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EDITED BY
Dídac Santos-Fita,
Autonomous University of Barcelona, Spain

REVIEWED BY
Nathalia Montserrat Castillo,
El Colegio de la Frontera Sur, Mexico
Shylock Muyengwa,
Center for Impact Evaluation and Research Design, Zimbabwe
Bibiana Vilá,
Camelidos y Ambiente. CONICET, Argentina

*CORRESPONDENCE
Jeffrey D. Haight
jdhaight@asu.edu

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Social-ecological drivers of metropolitan residents' comfort living with wildlife

Jeffrey D. Haight[1]*, Kelli L. Larson[2], Jeffrey A. G. Clark[3], Jesse S. Lewis[4] and Sharon J. Hall[1]

[1]School of Life Sciences, Arizona State University, Tempe, AZ, United States, [2]School of Geographical Sciences and Urban Planning and School of Sustainability, Arizona State University, Tempe, AZ, United States, [3]Natural Areas Conservancy, New York, NY, United States, [4]College of Integrative Sciences and Arts, Arizona State University, Mesa, AZ, United States

Introduction: Human-wildlife coexistence in cities depends on how residents perceive and interact with wildlife in their neighborhoods. An individual's attitudes toward and responses to wildlife are primarily shaped by their subjective cognitive judgments, including multi-faceted environmental values and perceptions of risks or safety. However, experiences with wildlife could also positively or negatively affect an individual's environmental attitudes, including their comfort living near wildlife. Previous work on human-wildlife coexistence has commonly focused on rural environments and on conflicts with individual problem species, while positive interactions with diverse wildlife communities have been understudied.

Methods: Given this research gap, we surveyed wildlife attitudes of residents across twelve neighborhoods in the Phoenix Metropolitan Area, AZ to ask: how do the environments in which residents live, as well as their values, identities, and personal characteristics, explain the degree to which they are comfortable living near different wildlife groups (coyotes, foxes, and rabbits)?

Results: We found that residents who were more comfortable living near wildlife commonly held pro-wildlife value orientations, reflecting the expectation that attitudes toward wildlife are primarily driven be an individual's value-based judgements. However, attitudes were further influenced by sociodemographic factors (e.g., pet ownership, gender identity), as well as environmental factors that influence the presence of and familiarity with wildlife. Specifically, residents living closer to desert parks and preserves were more likely to have positive attitudes toward both coyotes and foxes, species generally regarded by residents as riskier to humans and domestic animals.

Discussion: By improving understanding of people's attitudes toward urban wildlife, these results can help managers effectively evaluate the potential for human-wildlife coexistence through strategies to mitigate risk and facilitate stewardship.

KEYWORDS

coexistence, attitudes, human-wildlife interactions, urban ecology, conservation, coyotes, foxes, rabbits 2

1 Introduction

With a growing majority of humanity living within cities and towns, metropolitan areas have emerged as critical environments for investigating and managing human interactions with nature. The expansion of human development into natural environments has placed humans and wildlife into increasing degrees of co-occurrence and contact, particularly in suburban and exurban neighborhoods where the activities of people and wildlife tend to overlap most frequently (DeStefano and DeGraaf, 2003; McKinney, 2008; Magle et al., 2016). The outcomes of these human-wildlife encounters and other nature experiences are highly variable across urbanizing landscapes, where spatially heterogeneous social and environmental processes strongly shape people's environmental attitudes (Soga et al., 2016; Soulsbury and White, 2019), including their support for biodiversity conservation and their comfort living among different wildlife species. People's varying wildlife attitudes help predict the positive and negative impacts of wildlife interactions (Kansky et al., 2016; Larson et al., 2023), as well as people's changing behaviors toward wildlife (Manfredo, 2008a; Larson et al., 2023). As such, understanding wildlife attitudes, and how those attitudes are shaped by both human and environmental dynamics, is important for predicting the potential for human-wildlife conflict and co-existence within urbanizing environments (Parris et al., 2018; Apfelbeck et al., 2020; Bhatia, 2021).

Although research exploring human-wildlife interactions has rapidly expanded in recent years, studies of coexistence have been limited by the emphasis placed on conflicts with certain problematic species (e.g., carnivores), over positive interactions with diverse wildlife communities. Additionally, although the distributions of wildlife within cities have been extensively studied (Magle et al., 2012; McIntyre, 2014; Norton et al., 2016), the ecological and social factors that shape the outcomes of human-wildlife interactions remain relatively understudied within heterogeneous urbanized contexts, as compared to relatively rural landscapes (Hudenko et al., 2010; Reidinger and Miller, 2013; Soulsbury and White, 2015). Beyond conflicts, interactions can positively affect the well-being of both human and wildlife, with the characteristics and behaviors of people and wildlife species shaping people's perceptions of and attitudes towards wildlife (Díaz et al., 2018; Avolio et al., 2021; Bhatia, 2021). Since variation in attitudes may be particularly pronounced across socially and ecologically heterogenous urbanized landscape (Soulsbury and White, 2019), research is needed to quantify variation in and drivers of metropolitan residents' attitudes toward particular wildlife groups, which can signal the potential for coexistence based on varying levels of tolerance, acceptance, and appreciation.

In this study, we examined an array of social-ecological influences on metropolitan residents' comfort living near three groups of native mammalian wildlife – coyotes (*Canis latrans*), foxes (including gray fox, *Urocyon cinereoargenteus* and kit fox, *Vulpes macrotis*), and rabbits (including desert cottontail rabbit, *Sylvilagus audubonii*, and black-tailed jackrabbit, *Lepus californicus*). Specifically in diverse neighborhoods of the Phoenix Metropolitan Area, Arizona, USA (Larson et al., 2022), we combine social survey data and location-based environmental features to answer the question: how do ideological, environmental, and sociodemographic factors differently affect residents' varied comfort levels living near three wildlife groups? We generally expected that comfort around each wildlife group would be most strongly associated with ideological factors, including individuals' wildlife value orientations and attachment to the local desert environment (Manfredo, 2008b; Manfredo, 2008c; Chan et al., 2016). We further expected that comfort would be mediated by environmental and sociodemographic factors that influence either the frequency with which residents are likely to interact with these three wildlife groups or the ways in which residents perceive the risks associated with wildlife.

2 Literature review

While attitudes affect human-wildlife coexistence, the ultimate interactions between people and wildlife are shaped by a combination of personal, environmental, and social factors, along with the characteristics of specific wildlife. As detailed below, the relative influence of exposure to nature on attitudes toward diverse urban wildlife is poorly understood.

2.1 Conceptualizing coexistence with mammals

The concept of coexistence has recently emerged in the literature as a more holistic means of framing human-wildlife interactions in terms of both its positive and negative aspects (Bhatia, 2021; Pooley, 2021). Reflecting a trend away from a focus on conflict as the primary aspect of coexistence, Pooley et al. define human-wildlife coexistence as "a sustainable though dynamic state in which humans and wildlife co-adapt to sharing landscapes, where human interactions with wildlife are effectively governed to ensure wildlife populations persist in socially legitimate ways that ensure tolerable risk levels." (Pooley et al., 2021, pg. 784). Conceptualizations of coexistence vary from this general definition depending on how the research context relates to the concepts of conflict, tolerance, acceptance, and stewardship (Glikman et al., 2021), with these concepts often organized along a continuum of negative to positive interactions (Dietsch et al., 2019; Larson et al., 2023). An individual's 'comfort living near wildlife', as a relational measure of attitudes toward sharing space with wildlife, can signify where that individual sits along the conflict-stewardship continuum (Chan et al., 2016; Larson et al., 2023). However, various scholars acknowledge the simultaneous presence of, or potential for, both negative interactions (e.g., tolerance or acceptance of conflicts involving threats or nuisances) and positive interactions (i.e., appreciation of wildlife and habitat stewardship) as inherent in coexistence Bhatia, 2021; Hill, 2021).

