CITIZEN SCIENCE:
THEORY AND PRACTICE

Who Submits Koala Sightings? Profiling Residents and Identifying Opportunities to Enhance their Experience

RESEARCH PAPER

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ABSTRACT

Citizen science plays a major role in the conservation of koalas, an endangered species. However, koala sighting submissions are low. This study identified the characteristics of current citizen scientists and examined their experiences in reporting koalas across a range of local koala sighting programs. A total of 2,024 South East Queensland residents completed an online survey in 2022. Respondents answered a range of behavior-related questions that included the number of koala sightings they reported and information about the sighting experience. Other survey questions included demographic characteristics, knowledge of koalas, and engagement in koala conservation activities. Using a logistic regression model, we identified that residents who submit koala sightings are more likely to be male, have a greater knowledge of koalas, and engage in koala conservation activities. Respondents also provided insights about their experience of submitting koala sightings. Opportunities to improve the citizen science experience include training and education, timely feedback, improved app experiences, better communication, and improved coordination. The persistence of the challenges identified by respondents point to the need for program managers to be aware of organizational factors that are enhancing or negatively impacting the citizen science experience. A focus on controllable program factors will extend our understanding beyond the demographic characteristics of citizen scientists to successful approaches capable of recruiting and retaining a broader cross section of community to report sightings of endangered wildlife.

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KEYWORDS:
Citizen science; endangered species; koala conservation; koala sightings

TO CITE THIS ARTICLE:
Fechner, D, Foote, L and Rundle-Thiele, S. 2023. Who Submits Koala Sightings? Profiling Residents and Identifying Opportunities to Enhance their Experience. *Citizen Science: Theory and Practice*, 8(1): 63, pp. 1–17. DOI: https://doi.org/10.5334/cstp.617

INTRODUCTION

In February 2022, the Australian government changed the conservation status of the koala (*Phascolarctos cinereus*) from "vulnerable" to "endangered" in Queensland, New South Wales, and in the Australian Capital Territory. This follows significant declines in koala populations: Over the past 20 years, koala densities decreased by 54–80% in key habitat areas in South East Queensland (Rhodes et al. 2015). Koalas are vulnerable to extinction due to habitat loss, habitat fragmentation, vehicle strikes, dog attacks, and diseases (Dexter et al. 2018; Shumway et al. 2015). Other anthropogenic threats include swimming pool drownings, fencing that restricts movement to safe areas, and livestock attacks (David, Pang, and Rundle-Thiele 2019; Gonzalez-Astudillo et al. 2017; Jiang et al. 2021). Koalas suffering from disease and injury can be captured and treated by resource managers and wildlife carers if reported by the public. Accurate and timely reporting increases the chance of a koala's survival. Citizens who are knowledgeable about koalas and the threats they face can play an active role in their conservation.

Encouraging the public to submit koala sightings—known as citizen science—plays a key role within the 2020–2025 South East Queensland Koala Conservation Strategy (Department of Environment and Science 2020). Citizen science expands the spatial and temporal scope of traditional scientific efforts (Dickinson, Zuckerberg, and Bonter 2010) by enlisting and training non-scientist volunteers. Koalas are an ideal focal species for citizen science because koalas inhabit urban and peri-urban settings and are accessible to community members (Cristescu et al. 2019).

Community-based monitoring is a form of citizen science (Mamun and Natcher 2023) that empowers community members to play a role in resource management and to contribute to planning and decision-making (Conrad and Hilchey 2011; Danielsen et al. 2021). These efforts are typically led by community members and local organizations with the support and involvement of researchers and government agencies (Danielsen et al. 2022). Data collected by community volunteers has increased credibility among stakeholders because the community itself takes part in the collection process (Mamun and Natcher 2023). Further, community-based monitoring projects involving higher volunteer participation have been linked to a greater ability to positively influence biodiversity management (Cooper et al. 2007; Flower et al. 2016). These projects are especially useful to policymakers as they provide the opportunity for dialogue with the people who are most engaged and interested in the particular topic (Hollow et al. 2015). Koala monitoring by community members is especially helpful to resource managers because large numbers of volunteers have the potential to survey broad spatial ranges (Flower et al. 2016) and ultimately explain and predict the distribution of koalas (Sequeira et al. 2014).

Opportunities to participate in koala-focused citizen science programs in South East Queensland have been increasing, with several different yet overlapping initiatives launched in recent years alongside efforts to assess these programs and their associated technology with the goal of expanding and improving existing offerings. Programs are managed by local and state governments, resource management agencies, and nonprofit organizations, with some entities working in partnership with one another. These groups typically communicate the purpose of their programs as giving community members the opportunity to contribute to koala research, conservation, and management by providing population and habitat data that can be used to protect koalas. In addition, volunteers are asked to serve in a critically important "first responder" role by alerting authorities to the presence of sick and injured koalas. Different forms of technology are used to report koala sightings, including phone hotlines, internet-based survey forms, paper forms, and mobile apps (including their associated online platforms). Two different mobile apps have primarily been adopted by koala monitoring citizen science programs, iNaturalist (a joint initiative of the California Academy of Sciences and the National Geographic Society) and BioCollect (hosted by the Atlas of Living Australia), with some localities preferring one app over the other, and with some not using either. Each app has examples of localized projects set up within them by program managers; these allow for data to be consolidated and filtered. Regardless of the volunteer program in place and its coordination efforts, both mobile apps can be used throughout the South East Queensland region. Further, some programs use a combination of a hotline, web-based platforms, and mobile app, depending on the preferences and abilities of volunteers. However, despite these opportunities, the current koala sighting submission rate is low.

This study had two objectives aimed towards understanding, assessment, and development of koala citizen science programs in South East Queensland, Australia. First, we compared residents who had previously submitted koala sightings with those who had not based on their demographics, knowledge of koalas, and previous engagement in koala conservation initiatives. The second aim of the study was to identify opportunities for improving the experience of submitting koala sightings.

