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Perceptions of Lemur Conservation among Malagasy and Non-Malagasy

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Abstract: Lemurs are endemic to the island of Madagascar, a biodiversity hotspot that is considered one of the world's poorest countries. To understand how Malagasy and non-Malagasy perceive lemur conservation programs, we surveyed 331 people and compared the results of four audience groups: Malagasy conservation professionals, Malagasy not working in conservation, non-Malagasy conservation professionals, and non-Malagasy not working in conservation. We hoped to learn if Malagasy and non-Malagasy agree about lemur conservation priorities, if there are conservation threats and solutions that may be poorly prioritized due to disagreement about their importance, and what topics should be prioritized by conservation education programs. The four groups of survey respondents agreed that lemurs and people should be prioritized equally; disagreed about the importance of hunting, charcoal production, and logging as threats; and agreed about the importance of education for Malagasy people, reforestation, and patrolling forests as solutions. While they were interested in different topics related to lemur conservation, all would like to learn more about how threats facing lemurs are being addressed. Malagasy respondents were also interested in climate change and conservation technology, and non-Malagasy were also interested in Malagasy people working in conservation, conservation success stories, and conservation organizations working in Madagascar. More research is needed to fully understand how Malagasy and non-Malagasy perceptions are similar and different on a large scale and in specific regions, and how this impacts lemur conservation priorities.

Keywords: Madagascar, Malagasy, lemurs, primates, conservation, perceptions, online survey

Introduction

Madagascar is a biodiversity hotspot (Myers *et al.*, 2000) where 84% of land vertebrates are endemic, including lemurs (Goodman and Benstead, 2005). Lemurs are the world's most endangered group of mammals (Schwitzer *et al.* 2013); 98% of the 112 known species and subspecies are at risk of extinction and 31% are critically endangered (IUCN 2020). Madagascar is also home to over 26 million people and among the world's poorest countries (World Bank, 2020). This combination of rich biodiversity and extreme poverty leads to many conservation challenges (Rakotomanana *et al.* 2013). Much of the island's forests have been cleared to create agricultural land (McConnell and Kull, 2014), resulting in the loss of 44% of Madagascar's forest cover from 1953 to 2014 (Vieilledent *et al.* 2018). Slash-and-burn agriculture, known locally as *tavy*, has left infertile soil, erosion (Styger *et al.* 2007), fragments of unconnected wildlife habitat, and dwindling natural resources for Malagasy people (Harper *et al.* 2007).

Non-governmental organizations (NGOs) work to address these challenges by managing protected areas, conducting scientific research, rehabilitating pet lemurs, and providing healthcare, education, food, employment, training, and more for local people (Lemur Conservation Network n.d.). These NGOs include those that are founded and run by teams of Malagasy and non-Malagasy, and those founded and run by solely Malagasy teams that collaborate with organizations outside Madagascar for funding and other activities (Lemur Conservation Network n.d.). Collaboration among Malagasy and non-Malagasy is evident in the scientific record as well. The number of publications from universities and research institutes in Madagascar is growing, and many publications are co-authored

by Malagasy and non-Malagasy researchers (Gaillard and Gaillard 2011). During the Covid-19 pandemic, many non-Malagasy researchers and conservationists were unable to travel to Madagascar (Reuter *et al.* 2022), which made the importance of involving local stakeholders and conservation professionals even more apparent (Razanatsoa *et al.* 2021).

While collaboration between Malagasy and non-Malagasy is evident throughout conservation in Madagascar, these collaborations can be impacted by differing perceptions, worldviews, and value systems, and may result in competing or misunderstood priorities (Scales 2014; Reibelt *et al*. 2014). Non-Malagasy conservationists, for example, may value the protection of forests to maintain biodiversity, but Malagasy communities near the forest may prioritize land protection for spiritual beliefs and resource use (Golden 2014). To better understand the variety of perspectives from collaborators and stakeholders, conservation organizations are encouraged to seek input from diverse stakeholders and acknowledge and address differences (Scales 2014). Conservation practitioners from outside the communities where their programs will be implemented can use audience research to identify benefits and barriers to conservation action (Veríssimo *et al.* 2020). Using audience research to understand perceptions and perspectives of conservation can inform decision making and clarify the context in which programs will be implemented (Bennett 2016).

Perceptions of conservation in Madagascar have been studied; much of this research has emphasized the need for conservation to provide economic incentives. For instance, individuals living near Ranomafana, Andohahela, and Masoala national parks expressed that they value conservation but think it is economically unviable (Marcus 2001). People living near Lake Alaotra stated that they knew about Park Bandro but didn't know its purpose or how large it was: however, they were open to strategies to reduce the impact of natural resource use if they had economic benefits (Waeber *et al.* 2018). Interviews and focus groups with professionals at Masoala National Park and two nearby communities found many residents were confused about the park's goals but were open to alternative livelihoods (Ormsby and Kaplin 2005). Communities near Ankarafantsika National Park voiced support for programs that empowered them, provided economic benefits, and improved forest patrols and fire control (Aymoz *et al.* 2013).

Other studies have found that communities held priorities that conflicted with conservation, felt negatively impacted by conservation, or distrusted conservation workers. Communities in Ranomafana National Park did not feel they were included in decision making and some felt betrayed by the lack of negotiation during its establishment; while people were willing to cooperate with authorities, a lack of trust makes this challenging (Vuola and Pyhälä 2016). Conservation professionals and rural communities also hold differing priorities for the forest in western Madagascar (Scales 2012). The professionals see poverty as the underlying problem, promoting alternative livelihoods such as tourism that leave the forests intact; the rural communities feel that using forest resources shows respect for their ancestors and makes the land more productive (Scales 2012). Near Zahamena National Park, communities distrust conservation managers and are negatively impacted by restrictions on forest use (Raboanarielina 2012). Thus, while there have been efforts to include diverse perspectives in conservation, many Malagasy living near protected areas want to be more involved in decision making, and some needs are not being met. Additionally, Malagasy conservation experts recently called for increased efforts to integrate local professionals and communities into conservation through training and capacity building (Razanatsoa *et al.* 2021).

As we, the authors of this paper, are Malagasy and non-Malagasy conservation professionals who collaborate on lemur conservation programs, we wanted to learn about the perceptions of our peers working in conservation in Madagascar as well as those we aim to reach with outreach and education programs. We aimed to answer the following research questions: 1) Do Malagasy and non-Malagasy agree or disagree about lemur conservation priorities?; 2) Are there conservation threats and solutions that may be over- or under-prioritized due to differing perceptions of their importance?; and 3) On what topics should conservation education programs focus their efforts? We hope our research will encourage further conversations about effective collaboration between Malagasy and non-Malagasy conservation professionals, help build understanding and consensus among them, and inform, outreach to, and dialogue with those not working professionally in conservation.

Methods

We created a multilingual survey in SurveyMonkey and distributed it both online and in person. We divided respondents into four categories for comparison: Malagasy conservation professionals, Malagasy who do not work in conservation, non-Malagasy conservation professionals, and non-Malagasy people who do not work in conservation but are interested in lemurs or Madagascar. While those working outside of conservation may be professionals in other fields, for the remainder of this paper, we refer to these four categories as Malagasy professionals, Malagasy non-professionals, non-Malagasy professionals, and non-Malagasy non-professionals. We developed our survey in English, then translated it into Official Malagasy (SI Appendix A). The English survey questions and both the online and paper distribution methods were reviewed by the Internal Review Board at Miami University and received exemption (Protocol ID: 03976e); the Malagasy translation of the survey was not reviewed by the board. Malagasy responses to free text questions were translated into English by the co-authors Dr. Seheno Andriantsaralaza and Ms. Misa Rasolozaka, then all free-text responses were coded for themes and analyzed using Nvivo software.

Distribution

We shared links to the English and Malagasy survey online from 4 October 2021 to 4 January 2022 via the Lemur Conservation Network (LCN)'s social media accounts and email list, as well as nine Facebook groups that relate to Madagascar (Appendix B). Two posts on LCN's Facebook and Instagram accounts were promoted with $28 of paid advertising, targeting people in Madagascar who like LCN, as well as their friends, and people outside Madagascar who like LCN.

