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# The impact of reading a synthesis report on perceptions of palm oil in the global conservation community

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## Abstract

Tropical forest risk commodities including palm oil contribute to deforestation and biodiversity decline, making them a major focus of the international conservation community. Many in this community rely on scientific evidence to inform conservation decision-making, but the extent to which synthesized evidence influences perceptions across the diverse set of individuals that comprise the global conservation community remains unclear. We surveyed 470 conservation professionals living in 90 countries regarding their perceptions of palm oil, and evaluated the influence of reading a synthesis report on oil palm and biodiversity on these perceptions. We found that respondent perceptions of palm oil's impacts on the environment tended to align with scientific evidence, with high agreement among respondents. We found less agreement regarding the effectiveness of biodiversity conservation interventions in the palm oil sector. Respondents often evaluated interventions whose effectiveness had not yet been assessed in the scientific literature. Reading the full synthesis report led to significantly less negative perceptions of palm oil production's impacts on biodiversity and tropical rainforests but did not change perceptions of conservation intervention effectiveness. Given the substantial effort involved in developing synthesis reports about conservation, long-term studies exploring how these publications influence perceptions, knowledge, discourse, conservation decision-making, and conservation outcomes are needed.

## Author summary

Palm oil supplies more than a third of global edible oil demand. Development of oil palm plantations drives tropical deforestation and biodiversity loss but

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contributes to economies of producing countries like Indonesia and Malaysia. Since the early 2000s, the global conservation community has debated the appropriate set of interventions to improve palm oil production sustainability. Yet, the views of this community – which influence conservation policy and practice – have been unknown. We analyzed a survey of hundreds of individuals affiliated with diverse conservation organizations across the world regarding their perceptions before and after they read a situation analysis on palm oil and biodiversity prepared by the International Union for Conservation of Nature (IUCN). We found that while respondents agreed about the impacts of palm oil on the environment, they had more polarized views regarding the effectiveness of conservation policy interventions to address biodiversity loss in the palm oil sector. After reading the full IUCN report, respondents had significantly *less* negative assessments of the impacts of palm oil on biodiversity and tropical rainforests compared to a control group. Our findings advance understanding of how efforts to synthesize scientific evidence influence the views of decision-makers.

## 1. Introduction

The global conservation community is a heterogeneous collection of individuals including those within civil society organizations, governments, research societies, and Indigenous groups who together address the protection, management, and restoration of nature. The collective actions of this community influence governance of conservation concerns through advertising campaigns, policy recommendations, allocation of conservation funding, production and dissemination of scientific research, and lobbying efforts [1–3]. Yet, the impacts of these endeavors have often fallen far short of aspirational conservation goals [4].

To address this gap between conservation ambition and reality, many actors within this community have embraced the use of evidence for conservation decision-making [5,6]. Here we define evidence as useful, contextualized information that informs knowledge, or evidence-based belief [7]. Although several types of knowledge, including scientific, indigenous and local [8], and experiential [9] support conservation practice, international civil society organizations and researchers have typically focused on evidence and knowledge generated through application of scientific methods [10,11]. Such evidence may be fragmented and abstract, or inappropriately communicated to decision-makers [12]. It is particularly deficient in tropical systems [13].

In theory, open-access synthesis reports (e.g., [14]) can address these issues. They offer conservation professionals credible, collated, and clearly communicated scientific evidence, and reduce the time and effort required to read through primary literature which is sometimes behind a paywall [15]. Developing such reports may involve dozens of researchers, supported by a central organization, who often donate their time to identify and integrate information from credible sources. Reading synthesis reports can have measurable impacts. For instance, exposure to reports by the Intergovernmental Panel on Climate Change has changed public perceptions of climate change

[16]. After conservation practitioners received a synopsis of scientific evidence, the less experienced practitioners often changed hypothetical management practices to better align with the synthesized literature on practice effectiveness [15].

Yet, there is growing recognition that the space between conservation research and implementation cannot be filled by additional evidence alone [12,17]. Despite an expanding body of evidence in the realm of conservation including information provided in synthesis reports, individuals within the global conservation community continue to hold diverse and sometimes conflicting views on the legitimacy and effectiveness of conservation policies [18,19]. Although disagreements tend to be greater when clear scientific evidence on a process or problem is sparse [18], a lack of evidence with respect to conservation issues is not the only reason for conflicting views. Perceptions of the appropriate interventions for addressing biodiversity decline as well as the causes of such decline are based not only in scientific knowledge but also driven by a set of knowledge systems and values that differ across individuals and societies [20]. These perceptions can, in turn, influence the success of conservation programs [21].

Survey-based research across hundreds to thousands of conservation professionals from diverse world regions is one approach that researchers have applied to quantitatively elucidate the drivers of such diverse views. Sandbrook, Fisher [19] used an online survey to ascertain conservationists' views about the "new conservation" debate. The authors found that gender, age, educational background, career stage, and nationality were relevant to respondent perceptions. Isbell, Balvanera [22] surveyed biodiversity experts and found that recommendations regarding conservation budget allocation and the impacts of biodiversity loss differed significantly across experts' gender and geographic region of residency, but that diverse experts largely agreed upon rankings of biodiversity loss drivers. From their survey about the use of conservation science in policy, Rose, Sutherland [23] found that gender, experience, and world region rarely explained differences in respondent answers. These global studies indicate that individual level characteristics (e.g., gender) are often but not always correlated with their views.

Yet, to our knowledge, no systematic assessment has explored the role that individual knowledge, including that garnered from synthesis reports, plays in shaping the perceptions of a diversity of conservation professionals around the world. Understanding these linkages is critical to inform whether and how future synthesis efforts in the conservation field might change minds, and may also deepen understanding of how knowledge shapes differing views on conservation policy and practice. Given this gap, here we aim to evaluate relationships between knowledge and perceptions of conservation professionals. Specifically, we ask: 1) How well do perceptions of the global conservation community align with available evidence developed via scientific approaches? 2) How is degree of domain knowledge, experience, and/or source of information related to these perceptions? 3) How did reading a comprehensive report that synthesized scientific evidence affect these perceptions?

We explored these questions with a focus on palm oil, a major tropical commodity crop which comprised 37% of global vegetable oil production in 2022, the most recent year for which such global data were available at the time of writing [24]. Because palm oil production is often associated with deforestation and biodiversity loss [25], it has been a source of emotive public debate [26,27] and a target of policy interventions. For example, importing countries have restricted palm oil imports [28] while producing countries have developed new regulations intended to assure responsible production [29,30]. Several non-state market-driven conservation interventions such as voluntary certification aim to improve the sustainability of the palm oil sector [31]. Yet, the efficacy of these approaches at reducing deforestation and addressing socio-economic concerns often remain unclear [31,32]. Moreover, commodities such as cattle, timber, cacao, soybean, rubber, wood fiber, and minerals are also implicated in tropical forest loss [33–35], but may receive less attention from advocacy organizations [36]. Substituting palm oil for other oil crops could have unintended consequences such as a larger global cropland footprint because of oil palm's relatively high yields which may allow for land sparing at very large spatial scales [37,38]. Given these complex and contentious issues, several previous studies have explored consumer knowledge, perceptions, and/or behavior related to palm oil [25,39–43], while others assessed how experts perceive palm oil sustainability [44] and the conservation effectiveness of multi-stakeholder initiatives [45].

In December 2017, the International Union for Conservation of Nature (IUCN), which at the time integrated ~1,400 member organizations and ~15,000 affiliated experts to promote nature conservation and sustainable use of natural resources [46], released a draft report on Oil Palm and Biodiversity [47] for review by IUCN staff, members, and affiliates. The report synthesized evidence for palm oil impacts on biodiversity and evaluated sustainability governance mechanisms within the palm oil industry. The release of the draft report provided an opportunity to survey IUCN members before and after they read the report. We use these survey data to address our research questions. Methods are provided in Section 6. Our research advances understanding of the role that knowledge – including domain-specific knowledge, experience, sources of information, and synthesis reports – plays in shaping perceptions of conservation-minded individuals who influence conservation research and policy.

## 2. Results and discussion

### 2.1. Respondents were typically male, highly educated, and from Western countries

The first survey (S1 Questionnaire), provided in English, French, Spanish, and Indonesian to enhance accessibility, was released in December 2017 (see Materials and Methods 3.3). It assessed conservation community member perceptions regarding palm oil, and other information such as respondent characteristics (e.g., gender; Materials and Methods 3.2). A total of 875 individuals arrived at the survey website. Of these, 472 agreed to participate in the survey and 470 completed the questionnaire (Table A in S1 Appendix). Some respondents ($n = 57$) read the report before answering the initial questionnaire. The median duration to complete the questionnaire was 18 minutes. In March 2018, we resurveyed a subset of respondents – including those who did and did not read the report between surveys – using a reduced version of the initial questionnaire (S2 Questionnaire; Materials and Methods 3.2). In the second survey, 105 individuals (22% of the original sample) completed the questionnaire, with 83% of these reading the report for the first time, in part or in full, between surveys (Table A in S1 Appendix). The demographic characteristics of the respondents were similar in both surveys (Table A in S1 Appendix).

