

1 **Understanding complex drivers of wildlife crime to design effective conservation**
2 **interventions**
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4

5 **Abstract**

6 In conservation, understanding the drivers of behavior and developing robust interventions to
7 promote behavioral change is challenging and requires a multi-faceted approach. This is
8 particularly true for efforts to address illegal wildlife use, where pervasive - and sometimes
9 simplistic - narratives often obscure complex realities. In this paper, we apply a set of novel
10 techniques in an integrated approach to investigate the drivers and prevalence of wildlife crime
11 in communities surrounding two national parks in Uganda and predict the performance of
12 potential interventions designed to tackle these crimes. Although poverty is often assumed to
13 be a key driver of wildlife crime, we show that better off households, as well as those that suffer
14 from human wildlife conflict and those that do not receive any benefits from the parks' tourism
15 revenue-sharing, are more likely to be involved in certain types of wildlife crime, especially
16 illegal hunting. The interventions predicted to have the greatest impact on reducing local
17 participation in wildlife crime are those that aim to directly address the drivers including,
18 mitigating damage caused by wildlife and generating financial benefits for park-adjacent
19 households. This study demonstrates the power of a triangulated approach in gaining insights
20 into complex and hard-to-access behaviors, and highlights the importance of going beyond
21 single-driver narratives.

22 **Introduction**

23 Overexploitation of wildlife, including illegal use, is one of the greatest threats to the long-term
24 survival of wildlife populations around the globe (Maxwell et al. 2016). Yet, as with many of
25 the challenges currently faced in conservation, formulating an effective strategy to combat this
26 threat is hampered by the complexity of the underlying factors that drive human behavior
27 (Game et al. 2014). In such situations, there is a danger that conservationists rely on simple
28 narratives that paper over the true complexities of a given context. This temptation to intervene
29 based on weakly supported preconceptions particularly plagues efforts to reduce illegal use of
30 wildlife and stem the flow of illegal wildlife products from within protected areas. Here
31 conflicting narratives revolve not just around who is involved and what factors drive people to
32 become involved (Duffy et al. 2016) but also around false dichotomies to describe possible
33 solutions, of which enforcement vs. community engagement (Challender & Macmillan 2014a;
34 Challender & Macmillan 2014b; Phelps et al. 2014) or trophy hunting vs. photo tourism (Di
35 Minin et al. 2016) are just two examples. In the face of such competing arguments, robust
36 interventions require an evidence-based approach in which the relative importance of different
37 behavioral drivers is evaluated using a broad evidence base, and the likely performance of
38 alternative interventions robustly assessed prior to their implementation.

39 The importance of understanding animal behavior is widely acknowledged in conservation
40 science. However, human behavior and the factors that drive it remain woefully
41 underappreciated (Cowling 2014). Yet, in many contexts, it is human behavior that represents
42 the greatest threat to wildlife – no more so than in the case of wildlife crime. Effective
43 conservation action is thus dependent on understanding and addressing the motivations behind
44 that behavior (St John et al. 2013). Research is increasingly being conducted in this area
45 (Mackenzie & Harrter 2013; Nuno et al. 2013; Wilfred et al. 2017) but most studies apply a
46 limited number of methods, without the triangulation or broad perspective needed to reflect the
47 complexity of human behavior (von Essen et al. 2014). Similarly, while the use of predictive
48 methods to investigate the impact of behavior change interventions has increased (Travers et al.
49 2011; Moro et al. 2013; Williams et al 2014; Travers et al. 2016), such approaches remain
50 underutilized.

51 In this paper, we apply a multi-faceted approach to developing effective interventions to tackle
52 wildlife crime. Our approach integrates estimates of actual behavior, qualitative and
53 quantitative investigations of the attitudes and preferences of a range of different actors, and
54 reported future behavior under a series of different interventions designed to address wildlife
55 crime. Combining these different strands of investigation not only provides robust evidence
56 upon which interventions can be developed, but also the basis for future active adaptive
57 management through which progress can be assessed and corrective actions taken if required
58 (Grantham et al. 2010; Fig. 1). We apply such an approach to investigate the drivers and
59 prevalence of wildlife crime in villages surrounding Uganda's two largest national parks, Queen
60 Elizabeth Protected Area (QEPA) and Murchison Falls Protected Area (MFPA), and examine
61 the likely effectiveness of alternative interventions proposed to address wildlife crime within
62 the two parks. Uganda has strict protection laws for natural resources, such that, unless the
63 Uganda Wildlife Authority (UWA) has granted prior approval, extraction of most resources
64 inside protected areas is illegal. Consequently, wildlife crime covers a wide range of offences
65 from the collection of medicinal plants to hunting elephants for ivory. Hence, there is a wide
66 variety of actors engaged in wildlife crime with a diverse set of motivations, operating in
67 different areas (Critchlow et al. 2015), making effective policies to reduce wildlife crime
68 challenging to develop.

