



## Public engagement promotes consumer choice in favour of sustainable palm oil

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# 1 **Public engagement promotes consumer choice in favour of sustainable palm oil**

## 2 **Abstract**

3 Despite the superior productivity, utility and economic benefits of palm oil compared with  
4 other oil crops, the palm oil industry often receives negative publicity for its environmental  
5 impact and there is widespread confusion over the perception of palm oil. The fact is that it is  
6 difficult to avoid palm oil consumption, and consumer boycotts will do little to resolve the  
7 social and environmental issues associated with oil palm agriculture. Instead, greater  
8 awareness of the importance of certified sustainable palm oil (CSPO) is needed. We used a  
9 mixed-methods survey to explore public awareness of palm oil, and understand the factors  
10 influencing sustainable consumer choice. Our survey, conducted in the Rainforest Biome of  
11 the world-renowned Eden Project in the United Kingdom, a nation with relatively high  
12 environmental awareness, revealed that public awareness of palm oil was generally low and  
13 that consumers had poor knowledge of CSPO. We identified that the most significant barriers  
14 preventing consumer choice for CSPO products were unclear labelling, product availability  
15 and cost. We recommend that the palm oil industry focus on enhancing sustainability,  
16 promoting the benefits and increasing the visibility of CSPO in supply chains and final  
17 products, rather than waiting for consumer choice alone to drive change.

18 **Keywords:** oil palm, public awareness, public perception, consumer habits, sustainability

19

## 20 **Introduction**

21 We are living through the sixth mass extinction and human activities are destroying  
22 biodiversity at a rate significant enough for the Anthropocene to have been named after us  
23 (Pievani, 2014). Highly respected global institutions such as the United Nations (UN) and the  
24 European Parliament have declared a Climate and Ecological Emergency (European  
25 Parliament, 2019; UN Environment Programme, 2021), with public belief in the climate

26 emergency at 81% in the UK (Flynn *et al.*, 2021). The rapid expansion of the palm oil  
27 industry has had major negative consequences for the environment, yet the industry supports  
28 the livelihoods of millions of people globally (Padfield *et al.*, 2019). To resolve this palm oil  
29 paradox, the industry must adopt and develop sustainable practices underpinning the  
30 protection of land for biodiversity, ecosystem function, carbon capture and future crop  
31 production (Meijaard *et al.*, 2018; Corciolani *et al.*, 2019).

32 For more than two decades academic research has considered the impact and  
33 opportunities of the palm oil industry (Padfield *et al.*, 2019), yet the public's perception of  
34 palm oil has been influenced largely by the media (Yan, 2017; Jackson *et al.*, 2019). In 2018,  
35 the Christmas advertisement of a UK-based supermarket chain was not approved for  
36 broadcast by the non-governmental organisation (NGO) Clearcast because it was deemed too  
37 political. The advertisement, originally produced by Greenpeace, featured an animated  
38 orangutan (*Pongo* spp.) named "Rang-tan" and the impact of oil palm expansion on its  
39 rainforest habitat. The supermarket chain had intended to use the advertisement to promote  
40 their decision to remove palm oil and its derivatives from their own-brand products. The  
41 embargo generated major publicity and discussion on social media, as well as a petition  
42 against Clearcast's decision (Mundy, 2018a). The negative response was such that Clearcast  
43 took steps to protect its staff from the backlash, including permanent removal of some social  
44 media presence (Mundy, 2018b). Celebrities and politicians used their social media platforms  
45 to call attention to palm oil and the retailer's boycott of its use (Sweney, 2018). In the week  
46 following the release of the controversial "Rang-tan" advert [11<sup>th</sup> – 17<sup>th</sup> November 2018]  
47 input of the search terms "palm oil" and "sustainable palm oil" into the Google Search engine  
48 peaked in the UK (Mundy, 2018a). However, for every 100 searches using the term "palm  
49 oil", there were just six for "sustainable palm oil" (data extracted using Google Trends,

50 2019), suggesting that the spark in media attention did little to raise public awareness of  
51 sustainable palm oil, as Greenpeace had originally intended (Greenpeace, 2020).

52 A major challenge for producers is the perception that palm oil is an ‘environmentally  
53 damaging’ source of vegetable oil (e.g. Ostfeld *et al.*, 2019; Borrello *et al.*, 2019; Guadalupe  
54 *et al.*, 2019). More than 85% of the world’s palm oil is produced in Indonesia and Malaysia;  
55 the industry’s expansion in these countries has caused irreparable damage to Southeast Asia’s  
56 primary tropical rainforest through habitat clearance (Murphy, 2014), and has reduced their  
57 carbon storage potential (Guillaume *et al.*, 2018). As production continues to expand in  
58 regions of Africa and South America we are likely to see further environmental damage  
59 (Ocampo-Peñuela *et al.*, 2018), with further loss in forest cover destroying biodiversity and  
60 undermining our ability to mitigate climate change (Guillaume *et al.*, 2018).

61 Oil palm expansion undoubtedly threatens biodiversity, but it has not been the sole  
62 driver of biodiversity loss in the tropics (Russell, 2018; Myzabella *et al.*, 2019). For example,  
63 fibre plantations for pulp and paper production, illegal logging and hunting have all  
64 contributed to habitat and species decline (Sodhi *et al.*, 2004; Meijaard *et al.*, 2011; Abood *et*  
65 *al.*, 2015; Jackson *et al.*, 2019). Similarly, the production of palm oil alternatives, which have  
66 lower yields per unit area, can be more environmentally damaging than that of palm oil  
67 (Foster *et al.*, 2011; Parsons *et al.*, 2020). Shifts in consumer choice to palm oil alternatives  
68 would therefore not necessitate a better outcome for biodiversity (Foster *et al.*, 2011;  
69 Meijaard *et al.*, 2018; Jackson *et al.*, 2019). Moreover, consumer boycotts of palm oil can  
70 have significant negative socioeconomic impacts in palm oil producing regions including the  
71 loss of employment and out-competition of smallholders by larger concessions (Lee *et al.*,  
72 2014).