We also administered the survey in person in two areas of Madagascar. In November and December 2021, Dr. Hoby Ambinintsoa Rasoanaivo surveyed eight people in the village of Efoetse, including six Malagasy professionals, one Malagasy non-professional, and one non-Malagasy professional. Efoetse is in the Toliara region of southwest Madagascar at the entrance of Tsimanampesotse National Park. Dr. Rasoanaivo translated the survey from Official Malagasy to the local dialect (Tanalana), asked the questions verbally to each individual using the language and dialect preferred by the respondent, then noted their responses on paper. Additionally, in December 2021, Mr. Edgar Rabevao administered the survey to 70 people in the village of Befamatra in the rural commune of Doany, Andapa district in Madagascar's SAVA region. Befamatra is near the COMATSA corridor which links Marojejy National Park, Anjanaharibe Sud Special Reserve, and Tsaratanana Integral Nature Reserve. Mr. Rabevao describes this community, "Most of the people here are farmers and live on forest products. The lack of employment among young people also encourages them to exploit the forest." Mr. Rabevao translated the survey into the local Malagasy dialect (Tavaratra), then verbally asked the questions to one group of 21 women and one group of 49 men, all of whom were Malagasy non-professionals. Individuals from each group were asked questions together, and raised their hands to respond to questions. The number of people who agreed with each response for a question were counted and noted on paper. Later, the responses from in-person respondents were added to a Google Sheets spreadsheet and then entered manually into SurveyMonkey to combine them with online responses. Once combined, the complete data set was downloaded from SurveyMonkey and analyzed in Google Sheets.

Questions

The survey contained nineteen questions pertaining to demographics, perceptions of lemur conservation, Madagascar's future, and education programs (SI Appendix A). In-person, no questions were required, but all answered demographic questions and at least two others. Online, eight questions were required: six and seven (prioritization of people or lemurs), nine (hope for Madagascar), and eleven through fifteen (demographics). We wrote questions to be simple, specific, and objective, and not lead respondents to any particular response (Iarossi 2006). Upon further review of the data, however, we omitted questions one and seven from analysis because they could be unclear to respondents.

Demographics. Questions eleven to seventeen gathered demographics about respondents, including their profession, if they are Malagasy or not, and where they live. We used these questions to group respondents into the four categories noted earlier (Malagasy professionals, Malagasy non-professionals, non-Malagasy professionals, and non-Malagasy non-professionals). Forty-three Malagasy respondents surveyed in-person indicated that their profession was related to lemurs or conservation but described their work as "farming". These respondents were recategorized as non-professionals.

Perceptions of lemur conservation priorities. Through questions two through nine, we hoped to learn how and if perceptions of lemur conservation were similar or different between audience categories. Questions two and three (multiple choice) asked respondents to select three top threats and solutions; questions four (multiple choice) and five (free text) asked if any threats are too difficult to address; questions six (Likert scale) and eight (free text) asked how and why programs should prioritize people versus lemurs; and question 9 (free text) asked how respondents envision a future for Madagascar to provide additional insight into their priorities. The Likert scale for question six ran from one (conservation programs should prioritize lemurs only) to seven (conservation programs should prioritize people only), with the middle selection of four indicating equal prioritization of lemurs and people. Any response less than four indicated a higher prioritization of people, and any response greater than four indicated a higher prioritization of lemurs.

Education programs. Questions one, ten, and eighteen (all multiple choice) aimed to inform education programs for each audience category.

Additional thoughts. Question nineteen (free text) allowed respondents to add final thoughts or give more detail about any previous responses.

Statistical Analysis

T-tests were conducted in Google Sheets for the multiple-choice questions included in the analysis (two, three, four, six, ten, and eighteen) to determine if differences between responses for each audience category were statistically significant; t-tests were not conducted for free text questions. To prepare the data for t-tests, the responses for each participant were converted to numerical values. For all but question six (Likert scale), selected responses were converted to a one and unselected to a zero. Then, we performed a t-test to calculate p values for the statistical differences in responses between professional and non-professional Malagasy; professional and non-professional non-Malagasy; professional Malagasy and professional non-Malagasy; non-professional Malagasy and non-professional non-Malagasy; and all Malagasy and all non-Malagasy. For the Likert scale in question six, we performed four t-tests: 1) for the question

as a whole: using one through seven as noted in the question; 2) for prioritizing lemurs: assigning a one to responses of one, two, and three, and a zero for all others; 3) for prioritizing people: assigning a one to responses of five, six, and seven, and a zero for all others; and 4) for equal prioritization: assigning a one to responses of four, and a zero for all others. We rounded p values to two digits and considered p values ≤0.05 to be significant.

Limitation of the Survey Sample

In Madagascar, 22.3% of the total population is online and 16.3% of the population over age thirteen use Facebook (Kemp 2022), so the online survey was not able to reach all people in Madagascar. The paper survey was distributed in only two regions to a total of 78 people. Thus, the broad applicability of the data may be limited.

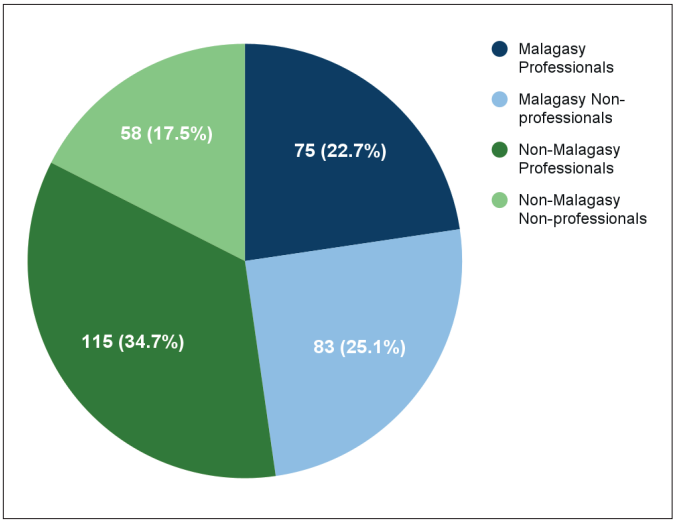

Figure 1. Number of respondents and distribution among the audience groups (n = 331).

Results

Posts advertising the survey online reached 14,105 people in Madagascar and 2,352 people outside Madagascar. Between both online and in-person survey distribution, we received 387 total responses, but 56 were excluded because they did not answer the question, "Are you Malagasy?". Of the 331 qualified respondents, 253 responded online and 78 responded in person.

Demographics

Respondents were unevenly divided among the four audience categories, with the largest portion being non-Malagasy professionals (34.74%; Fig. 1). Respondents lived in 23 countries, with the largest portion in Madagascar (67.54%; Fig. 2; SI Appendix C, Table C1). Most Malagasy lived in Madagascar (94.19% overall; 93.06% of professionals; 92.77% of non-professionals); non-Malagasy lived in 22 countries, with 45.09% from the United States and 26.59% from the United Kingdom. Respondents in Madagascar lived in fourteen regions (Fig. 3), with about half (50.7%) in SAVA, where 89.7% of the in-person surveys were administered, and 33.6% in Analalmanga, where the capital city of Antananarivo is located.