69 While there has been a long history of community engagement associated with Uganda's
70 protected areas, notably around Bwindi Impenetrable National Park (Blomley et al. 2014), this
71 has typically not received the same level of investment as law enforcement for most protected
72 areas. Expenditure on enforcement-based interventions to combat wildlife crime accounts for a
73 significant proportion of annual budgets at park level (Plumptre et al. 2014; Critchlow et al.
74 2015). Where community engagement approaches have been implemented by UWA, the focus
75 has mostly been on outreach and education, coupled with measures to mitigate wildlife damage
76 to crops and livestock. Efforts have also been made to increase the benefit park-adjacent
77 communities receive from protected areas through a process of revenue sharing (whereby 20%
78 of park entry fees are allocated to local governments to invest in development projects, such as
79 clinics, schools and small livestock schemes; Tumusiime & Vedeld 2012) and through formal
80 agreements with a small number of specialized resource users (e.g. collectors of firewood or
81 building materials) which provide for limited access to the parks. However, doubts remain as
82 to the effectiveness of these approaches (Infield & Namara 2011; Blomley et al. 2014,
83 Twinamatsiko et al. 2018), in particular their ability to change behavior rather than attitudes.

84 Here we apply the approach described in Fig. 1 to bring greater understanding of the relative
85 importance of different drivers of five commonly encountered wildlife crimes (firewood
86 collection, illegal grazing, illegal fishing, subsistence hunting and commercial hunting) in the
87 two study parks. We did this through a socio-economic survey of households living around
88 QEPA and MFPA, which included an indirect questioning component to improve willingness
89 to give truthful answers about sensitive behaviors (the unmatched count technique, UCT; Nuno
90 et al. 2013). We estimate the prevalence of the five wildlife crimes and investigate the profiles
91 of households engaged in these crimes. We couple this with two empirical approaches, scenario
92 interviews and a discrete choice experiment, to assess the likely performance of six alternative
93 interventions being considered by UWA to combat wildlife crime (Table 1). These included
94 "wildlife friendly" enterprises, wildlife scouts (local volunteers who help protect against crop-
95 raiding), increased law enforcement patrol effectiveness, regulated hunting using revenue-
96 sharing fund to support human wildlife conflict (HWC) mitigation, and the removal of resource
97 access agreements. We triangulate the findings of these empirical approaches against key-
98 informant interviews with active and reformed wildlife offenders and UWA staff.

99 **Methods**

100 The study employed a mixed methods approach, combining three survey-based instruments (a
101 socio-economic household survey, scenario interviews and a choice experiment) with
102 qualitative key-informant interviews and group discussions. Due to considerable linguistic
103 diversity between the two parks, it was necessary to employ two teams of enumerators for the
104 three survey-based methods (refer to SI for further details on our approach to control for this).

105 **Socio-Economic Household Survey**

106 A socio-economic household survey was conducted with 1968 households living in frontline
107 villages, which for the purposes of this study were defined as villages either directly bordering
108 QEPA or MFPA, or with at least 50% of village area within 3km of a park boundary. Villages
109 were stratified by district and randomly selected proportionally with the length of boundary
110 within each district and the sample size selected to ensure an even sampling distribution around
111 each park. Within each village, households were randomly selected from a list of households
112 maintained by village authorities. Data collection ran between February and May 2015. The
113 survey focused on key socio-economic variables thought to affect household involvement in
114 wildlife crime, including household poverty, livelihood strategy, participation in resource or

115 revenue sharing, experience of wildlife damage and perceptions of living close to conservation
116 areas. The selection of these variables was informed by a review of the relevant literature from
117 Uganda and elsewhere (Harrison et al. 2015b). Household poverty was measured using two
118 compatible approaches: the basic necessity survey (Davies and Smith 1998) and the Ugandan
119 multi-dimensional poverty index (UMPI; UBOS 2014a), a measure used by the Uganda Bureau
120 of Statistics to monitor national poverty levels. Both approaches use an index calculated from
121 household ownership of key assets and access to basic services that capture different
122 dimensions of poverty. Items for inclusion in the basic necessity survey were generated through
123 six participatory workshops held in park-adjacent villages.

124 **Unmatched Count Technique**

125 The prevalence of illegal activities among local people was investigated using an indirect
126 questioning method, the unmatched count technique (Nuno & St John 2015), which was
127 included as part of the socioeconomic household survey. Under this method, respondents were
128 shown a series of five cards, each relating to a different offence (firewood collection, grazing,
129 fishing, subsistence hunting and commercial hunting). At the beginning of each interview,
130 respondents were randomly allocated to either the control or treatment group. Control
131 households were shown cards with pictures of four non-sensitive items and were asked to give
132 the number of items relevant to them. For example, the control card relating to firewood
133 collection had four legal sources of firewood and respondents were asked to give the number
134 of items from which their household had obtained firewood in the past year (refer to SI for
135 further detail regarding the experimental design of the UCT). Treatment households were
136 shown cards containing the same items as the control cards but with the addition of one sensitive
137 item relating to the specific offence in question. For example, the firewood treatment card
138 contained an additional photo that represented collecting firewood from the adjacent park. The
139 composition of each card was designed such that all cards contained one item that was expected
140 to be relevant to nearly all respondents and one item that was expected to be relevant to none
141 of the respondents. In this way, responses were expected to fall within the upper and lower
142 bounds (i.e. between one and three for the control cards and between one and four for the
143 treatment cards), thereby ensuring that it was not possible to ascertain which of the items were
144 relevant to individual respondents.