The characteristics of our nonrandom sample suggest that our results best represent the perceptions of highly educated males residing in North American and European countries. In the first survey, respondents were mostly male (62% of respondents) and highly educated (87% had a master's or PhD degree). Almost half resided in Europe (31%) plus North America (14%). Many (29%) self-identified as researchers. Similar contemporaneous online surveys of conservation professionals also yielded respondents largely from North America and Europe [19,48]. In their survey on conservation technology, Speaker, O'Donnell [48] also found that >60% of respondents were male. Our sample may somewhat reflect the real distribution of conservation research capacity across world regions, which is highest in the United States and low across much of Africa [49].

Importantly, however, our sample was subject to selection bias because of the survey's voluntary nature. It was limited to individuals who could read one of the four languages of the survey. In countries where these languages are uncommon, this limitation may have skewed our sample toward individuals with more exposure to English than would be expected from a representative sample. Indeed, 78% of respondents in the first survey selected the English version of the questionnaire. The survey was also unlikely to reach conservation professionals in organizations unable to become IUCN members or affiliates (e.g., consulting companies) and those unable to pay dues. Most respondents were integrated into the IUCN network through member organizations, participation in Commissions, and/or direct employment. Only about 18% reported no IUCN connection. Although Indigenous organizations can be IUCN members, just three respondents in the original survey identified as being part of IUCN-member Indigenous organizations.

### 2.2. Knowledge of palm oil varied across respondents

To assess respondent exposure to palm oil issues, the first survey asked participants to self-report their time dedicated to palm oil (Materials and Methods 3.2). About half of the respondents (48%) spent no time on palm oil, and another third

spent between 1–20% of their time on palm oil (Fig 1C). Just a few (<6%) spent >60% of their time on palm oil issues. Many respondents had exposure to other tropical forest-risk commodities including timber (47% spent some time on timber) and cattle (36% spent some time on cattle).

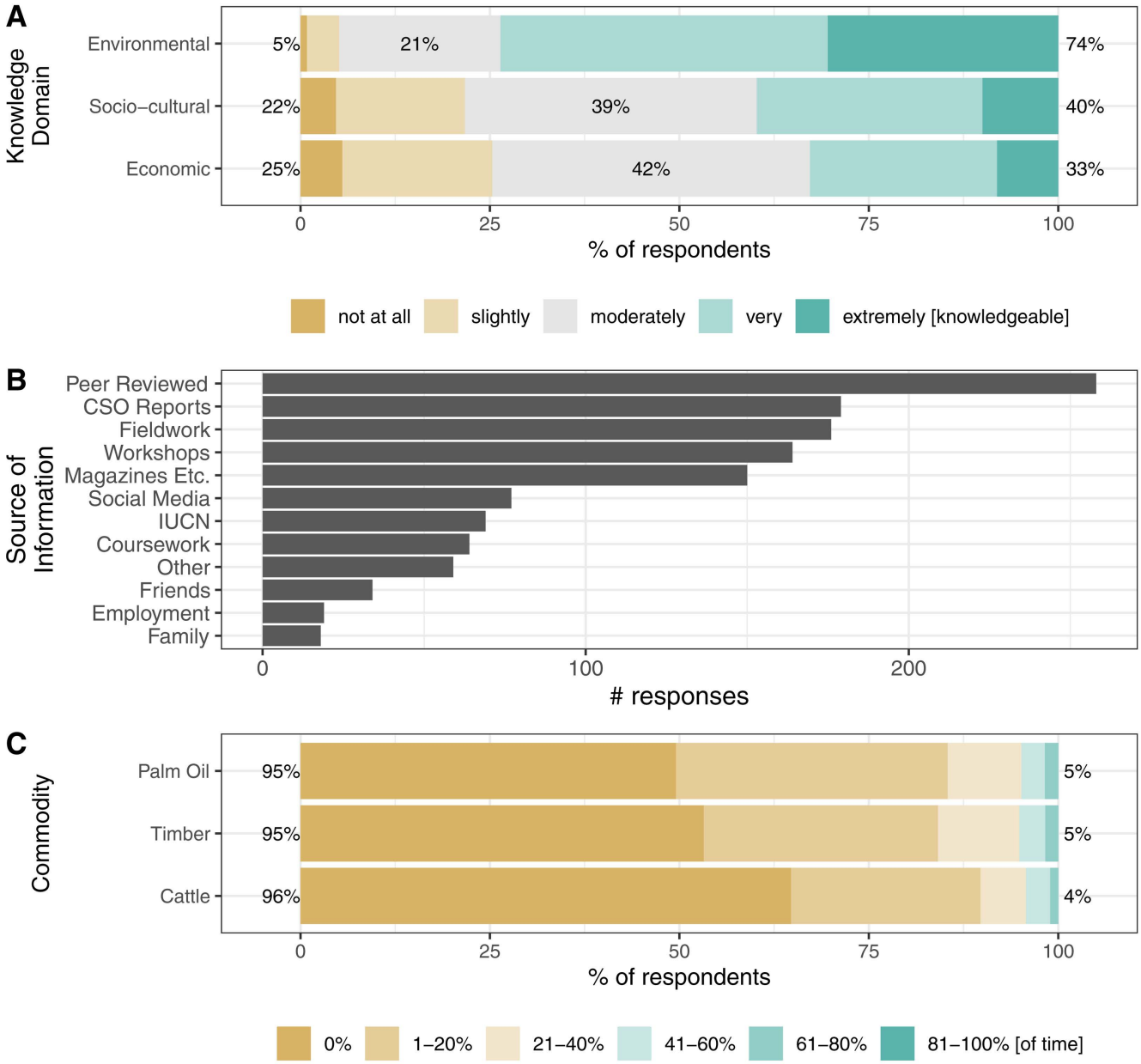


**Fig 1. Respondent knowledge, sources of information, and experience from the initial survey.** (A) Self-reported degree of domain (i.e., economic, environmental, and socio-cultural) knowledge of oil palm's impacts. Percentages are aggregated for the lowest (i.e., not at all and slightly knowledgeable), middle (i.e., moderately knowledgeable), and highest (i.e., very and extremely knowledgeable) categories for each knowledge type. (B) Sources of information regarding the oil palm industry; respondents selected up to three sources. (C) Self-reported percent of respondent time spent on palm oil, timber, and cattle issues. Percentages are aggregated for the lowest (i.e., 0-40%) and highest (i.e., 41-100%) response categories.

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To identify the sources of information underpinning respondent knowledge, the initial survey asked how respondents stayed informed on palm oil issues (Materials and Methods 3.2). Respondents' main source of information was peer-reviewed articles, followed by reports from civil society organizations, fieldwork, and workshops (Fig 1B, Table B in S1 Appendix).

We also asked participants to rate their knowledge of the economic, socio-cultural, and environmental impacts of the palm oil industry (Materials and Methods 3.2). Participants reported being more knowledgeable about palm oil's environmental than economic or socio-cultural impacts (Fig 1A). Economic and socio-cultural knowledge exceeded environmental knowledge for only 1% and 3% of respondents, respectively, while environmental knowledge exceeded economic and socio-cultural knowledge for 61% and 56% of respondents, respectively. Socio-cultural and economic knowledge ratings were highly correlated (S1 Spreadsheet). The choice an individual makes about what knowledge to acquire is unlikely to be random in that it may be related to other individual level characteristics such as values. For instance, respondents who have obtained greater socio-cultural and economic knowledge about palm oil may have more anthropocentric values, while those with greater environmental knowledge could have made the effort to acquire this knowledge because they hold more eco-centric values [50].

### 2.3. Palm oil impacts: Perceptions aligned with scientific knowledge in initial survey

We hypothesized that conservation community member perceptions about palm oil would align with scientific evidence. To test this hypothesis, we qualitatively compared respondent perceptions from the first survey with available evidence collated from relevant syntheses focused on oil palm (Materials and Methods 3.6). We also calculated polarization for each perception [19] to assess the degree of divergent views among conservation community members (Materials and Methods 3.5). We evaluated palm oil's impacts (reported in this section) as well as the effectiveness of conservation interventions in the palm oil sector (Results and Discussion 2.5) using this approach.

In the realm of biophysical palm oil impacts, the IUCN report [47] synthesized a large body of work that described substantial forest and biodiversity loss from oil palm expansion. The report also noted that in freshwater streams, oil palm development has been associated with warming and increased sediment and nutrient export [47]. In alignment with this evidence, most respondents to the initial survey agreed that palm oil production had negative effects on tropical rainforests (89% of responses), biodiversity (90%), and water quality (79%; Fig 2A). All three impacts had relatively low polarization scores, ranging from 0.12 (rainforests) to 0.21 (water; Table C in S1 Appendix).