73 Communication campaigns and customer purchasing decisions frequently favour  
74 products which are branded “palm oil free”, and perceived as healthier, more sustainable

75 options compared with those containing palm oil (Borrello *et al.*, 2019, Guadalupe *et al.*,  
76 2019). However, this is not necessarily the case (Jackson *et al.*, 2019), and puts pressure on  
77 the consumer to read product labels in order to detect palm oil and its derivatives. This  
78 approach assumes a high level of awareness and time on behalf of the consumer, and also  
79 depends on the availability of products. Whilst it is possible for consumers to identify and  
80 purchase products containing certified sustainable palm oil (CSPO), cost is likely to be a  
81 barrier preventing the purchase of CSPO or palm oil-free products given that they are often  
82 more expensive (Ostfeld *et al.*, 2019).

83         There is evidently some way to go before the palm oil paradox is resolved, but the  
84 industry has taken major steps to develop a code of conduct under the Roundtable on  
85 Sustainable Palm Oil (RSPO) (Jackson *et al.*, 2019). The RSPO aims to establish a globally  
86 sustainable palm oil industry, currently certifying ~20% of annually produced palm oil as  
87 sustainable (RSPO, 2018a). Alongside stakeholders in the palm oil industry, the RSPO  
88 develops and implements standards for sustainable production based on ethical, transparent  
89 and legal operations, respect for human rights, support for smallholders, optimisation of  
90 productivity, efficiency, positive impacts and resilience and protection, conservation and  
91 enhancement of ecosystems and the environment (RSPO, 2018b). For example, Sime Darby,  
92 an RSPO founding-member company, cancelled planned oil palm plantations in Cameroon as  
93 establishment would have necessitated destruction of existing forest (Feintrenie, 2014).

94         While the majority of sustainable palm oil comes from Southeast Asia, RSPO  
95 certification is on the rise in both South America and West Africa (RSPO, 2018a). Jackson *et*  
96 *al.* (2019) surmised that palm oil could become the most environmentally, socially and  
97 economically sustainable vegetable oil source through adherence to the RSPO principles and  
98 criteria. Given the potential of a globally sustainable palm oil industry, it is essential that we  
99 develop our understanding of the impact that palm oil research has on members of the public,

100 particularly in those nations where palm oil is produced and where it is consumed. The  
101 reaction to “Rang-tan” demonstrated how quickly an environmental campaign, intended to  
102 raise awareness of unsustainable agro-practices, can be ‘hijacked’ by misinformation and  
103 bias. However, impacts and opportunities for the sustainable production of oil palm vary by  
104 biogeographical region, and this requires clear communication to the public. A study by  
105 Reardon *et al.* (2019) found that consumer views of palm oil are shaped by location and can  
106 be impacted by campaigns and flows of information on palm oil. We therefore set out to  
107 establish, by way of introduction, which countries generate the most oil palm publications,  
108 before asking which research themes contribute most to those publications. We then ask,  
109 what is the level of public knowledge of palm oil in a typical consumer country, and how can  
110 consumers be encouraged to embrace sustainable palm oil?

## 111 **Methods**

### 112 **Literature search, selection criteria and data acquisition**

113 Google Scholar’s global database was searched in November 2019 for original peer-reviewed  
114 research, review papers and scientific reports (excluding patents and citations) using the  
115 search term [“palm oil” OR “oil palm”]. We confined the search dates between 2000, the year  
116 in which Myers *et al.* (2000) identified biodiversity “hotspots” threatened by severe habitat  
117 loss and exploitation, and 2018, the last full year of data available at the time of searching.  
118 Cited more than 12,000 times, Myers *et al.* (2000) were the first to associate deforestation  
119 and biodiversity losses with agricultural expansion in the tropics. Our search returned 17,900  
120 publications and consistent with Padfield *et al.* (2019), we found a near exponential increase  
121 in the number of publications per year containing the terms “palm oil” or “oil palm”.

122 To address Question 1, we randomly selected a subset of 200 publications from  
123 Google Scholar. This gave a reasonable sample size, whilst providing good resolution for  
124 analysis. We assigned each publication to a biogeographical region based on the locality of

125 the research. These regions, all key areas of oil palm cultivation and palm oil production,  
126 were Southeast Asia, South America, Africa or Global (where the publication took a global  
127 perspective rather than being region specific). To answer Question 2, keywords were  
128 extracted from the publications and used to align each publication to one of seven research  
129 impact themes: (1) Greenhouse Gas (GHG) Emissions, (2) Biodiversity, (3) Improving  
130 Sustainability, (4) Biofuels, (5) Working Conditions and Livelihoods, (6) Production  
131 Methods and Global Trends, and (7) Deforestation. Previous work has also identified these as  
132 key themes within oil palm literature (Sheil *et al.*, 2009).

### 133 **Questionnaires at the Eden Project**

134 To address Questions 3 and 4 we performed a mixed methods cross-sectional survey at the  
135 Eden Project. This visitor attraction, educational charity and social enterprise is located in the  
136 Southwest of England (Eden Project, 2019). Over one million people visit the Eden Project  
137 annually (Eden Project, 2018), with peak visitor flow in July and August. The visitors include  
138 education groups, local residents and tourists; 90% of visitors are from the UK, with 75%  
139 visiting while on holiday (2019). During schooling periods, adult visitors predominate  
140 alongside formal education school groups, whereas families with children predominate  
141 during school holidays (Elworthy, 2016).

142 The Eden Project's main attraction is the Rainforest Biome, which houses the world's largest  
143 indoor tropical rainforest. It was at the centre of this indoor rainforest that we designed and  
144 built an exhibit on the story of oil palm and palm oil. Our exhibit comprises several full-size  
145 oil palms with information displaying the story of the production, impact, opportunities and  
146 sustainability of palm oil (*Figure 1*). The exhibit, which also features the RSPO logo, is in the  
147 tropical crops section of the Rainforest Biome and all visitors have to pass this section of the  
148 visitor attraction (although they do not have to read the exhibition materials). Using a  
149 convenience sampling approach, we handed questionnaires to members of the public as they

150 passed the palm oil exhibition. A researcher handed out the paper questionnaires to  
151 consenting participants in July and August 2018. Due to high temperatures in the Rainforest  
152 Biome, the questionnaire was designed to take a maximum of five minutes to complete. As  
153 no personal data were collected, participation and the return of a completed questionnaire  
154 indicated consent for data collection. The questionnaire included open and closed questions  
155 about self-rated knowledge of palm oil, awareness of the RSPO logo, awareness of products  
156 containing palm oil, and attitudes towards sustainable palm oil consumption. Critically, we  
157 collected our data before the surge of negative attention engulfed palm oil in November 2018  
158 following the UK supermarket chain advertisement (Sweeney, 2018).