145 **Choice Experiment**

146 The choice experiment was used to elicit the preferences of local people for five of the
147 interventions under consideration (experimental constraints led to the exclusion of removing
148 resource access agreements from the choice experiment) and was conducted with 394 people.
149 All respondents had previously been interviewed as part of the socio-economic household
150 survey. Each respondent was presented with six choice cards in turn and for each card asked to
151 select one of two unlabeled alternatives they preferred. No opt out option was given. Each
152 alternative was described by five attributes (the proportion of revenue sharing funds to be
153 allocated to mitigating HWC, the number of wildlife scouts recruited in each village, the
154 probability that illegal hunters would be caught, whether regulated hunting was permitted or
155 not and average earnings from the development of wildlife friendly enterprises). Each attribute
156 had two or three distinct levels (refer to SI for further detail on the experimental design of the
157 choice experiment). All interviews were followed by a short debriefing session.

158 **Scenario Interviews**

159 To predict how each intervention was likely to perform if implemented, scenario interviews
160 were conducted with 119 people following the method used by Travers et al. (2016; refer to SI
161 for further detail on the experimental design of the scenario interviews). As with the choice
162 experiment, each respondent had previously participated in the socio-economic household
163 survey. Interview respondents were presented with a series of future scenarios, each describing
164 one of the interventions under consideration. For each scenario, respondents were asked how
165 they would respond. As the main indicator of behavior change, household involvement in
166 wildlife crime, is sensitive and vulnerable to bias, three proxy indicators were selected for
167 investigation in the scenario interviews: i) time allocation to non-sensitive, legal livelihoods, ii)
168 the perceived fairness of each intervention and iii) the probability of providing UWA with
169 information about illegal activity.

170 **Key Informant Interviews**

171 Key informant interviews were conducted with national and park level UWA staff, self-reported
172 hunters and bushmeat traders. The aim of interviewing hunters was to collect qualitative data
173 regarding their motivations, the methods they employ and their perceptions of the different
174 interventions considered in the scenario interviews and choice experiment. Interviews were
175 semi-structured and conducted with 50 active or reformed hunters in eight villages located
176 around MFPA. The responses of five known hunters were found to be highly inconsistent and
177 were removed from subsequent analysis. Key national and park level UWA staff were
178 interviewed individually regarding their perceptions of the factors that drive local people to
179 become engaged in illegal activities and which interventions they considered to be most
180 effective at addressing wildlife crime. In addition, a two-day workshop was held in July 2015
181 to investigate the preferences of headquarter and park level UWA staff for interventions to
182 combat wildlife crime.

183 **Analysis**

184 Hierarchical Bayesian regression models were used to analyze the results of the UCT, choice
185 experiment and scenario interviews. All analysis was conducted using the package rstan,
186 version 2.8.0 (Stan Development Team 2015a), in R, version 3.2.2 (R Core Team 2015).
187 Weakly informative half-Cauchy prior distributions (mean = 0, SD = 5) were assigned to
188 predictor standard errors following the Stan reference manual (Stan Development Team 2015b)
189 and an uninformative LKJ prior (shape factor = 1) was assigned to the covariance matrix.
190 Adequate convergence was indicated by taking Gelman-Rubin statistics with values ≤ 1.01
191 and visual inspection of traceplots. Four chains were analyzed in parallel, with the number of
192 burn-in iterations set to achieve time convergence. Standard deviations and credible intervals
193 for probability estimates at the 95% level were found by calculating the probability distribution
194 of each response state using the estimated parameter values for each post-warm up run. Analysis
195 of the UCT was split into two models (see SI for further details). Model 1 was used to produce
196 estimates of the mean prevalence of each of the five wildlife crimes and included interaction
197 terms between card type (i.e. the resource in question) and a treatment dummy as the only
198 predictor variables. Model 2 was used to investigate the drivers of illegal hunting (both
199 subsistence and commercial) and included additional interaction terms between card type, the
200 treatment dummy and household socio-economic characteristics as predictor variables.

201 **Results**

202 **Prevalence and drivers of wildlife crime**

203 We estimated the proportion of households across the two study sites that had engaged in the
204 five wildlife crimes at least once in the previous year (Fig. 2a, SI Table SI.1). These estimates
205 highlight the significant difference in the prevalence of the five wildlife crimes, ranging from
206 11% (95% credible interval (CI): 0.03, 0.19) of households for firewood collection to 42%
207 (95%CI: 0.32, 0.51) commercial hunting. They also show that the two crimes expected to have
208 the greatest impact on wildlife (subsistence and commercial hunting) are the most prevalent
209 among households living around MFPA and QEPA.

