Urban Ecosystems (2021) 24:35–48
https://doi.org/10.1007/s11252-020-01013-2

Who is abuzz about bees? Explaining residents' attitudes in Phoenix, Arizona

Kelli L. Larson[1,2] · Melissa Fleeger[2] · Susannah B. Lerman[3] · Megan M. Wheeler[4] · Riley Andrade[1] · Jeffrey A. Brown[5] · Sharon J. Hall[4] · Desiree L. Narango[6]

Published online: 7 June 2020

Abstract

Many stressors plague bee populations including habitat fragmentation and degradation, as well as pathogens and pesticide exposure. With bee communities at risk, conservation efforts are imperative. Although recent research has examined bee communities across cities, few studies have analyzed variation in human attitudes toward and perceptions of bees, or how these perspectives might influence bee conservation. We therefore analyzed residents' attitudes toward and perceptions of bees, specifically in metropolitan Phoenix, Arizona. Primarily drawing upon 2017 survey data (n = 496, 39% response rate), we posed the following questions: 1) What cognitive, environmental, and social factors explain whether people like or dislike bees? and 2) How do attitudes and perceptions about bees relate to land management practices, specifically landscaping choices, herbicide and pesticide use, and desert plantings? Overall, attitudes toward bees were mostly neutral with a slight trend toward dislike but most residents did not believe bees were problematic at their homes. Additional findings reveal that risk perceptions, ecological worldviews, and pet ownership significantly explained attitudes toward bees. Moreover, people who live closer to desert parks had relatively positive attitudes toward bees. Regarding yard management practices, both attitudes toward and perceptions of bees were positively correlated with adding desert plants to residential yards. Moreover, people who use pesticides had more negative attitudes toward bees. Our results indicate conservation potential for urban bee populations, for example, by planting native vegetation in residential areas near desert preserves. We hope this study will result in more attitudinal research on bee species and other understudied urban wildlife.

Keywords Environmental attitudes · Bee conservation · Human-wildlife interactions · Urban ecology

Introduction

Bees provide essential ecosystem services such as pollinating crops and maintaining biodiversity. 87% of flowering plants depend on pollinators for reproduction (Ollerton et al. 2011). Furthermore, animal-mediated crop pollination is responsible for roughly 35% of food production globally (Winfree et al. 2011). Of the approximately 20,000 species of bees that have

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

Melissa Fleeger
melissacfleeger@gmail.com

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

Megan M. Wheeler
mmwheele@asu.edu

Riley Andrade
rileyandrade@asu.edu

Jeffrey A. Brown
jeff.alexander.brown@gmail.com

Sharon J. Hall
sharonjhall@asu.edu

Desiree L. Narango
dnarango@gmail.com

1 School of Geographical Sciences and Urban Planning, Arizona State University, Tempe, AZ, USA

2 School of Sustainability, Arizona State University, Tempe, AZ, USA

3 USDA Forest Service Northern Research Station, Amherst, MA 01003, USA

4 School of Life Sciences, Arizona State University, Tempe, AZ, USA

5 Global Institute of Sustainability, Arizona State University, Tempe, AZ, USA

6 Advanced Science Research Center, City University of New York, New York, NY, USA

been described (Michener 2000), one species—the European honeybee (*Apis melifera*)—is the most abundant pollinator for cultivated plant crops (Hung et al. 2018). *A. melifera* has gained media attention due to recent dramatic population declines, but more than 30 other bee species are also imperiled, and population trends for many other species cannot be quantified due to a lack of data (IUCN 2019).

Native bees have experienced many stressors including habitat fragmentation and degradation, pathogens, climate change, pesticide exposure, and competition with introduced honeybees, which together are largely responsible for their recent declines (Thomson 2004; Vanbergen et al. 2013; Hamblin et al. 2018; Cariveau and Winfree 2015). These anthropogenic threats are proving to be a challenge for both wild and managed bee communities (Banaszak-Cibicka and Zmihorski 2012). However, human-dominated environments such as cities can also support bee populations when conservation actions, such as the local provisioning of habitat, are taken to preserve them (Frankie et al. 2009; Hülsmann et al. 2015).

Urban ecosystems may be especially important for pollinators as refugia from agricultural systems that have low floral diversity and high pesticide use (Hall et al. 2017). Numerous studies have found that urban land uses (e.g. yards) and habitat fragments within cities support bee communities that are comparable, or even more diverse, than nearby native ecosystems (Harrison et al. 2018; Choate et al. 2018; Landsman et al. 2019). Specifically, land management in residential yards can positively benefit bee populations through planting flower gardens (Frankie et al. 2009; Fetridge et al. 2008; Lowenstein et al. 2014; Baldock et al. 2019), natural landscaping (Hostetler and McIntyre 2001; Lerman and Milam 2016), reducing lawn-mowing frequency (Lerman et al. 2018), increasing bare ground for nesting sites (Quistberg et al. 2016), and reducing pesticide use (Muratet and Fontaine 2015). However, conservation efforts that successfully support native bees in urban areas require public support and involvement in creating beneficial habitat while mitigating negative human impacts. Research on public attitudes and behaviors towards bees can help shape people's amenability to increased conservation that facilitates coexistence.

Public attitudes towards wildlife reflect the societal acceptability and support for conservation initiatives that sustain pollinator-friendly actions in cities. Research on bees in cities has risen in recent years (for reviews, see Hernandez et al. 2009; Hall et al. 2017, plus Baldock et al. 2019). Yet very little research—in cities or otherwise—has examined people's attitudes or beliefs about bees specifically. Some studies have addressed attitudes on bees or "stinging insects", though often times in aggregate with other animals (e.g., Davey 1994; Bjerke et al. 1998; Arrindell 2000). Additional studies (e.g., Sing et al. 2016; Silva and Minor 2017) lack details about the factors that explain attitudes toward bees or how attitudes are associated with conservation-related behaviors.

Our research aims to reveal what people think of bees in the greater Phoenix region of Arizona, USA. In particular, we ask: 1) What cognitive, environmental, and social factors explain whether people like or dislike bees? And 2) How do attitudes and perceptions about bees relate to land management practices, specifically landscaping choices, herbicide and pesticide use, and desert plantings? For the first question, the extent of dislike represents affective attitudes. For the second question, perceptions reflect cognitive attitudes that capture beliefs about whether bees are problematic in people's local (home) environments. Perceptions about bees were also included as an explanatory variable for the first analyses, as theorized and detailed below.

Literature review

Defined as positive or negative evaluations of some "object" (Thurstone 1928), attitudes reflect the ways in which people think, feel, or intend to act regarding a particular issue (Dunlap and Jones 2002; Larson 2010; Heberlein 2012). As a multidimensional construct, attitudes include three elements: cognitive (i.e. beliefs), affective (i.e. emotions), and conative (i.e., behavioral intentions) elements. Generally, affective attitudes embody emotive expressions, while cognitive factors encompass knowledge or beliefs about what is real (Dunlap and Jones 2002; Larson et al. 2011a). For clarity, we refer to cognitive attitudes as risk perceptions, since they reflect beliefs about whether bees pose problems for residents. Structural factors control, constrain, or reinforce people's behaviors and experiences, which can in turn affect attitudes (Larson et al. 2010; Heberlein 2012). For our purposes, we evaluate environmental (e.g., nearness to desert preserves and landscaping type), and social (e.g., gender) attributes as structural factors that might influence people's experiences and interactions with bees and, by extension, their attitudes about them.