### 159 **Statistical Analysis**

160 After testing data for normality, we used one sample Chi-Square ( $\chi^2$ ) tests to assess the  
161 distribution of (a) the total number of publications by region ( $n = 200$  for all samples across  
162 Southeast Asia, South America, Africa or Global), and (b) publications by research theme. To  
163 assess the distribution of research themes within each of the different equatorial regions we  
164 used Chi-Square tests of independence ( $\chi^2$ ). All data collected from the Eden Project were  
165 transcribed from the questionnaire into Excel v10. A Wilcoxon signed rank test ( $Z$ ) was used  
166 to compare pre- and post-exhibition self-rated knowledge of palm oil. A Spearman  
167 correlation ( $r_s$ ) was used to quantify the relationship between self-rated knowledge and  
168 awareness of palm oil's use in consumable products, and a Mann-Whitney  $U$  test was used to  
169 assess awareness of the RSPO logo based on self-rated knowledge. Content analysis based on  
170 qualitative responses was used to identify the key factors that would encourage consumers to  
171 purchase CSPO products. All statistical analyses were performed in IBM SPSS Statistics for  
172 Windows Version 25.0 (IBM Corp, 2017).

### 173 **Results**

#### 174 **Question 1. Which countries generate the most oil palm publications?**



175 Within the randomly selected subset of publications ( $n = 200$ ), oil palm was the subject of a  
176 significantly higher number of publications in Southeast Asia ( $n = 88$ ) and Global ( $n = 75$ )  
177 than in South America ( $n = 19$ ) and Africa ( $n = 18$ ) ( $\chi^2 = 81.1$ ,  $df = 3$ ,  $p < 0.01$ , *Figure 2*).

178 **Question 2. Which research themes contribute most to those publications?**

179 Key research themes were not distributed equally, with significantly more publications falling  
180 into ‘Production methods and global trends’ ( $n = 49$ ) and ‘Working conditions and  
181 livelihood’ ( $n = 46$ ) than would be expected for an equal distribution (25-30 publications per  
182 theme) ( $\chi^2 = 46.12$ ,  $df = 6$ ,  $p < 0.01$ ; *Figure 3*). Conversely, ‘GHG emissions’ ( $n = 14$ ) and  
183 ‘Deforestation’ ( $n = 10$ ) had significantly fewer (*Figure 3*). The under-representation of these  
184 themes was also apparent in the distribution of publications by research theme within the four  
185 geographical regions, where distribution was also significantly uneven ( $\chi^2 = 0.008$ ,  $df = 18$ ,  $p$   
186  $< 0.05$ ).

187 **Question 3: What is the level of knowledge of palm oil in a typical consumer country?**

188 We collected data from 397 respondents (89% between the ages of 25 – 64 years old) in July  
189 and August 2018. The respondents assigned quantitative values to their knowledge of palm  
190 oil from a pre- ( $n = 395$ ) and post-exhibition ( $n = 375$ ) perspective (no knowledge = 0, some  
191 knowledge = 1, good knowledge = 2, expert knowledge = 3). Respondents generally rated  
192 their pre-exhibition knowledge of palm oil as poor, with a mean ‘knowledge value’ of 0.95 ( $\pm$   
193 0.03). However, visiting the palm oil exhibition increased this to 1.83  $\pm$  0.02, a significant  
194 positive impact ( $Z = -16.13$ ,  $p < 0.001$ ). *Figure 4* highlights this increase in cohort knowledge  
195 and shows that all respondents felt they had at least some knowledge of palm oil after visiting  
196 the exhibition. Complementary to this assessment, we asked respondents to indicate, from a  
197 list of commercially available products, which items that they were unaware contained palm  
198 oil prior to their visit. The greatest ‘unknowns’ were toothpaste, bread, detergent and  
199 shampoo (*Figure 5*). When asked if they were aware of RSPO certification before their visit

200 to the Eden Project, more than 90% ( $n = 387$ ) of respondents reported that they were not  
201 (*Figure 6*). Even after passing through the exhibit containing the RSPO logo, more than 80%  
202 of respondents ( $n = 361$ ) were unable to name the RSPO when their logo's identifying text  
203 was removed (*Figure 6*).

204 To gauge the accuracy of the respondents' self-assessment of their knowledge of palm  
205 oil, we compared their self-rated pre-exhibition knowledge with their pre-exhibition  
206 awareness of products containing palm oil. If their self-assessed knowledge was reasonably  
207 accurate, we would expect to see a negative correlation between their self-rated knowledge  
208 level, on a scale of 0-3, and the number of products that they were unaware contained palm  
209 oil. Indeed, we found a significant negative correlation ( $r_s = -0.371, p < 0.01$ ), indicating  
210 reasonable efficacy of respondents' self-assessment of their pre-visit knowledge levels.  
211 Similarly, respondents who rated their pre-visit knowledge as 'good' were found to be  
212 significantly more aware of the RSPO logo than those with 'some' knowledge ( $U = 6854, p =$   
213  $0.002, Figure 7$ ).

214 However, respondents' pre-visit knowledge of palm oil did not clearly align with pre-  
215 visit awareness of RSPO certification. One respondent, who reported 'expert' level pre-visit  
216 knowledge of palm oil, was not aware of RSPO certification, while ~4% of respondents who  
217 claimed to have 'no knowledge' of palm oil, reported that they were aware of RSPO  
218 certification. Generally, respondents performed poorly when asked to identify the RSPO logo  
219 (*Figure 7*). Only 21% and 7% of respondents who rated their post-visit knowledge as 'good'  
220 and 'expert' respectively were able to correctly name the RSPO logo, despite having some  
221 pre-existing awareness of CSPO and having just visited an exhibition that featured the RSPO  
222 logo.