Research has shown that factors supporting coexistence depend partly upon the characteristics of the wildlife that shape those

interactions (Hudenko et al., 2010). Discomfort around wildlife perceived as more hazardous to people (e.g. large carnivores, venomous animals) can signify the potential for conflict and the need to reduce risks to tolerable levels (Reidinger and Miller, 2013; Hadidian, 2015; Carter and Linnell, 2016; Bateman et al., 2021; Hill, 2021). Furthermore, levels of risk tolerance and acceptance vary substantially among people, with differences serving as fundamental sources of human-human conflict over how best to manage coexistence (Peterson et al., 2010; Lute and Gore, 2019; Hill, 2021). Much of the current literature on human-wildlife coexistence has focused on large mammalian carnivores in more rural environments (Soulsbury and White, 2019; Larson et al., 2023). Research has centered on fear as the primary emotive response (Jacobs and Vaske, 2019) and on cognitive beliefs about risks and impacts on people (Soulsbury and White, 2015; Bhatia, 2021). However, relatively few studies have directly addressed how attitudes toward wildlife depend upon the actual co-occurrence of humans and different wildlife species (i.e., their shared use of a space at a given point in time), the levels of which are expected to vary greatly across spatially heterogeneous urban environments (Soulsbury and White, 2019).

Conversely, comfort living near wildlife can also indicate the potential for positive forms of human-wildlife coexistence (adoration, appreciation, and stewardship), rather than risk tolerance (Bhatia, 2021; Larson et al., 2023). Yet studies directly measuring such positive outcomes of human-wildlife interactions have been limited, especially within relatively urbanized settings where positive encounters with wildlife may have the greatest benefit for residents lacking frequent nature experiences (Soulsbury and White, 2015; Soga et al., 2016). Within urbanized environments, fewer large mammal species and residents' lack of dependence on livelihoods directly impacted by wildlife (e.g., subsistence agriculture, hunting, livestock ranching) may result in fewer negative interactions and concerns from interacting with wildlife across more urbanized landscapes (Bateman and Fleming, 2012). Consequently, interactions with wildlife within metropolitan regions may have the potential to be more positive than in more rural settings, potentially producing greater benefits to residents' mental and spiritual well-being (Methorst et al., 2020; Larson et al., 2023). As such, previous research has suggested that managing for coexistence with diverse wildlife communities will require the simultaneous consideration of multiple types of coexistence (Glikman et al., 2021), especially within urbanized contexts.

2.2 Ideological factors in coexistence

Previous research has shown that an individual's wildlife attitudes – defined as positive or negative judgments toward wildlife – are primarily shaped by subjective cognitive and affective judgments, including different peoples' approaches to evaluating nature and its contributions to human well-being (Dunlap et al., 2000; Pascual et al., 2017; Díaz et al., 2018; Pascual et al., 2023). In particular, attitudes toward wildlife are typically reflective of an individual's wildlife value orientations, which include people's basic beliefs (also known as worldviews) regarding how people should interact with wildlife (Fulton et al., 1996; Manfredo, 2008c). Mutualistic dimensions of wildlife value orientations incorporate individuals' basic beliefs regarding wildlife protection and coexistence, signaling the potential for positive attitudes toward wildlife presence and persistence and reflecting appreciation-oriented concepts of human-wildlife coexistence (Teel and Manfredo, 2010; Chan et al., 2016; Glikman et al., 2021). In contrast, utilitarian dimensions of wildlife value orientations involve beliefs in human domination over and benefits from wildlife, reflecting anthropocentric worldviews that may drive distinct attitudes toward human-wildlife coexistence (Teel and Manfredo, 2010; Kaltenborn and Linnell, 2022). Although these domination-oriented wildlife values have been traditionally widespread across North America, their prevalence has also gradually decreased in recent decades, aligned with broader sociocultural shifts toward biocentric mutualism often linked with increasingly urban livelihoods (Manfredo et al., 2016; Dietsch et al., 2019; Manfredo et al., 2020).

Perceptions of human-wildlife interactions and attitudes toward wildlife are further a function of individuals' affective judgements about those wildlife and their environment, including place identity and emotional dispositions toward different types of animals (Williams and Vaske, 2003; Manfredo, 2008b; Jacobs and Vaske, 2019). Understanding people's place identities, or emotional attachments, is fundamental to interpreting how their attitudes toward their environments form (Williams and Vaske, 2003). Previous research has shown that wildlife themselves can help create and reinforce emotional attachments to place, particularly when wildlife-based experiences align with individuals' pro-wildlife dispositions (Anderson and Fulton, 2008; Folmer et al., 2013). The place-dependent outcomes of human-nature interactions can subsequently affect human attitudes and behaviors, with both functional and emotional place attachments being positively linked with support for civic conservation actions and concern for recreational impacts on wildlife (Payton et al., 2005; Eder and Arnberger, 2012). However, such studies of associations among place attachment and wildlife attitudes are limited, with very few considering how urbanization may alter place identity and its related environmental attitudes (Andrade et al., 2019; Warren et al., 2019).

2.3 Environmental factors in coexistence

The characteristics of a person's surrounding natural environment can influence their comfort living around wildlife, particularly by shaping the degree to which that person is exposed to nature and the likelihood with which they have personal experience with wildlife (Soulsbury and White, 2019). Fundamentally, differences in both natural and anthropogenic environmental conditions across urbanized landscapes drive the distributions of wildlife populations and communities over space and time (Magle et al., 2012; McIntyre, 2014; Aronson et al., 2016), with the conservation of wildlife habitats and provisioning of resources directly increasing the frequency with which people encounter wildlife in cities (DeStefano and DeGraaf, 2003; Fuller

et al., 2010). For instance, the human supplementation of food resources – whether direct (e.g., placement of bird feeders Ryan and Partan, 2014; Cox and Gaston, 2016)) or indirect (e.g., through landscape and waste management practices; (Yirga et al., 2015; Brown et al., 2022) – can concentrate wildlife movements within areas of high human use, magnifying the potential for human-wildlife interactions (Soulsbury and White, 2019).

The direct and indirect effects of environmental characteristics on wildlife attitudes can vary considerably, depending on how they influence the frequency of human-wildlife interactions, the positive or negative nature of the interactions, and the type of wildlife species involved (Kansky and Knight, 2014). For instance, increased encounters with wildlife that present moderate-to-low risks to human well-being (e.g., coyotes, foxes, and other mid-sized carnivores) may make residents more familiar with the hazards associated with those species (Soulsbury and White, 2019; Nardi et al., 2020), thereby reducing perceived risks and encouraging co-existence (Slovic, 1987; Zaradic et al., 2009). However, positive effects of wildlife exposure on attitudes may be most readily observed for species that are seen as benign and desirable (e.g., rabbits and other small herbivores), but not detected for wildlife that pose more direct threats to human well-being (e.g., venomous snakes and larger carnivores; Dickman, 2010; Bateman and Fleming, 2012; Reidinger and Miller, 2013; Kansky and Knight, 2014). For instance, attitudes toward coyotes, as a widespread, medium-sized carnivore found across North American cities, can vary greatly as a result of people's experiences, which range from positive encounters that elicit appreciation coyotes and encounters with negative outcomes such as loss of pets and rare attacks on people (Gehrt and Riley, 2010; Alexander and Quinn, 2011; Poessel et al., 2017). The role of environmental characteristics in shaping attitudes toward human-wildlife coexistence within urban environments, especially relative to attitudinal and sociodemographic factors, remains unclear.

2.4 Sociodemographic factors in coexistence

Lastly, attitudes toward wildlife are partially dependent upon an individual's personal and social characteristics, especially those associated with emotional responses to wildlife and vulnerability to environmental risks (Kansky and Knight, 2014; Pooley, 2021). For one, the safety of pets and other domestic animals (e.g., livestock) is a commonly cited risk associated with wildlife, with an individual's ownership of pets having the potential to decrease tolerance of carnivores (Hudenko et al., 2010; Poessel et al., 2013). However, pet ownership has more often been found to be associated with positive attitudes toward wildlife tolerance and stewardship (Bjerke et al., 2003; Shuttlewood et al., 2016; Greenspan et al., 2021), reflecting people's biophilic dispositions toward both wild and domestic animals (Kellert, 1985; Larson et al., 2023).