Factors that influence attitudes towards bees

Cognitive factors

Attitudinal theory stresses that general values, beliefs, and attitudes (e.g., about the environment broadly) can affect more specific attitudes about the environment (e.g., about bees in particular) (Stern 2000; Larson 2010; Heberlein 2012). In this study, we evaluated how relatively general values as well as specific beliefs influence affective attitudes about bees, respectively including ecological worldviews (Dunlap et al. 2000) and perceptions of bee-related risks. First, as general value orientations, ecological worldviews reflect basic beliefs about people's relationships with the environment, which are commonly measured with the New Ecological Paradigm (NEP) scale developed by Dunlap et al. (2000). The NEP scale constitutes several agree-to-disagree statements about the severity of human impacts on the environment, the extent to which nature is fragile and easily disturbed, and the degree to which growth is limited by natural resources. In essence, the series of statements reflect biocentric values (e.g., with the belief that plants and animals have as much right as humans to exist) in contrast to anthropocentric orientations (e.g., humans have the right to modify the natural environment to suit their needs; Larson et al. 2010). Perceptions constitute beliefs about what is true or not (Larson et al. 2009). Although perceptions are not always positive or negative, beliefs about risks constitute cognitive attitudes since they convey the extent to which particular events or phenomena are viewed negatively, for example, whether detrimental or unacceptable.

We predicted that people with relatively biocentric values would express stronger appreciation of bees, whereas people with anthropocentric values would more likely view bees negatively. Further, we hypothesized that residents who perceive bees as problematic would hold more negative affective attitudes (i.e., dislike) of them. We expected that beliefs about bee problems would have more influence on attitudes toward bees than the more general (i.e., not bee-specific) ecological worldviews. The latter prediction is based on the specificity principle in attitude theory, which underscores that the more relevant a belief or attitude is to the object under consideration (i.e., bees in our study), the more influential it will be compared to relatively general sentiments (Whittaker et al. 2006).

Environmental factors

Research has demonstrated that human experiences significantly affect environmental attitudes and risk perceptions (Slovic 1987; Heberlein 2012). Environmental factors, such as proximity to parks and other green infrastructure, significantly shape people's experiences in urban regions (Larson and Santelmann 2007; Andrade et al. 2019). Partly due to influences on the abundance and distribution of bees, people's experiences with bees or other wildlife may incite positive responses such as appreciation and enjoyment, or negative responses such as fear or anxiety (Kellert 1993). Consistent with experiences leading to positive attitudes, one study across four southeast Asian metropolitan regions found that personal interactions with bees heightened the belief that bees are *not* pests (Sing et al. 2016). This study also found that people's experiences with bees were linked to their perceived ecological value. Furthermore, positive views of bees persisted even when people had been stung, especially people surveyed in suburban areas where bee abundance and richness was high. In contrast, residents surveyed in central parts of the study cities had fewer experiences with bees and relatively negative attitudes toward them. Our study builds on this work by examining how a range of factors influence bee attitudes, and how those attitudes—as well as perceptions about bee risks—might influence land management.

Environmental factors that might influence experiences with bees include proximity to desert preserves, as well as the location of residents within a metropolitan region. In our study region of Phoenix, Arizona, past research has demonstrated that bees are more abundant in desert preserves compared to nearby urbanized lands (Hostetler and McIntyre 2001). Additional research suggests that proximity to natural areas may lead people to appreciate local ecosystems and wildlife (Larson and Santelmann 2007; Keniger et al. 2013; Andrade et al. 2019). Thus, we expected that geographic closeness to desert parks may lead people to have more experiences with bees and, thus, more positive attitudes toward them.

Regarding location across an urban gradient, the effects on bees are mixed. Some studies have found bees to be negatively affected by dense urbanization (e.g., Fetridge et al. 2008; Hernandez et al. 2009); however, other studies have found that dense cities can have similar (Guenat et al. 2019) or even higher richness and abundance than natural landscapes (Winfree et al. 2007; Fortel et al. 2016; Martins et al. 2017). Given conflicting findings in the literature, in addition to the uncertainty in how bee resources may be distributed across the metropolitan Phoenix area, we examined the extent to which residents of urban, suburban, and fringe (i.e. exurban, urban-wildland interface) neighborhoods were relatively positive or negative in their attitudes toward bees.

An additional environmental factor that might affect bees, and thus residents' experiences with them, is landscaping type. In the study area of semi-arid Phoenix, desert-style xeric residential yards, which included no grass cover and mostly rock groundcover, have specifically been found to be higher in bee richness and abundance compared to mesic lawns (Hostetler and McIntyre 2001). As a result, people with xeric landscapes at home, may experience bees more frequently and, thus, have stronger, potentially more positive attitudes toward them.

Another aspect of residential yards that may increase interactions with bees and affect bee attitudes is whether or not people have swimming pools. Many colony-nesting bees (e.g., honeybees, bumblebees *Bombus* spp.) are known to congregate at water sources to collect water for cooling their brood when temperatures are high (Nicolson 2009). Worker honeybees are some of the primary sources of stings (Moissett and Buchanan 2010), and pool use may increase risk (or perceived risk) of sting exposure. Thus, pool ownership may correlate with fear and negative views about bees due to disproportionately high interactions with stinging species. Alternatively, pool ownership could potentially lead to positive attitudes towards bees if interactions in and around pools create stronger appreciation and diminished fear of bees.

Social factors

Social factors also influence affective attitudes through a variety of mechanisms. Demographic attributes such as age, income, education, gender, and ethnicity may, for example, affect vulnerability to risks (Cutter et al. 2003; Larson et al. 2011a, b; Andrade et al. 2019). Regarding age, small children and the elderly are often more vulnerable to health risks than full-grown and healthy adults. According to the U.S. Department of Agriculture (USDA 2018), the elderly—especially those with weak cardiopulmonary health—are most susceptible to severe reactions to bee stings. This could lead to stronger dislike of bees by this demographic. Kellert (1993) found evidence of this outcome in relation to invertebrates broadly. In particular, elderly people expressed greater fear of invertebrates as well as stronger drives to exploit or harm them. Among a relatively young sample (with an average age of 35), Sing et al. (2016) also found that older residents (>45) in Asian cities disliked bees more than younger residents, although Bjerke and Østdahl (2004) found that older residents of Trondheim, Norway liked bumblebees more so than younger residents. As a result, we expected that older residents could dislike and fear bees more than younger adults.

People of lower socioeconomic status are also more vulnerable to risks, since they tend to have fewer resources or weakened capacity to cope and adapt (Cutter et al. 2003). For instance, people with lower income levels may lack money or access to health care to treat effects of bee stings or other risks. In Kellert (1993) study, income was not significantly related to views of invertebrates. However, people with college degrees were more knowledgeable, appreciative, and protectionistic about invertebrates compared to less educated individuals, who tended to be more fearful and held more utilitarian views of them. Bjerke and Østdahl (2004) also found that higher educational levels were associated with liking bumblebees. As a result, we expected that people with higher education levels may express more positive attitudes toward bees. Meanwhile, we did not expect income to significantly affect attitudes.

Theory and empirical evidence indicate that women have heightened risk perceptions compared to men (Davidson and Freudenburg 1996; Finucane et al. 2000; Larson et al. 2011a). According to socialization theory, women express greater concerns about environmental risks due to their caregiving roles and concerns about safety. In Kellert (1993) study, women expressed significantly greater fear toward invertebrates, and they were also less inclined to protect them compared to men. Earlier work cited by Kellert (Marks 1969; Agras 1985) suggests that women have also exhibited significant anxiety about invertebrates, and Bjerke and Østdahl (2004) reported that men like bumblebees more so than women. We therefore anticipate that women will express more negative attitudes regarding bees.

Ethnicity may play an influential role in attitudes toward bees since, in particular, Hispanic and Latinx people tend to view humans as a part of nature, and thus, often feel more subject to environmental risks (Lynch 1993; Schultz et al. 2000; Chase et al. 2016). In contrast, Anglos tend to hold views of domination towards the environment, such as beliefs that nature exists primarily for human benefits and that people are superior to wildlife. Research has shown that non-white minorities expressed greater concerns over environmental risks such as water pollution and scarcity than white people (e.g., Williams and Florez 2002; Larson et al. 2011b; Pearson et al. 2018). Overall, however, studies of how people of Latinx or Hispanic origins view animals of varying sorts, specifically bees, is lacking. Nevertheless, based on the extant literature on Latinx environmentalism, we anticipated that Latinx and Hispanic residents will have more negative attitudes about bees compared to Anglos.

