PUBLICATION INFORMATION

14

Food and livelihoods in park-adjacent communities:

The case of the Odzala Kokoua National Park

17

18 Germain A. Mavah [a,b], Stephan M. Funk [c], Brian Child [a], Marilyn E. Swisher [a], Robert
19 Nasi [d], John E. Fa [d,e*]

20

21 [a] *Center for African Studies, 3141 Turlington Hall, PO Box 117315, University of*

22 *Florida, Gainesville, FL 32611-7315, USA*

23 [b] *Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460,*

24 *USA*

25 [c] *Centro de Excelencia en Medicina Traslacional CEMT, Av. Alemania 0458,*

26 *Universidad de la Frontera, Temuco, Chile*

27 [d] *Center for International Forestry Research, CIFOR Headquarters, Bogor 16115,*

28 *Indonesia*

29 [e] *Division of Biology and Conservation Ecology, School of Science and the*

30 *Environment, Manchester Metropolitan University, Manchester M1 5GD, UK*

31
32 *Corresponding author.

33 *E-mail address*: jfa949@gmail.com (J.E.Fa)

34   **ABSTRACT**

35

36   Protected areas (PAs) in Central Africa provide unprecedented opportunities to

37   maintain ecosystem integrity and safeguard the unique wildlife of one of the most

38   biodiverse regions in the world. However, conflicts exist between wildlife protection,

39   and the needs of human populations adjacent to PAs. Although the use of wildlife

40   resources within PAs is nominally regulated, wildlife exploitation in the areas

41   surrounding parks benefit human nutrition and livelihoods of adjacent populations. In

42   2013-2014, we interviewed 28% of all known households in 37 villages surrounding

43   the Odzala Kokoua National Park (OKNP), Republic of Congo. We gathered

44   information on bushmeat consumption, income, material assets, and hunter

45   perception of the state of wildlife. We show that bushmeat species (mostly duikers,

46   small monkeys and porcupine) were consumed in 38-48% of meals, and 20-30% of

47   households earned cash from hunting wildlife in most villages; more than any other

48   single source of revenue, except cocoa. Although it remains unknown whether the

49   park was a reservoir for wildlife for areas around the studied villages, we showed

50   that more bushmeat was consumed closer to OKNP. By contrast, income from

51   bushmeat sales in villages closer to markets was greater, and as a corollary, market

52   access and household wealth were positively correlated. Overall, total household

53   income, income from bushmeat sales, travel time, and distance to the OKNP were

54   good predictors of household wealth. Wildlife, although considered more abundant

55   around villages closest to the park, was perceived as generally declining around all

56   village groups. Our results highlight the possible importance of PAs and adjacent

57   areas as reservoirs of wildlife and in maintaining wild meat resources used by the

58   surrounding human populations.

59

62

1. Introduction

Carefully managed protected areas (PAs) remain the cornerstone for the conservation of dwindling natural resources (Coad et al., 2015). PAs also play a significant role in providing ecosystem services for adjacent human communities, by benefiting these directly, for example through the consumption of food produced or obtained in or around PAs (Taylor, 2009; Stolton and Dudley, 2010; Ferraro et al., 2011; Turner et al., 2012). Indirect benefits are manifold and include income and employment (Angelsen and Wunder, 2003). However, park-adjacent communities experience costs e.g. no entry into nearby PAs, and their lack of acceptance of these rules can influence support for PAs and subsequent conservation related behaviours (Acquah et al., 2017). If not properly managed and included in management plans, these communities can generate negative impacts on biodiversity, human livelihoods, and human well-being (Ghimire and Pimbert, 1997; West et al., 2006; McElwee, 2010; Barrett et al., 2011; Redpath et al., 2013).

Satisfying basic needs of people living near PAs puts enormous pressure on the environment. One of the key challenges facing such communities in tropical forest areas is how to meet the need for sufficient, safe and nutritious food without exhausting the resources available. Often park-adjacent peoples rely on wild meat as the main source of sustenance and even livelihoods. However, unsustainable hunting of wild animals even within PAs is the most commonly reported threat (Schulze et al., 2018), due to mounting human population pressures, technological advances and the emergence of a booming commercial wild meat trade. Overexploitation of wild meat has direct impacts on the survival of some targeted species, especially large mammals (Dirzo et al 2014, Ripple et al, 2016), and will

88 affect the availability of sufficient foods to meet the dietary needs of those peoples

89 reliant on this resource. Ultimately, rural communities have the option of managing

90 existing wild meat resources more sustainably, turning to alternatives (including the

91 production of cash crops to generate income to buy food), or hunting wildlife to local

92 extinction and then moving to other source areas.

93

94   In the Republic of Congo (ROC), tropical moist forests cover over 200,000

95 km^2 or around 66% of the country (Mayaux et al., 2013). Significant populations of

96 species of high conservation concern (e.g. elephants, gorillas, chimpanzees, etc.)

97 are found within the 200 PAs (11.7% of the country's area) as well as within

98 unprotected forests. The latter include stretches of forest managed by logging

99 companies that exploit the important economic timber resources are also found

100 within the country's forests (Doumenge et al., 2015). Logging operations allow

101 access to remote areas and encourage more people to settle within concessions in

102 search of jobs, thus increasing hunting pressure for bushmeat (Clark et al., 2009;

103 Poulsen et al., 2009, 2011; Nasi et al., 2012). Increased hunting pressure can be

104 reduced or prevented through partnerships between timber companies and

105 conservation organisations, which can be successful in promoting the sustainable

106 management of wildlife resources within logging areas (Clark et al., 2009).

107

108   Understanding the role that PAs and logging concessions play in supplying

109 wild meat to the adjacent communities is essential to resolve or even prevent conflict

110 between policy-makers, local people, and managers (Oldekop et al., 2015).

111 Ensuring that wild meat is sustainably managed in areas peripheral to PAs will

112 positively contribute to the protection of biodiversity. To determine the level of

113 dependence on wild meat versus other foods and income sources it is crucial to

114 obtain data from which to establish a causal connection between people's livelihoods

115 and protected area management (Pullin et al., 2014). Foerster et al. (2011)

116 contrasted resource use and livelihoods in communities less influenced by a newly

117 established PA (i.e. further away from the park) and those closest to it. The influence

118 of proximity to the PA was significant. However, similar investigations in which the

119 use of resources and livelihoods in communities at different distances away from a

120 PA are scarce. In this paper, we study the contribution that park resources (wild

121 meat) and cultivation make to the livelihoods and well-being of communities located

122 at different distances from the Odzala-Kokoua National Park (OKNP) and the

123 Ngombé Forest Management Unit (NFMU), in the northern ROC. Thus, by

124 comparing communities that traditionally rely on park resources with those that do

125 not, we can develop future management strategies that balance human welfare and

126 conservation of biodiversity. We employ a cross-sectional design (De Vaus, 2001) to

127 examine how livelihoods and use of wildlife resources vary according to the distance

128 to the park and markets as predictor variables (Salafsky and Wollenberg, 2000;

129 Foerster et al., 2011). We test two main hypotheses: (1) greater market access

130 increases income from bushmeat sales and agriculture (mainly cocoa in this region)

131 and both are linked to higher household wealth, and (2) shorter distances to the park

132 increase the volume of bushmeat consumed and sold, and hence household income.

133

134 **Methods**

135 *2.1.   Study area*

136   The study area is located in northern Congo, Central Africa, 1.61361˚N,

137 16.05167˚E (Fig. 1). Human population density is around 0.8 inhabitants km^2

138 (unpublished data). The two main ethnic groups found in the area include several

139 Bantu sub-ethnicities (70%) and indigenous Pygmies (30%). The two groups have

140 co-existed for centuries. The main human settlement in the region is the town of

141 Ouesso, with about 30,000 residents. It is rapidly growing because new roads

142 connect it to Brazzaville and logging activities draw immigrants. There is also a

143 logging town, Ngombé, as well as several villages.

144

145   The OKNP is a protected area officially proclaimed a national park in 1935,

146 making it one of the oldest national parks in Africa. With 13,546 km^2 it is part of the

147 TRIDOM Transfrontier Park, which extends from the Congo into Gabon and

148 Cameroon (Kamdem-Toham et al., 2003). A secondary road from Ouesso to Sembé

149 (hereafter the OS road) in the west borders the northern perimeter of the park. The

150 Ouesso to Brazzaville road (N2) is found to the east of the park (Fig. 1).

151

152   The OKNP is situated within the catchment area of the Mambili River, which

153 drains the area towards the south. The park is within the savanna-forest boundary of

154 north-central Congo, allowing for a high biodiversity of flora and fauna, with species

155 from forest and savanna. The area is densely wooded in the northwest; towards the

156 south and east the forest becomes more open. In the south of the park an extensive

157 forest-savanna mosaic is found, including gallery forests and dry and swamp

158 savannas. Climate is typically equatorial with two dry and two wet seasons, 1,500

159 mm annual rainfall and a mean annual humidity of around 80%. Temperatures are

160 moderately high (23-25°C), with a low annual temperature range of 1-2°C

161 (Hecketsweiler et al., 1991).

162

2.2.   Village selection

164   Our study was conducted in villages located on the Ouesso-Sembé, Ouesso-

165   Liouesso, and Ouesso-Pikounda road axes (Fig. 1). Study villages were classified

166   into four comparison groups based primarily on their distance to Ouesso (one group

167   close, two distant groups and one quasi inaccessible), their proximity to OKNP, and

168   their most important economic activity; cocoa cultivation differentiates the two distant

169   groups (Table A1).