The palm oil industry contributes significantly to the economies of many tropical countries [47]. Accordingly, most (78%) respondents in the initial survey thought that palm oil production had positive effects on gross domestic product (polarization score of 0.19; Fig 2A; Table C in S1 Appendix). Research in Southeast Asia indicates that while oil palm development supports improved smallholder incomes overall, these effects are uneven across smallholders [51]. S1 Appendix Respondents were relatively divided regarding palm oil's impacts on smallholder incomes (57% positive effects; 26% negative effects; polarization score of 0.31; Fig 2A; Table C in S1 Appendix).

Land conflicts between palm oil companies and local residents have been frequently reported in peer-reviewed studies [51] and 79% of initial survey respondents perceived negative effects of oil palm on land rights (polarization score 0.23; Fig 2A; Table C in S1 Appendix). Oil palm development affects local food security in complex ways that depend on factors such as the degree of regional subsistence farming and household gender roles [51]. In the initial survey, while few respondents (5.7%) thought that palm oil production had extremely positive impacts on food security, responses were relatively evenly distributed across the range of extremely negative to somewhat positive impacts (polarization score 0.36; Fig 2A; Table C in S1 Appendix).

These findings suggest that palm oil production's impacts on concerns traditionally within the realm of conservation science (i.e., biodiversity and rainforests) – which were well substantiated in the peer reviewed literature but perhaps more disaggregated before the IUCN report – were both well-known and largely agreed upon across a diversity of conservation professionals before the IUCN report was published. Yet, for the impacts of palm oil production that are largely socio-economic, especially those that are more ambiguous or heterogenous (e.g., food security in palm oil producing countries), respondent perceptions were also more heterogenous.

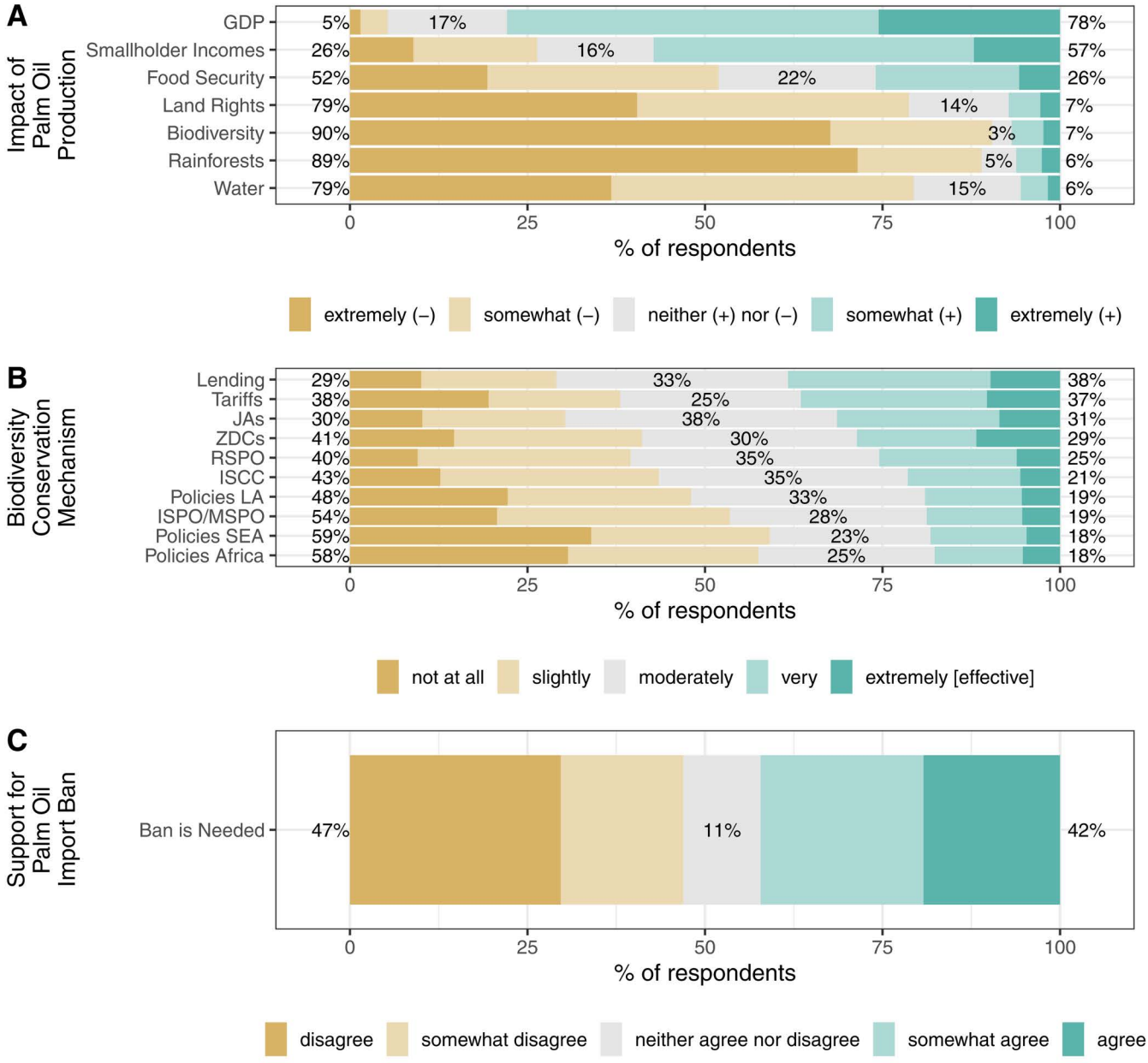


**Fig 2. Respondent perceptions regarding palm oil production's impacts, effectiveness of conservation interventions, and need for import ban from the initial survey.** (A) Impacts include biophysical (rainforests, biodiversity, water), economic (gross domestic product or GDP, smallholder incomes), and social (land rights, food security) impacts. (B) Interventions consist of certification systems including the International Sustainability and Carbon Certification (ISCC), Indonesian/Malaysian Sustainable Palm Oil (ISPO/MSPO), and the Roundtable on Sustainable Palm Oil (RSPO); regional government policies; other interventions including jurisdictional approaches (JAs), lending restrictions, tariffs and trade regulation, and zero deforestation commitments (ZDCs). (C) Distribution of perceptions regarding a ban on palm oil imports. Percentages are aggregated for the lowest two (e.g., extremely negative, somewhat negative), middle (e.g., neither positive nor negative), and highest two (e.g., somewhat positive, extremely positive) categories. Plots exclude respondents with "I do not know" responses, which were options for questions in (B) and (C). Results are summarized in Table C in S1 Appendix.

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### 2.4. Palm oil impacts: Economic knowledge was related to more favorable perceptions

To assess the role that knowledge plays in shaping conservation professional perceptions, we evaluated how respondent perceptions collected in the initial survey were related to respondent domain knowledge of, experience with, and sources of information about palm oil. This analysis used ordered logit regression (Materials and Methods 3.7.2), which is suited for dependent variables characterized by Likert-type items like those in our study [52,53]. We conducted several robustness and sensitivity checks (Materials and Methods 3.7.3). We undertook this analysis for palm oil impacts (reported here) as well as conservation intervention effectiveness (Results and Discussion 2.6) and a hypothetical palm oil ban (Results and Discussion 2.7).

After controlling for gender and region of residence, our ordered logit regression results indicated that some aspects of respondent knowledge and experience were consistently related to perceptions of palm oil production impacts (Table 1).