A final social factor that may influence environmental attitudes is pet ownership. Domestic animals are considered to be property or sometimes even family, both of which lead to heightened risk perceptions if these animals are under threat (Goodale et al. 2015). Thus, pet ownership could garner negative attitudes about bees due to concerns about potential stings. Outdoors pets like cats and dogs are particularly vulnerable to being stung by aggressive bee species; however, the public's perceived risk of bee injury is much higher than actual risk (Johnston and Schmidt 2001). On the other hand, pet ownership could potentially influence more positive views due to general biophilia (Kellert 1993). The latter hypothesis has garnered some support in the literature, particularly one study (Bjerke et al. 2003) that found that pet owners tended to like more species of animals (including insects) than did non-pet owners. Their results indicate that pet ownership is linked to more positive attitudes toward wildlife in general. Moreover, Shuttlewood et al. (2016) found a strong link between pet ownership and support for conservation in the UK, wherein survey respondents with pets were less likely to have a human-centric view of wildlife and more likely to support strategies that avoid species extinctions. Overall, we hypothesized a positive, biophilic effect for pet ownership for bee attitudes.

The influence of attitudes and perception on behavior

Attitudes are important to consider in conservation since they can influence related behaviors (Manfredo 2008; Heberlein 2012). Three types of residential behaviors may be important for bee habitat including choices in the type of landscaping installed and managed (see especially Hostetler and McIntyre 2001), the types of vegetation planted and maintained (Baldock et al. 2019; Hamblin et al. 2018; Lerman et al. 2018), and the use of pesticides (Jacobson et al. 2018;

Cariveau and Winfree 2015). We examine these three types of management practices in relation to both affective and cognitive attitudes toward bees to understand whether either or both types of attitudes influence these sets of practices.

Regarding landscape management, we examined residents' preferred and reported landscapes in relation to attitudes toward bees to test if positive attitudes are associated with relatively natural, xeric choices in the desert study area. Research has shown that landscape preferences and existing yards are important to distinguish since what people prefer does not always match the landscapes they have at home (see Wheeler et al. 2020 for an analysis of this mismatch and the associated drivers of preferred versus actual yards types). While preferences are partially correlated with actual yard types, previous decisions made by developers and residents can persist if current homeowners or residents do not invest in changes to their yards. Landscaping ideals can also be constrained by social norms or other institutional forces that prevent them from being realized. Hence, we hypothesized that attitudes toward bees would more likely influence preferences than actual landscapes since the latter tend to be constrained relative to people's ideals (Larson et al. 2017).

In addition, the types of plants in people's yards may provide food or habitat resources for bees. Flowering species, for example, have been associated with higher bee abundance and diversity (Lowenstein et al. 2014). Further, locally native plants attract bees, particularly in the desert southwest (Minckley et al. 2000). In our study, we examined the self-reported addition or removal of desert plants, with the hypothesis that people with positive attitudes about bees would be more likely to plant vegetation that provides resources for local desert-adapted wildlife than others (Goddard et al. 2013; Wignall et al. 2019). Meanwhile, we expected the opposite relationship for removal of desert plants.

Lastly, given the negative impacts that pesticides and herbicides can have on bee communities (Muratet and Fontaine 2015; Woodcock et al. 2017), we examined whether attitudes toward bees were significantly related to the application of yard chemicals. We included both pesticides (i.e., for controlling insects) and herbicides (i.e., for eliminating weeds) in our analysis. However, we anticipated that the relationship would be stronger between attitudes toward bees and pesticide use (i.e., direct effects to control insects such as bees) than for herbicide use (i.e. indirect effects that reduce flower abundance and contaminate pollen).

Methods

Study area

Our study region is Phoenix-Mesa-Scottsdale metropolitan area (hereafter, "Phoenix"), which encompasses several municipalities in central Arizona, USA. Phoenix has the 11th largest population in the United States and has a high proportion of Hispanic/Latinx residents (U.S. Census Bureau 2017, 2018). It is situated in the northern Sonoran Desert, and as such, experiences hot, dry conditions with a summer monsoon season and winter rains. The Sonoran Desert is home to the one of the highest diversities of native bee species in the world (Michener 1979; Hostetler and McIntyre 2001), the majority of which are solitary, plant-specialist, and ground-nesting bees adapted to desert ecosystems. The metro region has several large desert preserves, some embedded in the urban matrix and some on the outskirts of the developed area (Fig. 1).

Within the Phoenix region, features such as swimming pools and well-watered landscapes, including lawns, are common. Despite grassy landscapes being widespread throughout the area, desert-like but cultivated "xeric" landscapes are increasingly prevalent (Frost 2016; Larson et al. 2017). The local stream channels for the Salt River (Rio Salado) run through the metropolitan area but largely remain dry due to upstream storage in dams. However, some areas of the river channel have been restored and redeveloped in recent years (Fig. 1).

Survey implementation

The Phoenix Area Social Survey (PASS) was conducted in 2017 in 12 neighborhoods that were part of the Central Arizona-Phoenix Long Term Ecological Research (CAP LTER) project. The PASS aims to assess a range of resident attitudes, perceptions, and behaviors in connection with ecological characteristics of the urban landscape (Larson et al. 2017). The PASS has been deployed and refined four times since 2001; the most recent survey—conducted in 2017—uniquely included questions that capture attitudes toward bees (see below).

The study neighborhoods (Fig. 1) were defined by 2000 US Census block groups, and were selected to represent key demographics and locations in the Phoenix area and to overlap with ongoing ecological sampling. The initial sample comprised of 1400 addresses from the 12 neighborhoods, including 188 previously sampled addresses from the 2011 survey. New addresses were randomly selected from the U.S. Postal Service's Delivery Sequence and were stratified by neighborhood such that neighborhoods were approximately equally sampled.

The University of Wisconsin Survey Center administered the survey via mail between May 31 and September 152,017. Surveys were conducted by mail, with each address receiving a packet with a printed survey, return envelope, card to request a Spanish language survey, and $5 incentive. Three additional contacts were employed: one reminder to all addresses a week after the initial mailing and two full packet mailings to those

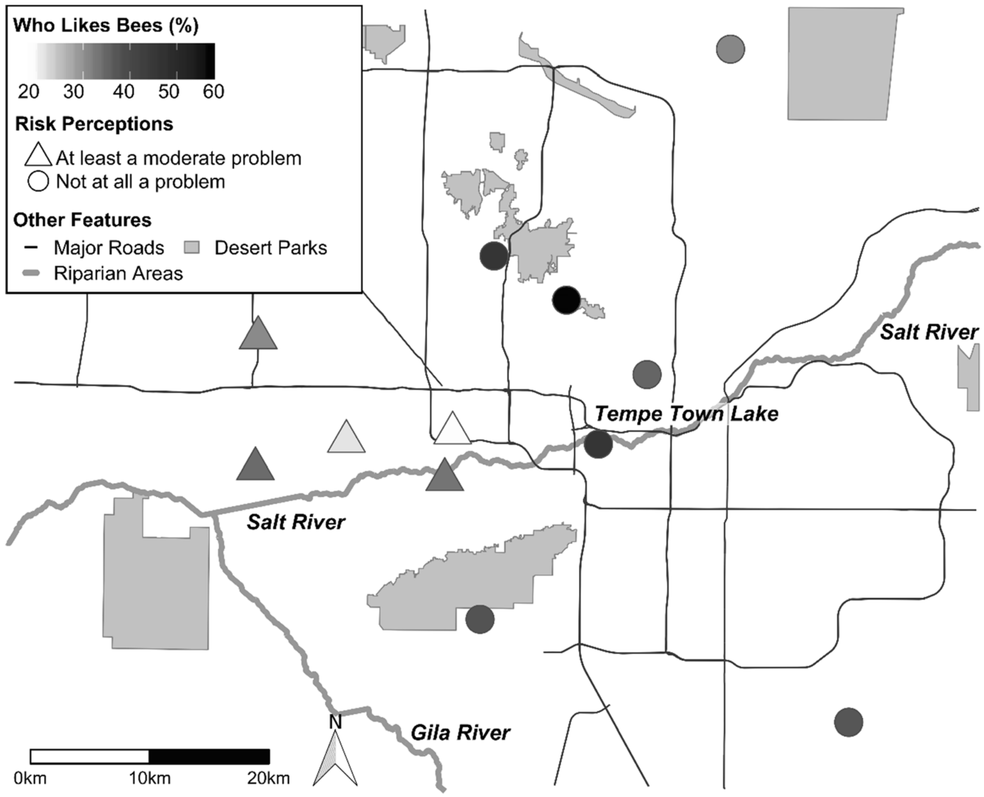

Fig. 1 Spatial distribution of attitudes and risk perceptions about bees in the 12 study neighborhoods. Neighborhood centroids are colored by the percent of respondents who selected that they somewhat or strongly like bees, with darker shades indicating that a higher percentage of respondents in the neighborhood liked bees. Triangles indicate neighborhoods where respondents were more likely to answer that bees were at least somewhat of a problem. This map was created in R