The findings of this research have immediate practical implications. Governments, social marketers, and other behavioral scientists can use the unique characteristics of

residents who have submitted koala sightings to design campaigns that can increase the number of people reporting koala sightings, and in so doing, contribute towards koala protection. Further, understanding the user experience of submitting koala sightings allows for implementing improvements to ensure repeated submissions.

SOCIODEMOGRAPHICS IN CITIZEN SCIENCE: APPLICATIONS AND RELEVANCE

Citizen science, also known as community science or public participation in scientific research (Theobald et al. 2015), is on the rise throughout the world (Kullenberg and Kasperowski 2016). Environmentally-focused projects now cover a diversity of habitats, taxa, and topics (Bonney et al. 2014). Australia, Europe, North America, South Africa, and India provide a significant contribution to the worldwide assemblage of citizen science initiatives addressing biodiversity challenges through the monitoring of species distribution, population abundance, phenological traits, and ecosystem function (Chandler et al. 2017). Most citizen science projects in Australia are local in scope and focus on one city, national park, or coastal area, while a third of all programs are broader and operate regionally (Golumbic 2020). The Queensland Government identified citizen science as a means of addressing goals such as increasing student participation in science, technology, engineering, and math initiatives; increasing community engagement in science activities; increasing scientists' engagement with the community; and increasing awareness and understanding of the science occurring in Queensland (Office of the Queensland Chief Scientist 2019).

A 2018 assessment of the current landscape of citizen science in Queensland found 138 citizen science projects situated within a wide range of topics with many focused on biodiversity (Office of the Queensland Chief Scientist 2018). During 2021–2022, the Queensland government funded 40 individual citizen science projects (Queensland Government 2021). While this level of uptake and support for citizen science is encouraging, a disconnect exists at the broader level, wherein only 3% of Queenslanders surveyed in 2018 (n = 54 of 1,128 total respondents) had heard the term "citizen science," despite 68% (n = 835) of respondents indicating a high level of interest in science (Office of the Queensland Chief Scientist 2018). This disparity represents both a challenge and an opportunity to engage more Queenslanders in citizen science initiatives.

Participants in citizen science programs often do not reflect the broader demographics of the areas in which the programs occur (Blake, Rhanor, and Pajic 2020; Martin et al. 2016; Pandya 2012; Pateman, Dyke, and West 2021), making demographic studies especially useful for directing focus on improving diversity, equity, inclusion, and representation within programs in order to prevent further marginalization of underrepresented groups. Many studies describe citizen science participants as highly educated, retired, white, older females, while other studies have not confirmed this participant profile (Robinson et al. 2021). A comprehensive review confirmed the ethnic and educational components of the prevailing narrative—a predominance of white and well-educated participants—but found a slight male bias and a variation in age and employment status amongst participants, which highlights the importance of considering the specific context of citizen science programs (The National Academies Press 2018).

The review also revealed that 10% of citizen science studies reported participant demographics, and of those that did, the majority were based in the United States (The National Academies Press 2018). Also, the educational backgrounds of participants are rarely found in published studies (Martin 2017). Further, many citizen science efforts are not published in peer review literature, reflecting a disconnect between academic and practitioner communities: Forty-seven of the 388 biodiversity-focused citizen science programs were published in peer-reviewed journals (Theobald et al. 2015). Few studies have focused on comparing demographics between inactive and engaged participants (Fischer, Cho, and Storksdieck 2021). Such discrepancies underscore the need for a more nuanced and targeted approach to exploring the demographic characteristics of citizen science initiatives and their implications for participation and program success.

VOLUNTEER MOTIVATION AND RETENTION

Benefits to the volunteers and the socioecological systems they inhabit include increasing awareness and science literacy, building social capital and conservation capacity, addressing knowledge gaps, democratizing science, and driving policy change (Blake, Rhanor, and Pajic 2020; Frensley et al. 2017; Kimura and Kinchy 2016; Shirk et al. 2012). Pro-environmental values have been shown to influence volunteer participation in citizen science (Martin et al. 2016); indeed, intrinsic motivation in the form of a desire to protect and improve the environment is arguably the most well-documented form of motivation in the citizen science literature (Bruyere and Rappe 2007; Robinson et al. 2021). Understanding the drivers and barriers linked to participation in citizen science is critical for ensuring the long-term success of these initiatives (Martin et al. 2016; Maund

et al. 2020; Measham and Barnett 2008). Fostering and maintaining volunteer motivation is a great challenge for citizen science programs. While research into motivation and retention was only relatively recently described as being in its infancy (Frensley et al. 2017; West and Pateman 2016), more studies have since appeared (Cox et al. 2018; Fischer, Cho, and Storksdieck 2021; Liñán et al. 2022; Maund et al. 2020; Robinson et al. 2021; I and Wehn and Almomani 2019), which provide useful insights into the factors motivating initial and sustained involvement in citizen science endeavors. Commonly cited factors that can serve as both barriers and drivers for volunteer motivation and retention include knowledge and skills, education and training, feedback, project relevance and salience, communication strategies, and the design and user-friendliness of digital tools. However, these insights are often context-dependent, and it should be recognized that volunteers are not a uniform group; their motivations not only vary from individual to individual but are overlapping, interdependent, and change over time (Cox et al. 2018; West and Pateman 2016). Further, inconsistencies in research questions and methodologies across the citizen science literature make it difficult to determine which motivations are the most important in a given setting (Martin et al. 2016). Against this background, we investigate the following three research questions:

> Research question #1: How do residents who submit koala sightings differ from those who do not in terms of sociodemographics, koala knowledge, and engagement in koala conservation activities?
>
> Research question #2: Which sociodemographic, koala knowledge, and engagement in koala conservation activities variables predict the odds of residents submitting koala sighting submissions?
>
> Research questions #3: What opportunities exist to improve the experience of submitting koala sightings?

METHODS

This section provides an overview of the participants who completed the online survey, a detailed description of the survey questions, and the statistical tests used to assess research question #1 and research question #2 as well as the qualitative data analysis approach applied to examine research question #3.