Perceptions of lemur conservation

Addressing human needs. When asked how conservation should prioritize lemurs and people, the average for all

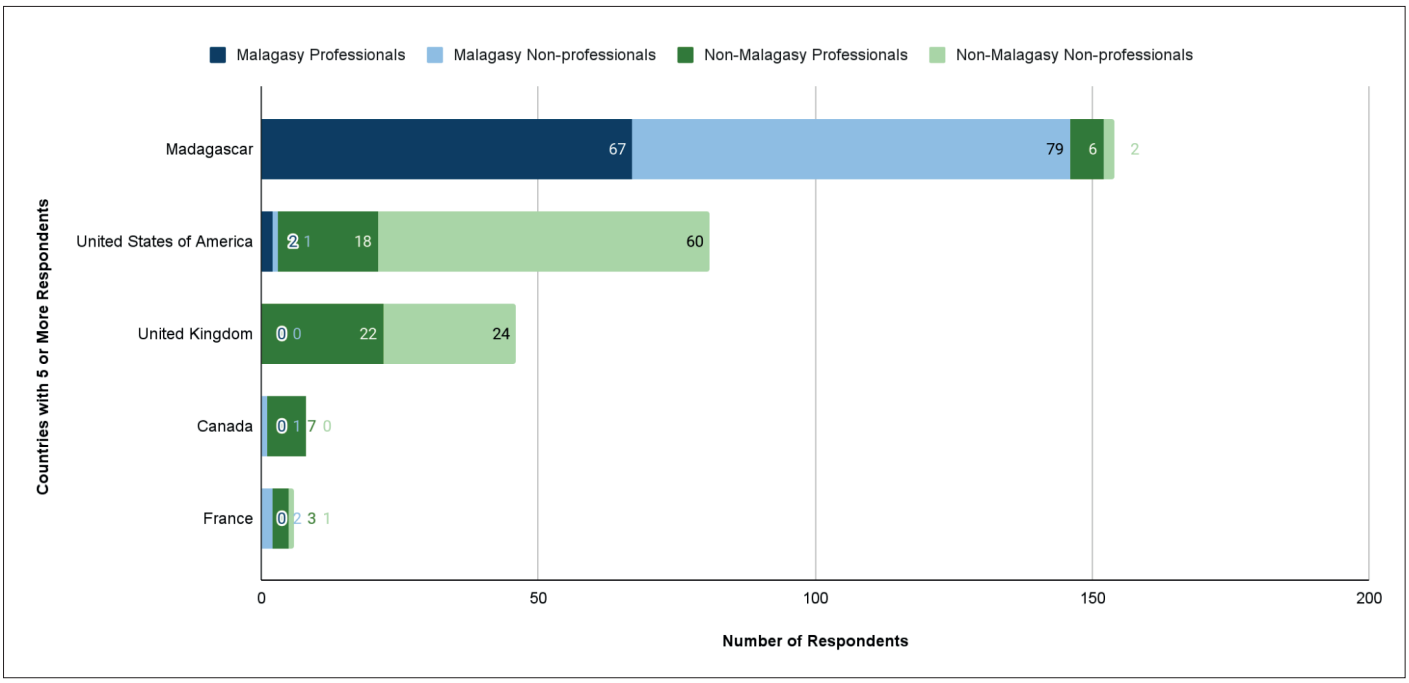

Figure 2. Responses to Question 15, "What country do you live in?" among audience groups, including countries with five or more respondents (n = 295 of 328 total respondents to this question).

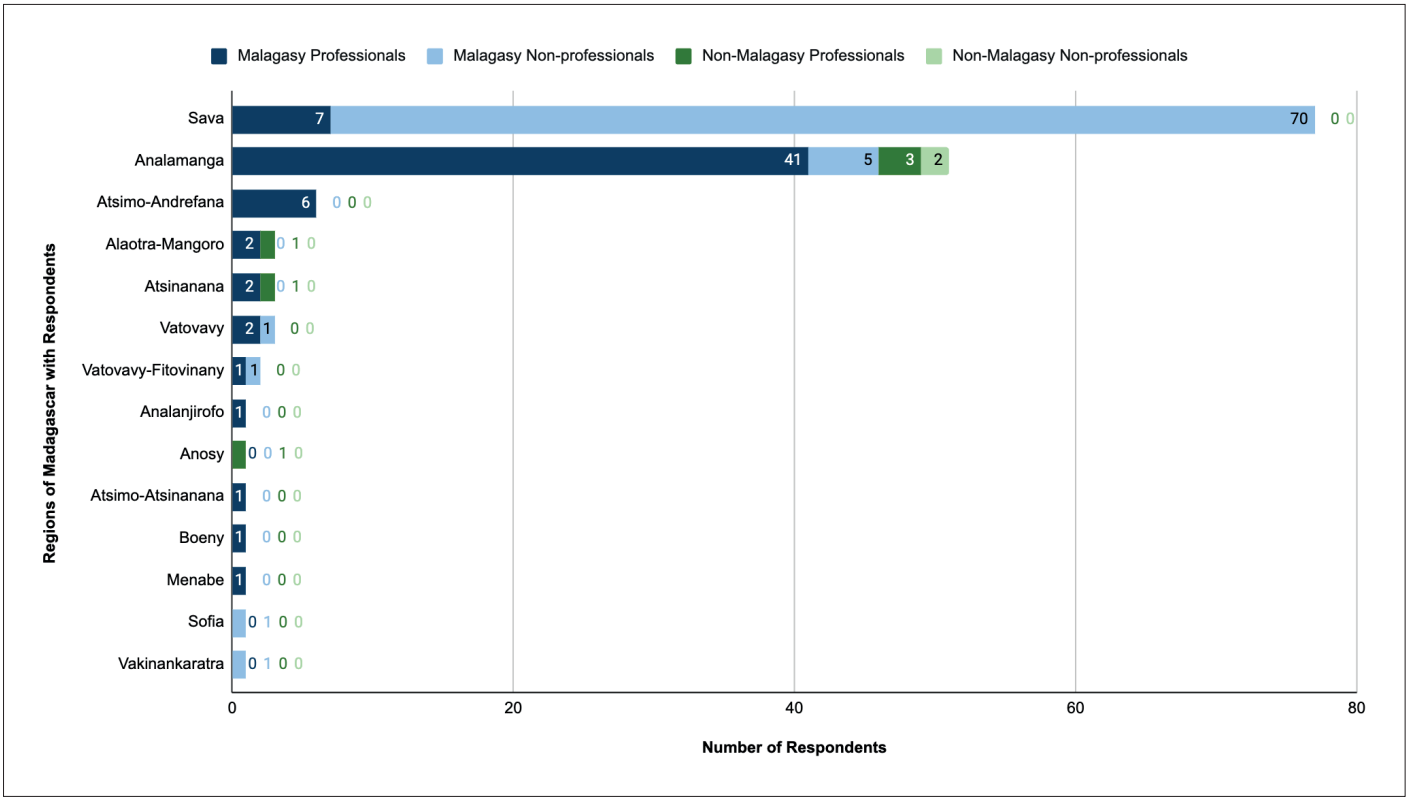

Figure 3. Responses to Question 16 asked to respondents living in Madagascar, "What region of Madagascar do you currently live in?" among audience groups, including all regions with respondents n = 152).