who had not responded after three weeks and after seven weeks. Completion incentives were offered in varying amounts based on randomly assigned groups as part of another experiment, with respondents offered \$5, \$25, or \$40 for either themselves or a charity organization (see experimental results in Smith et al. 2019).

496 completed surveys were returned for a response rate of 39.4%. Our sample is fairly representative of the study neighborhoods based on demographics (from the U.S. Census) including age (average was 51 years) and median household income levels (\$60-80 K). Yet the sample is relatively well educated, with more than half holding a Bachelor's degree or having gone to graduate school. Twenty percent of the survey respondents self-identified as Mexican or Latinx, as compared to the 30% in the study neighborhoods. We recognize our sample is limited to select neighborhoods and use caution in generalizing the results.

Survey variables

In the PASS, we included questions about bees, landscape types, and yard management. The two survey questions that asked residents about their attitudes and perceptions of bees included a Likert response scale. First, to determine attitudes towards bees, we asked: to what extent do you like or dislike bees? The responses were: dislike a lot (1), dislike somewhat (2), neither dislike nor like (3), like somewhat (4), and like a lot (5). Second, to measure perceived problems with bees, we asked: to what extent are bees a problem at your home? Response options included: not a problem (1), a small problem (2), a moderate problem (3), a big problem (4), and a very big problem (5). As an additional attitudinal explanatory factor, we measured environmental value orientations with the widely used New Ecological Paradigm (NEP) scale (Dunlap et al. 2000). This is a 15-statement question to which respondents express their level of agreement or disagreement (on a 5-point scale) with basic beliefs such as, "Plants and animals have as much right as humans to exist" (biocentric orientation), and "Humans have the right to modify the natural environment to suit their needs" (anthropocentric). All statements were reverse coded so that high values (5) reflect pro-ecological (biocentric) values.

Two survey questions asked residents about their landscape type. First we asked: "which of the following most resembles your yard?" in the front and back areas of the house. Seven possible responses were provided: (1) "a yard with grass, some shrubs and leafy trees", (2) "a yard with some grass and some crushed stone with plants, shrubs and trees", (3) "a yard with crushed stone and native desert plants and trees", (4) "a yard with patches of bare soil and little or no grass and trees", (5) "a yard with large areas of hard surface, such as flagstone or finished concrete, and plants and shrubs in containers", (6) "a balcony or patio without plants, shrubs, or trees", and (7) "a patio or balcony with garden area/flower beds/plants". Respondents could also choose "other" and write in their own response. These descriptions were recoded to represent the amount of grass in a yard, where (1) above was all grass, response (2) some grass, and responses (3–7) no grass. "Other" responses were classified as possible when grass or lack of grass was included in the description. To ensure the question reflects the extent to which a residents' current landscaping was entirely xeric (to address native habitat potential; Hostetler and McIntyre 2001), we combined front and back yard types to reflect parcel-level yard cover on a 1–5 scale, as follows:

(1) all grass (response 1 for both front and back yards),
(2) mostly grass (response 1 in one yard and 2 in the other),
(3) split between grass and another groundcover type (response 2 in front AND back, or response 1 in front/back and responses 3–7 in back/front),
(4) a little grass (response 2 in front OR back), and
(5) no grass in either front or back, (responses 3–7 in both front and back yards).

To identify whether people have a pool in their yard, we simply asked and recorded this variable as yes or no. We also asked a number of demographic questions on the survey. For the social drivers, age was calculated as 2017 minus the year residents were born. One case (for a reportedly 116 year old) was omitted from all analyses as an outlier (and a likely erroneous entry). Gender was reported as female or male. The ethnicity variable reflects whether residents identify as Hispanic or Latinx, inclusive of the following heritages: Mexican, Mexican-American, Chicano, Hispanic, or Latinx. All other, mostly Anglo respondents were coded as non-Hispanic/Latinx. Household income was measured on an 11-point scale, with (1) as $20,000 and under, (2–10) as increasing $20,000 increments, and (11) as more than $200,000. Education was coded by the highest level of achievement on a six-point scale with (1) as grades 1–8, (2) as grades 9–11, (3) completed high school or GED, (4) as community college or vocational/technical school, (5) Bachelor's degree, and (6) graduate degree. Lastly, we asked whether or not people had a dog(s) or cat(s).

Finally, to determine whether attitudes may have influenced these behaviors, we asked respondents about their specific yard management behaviors. First, we asked about both reported landscape types as well as residents' ideal preference. As explained above, the two landscape variables were measured on a five-point scale wherein (5) is entirely xeric yards and (1) is entirely grass. Second, to capture changes in vegetation, we asked separately if residents had added or removed any desert plants at their current residence, specifically during the last five years. Thirdly, we asked: "In the last year, have you or someone else applied chemicals to control insects or other pests in the outdoor areas of your home?" The response options were yes, no, and not sure. The same question was asked regarding herbicides, or "…to control weeds or unwanted plants."

Non-survey environmental variables

To assess how environmental factors might influence attitudes, we calculated the distance between the location of the survey respondents' home and the edge of the closest regional desert park (Fig. 1). Urban, suburban, and fringe (exurban) locations were defined respectively as: within 8 km of downtown Phoenix or within 2.4 km of other large-city downtowns; beyond those distances but in highly developed areas; and, along the metropolitan border with a significant amount of undeveloped land. All land cover attributes were measured using packages 'rgeos' (Bivand and Rundel 2018) and 'rgdal' (Bivand et al. 2018) in Program R version 3.5.1 (R Core Team 2018).

Statistical analyses

All analyses were run in SPSS V25. For the first research question, we ran ordinary least squares (OLS) regression to test how environmental views, geographic location, socioeconomics, pet ownership and the presence of a pool help explain attitudes towards bees (the response variable). We first ran the model including the xeric landscaping variable. We limited this second model to only single-family homes, since these residences tend to have distinct front and back yards in the study region. Since this limited our sample size ($n = 296$) and since the xeric landscaping variable did not significantly explain attitudes toward bees, we present the results for the model that excludes the landscaping variable and includes all landscaping types ($n = 436$; Table 2). Although some explanatory variables were correlated with each other, the models met standard criteria to avoid multicollinearity problems (Mansfield and Helms 1982). Specifically, all VIF statistics were 1.6 or below, and tolerance values were above 0.6.

For the second research question about how attitudes and perceptions about bees relate to landscape management, we ran Pearson's correlations for both attitudes towards bees and perceptions of bee problems and preferred and actual landscapes (i.e., extent of grass). For the binary variables for chemical applications and desert-adapted plantings, we conducted t-tests to determine whether attitudes and perceptions differ significantly based on these yard management practices.

