



Local Awareness and Interpretations of Species Extinction in a Rural Chinese Biodiversity Hotspot

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Incorporating local perspectives is fundamental to evidence-based conservation, for both understanding complex socio-ecological systems and implementing appropriate management interventions. How local communities understand extinction, and whether these views affect perceptions of biodiversity loss and the effect of anthropogenic activities, has rarely been evaluated explicitly in conservation projects. To target this data gap, we conducted 185 interviews to assess levels and patterns of understanding about wildlife decline and extinction in rural communities around Bawangling National Nature Reserve, Hainan, China, a priority conservation site that has experienced recent species losses. Interviewees showed varying awareness of declines and extirpation of local wildlife species. Two-thirds did not consider the permanent disappearance of wildlife to be possible; among those who did, only one-third could comprehend the scientific term “extinction.” Thinking extinction is possible was associated with identifying declined and extirpated species, but not with perceiving locally-driven human activities, such as hunting, as the reason for wildlife loss. The government was seen as the entity most responsible for conservation. Variation found around local perceptions of extinction, its drivers, and conservation responsibility demonstrates that comprehension of key conservation concepts should not be assumed to be homogenous, highlighting the challenge of transposing scientific concepts between different social and cultural settings. Proactively incorporating local perspectives and worldviews, especially by obtaining context-specific baseline understandings, has major implications for other contexts worldwide and should inform conservation planning and management.

Keywords: China, ethnic minority, extinction, Hainan Island, indigenous knowledge, interview survey, protected area, worldview

INTRODUCTION

A key objective of conservation science is to understand the patterns and drivers of species declines and extinction to reduce the loss of biodiversity (Soulé, 2013). In the Anthropocene, human activities are driving the sixth mass extinction and pose the greatest threats to wildlife (Dirzo et al., 2014; Ceballos et al., 2015). A robust understanding of extinction is therefore needed to both reduce negative human impacts and support conservation actions. Extinction can be studied with different sources of data, including ecological surveys, assessments of species

population trends and conservation status (Rodrigues et al., 2006; Collen et al., 2009), fossils and palaeoecological records (Turvey and Saupe, 2019), historical archives (Grace et al., 2019; Turvey et al., 2019), and local and traditional ecological knowledge (Aswani et al., 2018). Multiple sources of data yield more comprehensive understandings of species extinction, especially in data-poor contexts (Turvey et al., 2019). The increasing emphasis on using evidence in conservation research and decision-making (Sutherland et al., 2004) also includes the integration of social science theories and methods to incorporate human dimensions (Bennett et al., 2017; Moon et al., 2019). Traditional indigenous and/or rural communities often interact closely with the environment and are directly involved in activities negatively impacting biodiversity, such as hunting, habitat degradation, and human-wildlife conflicts (Dickman, 2010; Specht et al., 2015; Roe and Booker, 2019). Hence, to understand extinction patterns and processes, researchers and practitioners can benefit from proactive engagement with the perceptions, knowledge, and experiences of people in these communities (Bennett, 2016; Pyhälä et al., 2016). In many cases, such communities are also the focus for conservation interventions aimed at altering awareness and behaviors (Nilsson et al., 2016), but doing so effectively requires baseline understandings of local perceptions.

Ample evidence shows that traditional communities can have ecological knowledge about wildlife that others from outside these communities lack, and may also have different processes of knowing the environment compared with that of formally trained scientists (Berkes, 2004; Wheeler and Root-Bernstein, 2020). When engaging with multiple stakeholders in conservation, establishing mutually understood concepts should be a priority, and is important in helping diverse actors work toward a common goal. Conversely, a lack of shared understanding can be problematic as conflicts can arise from disagreements between stakeholders. For example, the rewilding movement has been hindered by a lack of consensus among stakeholders on terminology and goals, including around key ecological concepts such as what constitutes “wild” and “natural,” and on whose land should rewilding be done (Nogués-Bravo et al., 2016; Root-Bernstein et al., 2018). Addressing how people understand—or do not understand—fundamental conservation concepts such as species decline and its causes should therefore be a key objective in conservation management to reach common ground between stakeholders.

In these contexts, reaching a common understanding of extinction is therefore key to conservation. The concept of extinction in western scientific thought emerged at the end of the eighteenth century when Georges Cuvier demonstrated the phenomenon with evidence from the fossil record (Rudwick, 1998). This realization only came after several centuries of European exploration and colonization, which catalyzed rapid anthropogenic environmental change around the globe that led directly to numerous documented species extinctions, including the dodo (*Raphus cucullatus*), now the symbol of extinction (Turvey and Cheke, 2008). Nonetheless, the philosophical and intellectual framework, and even the necessary language and terminology, around the concept of extinction was lacking at

first, a shortfall subsequently perceived to have been an obstacle to further study of extinctions (Sodikoff, 2011; Wiens et al., 2020). Today, conservationists work in diverse social, political, and cultural contexts directly with traditional communities with independent intellectual traditions and worldviews that might not necessarily contain comparable concepts of extinction (Brooks et al., 2013; Albuquerque et al., 2019). Actively engaging with potentially different perspectives, especially in regions with a high diversity of belief systems and languages that often overlap with biodiversity hotspots (Maffi, 2005; Turvey and Pettorelli, 2014), would help guide conservation management. However, establishing a baseline of how local people view extinction is often a missing step in conservation planning and management. In this case, knowledge co-assessment and co-production between researchers and local people, using pluralistic and context-based approaches, can be effective at filling data gaps (Sutherland et al., 2017; Norström et al., 2020).

While the cultural significance of extinction has been studied through anthropological, psychological, and historical frameworks (Poling and Evans, 2004; Sodikoff, 2011; Rose et al., 2017), research on how non-scientists view the phenomenon of extinction and its implications for conservation is limited. A comparison of schoolchildren’s understanding of the death of individual animals with the disappearance of entire species (e.g., dinosaurs), and of the acceptance of the possibility of human extinction among adults, showed that demographic variation exists even in the same cultural context (Poling and Evans, 2004). Past extinctions can also indicate how losses of species were perceived. For instance, Maori ancestral sayings and expressions have been interpreted as reflecting local observations that the extinction of moa, an important food source, was driven by human exploitation (Wehi et al., 2018). Assessing current perceptions of species loss in traditional communities living within biodiversity-rich regions would therefore contribute more direct insights to inform management today and in the future.