223 **4. How can consumers be encouraged to embrace sustainable palm oil?**

224 After visiting the Eden Project’s palm oil exhibition, 78% of respondents reported that they  
225 were more likely or much more likely to buy certified sustainable palm oil products.  
226 Respondents identified that the most important factors that would encourage them to buy  
227 products containing CSPO were: (1) protection of primary rainforest (65%); (2) ensuring  
228 workers get a fair price for the palm oil they sell (25%); and (3) improving biodiversity on  
229 plantations (9%). Less than 1% of respondents stated that they ‘would not buy a product  
230 containing CSPO’ (0.3%) ( $n = 312$ ). We also assessed what factors may be preventing  
231 respondents from purchasing CSPO products and found: (1) unclear labelling (33%), (2)  
232 availability of products (24%), and (3) cost (23%) to be the most significant barriers ( $n =$   
233 312). Upon completion of the survey, respondents were asked to “tell us one fact about palm  
234 oil that you learnt from your visit today”. Content analysis of the responses ( $n = 332$ )  
235 produced 409 individual items which were assigned across five categories: (1) the  
236 pervasiveness of palm oil ( $n = 125, 31%$ ); (2) purchasing/consumption and awareness of  
237 sustainable palm oil ( $n = 122, 30%$ ); (3) biodiversity/environmental issues ( $n = 86, 21%$ ); (4)  
238 production and yield ( $n = 74, 18%$ ) and (5) other ( $n = 2, 0.5%$ ).

## 239 **Discussion**

240 Our aim was to explore public awareness of palm oil and RSPO certification and to  
241 understand how the palm oil industry can assist consumers in making informed and  
242 sustainable choices. This is important, as gaining a better understanding of how to harness  
243 consumer purchasing power will be key to driving sustainability further up the global agenda.  
244 In line with Padfield *et al.* (2019), we found that the number of peer-reviewed palm oil  
245 related publications has increased almost exponentially since the year 2000. With the  
246 majority of these publications focussed on Southeast Asia, comparatively few focused on oil  
247 palm agriculture in Africa and South America. This is perhaps not surprising given that  
248 Southeast Asia’s commercial oil palm cultivation boom began shortly after Malaysia’s

249 independence more than 60 years ago (Murphy, 2014), whereas oil palm expansion in other  
250 regions has largely taken place since 2000 (Carrere, 2013; Pardo Vargas *et al.*, 2015). Thus,  
251 the disparity in the number of palm oil publications across production regions that we  
252 observed was likely a fair representation of the distribution of global palm oil research within  
253 the academic literature. While research conducted in Southeast Asia has been largely reactive  
254 to oil palm expansion and its impacts, the likely gaps in knowledge arising from the gap in  
255 research from other growing regions present an opportunity for proactive research and clear  
256 communication of the benefits of sustainable palm oil. By applying knowledge gained  
257 through oil palm development in Southeast Asia to other growing regions in West Africa and  
258 South America, the global palm oil industry could vastly improve its sustainability. The  
259 reaction to the “Rang-tan” campaign demonstrates how public outrage at unsustainable agro-  
260 practices can spur consumer boycotting, but it also highlights the power of campaigning  
261 through storytelling. For example, in order to address the negative association between palm  
262 oil and the decline of the orangutan, there is an urgent need to deliver positive stories from  
263 Southeast Asia. Furthermore, communication of positive and innovative research in areas of  
264 new development, where there is still significant opportunity to develop truly sustainable  
265 palm oil practices, is of the utmost importance. For example, a recent study in Colombia  
266 showed that where oil palm plantations replaced pasture, carbon losses were reduced by 99.7  
267  $\pm$  9.6% when compared to rainforest conversion (Quezada *et al.*, 2019), thereby increasing  
268 the carbon sequestration potential of the landscape and sparing endemic-species-rich forest  
269 ecosystems (Ocampo-Peñuela *et al.*, 2018; Prescott *et al.*, 2016).

270         Publications were assigned to research categories using a ‘best-fit’ method; much of  
271 the research categorised showed some overlap between definitive themes. These overlaps  
272 were most common for ecological and environmental categories where, for example, it would  
273 have been feasible to assign a publication to either the Deforestation or Biodiversity category.

274 Nevertheless, we found ecological and environmental research (i.e. Biodiversity,  
275 Deforestation and GHG emissions) to be under-represented in the literature compared with  
276 publications that considered the social (i.e. Working conditions and livelihoods) and  
277 economic (i.e. Production methods and global trends) impacts and opportunities of oil palm.  
278 This suggests that more oil palm research has been conducted from an anthropocentric, rather  
279 than an ecocentric perspective. Padfield *et al.* (2019) made similar observations, and noted  
280 that peer-reviewed articles containing the terms “palm oil” or “oil palm” were heavily  
281 weighted towards engineering and biofuel topics. Topics such as land use change and  
282 biodiversity were far less common. Although landmark publications such as Myers *et al.*  
283 (2000) have highlighted the ecological consequences of intense anthropogenic activity, oil  
284 palm expansion has continued to drive deforestation and losses to biodiversity (Wilcove *et*  
285 *al.*, 2013). Disparities in the distribution of publications by research theme may indicate that  
286 the ecological and environmental impacts of the palm oil industry are less of a research  
287 priority than social and economic impacts. However, given that research is underpinned by  
288 funding availability, this could also suggest that funding, and especially industrial funding,  
289 favours socio-economic (i.e. anthropocentric) over ecological and environmental (i.e.  
290 ecocentric) research. This is concerning because as production expands in South America and  
291 Africa, where much of the population lives below the poverty line (World Bank, 2019),  
292 socio-economic research and development is likely to be prioritised over that of conservation  
293 (Billé *et al.*, 2012).

294 Our study, in line with previous work by Padfield *et al.* (2019), revealed a substantial  
295 volume of research into palm oil sustainability. Whilst this may highlight an historical  
296 disregard of sustainability (Morgans *et al.*, 2018), it is potentially indicative of a shift in the  
297 industry’s priorities in favour of sustainable development (Padfield *et al.*, 2019). This is  
298 evidenced by the fact that a non-trivial component (~20%) of palm oil produced globally is

299 now certified by the RSPO (Roundtable on Sustainable Palm Oil, 2018a). However, negative  
300 media attention and product boycotting have often drawn attention away from the benefits of  
301 CSPO and efforts to promote its production (Laurence *et al.*, 2010, Jackson *et al.* 2019). For  
302 this reason, we designed the palm oil exhibition in the Rainforest Biome at the Eden Project  
303 to provide the public with a balanced narrative of the scientific evidence on oil palm  
304 agriculture.