Results

On average, residents' attitudes about bees were relatively neutral but leaned toward slight dislike (Table 1). Among the survey respondents 19% liked bees "a lot," another 19% "somewhat" liked bees, and an additional 19% chose the "neither like nor dislike" option. Meanwhile, 26% disliked bees "a lot" and 17% "somewhat" disliked bees. By comparison, most people did not indicate that bees were problematic at their homes. Only 2% and 4%, respectively, believed that bees were a "very big" or "big" problem. Another 14% reported bees were a "moderate problem," 27% a "small problem, and 54% "not a problem." A Spearman's correlation test showed that the bee attitude and perception variables share approximately 38% ($p < 0.01$) of the variance.

Factors explaining attitudes toward bees

The regression model had an adjusted R^2 of 0.23 (F = 11.65, p < 0.01). Comparing the standardized beta coefficients (Table 2), perceived bee risks were the most significant factor explaining dislike of bees. The next most influential factor was distance to desert parks, with residents who live nearer to desert preserves expressing a stronger like of bees compared to those who live farther away (Fig. 1). Lastly, general ecological worldviews and pet ownership (both cats and dogs) positively influenced attitudes toward bees.

The other explanatory variables in the model, mostly demographic attributes and relative location within the metro region, were insignificant. However, four variables were significant at $\alpha < 0.10$ (Table 2). Two of these variables are especially noteworthy since they become significant when the variable for perceived bee problems is dropped from the model. Specifically, Latinx/Hispanic ethnicity was associated with negative attitudes toward bees, as was being female (see notes in Table 2).

Linkages between bee attitudes and perceptions and landscape management

Yard management practices varied considerably across our study neighborhoods (Table 3). On average, people preferred at least some grass, although most did not report having grassy yards. Meanwhile, about half added desert-adapted plants while only 15% reportedly removed desert plants. Lastly, about 70% of residents used pesticides to kill insects or other pests, and 59% used herbicides.

Regarding residents' landscape choices, neither attitudes nor perceptions about bees were associated with preferred landscapes (respectively, rho = 0.06, p = 0.18 and rho = −0.03, p = 0.57) or reported yard types (rho = −0.06, p = 0.27 for attitudes and rho = −0.01, p = 0.84). However, t-tests revealed differences in attitudes and perceptions about bees for chemical usage and adding desert plants. People who added desert plants in the past five years liked bees more than those who had not, and they also perceived bees as less of a problem (Table 4). Regarding pesticides, non-users more strongly liked bees and also perceived bees as less problematic compared to people who use pesticides. Meanwhile, people who used herbicides viewed bees as more problematic compared to non-users, but attitudes toward bees did not differ significantly based on herbicide use (Table 4).

Discussion

Understanding attitudes towards bees

In this study, beliefs about whether or not bees were a problem at people's homes were among the most influential factors related to whether or not people like or dislike bees. As expected, these cognitive attitudes were more influential than broader ecological worldviews, also known as value orientations. This finding confirms the specificity principle in attitude theory (Whittaker et al. 2006), and also has implications for the potential to shift public attitudes toward support of bee conservation initiatives since specific values and beliefs (i.e., about bees in our study) are more malleable compared to general ones (Manfredo 2008; Heberlein 2012). While focused messaging programs that target specific beliefs about bees and associated risks or concerns may be able to shift public perceptions and attitudes toward bees, the entrenchment of attitudes in broad-based environmental values (i.e., ecological worldviews) indicates attitudes may be difficult to change.

The biophilic effect of pet ownership has significant implications for attitudes toward wildlife in this and other studies (Bjerke et al. 2003; Shuttlewood et al. 2016). This positions pet owners as likely conservationists that could be influential leaders in biodiversity initiatives that involve, for example, planting native vegetation or otherwise providing habitat areas for bees or other pollinators and wildlife. People who live near nature preserves are another group who—based on positive attitudes toward bees as well as natural ecosystems (Andrade et al. 2019)—might become activists for bee and biodiversity conservation.

While environmental factors analyzed in this study were largely insignificant in explaining attitudes, this may be because residential location and landscaping features are poor proxies for people's experiences with bees. Given that personal experiences with wildlife are central to their willingness to live with them (Manfredo 2008), additional research should focus more precisely on understanding how varied experiences influence attitudes toward bees and other wildlife. Since perceptions of bee problems appear linked to gender and ethnic (i.e., Latinx/Hispanic) background in this and other studies (e.g., Davidson and Freudenberg 1996; Larson et al. 2011a for gender, and Schultz et al. 2000; Chase et al. 2016 for ethnicity), future research should also pay close attention to how personal experiences among women and different ethnic groups influence attitudes toward wildlife, especially in contrast to their worldviews and social-cultural perspectives.

Table 1 Descriptive Statistics for Dependent and Independent Variables for the entire Sample ($n = 496$)

Variables	Mean	Median	Std. Dev.	Minimum	Maximum	Valid N
Attitudes toward bees (5 = strongly like)	2.88	3.0	1.47	1	5	492
Cognitive factors						
Ecological worldview (5 = very biocentric)	3.70	3.7	0.70	1.5	5.0	495
Perceived bee problems (5 = very big)	1.74	1.0	0.98	1	5	490
Environmental factors						
Metro location (1 = urban)	1.98	2.0	0.89	1	3	495
Distance to desert park (kilometers)	5.63	5.4	4.29	0.04	16.0	495
Yard cover (5 = all xeric)[a]	4.20	5.0	1.02	1	5	330
Pool (2 = yes)	1.46	1.0	0.50	1	2	487
Social factors						
Age	51	51	18	18	96	487
Gender (2 = female)	1.60	2.0	0.49	1	2	487
Hispanic/Latinx (2 = yes)	1.22	1.0	0.41	1	2	475
Household income (5 = $80,000-100,000)	5.31	4.0	3.19	1	11	456
Education level (5 = Bachelor's degree)	4.58	5.0	1.21	1	6	483
Pet dog (2 = yes)	1.50	1.0	0.50	1	2	496
Pet cat (2 = yes)	1.23	1.0	0.42	1	2	496

[a] Yard cover was included in original regression models. Since it was insignificant and limited the sample to only single-family homes, we dropped it from the models presented herein

Connecting attitudes to behaviors

While the influence of attitudes on behaviors is often tenuous (Manfredo 2008; Heberlein 2012), we found evidence for significant relationships between attitudes and perceptions toward bees and particular land management practices. Specifically, when people like bees or view them as nonthreatening, they may be more likely to plant desert vegetation, which

Table 2 OLS Model Results: Explaining Attitudes toward Bees. Model $n = 436$ due to missing variables. Dark-shaded variables are significant at the $p < 0.05$ level, and light-shaded variables at the $p < 0.10$ level

Explanatory Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.42	0.74		3.26	0.001
Pro-ecological worldviews	0.28	0.10	0.13	2.85	0.005
Perceived bee problems[a]	−0.48	0.07	−0.32	−7.34	0.000
Distance to desert parks (km)	−0.04	0.17	−1.18	−2.32	0.021
Fringe/exurban location[b]	−0.07	0.08	−0.04	−0.84	0.402
Pool	−0.25	0.14	−0.09	−1.74	0.083
Age	0.01	0.00	0.09	1.90	0.058
Latinx/Hispanic[1]	−0.30	0.18	−0.09	−1.69	0.092
Women[1]	−0.23	0.13	−0.08	−1.81	0.071
Education	0.07	0.06	0.05	1.08	0.281
Income	−0.01	0.02	−0.03	−0.50	0.617
Dogs	0.44	0.13	0.15	3.39	0.001
Cats	0.36	0.15	0.10	2.38	0.018

[a] When the perceived risks from bees variable is dropped from the model, Latinx/Hispanic ethnicity ($t = -2.41$, $p = 0.016$) and women ($t = -2.17, p = 0.031$) become significant predictors at the $p < 0.05$ level. The in/significance of all other variables remain the same

[b] Residents located in the outer realms of the metropolitan region relative to central urban and intermediate suburban areas

Table 3 Frequencies of Land Management Practices. Total number of returned surveys N = 496