Research on species of conservation priority has sometimes explicitly investigated local peoples’ perceptions of the drivers of wildlife decline and extinctions, and has revealed further variation in understanding and awareness within these social-ecological systems. For example, different cultural groups inhabiting the same area in the Dry Chaco, Argentina, have different perceptions of the species that have become locally extinct and the timeframes of these extinctions, despite a consensus that the overall decline and extinction of wildlife species was mainly driven by hunting (Camino et al., 2016). Some indigenous peoples also have terminology describing local animal extinction and beliefs that wildlife decline was caused by overhunting and/or habitat destruction, recalled primarily by older people from their own experiences and established without the influence of western scientific concepts of extinction (de Azevedo et al., 2012; Forth, 2016). Conversely, other indigenous cultures appear not to have strong notions of extinctions being possible, such as not believing that wildlife or the forest ecosystem could disappear, and these views may again vary according to demographic factors (Casanova et al., 2014). Differences in understanding endangered species decline have also been

found between rural and urban residents in Brazil (de Azevedo et al., 2012). This complex variation in local understanding of extinction leads to further questions of whether these perceptions are driven by cultural traditions, livelihood methods, associated patterns of resource use, or other factors. Finally, it should not be assumed that communities are homogenous entities, nor that they would automatically take on responsibility for sustainable environmental management even if they associate species losses with their own activities (Agrawal and Gibson, 1999). Understanding how local people's perceptions of biodiversity loss relates to their sense of responsibility for conservation can therefore potentially be used to increase community involvement and a sense of ownership over natural resources, and promote pride, equity, and fair governance (Nilsson et al., 2016; Bennett et al., 2019).

In order to target these key data gaps in our understanding of extinction awareness, we investigated the following questions in village communities surrounding Bawangling National Nature Reserve (BNNR) in Hainan Province, China: (a) whether and how local people understand species decline and extinction, and their respective drivers; (b) what demographic variables covary with these perceptions; (c) whether people who think extinction is possible have favorable attitudes toward hunting, firewood collection, and use of natural resources; and (d) who local people think should be responsible for conservation, and what factors influence whether they identify different bodies as being responsible. The findings have major implications for how to engage proactively with local communities and identify shortfalls in conservation, while being sensitive to their views about biodiversity loss and associated local drivers. Overall, our results provide new understanding of human-wildlife relationships among non-western rural communities around a key protected area, and contribute transferrable insights to inform conservation at wider scales.

METHODS

Study Site

Interviews were carried out in villages within 3 km of the border of BNNR (Figure 1). The reserve (18°57'–19°11' N, 109°03'–109°17' E) has an area of about 300 square kilometers and straddles two counties on Hainan Island (Changjiang and Baisha Li Autonomous Counties). BNNR has been a priority for conservation management and scientific research partly because it contains the only surviving population of the Critically Endangered Hainan gibbon (*Nomascus hainanus*) (Chan et al., 2005b; Turvey et al., 2015). Gun ownership and logging were banned in 2001 and 1994, respectively (Davies and Wismer, 2007), but forest degradation and exploitation of wildlife within BNNR and other protected forests in Hainan continue to threaten local biodiversity (Zhang et al., 2010; Gong et al., 2017; Xu et al., 2017). Large carnivores such as the Asiatic black bear (*Ursus thibetanus*) and clouded leopard (*Neofelis nebulosa*) have probably disappeared from the reserve over the last two decades, and several other species such as the Chinese pangolin (*Manis pentadactyla*) are known to have undergone major declines and

are now extremely rare if not also extirpated (Fellowes et al., 2001; Turvey et al., 2019).

Numerous villages surround BNNR, with the nearest located within 1 km of the reserve boundary. Local communities are predominantly of Li ethnicity, with a few villages also comprised of people of Miao and Han ethnicity (Lian, 2003). Communities are typically low-income, with primarily agricultural-based economies. Until centrally planned conservation management of Hainan's forests began around 2000, these communities relied on natural resources from the surrounding forest environment for food, housing, and cultural and spiritual uses (Fauna and Flora International China Programme, 2005; Gu, 2019). Villages around BNNR cluster in three areas (Bawang, Qingsong and Wangxia), each of which share village-level government bureaus (*xiang*), shops and services, roads, and bus routes. The total human population of these three areas is c. 25,300 (National Bureau of Statistics, 2019).

Data Collection

An interview survey was conducted between February 27th and April 1st 2019 by the lead author and four local university undergraduate students. Students were recruited as part of a Chinese-UK institutional collaboration and provided with training in conservation social science skills to increase local conservation capacity. All of the villages within 3 km of BNNR, a total of 30 villages (15 in Changjiang County, 15 in Baisha County), were visited (Figure 1). Individual household interviews with a questionnaire format were conducted by going door-to-door and asking whether local residents aged 18 or above would like to participate. A target number of 10 people per village was aimed for (Guest, 2006); however, this was not always achieved because in smaller villages there were few people at home or willing to be interviewed. Interviews were carried out using methods previously used by Nash et al. (2016) and Turvey et al. (2017, 2019) in the same area. Participation was voluntary with verbal consent given before the interview began, and interviewees were informed that interviews were anonymous and they could withdraw at any time or could choose not to answer any question. Researchers' positions as independent from government authorities were clearly explained to interviewees, emphasizing that they were students wanting to learn about the local environment. Researchers were not accompanied by local officials because this has been known to affect responses (Davies and Wismer, 2007; Ratigan and Rabin, 2020). Standard Mandarin was used in all interviews, which the interviewees could understand. The study was approved and supported by Hainan University College of Forestry and the Research Ethics Committee at Royal Holloway, University of London (ID 535). Ethical considerations highlighted by Brittain et al. (2020) were further incorporated into all stages of research.

Substantial informal qualitative interviews and group discussions were conducted with local forest wardens and other local residents around BNNR and other reserves on Hainan prior to formal data collection, and information and observations obtained during these activities were used to guide questionnaire and survey design. Local people from communities around BNNR were not recruited as research assistants because

