlife: evaluating social-ecological patterns for snake removals. Glob Ecol Conserv 27:e01601

Bateman HL, Stromberg JC, Banville MJ, Makings E, Scott B, Suchy A, Wolkis D (2015) Novel water sources restore plant and animal communities along an urban river. Ecohydrology 8(5):792–811. https://doi.org/10.1002/eco.1560

Bhatia S (2021) More than just no conflict: examining the two sides of the coexistence coin. Front Conserv Sci 2:18

Bhatia S, Redpath SM, Suryawanshi K, Mishra C (2020) Beyond conflict: exploring the spectrum of human–wildlife interactions and their underlying mechanisms. Oryx 54(5):621–628

Bonnet X, Shine R, Lourdais O (2002) Taxonomic chauvinism. Trends Ecol Evol 17(1):1–3

Brown J, Larson K, Lerman S, Childers D, Andrade R, Bateman H, Hall S, Warren P, York A (2021) Urban Ecological Infrastructure (UEI) in the greater Phoenix, Arizona metropolitan area and surrounding Sonoran Desert region (2010–2017)[Data set]. Environmental Data Initiative

Bruskotter JT, Singh A, Fulton DC, Slagle K (2015) Assessing tolerance for wildlife: clarifying relations between concepts and measures. Hum Dim Wildl 20(3):255–270

Carter NH, Linnell JD (2016) Co-adaptation is key to coexisting with large carnivores. Trends Ecol Evol 31(8):575–578. https://doi.org/10.1016/j.tree.2016.05.006

Carter NH, Linnell JDC (2023) Building a resilient coexistence with wildlife in a more crowded world. PNAS Nexus 2:pgad030. https://doi.org/10.1093/pnasnexus/pgad030

Clark JA, May RM (2002) Taxonomic bias in conservation research. Science 297:191–192

Cocroft A, Lewis JS, Clark J, Haight J, Lerman SB, Snyder Z, Hall SJ (2024) Neighborhood ethnicity is related to mammal