Furthermore, difference in attitudes associated with wildlife and other sources of environmental risk are often aligned with individual's personal identities, particularly gender (Davidson and Freudenburg, 1996). For instance, previous research has indicated that people identifying as female may express greater safety concerns due to the presence of dangerous wildlife species (Zinn and Pierce, 2002). Conversely, women have also indicated positive attitudes toward wildlife more consistent with mutualistic and protectionist ideologies (Kellert and Berry, 1987), further indicating that gender identity is a key sociodemographic factor to consider in the examination of attitudes related to human-wildlife coexistence.

The formation of varying attitudes toward wildlife may be mediated by additional personal and social characteristics and identities that are associated with people's environmental worldviews and attitudes (e.g. ethnicity, class; Grove and Burch, 1997; Larson et al., 2016; Andrade et al., 2019). Subsequently, differences in ecological worldviews among ethnic or social groups have been documented as having varying relations with environmental risks (Larson et al., 2011; Larson et al., 2016). For instance, mutualistic worldviews rooted in Hispanic cultural traditions have been found to be fundamental factors in understanding opposition to lethal wildlife control in Tucson, Arizona, USA (Dietsch et al., 2012; Chase et al., 2016; Dietsch et al., 2019).

Income and education, as measures of affluence and knowledge, respectively, are widely recognized as driving access to experiences with wildlife and natural environments (Nilon, 2014; Andrade et al., 2019). Greater access to positive nature experiences is subsequently associated with decreasing peoples' perceived exposure to environmental risks and increasing benefits from nature (Van Velsor and Nilon, 2006; Andrade et al., 2019; Larson et al., 2023). The cultural contexts within which people interact with wildlife and for attitudes toward human wildlife coexistence are further shaped by factors such as race, ethnicity, gender, and age (Van Velsor and Nilon, 2006; Nilon, 2014; Pooley, 2021). Examination of attitudes toward wildlife needs to account for social-demographic variation in how interactions with wildlife are perceived.

2.5 Hypotheses

Based on current understanding of factors contributing to human-wildlife coexistence, we hypothesized that attitudes toward different wildlife species groups would be variably associated with ideological, environmental, and social factors. Specifically, we predicted that residents living in places where wildlife are more likely to be present are expected to be associated with either (a) increased familiarity with those species, and therefore, increased comfort; or (b) increased perceived risk from wildlife due to proximity and, therefore, reduced comfort. Furthermore, we expected that these potential associations between attitudes and environmental factors would be strongest for those wildlife that are generally perceived as more hazardous to people or domestic animals (i.e. coyotes and foxes). Conversely, we predicted that attitudes toward less hazardous wildlife (i.e. rabbits) would be most clearly associated with attitudinal factors and certain sociodemographic factors, such as pet ownership.

3 Methods

3.1 Study system

The Phoenix-Mesa-Scottsdale metropolitan area (i.e., metro Phoenix) is located within the Sonoran Desert of the southwestern USA. Situated in central Arizona, metro Phoenix is the fourth most rapidly growing metropolitan area in the USA, with a current population of roughly 4.8 million. A significant portion (32%) of the population is Hispanic/Latino (32%; U.S. Census Bureau, 2021). Historical patterns of urbanization within metro Phoenix have had widespread impacts on both social and ecological processes contributing to human-wildlife coexistence. Specifically, the sprawling outward growth of cities has surrounded and isolated remnants of desert within a matrix of human development and agriculture, putting certain residents in closer proximity to the desert parks and preserves (Andrade et al., 2019). For instance, previous research in the region has shown that how close residents live to these desert parks tend to be wealthier, have more positive attitudes toward the desert, and experience higher wildlife diversity and greater ecosystem services (Andrade et al., 2019; Warren et al., 2019; Brown, 2020).

The region's hot, semi-arid desert environment features natural vegetation communities that are predominantly composed of shrubland species, including palo verde (*Parkinsonia* spp.), mesquite (*Prosopis* spp.), creosote bush (*Larrea tridentata*), brittlebush (*Encelia farinosa*), and saguaro (*Carnegiea gigantea*). In contrast, the urban and suburban areas of the region are relatively lush, with higher levels of vegetation productivity and cover traditionally maintained by an extensive irrigation canal system (Buyantuyev and Wu, 2009; Larson et al., 2009). The region also hosts relatively high regional diversity of mammals, birds, reptiles, and amphibians within urban, suburban, and natural environments (Bateman et al., 2015; Jenkins et al., 2015; Banville et al., 2017), with the neighborhoods of metro Phoenix utilized by a variety of iconic desert wildlife species, such as coyotes, desert cottontail rabbit, javelina (*Pecari tajacu*), jackrabbits (*Lepus* sp.), gray fox, kit fox, roadrunners (*Geococcyx californianus*), rattlesnakes (*Crotalus* spp.) and Gambel's quail (*Callipepla gambelii*). Patterns of development and local vegetation and habitat management within and near neighborhoods affect the spatially distribution of wildlife species across residential landscapes, as well as the frequency with which those species interact with people and the need to manage human-wildlife coexistence (Bateman et al., 2021).

3.2 Study species

We focused this study on three local mammals – rabbits, foxes, and coyotes – whose varying size and behavior result in a range of positive and negative relationships with metropolitan residents, their domestic animals, and their livelihoods (Rea, 1998; Kays and Wilson, 2009; Curtis and Hadidian, 2010; Reidinger and Miller, 2013). Two species of rabbits are known to commonly occur in natural and urbanized areas of metro Phoenix: the desert cottontail rabbit and the black-tailed jackrabbit. Although human interactions of rabbits generally range between positive and benign within their native ranges (Long et al., 2020), negative attitudes toward co-existence with rabbits can result from their damage to crops and residential landscaping and potential spread of zoonotic diseases (Reidinger and Miller, 2013; Abu Baker et al., 2015; Simes et al., 2015), especially among individuals with agricultural and subsistence lifestyles. Although two species of foxes occur in metro Phoenix, only the gray fox is frequently observed in suburban and urban neighborhoods, while the kit fox typically occurs in undeveloped, flat desert areas. Interactions with and perceptions of foxes are generally expected to be more negative than those rabbits, as foxes can present real and perceived threats to the safety of domestic animals, including small pets and chickens, even though threats to humans are minimal (Macdonald, 1984; Hudenko et al., 2010; Soulsbury and White, 2015; Nardi et al., 2020). The coyote is widely distributed throughout the study area but is encountered most frequently in the region's desert parks and their surrounding neighborhoods. Due to their larger size and opportunistic behaviors, coyotes are regarded as presenting a greater danger to domestic animals than foxes, while also potentially threatening the safety of people, though attacks on humans are rare (Curtis and Hadidian, 2010; Soulsbury and White, 2015; Poessel et al., 2017; Nardi et al., 2020).

3.3 Sampling design and implementation

In 2021, we surveyed residents of twelve neighborhoods within this study area as part of the Phoenix Area Social Survey (Larson et al., 2022), which is a long-term study of the Central-Arizona Long-Term Ecological Research (CAP LTER) program (Figure 1). The twelve neighborhoods, delineated by Census Block Groups, were purposively selected to capture variation in sociodemographic characteristics (e.g. income level, ethnicity) and represent a range of local environments (e.g. levels of urbanization, proximity to natural areas). The survey was sent to 1,549 addresses between May and July 2021, with 496 addresses representing households surveyed in a previous (2017) iteration of the survey. An additional 1,053 addresses from the 12 neighborhoods were randomly provided by the Marking Systems Group, which comes from the U.S. Postal Service's Delivery Sequence Files.