PARTICIPANTS

We conducted a convenience sample survey study with residents living in South East Queensland, Australia. Respondents completed the survey between April and May 2022. We distributed the survey through online and offline channels including Facebook advertisements, council newsletters, university newsletters, newspaper articles, community events, environmental organizations, vets, animal shelters, barbers, shops, shopping centers, and medical centers. A total of 2,024 participants completed the survey: 76% of the sample were female, 62% had completed at least a bachelor's degree, and the average age was 48 years with a standard deviation of 17 years. Participants were informed that they give their consent to participate in the study by submitting their completed survey. The university human ethics committee approved this study (Ref No: 2021/580).

MEASURES

The main dependent variable in this study was respondents' participation in reporting koala sightings, which we assessed in two steps. First, we asked respondents to indicate if they knew how to submit koala sightings using a binary answer format (yes/no). We then asked participants who know how to report a koala sighting how many sightings they submitted in the past 12 months. Respondents chose from the following answer options: *0 times, 1 time, 2 times, 3 times, more than 3 times*, and *I did not see any koalas in the last 12 months*. We measured the following sociodemographics: gender; age measured in years; education, using six categories ranging from primary school to postgraduate degree; income, using nine categories ranging from below $33,000 to above $156,000; local city council area; and employment, using the designations full time, part time, and not in paid employment.

We used three questions to assess respondents' knowledge of koalas; participants selected the current koala conservation status from the following options: *vulnerable, endangered, critically endangered, extinct in the wild,* and *I do not know*. We assessed respondents' ability to identify a sick koala by showing them six images of koalas in random order in which three images displayed a sick koala. Respondents were asked to select all images showing a sick koala. Participants then selected the months when they believed koala breeding starts and ends.

We used three behaviors to assess respondents' previous engagement in koala conservation initiatives: donating to a koala conservation organization in the past 12 months, measured in dollars; volunteering for a koala conservation organization in the past 12 months, measured in days; and slowing down in areas where koalas may be present, using a slider scale ranging from 0% of the time (0) to 100% of the time (100).

Finally, we asked respondents who submitted at least one koala sighting the following open-ended question to

identify opportunities to improve their koala submission experience: "Are there any improvements that could be made to your koala reporting experience?"

DATA ANALYSIS

We created a binary outcome variable to differentiate respondents who submitted koala sightings from those who did not. We combined all respondents who indicated that they submitted at least one koala sighting into one group. All remaining respondents formed the second group.

We used the recorded age in years to create the following age groups: 18–24, 25–34, 35–44, 45–54, 55–64, and above 65. We computed a binary variable to differentiate between respondents who know how to identify a sick koala from those who do not. We grouped all respondents who correctly identified all sick koalas and did not wrongly identify a healthy koala as sick into one group. All other respondents formed the second group.

We created binary variables to differentiate between respondents who know when koala season breeding begins and starts. Respondents who selected July, August, or September as the start of the koala breeding seasons and January as its end represent the first group and the remaining respondents the second group. A newly computed binary variable differentiates respondents who know that the current koala conservation status is endangered from those who do not. We also computed a binary variable to differentiate between respondents who donated at least $1 to a koala conservation organization from those who did not. Similarly, a new binary variable differentiates between respondents who volunteered at least one day for a koala conservation organization from those who did not.

We conducted a chi square test to test for relationships between whether people submit koala sightings and sociodemographics, koala knowledge, volunteering, and donating. If the chi-square test found a significant relationship, we examined the adjusted standardized residuals to identify which category contributed to the significant difference (Sharpe et al. 2015). An adjusted standardized residual greater than +/–1.96 indicates that the number of observed cases in that cell is significantly larger or smaller than expected (Agresti 2007). We conducted an independent sample t-test to assess differences in slowing down in areas where wildlife might be present.

We then conducted a logistic regression analysis. In this analysis, people who submit koala sightings or not was the dependent binary variable, and sociodemographics, koala knowledge, and engagement in koala conservation activities were independent variables (Hosmer et al. 2013). We selected the following reference groups for the categorical variables: Brisbane, 18–24 age group, primary/high school degree, and income of less than $33,799.

To address research question #3, we conducted a qualitative content analysis to examine the responses to the open-ended question (Krippendorff 2004). "Problems" were separated from "solutions" as multiple respondents chose to highlight specific challenges in addition to suggesting improvements. Thematic categories were created to describe the barriers and drivers identified by respondents.

RESULTS AND ANALYSIS

Table 1 presents the results of comparing respondents who submitted at least one koala sighting in the past 12 months with respondents who did not, based on sociodemographics and previous engagement in koala conservation activities. Respondents who submit koala sightings differ significantly from those who do not in their age X^2 (5, N = 1945) = 29.633, p < 001. Respondents aged 18–24 (–3.6) and 25–34 (–2.8) submitted koala sightings less, and respondents aged 35–44 (2.7) and 45–55 (2.6) submitted more koala sightings. We found a significant relationship between respondents' area of residence and whether they submit koala sightings X^2 (11, N = 2024) = 66.553, p < 001. Respondents living in Brisbane (–4.1) and the Sunshine Coast (–2.9) submitted fewer koala sightings, and residents from Moreton Bay (5.5) reported more koala sightings. We found a significant relationship between respondents' education and whether they submit koala sightings X^2 (4, N = 2024) = 11.714, p = .02. Respondents with a primary/high school degree (–3.2) submitted significantly fewer koala sightings. Respondents who submit koala sightings did not differ from those who do not in gender X^2 (1, N = 1978) = 2.699, p = .1, income X^2 (8, N = 1454) = 12.244, p = .141, and employment status X^2 (2, N = 2024) = 2.559, p = .278.

Respondents who submit koala sightings have better abilities to identify sick koalas X^2 (1, N = 2011) = 27.846, p < .001, know more frequently when koala season starts and ends X^2 (1, N = 2024) = 29.475, p < .001, volunteer more X^2 (1, N = 2024) = 197.256, p < .001, donate more to koala conservation organizations X^2 (1, N = 2024) = 42.910, p < .001, and report that they slow down more frequently in areas where koalas might be present t(1952) = 3.954, p < 001 compared with those who do not submit koala sightings.