**Table 1. Final ordered logistic regression model specification coefficients for perceptions of palm oil production's impacts, presented as odds ratios.**

| RESPONSE VARIABLE (Respondent perception) | Impact of palm oil production: | | | | | | |
|---|---|---|---|---|---|---|---|
| | Biodiversity | Rainforests | Water | Land Rights | Food Security | Smallholder Incomes | GDP |
| **PREDICTOR VARIABLE (Respondent Characteristic)** | **Odds Ratio** | | | | | | |
| Gender - male | 1.187 | 1.631 | 1.685** | 1.599* | 1.626** | 0.973 | 0.817 |
| Region - Latin America | 2.279* | 1.721 | 0.881 | 1.398 | 1.369 | 1.231 | 0.510* |
| Region - Oceania | 1.255 | 1.004 | 0.645 | 0.515 | 1.513 | 0.944 | 0.788 |
| Region - Asia (other countries) | 3.253*** | 3.718*** | 2.190* | 3.026*** | 1.574 | 1.644 | 0.776 |
| Region - Africa | 4.920*** | 6.777*** | 2.888*** | 3.000*** | 4.944*** | 2.427** | 0.788 |
| Region - North America | 1.177 | 0.615 | 0.944 | 0.495* | 1.490 | 1.297 | 1.048 |
| Region - Indonesia & Malaysia | 3.094** | 3.348** | 0.809 | 1.593 | 2.914** | 1.844 | 1.477 |
| Time w/palm oil | 1.196 | 1.177 | 1.188* | 1.247* | 1.251** | 1.183 | 1.134 |
| Knowledge of economic impacts | 2.692*** | 3.183*** | 1.475** | 1.521*** | 1.495*** | 1.455** | 1.294* |
| Knowledge of environmental impacts | 0.391*** | 0.393*** | 0.626*** | 0.555*** | 0.647*** | 0.838 | 0.890 |
| Source of Information - IUCN | 0.710 | 0.851 | 0.714 | 1.008 | 0.688 | 1.059 | 0.789 |
| Source of Information - Peer Reviewed Articles | 0.873 | 0.665 | 0.641* | 0.857 | 0.924 | 0.824 | 0.828 |
| Source of Information - CSO Reports | | 0.471** | 0.69* | 0.819 | 0.785 | 1.343 | 0.997 |
| Source of Information - Fieldwork | 0.641 | 0.536* | 0.760 | 1.096 | 1.076 | 1.866** | 1.405 |
| Source of Information – Workshops | 1.036 | 1.152 | 1.074 | 1.202 | 1.468* | 1.753** | 1.159 |
| **MODEL STATISTIC** | **Value** | | | | | | |
| n | 470 | 470 | 470 | 470 | 470 | 470 | 470 |
| Residual deviance | 757 | 694 | 1057 | 1065 | 1310 | 1271 | 1070 |
| Akaike Information Criterion | 793 | 732 | 1095 | 1103 | 1348 | 1309 | 1108 |
| Brant test | 0.741 | 0.869 | 0.407 | 0.120 | 0.449 | 0.152 | 0.985 |
| Lipsitz test | 0.074 | 0.228 | 0.389 | 0.418 | 0.094 | 0.383 | 0.050 |
| Hosmer-Lemeshow Test | 0.658 | 0.816 | 0.886 | 0.458 | 0.884 | 0.563 | 0.028* |

Odds ratio values above (below) one indicate that the variable is associated with a likelihood of perceiving more positive (negative) levels of impact.

Where predictor variable values are blank, the variable was eliminated the from the model to ensure that it passed the Brant test.

For categorical predictor variables, reference groups to which other groups are compared are "female and other" for Gender, "Europe" for Region, and "not a main source" for Source of Information.

CSO = civil society organization; GDP = gross domestic product.

*p < 0.05;

**p < 0.01;

***p < 0.001

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These results had good coherence with generalized ordered logit models developed for sensitivity analysis (Table D in S1 Appendix).

All else equal, higher levels of self-identified economic knowledge were associated with a significant ($p < 0.05$) *increase* in the likelihood of a favorable perception of all impacts of oil palm production (Table 1). Similarly, greater environmental knowledge was related to a *decrease* in favorable perception across all impacts, an effect that was significant for all but smallholder income and gross domestic product (GDP). Moreover, respondents who spent more time with palm oil issues were more likely to have a more positive perception across all impacts, with a significant effect for water, land rights, and food security. Our finding that time spent on palm oil is often a significant correlate of perceptions contrasts with the null results of Rose, Sutherland [23], who defined experience in terms of years. We found fewer clear relationships between sources of information and respondent perceptions. Peer reviewed articles and workshops were consistently associated with, respectively, more negative and positive views across all palm oil impacts. Fieldwork, which allows individuals to directly observe the effects of palm oil production, was associated with more negative views of all biophysical impacts but more positive views of all social and economic impacts. The statistical significance of these relationships differed across impacts.

### 2.5. Conservation intervention effectiveness: Despite lack of scientific evidence, respondents ranked most conservation interventions as slightly to moderately effective

At the time of the initial survey, the effectiveness of most major governance mechanisms for conserving biodiversity in palm oil producing regions – including International Sustainability and Carbon Certification, Indonesian Sustainable Palm Oil certification, Malaysian Sustainable Palm Oil certification, Latin America and Africa government policies, tariffs and trade regulation, zero deforestation commitments, jurisdictional approaches, and lending – remained unevaluated using empirical ex-post approaches [47]. The IUCN report [47] described Roundtable on Sustainable Palm Oil certification's positive yet limited benefits for biodiversity and forest conservation, and the reduction of deforestation conferred by Indonesian government policies including the 2011 Forest Moratorium and public protected areas.

Despite the lack of scientific evidence on many of these programs and an "I do not know" option, most respondents to the initial survey (59–89% of respondents across questions) chose to answer questions about the effectiveness of conservation initiatives (Table C in S1 Appendix). They appeared to be least familiar with International Sustainability and Carbon Certification and government policies in Africa and Latin America (32–41% "I do not know" response rate) and most familiar with zero deforestation commitments and tariffs (12% and 18% "I do not know" response rates, respectively). Polarization scores for intervention effectiveness were higher than these scores for all impacts of palm oil production except those on food security, and ranged from 0.30 (Roundtable on Sustainable Palm Oil certification) to 0.41 (tariffs and trade regulation; Table C in S1 Appendix). This aligns with the idea that there is more disagreement regarding conservation issues for which there is less evidence [18].

On average, respondents perceived all mechanisms as slightly to moderately effective (Fig 2B). Certain interventions that had received little to no attention in the scientific literature around oil palm at the time (i.e., lending, jurisdictional approaches, tariffs and trade regulation, and zero-deforestation commitments) received higher effectiveness ratings than Roundtable on Sustainable Palm Oil certification and government policies in Southeast Asia, which had been positively evaluated in several peer-reviewed studies (Table C in S1 Appendix).

These results may reflect the knee-jerk nature of conservation policy, where novel interventions receive more attention than well-tested ones [54]. Alternatively, sources of information beyond peer-reviewed studies could have influenced respondent perceptions [55]. For instance, by December 2017, civil society organizations had developed multiple tools and datasets tracking the disclosure of zero-deforestation commitments by palm oil supply chain actors [56,57]. Although these datasets provided no information about the effectiveness of such policies, the high rates of policy adoption within the palm oil sector suggested high potential for impact [58].

### 2.6. Conservation intervention effectiveness: Individuals with greater self-reported economic knowledge tended to rate interventions as more effective

The significance of individual factors in explaining perceptions of conservation intervention effectiveness differed substantially across interventions (Table 2). Results from ordered logit models and models developed for sensitivity analysis were qualitatively similar (Table E in S1 Appendix).

As with perceptions of palm oil production's impacts, self-reported general domain knowledge was the most relevant variable related to different perceptions of conservation intervention effectiveness collected in the initial survey (Table 2).

**Table 2. Final ordered logistic regression model specification coefficients for perceptions of the effectiveness of biodiversity conservation mechanisms, presented as odds ratios.**