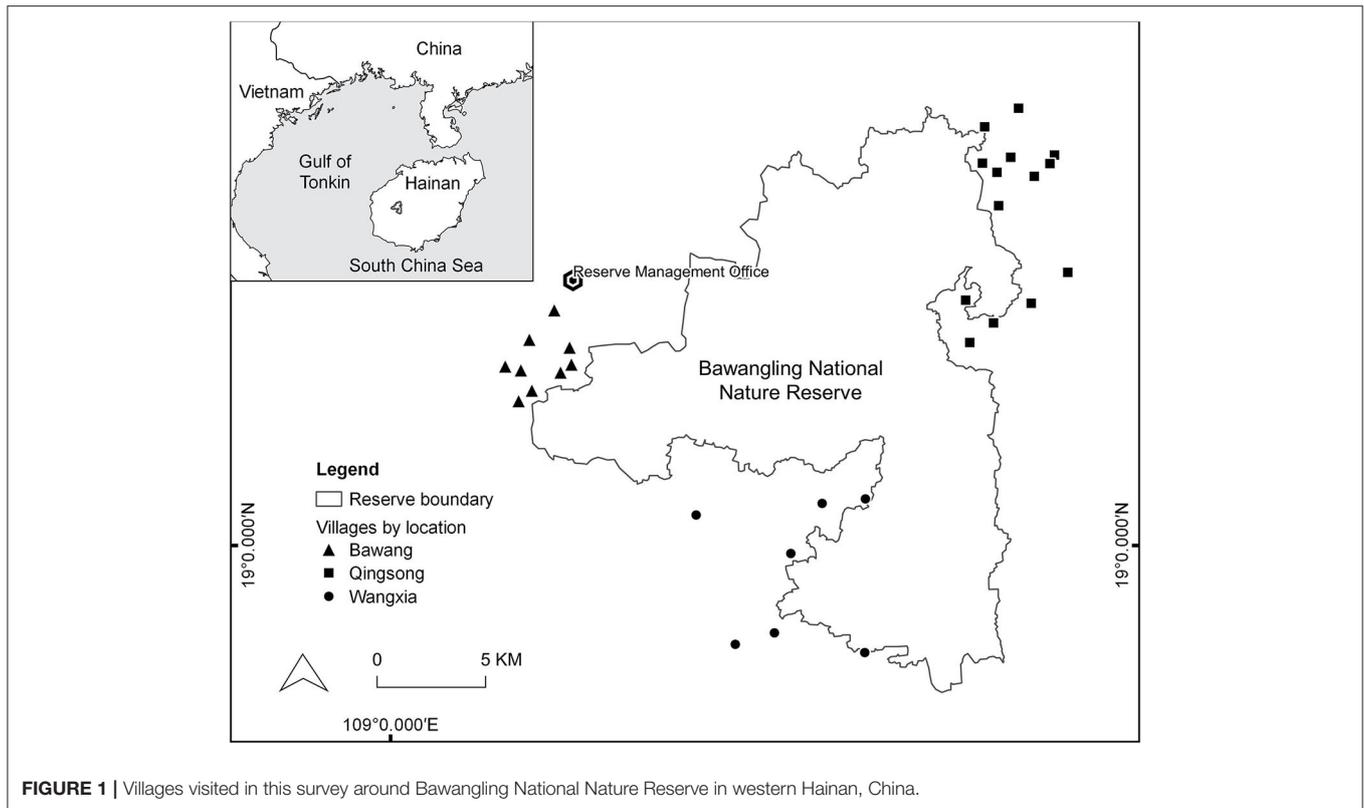


FIGURE 1 | Villages visited in this survey around Bawangling National Nature Reserve in western Hainan, China.

there are currently insufficient mechanisms between regional universities and local government on Hainan to enable full involvement of community members in conducting formal research in this study system. Whereas knowledge co-production is highly important, hunting, resource use, and attitudes toward conservation also represent potentially sensitive topics, and we consider that an appropriate first step is to assess the relevant information-content of local knowledge and advocate for its value in informing conservation management.

Using a standardized questionnaire with a mix of open and closed questions, information was first collected on interviewees' demographic characteristics, including gender, age, ethnicity, and highest level of education (**Supplementary Material**). All interviewees were asked whether they perceived any change in the overall abundances of local wildlife populations during the time they had lived in their village, and were then asked to free-list species they believed to have declined and to have disappeared completely from the surrounding area. They were then asked "is it possible for animals to disappear and never appear again?" followed by what they thought the word "extinction" (*"miejue"*) meant. Interviewees were also asked to list what they thought had caused both local decline and local disappearance of wildlife. To assess the relationship between relying on the reserve for resources and responsibility for conservation, all interviewees were presented with statements about three locally-driven human behaviors (it is acceptable to hunt, use natural resources from the reserve, and use firewood) and were asked

to respond with agree, disagree, or neither agree nor disagree. Finally, interviewees were asked who they thought should be responsible for doing conservation with open-ended questions. Interviewees could respond with "don't know" to any question. Open-ended questions were designed to encourage interviewees to provide further detail to their responses, with qualitative data gathered through these questions valuable for understanding and contextualizing local perceptions (Drury et al., 2011); interviewees could give more than one answer for these questions and were encouraged to provide further detail. Additional data collected in this interview survey have been analyzed separately (Ma, 2021).

Data Analysis

Responses about perceived change in overall wildlife abundances were totaled for each of the possible categories (no change, increased, decreased, don't know). The most frequently mentioned declined and locally extirpated species were identified by summing the number of people who free-listed each species. Reasons for decline and extirpation from open-ended questions were categorized as either locally-driven human activities (e.g., hunting, deforestation) or other drivers that are the result of regional or global changes (e.g., climate change). Responses to whether local or non-local people's activities caused wildlife decline, and attitudes toward hunting and using natural forest resources or firewood, were summed across all interviewees and converted to proportions. Responses for

who should do conservation were coded into five categories (reserve management, government, citizens, conservation professionals, and other), which captured the different levels of specificity given by interviewees (for example, provincial-level and village-level government were coded together with other levels of government, and forestry wardens were coded with reserve management).

All statistical analyses were performed in R version 3.5.2 (R Development Core Team, 2018). Generalized linear models (GLMs) with binomial error distributions and logit link functions were used to determine which demographic variables were associated with: (1) thinking wildlife abundances have undergone overall decline; (2) being able to free-list any locally declined species; (3) being able to free-list any locally extirpated species; and (4) thinking extinction is possible. All response variables were binary (yes or no). Model predictors included age (continuous), gender (categorical), village location (categorical), and formal education level (categorical). Education level was divided into four categories (none; primary school; middle school; and high school and above, including university). Only people of Li ethnicity were included in GLMs due to the imbalance in relative frequencies of interviewees belonging to different ethnic groups in our sample (92.4% Li, 6.6% Miao and Han). The same predictors, plus whether someone thought extinction is possible, were also used in GLMs with the binary response variables of: (1) thinking local human activities caused wildlife decline; (2) thinking local human activities caused wildlife extirpation; (3) thinking it is acceptable to use natural resources from the forest; (4) thinking citizens should be responsible for conservation; and (5) thinking the government should be responsible for conservation. Over 80% of interviewees reported that they were against hunting and in favor of firewood use, so Fisher's Exact test was used instead of GLMs to test for associations with these variables. Chi-square tests were used to investigate whether there was an association between free-listing any locally extirpated species and thinking extinction is possible.