170

171   *2.3.   Household data collection*

172   From July 2013 until June 2014 we gathered information from a total of 386

173   households (28% of the 1,382 known households), within 37 study villages in the

174   four village groups. Table A1 details main characteristics of the four village groups as

175   well as the number of villages and households sampled. Households were selected

176   at random within each study village where we conducted semi-structured

177   questionnaires with each household head (Table A2). Each questionnaire took

178   about 45 minutes to administer. They were applied by the principle investigator (PI),

179   a Master's student from Congo´s National School of Agricultural and Forestry

180   Sciences and a hired local guide. The PI trained the student and the guide. All three

181   interviewers conducted questionnaires in all villages in order to avoid biased results,

182   which might be introduced by subtle impacts of interview style on interviewees.

183

184   We documented household composition (number, age, and sex of all

185   household members), education, income, wealth and food consumption. To

186   determine the overall health status of all household members aged >1 year old, we

187   estimated the average of all household members' individual body mass index (BMI).

188   Individual household wealth was determined, first, by establishing an inventory of

189   cash reserves, household possessions and stocks of food items for own

190   consumption or sale. We then assigned monetary values to all possessions and food

191   items as declared by the respondents using current trading values in the local

192   currency, FCFA, as a baseline. The total estimated wealth was transformed into $US

193   using the exchange rate 1 $US = 500 FCFA. From these we partitioned the

194   distribution of wealth of all households into five quintiles, "poorest", "poor", "middle

195   income", "rich", and "richest". Each Individual household was then assigned to its

196   corresponding category or wealth index relative to all surveyed households. A

197   household´s total income and its income from bushmeat was valued as absolute

198   estimates in $US. Analyses of income from specific items (including bushmeat and

199   cocoa, Table A3) considered absolute values and percentage of the total income (i.e.

200   relative bushmeat income). Community coherence was estimated by the community

201   trust index and the perception of wildlife abundance by the interviewee´s assessment

202   (Table A3).

203

204   *2.4.   Statistical analyses*

205   The non-parametric Kruskal-Wallis test was used to examine whether the

206   samples come from village groups with equal medians. Boxplots were drawn to

207   visualize the distribution of data for the village groups. The alternative hypothesis is

208   that at least one pair of group villages has unequal medians. We quantified the

209   relationship between livelihood activities indices with the potential mediating

210   factors using the Spearman's rank correlation coefficient r_s and subsequently tested

211   for statistical significance. Because the same data set was used for several tests the

212   sequential Bonferroni correction (Holm, 1979), also known as the Holm-Bonferroni

213 correction, was applied and the corrected $p´$-values were report alongside the

214 uncorrected p-values. The sequential Bonferroni correction is increasingly being

215 rejected because it results in a low statistical power (Moran, 2003; Nakagawa, 2004).

216 To account for this problem, we did not decide on significance when $p < \boldsymbol{\alpha}=0.05 < p´$.

217 Significance applied for cases when $p < p´ < \boldsymbol{\alpha}=0.05$ and high significance for $p < p´$

218 $< \boldsymbol{\alpha}=0.01$. Because the regression analysis involving all pairwise comparisons of the

219 selected variables would result in a large number of multiple tests, we made the *a*

220 *priory* decision to apply statistical tests only to those pairwise correlations where the

221 absolute value of r_s, $|r_s|$, was larger than 0.1. This is a reasonable trade-off between

222 reducing statistical power by a larger number of multiple test and not further

223 evaluating cases where low values of r_s indicate a low explanatory power whether

224 the correlation is significant or not.

225

226 We evaluated the interactions between the potential mediating factors and

227 their effect on relative income from bushmeat by using a linear mixed effect model as

228 implemented in the lme4 package for R (Bates et al., 2014). We constructed a series

229 of models aided by the correlation coefficients between relative income from

230 bushmeat versus potential mediating factors and their significance, as calculated by

231 r_s. Altogether five parameters were significantly correlated with relative income from

232 bushmeat. As random effects the intercepts for village and village groups were used.

233 P-values were estimated by likelihood ratio tests for the full model against the model

234 without the specific fixed effect. All analyses were conducted using the R statistical

235 environment (R Foundation for Statistical Computing, 2016).

236

237

3. Results

3.1. Characteristics and market access of surveyed villages

Summary statistics of the socio-economic and livelihood variables across the four village groups, as well as the results of the Kruskal-Wallis tests, are shown in Table 1 (more details in Table A1). For the 37 villages sampled, we surveyed an average (Mean ± SD) of 12.2 ± 6.6 (group 1), 8.7 ± 5.5 (group 2), 12.2 ± 5.0 (group 3) and 6.0 ± 2.9 (group 4) households per village.

Group 4 villages were the furthest settlements from OKNP (approx. 16 times further away than group 1), about four times further than group 1 from Ouesso market. Group 2 and group 3 villages were closest to OKNP and between three and four times further away from Ouesso market than group 1. Travel times to Ouesso corresponded with the actual distance by road from village groups 1 to 3 but was significantly longer for group 4 villages due to their location away from main roads; this difference was highly significant (Table 1).

3.2. Households, income and expenditure

Across all villages, household size varied between 3 and 5 persons. Median and mean household size were highest for the two village groups closest to OKNP, with differences being highly statistically significant. Age of respondents did not vary significantly among villages, thus questionnaires were unbiased by age and, thus, experience of the respondents.

Education levels were similar among all village groups but the most remote village group (group 4) did not contain any person with a university education. Mean

263   household BMI was comparable between groups 1, 2 and 3, but slightly lower in

264   group 4, though the differences were not statistically significant. The community trust

265   index for all villages was low overall (median ≤ 2.3) with the exception of village

266   group 4 which was highest (median 2.7); differences were significant.

267

268   All households in the four village groups relied heavily on wild food resources

269   (ranging from 65% to 72% amongst village groups, Fig A1), followed by domestic

270   products (22% to 35%), imported meat (less than 8%) and other sources (less than

271   5%). Only village group 4 did not consume imported meat or other resources, relying

272   more on domestic products.

273

274   Differences between village groups in their monthly household income were

275   highly significant; highest values were reported for groups 2 and 3, medium values

276   for group 1 and lowest values for group 4. Income sources were highly diverse (Fig.

277   A2), including bushmeat sales, farming, cocoa, fishing, small commerce, salaries,

278   raphia wine, corn liquor, palm oil, gathering of NTFPs such as eru (*Gnetum*

279   *africanum*), livestock, and other activities such as handicrafts. However, income was

280   largest from the sale of bushmeat (ranging from 22% to 34% amongst village

281   groups), farming (13% to 28%), and cocoa cultivation (10% to 49%). Absolute and

282   relative incomes from bushmeat differed significantly between village groups (Fig. 2)

283   with the highest absolute incomes from this source reported from group 3 (mean =

284    $42, median = $0 and maximum = $480) and the lowest for group 4 (mean = $11,

285   median = $0 and maximum = $190). The statistical comparison yielded, however, an

286   undecided result. Income from cocoa was similarly distributed with highest values in

287   group 4 and lowest in group 4. In contrast to bushmeat the differences were highly

288   significant.

289

290   Total food expenditure was highly significantly different between village

291   groups and was lowest in group 4 (Table 1).

292

293   *3.3.   Wealth*

294   According to our wealth index, around 60% of all rural households were

295   extremely poor, with less than 10% considered rich (Table 1). Highest proportions of

296   extremely poor and poor people were found in group 2 (21.17%) and in group 4

297   (28.33%). Rich households were less common in group 2 (9.68%) and group 3

298   (8.66%). There were no rich people in group 4. Across village groups, wealth was

299   highly skewed and significantly different (Table 1, Fig. 2). Relative income from

300   bushmeat was more highly skewed across village group than absolute income (Fig.

301   2). The smallest and largest percentages were in group 4 and 3 villages,

302   respectively.

303

304   *3.5.   Relationships between bushmeat incomes and expenditures versus potential*

305   *mediating factors*

306   Correlations (r_s) between bushmeat and total incomes and expenditures relative

307   to potential mediating factors for all respondents are shown in Table 2.

308

309   Travel time to the market in Ouesso and distance to the OKNP were all

310   negatively correlated with expenditures and incomes. Total and relative incomes

311   from bushmeat versus travel time and distance, and the total income versus the

312 distance to the OKNP had relatively high r_s values, which were significant or highly

313 significant in all cases i.e. incomes and expenditures were highest for both

314 scenarios: nearer to the market and nearer to the OKNP. Bushmeat expenditure

315 contributed a large proportion of total consumption expenditure ($r_s = 0.49$) and was

316 highly significant. Bushmeat expenditure was also highly significantly correlated with

317 total income but to a smaller degree than total consumption expenditure ($r_s = 0.18$).

318 Income from cocoa was positively correlated with total income but negatively with the

319 relative income from bushmeat. Thus, the more cocoa sales the less the relative

320 income from bushmeat or vice versa. Wealth was significantly or highly significantly

321 correlated with all income and expenditure parameters (Fig. 3). Correlation was

322 negative only for absolute and relative bushmeat income, which indicates that

323 reliance on bushmeat income was associated with lower wealth. The data also

324 confirm that body mass indices were positively correlated with total income and

325 expenditures levels; whether total income and expenditure stemmed from bushmeat

326 or not had no effect. People reliant on bushmeat income, whether absolute or

327 relative to the total income, had higher trust in their communities than those that

328 depended less on bushmeat, reflecting a higher social coherence amongst

329 bushmeat hunters.