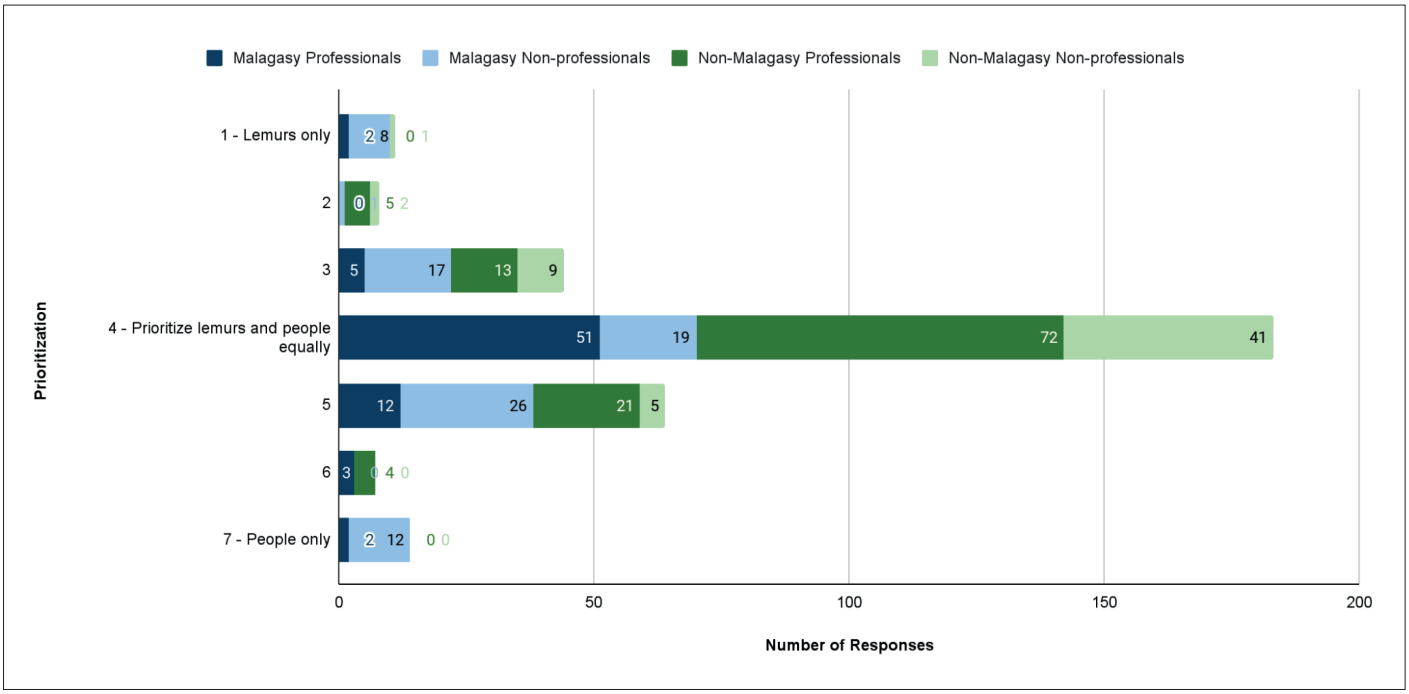

Figure 4. Responses to Question 6, "How should conservation organizations prioritize the needs of lemurs versus the needs of Malagasy people?" (n = 331).

respondents was 4.1 out of seven, indicating equal prioritization of lemurs and people. A little more than half (55.29%) stated conservation should place equal priority on the needs of humans and lemurs; 25.68% stated people should receive higher priority; and 19.03% stated lemurs should receive higher priority (Fig. 4). There was no significant difference in the average response between audience categories (SI: Appendix 4, Table D4). However, more Malagasy non-professionals than Malagasy professionals stated conservation should prioritize lemurs (31.33% and 9.33%; p = 0.00), and more non-Malagasy professionals than non-Malagasy non-professionals prioritized people (21.74% and 8.62%; p

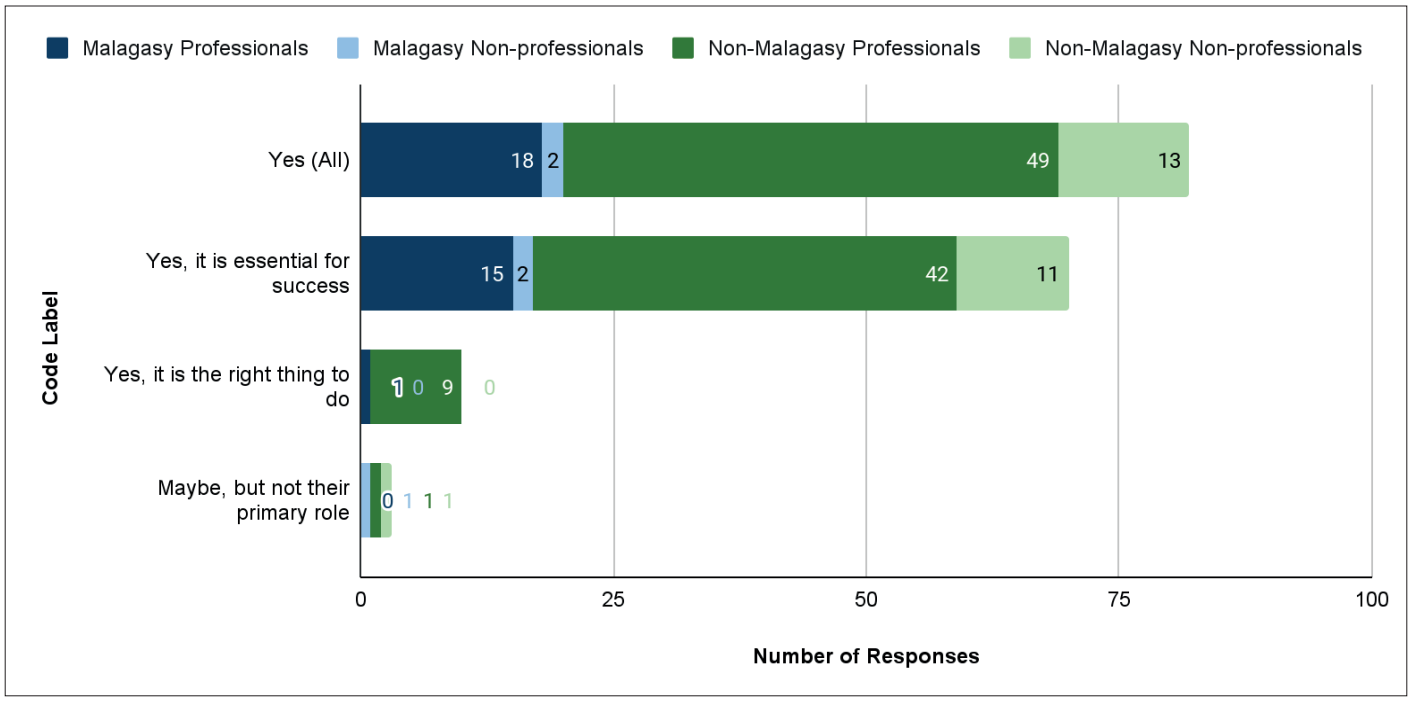

Figure 5. Coded free-text responses to Question 8: "Do you think lemur conservation organizations should address human needs in Madagascar? Why or why not?" (n = 225; codes with 5 or more responses).

= 0.03). In total, more Malagasy than non-Malagasy prioritized people (34.18% and 17.34%; p = 0.00).

The most common reason for why lemur conservation organizations should address human needs was that it is essential for conservation success (Fig. 5 and SI Appendix E, Table E1). Among responses with this code, 12 mentioned education, 12 mentioned poverty, and 11 mentioned hunting.

Conservation threats. Among all respondents, the top conservation threats for lemurs (Fig. 6) were logging (62.84%), farming or agriculture (53.47%), and hunting (51.66%). There was no significant difference between audience categories for farming or agriculture, or disease, but t-tests revealed differences for other threats (SI Appendix D, Table D1). More Malagasy professionals than Malagasy non-professionals perceived logging as a top threat (82.67% and 19.28%; p = 0.00) but there was no difference