| RESPONSE VARIABLE (Respondent perception) | Effectiveness of biodiversity conservation mechanism: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RSPO | ISCC | ISPO/ MSPO | Gov Pol SEA | Gov Pol Africa | Gov Pol Latam | Tariffs | ZDCs | JAs | Lending Restrictions |
| **PREDICTOR VARIABLE (Respondent Characteristic)** | **Odds Ratio** | | | | | | | | | |
| Gender - Male | 1.218 | 0.930 | 1.273 | 1.196 | 1.245 | | 1.113 | 0.999 | 0.679 | 0.717 |
| Region - Latin America | 2.594** | 1.852 | 2.897** | 0.762 | 1.202 | 0.454* | 1.373 | 0.949 | | 1.084 |
| Region - Oceania | 1.692 | 2.195 | 1.504 | 0.570 | 2.028 | 0.752 | 1.091 | 1.485 | 1.601 | 0.769 |
| Region - Asia (other countries) | 1.778 | 1.982* | 2.246* | | 3.159** | 2.235* | | | 2.263** | 1.794 |
| Region - Africa | 1.422 | 1.717 | 2.713** | 1.564 | 2.047* | 2.134 | 0.329** | 1.554 | 1.008 | 0.957 |
| Region - North America | 1.436 | 0.897 | 1.109 | 0.700 | 0.586 | 0.801 | 0.577 | 0.741 | 0.754 | 1.027 |
| Region - Indonesia & Malaysia | 1.748 | 0.987 | 1.773 | 1.142 | 1.104 | 1.866 | 0.487* | 0.980 | 1.440 | 1.076 |
| Work time with palm oil | 1.347** | 1.143 | 1.028 | | 1.219 | | 0.888 | | 1.207* | |
| Knowledge of economic Impacts | 1.473** | 1.264 | 1.341* | 1.788*** | 1.215 | 1.496** | 1.089 | 1.262* | 1.053 | |
| Knowledge of environmental Impacts | 0.708* | 1.010 | 0.684** | 0.605*** | 0.829 | 0.917 | 1.000 | 0.932 | 1.027 | 0.890 |
| Source of Information - IUCN | 0.877 | 1.087 | 1.056 | 0.911 | 0.887 | 0.730 | 1.031 | 0.913 | 0.887 | 1.076 |
| Source of Information - Peer Reviewed Articles | 0.796 | 0.786 | 0.711 | 0.869 | 0.959 | 0.966 | 0.905 | 0.777 | 0.674 | 0.809 |
| Source of Information - CSO Reports | 0.858 | 0.696 | 0.620* | 0.64* | 0.847 | 0.687 | 0.704 | | | 1.067 |
| Source of Information - Fieldwork | 0.668 | 0.694 | 0.592* | | 0.873 | 0.664 | 0.887 | 0.822 | 0.706 | 1.028 |
| Source of Information - Workshops | 0.889 | 0.957 | 1.037 | 1.076 | 1.063 | 1.050 | 0.597* | | 0.959 | 0.794 |
| **MODEL STATISTIC** | **Value** | | | | | | | | | |
| n | 377 | 322 | 357 | 362 | 306 | 279 | 389 | 416 | 363 | 368 |
| Residual deviance | 1040 | 904 | 1002 | 1015 | 866 | 783 | 1179 | 1271 | 1037 | 1090 |
| Akaike Information Criterion | 1078 | 942 | 1040 | 1047 | 904 | 817 | 1215 | 1301 | 1071 | 1124 |
| Brant test | 0.367 | 0.586 | 0.055 | 0.305 | 0.304 | 0.132 | 0.200 | 0.213 | 0.135 | 0.283 |
| Lipsitz Test | 0.429 | 0.012* | 0.417 | 0.642 | 0.281 | 0.167 | 0.788 | 0.897 | 0.900 | 0.198 |
| Hosmer-Lemeshow Test | 0.213 | 0.050 | 0.872 | 0.339 | 0.253 | 0.099 | 0.962 | 0.711 | 0.581 | 0.330 |

Odds ratio values above (below) one indicate that the variable is associated with a likelihood of perceiving higher (lower) levels of effectiveness.

Where predictor variable values are blank, the variable was eliminated the from the model to ensure that it passed the Brant test.

For categorical variables, reference groups to which other groups are compared are "female and other" for Gender, "Europe" for Region, and "not a main source" for Source of Information.

RSPO = Roundtable on Sustainable Palm Oil; ISCC = International Sustainability and Carbon Certification; ISPO = Indonesian Sustainable Palm Oil; MSPO = Malaysian Sustainable Palm Oil; ZDCs = zero-deforestation commitments; JAs = jurisdictional approaches; CSO = civil society organization.

*$p < 0.05$;

**$p < 0.01$;

***$p < 0.001$.

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Individuals more knowledgeable of palm oil's economic impacts were more likely to perceive Roundtable on Sustainable Palm Oil (RSPO) certification, Indonesian/Malaysian Sustainable Palm Oil (ISPO/MSPO), government policies of Southeast Asia and Latin America, and zero deforestation commitments as *more* effective. Higher environmental knowledge was correlated with *lower* ratings of all of these interventions, with significant effects for RSPO certification, ISPO/MSPO, and government policies in Southeast Asia. We found that people with more time dedicated to palm oil issues were significantly more likely to consider RSPO certification and jurisdictional approaches more effective. Previous studies using interview-based methods [44,45] also suggest that people with expertise in palm oil, including non-governmental organization representatives, think highly of RSPO certification's effectiveness at promoting sustainability and conservation. Source of information was rarely significantly correlated with ratings of intervention effectiveness. Unlike its relevance in explaining perceptions of palm oil's impacts, using peer-reviewed articles as a source of information was not a significant predictor of perception for any conservation intervention.

Although residence location was included in our model as a control variable (Table 2), it was sometimes a significant correlate of conservation professional perceptions [59]. For instance, we found that residents of Indonesia and Malaysia, major palm oil producing regions, were more likely to perceive tariffs and trade regulation as less effective than respondents based in Europe. Such policy proposals originated in Europe and have been criticized by producing country governments as being protectionist and discriminatory [60,61]. This finding aligns with previous studies indicating that perceptions of conservationists [19,22] and consumers of palm oil [42] vary across geographies.

### 2.7. Palm oil import ban: Respondents with more knowledge and experience in the palm oil sector were less likely to support a ban

Our initial survey revealed polarization within the conservation community regarding the need for importing countries to ban palm oil. Around 41% of respondents agreed that a ban on palm oil is needed while around 46% disagreed with a ban (Fig 2C), generating a polarization score of 0.51. This is higher than polarization for any of the views reported by Sandbrook, Fisher [19]. Respondents who dedicated more time to palm oil issues, were more knowledgeable about palm's economic impacts, and those who got their information from workshops were significantly less likely to support a ban (Table 3). Knowledge of environmental impacts was positively related to support for a ban (Table 3). Results were qualitatively similar across model specifications (Table F in S1 Appendix).

We did not ask respondents to explain their responses to this hypothetical ban question, but we can provide several suggestions for why professionals working on palm oil issues might have had less support for a ban. These individuals may be better informed about the complexity of fulfilling global demand for vegetable oil with lower-yielding oil crops (e.g., soy). For example, a ban on palm oil by importing countries without a corresponding reduction in the demand for vegetable oils has the potential for adverse spillover effects on other tropical regions [60,37]. These respondents may also have recognized the potentially negative implications of such trade restrictions on vulnerable smallholder palm oil producers [62].

Regardless of the reason for these differing views, or the actual effect that a ban on palm oil in importing countries might have on conservation goals, such conflicting perceptions have several implications for policy development. In theory, such conflict could lead to antagonism between policymakers in producing and consuming countries [63]. Yet, we detected no major differences in perceptions of respondents across leading palm oil producing countries (i.e., Indonesia/Malaysia) and Europe, where restrictions are already in place in some contexts. Another outcome could be the release of contradictory recommendations for decision-makers by conservation professionals who do and do not support bans and other trade barriers as effective and appropriate conservation interventions. Such contradictory recommendations could lead to political impasse [64] or conflicting governance mechanisms across regions [65]. On the other hand, these types of disputes may improve conflict management within the conservation community and motivate stakeholders to improve governance interventions [66,67]. For instance, rich debates [68–70] around the predicted conservation benefits and

**Table 3. Ordered logit regression full model results for the support of a ban on palm oil products, presented as odds ratios.**

| RESPONSE VARIABLE (Respondent perception) | Support for ban: Ban Needed |
|---|---|
| **PREDICTOR VARIABLE (Respondent Characteristic)** | **Odds Ratio** |
| Gender - male | 0.939 |
| Region - Latin America | 1.102 |
| Region - Oceania | 1.482 |
| Region - Asia (other countries) | 2.170** |
| Region - Africa | 0.613 |
| Region - North America | 0.752 |
| Region - Indonesia & Malaysia | 0.574 |
| Time w/palm oil | 0.688*** |
| Knowledge of economic impacts | 0.732** |
| Knowledge of environmental impacts | 1.513** |
| Source of Information - IUCN | 1.452 |
| Source of Information - Peer Reviewed Articles | 1.090 |
| Source of Information - CSO Reports | 0.900 |
| Source of Information - Fieldwork | 0.713 |
| Source of Information – Workshops | 0.649* |
| **MODEL STATISTIC** | **Value** |
| n | 458 |
| Residual deviance | 1337 |
| Akaike Information Criterion | 1375 |
| Brant Test | 0.081 |
| Lipsitz Test | 0.055 |
| Hosmer-Lemeshow Test | 0.051 |

Values above (below) one indicate that the variable is associated with a likelihood of higher (lower) support for a ban.

For categorical variables, reference groups to which other groups are compared are “female and other” for Gender, “Europe” for Region, and “not a main source” for Source of Information.

CSO = civil society organization

*p < 0.05;

**p < 0.01;

***p < 0.001.

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social costs of the EU’s regulation on deforestation – which will prevent imports of palm oil that does not meet several criteria starting in 2025 – may eventually lead to more effective importing country policies with respect to palm oil and other tropical commodities.

### 2.8. Reading the IUCN report led to less negative respondent perceptions of palm oil’s impacts on biodiversity and rainforests

We predicted that reading the IUCN palm oil report would influence the perceptions of global conservation community members. To test this prediction, we chose a quasi-experimental design to infer the causal impact of reading the report on perceptions. Our analysis applied a difference-in-difference model to responses collected in the initial and follow-up surveys (Materials and Methods 3.8).

For respondents who took both the initial and follow-up survey, the degree of individual change in responses varied widely across perception questions. Perceptions of palm oil impacts were consistently more stable (45–75% respondents did not change their rating across impacts; S1 Fig) than perceptions of the effectiveness of interventions (16–32% of respondents did not change their rating across interventions; S2 Fig).