Figure 1 shows mosaic plots which visualise the significant relationships between whether residents submit koala sightings and their sociodemographics, koala knowledge, and koala conservation activities. The width of

VARIABLE	% WHO SUBMIT KOALA SIGHTINGS (NUMBER IN SAMPLE)	% WHO DO NOT SUBMIT KOALA SIGHTINGS (NUMBER IN SAMPLE)	STATISTICAL SIGNIFICANCE
Socio-demographic factors			
Gender (1978)			
Male	26.1% (81)	21.9% (365)	$\chi 2 = 2.699$ $p = 0.1$
Female	73.9% (229)	78.1% (1303)	
Age			
18–24*-	6.2% (19)	13.5% (221)	**$\chi^2 = 29.633$ $p < .001$**
25–34*-	7.1% (22)	12.8% (210)	
35–44*+	15.6% (48)	16.4% (268)	
45–54*+	26% (80)	19.5% (320)	
55–64	25.6% (79)	18.9% (309)	
>65	19.5% (60)	18.9% (309)	
Area of residence			
Brisbane*-	13.8% (44)	24.3% (415)	**t(2024) = 66.553, $p < .001$**
Redland	15% (48)	16.5% (282)	
Moreton Bay*+	20.7% (66)	8.7% (149)	
Gold Coast	18.8% (60)	16.1% (274)	
Scenic Rim	3.4% (11)	3% (51)	
Logan	11.6% (37)	9.4% (160)	
Ipswich	2.2% (7)	3.7% (63)	
Noosa	2.5% (8)	1.6% (28)	
Somerset	1.9% (6)	2.8% (48)	
Toowoomba	3.4% (11)	3.8% (65)	
Lockyer Valley	2.8% (9)	1.5% (26)	
Sunshine Coast*-	3.8% (12)	8.4% (144)	
Education			
Primary/High school*-	10% (32)	17.2% (293)	**t(2024) = 11.714, $p = .02$**
Certificate	19.7% (63)	16.9% (288)	
Bachelor's degree	28.2% (90)	29% (494)	
Graduate certificate/diploma	21% (67)	18.3% (312)	
Postgraduate degree	21% (67)	18.7% (318)	
Income			
< $33,799	29.4% (68)	35.6% (435)	t(1454) = 12.244, $p < 141$
$33,800–$41,599	7.4% (17)	8.7% (107)	
$41,600–$51,999	10% (23)	8.9% (109)	
$52,000–$64,999	6.9% (16)	8.8% (108)	
$65,000–$77,999	9.1% (21)	9.1% (111)	
$78,000–$90,999	10.8% (25)	8.9% (109)	
$91,000–$103,999	7.4% (17)	8.1% (99)	
$104,000–$155,999	12.6% (29)	7.8% (96)	
> $156,000	6.5% (15)	4% (49)	

(contd.)

VARIABLE	% WHO SUBMIT KOALA SIGHTINGS (NUMBER IN SAMPLE)	% WHO DO NOT SUBMIT KOALA SIGHTINGS (NUMBER IN SAMPLE)	STATISTICAL SIGNIFICANCE
Employment			
Full-time	41.1% (131)	36.6% (624)	$\chi^2 = 2.559$ *p < .278*
Part-time	25.7% (82)	29% (494)	
Not in paid employment	33.2% (106)	33.2% (587)	
Koala knowledge			
Knowledge of koala conservation status			
Yes	67.4% (215)	57.1% (973)	**$\chi^2 = 11.829$ *p < .001***
No	32.6% (104)	42.9% (732)	
Ability to identify sick and healthy koalas			
Yes	37.5% (119)	23.4% (397)	**$\chi^2 = 27.846$ *p < .001***
No	62.5% (198)	76.6% (1297)	
Knowledge of when koala breeding season starts and ends			
Yes	11.9% (38)	4.3% (74)	**$\chi^2 = 29.457$ *p < .001***
No	88.1% (281)	95.7% (1631)	
Koala conservation activities			
Donating to a koala conservation organization			
Yes	39.8% (127)	22.5% (383)	**$\chi^2 = 42.910$ *p < .001***
No	60.2% (192)	77.5% (1322)	
Volunteering for a koala conservation organization			
Yes	32.3% (103)	6.2% (106)	**$\chi^2 = 197.256$ *p < .001***
No	67.7% (216)	93.8% (1599)	
Slowing down			
Mean	91.55%	85.86%	**t(1952) = 3.954, *p* < 001**

Table 1 Comparison of residents who submit koala sightings with those who do not, based on sociodemographics, koala knowledge, and engagement in koala conservation initiatives.

Notes:

1. Group numbers for gender, age, and income do not add up to 2,024 because some participants did not provide this information.
2. Significant results are in bold.
3. Groups for which adjusted residuals were greater than +2 are starred with a +.
4. Groups for which adjusted residuals were greater than –2 are starred with a –.

each column represents the number of participants in the category (Theus 2012).

LOGISTIC REGRESSION

We conducted a logistic regression analysis to investigate research question #2 and to assess which of the sociodemographics, koala knowledge, and koala conservation activities predict the odds of residents submitting koala sightings. The overall model was statistically significant ($\chi^2(38) = 266.64$, $p < .001$) with Nagelkerke R square 23.3% and correctly identified 85.4% of cases. As shown in Table 2, gender ($\chi^2(1) = 8.121$, $p = .004$), local government area ($\chi^2(12) = 45.337$, $p < .001$), knowledge of koala breeding season ($\chi^2(1) = 7.94$, $p < .005$), ability to identify sick koala ($\chi^2(1) = 8.94$, $p < .003$), volunteering ($\chi^2(1) = 83.512$, $p < .001$) and slowing down ($\chi^2(1) = 8.353$, $p < .001$) predicted statistically significantly the odds of residents submitting koala sightings.