330

331   Linear mixed models for relative income from bushmeat were built using the

332 absolute values of the correlations r_s in Table 2 as guidelines. The null model based

333 of the mean jointly with intercepts for villages and villages groups as random effects

334 was significantly different from the model with wealth as a fixed effect (likelihood ratio

335 test: $\chi^2 = 21.35$, df = 1, $p<0.00001$). The latter model was significantly different from

336 the model with wealth and travel time to the market as fixed effects ($\chi^2 = 8.12$, df = 1,

337    $p = 0.0043$). The addition of the distance to the OKNP and cocoa sales were not

338   significant ($\chi^2 = 0.008$, df = 1, $p = 0.93$ and $\chi^2 = 0.18$, df = 1, $p = 0.67$, respectively).

339   The model with wealth, travel time and the community trust index as fixed effects

340   was significantly different to the model of wealth and travel time only ($\chi^2 = 16.12$, df =

341   1, $p = 0.00006$). As the wealth and community trust indices might be interdependent,

342   we also evaluated the model of wealth, travel time and the community trust index

343   allowing for travel time x community trust interaction and compared with the model

344   without interaction. No significant interaction effects were observed ($\chi^2 = 0.39$, df = 1,

345    $p = 0.54$). The final model produced fixed effects of 0.28 ± 0.083 for the intercept, -

346   0.02 ± 0.005 for the time to the market, -0.48 ± 0.127 for wealth and 0.11 ± 0.026 for

347   the community trust index, respectively.

348

349   **4.   Discussion**

350   *4.1.   Market access, household income and bushmeat sales*

351   The variations of household income and bushmeat sales can be explained by

352   the villages' accessibility to markets in Ouesso (i.e. travel time), and by the ability to

353   sell their products to passengers along the road that connects Ouesso to Brazzaville.

354   The sale of forest products is an important source of household income, and part of

355   an income diversification strategy (Shackleton et al., 2011).

356

357   Market access is critical in generating income from bushmeat, farming, and

358   cocoa. This is clearly demonstrated by the fact that Village group 4, the remotest

359   group of settlements (travel to Ouesso only along the Sangha River, since there are

360   no roads) relied on subsistence uses rather than market sales. Thus, poor market

361   access results in lower household incomes. In this group of villages, forest product

362   prices are lower than prices in the other three village groups where there are local

363   weekly markets because of the easy access to Ouesso. Moreover, consumers travel

364   regularly from Ouesso to buy rural products, particularly bushmeat, an important

365   commodity sold by rural households (Bennett and Robinson, 2000). This possibility

366   improves household incomes. The high income of group 3 from cocoa cultivation

367   also emphasizes the importance of markets for household incomes. These villages

368   are on the Cameroon border, and since the cocoa crisis in the early 1990s, traders

369   from Cameroon buy cocoa in this area (Russell et al., 2011) but neglect plantations

370   elsewhere in the Congo.

371

372   Group 3, with the highest average household income from cocoa cultivation

373   has important implications for the discussion on alternative livelihoods and poaching.

374   The assumption is often made that cocoa can be an important alternative income

375   source that as a consequence will reduce the need for people to obtain cash and

376   therefore reduces hunting pressure. However, these villages also have the highest

377   average income from bushmeat ($41.8). This is because most cocoa plantation

378   owners were older, whereas most young people (who neither own nor inherit cocoa

379   plantations) were active in bushmeat hunting. Russell et al. (2011) argue that young

380   people turn to illegal hunting activities in the absence of access to land. Another

381   contributing factor is that group 3 is closer to the park, and although they are further

382   from markets than other village groups the status of the road is better. Group 1

383   ($26.7 as income from bushmeat sales) is far from the park but near to Ouesso while

384   group 2 ($30.5 as income from bushmeat sales), the group 1 is closest to Ouesso

385   but further from the park.

386

387   *4.2.   Household daily food expenditure*

388   Household expenditure on daily meals differed among village groups. The

389 three groups with easy access to Ouesso spent more money in comparison to group

390 4, demonstrating that income is affected by market access. In village group 4, with

391 no access to markets, people hunt more for subsistence rather than for trade, and

392 each family tries to produce what they need (e.g. cassava, raphia wine, palm oil,

393 maize). In rural areas, bushmeat consumption may be associated with people's

394 preferences or their culture, but the scarcity of bushmeat can push consumers to

395 change their preferences. In the largest towns in the country (i.e. Brazzaville and

396 Pointe Noire), bushmeat is a luxury good consumed by rich people (Mbete et al.,

397 2011). Although many people living in these cities originate from rural areas with

398 bushmeat-eating habits, they cannot afford bushmeat and are forced to consume

399 other sources of animal protein (Wilkie et al., 2005; Mbete et al., 2011). So rich

400 people in cities diversify animal protein intake to include bushmeat, whereas poor

401 people consume only the cheapest protein such as domestic meat (Auzel and Wilkie,

402 2000; Wilkie et al., 2005).

403

404   *4.3.   Wealth*

405   People are poorest in the remote villages with few markets (group 4) and also

406 in the villages nearer Ouesso (group 1) where forest products and wildlife, which

407 constitute the main source of income, are severely depleted because of human

408 pressure. Villages close to the park but further from Ouesso (groups 2 and 3)

409 presumably benefit from wildlife dispersing out of the park where hunting is still

410 productive, supporting a weekly bushmeat market. As noted, cocoa cultivation is a

411   major source of income contributing about 49% of income in group 3, but aside from

412   this localized group, cocoa farming is underdeveloped in the study area.

413

414   *4.5.   General findings and conclusions*

415   Overall, we show that household income is negatively associated with

416   distance to the park, with household consumption expenditures, income from cocoa

417   sales, and wealth index, but is not related to travel time. These associations suggest

418   that people with better access to markets and the park tended to be richer because

419   of their income primarily from bushmeat sales, whereas those further away from the

420   park obtained less revenue from bushmeat and were overall poorer. Foerster et al.

421   (2011) report similar findings for Gabon, in which the authors suggest that because

422   richer hunting zones are found closer to the park, people in these localities are able

423   to hunt more and to sell. Greater access to wildlife also had an effect in permitting

424   beneficiaries to spend more money on bushmeat than poorer people, but also to sell

425   more bushmeat. However, wealthier people depended less on selling bushmeat, but

426   those who sold bushmeat were generally poor. Other studies suggest this (Scherl,

427   2004; Shackleton et al. 2011).

428

429   Dependence of rural peoples on forest resources is marked, as shown in our

430   study. Wildlife is an important source of both cash and food, similar to other locations

431   around the Congo basin (Wilkie and Carpenter, 1999; Wilkie et al., 2006; Van Vliet

432   and Nasi, 2008; Foerster et al., 2011) and in some African drylands (Von Richter and

433   Butynski, 1973). In our study, hunters are pushed to sell much of the bushmeat they

434   harvest for markets in Ouesso and even beyond (Brazzaville), where bushmeat is a

435   popular delicacy and usually sell at much higher prices. Such increase in commercial

436   hunting and trade to secondary towns and large cities in the country places

437   unprecedented pressures on wildlife populations in the region. This situation may be

438   reflected in the responses given by interviewed hunters who suggest that in all

439   villages, except those furthest away, wildlife is perceived to be decreasing. As shown

440   in other studies in the region (Noss, 1998; Muchaal and Gandjui, 1999; Poulsen et

441   al., 2009) current harvest rates around the OKNP could be much higher than

442   sustainable levels.

443

444   With growing human populations, urban areas, roads, and markets the

445   demand for bushmeat increasingly threatens its sustainability. More importantly, the

446   demand for bushmeat is growing in the absence of local regulations to protect

447   wildlife resources. Scarcity should drive up both the price and the production of

448   wildlife, but in the absence of clear property rights wildlife is exploited rather than

449   produced sustainably. Legally, wildlife is owned by the central government which is

450   unable to exert its "rights of exclusion" and the richest wildlife habitats are rarely

451   visited by most governmental agencies which in any case lack the human and

452   financial resources to effectively enforce laws even in even easy to reach areas

453   (Rowcliffe et al., 2004) - the government officials' "authoritative reach exceeds their

454   implementational grasp" (Murphree, 2000:4). The result is a humanly constructed

455   stalemate and an economically incoherent wildlife economy, where local people

456   deplete the resource over which their livelihood depends, while the state lacks

457   strategies and the human and financial resources to enforce laws at the village level.

458   In public meetings, people regularly stated "wildlife is for the state" and asked "how

459   can we take care of something that doesn't belong to us?" Thus, central control of

460   wildlife management disenfranchises local people, causing them to shirk any

461   responsibility for a resource that is "owned" by an outside entity. The seeming lack of

462   local conservation action despite the key contribution of wild resources to local

463   livelihoods is a paradox. The likely cause is weak local property rights (Schlager and

464   Ostrom, 1992; Hanna et al., 1996) and disempowerment of local people with respect

465   to their wildlife.

466

467   Given the high dependence of human livelihoods on forest resources in our

468   study area, as in other similar localities, the future of wildlife and PAs may lie in the

469   sustainable use of wild resources rather than non-use to strengthen the resilience of

470   the poor (Roe and Elliott, 2004; Sanderson and Redford, 2003). Livestock is not an

471   effective alternative activity to bushmeat hunting for forest dwellers in central Africa

472   (Russell et al., 2011) but, even if it were, the result of encouraging people to use

473   livestock rather than wildlife is simply for domestic species to replace wild ones. The

474   ecological reality is that forests (and drylands) often cannot produce more raw

475   commodities. In southern Africa, therefore, wildlife replaced livestock commodity

476   production once proprietorship was devolved to landholders, and because wildlife

477   could be converted into much higher values through trophy hunting and, in a few

478   places, through tourism. Reversing these trends may well require approaches like

479   those implemented in Namibia (NACSO, 2015).