Landscape Management Variables	Frequency (No. of Respondents)	Percent	Valid N
Landscape Types			
Preferred (mean = 3.25, st. dev. = 1.44)			
All grass (1)	89	18.7%	476
Mostly grass (2)	53	11.1%	476
About half grass (3)	110	23.1%	476
A little grass (4)	97	20.4%	476
No grass (5)	127	26.7%	476
Reported (mean = 4.14, st. dev. = 1.06)			
All grass (1)	15	4.0%	378
Mostly grass (2)	9	2.4%	378
About half grass (3)	96	25.4%	378
A little grass (4)	71	18.8%	378
No grass (5)	187	49.5%	378
Vegetation Changes			
Added desert plants	202	49.9%	405
Removed desert plants	61	15.2%	401
Chemical Applications			
Pesticide use[a]	348	70.2%	435
Herbicide use[b]	294	59.3%	464

[a] The survey question for the *pesticide* variable referred to the use of chemicals "to kill insects or other pests"

[b] The survey question for the *herbicide* variable referred to the use of chemicals "to kill weeds." Missing responses include "don't know" or "does not apply"

can positively benefit local bee populations as well as birds and other native wildlife (Frankie et al. 2009; Narango et al. 2018; Baldock et al. 2019). However, since people who view bees as threatening are more likely to spray herbicides, which can be harmful to bees (Motta et al. 2018), we suggest caution to avoid restoring bee habitat in areas that may become an ecological trap (Schlaepfer et al. 2002) due to chemical usage.

Attitudes towards bees do not appear related to people's preferred or actual landscaping types, perhaps because people do not design their yards for bees. Although research has found that attracting wildlife and provisioning of habitat are somewhat important priorities in residents' landscaping choices, the desire for attractive yards that are easy to maintain likely overrides wildlife values in yard management (Larson et al. 2016). Moreover, past landscaping decisions may constrain people's yards in ways that lead to disconnects between attitudes toward wildlife and yard management decisions (Larson et al. 2017). As a whole, efforts to support biodiversity conservation through

Table 4 t-Test results on the differences in bee attitudes and bee perceptions with regard to different management practices. Means and standard deviations shown for when respondents did (Yes) or did not (No) perform the management practice

	Pesticide Use				Herbicide Use			
	Yes	*No*	*t-stat*	*P*	*Yes*	*No*	*t-stat*	*P*
Bee Attitudes (5 = Strongly Like)	2.80 (1.45)	3.17 (1.53)	2.28	0.023	2.84 (1.49)	3.04 (1.46)	1.37	0.171
Bee Perceptions (5 = Big Problem)	1.80 (1.02)	1.60 (0.90)	−1.84	0.023	1.86 (1.08)	1.59 (0.79)	22.85	0.005
	Added Desert Plants				Removed Desert Plants			
	Yes	*No*	*t-stat*	*P*	*Yes*	*No*	*t-stat*	*P*
Bee Attitudes (5 = Strongly Like)	3.18 (1.44)	2.65 (1.45)	3.62	<0.001	2.85 (1.49)	2.92 (1.46)	−0.33	0.74
Bee Perceptions (5 = Big Problem)	1.64 (0.91)	1.94 (1.09)	−3.03	0.003	1.77 (0.95)	1.79 (1.02)	−0.16	0.87

wildlife-friendly (or benign) residential yards (e.g., the National Wildlife Federations Certified Wildlife Habitat™ program, Widows and Drake 2014), must address these landscaping priorities and constraints (e.g., through careful design features and incentives).

Conservation implications

Coupled social-ecological research could help untangle the factors that influence perceived bee problems. Research has established that perceptions of risks do not always equate to actual risks (Slovic 1987, 2000). However, further research is needed to unpack the extent to which perceived risks are associated with actual problems (e.g., presence of bee hives, local occurrences of stings or health effects), in addition to linking perceptions more closely with specific, negative experiences (such as stings or allergies) or positive ones (based on recreational or educational experiences). It remains unknown how accurately the public can identify different bee species as well as their distinction from other non-bee stinging insects. Evidence suggests that the public is not adept at identifying bee species; for example, people often misidentify wasps, hoverflies, and other invertebrates as types of bees, while failing to recognize many common native bee species that are not honeybees or bumblebees (Goulding et al. 2005; Wilson et al. 2017). Although the ability to identify bee species may or may not directly affect attitudes, it may influence perceived risks—for example, if aggressive wasps are believed to be bees. Targeted information and messaging about specific bees of conservation value (e.g., desert specialists in the study region) may be worthwhile, especially in places that can provide valuable habitat (e.g., residential gardens).

As research more closely examines public attitudes toward bees and implications for conservation efforts, we recommend comparing the relationship between physical and functional traits of bees that are identified by the public (such as size, color, sociability, and aggressiveness) relative to the attributes that we know (or believe) are important to people (such as their visibility, aesthetic appeal, tendency to swarm, and propensity to sting). Risk perception theory has well established that the characteristics of risks—such as whether impacts are deadly, or acute versus chronic—influence perceptions of risks, including the public's willingness to tolerate or live with them (Slovic 1987, 2000). Thus, using a trait-based, or attribute-based, approach offers a framework to link functional traits of bee species to people's attitudes toward them, thereby advancing knowledge and practice to garner support for conserving under-appreciated bee species.

While we know that direct experiences with wildlife can influence perceptions and attitudes toward them (Manfredo 2008; Heberlein 2012), additional research could examine the more precise nature of these relationships. This is especially true for taxa (such as bees or other insects) that are understudied and poorly recognized, yet of significant value for biodiversity and ecosystem services. The 'familiarity thesis' is particularly worthy of future research since studies have found conflicting evidence for whether or not experiences with wildlife or other hazards lead to positive or negative perceptions and attitudes (e.g., Wachinger et al. 2013; Goodale et al. 2015). Such research could also help identify the underlying mechanisms for feelings of fear, disgust, and worry about contamination, disease, or health effects related to animals, as discussed in earlier literature (e.g., Davey 1994; Arrindell 2000).

Conclusion

Overall, this study shows that a combination of cognitive, environmental, and social factors significantly affects whether or not people like bees. While we found that, on average, residents hold neutral to slightly negative attitudes toward bees, other findings bode well for conservation efforts, specifically: people did not commonly think that bees were problematic at their homes, and a significant portion of them (more than a third of survey respondents in our study) feel positively toward them. Promoting and incentivizing the planting of floral resources and other beneficial vegetation offer specific mechanisms for conservation in areas where attitudes are positive. Another suggestion based on our findings is to avoid the provisioning of bee habitat in areas where people use pesticides, or otherwise targeting those areas to encourage residents how to minimize pesticide use or adopt alternatives such as integrated pest management (Andrews and Rose 2018).

While our study is informative, especially in light of the lack of attitudinal research on bees and other arthropods, additional research on understudied wildlife is essential to informing biological conservation initiatives that are supported by society. We especially recommend research on public perceptions and attitudes toward wildlife that incorporates a more species-specific approach that links biological traits to attributes that people tend to view as positive or negative. With such refined, interdisciplinary approaches, researchers and practitioners can better reveal and respond to the particularities of people's beliefs about and affinities toward wildlife in need of conservation.

Acknowledgements This material is based upon work supported by the National Science Foundation under grant numbers DEB-1637590 and DEB-1832016, Central Arizona-Phoenix Long-Term Ecological Research Program (CAP LTER), as well as grant number MSB FRA 1638725, Alternative Ecological Futures for the American Residential Macrosystem. We thank Abigail York for her leadership in co-directing the survey effort that provided data for this study.