210 One of the most pervasive narratives associated with wildlife crime is that people hunt because
211 they are poor and the potential earnings, particularly for high value species such as elephants
212 or pangolins, are too great to ignore (Duffy et al 2016). However, our findings suggest that, for
213 our study area, this narrative is too simplistic. Contrary to the expected relationship, poorer
214 households were significantly less likely to illegally hunt than better off households (Fig. 2b,
215 SI Table SI.2). Better off households in the sample had levels of wealth that put them in the
216 middle class bracket nationally. Of the two possible explanations for this result (that households
217 are more likely to hunt because they are better off or that they have become better off through
218 hunting), the latter is supported by the findings of interviews conducted with known hunters.
219 People who hunt for at least 15 days per month reported earnings ranging between US\$120-
220 500 per month, which is significantly greater than average household income in Uganda (UBOS
221 2014b).

222 The findings of the hunter interviews suggest that a lack of alternative employment options may
223 be a more important driver than material poverty. The need to earn money was cited as the
224 primary motivation to hunt by 39 of the 42 interviewed hunters asked, with several claiming
225 that no alternative means of earning money was available to them, particularly during the dry
226 season. This leads some people to hunt to meet specific needs, such as medical bills or school
227 fees, while for others hunting is the primary income source. In contrast, providing meat for
228 domestic consumption was only cited as the primary motivation to hunt by two of the 42
229 interviewed hunters. The interviews with hunters also suggested that achieving higher social
230 status, which is accorded only to a few senior hunters in each village, was not a significant
231 motivation for most.

232 In addition to the potential financial benefits, households that had reported suffering from HWC
233 were 65% more likely to hunt commercially and 80% more likely to hunt for subsistence than
234 those who had not (Fig. 2b). Similarly, households that felt they had not benefited from revenue
235 sharing were 27% more likely to hunt commercially and 36% more likely to hunt for
236 subsistence (Fig. 2b) than those that had not. These results are important, as they suggest that
237 how local people perceive the costs and benefits of living near protected areas is directly
238 correlated with their behavior. It also shows that how people perceive benefits to be distributed
239 may be more important than the reality of the situation as, in many cases, people were found to
240 be unaware of local development projects had been funded by revenue sharing. If people
241 perceive benefits to be distributed unfairly, negative behaviors may develop that might
242 otherwise not have been present (Harrison et al. 2015a).

243 Another factor that may influence involvement in wildlife crime is the likelihood of being
244 caught and the severity of penalties (Keane et al. 2008). Key informant interviews conducted
245 with known hunters suggested that the threat of ranger patrols was not a sufficient deterrent to

246 bring about behavior change. The individual rate of encounters with patrols (ranging from
247 seeing rangers inside the park to being chased or direct ranger interactions) reported by hunters
248 was approximately 1 in every 5 incursions into the park, whereas the reported detention rate
249 was only 1 in every 500-1000 incursions. Hunters also suggested that the penalties issued, if
250 arrested, were not a deterrent. The average sentence for the 13 interviewed hunters who had
251 been previously arrested was three months in prison and a US\$120 fine (equivalent to the
252 expected earnings from just eight incursions). Despite reports of fatal shootings or hunters
253 going missing inside the park, hunters use these low detention rates and limited consequences
254 of arrest to justify their belief that the benefits of hunting outweigh the risks.

255 **Stakeholder preferences for anti-wildlife crime interventions**

256 While preferences alone are not always a true indicator for how people behave, they are an
257 important consideration in the selection and design of programs aiming to change behavior (St
258 John et al. 2010). The results of the discrete choice experiment reveal the preferences of local
259 people, measured on a scale ranging from -1 (the least preferred option) to 1 (the most preferred
260 option), for five interventions (Table 2). At MFPA, the most preferred option was the
261 introduction of wildlife friendly enterprises (mean preference (pref)=-0.49; 95%CI: 0.19, 0.83),
262 closely followed by wildlife scouts. The preferences of people living around QEPA were
263 notably different, with mitigation for HWC the most preferred intervention (pref=-1.00;
264 95%CI: 0.60, 1.45). This is particularly striking, as people living around MFPA expressed no
265 preference for mitigation for HWC, except through wildlife scouts. The least preferred
266 intervention, with negative preferences at both sites, was regulated hunting. This may be
267 slightly surprising given the high proportion of households estimated to be hunt illegally, but
268 was explained in debriefings by an overall distrust that such a scheme could be managed
269 sustainably or equitably and by the fact that it had no financial benefit, as all offtake would be
270 meant for home consumption. The only exception to this was for people who were already
271 members of resource user groups, who expressed neither preference nor aversion for regulated
272 hunting at either MFPA (pref=-0.01; 95%CI: -0.18, 0.15) or QEPA (pref=-0.05; 95%CI: -0.08,
273 0.20). More surprising was the mild support found at both sites for increased effectiveness of
274 law enforcement, which runs counter to the common assumption that local people are opposed
275 to ranger patrols.

276 For UWA staff from both parks, the preferred anti-wildlife crime intervention options were
277 elicited through a separately held workshop. These were: i) increasing the effectiveness of law
278 enforcement through ranger patrols, intelligence gathering and raising awareness among local
279 magistrates, ii) wildlife friendly enterprises and iii) mitigating HWC. Encouragingly, the most
280 preferred interventions match those of local people expressed through the choice experiment,
281 although the order of preference differs, with UWA staff prioritizing law enforcement.