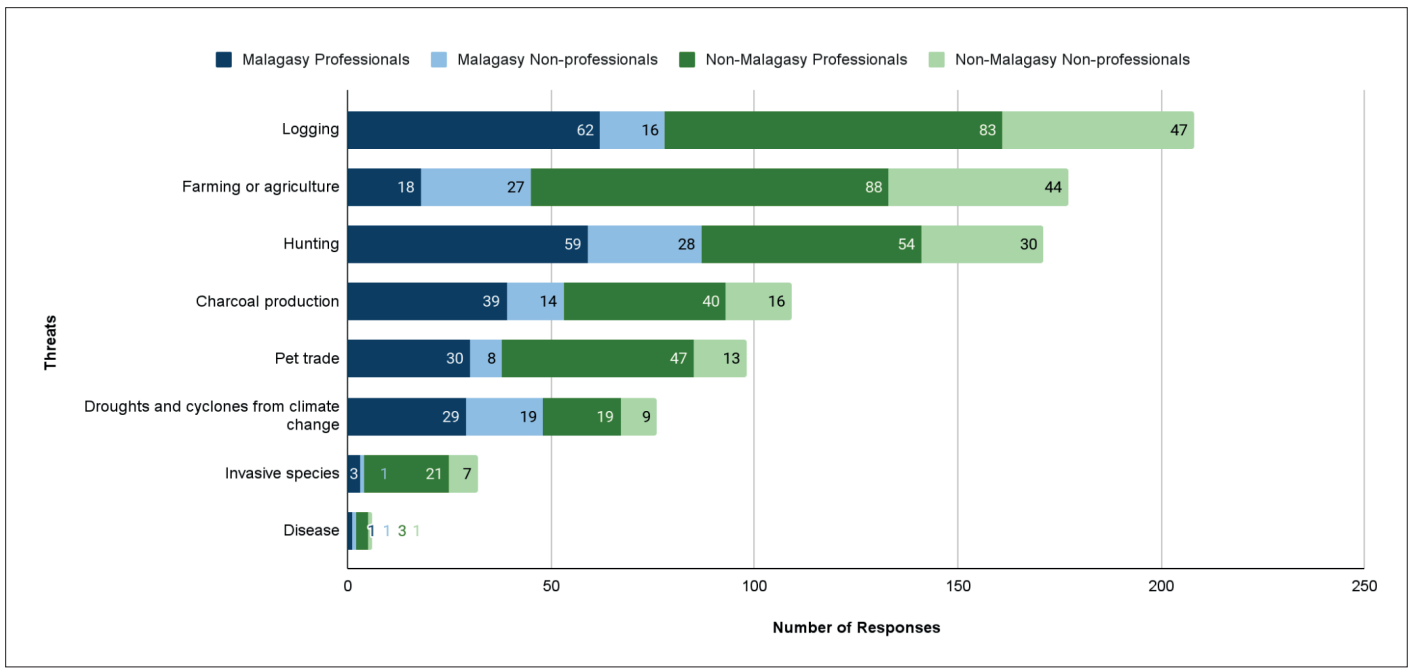

Figure 6. Responses to Question 2 "What do you think are the main threats facing lemurs?" (n = 321).

in the perception of logging as a threat between Malagasy and non-Malagasy professionals (p = 0.10). More Malagasy than non-Malagasy professionals perceived hunting as a top threat (78.67% and 46.96%; p = 0.00), and more Malagasy professionals than Malagasy non-professionals selected hunting (78.67% and 33.73%; p = 0.00). Charcoal production was the third most selected threat among Malagasy professionals (52.00%), but less prevalent among Malagasy non-professionals (16.87%; p = 0.00) and non-Malagasy professionals (34.78%; p = 0.02). Droughts or cyclones from climate change were more prevalent among Malagasy than non-Malagasy (30.38% and 16.18%; p = 0.00), and invasive species were more prevalent among non-Malagasy than Malagasy (16.18% and 2.53%; p = 0.00). Malagasy and non-Malagasy professionals agree on the threat of the pet trade (40.00% and 40.87%; p = 0.91), but Malagasy professionals were more likely than Malagasy non-professionals to select it (40.00% and 9.64%; p = 0.00).

When asked if any of these threats are too difficult to address, the top selections were droughts and cyclones from climate change, logging, and farming or agriculture (Fig. 7). Overall, 34.44% stated that all of the threats could be addressed, but Malagasy were less likely than non-Malagasy to make this selection (13.92% and 53.18%; p = 0.00; SI Appendix C, Table C3). Malagasy were more likely than non-Malagasy to state that logging (27.85% and 7.51%; p = 0.00), farming or agriculture (25.32% and 7.51%; p = 0.00), hunting (23.42% and 6.94%; p = 0.00), charcoal production (24.05% and 5.78%; p = 0.00), and the pet trade (12.66% and 5.78%; p = 0.03) were conservation threats for lemurs that were too difficult to address.

Conservation solutions. Among all respondents, the most selected conservation solutions (Fig. 8) were education for Malagasy people (51.96%), reforestation (50.15%), and sustainable farming techniques (47.73%), but there were significant differences between audience categories for many solutions (SI Appendix D, Table D2). Top solutions selected by more Malagasy professionals than non-Malagasy professionals included education for Malagasy people (82.67% and 53.91%; p = 0.00), patrolling the forests (61.33% and 32.17%; p = 0.00), creating more national parks (60.00% and 39.13%; p = 0.00), alternative cooking fuels or stoves (44.00% and 20.87%; p = 0.00), ecotourism (41.33% and 17.39%; p = 0.00), and fire control (48.00% and 6.09%; p = 0.00). Sustainable farming techniques were more frequently selected by non-Malagasy professionals than Malagasy professionals (63.48% and 48.00%; p = 0.04).

Madagascar's future. When asked to envision a future for Madagascar, many stated that they hoped Madagascar would achieve sustainability for both people and the environment, others offered specific solutions, and five stated they had little hope (Fig. 9 and SI Appendix E, Table E2).

Educational programs. Questions 10 (experience with lemurs as a child) and 18 (topics of interest) were designed to inform conservation education programs for each audience category. The most selected childhood experience was "visited a zoo and saw lemurs" (51.06%), but responses varied between audience categories (Table D5). Non-Malagasy were more likely than Malagasy to have visited a zoo (69.94% and 41.74%; p = 0.00); among Malagasy, professionals were more likely than non-professionals (52.00% and 10.84%; p = 0.00). Malagasy were more likely than non-Malagasy to have known someone who had a lemur as a pet (30.43% and 0.58%; p = 0.00); there was no difference between Malagasy professionals and non-professionals (p = 0.37). The one experience which did not differ between

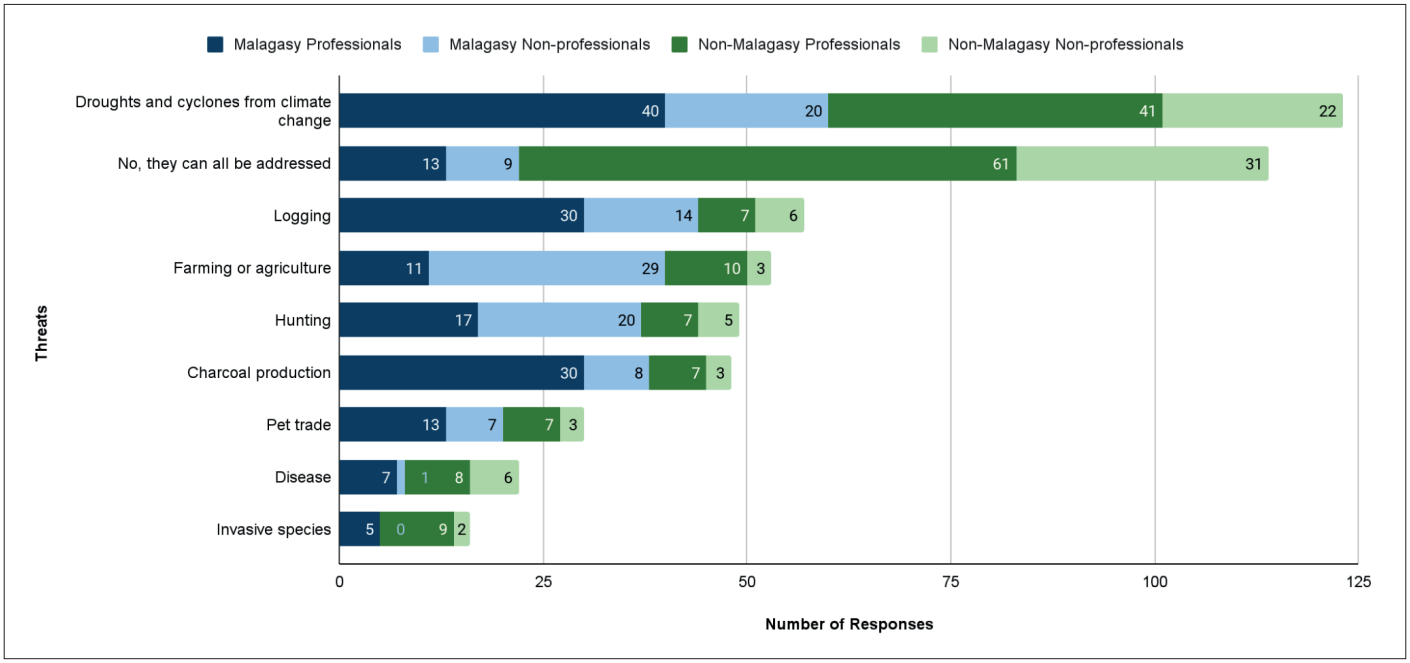

Figure 7. Responses to Question 4, "Do you think any of these threats are too difficult to address?" (n = 321).

audience categories was seeing a movie about lemurs, which was selected by 34.74% overall, 37.39% of Malagasy, and 32.95% of non-Malagasy.