Author's contribution All authors contributed to this manuscript. Material preparation, data collection and analysis were performed by

Kelli L. Larson, with assistance by Melissa Fleeger and Megan Wheeler. Graphics were developed by Kelli Larson, Riley Andrade, and Susannah Lerman. The first draft of the manuscript was written by Kelli L. Larson, with some parts initially drafted by Melissa Fleeger and Megan Wheeler. Susannah Lerman led organizational and editorial improvements. Kelli Larson and Susannah Lerman revised the manuscript to address reviewers' comments. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

References

Agras WS (1985) Panic. W.H. Freeman, New York

Andrade R, Larson K, Hondula D, Franklin J (2019) Social-spatial analyses of attitudes toward the desert in a southwestern U.S. City. Ann Am Assoc Geograph 109(6):1845–1864

Andrews HM, Rose MA (2018) Protecting pollinators while using pesticides. Agricultural and natural resources (ARN-68) fact sheet. Ohio State University extension. https://ohioline.osu.edu/factsheet/anr-68. Accessed 26 April 2020

Arrindell WA (2000) Phobic dimensions: IV. The structure of animal fears. Behav Res Ther 38(5):509–530

Baldock KCR, Goddard MA, Hicks DM, Kunin WE, Mitschunas N, Morse H, Osgathorpe LM, Potts SG, Robertson KM, Scott AV, Staniczenko PPA, Stone GN, Vaughan IP, Memmott J (2019) A systems approach reveals urban pollinator hotspots and conservation opportunities. Nat Ecol Evol 3(3):363–373

Banaszak-Cibicka W, Zmihorski M (2012) Wild bees along an urban gradient: winners and losers. J Insect Conserv 16(3):331–343

Bivand R, Rundel C (2018) RGEOS: Interface to geometry engine - open source ('GEOS'). R package version 0.4–2. https://CRAN.R-project.org/package=rgeos. Accessed 20 Oct 2019

Bivand R, Keitt T, Rowlingson B (2018) RGDAL: bindings for the 'geospatial' data abstraction library. R package version 1.3–6. https://CRAN.R-project.org/package=rgdal. Accessed 20 Oct 2019

Bjerke T, Østdahl T (2004) Animal-related attitudes and activities in an urban population. Anthrozoös 17(2):109–129

Bjerke T, Odegardstuen T, Kaltenborn B (1998) Attitudes toward animals among Norwegian adolescents. Anthrozoös 11(2):79–86

Bjerke T, Østdahl T, Kleiven J (2003) Attitudes and activities related to urban wildlife: pet owners and non-owners. Anthrozoös 16(3):252–262

Cariveau D, Winfree R (2015) Causes of variation in wild bee responses to anthropogenic drivers. Curr Opin Insect Sci 10:104–109

Chase LD, Teel TL, Thornton-Chase MR, Manfredo MJ (2016) A comparison of quantitative and qualitative methods to measure wildlife value orientations among diverse audiences: a case study of Latinos in the American southwest. Soc Nat Resour 29(5):572–587

Choate BA, Hickman PL, Moretti EA (2018) Wild bee species abundance and richness across an urban–rural gradient. J Insect Conserv 22(3–4):391–403

Cutter SL, Coruff BJ, Shirley WL (2003) Social vulnerability to environmental hazards. Soc Sci Q 84(2):242–261

Davey G (1994) Self-reported fears to common indigenous animals in an adult UK population: the role of disgust sensitivity. Br J Psychol 85(4):541–554

Davidson DJ, Freudenburg WR (1996) Gender and environmental risk concerns. Environ Behav 28:302–339

Dunlap RE, Jones RE (2002) Environmental concern: conceptual and measurement issues. In: Dunlap RE, Michelson W (eds) . Handbook of Environmental Sociology Greenwood, Connecticut, pp 482–524

Dunlap RE, Van Liere KD, Mertig AG, Jones RE (2000) New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. J Soc Issues 56(3): 425–442

Fetridge ED, Ascher JS, Langellotto GA (2008) The bee fauna of residential gardens in a suburb of New York City (Hymenoptera: Apoidea). Ann Entomol Soc Am 101(6):1067–1077

Finucane M, Slovic P, Mertz C, Flynn J, Satterfield T (2000) Gender, race, and perceived risk: the 'white male' effect. Health Risk Soc 2(2):159–172

Fortel L, Henry M, Guilbaud L, Mouret H, Vaissiere BE (2016) Use of human-made nesting structures by wild bees in an urban environment. J Insect Conserv 20(2):239–253

Frankie G, Thorp R, Hernandez J, Rizzardi M, Ertter B, Pawelek J, Witt S, Schindler M, Coville R, Wojcik V (2009) Native bees are a rich natural resource in urban California gardens. Calif Agric 63(3):113–120

Frost D (2016) An eye on every drop. Mag Am Plan Assoc 82:35–41

Goddard MA, Dougill AJ, Benton TG (2013) Why garden for wildlife? Social and ecological drivers, motivations and barriers for biodiversity management in residential landscapes. Ecol Econ 86:258–273

Goodale K, Parsons GJ, Sherren K (2015) The nature of the nuisance—damage or threat—determines how perceived monetary costs and cultural benefits influence farmer tolerance of wildlife. Diversity 7(3):318–341

Golding Y, Ennos R, Sullivan M, Edmunds M (2005) Hoverfly mimicry deceives humans. J Zool 266(4):395–399

Guenat S, Kunin WE, Dougill AJ, Dallimer M (2019) Effects of urbanisation and management practices on pollinators in tropical Africa. J Appl Ecol 56(1):214–224

Hall DM, Camilo GR, Tonietto RK, Ollerton J, Ahrné K, Arduser M, Ascher JS, Baldock KCR, Fowler R, Frankie G, Goulson D, Gunnarsson B, Hanley ME, Jackson JI, Langellotto G, Lowenstein D, Minor ES, Philpott SM, Potts SG, Sirohi MH, Spevak EM, Stone GN, Threlfall CG (2017) The city as a refuge for insect pollinators. Conserv Biol 31:24–29

Hamblin A, Youngsteadt L, Frank E (2018) Wild bee abundance declines with urban warming, regardless of floral density. Urban Ecosyst 21(3):419–428

Harrison T, Gibbs J, Winfree R (2018) Forest bees are replaced in agricultural and urban landscapes by native species with different phenologies and life-history traits. Glob Chang Biol 24(1):287–296

Heberlein TA (2012) Navigating environmental attitudes. Oxford University Press

Hernandez JL, Frankie GW, Thorp RW (2009) Ecology of urban bees: a review of current knowledge and directions for future study. Cities Environ 2(1):1–15

Hostetler NE, McIntyre ME (2001) Effects of urban land use on pollinator (Hymenoptera: Apoidea) communities in a desert metropolis. Basic Appl Ecol 218:209–218

Hülsmann M, von Wehrden H, Klein AM, Leonhardt SD (2015) Plant diversity and composition compensate for negative effects of urbanization on foraging bumble bees. Apidologie 46(6):760–770

Hung KLJ, Kingston JM, Albrecht M, Holway DA, Kohn, JR (2018) The worldwide importance of honey bees as pollinators in natural habitats. Proc R Soc B Biol Sci 285(1870):2017–2140

IUCN (2019) The IUCN red list of threatened species. IUCN. http://www.iucnredlist.org. Accessed 24 Oct 2019

Jacobson M, Tucker E, Mathiasson M, Rehan S (2018) Decline of bumble bees in northeastern North America, with special focus on Bombus terricola. Biol Conserv 217(C):437–445

Johnston AN, Schmidt JO (2001) The effect of africanized honey bees (Hymenoptera: Apidae) on the pet population of Tucson: a case study. Am Entomol 47(2):98–103

Kellert SR (1993) Values and perceptions of invertebrates. Conserv Biol 7(4):845–855

Keniger LE, Gaston KJ, Irvine KN, Fuller RA (2013) What are the benefits of interacting with nature? Int J Environ Res Public Health 10(3):913–935

Landsman AP, Ladin ZS, Gardner D, Bowman JL, Shriver G, D'Amico V, Delaney DA (2019) Local landscapes and microhabitat characteristics are important determinants of urban–suburban forest bee communities. Ecosphere 10(10):E02908

Larson KL (2010) An integrated theoretical approach to understanding the sociocultural basis of multidimensional environmental attitudes. Soc Nat Resour 23(9):898–907

Larson K, Santelmann M (2007) An analysis of the relationship between residents' proximity to water and attitudes about resource protection. Prof Geogr 59(3):316–333