305 Our survey at the Eden Project provided a good insight into the public’s awareness of  
306 palm oil before the “Rang-tan” advertising campaign went viral, and an opportunity to  
307 understand the effectiveness of the exhibition as a platform for public engagement of a  
308 complex socio-economic and environmental issue. Our results indicated that engagement  
309 with the exhibit content had a significant and positive impact on respondents’ knowledge of  
310 palm oil and its products. Participants generally had poor knowledge of palm oil and its use  
311 in consumer products, with less than 20% of respondents reporting to have had a ‘good  
312 knowledge’ of palm oil before visiting the exhibition (*Figure 4*). This demonstrates that  
313 despite an exponential increase in palm oil research, a disconnect remains between academic  
314 research and public awareness of palm oil. Thus, exhibitions such as ours at the Eden Project  
315 will become an increasingly important tool for addressing the challenge of convincing  
316 consumers to buy CSPO (Laurance *et al.*, 2010). Awareness of palm oil in consumer products  
317 varied by product type, and we found that respondents were most likely to be unaware that  
318 personal care and household products such as toothpaste (70% unaware) and laundry  
319 detergent (53% unaware) contained palm oil. Consumers were far less likely to be unaware of  
320 palm oil’s prevalence in food products such as margarine (18% unaware) and biscuits (27%  
321 unaware), and this is likely to be a response to palm oil’s portrayal in the media which has  
322 frequently focused on demand from the food industry (Jackson *et al.*, 2019). After visiting the  
323 exhibit, none of the respondents reported ‘no knowledge’ of palm oil. Thus, our results

324 provide further evidence of the effectiveness of scientific exhibits for engaging consumers  
325 and improving awareness of complex environmental issues.

326 A study by Ostfeld *et al.* (2019) revealed that recognition of the RSPO's logo was  
327 effectively zero, and thus recommended that government policies should be amended to  
328 require companies to source 100% CSPO instead of relying on consumers to demand and  
329 purchase products containing CSPO. We similarly observed a near complete inability of  
330 participants to name the RSPO logo, even after visiting the exhibition, which clearly displays  
331 the RSPO logo. This suggests that simply displaying the RSPO 'ecologo' is not enough and  
332 will not be sufficient to encourage a change in the buying habits of consumers. This can be  
333 remedied, as other ecolabels are widely recognised, for example the Fairtrade logo was  
334 recognised by 82% of shoppers in the UK (Ostfeld *et al.*, 2019). Though Fairtrade was  
335 established over 25 years ago, its reputability has been underpinned by extensive outreach  
336 work, advertising and marketing in the mainstream media (Fairtrade Foundation, 2019). At  
337 present, the RSPO logo is rarely used as a consumer-facing label, thus may not be considered  
338 an immediately applicable tool for engaging consumers (Ostfeld *et al.*, 2019). Therefore,  
339 efforts from the RSPO and its member companies to increase visibility within the mainstream  
340 media in countries that are major consumers of palm oil would likely pay dividends in terms  
341 of public understanding, RSPO logo recognition and willingness to support CSPO.

342 Indeed, we found that the Eden Project's palm oil exhibit had a major and positive  
343 impact on the willingness of visitors to support CSPO, with 78% of respondents reporting  
344 that they were more likely or much more likely to buy CSPO products after visiting the  
345 exhibit. This clearly evidences the positive role that tourism attractions and botanical gardens  
346 can play in raising awareness and changing attitudes towards environmental issues. There is  
347 much evidence that tourists value the environment and with targeted, relevant  
348 communications, could be encouraged towards more sustainable consumption behaviour

349 (Font and McCabe, 2017). While visitors to attractions such as the Eden Project could be  
350 considered a key audience for CSPO products, efforts must also be made to ensure that  
351 learning opportunities for improved awareness of CSPO as well as access to products are  
352 available to audiences beyond those who would visit an educational charity and visitor  
353 destination.

354         Despite finding that palm oil publications regarding ‘Biodiversity’ and  
355 ‘Deforestation’ were under-represented in comparison with other themes in the literature,  
356 when we asked visitors at the Eden Project what would encourage them to purchase CSPO,  
357 ‘protection of primary rainforest’ was found to be of the highest priority (65%). When  
358 respondents were asked to relay one fact about palm oil that they had learnt from their visit,  
359 the ‘pervasiveness of palm oil’ (31%) as well as ‘awareness of sustainable palm oil’ (30%)  
360 were most common responses. This contrasts with the broad unawareness of the presence of  
361 palm oil in different product groups that respondents reported before visiting the exhibition.  
362 Reported barriers to purchasing CSPO did not indicate a lack of interest in or willingness to  
363 support CSPO; we identified that unclear labelling, lack of product availability and cost were  
364 the key factors inhibiting consumer choice. The responses provided in our survey of  
365 consumers were generally consistent with those reported from palm oil industry stakeholders  
366 by Padfield *et al.* (2019). Though our respondents did not explicitly state that protecting  
367 biodiversity was the most important factor that would encourage consumers to purchase  
368 CSPO products, the protection of rainforest will certainly serve to protect biodiversity.  
369 Together, this suggests that while consumers are concerned with the prevalence of palm oil in  
370 products, the use of positive messages such as the protection of rainforest or fair prices for  
371 workers will be key to encouraging consumers to make sustainable purchasing decisions  
372 rather than boycotting palm oil altogether. This should alleviate fears from manufacturers and  
373 retailers over drawing attention to the fact that they are using palm oil (Chaudhari and



374 Purkayastha, 2011; Ostfeld *et al.*, 2019), and provide direction for future marketing and  
375 campaigning decisions. In addition, this finding can inform improvement of the RSPO's  
376 operations. The roundtable has attracted criticism for ineffective monitoring and its failure to  
377 halt the destruction of primary rainforest and provide beneficial ecological outcomes for its  
378 approved members (Schouten and Glasbergen, 2011; Morgans *et al.*, 2018). Thus,  
379 prioritization of rainforest conservation, paired with effective communication of this through  
380 campaigns and exhibitions, may increase support and demand for certified palm oil.