Overall, the most selected topic of interest was how threats facing lemurs are being addressed (47.73%; Fig. 11), but there were some differences between audience categories (SI Appendix D, Table D6). While most non-Malagasy non-professionals were interested in this topic (70.69%), they were not significantly more interested than non-Malagasy professionals (56.52%; p = 0.07) but were more interested than Malagasy non-professionals (24.10%; p = 0.00). Malagasy professionals were more interested than non-Malagasy professionals in technology used for lemur conservation (46.67% and 26.09%; p = 0.00), and less interested in Malagasy people working in conservation (18.67% and 54.78%; p = 0.00). Non-Malagasy were more interested than Malagasy in conservation success stories (39.88% and 22.61%; p = 0.00) and lemur behavior (30.06% and 18.26%; p = 0.00), while Malagasy were more interested than non-Malagasy in climate change in Madagascar (20.00% and 16.18%; p = 0.00). While this was the most selected interest for Malagasy non-professionals (34.94%), this was not significantly different from Malagasy professionals (22.67%; p = 0.09).

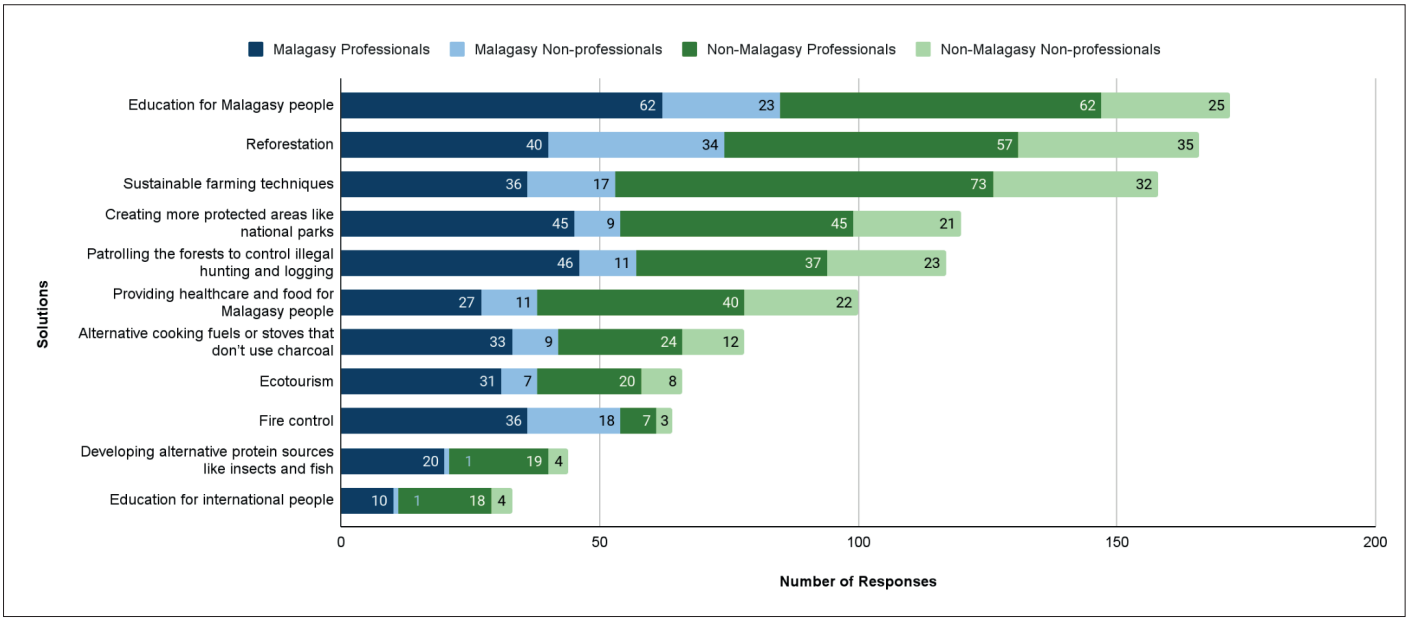

Figure 8. Responses to Question 3, "What do you think are the most important solutions to the threats facing lemurs?" (n = 321).

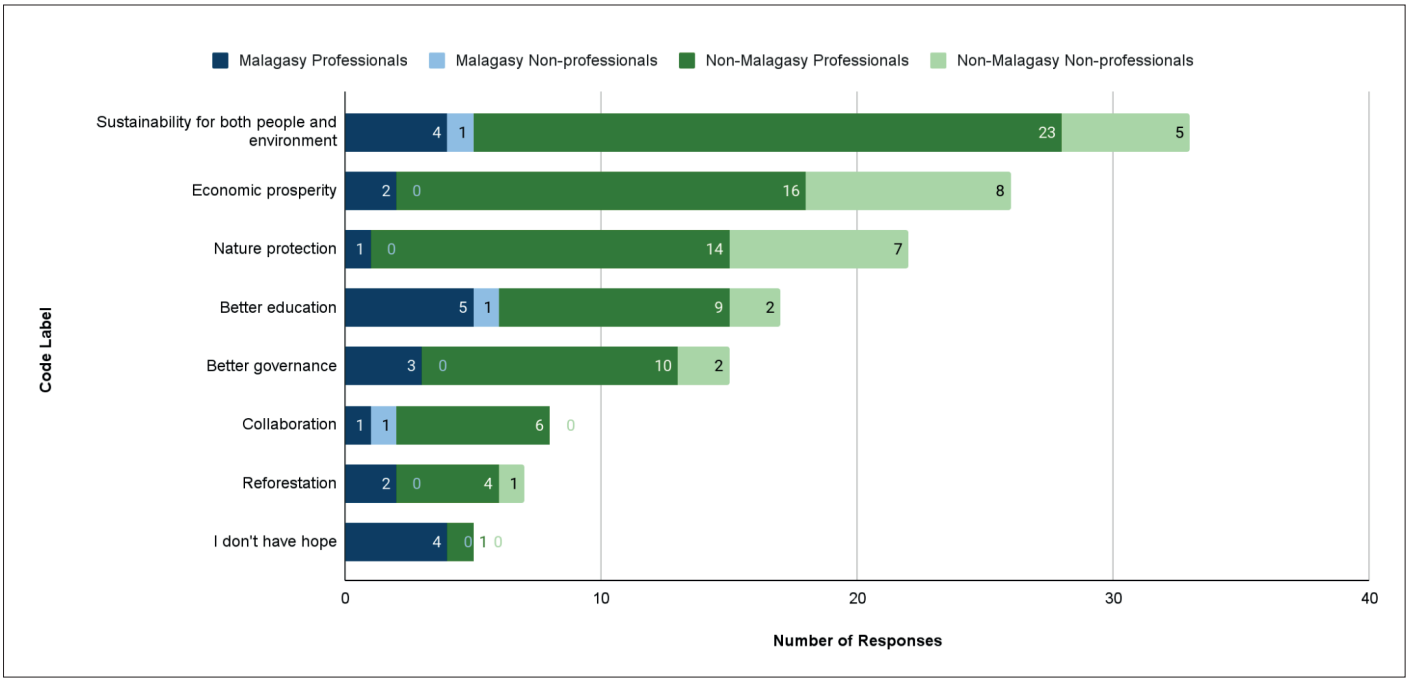

Figure 9. Coded free-text responses to Question 9, "What do you hope for the future of Madagascar?" (n = 263; codes with five or more responses).