occupancy and activity across a desert metropolitan area. Ecosphere 15(6):e4902. https://doi.org/10.1002/ecs2.4902
Cohen J (1988) Statistical power analysis for the behavioral sciences, 2nd ed. Hillsdale, MI
Collins MK, Magle SB, Gallo T (2021) Global trends in urban wildlife ecology and conservation. Biol Conserv 261:109236
Connors JP, Short Gianotti A (2023) Becoming killable: White-tailed deer management and the production of overabundance in the Blue Hills. Urban Geogr 202344(10):2121–2143
Dewitz J (2021) National land cover database (NLCD) 2019 products. United States Geol Surv. https://doi.org/10.5066/P9KZCM54
Dietsch AM, Manfredo MJ, Sullivan L, Bruskotter JT, Teel TL (2019) A multilevel systems view of values can inform a move towards human-wildlife coexistence. In: Frank B, Glikman JA, Marchini S (eds) Human-wildlife interactions: turning conflict into coexistence. Cambridge University Press, UK, 20–44
Draheim MM, Parsons EC, Crate SA, Rockwood LL (2019) Public perspectives on the management of urban coyotes. J Urban Ecol 5(1):juz003
Enloe A, Clark JAG, Lewis JS, Albuquerque FS, Hughes B, Bateman HL (2024) Beyond the front yard: investigating environmental drivers of residential snake removals across two spatial scales in a desert city. Urban Ecosyst 27(6):2151–2163
Frank B, Glikman JA (2019) Human-wildlife conflicts and the need to include coexistence. In: Frank and Glikman (eds) Human-wildlife interactions: Turning conflict into coexistence. Cambridge University Press, UK, pp 1–19
Fulton D, Manfredo MJ, Lipscomb J (1996) Wildlife value orientations: a conceptual and measurement approach. Hum Dim Wildl 1:4–47. https://doi.org/10.1080/10871209609359060
Glikman JA, Frank B, Ruppert KA, Knox J, Sponarski CC, Metcalf EC, Marchini S (2021) Coexisting with different human-wildlife coexistence perspectives. Front Conserv Sci 2:703174
Grade AM, Warren PS, Lerman SB (2022) Managing yards for mammals: mammal species richness peaks in the suburbs. Landsc Urban Plann 220:104337. https://doi.org/10.1016/j.landurbplan.2021.104337
Grove JM, Burch WR (1997) A social ecology approach and applications of urban ecosystem and landscape analyses: a case study of Baltimore, Maryland. Urban Ecosyst 1:259–275
Guénard B, Hughes AC, Lainé C, Cannicci S, Russell B, Williams G (2025) Limited and biased global conservation funding means most threatened species remain unsupported. Proc Natl Acad Sci 122(9):e2412479122. https://doi.org/10.1073/pnas.2412479122
Hadidian J (2015) Wildlife in U.S. cities: managing unwanted animals. Animals 5:1092–1113. https://doi.org/10.3390/ani5040401
Haight JD, Hall SJ, Fidino M, Adalsteinsson SA, Ahlers AA, Angstmann J, Anthonysamy WJB et al (2023a) Urbanization, climate and species traits shape mammal communities from local to continental scales. Nat Ecol Evol 7(10):1654–1666. https://doi.org/10.1038/s41559-023-02166-x
Haight JD, Larson KL, Clark JA, Lewis JS, Hall SJ (2023b) Social-ecological drivers of metropolitan residents' comfort living with wildlife. Front Conserv Sci 4:1248238
Hall DM, Camilo GR, Tonietto RK, Ollerton J, Ahrné K, Arduser M, Threlfall CG (2017) The city as a refuge for insect pollinators. Conserv Biol 31(1):24–29
Hamazaki T, Tanno D (2002) Totemization of wildlife and NIMBY among US college students. Hum Dimens Wildl 7(2):107–121
Hayes Hursh S, Perry E, Drake D (2024) What informs human–nature connection? An exploration of factors in the context of urban park visitors and wildlife. People Nat 6(1):230–244
Heberlein TA (2012) Navigating environmental attitudes. Oxford University Press, England