RESULTS

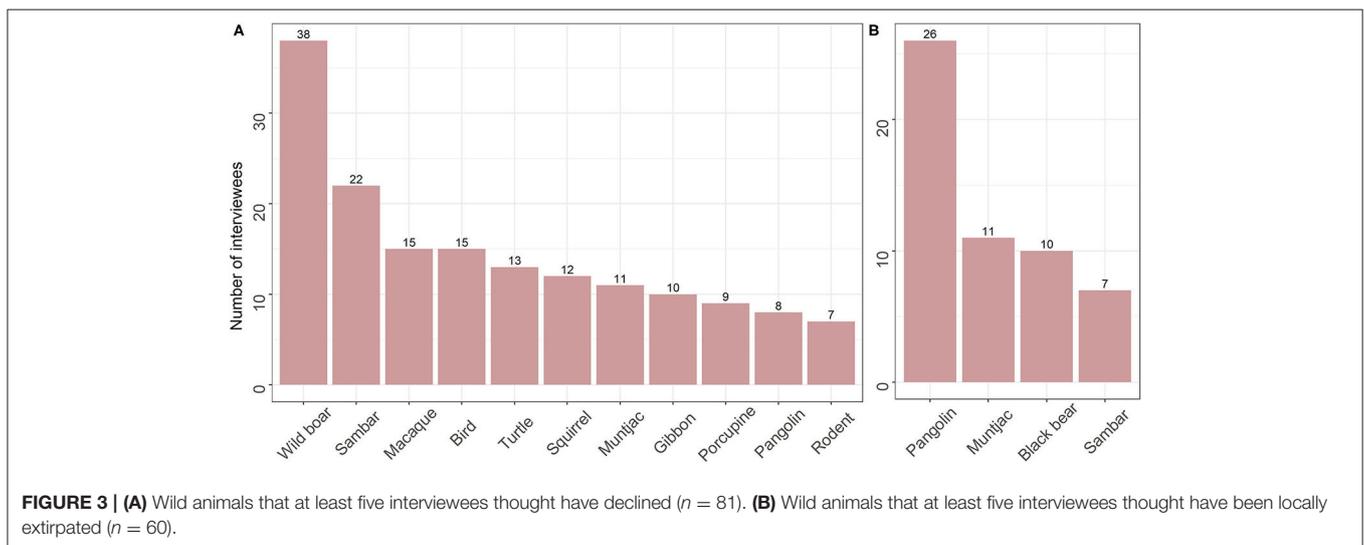
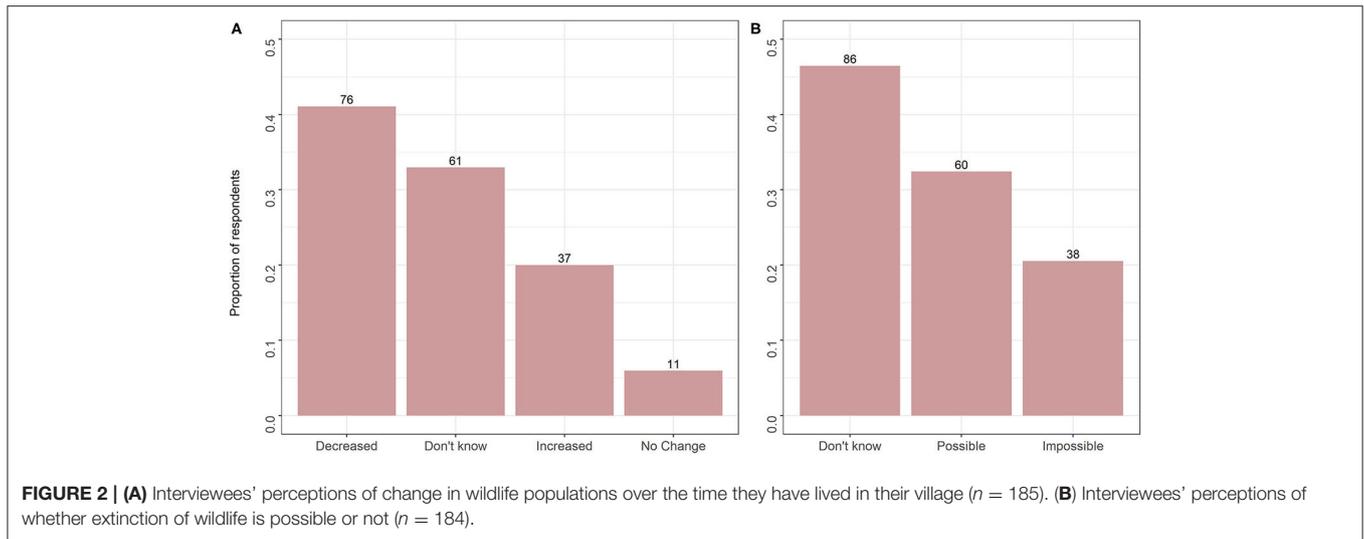
A total of 185 people were interviewed. People interviewed per village varied from 2 to 20. Two-thirds of interviewees were from villages in the Qingsong area (**Supplementary Table 1**). About two-thirds of the interviewees were men (70.2%), and overall they had relatively low levels of formal education, with most having only reached middle school (88.6%).

Less than half (76, 41%) of all interviewees perceived a decrease in wildlife populations, in contrast to the number of interviewees who perceived an increase (37, 20%) (**Figure 2A**). Declines were often perceived based on direct personal experience; for example, one interviewee recounted that “Seven to eight years ago, when I went up the nearby mountains, sometimes I saw animal footprints, but I no longer see them now.” Many people did not know whether wildlife populations had changed (61, 30%); one interviewee explained that this was because “[people] are not allowed to go into the forest, so [we] do not see animals

and do not know if they have declined.” Very few people (11, 6%) thought there was no change. Age (binomial GLM, $n = 169$, $\chi^2 = 11.748$, $df = 1$, $p = 0.001$) and village location (binomial GLM, $n = 169$, $\chi^2 = 8.814$, $df = 2$, $p = 0.012$) were significantly associated with whether someone was more likely to perceive a decline in wildlife populations. Older people (estimate = 0.043, standard error = 0.015, z -value = 2.968, $p = 0.003$) and people in Qingsong (estimate = 1.332, standard error = 0.522, z -value = 2.554, $p = 0.011$) and Wangxia (estimate = 1.461, standard error = 0.632, z -value = 2.310, $p = 0.021$) were more likely to think wildlife had declined (**Supplementary Table 2**).