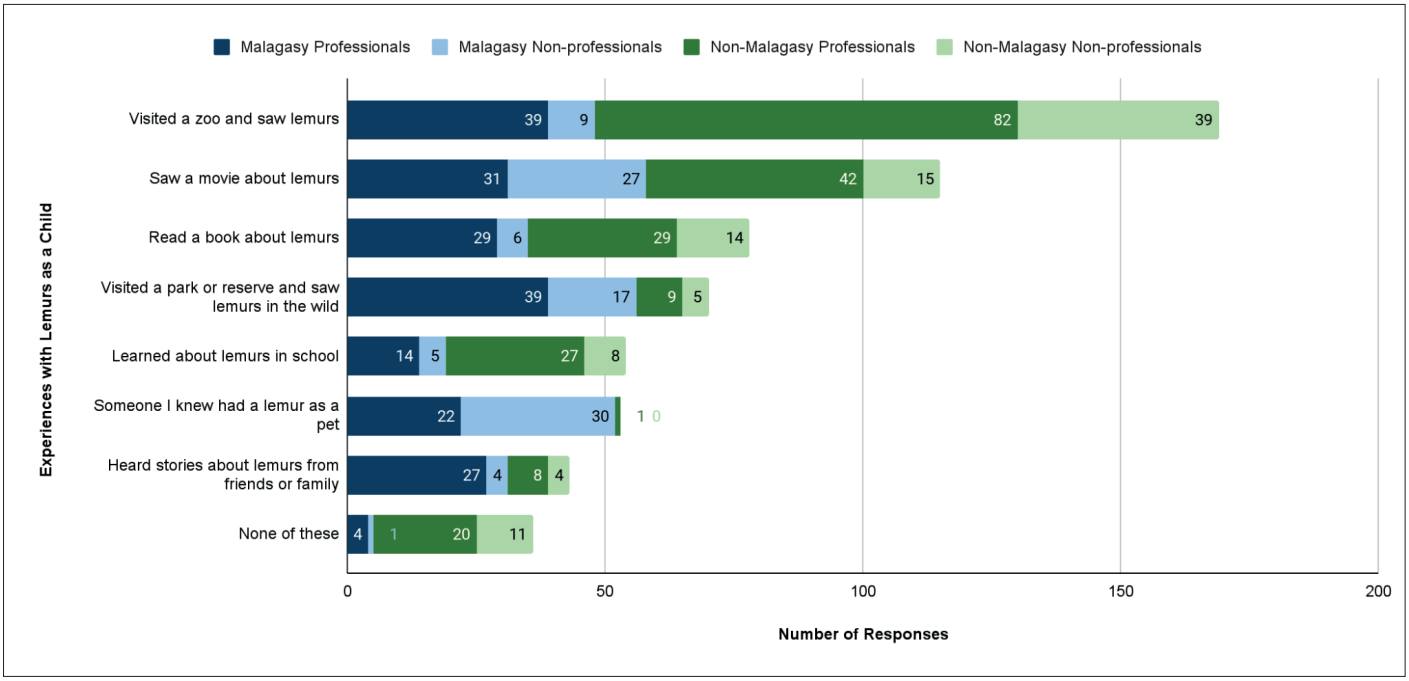

Figure 10. Responses to Question 10, "When you were a child, which of the following experiences did you have?" (n = 321).

Additional thoughts. Some added comments in the final free text question. SI Appendix E, Table E3 summarizes these responses by theme (n = 71), excluding statements expressing thanks, an interest in volunteering, or details about the respondent, as well as codes with less than five responses.

Discussion

Priorities for lemur conservation

Based on our research, Malagasy and non-Malagasy audiences may prioritize some conservation threats differently but many solutions similarly. Educational programs and a reassessment of priorities may be able to address these differences, but more research is needed to fully understand perceptions of lemur conservation and how they impact programs in Madagascar.

Weighing the needs of lemurs and the needs of people. We anticipated a difference between Malagasy and non-Malagasy about prioritizing the needs of people and lemurs, but they agreed that conservation programs should prioritize lemurs and people equally (Fig. 4). This was reiterated in responses to question nine, "What do you hope for the future of Madagascar?", as sustainability for both people and the environment was the most common response (Fig. 9). Conservation organizations could use this consensus to build support by reassuring staff, stakeholders, and communities that they all share similar values. While this agreement about priorities existed, some free text responses suggest that Malagasy communities near protected areas may feel that conservation organizations spend too few resources on human needs. A Malagasy professional coded as funding stated, "Local communities are always being asked to do the hard work almost for free while they can't even earn the amount needed to feed their families. They know how much money NGOs are spending just to visit them but see that they are very reticent to spend money for the people" (SI Appendix E, Table E3). This connection to economics reiterates previous research on Malagasy perceptions of conservation (Marcus 2001; Waeber *et al.* 2018; Ormsby and Kaplin 2005; Aymoz *et al.* 2013). Conservation programs may increase community support if they reconsider the allocation of funds, increase funding transparency, ensure that people feel they are paid fairly, and seek further collaboration with humanitarian organizations.

Conservation threats. Among professionals, both hunting and charcoal production were more frequently selected by Malagasy than non-Malagasy (Fig. 6), as 78.67% of Malagasy but just 46.96% of non-Malagasy selected hunting ($p = 0.00$), and 52.00% of Malagasy but just 34.78% of non-Malagasy selected charcoal production ($p = 0.02$). Malagasy professionals were also more likely than non-Malagasy professionals to state these threats were too difficult to address (Fig. 7), as 40.00% of Malagasy but just 9.64% of non-Malagasy professionals identified charcoal production as too difficult ($p = 0.00$), and 22.67% of Malagasy and 6.09% of non-Malagasy professionals identified hunting ($p = 0.00$). Additionally, ten respondents mentioned hunting in free text responses regarding why addressing human needs is essential for conservation success. For logging, Malagasy and non-Malagasy professionals both selected it as one of the three most important threats (82.67% and 72.17%; $p = 0.10$), but Malagasy professionals were more likely than non-Malagasy to say it was too difficult to address (40.00% and 6.09%; $p = 0.00$). Since most Malagasy professionals lived in Madagascar (Fig. 2), they may have more personal