Specifically, being female reduces the predicted odds of submitting sightings by 0.607 (95% confidence interval [CI].431–.056). Residents aged 46–55 are 2.1 (95% CI 1.060–4.219) and residents aged 56–65 are 2.2 (95% CI

VARIABLE	B	SE	WALD	SIG.	EXP(B)	95% CI FOR EXP(B)	
						LOWER	UPPER
Sociodemographics							
Female	–.499	.175	8.121	.004	.607	.431	.856
Age			9.841	.080			
25–35	.075	.399	.035	.851	1.078	.494	2.354
36–45	.504	.361	1.950	.163	1.655	.816	3.355
46–55	.749	.352	4.514	.034	2.114	1.060	4.219
56–65	.799	.351	5.177	.023	2.223	1.117	4.422
Above 65	.592	.373	2.521	.112	1.807	.870	3.752
Local government area			45.337	<.001			
Redland	.348	.257	1.836	.175	1.416	.856	2.342
Moreton Bay	1.300	.254	26.129	<.001	3.670	2.229	6.041
Gold Coast	.732	.242	9.147	.002	2.080	1.294	3.344
Scenic Rim	.624	.426	2.151	.142	1.867	.811	4.299
Logan	.743	.281	7.022	.008	2.103	1.214	3.645
Ipswich	–.047	.487	.009	.924	.954	.367	2.481
Noosa	.317	.522	.370	.543	1.373	.494	3.818
Somerset	.293	.493	.353	.553	1.340	.510	3.523
Toowoomba	.020	.432	.002	.963	1.020	.438	2.377
Lockyer Valley	1.053	.502	4.405	.036	2.866	1.072	7.663
Sunshine Coast	–.476	.370	1.650	.199	.622	.301	1.284
Income			9.830	.364			
$33,800–$41,599	–.502	.353	2.031	.154	.605	.303	1.207
$41,600–$51,999	–.084	.312	.072	.789	.920	.499	1.696
$52,000–$64,999	–.560	.355	2.489	.115	.571	.285	1.145
$65,000–$77,999	–.251	.335	.560	.454	.778	.404	1.501
$78,000–$90,999	–.002	.321	.000	.994	.998	.532	1.872
$91,000–$103,999	–.557	.373	2.232	.135	.573	.276	1.190
$104,000–$155,999	.250	.336	.555	.456	1.284	.665	2.481
$156,000 or more	–.309	.446	.481	.488	.734	.307	1.758
Prefer not to say	–.296	.218	1.838	.175	.744	.485	1.141
Education level			3.399	.493			
Certificate	.398	.279	2.027	.155	1.488	.861	2.574
Bachelor degree	.313	.271	1.335	.248	1.368	.804	2.328
Graduate Certificate/Diploma	.304	.283	1.155	.283	1.355	.778	2.360
Postgraduate degree	.509	.289	3.090	.079	1.663	.943	2.933
Employment status			1.056	.590			
Part time	–.169	.206	.672	.412	.845	.564	1.265
Not in paid employment	–.216	.226	.914	.339	.806	.518	1.254

(contd.)

VARIABLE	B	SE	WALD	SIG.	EXP(B)	95% CI FOR EXP(B)	
						LOWER	UPPER
Koala knowledge							
Knowledge of koala status	.218	.152	2.057	.151	1.244	.923	1.677
Knowledge of breeding season	.709	.252	7.944	.005	2.032	1.241	3.326
Ability to identify sick koala	.465	.156	8.940	.003	1.592	1.174	2.160
Koala conservation activities							
Donating	.313	.160	3.793	.051	1.367	.998	1.872
Volunteering	1.707	.187	83.512	<.001	5.512	3.822	7.949
Slowing down in wildlife areas	.012	.004	8.353	.004	1.012	1.004	1.020
Constant	−4.111	.522	62.096	<.001	.016		

Table 2 Logistic regression with submitting koala sightings as dependent variable and sociodemographic, koala knowledge, and engagement in koala conservation initiatives as independent variables.

Notes: B: Coefficient, CI: Confidence interval, SE: Standard error, Exp (B): exponential value of B.

1.117–4.422) times more likely to submit koala sightings than those aged 18–24. Compared with residents from Brisbane, residents from Redland are 3.7 times more likely (95% CI.856–2.342), residents from the Gold Coast are twice as likely (95% CI 1.294–3.344), residents from Logan are also approximately twice as likely (95% CI 1.214–3.645), and residents from Lockyer Valley are 2.9 times as likely (95% CI 1.072–7.663) to submit koala sightings. The predicted odds ratio of submitting koala sightings changes by 1.2 (95% CI.923–1.677) when residents know that koalas are an endangered species, by 2.0 (95 CI 1.241–3.326) when they know that breeding season starts between July and September and ends in January, and by 1.6 (95% CI 1.174–2.160) when residents are able to identify sick koalas. We found a relationship between whether people submitted a koala sighting and donated (effect = .313, z-value = 1.96, p-value = .*051)* or volunteered for a koala conservation organization (effect = 1.707, z-value = 9.13, *p-value < .001)*. With every 1% increase in slowing down in areas where wildlife might be present, the predicted odds of submitting koala sightings increases by 1.0 (95% CI 1.004–1.020). We did not find any significant differences in income ($\chi^2(9) = 9.830$, $p < .364$), education ($\chi^2(4) = 3.399$, $p < .493$), and employment status ($\chi^2(2) = 1.056$, $p < .590$).

Figure 2 visualises the individual main effects of gender, koala status knowledge, ability to identify a sick koala, volunteering, donating, and breeding season knowledge on whether people submit koala sightings. As can be seen, volunteering and breeding seasons have the strongest effect on whether people submit koala sightings because the lines are steep and the confidence intervals do not overlap.

Table 3 presents representative quotes from the open-ended question within our survey, *"Are there any improvements that could be made to your koala reporting experience?"* People who report koala sightings gave detailed feedback identifying frustrations and challenges, and indicated solutions that would improve their experiences with citizen science programs. A total of 82 responses were received and analyzed. Responses were classified as either a problem or a solution and categorized according to themes in the form of perceived barriers and drivers related to reporting sightings; some responses addressed multiple categories. Six main barrier/driver thematic categories were identified and are described below in their order of prevalence.