381 Awareness in botanical gardens and other relevant settings can have a measurable  
382 impact on awareness and knowledge of palm oil and the issues surrounding it, but this is not  
383 the only form of communication that is needed to effect change. Environmentalism is a fast-  
384 moving field, with foci often changing with each new 'crisis' reported (Goldsmith and  
385 Goldsmith, 2011). Longer-term engagement with relevant information is needed, particularly  
386 in a time when 'fake news' and viral online content can rapidly disseminate facts and  
387 information which may have a negative impact on the environment and wildlife, however  
388 unintended (Clarke *et al.*, 2019). The role of scientists should be dualistic in nature, working  
389 towards engaging the public in discussion while supporting the development and  
390 implementation of sustainable practices. In the UK, the success of a collaborative approach is  
391 demonstrated by Chester Zoo's "Sustainable Palm Oil City" initiative, which has led to  
392 Chester becoming the first sustainable palm oil city in the world. The campaign, alongside  
393 increasing consumer awareness, assisted >50 organisations including manufacturers,  
394 restaurants, cafes, and educational institutions to audit their supply chains and make a time-  
395 bound commitment to using 100% RSPO certified palm oil (Chester Zoo, 2019a). Through  
396 providing a toolkit, educational resources, and an incentive for local businesses, Chester Zoo  
397 expanded its reach to new audiences (Ancrenaz *et al.*, 2018; Chester Zoo, 2019b). They also  
398 addressed some of the key barriers to sustainable palm oil consumption identified by our

399 study, such as unclear labelling and lack of availability. Similar initiatives are now under  
400 development in Bristol, Newquay, and Oxford (Bristol Zoo, 2018; Chester Zoo, 2019c).  
401 Increasing public awareness is key to improving the reputation of sustainable palm oil, and  
402 cross-organisational collaboration will allow stakeholders throughout the supply chain to feel  
403 confident in promoting what has become an essential ingredient to 21<sup>st</sup> Century life.

#### 404 **Conclusions**

405 Consumer awareness of palm oil and its prevalence in products remains low in the UK, as  
406 does knowledge of CSPO, and the RSPO. However, consumers will support rather than  
407 boycott products which protect rainforests, which should encourage manufacturers to  
408 promote their use of CSPO. This will be important in driving change, but the palm oil  
409 industry needs to do more to increase awareness of CSPO. Visitor attractions and educational  
410 charities such as the Eden Project represent an effective opportunity to support public  
411 engagement and raise awareness of the complex underlying issues and the viability of CSPO  
412 as a solution. Public perception of the palm oil industry could be improved through further  
413 outreach work and positive storytelling led by un-biased parties.

#### 414 **References**

415 Abood, S A; Lee, J S H; Burivalova, Z; Garcia-Ulloa and Koh, J L P (2015). Relative  
416 contributions of the logging, fibre, oil palm, and mining industries to forest loss in Indonesia.  
417 *Conservation Letters*, 8: 58-67. <https://doi.org/10.1111/conl.12103>  
418 Ancrenaz, M; Barton, C; Riger, P and Wich, S (2018). Building relationships: how zoos and  
419 other partners can contribute to the conservation of wild orangutans *Pongo* spp. *International*  
420 *Zoo Yearbook*, 52 (1), pp. 164-172.  
421 Billé, R; Lapeyre, R and Pirard, R (2012). Biodiversity conservation and poverty alleviation:  
422 a way out of the deadlock? *Surveys and Perspectives Integrating Environment & Society*,  
423 5(1): 1-15.

424 Borrello, M; Annunziata, A and Vecchio, R (2019). Sustainability of palm oil: drivers of  
425 consumers' preferences. *Sustainability*, 11: 4818. doi:10.3390/su11184818

426 Bristol Zoo (2018). *Palm Oil: Promoting sustainable palm oil*. [https://bristolzoo.org.uk/save-](https://bristolzoo.org.uk/save-wildlife/conservation-and-research/palm-oil-project)  
427 [wildlife/conservation-and-research/palm-oil-project](https://bristolzoo.org.uk/save-wildlife/conservation-and-research/palm-oil-project)

428 Carrere, R (2013). *Oil palm in Africa: Past, Present and Future Scenarios*. World Rainforest  
429 Movement, 79 pp.

430 Chaudhari, A and Purkayastha, D (2011). Greenpeace, Nestlé and the palm oil controversy:  
431 Social media driving change? Report 911-010-1 *IBS Centre for Management Research*, 24  
432 pp.

433 Chester Zoo (2019a). *Chester Named World's First Sustainable Palm Oil City*.  
434 [https://www.chesterzoo.org/whats-happening/zoo-news/2019/03/chester-named-worlds-first-](https://www.chesterzoo.org/whats-happening/zoo-news/2019/03/chester-named-worlds-first-sustainable-palm-oil-city)  
435 [sustainable-palm-oil-city](https://www.chesterzoo.org/whats-happening/zoo-news/2019/03/chester-named-worlds-first-sustainable-palm-oil-city)

436 Chester Zoo (2019b). *Our Sustainable Palm Oil Challenge*.  
437 <https://www.chesterzoo.org/what-you-can-do/our-campaigns/sustainable-palm-oil/>

438 Chester Zoo (2019c). *UK Cities and Towns Join Sustainable Palm Oil City Movement*.  
439 [https://www.chesterzoo.org/news/uk-cities-and-towns-join-sustainable-palm-oil-city-](https://www.chesterzoo.org/news/uk-cities-and-towns-join-sustainable-palm-oil-city-movement/)  
440 [movement/](https://www.chesterzoo.org/news/uk-cities-and-towns-join-sustainable-palm-oil-city-movement/)

441 Clarke, T A; Reuter, K E; LaFleur, M and Schaefer, M S (2019). A viral video and pet lemurs  
442 on Twitter. *PLOS ONE*, 14(1): e0208577. <https://doi.org/10.1371/journal.pone.0208577>

443 Corciolani, M; Gistri, G and Pace, S (2019). Legitimacy struggles in palm oil controversies:  
444 an institutional perspective. *Journal of Cleaner Production*, 212(1): 1117-1131.