University of Northern Iowa's Center for Social and Behavior Research administered the survey via a six-wave mailing, including an advance letter with a link to the online version of the survey, three full questionnaire packets with self-addressed return envelopes, and two reminder postcards sent in-between and after mailings (Larson et al., 2022). A $5 cash pre-incentive was included in the first questionnaire packet, regardless of response, and respondents were sent an additional $25 post-response incentive. The cover letters and postcards informed individuals in Spanish that they could request a Spanish version of the survey via a phone number and email. The third mailed questionnaire included both an English and Spanish version for all households with Hispanic

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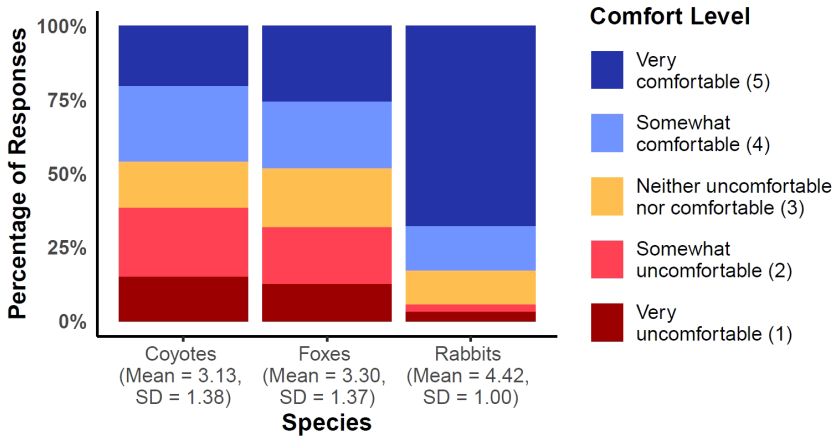

FIGURE 1
Summary of levels of comfort living near three wildlife groups – coyotes, foxes, and rabbits – as reported by metropolitan residents surveyed across twelve neighborhoods in the Phoenix Metropolitan Area, Arizona, USA.

surnames (n = 245). Out of the 1375 successfully delivered surveys, a total of 509 eligible residents participated in the survey, with an overall response rate of 35.6%.

3.4 Sample demographics

Survey respondents and neighborhoods varied in terms of the sociodemographic characteristics of interest in this study (Table 1). For all sociodemographic questions in the survey, respondents were provided with a refuse/prefer not to answer option. Most survey respondents identified their gender as female (62.9%), followed by male (36.7%) and non-binary (0.4%). 63% of respondents reported that they owned either a cat or dog at home. We measured income on an 11-point interval scale by asking respondents to select the median combined income of all household members from a provided list of $20,000 increments, from $20,000 and under (1) to more than $200,000 (11). Similarly, we evaluated level of education by asking respondents to select the highest level of school they have had the chance to complete, which we then quantified on a 7-point interval scale ranging from the completion of grades 1-8 to the attainment of a graduate or professional degree. Measured as such, the median respondent had a household income of approximately $100,000 and at least a community college or vocational school education, with 62% of respondents having completed a bachelor's degree or higher. The average respondent age was 54 years old, which we measured by subtracting the respondent-provided birth year from the year in which the survey was conducted (2021). Regarding race/ethnicity, 68% of respondents identified as White/Anglo, 20% as Hispanic/Latino, 6% as Black/African American, 5% as Asian or Asian American, 1% as Native American or American Indian, and 3% as "other", with multiple responses being provided as an option (Larson et al., 2022).

TABLE 1 Summary statistics of sociodemographic characteristics of metropolitan residents surveyed across twelve neighborhoods in the Phoenix Metropolitan Area, Arizona, USA.

Explanatory Variable	Mean	SD	Range	Valid N
Gender (female or non-binary)	62.70%	N/A	0-100 (% respondents)	499
Pet ownership	62.58	N/A	0-100 (% respondents)	489
Income	5.87	3.34	1-11	483
Education	5.31	1.59	1-7	497
Age	54.28	17.38	18-100	491
Black Identity	6.10%	N/A	0-100 (% respondents)	495
Latino Identity	20.40%	N/A	0-100 (% respondents)	495
White Identity	68.90%	N/A	0-100 (% respondents)	495

See text for description of variables.
Mean, standard deviation (SD), range of possible response values, and number of respondents (Valid N) shown. N/A, not applicable.

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3.5 Data and variables

3.5.1 Dependent variables: comfort living near wildlife

We measured our dependent variables representing residents' attitudes toward wildlife on five-point ordinal scale. Specifically, the survey read: "Below is a list of wildlife that live in the greater Phoenix area. Please tell us how comfortable or uncomfortable you would feel seeing the following wildlife in and around where you live." Participants were provided with a list of common names for wildlife species and species groups, including "Coyotes", "Foxes", and "Rabbits" and verbatim response options included: very uncomfortable (1), somewhat uncomfortable (2), neither uncomfortable nor comfortable (3), somewhat comfortable (4) and very comfortable (5). For consistency in terminology, we refer to these reported comfort levels as "comfort living near" each type of wildlife. Survey responses reflected individuals' general attitudes about "Coyotes", "Foxes", and "Rabbits", which are widely known groups of animals in the region. The explanatory variables in our models include survey data (i.e., for ideological and sociodemographic variables) and geospatial data reflecting environmental variables.

3.5.2 Ideological explanatory variables

Our models included two value-based ideological variables to reflect 1) wildlife value orientations (i.e., emphasizing utilitarian benefits and domination versus protection and mutualism) and 2) desert identity (i.e., as a measure of place attachment). First, we measured wildlife value orientations using nine survey items adapted from previous research (Fulton et al., 1996; Manfredo, 2009; Teel and Manfredo, 2010; Manfredo et al., 2016; Vaske et al., 2023) that assess different dimensions of basic beliefs about people's relationships with wildlife (see Table 2). Respondents were asked to rate their level of agreement with a series of statements, with responses ranging from strongly disagree (1) to strongly agree (5) with neutral (3) in the middle. The first three survey items measured value orientations related to respondents' residential wildlife experiences (i.e. their appreciation of wildlife in their local environments; Fulton et al., 1996). The remaining six items, modified from Manfredo et al. (2009), assessed respondents' beliefs regarding human domination of wildlife (i.e. utilitarian uses such as hunting, and lethal population control) and mutualistic beliefs (i.e. values promoting wildlife protection and positive coexistence). We combined these wildlife value orientation scales by inverting responses to the three domination items (items 4-6 in Table 2) – so that higher numbers reflected pro-wildlife values – and then averaging all nine items, creating a reliable composite scale of pro-wildlife value orientation (Cronbach's alpha = 0.77).

Second, we measured desert-based place identity (i.e., *desert identity*) using a standardized survey scale adapted from Williams and Vaske (2003). As a measure of place attachment, respondents were asked to rate their level of agreement with five statements about their relationship to the region's desert parks (Table 3). Survey-provided response options ranged from strongly disagree (1) to strongly agree (5) with neutral (3) in the middle. We then averaged all five items into a reliable composite scale for desert identity (Cronbach's alpha = 0.96).

TABLE 2 Summary statistics of wildlife value orientations reported by metropolitan residents surveyed across twelve neighborhoods in the Phoenix Metropolitan Area, Arizona, USA.

Explanatory Variable	Mean	SD	Valid N
Pro-Wildlife Value Orientation (Cronbach's alpha = 0.77)	3.92	1.11	497
I notice the birds and wildlife around me most days.	4.26	1.03	498
The wildlife I see in and around where I live are important to me.	4.07	1.09	499
Having wildlife around my home is important to me.	4.01	1.12	499
It is acceptable for people to kill wildlife if they think it poses a threat.*	2.68	1.32	498
Wildlife are on earth primarily for people to use.*	1.82	1.00	498
The needs of humans should take priority over protecting wildlife.*	2.48	1.27	496
I want to protect wildlife.	4.26	0.88	493
I care about wildlife as much as I do other people.	3.43	1.27	495
We should strive for a world where humans and wildlife can live side by side.	4.23	0.99	497

The statements for each survey item reflect verbatim wording on the survey, adapted from Fulton et al., 1996 and Manfredo, 2009. '*' indicates values that were reverse-coded prior to averaging all nine scale items into the single index of 'Pro-Wildlife Value Orientation'. Average value for each response, standard deviation SD, and number of respondents for each response shown.

TABLE 3 Summary statistics of desert identity reported by metropolitan residents surveyed across twelve neighborhoods in the Phoenix Metropolitan Area, Arizona, USA.