480

481   Though this study does identify significant associations, its cross-sectional

482   rather than experimental design does not confirm causality (Bryman, 2008; Agresti

483   and Finlay, 2009). Therefore, further research is needed to investigate the

484   relationship among variables in terms of the causes and effects. In addition, we ask

485   what will motivate local people to take action to conserve wildlife. Despite this, our

486 results have generated a new hypothesis. Thus, the distance to the town did not

487 provide strong clarification on rural livelihood activities' variation. However, the travel

488 time from Ouesso to village that characterizes market access and offers a clearer

489 explanation regarding the associations among variables (i.e. this is an effective

490 predictor of livelihoods variation and-or association). Surrounding this study area, it

491 is argued, "the impacts of conservation-related displacement need to be understood

492 in the context of the other major land-use changes occurring in the region" (Curran et

493 al., 2009, Ridell, 2013). The recognition of the starting point for interventions will

494 facilitate the task when setting biodiversity conservation and poverty elimination

495 goals (Adams et al., 2004). In other words, for the future evaluation of park

496 management effects, these variables can be used to assess trends, comparing

497 villages with the park effects to control villages (i.e. without the park effects). Child

498 (2014) argues that we should establish a relationship between the economic value of

499 the PAs and their benefit to local people, and then this can enable PAs to undertake

500 conservation actions in their buffer zones.

501

509

510

22

References

511 **References**

512 Acquah, E., Rollins, R., Dearden, P. & Murray, G. (2017). Concerns and benefits of

513   park-adjacent communities in Northern Ghana: the case of Mole National

514   Park. Int. J. Sust. Dev. World 24, 316-327.

515 Adams, W.M., Aveling, R., Brockington, D., Dickson, B., Elliott, J., Hutton, J., Roe,

516   D., Vira, B., Wolmer, W., 2004. Biodiversity conservation and the eradication

517   of poverty. Science 306, 1146-1149.

518 Agresti, A., Finlay, B., 2009. Statistical methods for the social sciences, 4th Ed.

519   Prentice-Hall.

520 Angelsen, A., Wunder, S., 2003. Exploring the forest–poverty link: key concepts,

521   issues and research implications (No. CIFOR Occasional Paper no. 40, pp.

522   viii-58p). CIFOR, Bogor, Indonesia.

523 Auzel, P., Wilkie, D., 2000. Wildlife use in northern Congo: Hunting in a commercial

524   logging concession. In: Robinson J.G., Bennett E.L. (Eds.), Hunting for

525   Sustainability in Tropical Forests. Columbia University Press New York, pp.

526   413–426.

527 Barrett, C.B., Travis, A.J., Dasgupta, P., 2011. On biodiversity conservation and

528   poverty traps. Proc. Natl. Acad. Sci. U.S.A. 108, 13907-13912.

529 Bates, D., Mächler, M., Bolker, B., Walker, S., 2014. Fitting linear mixed-effects

530   models using lme4. ArXiv Prepr. ArXiv14065823.

531 Bennett, E.L., Robinson, J.G., 2000. Hunting for Sustainability in Tropical Forests.

532   Columbia University Press, New York.

533 Bryman, A., 2008. Social research methods. 3rd Ed. Oxford University Press,

534   Oxford.

535   Child, B.A., 2014. Parks in transition: adapting to a changing world. Oryx 48, 469-

536   470.

537   Clark, C.J., Poulsen, J.R., Malonga, R., Elkan, Jr. P.W., 2009. Logging concessions

538   can extend the conservation estate for Central African tropical forests.

539   Conserv. Biol. 23, 1281–1293.

540   Coad, L., Leverington, F., Knights, K., Geldmann, J., Eassom, A., Kapos, V.,

541   Kingston, N., de Lima, M., Zamora, C., Cuardros, I., Nolte, C., Burgess, N.D.,

542   Hockings, M., 2015. Measuring impact of protected area management

543   interventions: current and future use of the Global Database of Protected Area

544   Management Effectiveness. Phil. Trans. R. Soc. B 370: 20140281. http:--

545   dx.doi.org-10.1098-rstb.2014.0281

546   Curran, B., Sunderland, T., Maisels, F., Oates, J., Asaha, S., Balinga, M., Defo, L.,

547   Dunn, A., Telfer, P., Usongo, L., Von Loebenstein, K., Roth, P., 2009. Are

548   Central Africa's protected areas displacing hundreds of thousands of rural

549   poor? Conserv. Soc. 7, 30–45.

550   De Vaus, D., 2001. Research design in social research. London, Sage Publications.

551   Dirzo, R., Young, H.S., Galetti, M., Ceballos, G., Isaac, N.J.B., Collen, B., 2014.

552   Defaunation in the Anthropocene. Science 345, 401-406.

553   Doumenge C., Palla F., Scholte P., Hiol Hiol F., Larzillière A., 2015. Aires pro-

554   tégées d'Afrique centrale – État 2015. Kinshasa and Yaoundé, OFAC.

555   Ferraro, J.P., Hanauera, M., Sims, R.E.K., 2011. Conditions associated with

556   protected area success in conservation and poverty reduction. Proc. Natl.

557   Acad. Sci. U.S.A. 108, 13913-13918.

558   Foerster, S., Wilkie, D.S., Morelli, G. A., Demmer, J., Starkey, M., Telfer, P., Steil,

559   M., 2011. Human livelihoods and protected areas in Gabon: a cross-sectional

560   comparison of welfare and consumption patterns. Oryx 45, 347-356.

561   Ghimire, K.B., Pimbert, M.P., 1997. Social change and conservation: environmental

562   politics and impacts of national parks and protected areas. Earthscan,

563   London.

564   Hanna, S.S., Folke, C., Maler, K.-G., 1996. Rights to nature: Ecological, economic,

565   cultural, and political principles of institutions for the environment. Island

566   Press, Washington DC.

567   Hecketsweiler, P., Doumenge, C., Mokoko Ikonga, J., 1991. Le parc national

568   d'Odzala, Congo. IUCN. Gland, Switzerland.

569   Holm, S., 1979. A simple sequentially rejective multiple test procedure. Scand. J.

570   Stat. 65–70.

571   Mayaux, P., Pekel, J.-F., Desclée, B., Donnay, F., Lupi, A., Achard, F., Clerici, M.,

572   Bodart, C., Brink, A., Nasi, R., Belward, A., 2013. State and evolution of the

573   African rainforests between 1990 and 2010. Phil. Trans. R. Soc. B 368,

574   20120300. http://dx.doi.org/10.1098/rstb.2012.0300

575   Mbete, A.R., Mboko, B.H., Racey, P., Ntsakala, M.A., Nganga, I., Doucet, L.J., 2011.

576   Household bushmeat consumption in Brazzaville (Congo). Biol. Sciences, 4,

577   187-202.

578   McElwee, P.D., 2010. Resource use among rural agricultural households near

579   protected areas in Vietnam: the social costs of conservation and implications

580   for enforcement. Environ. Manage. 45, 113–131.

581   Moran, M.D., 2003. Arguments for rejecting the sequential Bonferroni in ecological

582   studies. Oikos 403–405.

583 Muchaal, P.K., Ngandjui, G., 1999. Impact of village hunting on wildlife populations in
584   the western Dja Reserve, Cameroon. Conserv. Biol. 13, 385-396.

585 Murphree, M.W., 2000. Boundaries and borders: The question of scale in the theory
586   and practice of common property management. Paper presented at the Eighth
587   Biennial Conference of the International Association for the Study of Common
588   Property, Bloomington, Indiana.

589 NASCO: Namibia Association of Community Based Natural Resource Management
590   Support Organization, 2015. What is CBNRM? (NACSO: CBNRM in Namibia
591   http:--www.nacso.org.na-what_is_cbnrm.php

592 Nakagawa, S., 2004. A farewell to Bonferroni: the problems of low statistical power
593   and publication bias. Behav. Ecol. 15, 1044–1045.

594 Nasi, R., Billand, A., van Vliet, N., 2012. Managing for timber and biodiversity in the
595   Congo Basin. Forest Ecol. Manag. 268, 103–111.

596 Noss, A.J., 1998. The impact of cable snare hunting on wildlife populations in the
597   forest of the Central African Republic. Conserv. Biol. 12, 390-398.

598 Oldekop, J.A., Holmes, G., Harris, W.E., Evans, K.L. 2016. A global assessment of
599   the social and conservation outcomes of protected areas. Conserv. Biol. 30,
600   133–141.

601 Poulsen, R.J., Clark, J.C., Mavah, G.A., Elkan, P., 2009. Bushmeat supply and
602   consumption in a tropical logging concession in northern Congo. Conserv.
603   Biol. 23, 1597–1608.

604 Poulsen, J.R., Clark, C.J., Bolker, B.M., 2011. Decoupling the effects of logging and
605   hunting on an Afrotropical animal community. Ecol. Appl. 21, 1819–1836.

606 Pullin, A.S., Bangpan, M., Dalrymple S., Dickson, K., Haddaway, N.R., Healey J.R.,
607   Hauari, H., Hockley, N., Jones, J.P.G., Knight, T., Vigurs, C., Oliver S., 2014.