Only 34% of respondents who participated in both surveys (36/105 respondents) read the full report (Table A in S1 Appendix). This suggests that interest in reviewing the report did not translate into willingness to read it, consistent with previous research on the science-implementation gap in the realm of conservation [15]. Due to the report's length (116 pages) and limited available time, it is possible that individuals read parts that they considered more relevant to their professional focus or existing knowledge, rather than reading sections less familiar to them [71]. Among individuals who read only part of the report, we detected no significant counterfactual change in any perception (Table G, Table H, and Table I in S1 Appendix). This suggests that such behavior restricted the report's impact on perceptions. Yet, our ability to detect any effect of reading part of the report was limited by our small resurvey sample size.

Among respondents who read the full IUCN report between surveys, we found some counterfactual changes in perceptions. Relative to respondents who did not read the report or who read it before the initial survey, after individuals read the full report, they rated palm oil as less harmful to rainforests and biodiversity than before they read the report (Table G in S1 Appendix). These two impact categories (i.e., rainforests and biodiversity) comprised the major focus of the IUCN report. This finding is notable given that other publications with different messages were released at about the same time as the IUCN report [26]. Conflicting messages across reports potentially add complexity to the communication process, which may increase the importance of values, attitudes, and subjective norms in decoding and processing new information [72]. Our finding of no significant counterfactual change in perceptions of other impacts that were not the report's main focus (i.e., impacts on water and socio-economic concerns; Table G in S1 Appendix) adds weight to our interpretation that the change in perceptions between surveys was due to reading the IUCN report. Yet, we emphasize that this change was small, a mean difference of +0.19 (S1 Fig). Moreover, only 33% and 22% of full report readers changed their ratings of biodiversity and rainforest impacts, respectively – the remainder had stable responses across surveys (S2 Fig).

In contrast, we found no significant change in respondent perceptions of the effectiveness of any conservation intervention or support for a ban on palm oil imports, even for respondents who read the full report (Table H and Table I in S1 Appendix). As described above (Results and Discussion 2.5), few studies with such evidence had been published in time for inclusion in the IUCN report, restricting the report's potential to shift these perceptions. Given that several then-untested conservation interventions in the palm oil sector (e.g., zero deforestation commitments by companies) have since been evaluated in peer reviewed studies, a synthesis regarding evidence for the effectiveness and equity of conservation interventions may now be better positioned to alter views. However, many other factors influence normative perceptions regarding what actions humans should take to achieve conservation goals [20]. We cannot eliminate the possibility that experts are less likely to modify views of appropriate conservation interventions, compared to anthropogenic impacts on the environment, based on a single report.

People who read some or all of the report between surveys did increase their willingness to rate conservation intervention effectiveness (Table J in S1 Appendix). These individuals selected "I do not know" less frequently in the follow up survey for all conservation interventions except International Sustainability and Carbon Certification (ISCC; for which the "I do not know" response rate did not change) and tariffs and trade regulation (for which the "I do not know" response rate increased). Overall, the mean "I do not know" response rate across all ten effectiveness questions declined from 25 ± 11% to 17 ± 10% for these report readers. In contrast, individuals who never read the report selected "I do not know" more frequently in the follow up survey (mean of 12 ± 10% in the initial survey compared to 23 ± 14% in the follow up survey). The report may have increased respondents' knowledge about conservation interventions in the palm oil sector, even if it did not measurably change the perceptions of respondents who were already knowledgeable about interventions before reading the report.

### 2.9. Limitations

Our study had several limitations. First, we evaluated only the immediate (<3 months) change in conservation professional perceptions, which may not represent longer-term shifts. Second, respondents were asked to review and provide feedback on a draft of the report, engagement that may differ from that of readers of the finalized report. Third, our sample was biased toward English-speaking, highly educated males residing in Western countries. Given this bias, our ability to generalize our findings to the full global conservation community is limited. Nevertheless, we took several measures to support the *internal* validity of our findings. To reduce response bias, at the survey design phase, an interdisciplinary team focused on question phrasing, order, and response category selection (Materials and Methods 3.2). The alignment between scientific understanding regarding the impacts of palm oil, and responses to questions about these impacts, support the validity of these survey questions. When we tested for consistency by computing response correlations across initial and follow-up surveys, we found positive and significant correlations for all impact and effectiveness items (Table K in S1 Appendix), underscoring the reliability of our survey instrument. To mitigate omitted variable bias, our models controlled for region of residency and gender (Materials and Methods 3.7.1). To support model validity, we ensured that models met key assumptions (e.g., the parallel trends test; Materials and Methods 3.7.3). About 12% of initial survey respondents had read some or all of the report before they took the first survey (Table A in S1 Appendix). Compared to respondents who did not read the report before the survey (S3 Fig), these respondents self-reported higher oil palm work time and knowledge (S4 Fig). Their perceptions reported on the initial survey may have been somewhat shaped by reading the report.

Finally, it is well-known that people tend to overestimate their own knowledge. This effect may be amplified for those with less knowledge ("Dunning-Kruger" effect; [73]). We argue that our significant findings with respect to knowledge domain variables are likely robust to this effect. First, because prior studies (e.g., [73,74]) suggest that the relationship between measured and self-estimated attributes like knowledge is positive, maintaining the ranking of knowledge levels within and across individuals. Second, because self-assessment reduces the magnitude of differences in knowledge across individuals [73]. In our study, this would reduce the ability to detect a real relationship between knowledge and perception. Nevertheless, our significance testing revealed several strong relationships between self-reported knowledge and peoples' perceptions. This was true even after controlling for gender and region of residency, which have proven significant determinants of views in previous research on conservation community members [19,22]. As discussed above, however, it is possible that self-assessment of knowledge within domains was a proxy for another variable (e.g., ecocentric versus anthropocentric values) not evaluated in this study.

### 2.10. Implications

Our finding of a limited impact of reading a synthesis report on the perceptions of conservation professionals might prove useful to conservation organizations and researchers considering whether to undertake evidence synthesis efforts. We emphasize, however, that even if reading synthesized evidence does not change perceptions (and potentially conservation decision-making), synthesis can reduce the time and cost needed to understand a large literature, and identify knowledge gaps for further research efforts [15]. Indeed, by February 2025, the 2018 IUCN report had been downloaded 83,551 times, with annual downloads remaining stable across years, suggesting continuous interest and potential further impact of the report on perceptions beyond what we measured here. To fully understand the long-term benefits of such synthesis, including whether and how it is incorporated into conservation practice and policy, longer-term studies using different approaches (e.g., expert elicitation) that better target diverse conservationists (e.g., a random sample from the full conservation community population) engaging with synthesis reports in a variety of ways is needed.

The IUCN report and others like it represent a form of one-way communication that provides no feedback on how individuals decoded and interpreted content [12]. Managing the science-action gap involves, among other factors, promoting two-way communication between scientists and practitioners [12]. We recommend that organizations like the IUCN tailor

messages and media selection to specific stakeholders to better deliver key information to different user groups. This may help to close the science-practice gap and better tackle the rapid loss of global biodiversity.

Finally, conservation organizations that hire and manage employees may find our results regarding the significant relationships between time spent on palm oil and sources of information, and perceptions, useful. For instance, organizations may wish to prioritize sending staff to the field and to workshops, or require them to focus on a single commodity or conservation pressure like oil palm, to allow them to develop expertise in and direct observation of the conservation pressure. Conservation organizations may also want to prioritize hiring staff with long-term lived experience with conservation pressures (e.g., individuals who grew up in and around oil palm plantations) who have local and/or experiential knowledge that complements scientific knowledge [8,9].

### 2.11. Conclusions

By analyzing surveys of conservationists' perceptions before and after they read a report synthesizing conservation evidence, we provide insights into how knowledge shapes the views of diverse conservation professionals. Specifically, we found that after a full reading of a synthesis report on a tropical oil crop (i.e., oil palm) that is associated with deforestation and biodiversity loss in both the academic literature and the public view, compared to a control group, people had *less* negative assessments of the impacts of this crop on biodiversity and tropical rainforests. We argue that this change is likely to be causally related to reading the synthesis report. However, while the change in perception of impacts on biodiversity and rainforests was statistically significant, its magnitude was small. Moreover, most respondents had knowledge of palm oil's impacts that aligned with the weight of scientific evidence on the subject even before they read the report. Indeed, reading the report had no apparent influence on perceptions of the effectiveness of conservation policies and programs in the oil palm sector, which were not well understood at the time. Our finding that knowledge is associated with perceptions builds on previous surveys [19,22] of the global conservation community that found links between individual level characteristics, like gender and geographic region, and perceptions. We conclude that for conservation professionals who are already highly knowledgeable about how human actions affect the environment, reading a synthesis report may simply refine or moderate – rather than generate major shifts in - perceptions.