Explanatory Variable	Mean	SD	Valid N
Desert identity index (Cronbach's alpha = 0.96)	3.59	1.07	502
I feel the desert parks in the Valley are a part of me.	3.82	1.06	504
The desert parks in the Valley are very special to me.	3.50	1.12	503
I identify strongly with desert parks in the Valley.	3.53	1.17	502
I am very attached to the desert parks in the Valley.	3.76	1.13	503
The desert parks in the Valley mean a lot to me.	3.64	1.11	503

The statements for each scale item reflect verbatim wording on the survey, adapted from the standardized statements of Williams and Vaske (2003). Average value for each response, standard deviation (SD), and number of respondents for each response shown.

3.5.3 Environmental explanatory variables

We assessed the local environmental conditions experienced by each survey respondent based on environmental variables associated with wildlife presence and residents' access to nature-based experiences, specifically urbanization, vegetation, and distance to desert parks. We measured *urbanization* as the mean percent impervious surface coverage within 1 km of each respondent using data from the 2019 National Land Cover Database (Dewitz, 2021). We quantified *vegetation* using the mean value of Normalized Difference in Vegetation Index (NDVI) within 1 km of each resident, based on 2018 MODIS imagery (de Albuquerque, 2020). We used a 1-km buffer around each respondent since it is a comparable scale to a 10-minute walkshed for people (Rigolon, 2016; Larson et al., 2022), as well as a typical scale used in analyses of wildlife distributions (McGarigal et al., 2016). We measured the *distance to desert parks* as the log-transformed Euclidean distance to the nearest park or preserve with predominant natural desert vegetation, which we derived from park boundary data from the Trust for Public Lands (Brown et al., 2021). Finally, to quantify the degree to residents directly experience desert parks, we asked survey respondents. Specifically, respondents were asked the question "Thinking about the past year or so, how often have you typically visited the following types of areas?" and provided with a list of areas including "Desert parks or open spaces in the Valley". Response options ranged from "Never" (1) to "At least once a week or more" (5).

3.5.4 Sociodemographic explanatory variables

Finally, we used data collected in the 2021 PASS to quantify sociodemographic variables selected for their anticipated roles in mediating the outcomes of human-environment interactions. Specifically, we predicted that the variables *pet ownership* and *gender* may have risk-related effects on comfort living with all three species, since previous research has indicated that pet owners tend to have increased tolerance of wildlife and that men may express lesser safety concerns associated with wildlife (Zinn and Pierce, 2002; Shuttlewood et al., 2016). We coded pet ownership as a binary variable, classifying pet ownerships as 1 and people without pets as 0. For purposes of analysis, we also considered respondent self-reported *gender* as a binary variable, coded as 0 for male and 1 for female or non-binary, with the latter groups having been combined for the purpose of statistical analysis due to their historically similar socialization as relatively marginalized gender identities.

Additionally, we included the demographic variables of income, education, age, race, and ethnicity largely as control variables in the analysis. For ethnicity, we coded the variable for *Latino identity* to reflect whether (1) or not (0) respondents self-identified as either "Mexican, Mexican-American, Chicano, Hispanic, or Latino". Likewise, we coded binary variables of *black identity* and *white identity* based on whether respondents self-identified as "Black/African American" or "White/Anglo", respectively. For age, education, and income, the variables included the continuous and ordinal measures described above.

3.6 Statistical analyses

We evaluated the influence of ideological, environmental, and sociodemographic variables on comfort around each wildlife species using generalized linear mixed models (GLMM), which we fit in the R programming language 4.0.1 using the *glmmTMB* package (Brooks et al., 2017; R Core Team, 2020). First, we tested for correlations between each pair of explanatory variables, confirming a lack of bivariate collinearity ($r < 0.5$), and then standardized all continuous explanatory variables and. Secondly, we fit three multivariate GLMMs for each species that included subsets of explanatory variables (i.e., ideological only, environmental only, sociodemographic only) as fixed effects and the neighborhood as a random effect (intercept). Inclusion of the neighborhood random intercept enabled us to account for among-neighborhood variation in attitudes associated with other potential explanatory factors not already incorporated into the model, such as varying number of responses per neighborhood. Thirdly, we fit a global model for each species, with each including all explanatory variables as fixed effects (Eq. 1; Figure 1). We then used the Akaike Information Criterion (AIC) to compared the relative support of each partial model to that of the global model for each species, with the lowest model AIC indicating the best model with the highest relative quality (Burnham and Anderson, 2002). Finally, we used the R package 'performance' (Lüdecke et al., 2021) and the Variable Importance Factor (VIF) to verify low multi-collinearity (VIF< 5) among explanatory variables included within the global models (Supplementary Table 1).

$$\begin{aligned} Comfort \sim\ & WVO + DesertIdentity + Urbanization \\ & + Vegetation + DistanceToDesertParks + Income \\ & + Education + Age + PetOwnership + Gender \\ & + BlackIdentity + LatinoIdentity + WhiteIdentity \\ & + (1 \mid Neighborhood) \end{aligned} \quad \text{Eq. 1}$$

4 Results

4.1 Variation in comfort living near wildlife

Respondents' reported comfort living near coyotes, foxes and rabbits varied among the three species and among neighborhoods. On average, respondents felt neutral-to-slightly comfortable near coyotes (mean = 3.13), slightly more comfortable living near foxes (mean = 3.30), and quite comfortable living near rabbits (mean = 4.42; Figure 1). 46.1% of respondents reported some level of comfort living near coyotes, as compared to the 48.3% of respondents comfortable around foxes and 82.9% comfortable around rabbits. Conversely, 38.3% of respondents reported being uncomfortable living near coyotes, 31.8% with foxes, and 5.6% with rabbits. 15.6% of respondents reported neutral attitudes toward coyotes, 19.9% were neutral toward foxes, and 11.5% were neutral toward rabbits.

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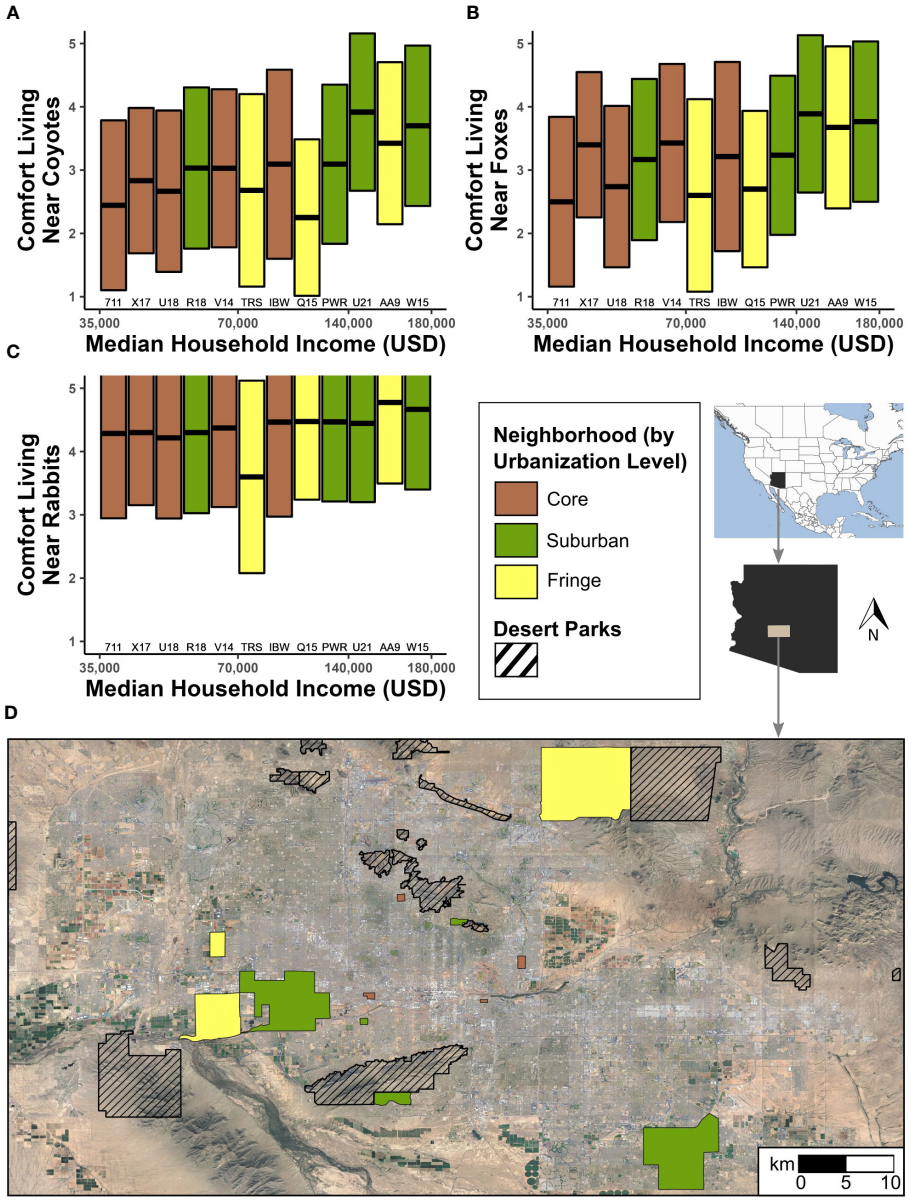