TECHNOLOGY PLATFORM

This category outnumbered all others, with nearly a third of the comments addressing either the ease of use of the mobile apps and web interfaces, or their specific design features. Many found the platforms to be difficult to use and advocated for simpler, more intuitive systems. Some expressed confusion about which platform(s) they were supposed to use to report sightings in their area. Others reported having issues with map features, photo uploading systems, and other functions.

COMMUNICATION AND PROMOTION

Respondents noted that there was a general lack of awareness about the opportunity to report koala sightings as well as the existence of the mobile apps and online platforms themselves. Many called for the programs to be advertised more and better, and specific communications

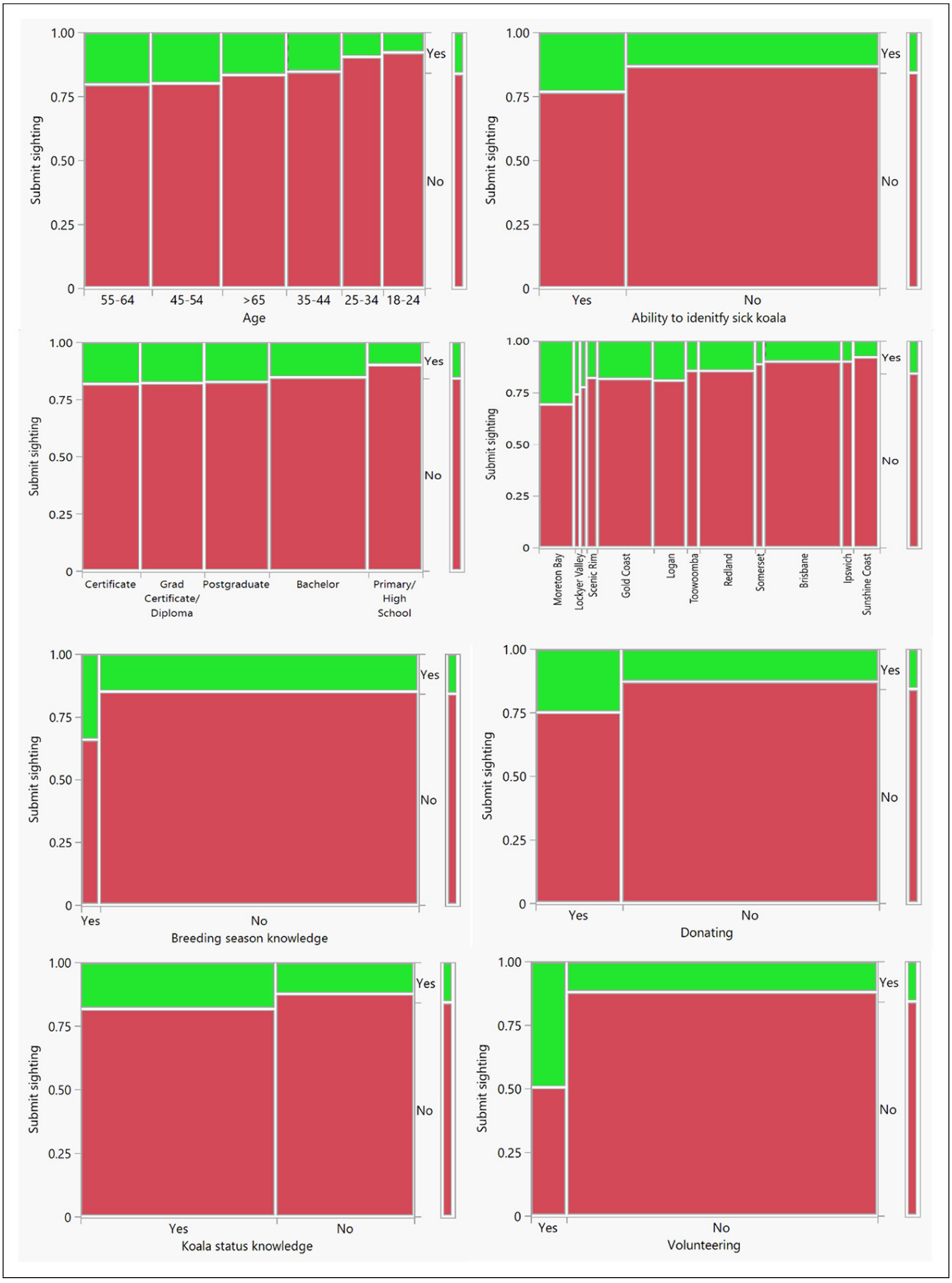

Figure 1 Relationships between whether residents submit koala sightings and their sociodemographics, koala knowledge and koala conservation activities.