Among all interviewees, 81 (44%) were able to free-list at least one species they perceived to have locally declined. In total, 11 species or species groups were identified by at least five people. The most frequently mentioned declined species were wild boar (*Sus scrofa*, $n = 38$), sambar deer (*Rusa unicorn*, $n = 22$), rhesus macaque (*Macaca mulatta*, $n = 15$), and birds ($n = 15$) (**Figure 3A**). One interviewee stated that “in the past, wild boars would eat the crops, but now they do not anymore.” Most listed wildlife were mammals, but some interviewees also mentioned turtles ($n = 13$), and fish, insects, and snakes (all listed by fewer than five people), including one mention of pythons. Of the people who mentioned turtles, three specifically identified golden coin turtle (*Cuora trifasciata*), two identified big-headed turtle (*Platysternon megacephalum*), and one described a small aquatic turtle. Age (binomial GLM, $n = 167$, $\chi^2 = 7.403$, $df = 1$, $p = 0.007$) and village location (binomial GLM, $n = 167$, $\chi^2 = 11.499$, $df = 2$, $p = 0.003$) were significantly associated with someone being able to name at least one species perceived as being locally declined. Older people (estimate = 0.031, standard error = 0.014, z -value = 2.206, $p = 0.027$) and people in Qingsong (estimate = 1.367, standard error = 0.491, z -value = 2.785, $p = 0.015$) compared to Bawang were more likely to identify at least one locally declined species (**Supplementary Table 3**).

In total, 60 interviewees (32%) were able to free-list at least one species they perceived to have become locally extirpated. Only four species were reported by more than five people: Chinese pangolin ($n = 26$), red muntjac (*Muntiacus vaginalis*, $n = 11$), Asiatic black bear ($n = 10$), and sambar deer ($n = 7$) (**Figure 3B**). Several interviewees described the disappearance of pangolins in further detail: “Pangolins disappeared twenty years ago. I have not seen one; I have heard of them, but they no longer exist now”; and “Pangolins have gone extinct. They are valuable and were not protected. Villagers would go looking for them after the rain by following their footprints.” In addition, four people mentioned civets (with two people specifically naming masked palm civet *Paguma larvata*); three people mentioned turtles (including two who named golden coin turtle); fish and toads were each mentioned once; and birds were not generally identified to species group or species level, except for pheasant (two), owl (one), crested myna (one), and parrot (one). The disappearance of fish was attributed to water depletion: “Fish have disappeared locally. Before there was plenty of water, but the water has gradually dried up.” Age (binomial GLM, $n = 167$, $\chi^2 = 7.779$, $df = 1$, $p = 0.005$) and village location (binomial GLM, $n = 167$, $\chi^2 = 11.888$, $df = 2$, $p = 0.003$) were significantly associated with someone being able to name at least one species

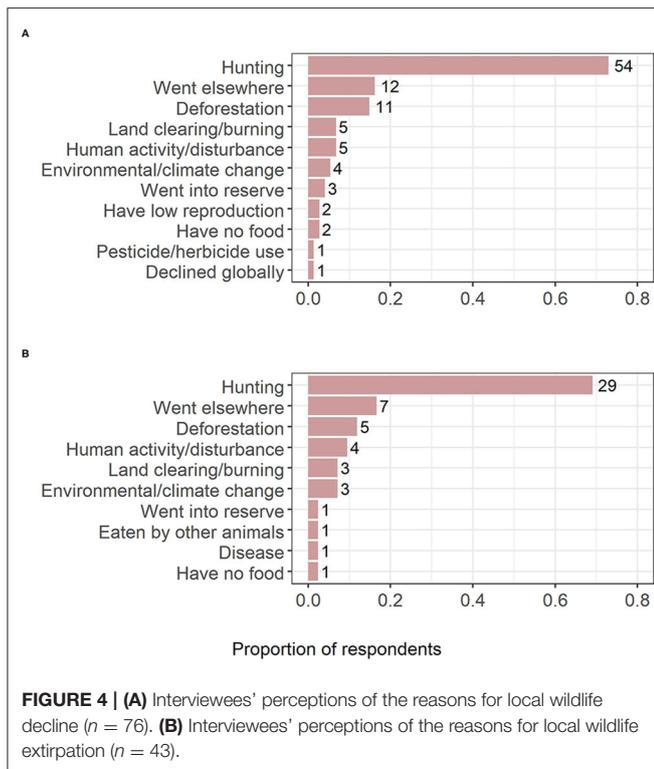


perceived as being locally extirpated. Older people (estimate = 0.033, standard error = 0.015, z -value = 2.283, $p = 0.022$) and people in Qingsong (estimate = 1.819, standard error = 1.819, z -value = 2.760, $p = 0.015$) compared to Bawang were more likely to identify at least one locally extirpated species (**Supplementary Table 3**).

Many people stated they did not know the reasons for local wildlife decline (106, 57%) or extirpation (138, 75%). The most frequently identified cause for both local wildlife decline and extirpation was hunting; for example, one interviewee stated that “*In the past, the elders had to survive and needed to hunt animals. Because the animals were hunted a lot, they decreased.*” Another interviewee stated that “*business owners would pay for people to hunt. When there were too many [animals hunted] and they could not all be eaten in the villages, they were given away.*” A range of other local drivers were also identified; for example, declines or extirpations were also considered to be caused by factors such as “*human destruction—deforestation, clearing land, and hunting,*”

or because “*The forest has decreased because trees have been cut down, and the land has turned barren because it got burnt; the animals have nowhere to live.*” However, other local human activities, including habitat loss and degradation (deforestation, land clearing, or burning), disturbance by humans, and herbicide or pesticide use, were reported far less frequently than hunting (**Figure 4**).

Of the 76 people who reported reasons for wildlife decline, 62 (82%) identified at least one local human activity, while 12 (16%) identified other reasons (**Figure 4A**); two answers were not classified due to ambiguity (“*because of the government*” and “*animals got protected*”). More interviewees thought local people were responsible for the activities causing wildlife decline (47, 25%) compared to those who thought that decline was caused by non-local people’s activities (35, 19%), but nearly two-thirds (122, 66%) of interviewees did not know. In contrast, of the 43 people who gave reasons for local wildlife extirpation, 36 (84%) were able to identify at least one local human activity



as the reason, while 6 (14%) listed other reasons (Figure 4B); one answer was not classified due to ambiguity (“*animals got protected*”).

Village location was the only variable significantly associated with thinking wildlife decline was caused by local human activities (binomial GLM, $n = 164$, $\chi^2 = 14.460$, $df = 2$, $p = 0.001$), with interviewees in Qingsong more likely to think local human activities were responsible (estimate = 1.614, standard error = 0.601, z -value = 2.684, $p = 0.007$). Conversely, interviewees with a higher education level were more likely to think wildlife extirpation was caused by local human activities (binomial GLM, $n = 164$, $\chi^2 = 14.057$, $df = 3$, $p = 0.003$), but no significant differences were found between education levels (Supplementary Table 3). Thinking extinction is possible was not significantly associated with identifying local human activities as the cause of wildlife decline or extirpation (Supplementary Table 2).