282 **Predicted effectiveness of interventions in reducing wildlife crime**

283 The results of the scenario interviews suggest that wildlife friendly enterprises were likely to
284 be the most effective means of increasing the percentage of people who would allocate more
285 time to pursuing legal activities at both MFPA (87%; 95%CI: 50%, 100%); Fig. 3a, SI Table
286 SI.3) and QEPA (64%; 95%CI: 16%, 97%). For the households that reported suffering from
287 HWC (one of the categories of household most likely to be involved in wildlife crime), wildlife
288 friendly enterprises, wildlife scouts and mitigating HWC were all found to be highly effective
289 at encouraging people to spend more time pursuing legal livelihoods at both sites. This shows
290 that, although the response to these interventions may differ between the two parks, three of the

291 interventions considered are predicted to have a significant impact on the behavior of the people
292 most likely to be involved in illegal hunting.

293 With respect to the perceived fairness of the interventions considered, wildlife friendly
294 enterprises, HWC mitigation and wildlife scouts were all considered either 'very fair' or 'fair',
295 with no difference observed between the two sites (Fig. 3b, SI Table SI.4). Wildlife friendly
296 enterprises again performed best, with a higher probability of being considered 'very fair' than
297 both HWC mitigation (99.7% of model runs) and wildlife scouts (100% of model runs).
298 Although withdrawing resource access agreements was generally found to be fair or very fair,
299 only 7% of people who already belonged to resource user groups considered this to be fair or
300 very fair. Conversely, while only 33% of non-members of resource groups found regulated
301 hunting to be fair or very fair, group members widely perceived this to be a fair intervention
302 (88% fair or very fair). These findings suggest that, although local perceptions of certain
303 conservation interventions are widely positive, perceptions of other interventions will vary
304 according to a group's experience of similar interventions or the expected impact on their
305 livelihoods.

306 The interventions predicted to be most likely to encourage communities to provide intelligence
307 and information about illegal activities to UWA were, again, wildlife friendly enterprises,
308 mitigating HWC and wildlife scouts (Fig. 3c, SI Table SI.5). For these three interventions, the
309 percentage of people who felt they would be more likely to provide information was 82%
310 (95%CI: 68%, 97%), 79% (95%CI: 63%, 95%) and 57% (95%CI: 39%, 75%) respectively. A
311 small percentage of people (29%; 95%CI: 10%, 45%) were also more likely to provide
312 information under regulated hunting, while removing resource access had no effect. These
313 results suggest that community engagement approaches can be effective not just in reducing
314 opportunity for households to engage in wildlife crime, but also in improving relations with
315 park authorities so that people feel more inclined to provide assistance to law enforcement
316 efforts.

317 **Discussion**

318 The demand for evidence-based conservation interventions (Sutherland et al. 2004; Pullin &
319 Knight 2005; Ferraro & Pattanyak 2006; Cook et al. 2010) requires sufficient evidence on
320 which to base decisions. Where commonly held but untested narratives feed into decision-
321 making, underlying assumptions about behavioral drivers should be interrogated. In Uganda,
322 as elsewhere (Duffy et al. 2016), there is a widespread belief that poverty is a leading cause of
323 wildlife crime. However, our findings suggest that the situation is more nuanced than this, with
324 better off households more likely hunt illegally than poorer households. While this suggests
325 that immediate need may not currently be a primary driver, opportunities to earn money remain
326 limited in many rural communities. Hence, poverty may have been the original driver of hunting
327 for households that have since become better off through hunting. Involvement in wildlife crime
328 offers an additional income stream, which in some cases is highly lucrative, such that those
329 involved have a competitive advantage over households that choose not to be. A focus on poorer
330 households may therefore miss the households that have the greatest impact on wildlife. Instead,
331 a broader focus on the creation of income-generating opportunities, particularly during seasons
332 in which agricultural labor demands are low, may be more effective. It is important, however,
333 that efforts to provide such opportunities learn from the lessons of past programs that were
334 often based on weak assumptions, such as the substitutability of livelihoods (Wright et al. 2016).

335 It is also important to understand local people's perceptions of conservation (Bennett 2016) and
336 the role these can play in determining behavior and intervention outcomes.