## 3. Materials and methods

### 3.1. Ethics statement

Our study was reviewed and approved by the University of Hawai'i Human Studies Program (protocol number 2017–01003). All participants provided written consent to participate in the study. De-identified survey data used in our analysis are available as S1 Data.

### 3.2. Survey design

We developed a two-stage survey, consisting of an initial questionnaire (S1 Questionnaire) and a second reduced version of that initial questionnaire (S2 Questionnaire), designed to answer our research questions.

We took several measures to reduce response bias – where respondents provide answers that are influenced by factors beyond the focus of the question - when designing the questionnaire. In wording questions, we used neutral language. In selecting answers, we provided balanced options that covered the full range of possible responses. To address order bias, where the sequence of questions or answers influences responses, we carefully considered question and response order, grouped similar questions together, and used randomization where possible for both questions (e.g., impact questions) and responses (e.g., sources of information). To minimize forced responses, where respondents do not have an answer to a question but are forced to respond regardless, we included an "I do not know" option where we thought respondents might not have enough information to respond. To ensure clarity of the initial questionnaire, two pretests were conducted: one with six experts on oil palm-related conservation issues, and one with five graduate students

in the Department of Natural Resources and Environmental Management at the University of Hawai'i. Based on feedback from these pretests, we refined the questionnaire. The questionnaire did not change substantially after these pretests.

The questionnaires were constructed to assess conservation community member perceptions before individuals read the IUCN report. Here, we use the definition of perceptions provided by Bennett [6]: "perceptions refers to the way an individual observes, understands, interprets, and evaluates a referent object, action, experience, individual, policy, or outcome". Perceptions differ across individuals due to complex interactions between multiple factors at the individual level (e.g., knowledge, gender), and the social context in which the individual is embedded [6,75].

The initial questionnaire asked respondents to self-report their perceptions on: 1) palm oil production impacts across biophysical, social, and economic realms; 2) conservation mechanism effectiveness at conserving biodiversity in palm oil producing regions; and 3) a hypothetical ban on palm oil imports. We used five-point Likert-type scales for all of these measures. For palm oil impacts, the scale consisted of: extremely positive, somewhat positive, neither positive nor negative, somewhat negative, and extremely negative. For conservation mechanism effectiveness, the scale was: extremely effective, very effective, moderately effective, slightly effective, and not at all effective. For the ban, the scale consisted of: agree, somewhat agree, neither agree nor disagree, somewhat disagree, and disagree. We included an "I do not know" option for effectiveness and support for a ban because we did not expect all respondents to be highly knowledgeable regarding palm oil policy interventions.Questions about biophysical impacts were adapted from text in the IUCN report, section two, entitled "Oil palm impacts on biodiversity". Social and economic impacts were not synthetically addressed in the IUCN report, which focused on biodiversity and other environmental contexts. However, we included questions related to social and economic impacts for two reasons. First, to serve as a control on change in perceptions for the synthesized biophysical impact categories after respondents read the report. Second, to evaluate degree and correlates of perceptions regarding palm oil's impacts in the socio-economic realm. Questions on conservation intervention effectiveness and the hypothetical palm oil ban were adapted from text in IUCN report section three, entitled "Environmental governance to mitigate oil palm impacts to biodiversity". The effectiveness of lending restrictions was not synthesized in this section.

The initial questionnaire also collected information about respondent knowledge, sources of information, and experience. To measure degree of understanding within general knowledge domains, we asked participants to rate their knowledge of economic, socio-cultural, and environmental impacts of the palm oil industry using a five-point unipolar Likert scale. To identify the sources of information underpinning respondent knowledge, we asked respondents to select up to three main sources of information regarding palm oil. We asked about diverse sources because experiential knowledge acquired through direct system interaction [9,76], information provided by civil society organizations [55], and advice from other conservation professionals [71] have all been found to shape a conservation practitioner's knowledge. To assess respondent exposure to evidence related to palm oil impacts and conservation interventions, we asked participants to self-report their time dedicated to palm oil issues. Such palm oil focus may offer the ability to observe the impact of palm oil or the success of a policy intervention directly, or faster access to results of studies exploring these relationships, thereby reducing reliance on other sources of information. Indeed, personal experience can be more critical in affecting perceptions of environmental risk than external sources of information [77].

Finally, we collected individual (e.g., gender, age) and contextual (e.g., region of residency) factors likely to be correlated with perceptions [6,59].

The second questionnaire was a reduced version of the initial questionnaire and was designed to assess changes in perceptions after survey respondents read the draft IUCN report. Therefore, it included questions about perceptions, and also asked about how much of the draft report was read (all, some, or none).

### 3.3. Data collection

We used a non-random sampling approach where individuals opted into taking the survey. We took this approach because the IUCN invited conservation professionals to review a draft of its report on oil palm and biodiversity prior to final

report publication. This provided a unique opportunity to assess individual perceptions before and after reading the report, in a setting where such report-reading would have happened even without the survey, for a diverse group of respondents including those not working directly on palm oil issues. We recognize that our approach likely introduces sampling bias (Results and Discussion 2.1).

Data were collected through self-administered online questionnaires (S1 Questionnaire and S2 Questionnaire) in English, French, Spanish, and Indonesian using Qualtrics Version XM [78]. On December 22, 2017, the IUCN sent an email asking all IUCN Members and Commission members to review a draft of the report and inviting them to answer the initial questionnaire before accessing the report. This survey closed on January 31, 2018. Those who agreed to participate in a follow-up survey were asked, via email, to complete the second questionnaire in March 2018. Respondents to the first survey were offered the option to remain anonymous, but could only take the follow-up survey if they provided their email address. After the survey closed, responses were filtered to remove partial and duplicate records.

### 3.4. Reliability of responses

We assessed the reliability of our survey by measuring the correlation between responses to questions in the initial and follow-up surveys (i.e., test-retest reliability) using Spearman's rank correlation which measures the strength and direction of the association between two ranked variables and is appropriate for ordered Likert-type data [79].

### 3.5. Polarization

To understand the degree to which conservation community member perceptions diverged from one another, we followed the approach of Sandbrook, Fisher [19] and calculated the degree of response polarization for each perception. To do so, we used the "polarization" function from the R package *agrmt* [80]. The polarization metric ranges from zero (all observations in the same category) to one (half of observations are in one category, and half are in another non-neighboring category). "I do not know" responses were omitted from this analysis.

### 3.6. Scientific Evidence

To test the expectation that conservation community member perceptions aligned with available scientific evidence before IUCN report publication, we qualitatively compared respondent perceptions of palm oil impacts and intervention effectiveness to evidence generated from scientific studies about these subjects. To do so, we drew on syntheses of scientific findings on palm oil sustainability to represent current scientific evidence regarding palm oil production conservation intervention effectiveness [47] and biophysical [47], social [51], and economic [51] impacts. We only considered empirical ex-post information from studies published through 2017.

### 3.7. Regression analysis

We hypothesized that respondent perceptions regarding palm oil impacts (e.g., on biodiversity), the effectiveness of interventions designed to assess these impacts (e.g., sustainability certification), and support for a hypothetical palm oil import ban were partially a function of respondent knowledge of palm oil. We used ordered logit regression, which we chose because it is appropriate for ordered responses like those collected with Likert-type scales [52,53], supplemented by several robustness and sensitivity checks to evaluate this hypothesis using data from the initial survey.

**3.7.1. Variable selection.** We designed models for inference (i.e., hypothesis testing) rather than exploration (i.e., hypothesis generation) or prediction [81]. Therefore, we carefully selected dependent and independent variables to represent the potential relationship between perception and knowledge, and included demographic variables as controls.

As dependent variables in our models, we used respondent perceptions of palm oil production's impacts on environmental, economic, and socio-cultural concerns, the effectiveness of policies and programs at conserving biodiversity in

palm oil producing regions, and support for a hypothetical palm oil ban (Table L in S1 Appendix). For palm oil's impacts, we selected a subset of all questions on the survey (7/14 questions focused on impacts) to illustrate variation in findings across biophysical, social, and economic impacts. For effectiveness, we used all questions from the survey. Responses of "I do not know" were excluded from corresponding regression analyses.

As independent variables, we used several measures of knowledge (Fig 1, Table M in S1 Appendix). Specifically, we used self-reported level of knowledge across general knowledge domains, respondent sources of information regarding palm oil, and respondent time spent with palm oil. We selected the top four sources of information reported by respondents (i.e., peer-reviewed articles, fieldwork, workshops, and reports from civil society organizations) plus the IUCN to include in our models. We measured the strength and direction of the monotonic relationship between categorical independent variables using Spearman's rank correlation (S1 Spreadsheet), an approach suitable for Likert-type data [79]. To address multicollinearity, if two predictors were strongly associated (coefficient > |0.7|), we excluded one of the variables from the logit regression model [82]. Based on this logic, we excluded self-reported knowledge of socio-cultural palm oil production impacts from our analysis because it was strongly correlated with knowledge of economic impacts.