Jenkins SC, Lachlan RF, Osman M (2024) An integrative framework for mapping the psychological landscape of risk perception. Sci Rep 14:10989. https://doi.org/10.1038/s41598-024-59189-y
Kansky R, Kidd M, Knight AT (2014) Meta-analysis of attitudes toward damage-causing mammalian wildlife. Conserv Biol 28:924–938. https://doi.org/10.1111/cobi.12275
Kasperson RE, Renn O, Slovic P et al (1988) The social amplification of risk: a conceptual framework. Risk Anal 8:177–187. https://doi.org/10.1111/j.1539-6924.1988.tb01168.x
Kuras ER, Warren PS, Zinda JA, Aronson MFJ, Cilliers S, Goddard MA, Nilon CH, Winkler R (2020) Urban socioeconomic inequality and biodiversity often converge, but not always: a global meta-analysis. Landsc Urban Plan 198:103799
Larson KL, Clark JA, Bateman HL, Enloe A, Hughes B (2024) To kill or not to kill? Exploring normative beliefs and attitudes toward snakes. Biol Conserv 290:110399
Larson KL, Clark JAG (2023) Human motivations and constraints in urban conservation. In: Lambert M, Schell C (eds) Urban biodiversity and equity: Justice-centered conservation in cities. Oxford University Press, UK, 47–64
Larson KL, Fleeger M, Andrade R, Wheeler MM, Hall S, Brown J, Lerman S, Narango D (2021) Who is abuzz about bees? Explaining residents' attitudes in Phoenix, Arizona. Urban Ecosyst 24:35–48. https://doi.org/10.1007/s11252-020-01013-2
Larson KL, Rosales Chavez JB, Brown JA, Morales-Guerrero J, Avilez D (2023) Human–wildlife interactions and coexistence in an urban desert environment. Sustainability 15(4):3307
Lerman SB, Contosta AR, Milam J, Bang C (2018) To mow or to mow less: lawn mowing frequency affects bee abundance and diversity in suburban yards. Biol Conserv 221:160–174
Lerman SB, Narango DL, Avolio ML et al (2021) Residential yard management and landscape cover affect urban bird community diversity across the continental USA. Ecol Appl 31:e02455. https://doi.org/10.1002/eap.2455
Liordos V, Foutsa E, Kontsiotis VJ (2020) Differences in encounters, likeability and desirability of wildlife species among residents of a Greek city. Sci Total Environ 739:139892. https://doi.org/10.1016/j.scitotenv.2020.139892
Loss SR, Will T, Marra PP (2013) The impact of free-ranging domestic cats on wildlife of the United States. Nat Commun 4:1396
Lute ML, Gore ML (2019) Broadening the aperture on coexistence with wildlife through lenses of identity, risk and morals. In: Frank B, Glikman JA, Marchini S (eds) Human-wildlife interactions: turning conflict into coexistence. Cambridge University Press, UK, 45–64
Lute ML, Serenari C, Drake MD, Peterson MN, Jensen J, Belyea C, Olfenbuttel C, White M (2020) Modeling urban socio-ecological drivers of human–carnivore coexistence. J Urban Ecol 6(1):juaa022
Macdonald EA, Hinks A, Weiss DJ, Dickman A, Burnham D, Sandom CJ, Malhi Y, Macdonald DW (2017) Identifying ambassador species for conservation marketing. Glob Ecol Conserv 12:204–214
Machlis GE, Force JE, Burch JW (1997) The human ecosystem part I: the human ecosystem as an organizing concept in ecosystem management. Soc Natur Resourc 10(4):347–67
Magle SB, Fidino M, Lehrer EW, Gallo T, Mulligan MP, Ríos MJ, Ahlers AA, Angstmann J, Belaire A, Dugelby B, Gramza A (2019) Advancing urban wildlife research through a multi-city collaboration. Front Ecol Environ 17(4):232–239
Manfredo MJ (2008) Who cares about wildlife? Social science concepts for exploring human-wildlife relationships and conservation issues. Springer US, New York, 141–166
Manfredo MJ, Teel TL, Don Carlos AW, Sullivan L, Bright AD, Dietsch AM, Fulton D (2020) The changing sociocultural context of wildlife conservation. Conserv Biol 34(6):1549–1559. https://doi.org/10.1111/cobi.13493