608   Assessing the effects of terrestrial protected areas on human well-being: A

609   STAP Advisory Document. Global Environment Facility, Washington, D.C.

610   R Foundation for Statistical Computing, 2016. R

611   Redpath, S.M., Young, J., Evely, A., Adams, W.M., Sutherland, W.J., Whitehouse,

612   A., Amar, A., Lambert, R.A., Linnell, J.D.C., Watt, A., Gutirrez, R.J., 2013.

613   Understanding and managing conservation conflicts. Trends Ecol. Evol,, 28,

614   100-109.

615   Ripple, W.J., Abernethy, K., Betts, M.G., Chapron, G., Dirzo, R., Galetti, M., Levi, T.,

616   Lindsey, P.A., Macdonald, D.W., Machovina, B., Newsome, T.M., Peres, C.A.,

617   Wallach, A.D., Wolf, C., Young, H., 2016. Bushmeat hunting and extinction

618   risk to the world's mammals. R. Soc. open sci. 3, 160498.

619   http://dx.doi.org/10.1098/rsos.160498

620   Roe, D., Elliott, J., 2004. Poverty reduction and biodiversity conservation: rebuilding

621   the bridges. Oryx, 38, 137-139.

622   Rowcliffe, J.M., De Merode, E., Cowlishaw, G., 2004. Do wildlife laws work? Species

623   protection and the application of a prey choice model to poaching decisions.

624   Proc. R. Soc. Lond. Ser. B. Biol. Sci., 271, 2631-2636.

625   Russell, D., Mbile, P., Tchamou, N., 2011. Farm and forest in Central Africa:

626   Towards an integrated rural development strategy. J. Sustainable For. 30,

627   111-132.

628   Salafsky, N., Wollenberg, E., 2000. Linking livelihoods and conservation: A

629   conceptual framework and scale for assessing the integration of human needs

630   and biodiversity. World Dev. 28*, 1421-1438.

631   Sanderson, S.E., Redford, K.H., 2003. Contested relationships between biodiversity

632   conservation and poverty alleviation. Oryx, 37, 389-390.

633   Schulze, K., Knights, K., Coad, L., Geldmann, J., Leverington, F., Eassom, A., Marr,

634   M., Butchart, S.H.M., Hockings, M., Burgess, N. 2018. An assessment of

635   threats to terrestrial protected areas. Conserv. Lett.

636   e12435.wileyonlinelibrary.com/journal/conl1of10https://doi.org/10.1111/conl.1

637   2435

638   Scherl, L.M., 2004. Can protected areas contribute to poverty reduction?

639   Opportunities and limitations. IUCN, Gland, Switzerland and Cambridge, UK.

640   Schlager, E., Ostrom, E., 1992. Property-rights regimes and natural resources: a

641   conceptual analysis. Land Econ. 68, 249–262.

642   Schulze, K., Knights, K., Coad, L., Geldmann, J., Leverington, F.,Eassom, A., Marr,

643   M., Butchart, S.H.M., Hockings, M., Burgess, Neil D., 2018. An assessment of

644   threats to terrestrial protected areas. Conserv. Lett. 2018;e12435.

645   https://doi.org/10.1111/conl.12435

646   Shackleton, S., Delang, C.O., Angelsen, A., 2011. From subsistence to safety nets

647   and cash income: exploring the diverse values of non-timber forest products

648   for livelihoods and poverty alleviation, in Shackleton, S., Shackleton, C.,

649   Shanley, P. (Eds.) Non-Timber Forest Products in the Global Context.

650   Springer, Berlin, Heidelberg, pp. 55-81

651   Stolton, S., Dudley, N., 2010. Vital sites: The contribution of protected areas to

652   human health. WWF and Equilibrium, Gland, Switzerland.

653   Taylor, R., 2009. Community based natural resource management in Zimbabwe: the

654   experience of CAMPFIRE. Biodivers. Conserv. 18, 2563–2583.

655   Turner, W.R., Brandon, K., Brooks, T.M., Gascon, C., Gibbs, H.K., Lawrence, K.S.,

656   Mittermeier, R.A., Selig, E.R., 2012. Global biodiversity conservation and the

657   alleviation of poverty. BioScience 62, 85-92.

658   Van Vliet, N., Nasi, R., 2008. Hunting for livelihood in northeast Gabon: patterns,

659   evolution, and sustainability. Ecol. Soc. 13(2), 33. http:--

660   www.ecologyandsociety.org-vol13-iss2-art33-.

661   Von Richter, W., Butynski, T., 1973. Hunting in Botswana. Botsw. Notes Rec. 5, 191-

662   208.

663   West, P., Igoe, J., Brockington, D., 2006. Parks and peoples: the social impact of

664   protected areas. Annu. Rev. Anthropol. 35, 251-277.

665   Wilkie, D.S., Carpenter, J.F., 1999. Bushmeat hunting in the Congo Basin: an

666   assessment of impacts and options for mitigation. Biodivers. Conserv. 8, 927-

667   955.

668   Wilkie, D., Starkey, M., Abernethy, K., Effa, N.E., Telfer, P., Godoy, R., 2005. Role of

669   prices and wealth in consumer demand for bushmeat in Gabon, central Africa.

670   Conserv. Biol. 19, 268-274.

671   Wilkie, S.D., Morelli, A.G., Demmer, J., Starkey, M., Telfer, P., Steil M., 2006. Parks

672   and people: Assessing the human welfare effects of establishing protected

673   areas for biodiversity conservation. Conserv. Biol. 20, 247–249.

674

675

676

FIGURE LEGENDS

678

679 **Figure 1.** Location of the study area, villages and the Odzala Kokoua National

680 Park OKNP (Northern Congo).

681

682 **Figure 2.** Distribution of bushmeat related livelihood variables across the four

683 village groups GP1 to GP4. Each box covers 50% of the respective

684 data (i.e. first to third quartile). Bold lines indicate medians, whiskers

685 indicate 1.5 the interquartile ranges and dots suspected outliers.

686

687 **Figure 3.** Association between potential mediating factors and incomes and

688 expenditures from bushmeat. Those associations are shown which

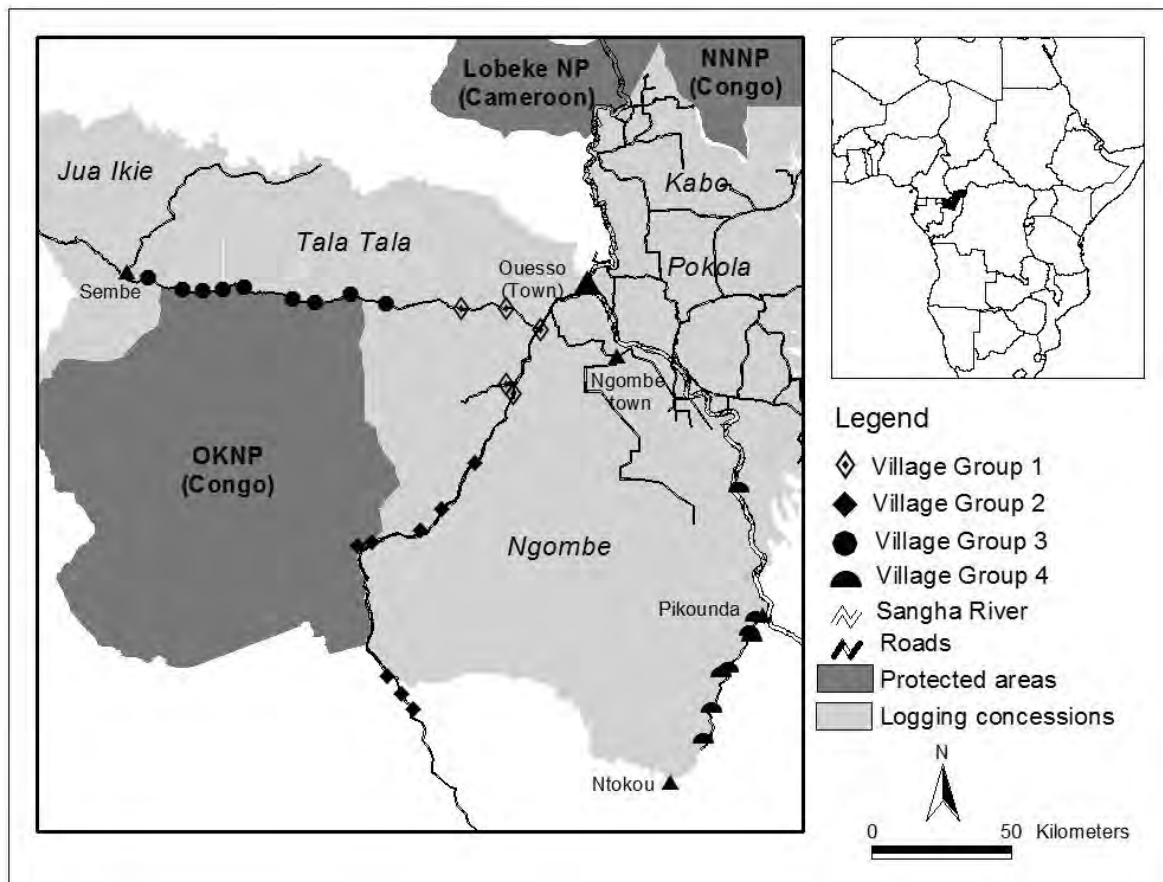689 were significant or highly significant (Table 2).