Of all interviewees, 86 (47%) were not sure whether wildlife species could go extinct based on the description of the concept of extinction (“is it possible for animals to disappear completely?” Figure 2B), while 60 (32%) thought it was possible, and 38 (21%) thought it was impossible. Interviewees who thought it was impossible for animals to disappear completely explained that “*the animals have run away but will return*,” “*animals may exist elsewhere*,” or “*as long the forest exists there should be animals*.” Age (binomial GLM, $n = 168$, $\chi^2 = 11.670$, $df = 1$, $p = 0.001$) and village location (binomial GLM, $n = 168$, $\chi^2 = 6.854$, $df = 2$, $p = 0.032$) were significantly associated with whether someone was more likely to think it was possible for animals

to disappear completely (Supplementary Table 2). Older people were more likely to think it was possible for animals to disappear completely (estimate = 0.045, standard error = 0.015, z -value = 2.988, $p = 0.003$), but there were no significant differences between the three village locations detected by *post-hoc* tests. An association was found between considering it was possible for animals to disappear completely and being able to list locally extirpated species (chi-square test, $\chi^2 = 28.189$, $n = 183$, $df = 1$, p -value < 0.001); more people both recognized local extirpation of wildlife and thought it was possible for animals to disappear completely than expected (36 observed vs. 20 people expected).

In contrast, of the 60 people who thought it was possible for animals to disappear completely, 37 (62%) did not understand the scientific term “extinction,” and only 21 (35%) provided an explanation of what it meant. Definitions of extinction given by interviewees typically included “*animals have disappeared forever*,” “*all died out*,” or “*all got killed or captured*.” Interviewees also understood extinction as “*some animals existed before but have disappeared now*” or “*a particular species has been destroyed and no longer exists*.” Specifically, the concept of overexploitation was linked to extinction by one interviewee, as “[*some*] *animals only have one offspring per year, people caught two or two each time they hunted, so the animals are all gone*.” Of the 124 people who were not certain it was possible for animals to disappear completely, 38 (31%) still described the meaning of the term “extinction,” while 86 (69%) were neither certain it was possible for animals to disappear completely nor understood the term “extinction.” In addition, three people said dinosaurs went extinct in the past, but emphasized that it is impossible for animals to go extinct now.

Just under half of interviewees (45%) thought it was acceptable to use natural resources from the forest. Most interviewees (172, 95%) had a positive attitude toward using firewood for powering stoves for cooking. In contrast, most interviewees were against hunting (146, 81%), but some (24, 13%) had a neutral attitude. Thinking it is acceptable to use natural resources from the forest was significantly associated with thinking it was possible for animals to disappear completely (binomial GLM, $n = 166$, $\chi^2 = 5.310$, $df = 1$, $p = 0.021$) and village location (binomial GLM, $n = 166$, $\chi^2 = 6.980$, $df = 2$, $p = 0.031$). Interviewees who thought it was possible for animals to disappear completely were more likely to think it is acceptable to use natural resources (estimate = 0.846, standard error = 0.371, z -value = 2.279, $p = 0.023$), and those in Wangxia were more likely to think it is acceptable (estimate = 1.455, standard error = 0.578, z -value = 2.519, $p = 0.012$) (Supplementary Table 3). There was no association between whether an interviewee thought it was possible for animals to disappear completely and whether they thought it is acceptable to use firewood (Fisher’s Exact Test, $n = 168$, odds ratio = 2.07, 95% confidence interval = 0.39–20.67, $p = 0.49$), or that it is acceptable to hunt (Fisher’s Exact Test, $n = 168$, odds ratio = 1, 95% confidence interval = 0.21–3.94, $p = 1$).

In total, most interviewees (165, 89%) thought wildlife should be protected. Among these, 137 (74%) identified at least one group of people they thought should be responsible for conservation, while 28 did not know (15%). Sixteen people (9%) were unsure whether wildlife should be protected, and

one person did not think so. Of the interviewees who thought wildlife should be protected, reserve management was thought to be responsible by the most people (64, 47%), followed by ordinary citizens (60, 44%) and various levels of government (43, 31%) (Figure 5). Only five people (4%) thought conservation professionals should be responsible for conservation. One interviewee who thought the forestry bureau was responsible reasoned that it is “because the central government gives them funding,” but also thought that each person also has a role, “because otherwise future generations would not see wildlife.” Individual responsibility was not seen as sufficient, however, as one interviewee pointed out: “All people should be responsible ... it is useless if only one person protects [wildlife] but others still hunt.” Others thought the government should be responsible because “unless the government promotes [conservation], people would not understand and would eat all the animals,” and because “the government has to manage the public, otherwise people would hunt as they please.” One interviewee further explained that “unless the government owns the wildlife, people will go into the forest. If wildlife is privately managed (e.g., contracted out to business owners), it will be depleted by hunting,” suggesting that centrally managed conservation is necessary.

Demographic variables and perceptions of extinction had varying effects on perceptions of responsibility for conservation. Age (binomial GLM, $n = 162$, $\chi^2 = 6.423$, $df = 1$, $p = 0.011$) and education level (binomial GLM, $n = 162$, $\chi^2 = 24.638$, $df = 3$, $p < 0.001$) were associated with thinking all citizens are responsible for conservation, with younger people (estimate = -0.039 , standard error = 0.016 , z -value = -2.396 , $p = 0.017$) and those with higher education more likely to think all citizens are responsible (Supplementary Table 2). Age was also associated with thinking the government is responsible for conservation (binomial GLM, $n = 165$, $\chi^2 = 12.351$, $df = 1$, $p < 0.001$), with older people more likely to hold this opinion (estimate = 0.047 , standard error = 0.015 , z -value = 3.190 , $p = 0.001$). Gender, village location, and whether someone believed extinction was possible were not significant predictors of whether interviewees held either opinion (Supplementary Table 2).

DISCUSSION

In order to develop appropriate methods to mitigate unsustainable interactions between local communities and threatened biodiversity, it should neither be assumed that all cultures share the western scientific understanding of extinction, nor that people not exposed to western scientific thinking cannot comprehend extinction (Casanova et al., 2014; Forth, 2016; Wehi et al., 2018). Understanding local perceptions of extinction and associated worldviews, knowledge levels, and attitudes is essential to avoid erroneous assumptions in conservation planning, and to enable stakeholders to reach a shared consensus about conservation issues and goals. We addressed this data gap by evaluating the understanding of species extinction and decline around a key protected area in Hainan, China.