Larson KL, White D, Gober P, Harlan S, Wutich A (2009) Divergent perspectives on water resource sustainability in a public-policy-science context. Environ Sci Pol 12:1012–1023

Larson KL, Cook E, Strawhacker C, Hall S (2010) The influence of diverse values, ecological structure, and geographic context on residents' multifaceted landscaping decisions. Hum Ecol 38(6):747–761

Larson KL, Ibes DC, White DD (2011a) Gendered perspectives about water risks and policy strategies: a tripartite conceptual approach. Environ Behav 43(3):415–438

Larson KL, Wutich A, White D, Munoz-Erickson TA, Harlan SL (2011b) Multifaceted perspectives on water risks and policies: a cultural domain approach in a southwestern city. Hum Ecol Rev 18(1):75–87

Larson KL, Nelson K, Samples S, Hall S, Bettez N, Cavender-Bares J, Groffman P, Grove M, Heffernan J, Hobbie S, Learned J, Morse JL, Neill C, Ogden L, O'Neil-Dunne J, Pataki D, Polsky D, Roy Chowdhury R, Steele M, Trammell TLE (2016) Ecosystem services in managing residential landscapes: value priorities, dimensions, and cross-regional patterns. Urban Ecosyst 19(1):95–113

Larson KL, Hoffmann J, Ripplinger J (2017) Legacy effects and landscape choices in a desert. Landsc Urban Plan 165:22–29

Lerman S, Milam J (2016) Bee fauna and floral abundance within lawn-dominated suburban yards in Springfield, MA. Ann Entomol Soc Am 109(5):713–723

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

Lowenstein DM, Matteson KC, Xiao I, Silva AM, Minor ES (2014) Humans, bees, and pollination services in the city: the case of Chicago, IL (USA). Biodivers Conserv 23(11):2857–2874

Lynch B (1993) The garden and the sea – United States Latino environmental discourses and mainstream environmentalism. Soc Probl 40(1):108–124

Manfredo M (2008) Who cares about wildlife? Social science concepts for exploring human-wildlife relationships and conservation issues. Springer, Colorado

Mansfield ER, Helms BP (1982) Detecting multicollinearity. Am Stat 36(3a):158–160

Marks IM (1969) Fears and phobias. Academic Press, New York

Martins K, Gonzalez T, Lechowicz A (2017) Patterns of pollinator turnover and increasing diversity associated with urban habitats. Urban Ecosyst 20(6):1359–1371

Michener CD (1979) Biogeography of the bees. Ann Mo Bot Gard 66(3):277–347

Michener CD (2000) The bees of the world. JHU Press, Baltimore

Minckley RL, Cane JH, Kervin L (2000) Origins and ecological consequences of pollen specialization among desert bees. Proc R Soc Lond Ser B Biol Sci 267(1440):265–271

Moissett B, Buchanan S (2010) Bee basics: an introduction to our native bees. USDA, Forest Service

Motta EVS, Raymann K, Moran NA (2018) Glyphosate perturbs the gut microbiota of honey bees. Proc Natl Acad Sci 115(41):10305–10310

Muratet A, Fontaine B (2015) Contrasting impacts of pesticides on butterflies and bumblebees in private gardens in France. Biol Conserv 182:148–154

Narango DL., Tallamy DW, Marra PP (2018) Nonnative plants reduce population growth of an insectivorous bird. Proceedings of the National Academy of Sciences USA 1–6

Nicolson SW (2009) Water homeostasis in bees, with the emphasis on sociality. J Exp Biol 212(3):429–434

Ollerton J, Winfree R, Tarrant S (2011) How many flowering plants are pollinated by animals? Oikos 120:321–326

Pearson A, Schuldt J, Romero-Canyas R, Ballew M, Larson-Konar D (2018) Diverse segments of the US public underestimate the environmental concerns of minority and low-income Americans. Proc Natl Acad Sci U S A 115(49):12429–12434

Quistberg R, Bichier P, Philpott S (2016) Landscape and local correlates of bee abundance and species richness in urban gardens. Environ Entomol 45(3):592–601

R Core Team (2018) R: a language and environment for statistical computing. R Foundation for Statistical Computing. https://www.R-project.org/. Accessed 20 Oct 2019

Schlaepfer MA, Runge MC, Sherman PW (2002) Ecological and evolutionary traps. Trends Ecol Evol 17:474–480

Schultz PW, Unipan JB, Gamba RJ (2000) Acculturation and ecological worldview among Latino Americans. J Environ Educ 31(2):22–27

Shuttlewood CZ, Greenwell PJ, Montrose VT (2016) Pet ownership, attitude toward pets, and support for wildlife management strategies. Hum Dimens Wildl 21:180–188

Silva A, Minor E (2017) Adolescents' experience and knowledge of, and attitudes toward, bees: implications and recommendations for conservation. Anthrozoös 30(1):19–32

Sing K, Wang W, Wan T, Lee P, Li Z, Chen X, Wang Y, Wilson J (2016) Diversity and human perceptions of bees (Hymenoptera: Apoidea) in southeast Asian megacities. Genome 59(10):827–839

Slovic P (1987) Perception of risk. Science 236:280–285

Slovic P (2000) The perception of risk. Earthscan Publications, London

Smith VK, Larson KL, York A (2019) Using quality signaling to enhance survey response rates. Appl Econ Lett:1–4. https://doi.org/10.1080/13504851.2019.1646869

Stern PC (2000) New environmental theories: toward a coherent theory of environmentally significant behavior. J Soc Issues 56(3):407–424

Thomson D (2004) Competitive interactions between the invasive European honey bee and native bumble bees. Ecology 85(2):458–470

Thurstone LL (1928) Attitudes can be measured. Am J Sociol 33:529–554

U.S. Census Bureau (2017) 2013–2017 American community survey 5-year estimates, Phoenix-Mesa-Scottsdale AZ Metro Area Total Population. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_B01003&prodType=table. Accessed 4 Feb 2019

U.S. Census Bureau (2018) Annual estimates of the resident population: April 1, 2010 to July 1, 2017. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2017_PEPANNRES&src=pt. Accessed 4 Feb 2019

Vanbergen AJ, Baude M, Biesmeijer JC, Britton NF, Brown MJ, Brown M, Bryden J, Budge GE, Bull JC, Carvell C et al (2013) Threats to an ecosystem service: pressures on pollinators. Front Ecol Environ 11:251–259

Wachinger G, Renn O, Begg C, Kuhlicke C (2013) The risk perception paradox—implications for governance and communication of natural hazards. Risk Anal 33(6):1049–1065

Wheeler M, Larson KL, Andrade R (2020) Attitudinal and structural drivers of residential yard choices: a comparison of preferred versus actual landscapes. Urban Ecosyst 23:659–673. https://doi.org/10.1007/s11252-020-00928-0

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(6):515–530

Widows SA, Drake D (2014) Evaluating the National Wildlife Federation's certified wildlife habitat™ program. Landsc Urban Plan 129:32–43

Wignall VR, Alton K, Ratnieks FL (2019) Garden Centre customer attitudes to pollinators and pollinator-friendly planting. PeerJ 7:E7088

Williams B, Florez Y (2002) Do Mexican Americans perceive environmental issues differently than Caucasians: a study of cross-ethnic variation in perceptions related to water in Tucson. Environ Health Perspect 110(2):303–310

Wilson JS, Forister ML, Carril OM (2017) Interest exceeds understanding in public support of bee conservation. Front Ecol Environ 15:460–466

Winfree R, Griswold T, Kremen C (2007) Effect of human disturbance on bee communities in a forested ecosystem. Conserv Biol 21:213–223

Winfree R, Gross BJ, Kremen C (2011) Valuing pollination services to agriculture. Ecol Econ 71(C):80–88

Woodcock BA, Bullock JM, Shore RF, Heard MS, Pereira MG, Redhead J, Ridding L, Dean H, Sleep D, Henrys P, Peyton J (2017) Country-specific effects of neonicotinoid pesticides on honey bees and wild bees. Science 356(6345):1393–1395