690

691

692

694

695
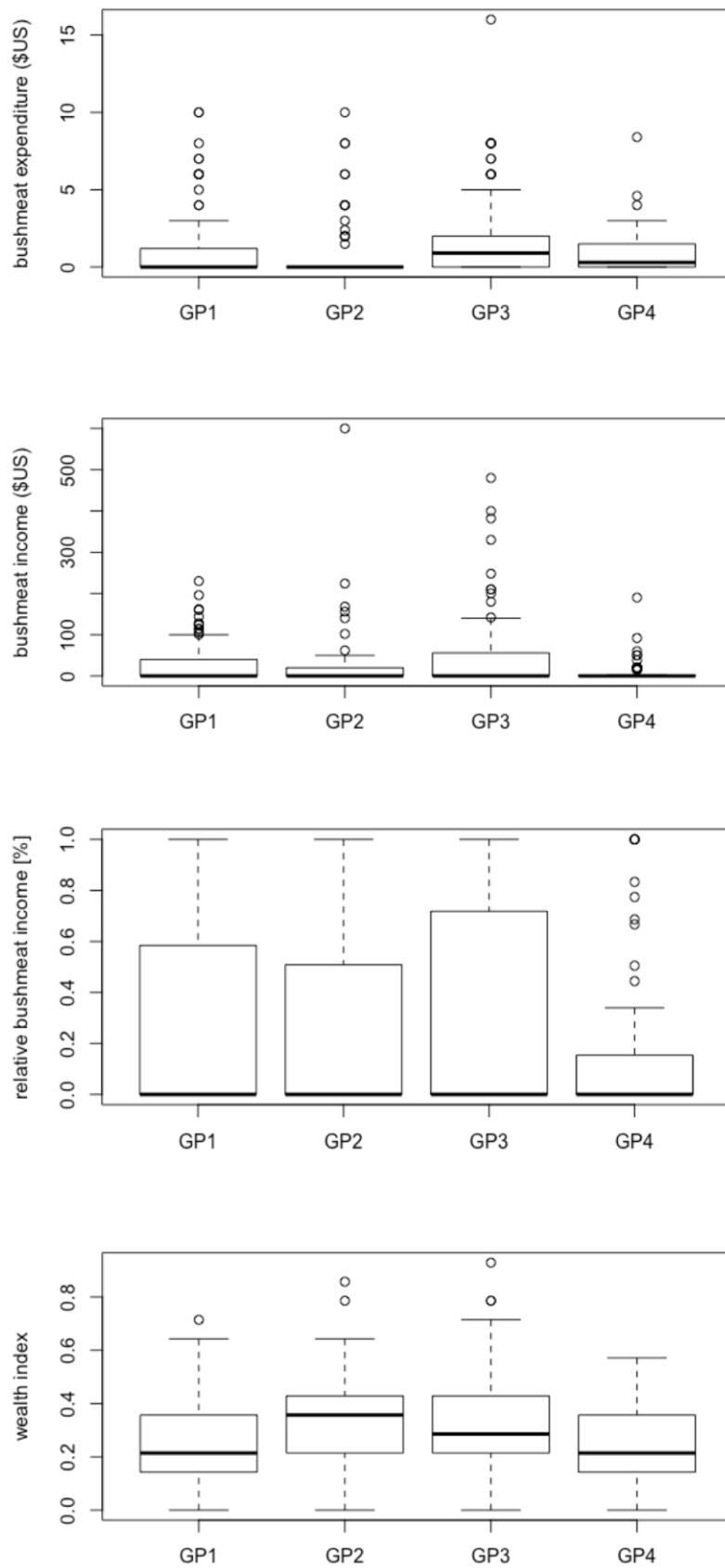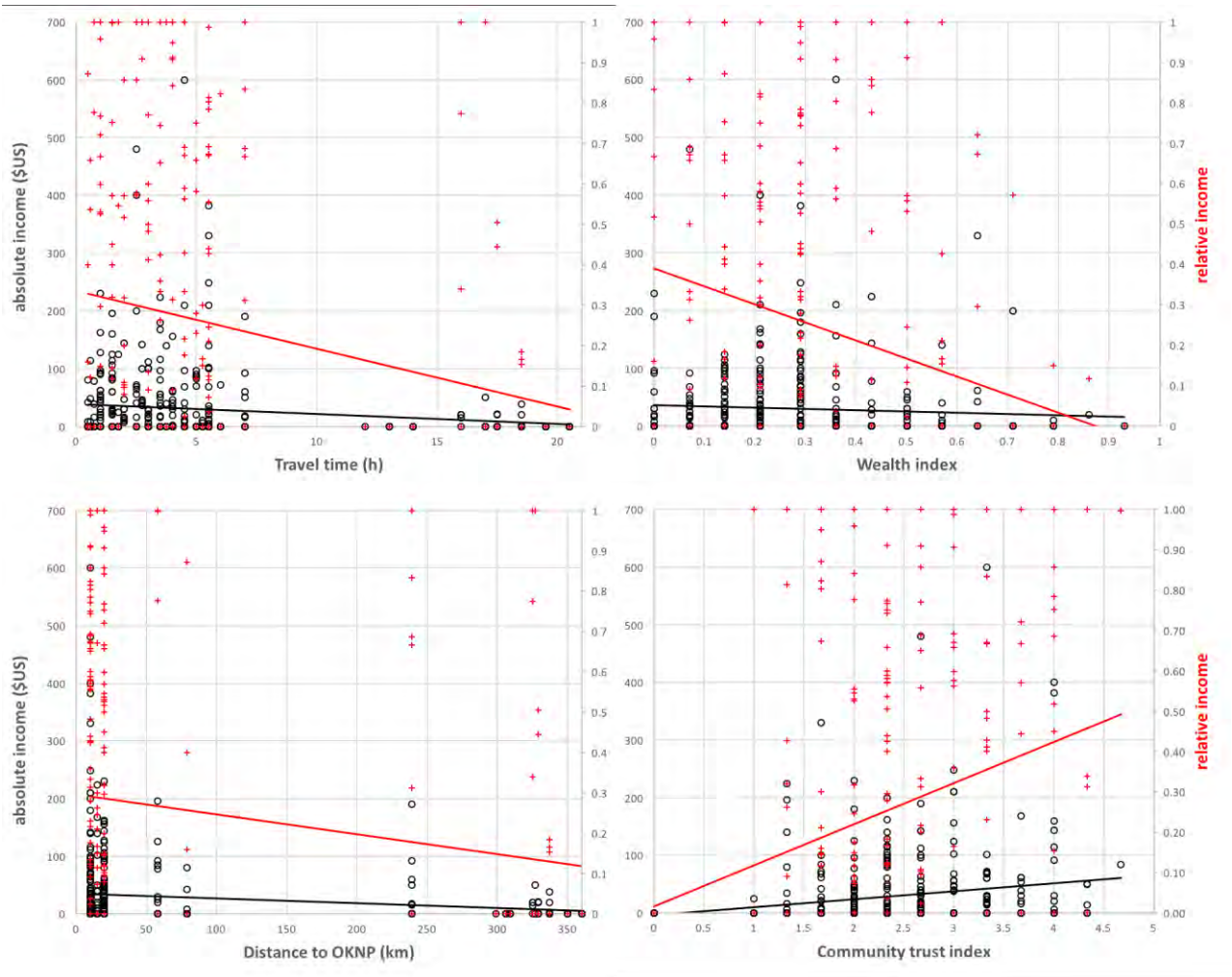
696

697   Fig. 2

698

Fig. 3

Parameter	group 1 $n_{min}=133, n_{max}=136$ 11 villages μ | Mdn	range	group 2 $n_{min}=59, n_{max}=63$ 8 villages μ | Mdn	range	group 3 $n_{min}=115, n_{max}=127$ 9 villages μ | Mdn	range	group 4 $n_{min}=n_{max}=60$ 9 villages μ | Mdn	range	Kruskal-Wallis test χ^2	p	p'	Σ
Survey villages and market access												
Distance to OKNP	30.4 | 20	20-79	14.5 | 15	10-20	10.0 | 10	10-10	316 | 328	239-360	-	-	-	-
Distance to Ouesso	53.1 | 48	25-85	176.8 |200	100-215	138.8 | 143	69-190	212.0 | 224	135-256	-	-	-	-
Travel time to Ouesso market	1.4 | 1	0.5-3	4.8 | 5	3.3-5.5	4.1 | 4	2.5-6	15.6 | 17.3	7-20	309	<.001	<.001	**
Household size	4.4 | 4	1-13	4.4 | 5	1-9	5.3 | 5	1-17	3.3 | 3	1-9	31.6	<.001	<.001	**
Respondent age	47.3 | 46	20-86	45.0 | 42	20-80	47.9 | 46.5	24-79	50.0 | 44	24-82	2.8	.417	.818	
Respondent education level	1.3 | 1	0-4	1.7 | 2	0-4	1.3 | 1	0-4	1.1 | 1	0-3	12.3	.006	.038	*
Respondent BMI	23.9 | 23.6	17.7-42.6	23.6 | 22	18-37.6	23.2 | 23.2	14.7-31	22.3 | 22.3	16.8-29.5	8.9	.031	.154	?
Community trust index	2.3 | 2.3	2-4.7	2.3 | 2	0-4	2.4 | 2.3	0-4	2.9 | 2.7	0-4.3	30.6	<.001	<.001	**
Household income, food consumption & wealth												
Total income $US	81.2 | 66	0-355	96.3 | 60	0-600	170.7 | 105	0-1170	55.0 | 33.3	0-320.8	38.2	<.001	<.001	**
Income from bushmeat $US	26.9 | 0	0-230	30.5 | 0	0-600	41.5 | 0	0-480	10.5 | 0	0-190	8.1	.045	.179	?
Income from cocoa $US	0.1 | 0	0-16.7	0 | 0	0-133	90.2 | 0	0-1320	4.7 | 0	0-35	90.4	<.001	<.001	**
Expenditure bushmeat $US	1.1 | 0	0-10	1.1 | 0	0-10	1.5 | 0.8	0-16	1.0 | 0.3	0-8.4	6.9	.076	.228	no
Expenditure consumption $US	3.9 | 2.4	0-10	4.5 | 4.1	0-13.7	2.9 | 2.4	0-0	2.3 | 2.2	0-7	27.7	<.001	<.001	**
Wealth index	0.3 | 0.2	0-0.7	0.3 | 0.4	0-0.9	0.3 | 0.3	0-0.9	0.2 | 0.3	0-0.6	17.4	.001	.004	**
Perception of abundance	3	0-4	3	0-4	3	0-4	3	0-4	2.9	.41	.818	