445 Eden Project (2018). Eden Project Annual Review 2017/18. Available from  
446 <https://www.edenproject.com/eden-story/about-us/annual-and-sustainability-reports>

447 Eden Project (2019). Admission. <https://www.edenproject.com/buy-tickets-0>

448 Elworthy, J (2016). Eden Project palm oil exhibit proposal to University of the West of  
449 England (UWE). Unpublished market research data

450 European Parliament (2019). The European Parliament Declares Climate Emergency.  
451 [https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/the-european-](https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/the-european-parliament-declares-climate-emergency)  
452 [parliament-declares-climate-emergency](https://www.europarl.europa.eu/news/en/press-room/20191121IPR67110/the-european-parliament-declares-climate-emergency)

453 Fairtrade Foundation (2019). The history of Fairtrade. [https://www.fairtrade.org.uk/What-is-](https://www.fairtrade.org.uk/What-is-Fairtrade/The-impact-of-our-work/The-History-of-Fairtrade)  
454 [Fairtrade/The-impact-of-our-work/The-History-of-Fairtrade](https://www.fairtrade.org.uk/What-is-Fairtrade/The-impact-of-our-work/The-History-of-Fairtrade)

455 Feintrenie, L (2014). Agro-industrial plantations in Central Africa, risks and opportunities.  
456 *Biodiversity and Conservation*, 23(6): 1577–1589.

457 Flynn, C; Yamasumi, E; Fisher, S; Snow, D; Grant, Z; Kirby, M; Browning, P;  
458 Rommerskirchen, M and Russell, R (2021). People’s Climate Vote; Results. UNDP and  
459 University of Oxford, 68 pp.

460 Font, X and McCabe, S (2017). Sustainability and marketing in tourism: its contexts,  
461 paradoxes, approaches, challenges and potential. *Journal of Sustainable Tourism*, 25(7): 869-  
462 883.

463 Foster, W A; Snaddon, J L; Turner, E C; Fayle, T M; Cockerill, T D; Ellwood, M D F; Broad,  
464 G R; Chung, A Y C; Eggleton, P; Vun Khen, C and Yusah, K M (2011). Establishing the  
465 evidence base for maintaining biodiversity and ecosystem function in the oil palm landscapes  
466 of South East Asia. *Philosophical Transactions of the Royal Society B*, 366: 3277–3291.

467 Goldsmith, E B and Goldsmith, R E (2011). Social influence and sustainability in households.  
468 *International Journal of Consumer Studies*, 35: 117–121.

469 Greenpeace (2020). *Palm Oil*. <https://www.greenpeace.org.uk/challenges/palm-oil/>

470 Guadalupe, G; Lerma-García, M; Fuentes, A; Barat, J; Bas, M and Fernández-Segovia,  
471 I (2019). Presence of palm oil in foodstuffs: consumers’ perception. *British Food Journal*,  
472 121(9): 2148-2162. <https://doi.org/10.1108/BFJ-09-2018-0608>

473 Guillaume, T; Kotowska, M.M; Hertel, D; Knohl, A; Krashevskaya, V; Murti Laksono, K;  
474 Scheu, S and Kuzyakov, Y (2018). Carbon costs and benefits of Indonesian rainforest  
475 conversion to plantations. *Nature Communications* 9: 2388. [https://doi.org/10.1038/s41467-](https://doi.org/10.1038/s41467-018-04755-y)  
476 [018-04755-y](https://doi.org/10.1038/s41467-018-04755-y)

477 Jackson, T A; Crawford, J W; Traeholt, C and Sanders, T A B (2019). Learning to love the  
478 world's most hated crop. *Journal of Palm Oil Research*, 31(3): 331-347.

479 Laurance, W F; Koh, P K; Butler, R; Sodhi, N S; Bradshaw, C J; Neidel, D; Consunji, H and  
480 Vega, J M (2010). Improving the performance of the roundtable on sustainable palm oil for  
481 nature conservation. *Conservation Biology*, 24(2): 377-381.

482 Lee, J S H; Garcia-Ulloa, J; Ghazoul, G; Obidzinski, K and Pin Koh, L (2014) Modelling  
483 environmental and socio-economic trade-offs associated with land-sparing and land-sharing  
484 approaches to oil palm expansion. *Journal of Applied Ecology*, 51(5): 1366-1377.

485 Meijaard, E; Buchori, D; Hadiprakarsa, Y; Utami-Atmoko, S S; Nurchahyo, A; Tjiu, A;  
486 Prasetyo, D; Nardiyono, Christie, L; Ancrenaz, M *et al.* (2011). Quantifying killing of  
487 orangutans and human-orangutan conflict in Kalimantan, Indonesia *PLoS ONE* 6: e27491.  
488 <https://doi.org/10.1371/journal.pone.0027491>

489 Meijaard, E; Garcia-Ulloa, J; Sheil, D; Wich, S A; Carlson, K M; Juffe-Bignoli, D; and  
490 Brooks, T M (eds.) (2018). Oil palm and biodiversity. A situation analysis by the IUCN Oil  
491 Palm Task Force. IUCN Oil Palm Task Force Gland, Switzerland: IUCN. xiii + 116pp.

492 Morgans, C; Meijaard, E; Santika, T; Law, E; Budiharta, S; Ancrenaz, M and Wilson, K  
493 (2018). Evaluating the effectiveness of palm oil certification in delivering multiple  
494 sustainability objectives. *Environmental Research Letters*. 13 (6), pp. 064032.

495 Mundy, C (2018a). Response to coverage of decision not to clear the Iceland ad.  
496 [https://www.clearcast.co.uk/blog/clearcasts-md-responds-to-coverage-of-their-decision-not-](https://www.clearcast.co.uk/blog/clearcasts-md-responds-to-coverage-of-their-decision-not-to-clear-the-iceland-ad/)  
497 [to-clear-the-iceland-ad/](https://www.clearcast.co.uk/blog/clearcasts-md-responds-to-coverage-of-their-decision-not-to-clear-the-iceland-ad/)

498 Mundy, C (2018b). Clearcast's MD speaks out on abuse directed at staff following Iceland  
499 decision. [https://www.clearcast.co.uk/blog/clearcasts-md-speaks-out-on-abuse-following-](https://www.clearcast.co.uk/blog/clearcasts-md-speaks-out-on-abuse-following-iceland-decision/)  
500 [iceland-decision/](https://www.clearcast.co.uk/blog/clearcasts-md-speaks-out-on-abuse-following-iceland-decision/)

501 Murphy, D J (2014). The future of oil palm as a major global crop: opportunities and  
502 challenges. *Journal of Oil Palm Research*, 26(1): 1-24.

503 Myers, N; Mittermeier, R; Mittermeier, C; da Fonseca, G and Kent, J (2000) Biodiversity  
504 hotspots for conservation priorities. *Nature*, 403(6772): 853-858.