Manfredo MJ, Teel TL, Henry KL (2009) Linking society and environment: a multilevel model of shifting wildlife value orientations in the western United States. Soc Sci Q 90:407–427. https://doi.org/10.1111/j.1540-6237.2009.00624.x
Mansfield ER, Helms BP (1982) Detecting multicollinearity. Am Stat 36(3a):158–160
Moll RJ, Green AM, Allen ML, Kays R (2025) People or predators? Comparing habitat-dependent effects of hunting and large carnivores on the abundance of North America's top mesocarnivore. Ecography 2025(1):e07390. https://doi.org/10.1111/ecog.07390
Ngo KM, Hosaka T, Numata S (2019) The influence of childhood nature experience on attitudes and tolerance towards problem-causing animals in Singapore. Urban Urban Green 41:150–157. https://doi.org/10.1016/j.ufug.2019.04.003
Nieminen P (2022) Application of standardized regression coefficient in meta-analysis. BioMedInfo 2(3):434–458
Nyhus PJ (2016) Human–wildlife conflict and coexistence. Annu Rev Environ Resour 41:143–171
Ozili PK (2023) The acceptable R-square in empirical modelling for social science research. Social research methodology and publishing results. IGI global, USA, 134–143
Pooley S, Bhatia S, Vasava A (2021) Rethinking the study of human–wildlife coexistence. Conserv Biol 35(3):784–793
Prévot A-C, Cheval H, Raymond R, Cosquer A (2018) Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. Biol Conserv 226:1–8. https://doi.org/10.1016/j.biocon.2018.07.008
QGIS Development Team (2021) QGIS Geographic Information System. QGIS Association. http://qgis.org
R Core Team (2021) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria
Reidinger RF, Miller JE (2013) Wildlife damage management: prevention, problem-solving and conflict resolution. John Hopkins University, Maryland
Roll U, Feldman A, Novosolov M et al (2017) The global distribution of tetrapods reveals a need for targeted reptile conservation. Nat Ecol Evol 1:1677–1682
Rowland-Shea J, Doshi S, Edberg S, Fanger R (2020) The Nature Gap: Confronting Racial and Economic Disparities in the Destruction and Protection of Nature in America. Center for American Progress https://www.americanprogress.org/article/the-nature-gap/
Sampson L, Van Patter L (2020) Advancing best practices for aversion conditioning (humane hazing) to mitigate human–coyote conflicts in urban areas. Hum-Wildl Interact 14(2):166–83
Scott J, Kikken M, Rose M, Colyer P (2016) Nimbyism and nature: whose backyard is it anyway? In: Maheshwari B, Thoradeniya B, Singh VP (eds) Balanced urban development: options and strategies for liveable cities. Water Science and Technology Library, vol 72. Springer, Cham. https://doi.org/10.1007/978-3-319-28112-4_3
Slovic P (1987) Perception of risk. Science 236:280–285. https://doi.org/10.1126/science.3563507
Soulsbury CD, White PC (2015) Human–wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. Wildl Res 42(7):541–553
Tan AS, de la Torre JA, Wong EP, Thuppil V, Campos-Arceiz A (2020) Factors affecting urban and rural tolerance towards conflict-prone endangered megafauna in Peninsular Malaysia. Glob Ecol Conserv 23:e01179. https://doi.org/10.1016/j.gecco.2020.e01179
Teel TL, Manfredo MJ (2010) Understanding the diversity of public interests in wildlife conservation. Conserv Biol 24:128–139. https://doi.org/10.1111/j.1523-1739.2009.01374.x
Teixeira B, Hirsch A, Goulart VDLR, Passos L, Teixeira CP, James P, Young R (2015) Good neighbours: distribution of black-tufted marmoset (*Callithrix penicillata*) in an urban environment. Wildl Res 42(7):579. https://doi.org/10.1071/wr14148
Troudet J, Grandcolas P, Blin A, Vignes-Lebbe R, Legendre F (2017) Taxonomic bias in biodiversity data and societal preferences. Sci Rep 7(1):9132
Turo KJ, Gardiner MM (2019) From potential to practical: conserving bees in urban public green spaces. Front Ecol Environ 17:167–175. https://doi.org/10.1002/fee.2015
Whittaker D, Vaske JJ, Manfredo MJ (2006) Specificity and the cognitive hierarchy: value orientations and the acceptability of urban wildlife management actions. Soc Nat Resour 19:515–530. https://doi.org/10.1080/08941920600663912
Wierucka K, Hatten CE, Murphy D, Allcock JA, Andersson AA, Bojan JW, Dingle C (2023) Human-wildlife interactions in urban Asia. Glob Ecol Conserv e02596
Zepeda E, Sih A, Schell CJ, Gehrt S (2025) Impacts of urban heterogeneity in environmental and societal characteristics on coyote survival. Urban Ecosyst 28:1–12. https://doi.org/10.1007/s11252-024-01643-w
Zsido AN, Coelho CM, Polák J (2022) Nature relatedness: a protective factor for snake and spider fears and phobias. People Nat 4(3):669–682. https://doi.org/10.1002/pan3.10303