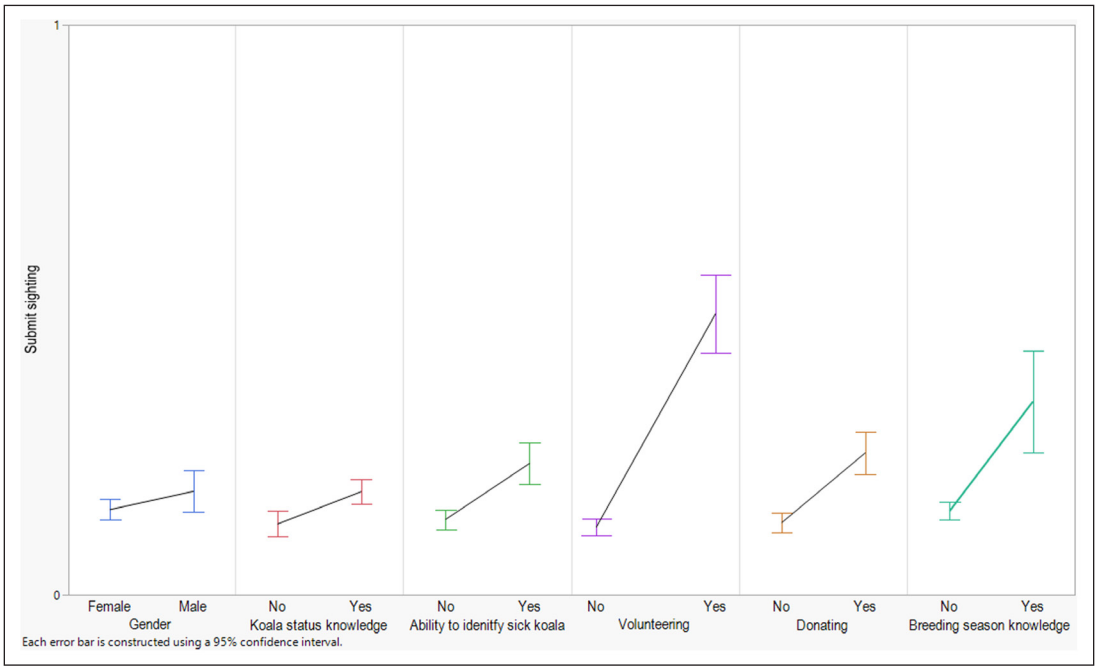

Figure 2 Individual main effects of gender, koala status knowledge, ability to identify a sick koala, volunteering, donating, and breeding season knowledge.

channels and venues for promotional efforts (e.g., sausage sizzles at Bunnings) were suggested.

FEEDBACK

Frustration at the lack of feedback about the data they had submitted was another common response. Some reported that they never heard anything from the program they were participating in, so they were unsure their sightings were received. Others wanted to see the results of their surveys and learn how the data they submitted were being used.

EDUCATION AND TRAINING

Respondents' comments indicated that more education and training is necessary in order to promote the specific skills and knowledge needed for reporting koala sightings, such as how to distinguish a sick koala from a healthy one.

COLLABORATION AND COORDINATION

While many of the comments address organizational practices in a broad sense, multiple respondents explicitly called for improved coordination and collaboration among groups, as well as the centralization and sharing of resources.

RELEVANCE AND PRACTICAL VALUE

Respondents wanted to know the purpose of the citizen science program and if/how the data were linked to conservation action. In addition, several individual comments identified external factors of concern to respondents; these include lack of reliable mobile/internet coverage, response time for koala rescue, the local policy landscape, and unintended consequences (e.g., land development decisions based on citizen science data).

IMPLICATIONS FOR CITIZEN SCIENCE INITIATIVES

The aims of this study were twofold. First, this study sought to extend understanding of psychographic and demographic characteristics of people participating in citizen science programs. Second, this study aimed to understand the experiences of citizen scientists.

CHARACTERIZING CITIZEN SCIENTISTS

Two research questions sought to understand whether demographic and psychographic factors differed for those who report koala sightings. While some citizen science researchers have cautioned against considering demographic factors within certain contexts (Pateman, Dyke, and West 2021), a consideration of who is most likely to serve as a citizen scientist provides a pragmatic starting point for any citizen science project aiming to increase sightings and reporting for endangered species such as koalas. Taken together, past research has identified that citizen science participants in many programs are most likely to be highly educated, retired, white, older females (Robinson et al. 2021), though some recent research indicates a slight male bias and variations in age

BARRIER/DRIVER CATEGORY	REPRESENTATIVE PARTICIPANT QUOTES	
	PROBLEMS	SOLUTIONS
Technology platform	"It wasn't easy to figure out but once I did it, was alright. If I wasn't retired and had time to spend working it out probably would have abandoned reporting the sighting."	"The platforms need to be easy to find for members of the public and self-explanatory to use." "Make easier and less reliant on technical skills."
Ease of use	"The app is not intuitive and would be a barrier to people less tech savvy to report." "Registration is too long and complicated" "It was hard to put my exact location" "Current websites contain outdated links"	"User friendly online forms."
Design and features		"Need to have a profile that allows us to see previous reportings and local area reports." "An app that allows people to put GPS coordinates that is easy for the general public, non-scientists and kids to use." "There should be only one central database overseen by a government department for reporting healthy koala sightings."
Communication and promotion	"The app is also not well marketed and known in this area" "More people need to know about it as many people are unaware and lots of sightings are go unreported."	"There needs to be more publicity and advice on how to report sightings." "Need to promote the recording of any sighting by general public anywhere any time."
Feedback	"I don't know enough about what happens to data to know if it could be improved. I have had no feedback on any reporting that I have done." "There is no follow up." "Never got a response."	"It would be good to receive acknowledgment (brief) that the information has been received." "Maybe providing feedback about the koala that was reported, if possible"
Education and training	"Others aren't aware of the need to report or how to ID sick koalas" "Many people are not aware reporting is possible or important"	"More education of the public." "Would love to see some of the tracking data to better understand their movements in our area."
Collaboration and coordination		"Coordination of information for interested people in various geographical areas." "Cooperation and collaboration of those working in the koala conservation fields" "Coordination of koala counts across SEQ"
Relevance and practical value		"Acknowledgement from council/government that they are aware of this data and that it is important to their planning to ensure all efforts can be made to protect koalas." "Exactly how the data is being put to use. It's disheartening to report in an area only to see it be bulldozed."

Table 3 Survey respondents' recommendations to improve citizen science programs.

and employment status (The National Academies Press 2018). This study provides further support suggesting that older residents are more likely to submit koala sightings. However, our study found that males were more likely to submit koala sightings, and did not suggest that education influences whether or not residents submit koala sightings.

The fact that koala knowledge differed significantly between those who report sightings and those who do not indicates the need for and value of education and training, which is a common recommendation in the citizen science literature (Cox et al. 2018; Martin et al. 2016; Measham and Barnett 2008; Robinson et al. 2021). Program improvement insights (Table 3) also make it clear that people participating in citizen science are seeking and would benefit from further education and training.

Approaches such as those reported in this study offer an important starting point to increase uptake in citizen science. Appeals to older residents who support koala conservation organizations should yield the highest enrolments into citizen science programs.