FIGURE 2
Average levels of comfort living near **(A)** coyotes, **(B)**, foxes, and **(C)** rabbits, as reported within **(D)** twelve neighborhoods in the Phoenix Metropolitan Area, Arizona, USA. Midlines indicate neighborhood-mean comfort level, while upper and lower ends of the boxes depict one standard deviation above and below the mean (approximating a 68% confidence interval). We present average comfort in relation to each neighborhood's median household income, from the 2020 US Census. Neighborhoods are depicted by their broad level of urbanization (based on mean percentage of impervious surface cover), with *Fringe* neighborhoods being located along the edge of the metropolitan area and having<20% impervious surface, *Suburban* neighborhoods being moderately urbanized (20%-50% impervious surface), *Core* neighborhoods representing areas nearer the urban core with relatively high urbanization (>50% impervious surface).

Mean reported comfort living near each species also varied among neighborhoods, ranging between 2.24 and 3.92 for coyotes, 2.50 and 3.89 for foxes, and 3.60 and 4.78 for rabbits. Comfort living near coyotes and foxes was generally highest in higher-income neighborhoods closer to desert parks (Figure 2). Comfort also tended to be lower neighborhoods with more residents identifying as Hispanic/Latino and in neighborhoods where wildlife value orientations were generally lower (i.e., more anti-wildlife).

4.2 Factors associated with comfort living near wildlife

The relative associations of ideological, environmental, and sociodemographic factors with residents' reported comfort varied among the global models for each wildlife species, which were more supported (lower AIC) than all partial models (Table 4). Overall, the explanatory variables best explained residents' comfort levels living

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TABLE 4 Summary of model selection results for mixed-effects models of comfort living near three wildlife species.

Model	K	Coyote	Foxes	Rabbits
Global	**17**	**1535.88**	**1519.70**	**1309.79**
Ideological only	5	1660.25	1653.52	1395.31
Environmental only	7	1672.08	1679.71	1413.43
Sociodemographics only	11	1590.32	1575.19	1319.83

Values depict the number of parameters (K) and Akaike Information Criterion (AIC) for each global or partial model. Lower AIC values indicate higher relative quality (i.e., better fit), with the value of the best-fit model for each species indicated in boldface.

around coyotes and foxes (conditional R^2 of 0.23 and 0.25, respectively) compared to rabbits (0.19). Pro-wildlife value orientation was the variable most positively associated with greater comfort living with all three wildlife groups – i.e. residents who were more comfortable living near wildlife tended to hold beliefs that were more mutualistic and less domination-oriented (Tables 5-7; Supplementary Figure 1). Higher-income respondents were more comfortable living near coyotes (Figure 2A). Women were significantly less comfortable living near coyotes and foxes compared to men, but gender was insignificant for rabbits. Meanwhile, older residents were less comfortable with foxes and rabbits than younger residents, yet age was insignificant for coyotes. White residents and those who live nearer to desert parks reported greater comfort living near foxes, as compared to non-white residents and those living further from desert parks (Figure 2A, B). Comfort near rabbits was positively associated with pet ownership. Lastly, we did not detect a significant relationship between comfort living near any species and either desert identity, urbanization, or vegetation within the global models.

Although the most supported model for each species was the global model, certain variables not found to have statistically significant effects (at the $p < 0.05$ level) in the global model showed substantial relationships in the partial model containing that variable, and vice versa (Table 8). For instance, comfort living near foxes was positively associated with pet ownership within the sociodemographic-only partial model ($p = 0.006$) and negatively

TABLE 5 Multivariate generalized linear mixed model results for comfort living near coyotes, showing beta estimates (standardized effect sizes) with significance levels indicated using p-values and 95% confidence intervals (CI).

Fixed Effect	Beta Estimate	p-value	95% CI
Intercept	3.29	<0.001	2.90, 3.69
Ideological			
Wildlife Value Orientation	**0.40**	<0.001	0.28, 0.52
Desert Identity	-0.04	0.58	-0.18, 0.09
Environmental			
Urbanization	-0.11	0.08	-0.23, 0.00
Vegetation	-0.08	0.31	-0.22, 0.05
Distance to Desert Parks	-0.17	0.06	-0.33, 0.02
Desert Park Visitation	0.07	0.32	-0.06, 0.20
Sociodemographic			
Income	**0.23**	<0.01	0.09, 0.38
Education	-0.07	0.28	-0.20, 0.06
Age	0.02	0.81	-0.11, 0.14
Pet Ownership	0.08	0.50	-0.16, 0.32
Gender	**-0.39**	<0.01	-0.63, -0.16
Black Identity	-0.50	0.08	-1.05, 0.06
Latino Identity	-0.04	0.85	-0.35, 0.30
White Identity	0.08	0.42	-0.29, 0.47

Boldface emphasizes relationships with a significance level of $p < 0.01$. Conditional $R^2 = 0.23$. Neighborhood random effect variance = 0.02 (standard deviation = 0.14).

TABLE 6 Multivariate generalized linear mixed model results for comfort living near foxes, showing beta estimates (standardized effect sizes) with significance levels indicated using p-values and 95% confidence intervals (CI).

Fixed Effect	Beta Estimate	p-value	95% CI
Intercept	3.17	<0.001	2.78, 3.56
Ideological			
Wildlife Value Orientation	**0.41**	<0.001	0.29, 0.53
Desert Identity	-0.02	0.77	-0.15, 0.11
Environmental			
Urbanization	-0.11	0.06	-0.22, 0.00
Vegetation	-0.01	0.92	-0.13, 0.12
Distance to Desert Parks	**-0.19**	0.01	-0.33, -0.05
Desert Park Visitation	0.00	0.94	-0.13, 0.12
Sociodemographic			
Income	0.08	0.26	-0.06, 0.23
Education	-0.12	0.08	-0.24, 0.01
Age	**-0.17**	0.01	-0.29, -0.04
Pet Ownership	0.22	0.07	-0.02, 0.45
Gender	**-0.45**	<0.001	-0.68, -0.22
Black Identity	-0.40	0.15	-0.95, 0.14
Latino Identity	-0.17	0.43	-0.59, 0.25
White Identity	**0.45**	0.02	0.08, 0.83

Boldface emphasizes relationships with a significance level of $p < 0.01$. Conditional $R^2 = 0.25$. Neighborhood random effect variance = 0.00 (standard deviation = 0.00).

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TABLE 7 Multivariate generalized linear mixed model results for comfort living near rabbits, showing beta estimates (standardized effect sizes) with significance levels indicated using p-values and 95% confidence intervals (CI).