505 Myzabella, N; Fritschi, L; Merdith, N; El-Zaemey, S; Chih, H J and Reid, A (2019).  
506 Occupational health and safety in the palm oil industry: A systematic review. *The*  
507 *International Journal of Occupational and Environmental Medicine*, 10(4): 159-173.

508 Ocampo-Peñuela, N; Garcia-Ulloa, J; Ghazoul, J and Etter, A (2018). Quantifying impacts of  
509 oil palm expansion on Colombia's threatened biodiversity. *Biological Conservation*, 224:  
510 117-121.

511 Ostfeld, R; Howarth, D; Reiner, D and Krasny, P (2019). Peeling back the label-exploring  
512 sustainable palm oil ecolabelling and consumption in the United Kingdom. *Environmental*  
513 *Research Letters*, 14, 014001. doi: 10.1088/1748-9326/aaf0e4

514 Padfield, R; Hansen, S; Davies, Z G; Ehrensperger, A; Slade, E M; Evers, S;  
515 Papargyropoulou, E; Bessou, C; Abdullah, N; Page, S *et al.* (2019). Co-producing a Research  
516 Agenda for Sustainable Palm Oil. *Frontiers for Global Change*, 2, DOI:  
517 10.3389/ffgc.2019.00013

518 Pardo Vargas, L E; Laurance, W F; Clements, G R and Edwards, W (2015). The impacts of  
519 oil palm agriculture on Colombia's biodiversity: what we know and still need to know.  
520 *Tropical Conservation Science*, 8(3): 828-845.

521 Parsons, S; Raikova, S and Chuck, C J (2020). The viability and desirability of replacing  
522 palm oil. *Nature Sustainability*, 3: 412-418. doi:10.1038/s41893-020-0487-8

523 Pievani, T (2014). The sixth mass extinction: Anthropocene and the human impact on  
524 biodiversity. *Rendiconti Lincei. Scienze Fisiche e Naturali*, 25: 85–93.  
525 <https://doi.org/10.1007/s12210-013-0258-9>

526 Prescott, G; Gilroy, J; Haugaasen, T; Medina Uribe, C; Foster, W.A. and Edwards, D (2016).  
527 Reducing the impacts of Neotropical oil palm development on functional  
528 diversity. *Biological Conservation*. 197pp. 139-145.

529 Quezada, J; Etter, A; Ghazoul, J; Buttler, A and Guillaume, T (2019). Carbon neutral  
530 expansion of oil palm plantations in the Neotropics. *Science Advances*. 5 (11), pp. eaaw4418.

531 Reardon, K; Padfield, R and Salim, H K (2019). Consumers don't see tigers dying in palm oil  
532 plantations: a cross-cultural comparative study of UK, Malaysian and Singaporean consumer  
533 views of palm oil. *Asian Geographer*. 36(2): 117-141. doi: 10.1080/10225706.2019.1621187

534 Roundtable on Sustainable Palm Oil (2018a). RSPO Impact Report 2018. Impacts and  
535 Evaluation Division, RSPO Secretariat, Kuala Lumpur, Malaysia. 86 pp.

536 Roundtable on Sustainable Palm Oil (2018b). Principles and criteria for the production of  
537 sustainable palm oil 2018. Roundtable on Sustainable Palm Oil, Kuala Lumpur, Malaysia.  
538 137 pp.

539 Russell, M (2018). Palm Oil: Economic and environmental impacts. *European Parliamentary*  
540 *Research Service*. [https://epthinktank.eu/2018/02/19/palm-oil-economic-and-environmental-](https://epthinktank.eu/2018/02/19/palm-oil-economic-and-environmental-impacts/)  
541 [impacts/](https://epthinktank.eu/2018/02/19/palm-oil-economic-and-environmental-impacts/)

542 Schouten, G and Glasbergen, P (2011). Creating legitimacy in global private governance: The  
543 case of the Roundtable on Sustainable Palm Oil. *Ecological Economics*. 70(11), pp. 1891-  
544 1899.

545 Sheil, D; Casson, A; Meijaard, E; van Noordwijk, M; Gaskell, J; Sunderland-Groves, J; Werts,  
546 K and Kanninen, M (2009) *The impacts and opportunities of oil palm in Southeast Asia:*

547 *What do we know and what do we need to know?* (51) Bogor, Indonesia: Centre for  
548 International Forestry Research  
549 Sodhi, N S; Koh, L P; Brook, B W and Ng, P K L (2004). Southeast Asian biodiversity: an  
550 impending disaster. *Trends in Ecology & Evolution*, 19(12): 654-660.  
551 Sweney, M (2018). Iceland to let loose animatronic orangutan after Christmas ad ban. The  
552 Guardian. [https://www.theguardian.com/business/2018/nov/14/iceland-let-loose-animatronic-](https://www.theguardian.com/business/2018/nov/14/iceland-let-loose-animatronic-orangutan-after-christmas-advert-ban-palm-oil)  
553 [orangutan-after-christmas-advert-ban-palm-oil](https://www.theguardian.com/business/2018/nov/14/iceland-let-loose-animatronic-orangutan-after-christmas-advert-ban-palm-oil)  
554 UN Environment Programme. 2021. Facts about the Climate Emergency.  
555 <https://www.unep.org/explore-topics/climate-change/facts-about-climate-emergency>  
556 Wilcove, D S; Giam, X; Edwards, D P; Fisher, B and Koh, L P (2013) Navjot's nightmare  
557 revisited: logging, agriculture and biodiversity in Southeast Asia. *Trends in Ecology and*  
558 *Evolution*, 28(9): 531-540.  
559 World Bank (2019). *Poverty and Inequality: Featured Indicators (Poverty headcount ratio at*  
560 *national poverty lines)*. [http://datatopics.worldbank.org/world-development-](http://datatopics.worldbank.org/world-development-indicators/themes/poverty-and-inequality.html#featured-indicators_1)  
561 [indicators/themes/poverty-and-inequality.html#featured-indicators\\_1](http://datatopics.worldbank.org/world-development-indicators/themes/poverty-and-inequality.html#featured-indicators_1)  
562 Yan, N W (2017). A makeover for the world's most hated crop. *Nature*, 543: 306-308.  
563 doi:10.1038/543306a

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### 565 **Competing interests**

566 This work was conducted independently with all authors employed by an academic research  
567 institution, and there are no conflicting interests to declare.

568