337 Our finding that people who perceive that their wellbeing is suffering due to HWC, or do not
338 feel like they are benefiting from revenue sharing, are more likely to be engaged in illegal
339 hunting suggests that local attitudes towards park authorities (and conservation more widely)
340 cannot be ignored. It also suggests that outreach and educational activities, which have been a
341 focus of UWA's community engagement, are unlikely to be sufficient to elicit behavior change.
342 Where investment has been made in incentive-based projects, these have often not been
343 sufficiently linked to conservation outcomes or the specific behaviors that pose a threat to
344 wildlife (Harrison et al 2015a). Encouragingly, our results predict that people who suffer HWC
345 – precisely those whose behavior we aim to influence – are more likely than others to change
346 their behavior if interventions that directly address these concerns are implemented. This result
347 reflects our overall finding that interventions that address the underlying drivers of wildlife
348 crime are most likely to result in positive outcomes. This argues against blanket application of
349 particular "in vogue" approaches across a range of circumstances, but rather for targeting
350 specific interventions to address specific drivers of wildlife crime. At MFPA, our findings
351 suggest that wildlife friendly enterprises, which enhance the income-generating potential of
352 agricultural products (thereby reducing the need to use wildlife crime as an alternative source
353 of income), may be most effective. At QEPA, increasing investment in long-term, effective
354 mitigation of HWC may be a more important step to improving people's perceptions of
355 conservation and their relations with park authorities. Currently, despite public commitment to
356 tackling HWC, some within UWA consider that local people should be responsible for
357 preventing the damage caused by wildlife. Although this corresponds to research that has shown
358 that locally administered mitigation activities tend to be more effective (Hedges et al. 2010), it
359 ignores the costs incurred by local people (both through damage to crops, livestock and people
360 and in implementing mitigation measures). Providing greater and more consistent financial
361 support for mitigation measures would improve the situation.

362 Our finding that increasing the effectiveness of law enforcement would, on average, be
363 positively received by local people (in addition to being strongly supported by UWA staff) is
364 encouraging because it suggests that it may be possible to change the social acceptability of
365 wildlife crime. It also dispels the idea that law enforcement and community engagement are
366 discrete choices, whose objectives are automatically opposed. This is supported by our finding
367 that local reporting of illegal activities, an essential element of efforts to combat illegal trade in
368 high value species (Linkie et al 2015; Cooney et al. 2016), is predicted to be increased through
369 greater community engagement. This would require an improved working relationship between
370 local people and rangers, since the provision of information is risky for informants and requires
371 effective and timely support from law enforcement personnel (Wilkie et al. 2016), again
372 highlighting the need for local support of law enforcement activities. A balanced approach, in
373 which law enforcement and community engagement interventions are complementary actions,
374 would therefore be most effective in incentivizing behavioral change.

375 In addition to predicting the effectiveness of conservation interventions, the feasibility of their
376 implementation should be considered. For alternative livelihood projects, which have a history
377 of mixed success, investment in local institutions is critical. This can take significant investment
378 of both time and financial resources, and requires sufficient capacity within wildlife authorities.
379 UWA's community conservation staff lack the skills, budget and manpower needed to design
380 and support such programs. Consequently, while wildlife friendly enterprises are predicted to
381 perform well in reducing wildlife crime, it may be some time before they can have a meaningful
382 impact. Conversely, greater and more consistent investment in mitigating HWC should result
383 in more immediate impacts and UWA staff are already familiar with many of the measures to
384 be put in place. A sensible strategy may be to invest first in greater protection from HWC, both

385 as a means of reducing the costs associated from living close to wildlife and improving
386 relationships between the park staff and local communities. At the same time, UWA's
387 community conservation staff can be trained to design, implement and monitor more complex
388 livelihood programs. Strategic partnerships with other sectors of government (e.g. agricultural
389 extension or social protection) could also be used to leverage greater impact from such
390 interventions.

391 By taking the novel approach of integrating an investigation of the drivers of wildlife crime
392 with a predictive assessment of the effectiveness of alternative interventions, we have identified
393 the actions most likely to reduce illegal wildlife use at the two national parks. The
394 recommendations derived from this research have since been incorporated into park-level
395 action plans to address wildlife crime (Travers et al. 2017) and are currently being piloted at
396 MFPA. This piloting process will enable greater understanding of the costing, feasibility and
397 likely impact to be obtained. However, it is important to recognize that at a finer scale than we
398 considered here, there are likely to be other sociological, historical and cultural factors that will
399 affect both how people behave, and how they perceive and respond to interventions aimed at
400 reducing wildlife crime. In the event that similar approaches to ours are implemented on a wider
401 scale, it is important that the local context is taken into account, as illustrated by the finding
402 that preferences for different interventions varied between QEPA and MFPA. This will be
403 particularly true for Uganda's forested parks that are likely to have a different set of drivers
404 from the largely savannah woodland parks included in this study (Harrison et al. 2015b).
405 Consequently, any wider rollout should be accompanied by a process of monitoring and active
406 adaptive management to account for changing conditions and the inherent uncertainty
407 associated with the use of predictive approaches (Grantham et al 2010).

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Tables

Table 1: Intervention options considered for combatting wildlife crime at QEPA and MFPA.

Intervention	Description
Human wildlife conflict mitigation	50% of revenue sharing funds would be allocated to activities aimed at mitigating human wildlife conflict.
Wildlife scouts	Two people from each village would be employed by UWA to respond to incidences of human wildlife conflict in their village.
Wildlife friendly enterprises	A “wildlife friendly” enterprise scheme, for which participation would be dependent on signing an agreement not to be involved in wildlife crime. Average earnings would be 500,000 shillings per year and non-compliant households would be suspended for one year.
Increased patrol effectiveness	The probability that illegal activities within the parks is detected would be increased by a factor of 10.
Removal of resource access	All formal agreements between UWA and local communities that allow certain resources to be harvested from the parks would be withdrawn.
Regulated hunting	Resource access agreements would be expanded to allow certain species to be hunted using permitted methods. Only hunting for home consumption would be permitted and offtake numbers and zones in which hunting was permitted would be set each year.