705

706 **Table 2**. Association between potential mediating factors and incomes and expenditures from bushmeat. Spearman´s rank
707 correlation r_s, sample sizes n and outcomes from the test statistics are presented. Tests were only performed when r_s explains at
708 least 10% of the observed variance. Observed p and the $p´$-values adjusted with the Holm-Bonferroni sequential correction
709 approach are shown. Significance as in Table 1.

Potential mediating factors	n	Bushmeat consumption expenditure ($US) n=386		Total consumption expenditure ($US) n=383		Income from bushmeat ($US) n=386		Total income ($US) n=386		Relative income from bushmeat n=359	
		r_s	p / p´	r_s	p / p´	r_s	p / p´	r_s	p / p´	r_s	p / p´
Travel time to Quesso market	386	-0.03	-	-0.01	-	-0.15 *	0.004 / 0.022	-0.02	-	-0.17 **	<0.001 / 0.007
Distance to OKNP	386	-0.02	-	-0.09	- / -	-0.13 *	0.011 / 0.033	-0.30 **	<0.001 / <0.001	-0.12 *	0.018 / 0.037
Total consumption expenditure ($US)	383	0.49 **	<0.001 / <0.001	N/A	N/A	0.09	-	0.18 **	<0.001 / 0.003	0.04	-
Income from cocoa sale ($US)	386	0.06	-	-0.08	-	-0.08	-	0.32 **	<0.001 / <0.001	-0.17 **	<0.001 / 0.007
Wealth index	386	0.16 *	0.002 / 0.015	0.28 **	<0.001 / <0.001	-0.13 *	0.008 / 0.032	0.21 **	<0.001 / <0.001	-0.22 **	<0.001 / <0.001
BMI	367	-0.06	-	0.11 *	0.018 / 0.037	-0.02	-	0.15 *	0.003 / 0.022	0.04	-
Community Trust Index	386	0.08	-	0.01	-	0.19 **	<0.001 / 0.002	0.08	-	0.17 **	<0.001 / <0.001

710

711 **Supplementary Information**

712

713

714 **Table A1.** Summary of the four surveyed village groups surrounding the Odzala-
715 Kokoua National Park northern Congo (Figure 1).
716

	Village group			
	1	2	3	4
Villages sampled (n)	11	8	9	9
Households sampled (n)	136	62	128	60
Average distance to OKNP (km)	30	14	10	316
Road access	On main north-south and east-west roads, good road conditions, high levels of traffic	On main north-south road, good road conditions, high levels of traffic	On main east-west road, good road conditions, high levels of traffic	No road access, access by boat only
Access to OKNP	Via both the main north-south and east-west roads	Via the main north-south roads, which straddles part of the eastern park border	Via the main east-west road, which straddles most of the northern park border	No access
Access to local bushmeat markets	Weekly market in some villages e.g. Liouesso and Attention	Weekly bushmeat market in some villages e.g. Mokouagonda and Moyoye	Weekly market in some villages e.g. Kokoua and Seka	No markets
Cacao cultivation	None	High	High	Low
Hunting pressure extended on OKNP	High	High	High	Low

717
718

37

719 **Table A2. Heads of Households' Questionnaire**
720

Village: Date: Investigator: Questionnaire #:

721
722 Name of household head (HH):

723
724
725 **1. Demographic information**

726
727 Please, how many individuals do you have in your household? :

728

Name	Relationship -HH	M-F	Age	Ethnicity	Education level	Weight	Height	Mid upper arm ⊘

729
730
731 **2. Wealth assessment (basket of assets): Please, do you have these goods?**

732

Items	# Unit	Cost per unit	Total Cost
Shotgun (i.e. for hunting)			
Wood bed			
Mattress			
Watch-Clock			
Stereo			
Radio			
DVD player			
Scooter			
Bicycle			
Livestock #			
Poultry #			
House_sheet metal roof			
Power Generator			
TV			
Other			

733
734
735 **3. How important is wildlife for your household?**
736

Very little:　　　　Little:　　　　Some:　　　　A lot of:　　　　Great deal:

737
738
739 **3. Household consumption: Please fill out the following table regarding your**
740 **expenditure for food in the last 48h**

Products	Source					
	Wild		Domestic		Manufactured	
	Unit	Cost	Unit	Cost	Unit	Cost

741
742
743 **4. Transitory income of household heads: What are the quantity and the**
744 **values of your forest products and crops for both use and sale over past**
745 **month or season?**

Products	Quantity collected	Unity	Own use	Sold	Price per unit	Type of Market	Income

746
747
748 **5. Importance of hunting in household income compared with other activities**

Designation	1	2	3	4	5
Farming					
Cacao					
Fishing					
Hunting					
NTFPs (specify)					
Livestock					
Job					
Pensions					
Traditional practitioners					
Money from town					
Other (specify)					

749
750 **6. Please, what are your hunting motivations**
751

To increase household income: Traditional activity: Good product to sell: Other (specify):

752
753 **7. Community trust: Please indicate whether you agree or disagree with the**
754 **following statements**
755

Items	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Would you trust a neighbor to look after your house when you had to leave the village					
Would you trust a neighbor to look after your money					
Whether a machete left outside overnight would still be there in the morning					

756
757
758 **8. Disease vulnerability**
759
760 Please, in the past year, have any of you suffered from the following diseases?
761

Diarrhea: Kwashiorkor: Malaria: Other(specify):

762
763
764 **9. Food security**
765
766 How many times in the past five years has your family not been able to get enough
767 food? Number of months without enough food?
768

20012:   2011:   2010:   2009:   2008:   2007:

Why:

769
770
771 **10. Compared to 10 years ago, are your forest resources more or less**
772 **abundant today and explain why?**
773

Wild resources	Don't know (1)	No change (2)	Decrease (3)	Increase (4)
Wildlife				
Fish				
Caterpillar				
Irvingia sp				
Nkoko				
Other (specify)				

774

775
11. How far can we find the following wildlife species? Please specify how many walk time to find these species

Gorillas: Chimpanzees   Small monkey: Brush-tailed porcupine:

Bleu duiker: Peter's duiker: Bush pig: Other (specify):

12. What major events have affected your livelihood in the past 5 years?

1:                              2:   3:

What caused?

How did you respond?

781
13. What are the three biggest challenges to your livelihood that you are worried about and explain?

1:                              2:   3:

785
14. Compared to 5 years ago, is your household more or less prosperous today and explain why?

More abundant   Less prosperous   No change   Don' t know

15. Participation in community actions

Are you member of any associations in the village?

Yes: No:

Named them:

Social-Economic objective:

Do they interact with other villages?

800 **A. Focus Group**
801
802 Village: GPS X: Y: Distance to Ouesso:
803
804 Travel time: Distance to park: Population estimate:
805
806 1.   What are your principle activities in the village? For men, for women?
807
808
809 2.   What is the most important hindrance in community projects in your village?
810   Why? How do you can overcome it?
811
812
813 3.   What types of associations do you have in your community?
814
815
816 4.   Do you any informal rules or regulations of access to your forest? If so, how
817   strong are they comparing to formal?
818
819
820 5.   What factor influence the most pressure on wildlife in your village?
821
822
823 6.   Please sort your most important hunting motivations
824 Increase household Income: Traditional activity (culture):   Bushmeat has high
825 benefit:
826
827
828 7.   What can we do to use wildlife for long term?
829
830
831 8.   Can you report any poaching event in the village to village's authorities?
832
833
834 9.   What do you know about wildlife?
835
836 Measures of control wildlife:
837
838 Benefits:
839
840 Trends (increase or decrease):
841
842 10. What are the consequences of wildlife extinction?
843
844
845 11. What actions should you take according to you?
846
847
848 12. Why are you not taking these actions?