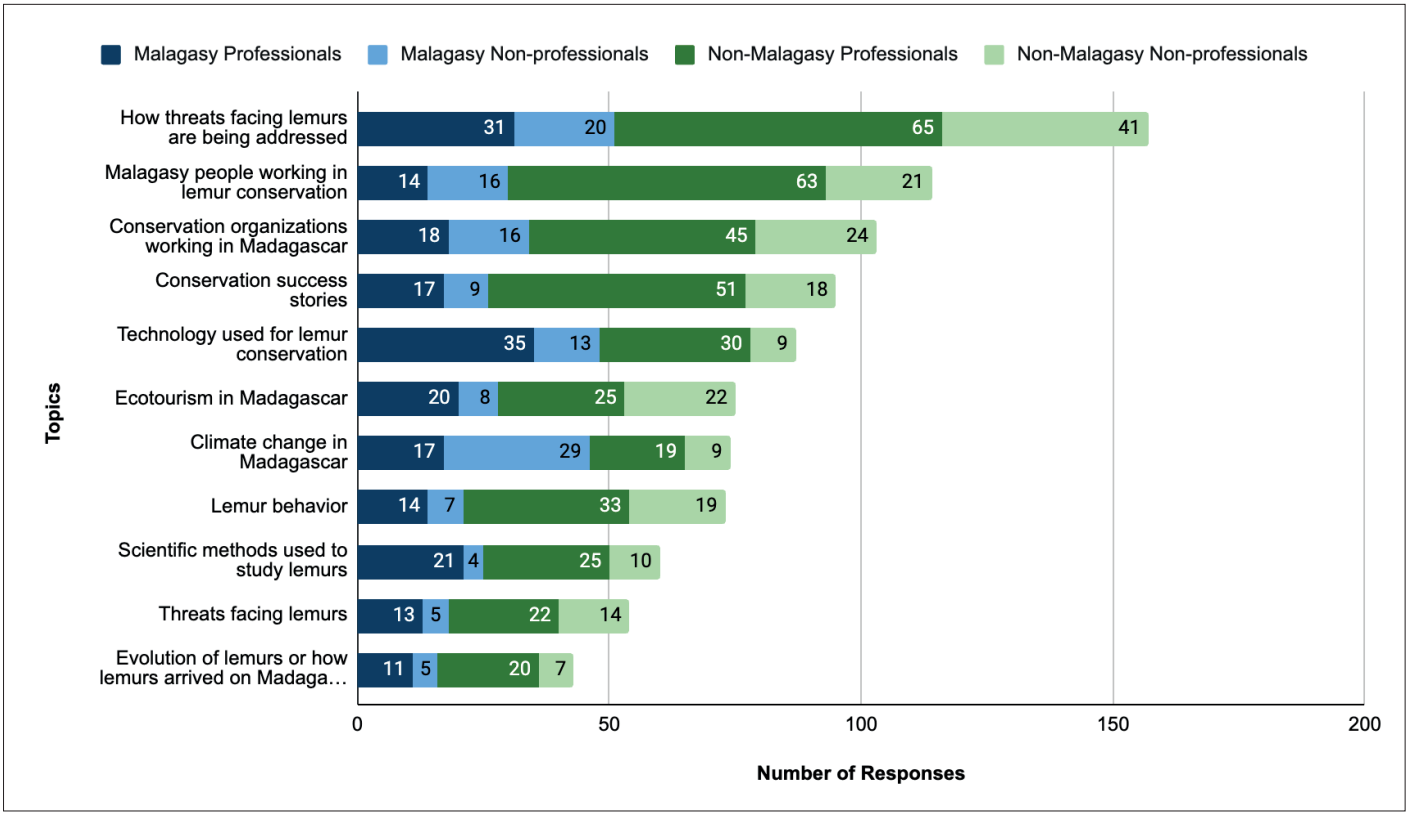

Figure 11. Responses to Question 18, "Which of the following topics are you most interested in learning more about?" (n = 320).

knowledge of logging, such as the conflicting perceptions of forest use between conservation professionals and rural Malagasy (Scales 2012; Raboanarielina 2012). The differing perceptions between Malagasy and non-Malagasy professionals of the threats of hunting, charcoal production, and logging warrant further research to determine if they are under-prioritized by conservation programs.

Conservation solutions. Previous studies of Malagasy perceptions of conservation emphasized the need for economic incentives (Marcus 2001; Waeber *at al.* 2018; Ormsby and Kaplin 2005; Aymoz *et al.* 2013), but the top solutions selected by Malagasy in our survey did not (Fig. 8). Multiple choice responses for this question included two directly tied to economic benefits (ecotourism, and healthcare and food for Malagasy) but there was not a general option for alternative livelihoods. Among professionals, Malagasy and non-Malagasy agreed on the importance of healthcare and food (36.00% and 34.78%; p = 0.86) but disagreed on the importance of ecotourism (41.33% and 17.39%; p = 0.00). As ecotourism is a type of alternative livelihood, this may reinforce this previous research about the need for economic benefits from conservation.

Overall, the top three solutions selected by Malagasy included education for Malagasy people (53.80% of all Malagasy, with 82.67% of professionals and 27.71% of non-professionals), reforestation (46.84% of all Malagasy, with 53.33% of professionals and 40.96% of non-professionals), and patrolling the forests (36.08% of all Malagasy, with 61.33% of professionals and 13.25% of non-professionals). Compared to all Malagasy, non-Malagasy agreed with these solutions (education for Malagasy people = 50.29%, p = 0.52; reforestation = 53.18%, p = 0.25; patrolling forests = 34.68%; p = 0.79), so they may be adequately prioritized in conservation programs.

We anticipated that fire control and sustainable farming techniques would be selected as top solutions, because fires are cited as a primary cause of deforestation and land degradation in Madagascar (Cochrane *et al.* 2009; Rakotomanana *et al.* 2013; Styger *et al.* 2007). Used across the island to prepare land for zebu pasture (Aymoz *et al.* 2013) and slash-and-burn agriculture, fires can also be difficult to control (Cochrane *et al.* 2009). While both fire control and sustainable farming techniques were selected by 48.00% of Malagasy professionals, they were the fourth and fifth most selected solutions by this group. Fire control was the least selected solution by non-Malagasy professionals (6.09%; p = 0.00) and all non-Malagasy (5.78%; p = 0.00). Sustainable farming techniques were the most selected solution by non-Malagasy (60.19% overall; 63.48% of professionals; 55.17% of non-professionals), but less selected by Malagasy (33.54% overall; 48.00% of professionals; 20.48% of non-professionals; p = 0.00 comparing all Malagasy to all non-Malagasy). Thus, more research is needed to determine if fire control and sustainable farming techniques are adequately prioritized.

Education programs

Education programs could focus on topics that audience groups stated they were most interested in (Fig. 11), emphasize threats and solutions where there was a difference between professionals and non-professionals (SI Appendix D, tables D1 and D2), or focus on childhood activities most common among respondents, such as zoos, movies, or books (Fig. 10). Additionally, only 35.44% of Malagasy stated that they had seen lemurs in the wild as a child, so education programs that take Malagasy children into national parks may be beneficial.

Non-Malagasy professionals and non-professionals were most interested in how threats facing lemurs are being addressed (56.52% and 70.69%; $p = 0.07$). These professionals were keen to learn about Malagasy people working in conservation (54.78%) and conservation success stories (44.35%), whereas non-professionals wanted to learn about conservation organizations working in Madagascar (41.38%) and ecotourism (37.93%). There were no differences between non-Malagasy professionals and non-professionals for conservation threats or solutions, which may illustrate that current outreach programs to non-Malagasy audiences are effectively communicating the threats and solutions prioritized by non-Malagasy professionals.

Malagasy professionals and non-professionals were both interested in learning how threats facing lemurs are being addressed as it was one of the most selected topics for both (41.33% and 24.10%; $p = 0.02$). Malagasy non-professionals were most interested in learning about climate change (34.94%), and Malagasy professionals were most interested in learning about conservation technology (46.67%). Differences between Malagasy professionals and non-professionals for the importance of logging, hunting, charcoal production, and the pet trade were apparent, which may point to a need for education on these topics. For instance, 82.67% of Malagasy professionals but just 19.28% of non-professionals selected logging as a top threat ($p = 0.00$); 78.67% of professionals but just 33.73% of non-professionals selected hunting ($p = 0.00$); 52.00% of professionals but just 16.87% of non-professionals selected charcoal production ($p = 0.00$); and 40.00% of professionals but just 9.64% of non-professionals selected the pet trade ($p = 0.00$). As logging (Rakotomanana *et al*. 2013), hunting (Borgerson 2015), charcoal production (Steffens *et al.* 2020), and the pet trade (LaFleur *et al.* 2017) are conservation threats for lemurs, education programs about these topics may help gain support among Malagasy non-professionals for solutions that address these threats.

Conclusion

Insights into the perceptions of lemur conservation may help align priorities, threats, and solutions among Malagasy and non-Malagasy who do and do not work in conservation. Our survey found agreement that lemurs and people should be prioritized equally, but this may not translate into the fair treatment of local communities whose needs remain unmet. Our results also indicate that hunting, charcoal production, and logging may be under-prioritized as threats; and education for Malagasy people, reforestation, and patrolling of forests may be adequately prioritized as solutions. While fire for slash-and-burn agriculture is often cited as a driver of deforestation in Madagascar (Cochrane *et al.* 2009; Rakotomanana *et al.* 2013), fire control and sustainable farming techniques were not among the top priorities for those surveyed. More research is needed to determine if these solutions should be higher priorities. Additionally, our survey found that Malagasy and non-Malagasy professionals and non-professionals were interested in some different topics related to lemur conservation, but all audiences were interested in how threats facing lemurs are being addressed. Education programs for Malagasy may want to discuss climate change and conservation technology, and those for non-Malagasy may want to cover Malagasy people working in conservation, conservation success stories, and conservation organizations working in Madagascar.

More research is needed to understand perceptions of lemur conservation on a large scale, in specific regions of Madagascar, and among those who did not respond to this survey. We recommend that conservation organizations use a survey like this to aid discussions about priorities. We hope this will help increase understanding and inform decisions, and that alignment will lead to increased conservation success.

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Supplementary Information

Can be found at:
<http://www.primate-sg.org/storage/pdf/PC37_Venart_et_al_Percep_lemurs_Suppl_info.docx>

Appendix A. Survey Questions in English and Malagasy.
Appendix B. Survey Recruitment Platforms. Table B1.
Appendix C. Geographic Location of Respondents. Table C1.
Appendix D. P Values for Multiple Choice Questions. Tables D1–6.
Appendix E. Examples of Responses for Free-Text Questions. Tables E1–3.

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