Table 2: Local people’s preference estimates¹ for intervention options aimed at reducing wildlife crime at MFPA and QFNP. Sample N = 394.

Coefficient	Posterior mean (95% credible interval)	
	Murchison Falls NP	Queen Elizabeth NP
Human wildlife conflict mitigation	0.05 (-0.23, 0.34)	1.0 (0.60, 1.45)
Wildlife scouts	0.38 (0.20, 0.59)	0.64 (0.37, 0.97)
Wildlife friendly enterprises	0.49 (0.19, 0.83)	0.35 (0.03, 0.68)
Increased patrol effectiveness	0.09 (0.01, 0.17)	0.23 (0.12, 0.36)
Regulated hunting	-0.14 (-0.28, -0.02)	-0.08 (-0.20, 0.04)

¹ Relative preferences range on a possible scale from -1 (least preferred option) to +1 (most preferred option)

Figure Legends

Figure 1: An adaptive management cycle for addressing wildlife crime in which the investigation of stakeholder attitudes and preferences, estimation of current behavior and behavioral drivers and application of predictive approaches can inform the design of interventions.

Figure 2: 2a. Estimates of the percentage of households involved in illegal activities. 2b. Marginal effect of household covariates on the percentage of households involved in subsistence and commercial hunting. Error bars show 95% credible intervals. N = 1968.

Figure 3: Paneled figure of three scenario interview indicators (A. time allocation; B. intervention fairness; C. probability of providing information). For each scenario (each bar), the probability of possible responses is shown. Figure 3A gives the probability of responses for households that suffer/do not suffer from human wildlife conflict (HWC) in both MFPA and QEPA. Figure 3B gives the probability of responses for households with/without resource access. N = 119.