Responses to free-listing questions indicate that a relatively large proportion of people living close to BNNR are aware of local species declines. While there have not been regular systematic wildlife surveys inside the reserve (Fellowes et al., 2001; Chan et al., 2005a; Lau et al., 2010), other recent interview surveys conducted around BNNR provide independent data on reductions in sightings of several mammal species (e.g., sambar) that are consistent with local perceptions of wildlife decline documented in this study (Nash et al., 2016; Turvey et al., 2019; Wang et al., 2021). Furthermore, continued hunting of birds and turtles is documented in adjacent reserves in Hainan, and local people in these landscapes perceive that population declines are caused by overhunting (Gong et al., 2009; Liang et al., 2013, Gong et al., 2017). Awareness of the potential for local wildlife decline is well-documented in both environmental history and other traditional societies. For example, sustainable hunting and fishing practices exist among many indigenous cultures (Berkes et al., 2000; Wheeler and Root-Bernstein, 2020). Formal governance structures, such as medieval European hunting regulations and forest conservation, also demonstrate past awareness of the risk of wildlife decline and a desire to prevent it (Young, 1978). Indeed, millennia-old philosophical traditions in China promoted the moderate and sustainable usage of natural resources to prevent their depletion, indicating an understanding of concepts of biodiversity loss

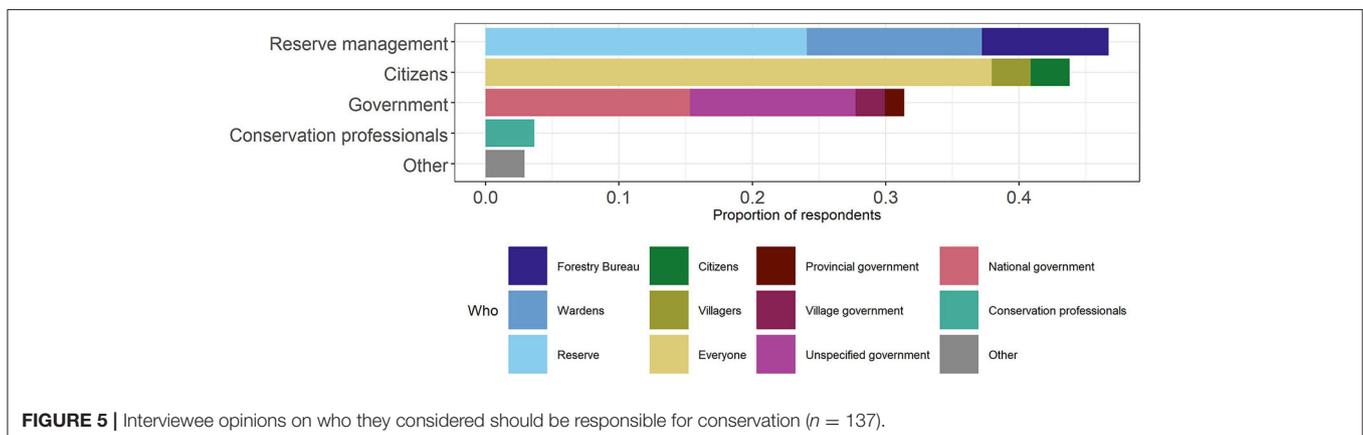


FIGURE 5 | Interviewee opinions on who they considered should be responsible for conservation (n = 137).

(Sterckx, 2019), and notions of local species decline directly influenced Chinese environmental management practices from the eleventh century BCE (Cui and Wang, 2001; Marks, 2007). Sustainable management practices also exist within both rural ethnic minority and Han communities in China today (Coggins, 2003; Urgenson et al., 2010; Shen et al., 2015). Overall, these findings reaffirm the value of incorporating local ecological knowledge in species conservation, especially in data-poor environments (Berkes et al., 2000; Turvey et al., 2010, 2014).

Responses to free-listing questions also indicate that relatively many people living close to BNNR are aware not only of local species declines but also of local species extirpations, as reflected by the differences in the most frequently perceived locally extirpated species (pangolin, muntjac, black bear, sambar) and declined species (wild boar, sambar, macaque, birds, turtles). These responses are consistent with the findings of previous studies suggesting that pangolin and black bear may have disappeared from BNNR (Fellowes et al., 2001; Turvey et al., 2019). However, although we found that perception of local extirpation of species and considering it was possible for animals to disappear completely are linked, our results also demonstrate that a relatively low proportion of interviewees considered that the permanent disappearance of animals is possible. While culturally salient extinction “icons” exist in both western and eastern societies (Turvey and Cheke, 2008; Heise, 2010), the association between awareness of local extirpation and acknowledging global extinction is thus not necessarily obvious. For example, the Lewis and Clark expedition across western North America in the early nineteenth century was partly motivated by Thomas Jefferson’s belief that mastodons were not extinct and might still exist somewhere in as-yet unexplored territories (Thompson, 2009). Therefore, the existence of a causal relationship between understandings of local extirpation and global extinction warrants further comparative research across differing social and cultural contexts.

A limited awareness of the possibility of extinction has also been documented elsewhere in other rural communities around protected areas. For instance, many local people living close to Cantanhez Forest National Park in Guinea-Bissau believed that neither wildlife nor the forest ecosystem would disappear, with such views related to religious beliefs (Casanova et al., 2014). The concept of extinction caused by anthropogenic change to natural environments was recognized independently by Chinese scholars in the early nineteenth century (Marks, 2007). However, the lack of widespread acceptance of extinction in rural Hainan could potentially have roots in classical Chinese culture, which was heavily influenced by Buddhist, Taoist, and Confucian philosophies in which human and animals are all interconnected components of nature and coexist in harmony (Grumbine and Xu, 2011; Sterckx, 2019). In these belief systems, nature was a rather abstract construction, which may have been why understandings of concrete ecological phenomena were largely absent; instead, observations of nature were typically framed and explained in moral terms or as metaphors for human behavior (Grumbine and Xu, 2011; Sterckx, 2019).

The low number of people who could explain the meaning of the scientific term “extinction” (“*miejue*”), even among those

who thought that the permanent disappearance of animals is possible, has further implications for conservation practice, especially for communication and awareness-raising. It is not surprising that this formal scientific term is not well-understood by ethnic minority communities who live in rural settlements and have low levels of formal education. Indeed, confirming species extinction is conceptually and practically challenging, an issue that is further hindered by the lack of robust evidence to assess possible continued survival of many rare and enigmatic species (McKelvey et al., 2008; Roberts et al., 2010). Local people should therefore not be expected to have a consistent understanding of extinction, especially considering the different experiences they have with the environment compared to those of authorities, researchers, and conservation professionals. However, if this formal term is widely used in awareness-raising about conservation, mismatches in understanding could result in low uptake of the key messages being communicated. If such discrepancy can be found within one social-ecological system, it may therefore be even more prevalent when transposing conservation concepts internationally between vastly different cultures and languages.