Fixed Effect	Beta Estimate	p-value	95% CI
Intercept	4.24	<0.001	3.92, 4.54
Ideological			
Wildlife Value Orientation	**0.22**	<0.001	0.12, 0.31
Desert Identity	0.01	0.92	-0.10, 0.11
Environmental			
Urbanization	-0.08	0.14	-0.17, 0.03
Vegetation	0.00	0.97	-0.12, 0.11
Distance to Desert Parks	0.05	0.50	-0.09, 0.18
Desert Park Visitation	0.01	0.88	-0.09, 0.10
Sociodemographic			
Income	0.10	0.11	-0.01, 0.22
Education	-0.03	0.51	-0.14, 0.06
Age	**-0.17**	0.001	-0.26, -0.06
Pet Ownership	**0.22**	0.02	0.04, 0.41
Gender	-0.12	0.19	-0.30, 0.07
Black Identity	-0.20	0.36	-0.62, 0.25
Latino Identity	-0.29	0.09	-0.61, 0.06
White Identity	0.25	0.10	-0.04, 0.55

Boldface emphasizes relationships with a significance level of $p < 0.01$. Conditional $R^2 = 0.19$. Neighborhood random effect variance = 0.03 (standard deviation = 0.17).

associated with urbanization within the environmental-only partial model ($p = 0.045$), whereas neither relationship was statistically significant in the global model (although $p < 0.1$ for both variables; Table 7). Conversely, comfort living near foxes was lower among older respondents in the global model ($p = 0.001$), but not in the partial sociodemographic-only model ($p = 0.090$). In the partial models, comfort living near coyotes was significantly greater among respondents living closer to desert parks ($p = 0.004$, *vs.* $p = 0.315$ in the global model) and respondents who visited desert parks more frequently ($p = 0.037$, *vs.* $p = 0.059$ in the global model).

5 Discussion

Overall, residents of Metropolitan Phoenix, Arizona, USA are somewhat comfortable living near mammals, which bodes well for coexistence. Yet the degree to which residents tolerate and accept the presence of coyotes, foxes, and rabbits in and around their neighborhoods depends upon various combinations of personal, social, and environmental characteristics. In our study, the data supported our hypotheses that comfort living near wildlife was most strongly associated with an individual's value-based judgements. Residents with more mutualistic, pro-wildlife value orientations were more likely to express greater comfort living near coyotes, foxes, and, to a lesser degree, rabbits. These varying levels of ideologically-based comfort may indicate different points along the conflict-coexistence continuum (Dietsch et al., 2019; Glikman et al., 2021; Larson et al., 2023), where discomfort could signify the potential for conflict whereas moderate comfort might signal tolerance, and high levels of comfort even opportunities for wildlife acceptance and stewardship (Manfredo et al., 2016; Bhatia, 2021).

By showing that values are the primary predictor of comfort, our results indicate that people's ideological beliefs may present a key challenge to influencing attitudes, given that value-based beliefs tend to be static and resistant to change in general and as a result of outreach efforts (Manfredo, 2008c; Heberlein, 2012). However, given recent generational shifts toward mutualism, especially in metropolitan areas, changing wildlife value orientations may forecast growing potential for wildlife appreciation and stewardship in urbanizing regions (Teel and Manfredo, 2010; Manfredo et al., 2016; Dietsch et al., 2019; Manfredo et al., 2020). These results further emphasize that the management of human-wildlife coexistence will be most effective when centered on navigating the diverse ways in which humans value nature (Heberlein, 2012), including the cultural beliefs and societal practices that shape their perceptions of interactions with wildlife (Díaz et al., 2018; IPBES, 2022; Pascual et al., 2023). Finally, comfort levels were further mediated by residents' local environmental context and sociodemographic characteristics, and by the traits of the wildlife involved, highlighting how consideration of the diversity of the human experience is fundamental to promoting pro-coexistence attitudes and behaviors using relational strategies that are effectively tailored to particular places, people, and wildlife taxa.

5.1 Roles of environment and sociodemographics

Although residents' comfort living near wildlife may be strongly grounded in their wildlife values, differences in comfort also reflect people's potential experiences with wildlife and natural environments more broadly. For instance, within our global model, living closer to the region's desert preserves was associated with higher comfort living near foxes, a carnivore that may threaten pets and other domestic animals (Curtis and Hadidian, 2010; Nardi et al., 2020). Additionally, partial (environmental variables only) model results of comfort living near coyotes indicated that proximity to desert preserves may have a positive relationship with attitudes toward even riskier species (Hudenko et al., 2010; Poessel et al., 2013), though the absence of this relationship in the global model suggests that adjacency to natural areas may be associated with other personal or social drivers of attitudes toward coyotes. These results support the hypothesis that living in environments where wildlife are more likely to be present and interact with people can lead to residents becoming more familiar with wildlife and developing attitudes more consistent with tolerance and acceptance (Soulsbury and White, 2019; Glikman et al., 2021).

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TABLE 8 Summary of model results across all global and partial models for all three dependent variables (i.e., comfort living near coyotes, foxes, and rabbits).

Explanatory Variables		Coyotes (R^2 = 0.23)	Foxes (R^2 = 0.25)	Rabbits (R^2 = 0.19)
Ideological		(R^2 = 0.17)	(R^2 = 0.16)	(R^2 = 0.09)
	Wildlife Value Orientation	***Both (+)***	***Both (+)***	***Both (+)***
	Desert Identity	Neither	Neither	Neither
Environmental		(R^2 = 0.11)	(R^2 = 0.09)	(R^2 = 0.07)
	Urbanization	Neither	*Partial only (-)*	Neither
	Vegetation	Neither	Neither	Neither
	Distance to Desert Parks	*Partial only (-)*	***Both (-)***	Neither
	Desert Park Visitation	*Partial only (+)*	Neither	Neither
Socio-demographic		(R^2 = 0.13)	(R^2 = 0.15)	(R^2 = 0.12)
	Income	***Both (+)***	Neither	Neither
	Education	Neither	Neither	Neither
	Age	Neither	**Global Only (-)**	***Both (-)***
	Pet Ownership	Neither	*Partial only (+)*	***Both (+)***
	Gender	*Partial only (-)*	***Both (-)***	Neither
	Black Identity	Neither	Neither	Neither
	Latino Identity	Neither	Neither	Neither
	White Identity	Neither	***Both (+)***	Neither

Text indicates whether each explanatory variable was significantly associated with the dependent variables in only the global model containing all variables, only the partial model including that variable, or both or neither. Parentheticals after each significant effect indicate the directionality of the relationship between that variable and comfort around wildlife. R^2 values indicate the proportion of variance explained by the combination of fixed and random effects in each global or partial model (bolded and un-bolded, respectively).

Differences in comfort living near wildlife may also be mediated by certain sociodemographic characteristics, particularly those associated with two types of concerns that are often involved in conflict: that is, for the well-being of people and their households and for the protection and well-being of wildlife (Macdonald, 2023). For instance, our global and partial model results for rabbits – a relatively benign group of wildlife – indicated even greater comfort among pet owners, suggesting the potential for appreciation of wildlife and care for their well-being. However, harm to pets is a major form of human-wildlife interaction and potential conflict within metropolitan regions (Curtis and Hadidian, 2010; Reidinger and Miller, 2013; Nardi et al., 2020). As such, only our partial (sociodemographic) model for fox indicated that pet owners were more comfortable living near foxes, signaling relative tolerance of urban-adapted foxes among people who might be negatively impacted due to concerns about their pets. The increased comfort of pet owners near wildlife may reflect emotional dispositions in favor of animals more broadly, whether innate (biophilic), conditioned (through experiences), or the confluence of both (Bjerke et al., 2003; Slagle and Bruskotter, 2019). Despite residents' expressed concerns about predators harming pets (Soulsbury and White, 2015; Larson et al., 2023), which is often cited as a predominant form of human-wildlife conflict in urbanized areas, our results show that positive, biophilic predispositions may overcome concerns and therefore foster tolerance, or even acceptance or appreciation, of concerning wildlife that pose a threat (Bjerke et al., 2003; Albert et al., 2018), However, the degrees to which people are willing to coexist with certain wildlife over others and the pathways by which pets mediate human-wildlife interactions may be muddled by distinct groups of people responding in divergent ways (e.g., pet owners who wish to avoid or deter predators due to threats versus those who accept threats and use other strategies to keep their pets safe).