Finally, we selected control variables to include as predictors. We note that self-reported measures of knowledge are widely used by researchers yet are inherently subjective [83]. They may produce inconsistent results if they do not represent actual differences between individuals [84]. For example, researchers have found that women under report their knowledge compared to men [85]. Moreover, individual level and contextual factors beyond knowledge (e.g., proximity to palm oil plantations) are likely to influence perceptions [19,22,59,86]. To control for these influences, we included respondent gender and region of residency as predictor variables in our regression models (Table M in S1 Appendix). To generate region of residency, we classified country of residency into seven regions based on FAOSTAT's classification [87], but separated the two main global palm oil-producing countries, Indonesia and Malaysia, from the rest of Asia.

**3.7.2. Ordered logit regression.** Ordered logit regression models are suited for handling ordered responses collected through Likert-type items characterized by, for example, non-equidistant response categories and non-normality in the distribution of ordinal responses [52]. They measure the effect of categorical and continuous predictor variables on the probability of an ordinal outcome variable [53].

To develop our main ordered logit regression models, we used the proportional odds logit regression *(polr)* function from the package *MASS* in R [88], which parameterizes the model as follows [89,90]:

$$logit\left(P(Y \leq j)\right) = \propto_j - \eta_1 x_1 - \cdots - \eta_p x_p, \qquad j = xFEFF; 1, \ldots, J-1 \tag{1}$$

Here, $P(Y \leq j)$ is the cumulative probability that $Y$ (ordinal outcome) falls at or below a specific category $j$ within $J$ categories. On the right side of the equation are the intercepts (α) for each category and coefficients ($\eta$) for predictors ($x$) 1 through $p$. We used the p-value associated with each predictor to assess significant relationships between these predictors and perceptions.

Because these coefficients are not straightforward to interpret, we converted them to odds ratios (*ORs*):

$$OR_i = e^{\eta_i} \tag{2}$$

Odds ratios represent the probability of an individual with a characteristic represented by predictor $x_i$ selecting a more (OR > 1) or less (OR < 1) negative perception. We reported these odds ratios to indicate the direction of the relationship between predictors and perceptions.

**3.7.3. Robustness and sensitivity checks.** We conducted several model robustness and sensitivity checks.

To assess ordered logit regression model goodness of fit, we selected the Lipsitz and Hosmer-Lemeshow tests from the R package *gofcat* [91]. Small p-values <0.05 are an indication of poor model fit. We also report the Akaike information criterion (AIC), an estimator of relative model quality across different model specifications, for all models. For each

model, we computed the variance inflation factor (VIF), which has a lower bound of 1 and no upper bound, in R using the *car* package [92]. VIFs for individual predictor variables ranged from 1.05 to 2.3 across all full and reduced ordered logit regression models. No VIF exceeded 5.0, a level that signifies high multicollinearity, therefore we took no further steps to eliminate correlated variables from our model.

Ordered logit regression requires that the model meets the parallel regression assumption [93]. To assess whether full models passed this assumption, we applied the Brant test using the R package *gofcat* [91]. If the Brant omnibus probability was <0.05 (Table N, Table O and Table P in S1 Appendix), we considered the parallel regression assumption violated.

For the "full" models with a Brant omnibus p-value <0.05, we developed "reduced" ordered logit specifications with fewer predictor variables. To do so, we excluded the variable with the lowest individual p-value <0.05 one by one, until we obtained a Brant omnibus p-value ≥0.05.

Additionally, for all full models with individual predictors that violated the parallel regression assumption (i.e., had a Brant p-value <0.05), we estimated a full generalized ordered logit regression model with heteroskedasticity using the *oglmx* function in the R package *OGLMX* [94]. This approach allowed us to include predictors with Brant test p-values <0.05 in the model's variance equation, which addresses the problem of failing the parallel regression assumption.

We then compared the full ordered logistic regression models to reduced ordered logistic regression models. To do so, we used the likelihood ratio test of nested (generalized) models from the R package *lmtest* [95]. Model comparisons are reported in Table Q and Table R in S1 Appendix. Here, p-values <0.05 indicate that the full ordered logistic regression model represents a better specification than the reduced ordered logistic regression model.

In the main text, we report results from the full or reduced ordered logit regression models that passed the Brant test (Table 1, Table 2, Table 3). In S1 Appendix, we report full ordered logit regression models (Table S, Table T) and full generalized ordered logit regression models (Table D, Table E, Table F).

### 3.8. Difference-in-differences

We predicted that reading the IUCN report would measurably influence perceptions of global conservation community members. To test this prediction, we used a difference-in-differences method. This quasi-experimental technique is designed to measure the causal effect of an intervention (i.e., reading the IUCN report) by comparing differences in an outcome variable (i.e., perceptions of palm oil impacts, conservation intervention effectiveness, and support for a ban) between a treatment and control group before and after the intervention [96]. We designated respondents who did not read the report between surveys or read it before answering the first survey as the control group. For the treated group of respondents who read the report between surveys, we discerned between full and partial reading of the report between surveys (Table M in S1 Appendix). We chose a "gain" score specification for our model [97]:

$$\triangle Y = \beta_0 + \beta_1 T_{all} + \beta_2 T_{part} + \varepsilon \quad (3)$$

Here, ΔY represents the change in perceptions between the first and second surveys. *T* represents treatments of reading *all* or *part* of the IUCN report. In this two-group difference-in-differences design, $\beta_0$ represents the average outcome for the control group and $\beta_0 + \beta_i$ represents the average outcome for the treated group, where $i = 1$ represents reading the full report and $i = 2$ represents reading part of the report [98] (Table M in S1 Appendix). The error terms is ε.

## Supporting information

**S1 Fig. Change in respondent ratings regarding the impacts of oil palm between the initial and follow-up surveys, across individuals who read all, part, or none of the IUCN report.** Blue dashed vertical lines denote the mean change in responses. The y-axis has been scaled to represent the percent of responses in each bin, with zero

representing no change in response and positive (negative) values representing more positive (negative) evaluations of oil palm's impacts. GDP = gross domestic product.
(TIF)

**S2 Fig. Change in respondent ratings regarding the effectiveness of interventions to address the biodiversity impacts of palm oil between the initial and follow-up surveys, across individuals who read all, part, or none of the IUCN report.** Blue dashed vertical lines denote the mean change in responses. The y-axis has been scaled to represent the percent of responses in each bin, with zero representing no change in response and positive (negative) values representing more positive (negative) evaluations of intervention effectiveness. ISCC = International Sustainability and Carbon Certification; ISPO/MSPO = Indonesian/Malaysian Sustainable Palm Oil; RSPO = Roundtable on Sustainable Palm Oil; Latam = Latin America; SEA = Southeast Asia; JAs = jurisdictional approaches; ZDCs = zero deforestation commitments.
(TIF)

**S3 Fig. Respondent knowledge from the initial survey, for respondents who did not read the report before the survey.** (A) Self-reported degree of domain (i.e., economic, environmental, and socio-cultural) knowledge of oil palm's impacts. Percentages are aggregated for the lowest (i.e., not at all and slightly knowledgeable), middle (i.e., moderately knowledgeable), and highest (i.e., very and extremely knowledgeable) categories for each knowledge type. (B) Sources of information regarding the oil palm industry; respondents selected up to three sources. (C) Self-reported percent of respondent time spent on palm oil, timber, and cattle issues. Percentages are aggregated for the lowest (i.e., 0–40%) and highest (i.e., 41–100%) response categories.
(TIF)

**S4 Fig. Respondent knowledge from the initial survey, for respondents who read the draft report before the survey.** (A) Self-reported degree of domain (i.e., economic, environmental, and socio-cultural) knowledge of oil palm's impacts. Percentages are aggregated for the lowest (i.e., not at all and slightly knowledgeable), middle (i.e., moderately knowledgeable), and highest (i.e., very and extremely knowledgeable) categories for each knowledge type. (B) Sources of information regarding the oil palm industry; respondents selected up to three sources. (C) Self-reported percent of respondent time spent on palm oil, timber, and cattle issues. Percentages are aggregated for the lowest (i.e., 0–40%) and highest (i.e., 41–100%) response categories.
(TIF)

**S1 Data. De-identified survey data used in our analysis.**
(XLSX)

**S1 Questionnaire. Initial survey instrument, open from December 2017 to January 2018.**
(PDF)

**S2 Questionnaire. Follow-up survey instrument, open in March 2018.**
(PDF)

**S1 Spreadsheet. Pairwise Spearman's rank correlation between all variables used in regression models.**
(XLSX)

**S1 Appendix. All supplementary tables referenced in the manuscript.**
(DOCX)

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