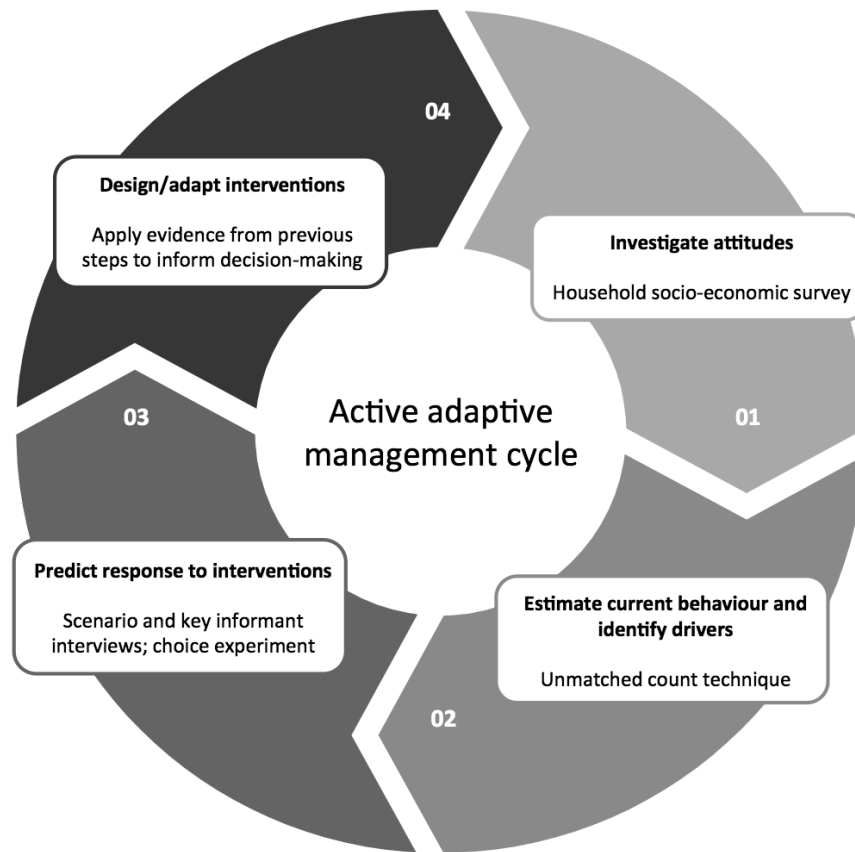


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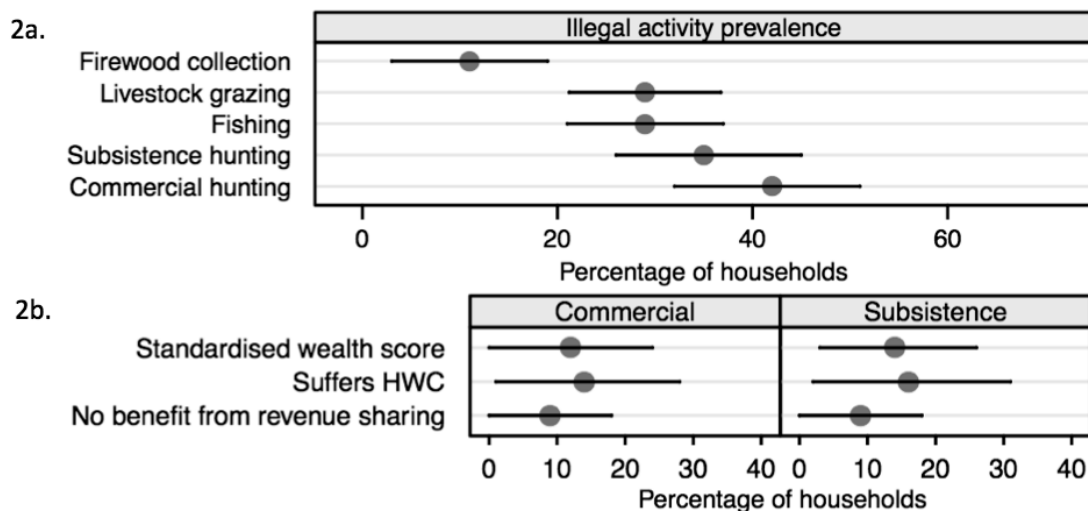


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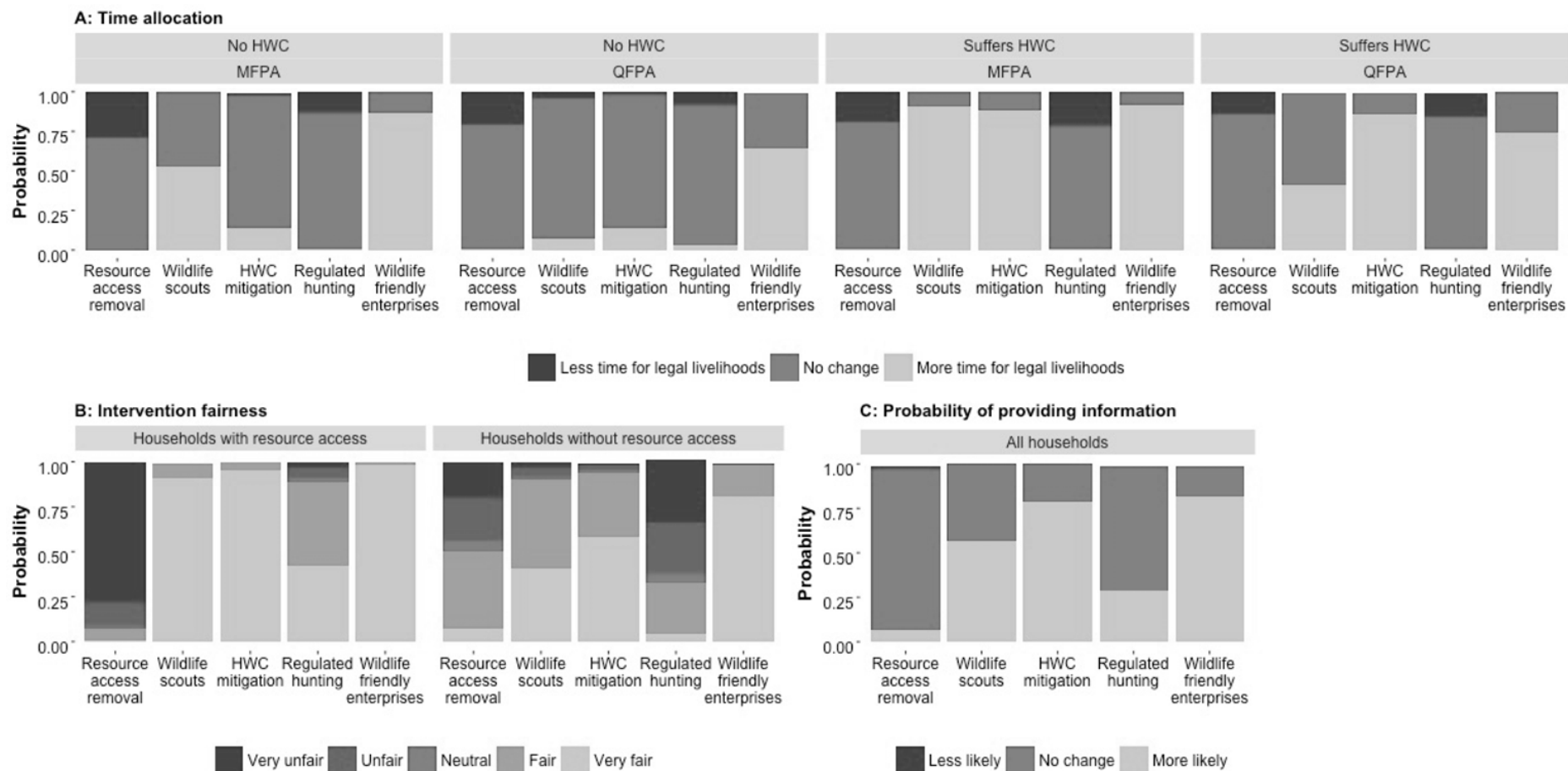


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