Generally, attitudes toward wildlife are potentially confounded by complex personal and social factors that require further research, including complex value sets, as well as aesthetic preferences for (Gunnthorsdottir, 2001; De Pinho et al., 2014) and cultural associations with (Prokop et al., 2011; Jacques-Coper et al., 2019; Thekaekara et al., 2021) certain wildlife. Our results specifically show that personal factors that are associated with people's variable tolerance of wildlife risks and damages, such as age, socioeconomic status, and gender identity, may further influence the outcomes of human-wildlife interactions and people's resulting wildlife attitudes and behaviors (Zinn and Pierce, 2002; Soulsbury and White, 2019). For instance, we found that men in our study generally reported greater comfort living near foxes and coyotes, consistent with previous studies indicating generally lower wildlife risk aversion (Kellert and Berry, 1987; Zinn and Pierce, 2002). However, further research is needed to better understand how perceptions of human-wildlife encounters (i.e., positive, neutral, or negative; acceptable or

acceptable) affect their wildlife attitudes through people's prior expectations, emotional dispositions, and perceptions of risks (Jacobs and Vaske, 2019; Slagle and Bruskotter, 2019).

5.2 Roles of species traits

The nature of encounters between people and wildlife depends on the varied characteristics of wildlife species, particularly as they pertain to hazards to and benefits for human well-being. The potential for attitudes representing wildlife tolerance and acceptance to vary among individuals as a function of their values and experiences may be greatest for species that have been more historically stigmatized (George et al., 2016), including larger mammalian carnivores and venomous snakes (Bateman and Fleming, 2012; Bateman et al., 2021). This concept was supported by our findings that residents living closer to desert parks were generally more comfortable living near coyotes and foxes, but not necessarily rabbits. Since greater experiences with nature and exposure to associated risks have been linked to lower risk perceptions and positive wildlife attitudes (Slovic, 1987; Zaradic et al., 2009), increasing people's familiarity with potentially threatening wildlife and their behaviors may help to gradually build tolerance and acceptance of these species (Carter and Linnell, 2016). Thus, improving access to positive nature-based experiences – particularly among youth, whose environmental values are generally more dynamic (Manfredo, 2008c; Soga et al., 2016) – is vital to enhancing the long-term growth in potential for coexistence.

Attitudes toward less-feared wildlife, such as rabbits, whose presence typically elicits more positive affective and cognitive responses of joy and appreciation (Kellert, 1985; Kellert, 1993; George et al., 2016; Jacobs and Vaske, 2019), appear less associated with environmental experiences and more closely associated with people's sociodemographic characteristics. For instance, our results indicated that variation in comfort living near rabbits (which was generally high to begin with) was not associated with residents' proximity to desert parks or as strongly influenced by wildlife value orientations. However, even relatively benign wildlife can exhibit traits and behaviors that directly impact people's livelihoods and lifestyles, shaping attitudes toward those species in subtler, less certain ways (Hudenko et al., 2010). For example, comfort living with rabbits may be lower within areas of greater agricultural activity and in more extensively landscaped neighborhoods, where concerns over potential damage to plants valued by people may decrease tolerance of rabbit presence (Abu Baker et al., 2015; Simes et al., 2015). In such cases, coexistence might be more effectively facilitated through approaches that move beyond the ecological factors that shape nature-based experiences and toward approaches that more strongly consider the human drivers of wildlife attitudes, including how different people's perceptions of the same wildlife may vary according to those people's diverse lifestyles and livelihoods that influence the frequency and positivity of human-wildlife encounters.

5.3 Limitations and future research

To build a deeper understanding of the human and environmental factors that shape wildlife attitudes, future research could test relationships in different social-ecological contexts, including other species, other human populations, and other places. As it was not our intention to obtain a representative, generalizable sample in this study, we have focused our interpretation on local relationships with the explanatory variables within this study neighborhoods. Although we were limited by available data to a select few species and environmental variables, our survey methods coupled with geospatial data enabled us to detect substantial patterns of residents' attitudes in relation to the environmental and sociodemographic characteristics of neighborhoods. However, we were unable to determine causal relationships such as the direct impacts of wildlife encounters on residents' attitudes. Exploration of causality requires follow-up studies that incorporate qualitative and experiential research methods to examine people's interactions with wildlife and how they have shaped their tolerance, acceptance, and stewardship (Soulsbury and White, 2019). In such future studies of coexistence, it is vital to consider both attitudes and behaviors toward wildlife, since even though attitudes can signal the potential cognitive outcomes of human-wildlife interactions, behavioral responses to those interactions (including both mutually beneficial and detrimental practices) often diverge from attitudes (Larson et al., 2023).

Our results additionally emphasize how the diversity of human interactions with wildlife is rooted in culturally and emotionally informed perceptions of wildlife characteristics. As survey-based methodologies do not effectively capture various cultural dimensions of relationships with wildlife (IPBES, 2022), future studies would benefit from the greater use of ethnographic approaches to examine cultural beliefs and shared experiences that shape wildlife values and attitudes (Prokop et al., 2011; Jacques-Coper et al., 2019; Thekaekara et al., 2021). Finally, the roles of species' ecological and phenotypic traits as drivers of people's emotional and cognitive responses to wildlife (and the risks those wildlife potentially pose) are a key topic of future study (Jacobs and Vaske, 2019), one that requires examining more taxonomically and functionally diverse wildlife taxa that have various relationships with people.

5.4 Implications for coexistence

Different levels of comfort living near wildlife can signal alternative strategies for promoting human-wildlife coexistence, as comfort considers both positive and negative responses to wildlife and associated predictors of those responses, especially people's wildlife values. Our results indicated that the ability to expand wildlife acceptance and stewardship will be closely tied to shifts in wildlife value orientations away from domination and toward mutualism across the U.S. (Manfredo et al., 2020), which may

also be a major source for future human-human conflict due to the potential for disagreements over how best to manage wildlife populations and their coexistence with people in heterogeneous urbanizing regions (Lute and Gore, 2019). As such, we recommend that wildlife management practices continue to move beyond the prediction and mitigation of human-wildlife conflicts and toward the addressing human-human conflicts and the promotion of environmental stewardship, all while considering the diverse manners in which people value their interactions with wildlife (Lute and Gore, 2019; Bhatia, 2021; IPBES, 2022; Pascual et al., 2023). For instance, greater understanding of how wildlife attitudes, including comfort, may facilitate the incorporation of coexistence into multi-scale conservation planning efforts within landscapes increasingly dominated by human activity (Parris et al., 2018; Marchini et al., 2019; Apfelbeck et al., 2020; Kay et al., 2022). The success of these conservation efforts and the identification of stakeholders fall along the conflict-to-coexistence continuum depend upon human and wildlife behaviors rooted in complex social, ecological, and place-based relationships (Dietsch et al., 2019; Carter and Linnell, 2023).

6 Conclusion

Metropolitan residents express a great degree of comfort living near mammals, possibly indicating broad wildlife acceptance and tolerance, and thus, the potential for human-wildlife coexistence. Not only did we show that the ability to enhance coexistence is tied to broader cultural trends, due to the strongly ideological foundation of wildlife comfort, our results highlighted how the influences of sociodemographic, environmental, and species characteristics on attitudes suggest additional place-based and individualized opportunities to enhance wildlife tolerance, acceptance, and stewardship. With wildlife attitudes serving as significant indicators of behavioral intent regarding people's willingness to coexist, further exploration of wildlife attitudes and their drivers remains vital to the success of conservation efforts in an urbanizing world.

Data availability statement

Datasets analyzed in this study are currently in an embargo period while being analyzed and published by the investigators. People interested in the data should contact the lead author Jeffrey Haight (jdhaight@asu.edu) and 2021 Phoenix Area Social Survey Director Kelli Larson (Kelli.Larson@asu.edu). The data will be made publicly available by 2025 via the Central Arizona-Phoenix Long-Term Ecological Research program.

Ethics statement

The studies involving humans were approved by Arizona State University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

The manuscript was primarily conceptualized and written by JH (first author) and KL (senior author). JC prepared the data for analysis. JH and JC conducted the statistical analyses. SH and JL provided funding for the work, and all authors reviewed the manuscript, aided in interpretation of results, and contributed revisions. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2023.1248238/full#supplementary-material

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