INSIGHTS INTO RETAINING CITIZEN SCIENTISTS

The nature and degree of the challenges identified by participants, coupled with the fact that overall participation in citizen science initiatives in South East Queensland is low, suggest that an emphasis should be placed upon promoting volunteer recruitment and retention. Past research has identified that numerous factors affect retention rates in citizen science programs, including participants' knowledge and skills; the presence and quality of education and training; receipt of feedback and communication from organizers; awareness of project relevance and salience; and the design and user-friendliness of digital tools (Cigliano et al. 2015; Cox et al. 2018; Fischer, Cho, and Storksdieck 2021; Frensley et al. 2017; Gharesifard and Wehn 2016; Liñán et al. 2022; Martin et al. 2016; Measham and Barnett 2008; West and Pateman 2016). This study supports previous findings. Respondents advocated for program improvements that would make reporting sightings easier and more convenient. The overwhelming majority of the comments focused on the technical shortcomings of existing mobile apps, a factor previously identified (Cigliano et al. 2015; Gharesifard and Wehn 2016; Liñán et al. 2022; Martin et al. 2016; Martin et al. 2016; Robinson et al. 2021). Many stressed the need for more guidance and training, indicating that they did not know what to report or where and how to report it. The need for ongoing education and training to support citizen science programs is also well represented in the literature (Cox et al. 2018; Martin et al. 2016; Measham and Barnett 2008; Robinson et al. 2021).

Many alluded to frustrations resulting from a lack of feedback after they'd reported a sighting, or from not knowing if or how the data they contributed would translate to conservation action. It appears that programs' current efforts to communicate the purpose of their initiatives have not entirely reached and/or resonated with participants from a conservation standpoint. The need to provide timely and relevant feedback is frequently cited as a recommendation (Fischer, Cho, and Storksdieck 2021; Gharesifard and Wehn 2016; Robinson et al. 2021; West and Pateman 2016). Further, Frensley and colleagues (2017) identified the lack of tangible real-world projects as a key theme affecting volunteer retention; interviewees wanted to participate in projects they viewed as practical, valuable, and salient. Respondents also suggested strategies to promote citizen science programs, and recommended specific communications channels and tactics, another theme commonly encountered in the literature (Fischer, Cho, and Storksdieck 2021; Pateman, Dyke, and West 2021). To be more effective, communications can be designed to amplify social norms (Martin et al. 2016). Several noted the existence of overlapping and duplicative programs and reporting tools, and suggested that more collaboration and coordination occur in the region. Other comments addressed broader issues and external factors such as policy agendas.

Most citizen science projects in Australia are local in scope, focusing on only one city, national park, or coastal area, while a third of all programs are broader and operate regionally (Golumbic 2020). Comments relating to fragmentation in mobile apps and online systems reflect the localized structure of citizen science efforts currently underway in Australia. Coordination and collaboration was recommended by study participants, and in moving forward, concerted effort is needed to deliver a cross-coordinated initiative. Such effort would ensure resources could be deployed to ensure timely feedback and that a greatly improved citizen scientist experience would be provided for the people who sign up to and participate in citizen science programs. Moreover, a coordinated effort reduces investments and time spent on different apps, online maps, and more.

Many of our respondents' suggestions to improve program delivery align with citizen science literature. The persistence of issues raised indicates that citizen science programs struggle with organizational culture and capacity challenges that are more structural in nature. Indeed, most respondents' comments centered on organizational practices, and they referred to low or no systems being in place to support individuals. Many of the solutions suggested by respondents are pragmatic and realizable in nature. Further, it is critically important to understand both organizational and dispositional (demographic) variables related to volunteer retention beyond initial engagement (Penner 2002). Thus, we recommend that citizen science program managers prioritize identifying and addressing organizational-level barriers through ongoing assessment and evaluation with the goal of building capacity and tailoring efforts to meet the needs and wants of citizen scientists who take up calls to volunteer and support ongoing efforts.

CONCLUSION, LIMITATION, AND FUTURE RESEARCH

Endangered species, such as koalas, need community, governments, and organizations to take more action if they are to thrive and survive. This study had two objectives aimed towards gaining insights that can be used to improve citizen science programs in South East Queensland, Australia. Residents who have previously submitted koala sightings were compared with those who have not to understand more about the differences in demographics, in knowledge of koalas, and in previous engagement in

koala conservation initiatives. The second aim of this study was to identify opportunities for improving the experience of submitting koala sightings. This study identified characteristics of people most likely to participate in citizen science programs focused on koalas. Data suggests many areas for program improvement. Increased participation in koala sighting and other citizen science programs needed to monitor koala populations will be achieved by focusing program promotion approaches on older residents, who are the most likely program adopters. This study identifies a range of controllable factors that can be managed to increase the number of times people lodge sightings. Improved communications and technology experiences, feedback on data collected, training, and more should be monitored and measured by funders of citizen science programs, ensuring a continual improvement focus is attained. Finally, fragmented effort dominates the citizen science landscape, creating frustrations for citizen scientists. Significant gains could be made from cross-coordinated efforts. Formation of partnerships and funding models that reward coordinated efforts are recommended.

ETHICS AND CONSENT

The university human ethics committee approved this study (Ref No: 2021/580).

FUNDING INFORMATION

This work was supported by the Department of Environment and Science [DES 12174]. The funder played no role in study design, collection, analysis and interpretation of data or the decision to submit the paper for publication. They accept no responsibility for contents.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

David Fechner: Conceptualization, Methodology, Analysis, Writing – original draft, Writing – review & editing, Visualization. Liz Foote: Conceptualization, Methodology, Analysis, Writing – original draft, Writing – review & editing. Sharyn Rundle-Thiele: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Resources.

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TO CITE THIS ARTICLE:
Fechner, D, Foote, L and Rundle-Thiele, S. 2023. Who Submits Koala Sightings? Profiling Residents and Identifying Opportunities to Enhance their Experience. *Citizen Science: Theory and Practice,* 8(1): 63, pp. 1–17. DOI: https://doi.org/10.5334/cstp.617

Submitted: 13 February 2023 **Accepted:** 19 October 2023 **Published:** 27 November 2023