849 **Table A3.** Human livelihood variables assessed through questionnaires.
850
851

Study variable	Measurements	Measurement units
Access to the main town Ouesso	Reported travel time village - Ouesso	minutes
Distance to Ouesso and OKNP	Distances from village according administrative records	km
Gender	Gender of household head	male / female
Age	Age of household head	years
Ethnicity	Self-assignment of ethnic group	Bantu, indigenous Pygmy groups
Level of the education	Level of the education of each household member	Index: no school (0), primary school (1), secondary school (2), high school (3), university (4)
Body mass index BMI	Weight and height of all household members aged 1 year or above	averaged BMI over all household members
Household size	all household members	n
Household food composition	Bushmeat, fish, domestic animals, vegetables from farm, vegetables from forest, imported protein, others	Composition of last main household meal in percent
Household expenditure for all food	Monetary value of all food items bought for last main household meal	Monetary value in the local currency FCFA, translated into $US using the exchange rate $US 1 = 500 FCFA
Household expenditure for bushmeat	As above but for bushmeat only	As above
Sources of income	Bushmeat trade, farming, cocoa, small commerce, salary, corn liquor, fishing, raffia wine, gathering, livestock, palm oil, handcrafts, and other items sold during the last season or this year	As above

852

Study variable	Measurements	Measurement units
Household income from any sold food items	Estimated value of any food items sold during the last season or this year including	As above
Income from cocoa sale	As above for cocoa only	As above
Income from bushmeat sale	As above for bushmeat only	As above
Community Trust index	How are neighbours trusted to look after one´s house	Strongly mistrust (1), mistrust (2), neutral (3), trust (4), strongly trust (5)
Wildlife abundance perception	Perception of wildlife abundance	Index: don't know or not specified (0), no change (1), decrease (2), increase (3)
Household wealth	Sum of monetary value of itemized household possessions	Monetary value in the local currency FCFA, translated into $US using the exchange rate $US 1 = 500 FCFA
Household wealth index	Household wealth in relation to all other surveyed households	Partition of the distribution of wealth of all households into five quintiles, which were categorized as "poorest", "poor", "middle income", "rich", and "richest". Each Individual household was then assigned to the adequate category,

853

854　　**Table A4.** Average prices of principal products sold surrounding Odzala-Kokoua

855　　National Park OKNP (northern Congo). Prices in $US are converted from the local

856　　currency FCFA (see Table A3).

Rural products	Village Groups				Ouesso
	1	2	3	4	
Red duikers ($-Kg)	1.30	1.30	1.30	0.70	3.30
Blue duikers ($-Kg)	1.60	1.60	1.60	1.20	2.40
Small monkeys ($-Kg)	1.30	1.30	1.30	1.00	2.00
Porcupine ($-Kg)	2.00	2.00	20	1.30	4.00
Raffia wine ($-liter)	0.30	--	0.30	0.10	0.60
Palm oil ($liter)	1.00	1.00	1.00	0.50	2.00
Gnetum africanum ($-Unit)	0.40	0.40	0.20	0.10	1.00
Local chicken ($-unit)	4.00	4.00	4.00	2.00	8.00
Corn ($-3 ears of corn)	0.60	0.60	0.60	0.10	0.60

857
858

859 **Table A5.** Potential explanation of associations between assessed livelihoods.

860

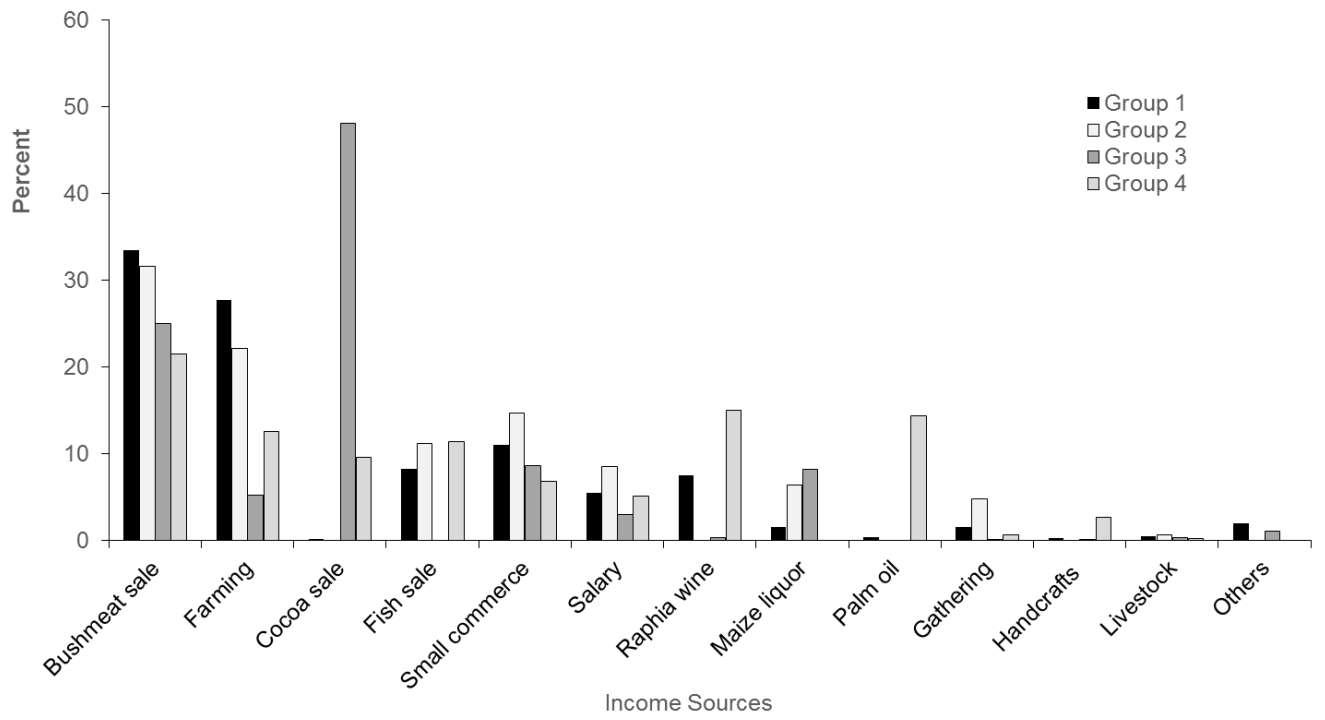|	Possible associations among variables	Direction of significant association	Explanation
1	Market access and bushmeat income	-	It is harder to sell bushmeat to distant markets. As market accessibility declines (i.e. travel times increase), bushmeat becomes more difficult to transport and sell, or transport costs exceed the price in the market
2	Market access and community wealth	+	Communities with access to markets are wealthier. People successfully use markets to increase their household wealth
3	Distance to park and expenditure, income, wealth	-	The further from the park people are, the poorer they are, because there are fewer forest products (and village group 4 is both far from the park and far from markets)
4	Distance to the park and bushmeat sales	-	Local people far away from the park have less wildlife resources to hunt and sell
5	HH expenditure and bushmeat purchases	+	Wealthier people choose to spend money on bushmeat, and-or poor people have no money to spend on bushmeat. Richer households buy more bushmeat
6	Household expenditure and bushmeat sales	+	The more wealthy people are, the less they depend on selling bushmeat, or people who depend mainly on selling bushmeat remain poor
7	HH expenditure and HH income-community wealth	+	Richer households spend more money
8	Cocoa sales and household income, wealth	+	Cocoa production is a key component of household income in some villages (group 3) in the region and allows people to purchase more goods
9	Bushmeat sales and wealth index	-	This is opposite to 5 and 6 because results show a very low negative correlation between wealth index and income from bushmeat sales. This means richer people sell less bushmeat.

861
862

863   Figure A1. Main food sources

864
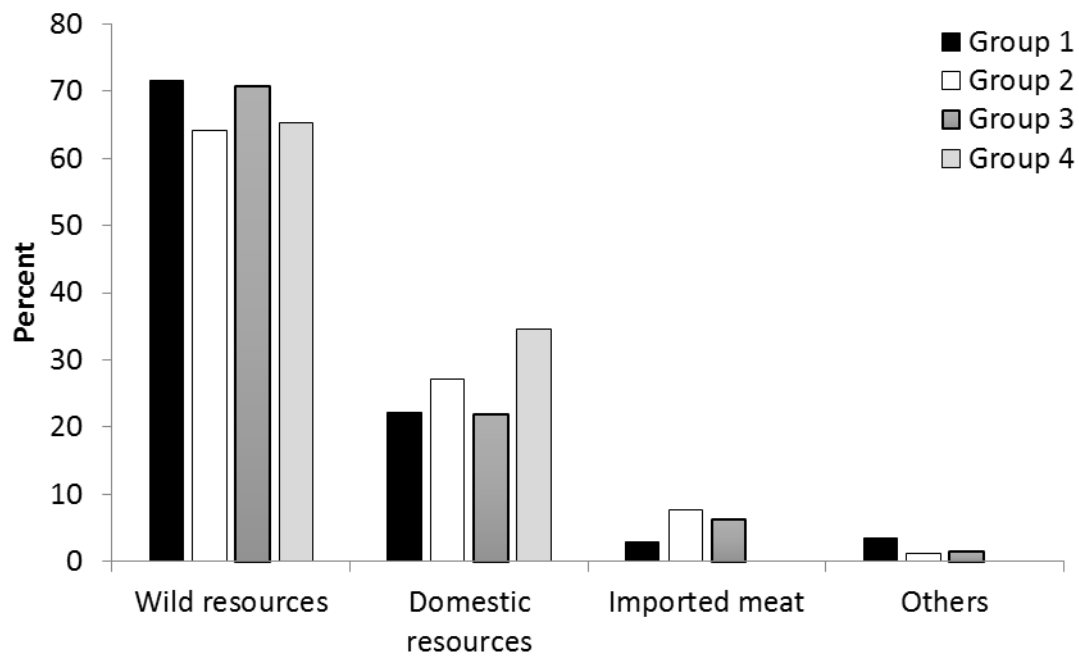
865

866

867

868　Figure A2. Income sources
869

870
871