We also found that perceptions of both wildlife decline and extinction were further influenced by demographic and geographic factors. The association between older age and greater understanding of species loss may be attributed to more experience of local environments, consistent with other studies showing that community elders often have more ecological knowledge (Turvey et al., 2010; Forth, 2016). In Hainan and elsewhere, erosion of local and traditional ecological knowledge has been found to accompany biodiversity loss and ecological degradation (Kai et al., 2014; Turvey et al., 2018). Conversely, the observed different levels of understanding species loss between village locations around BNNR may reflect variation in levels of implementation of conservation awareness-raising activities in different communities around the protected area. The conservation flagship species of BNNR, the critically endangered Hainan gibbon, has been the focus of most awareness-raising activities previously conducted in this region (Fauna and Flora International China Programme, 2007, 2008; Kadoorie Farm and Botanic Garden, 2016, 2018), and more conservation-relevant information focused around this species has been available from billboards, murals, and education activities in the Qingsong region (Qian et al., 2021). The greater level of general understanding of species decline and extinction seen in this region may thus suggest a potential link between exposure to gibbon-specific awareness-raising and higher levels of general extinction knowledge.

The most frequently identified reason for wildlife extinction was hunting, and few people knew about any other drivers of decline or extinction. Awareness of hunting as a threat may reflect local people’s direct personal experiences, either having hunted themselves, or having observed or heard from others such as village elders who hunted in the past. In a separate recent study, many local people around BNNR also reported that their knowledge about threats to the Hainan gibbon came from experience of hunting or observing hunting activities (Qian et al., 2021). Elsewhere, local peoples who traditionally practice

subsistence hunting also have a high degree of consensus that hunting is the main driver of local biodiversity loss, and have proposed hunting restrictions as conservation solutions (Camino et al., 2016). To achieve a more robust evaluation of hunting threats, interview responses should be triangulated with other methods to evaluate the impact of different human activities, such as monitoring evidence of hunting such as traps and market surveys (Gong et al., 2009; Gaillard et al., 2017).

Local perceptions of the possibility of extinction, the species affected, and the causes of species decline have important implications for conservation awareness-raising activities. The overall low level of knowledge of species extinction and its drivers highlights the need to promote understanding of key conservation concepts when engaging with local communities. Variation in awareness of the drivers of biodiversity loss, especially of hunting compared with other causes such as habitat degradation and disturbance by human activities, suggests that future awareness-raising should include information not only on the conservation-priority species present in the landscape, but also on the various processes causing species decline. It is also important to assess if, how and where local human activities are currently impacting biodiversity to better focus awareness-raising and other mitigation measures to where they are most needed. For example, awareness-raising at BNNR could be specifically designed to target the identified gaps in local understanding of extinction by emphasizing that the Hainan gibbon is only found in this reserve and nowhere else, the species' existence depends solely on habitat inside the reserve, and the likelihood of irreversible extinction increases without support for conservation actions.

To local people living close to BNNR, responsibility for conservation was primarily thought to be borne by the government, but the participation of the general public was also seen as important. Reserve authorities, including the forestry bureau, management office, and reserve wardens, were perceived to be most responsible for wildlife conservation, suggesting that local people associate reserve staff the most with conservation or receive the most exposure to conservation from reserve staff. In contrast, few people identified conservation professionals as being responsible, possibly reflecting the more limited activities of the few conservation organizations active at BNNR, and their temporally and geographically more patchy engagement with local communities (Fauna and Flora International China Programme, 2005, 2007; Turvey et al., 2015; Kadoorie Farm and Botanic Garden, 2016, 2018). Overall, national-level government was perceived to be more responsible than provincial-level or village-level government. The increased likelihood of older people to have this view may reflect the last few decades of state-led environmental management directives in recent Chinese history (Marks, 2017; Mao and Zhang, 2018). In contrast, younger people and those with higher education levels were more likely to think everyone is responsible, suggesting a potential shift toward the belief that conservation should involve all members of society. For example, birdwatching is increasingly popular in China, and many birdwatchers, typically those who are higher educated, younger, and wealthier, have expressed their environmental concerns (Walther and White,

2018), presenting opportunities for raising regional awareness about the extinction crisis through nature-based education and leisure activities.

Drawing upon local knowledge via research co-production between local people, scientists, and practitioners is therefore a vital way to ensure that local perspectives are not only documented, but also can be readily incorporated into conservation management (Nel et al., 2015; Norström et al., 2020). We acknowledge that this research does not constitute knowledge co-production, as local community members are not co-authors, and the conclusions drawn from the data are instead the researchers' interpretation of local people's knowledge, awareness, and attitudes. Further in-depth qualitative research, involving interactive co-learning processes (Norström et al., 2020), could help triangulate the results found in this study to tackle this limitation. Due to the potentially sensitive nature of what could be discussed, e.g., illegally entering protected areas and hunting, no local people were identified to protect their identities, and thus it was not possible to include any as co-authors while ensuring anonymity (Brittain et al., 2020). Additionally, because one aim of this study was to investigate underlying patterns of local perceptions of extinction, interviewees were conducted opportunistically rather than by identifying local experts. Nonetheless, the inclusion of local knowledge is integral to the long-term conservation programme that this research is part of, which aims to amplify local communities' perspectives in the management of Hainan's protected areas. However, we are also aware that while knowledge was gathered directly from local people, this process does not guarantee that they will have more power in conservation decision-making (Latulippe and Klenk, 2020).

Consistent with similar studies conducted in this region (Nash et al., 2016; Turvey et al., 2019), our sample was biased toward men and people with lower levels of education, possibly because men can have a higher willingness to interact with strangers in rural China, and might be more likely to agree to be interviewed compared to women (Ratigan and Rabin, 2020). The villages we surveyed represent some of the poorest and underdeveloped communities in Hainan (and indeed across China), which is why overall education levels are low amongst interviewees (Davies and Wismer, 2007; Gu and Wall, 2007), and people who attain higher education from such communities in China tend to migrate to urban areas to seek better employment opportunities (Gu and Wall, 2007). We recognize that the lower representation of women and people with higher levels of education may be a limitation in this study; however, because these demographic groups tend to be the ones that conservation will both engage with and impact, it is important to take their perceptions into account for conservation outreach and management.

Overall, our results demonstrate the importance of engaging proactively with varying understandings of wildlife extinction, because doing so can help different stakeholders—local communities, researchers, and management authorities—reach consensus on the key ecological concepts underpinning conservation goals. The contrast between

many interviewees acknowledging local wildlife extirpation but considering that extinction is not possible highlights the nuances within local perceptions of species decline. It is therefore important to avoid the assumption that people from varying cultural and socioeconomic backgrounds will have homogenous views of species extinction. Finally, our results also reaffirm the contributions of local ecological knowledge to understanding wildlife decline, and advocate for the inclusion of such knowledge, co-produced with local communities, as crucial evidence for conservation.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Royal Holloway, University of London Research Ethics Committee. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

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AUTHOR CONTRIBUTIONS

HM, SP, and ST designed the study, analyzed the data, and wrote the manuscript. HM, TG, XW, CY, and HZ collected data. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcosc.2021.689561/full#supplementary-material>

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

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