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Research

The pleasure of pursuit: recreational hunters in rural Southwest China exhibit low exit rates in response to declining catch

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ABSTRACT. Hunting is one of the greatest threats to tropical vertebrates. Examining why people hunt is crucial to identifying policy levers to prevent excessive hunting. Overhunting is particularly relevant in Southeast Asia, where a high proportion of mammals and birds are globally threatened. We interviewed hunters in Southwest China to examine their social behavior, motivations, and responses to changes in wildlife abundance. Respondents viewed hunting as a form of recreation, not as an economic livelihood, and reported that they would not stop hunting in response to marked declines in expected catch. Even in scenarios where the expected catch was limited to minimal quantities of small, low-price songbirds, up to 36.7% of respondents said they would still continue to hunt. Recreational hunting may be a prominent driver for continued hunting in increasingly defaunated landscapes; this motivation for hunting and its implications for the ecological consequences of hunting have been understudied relative to subsistence and profit hunting. The combination of a preference for larger over smaller game, reluctance to quit hunting, and weak enforcement of laws may lead to hunting-down-the-web outcomes in Southwest China.

Key Words: *harvesting; hunting; interviews; management; natural resource governance*

INTRODUCTION

Overexploitation is a major driver of endangerment for the majority of International Union for Conservation of Nature (IUCN) Red-Listed vertebrates (Rosser and Mainka 2002, Maxwell et al. 2016). Effective hunting management requires compliance, which rests on hunter motivations and behavior (Lee et al. 2009, St John et al. 2011, 2013, Steinmetz et al. 2014). Understanding hunter motivations to better regulate hunting is crucial, given that hunting pressure exceeds sustainable thresholds for many species across the global tropics (Peres 2001, Fa et al. 2002, Milner-Gulland and Bennett 2003, Wilkie et al. 2011, Dirzo et al. 2014, Harrison et al. 2016).

Profit and subsistence have been posited as the primary motives for hunters in tropical, developing countries (Damania et al. 2005, Sirén et al. 2006, Bennett et al. 2007, van Vliet and Nasi 2008, Brashares et al. 2011, Golden et al. 2013). However, the nonmaterial entertainment value of hunting—the thrill of the chase and social benefits provided by hunting—may also be a prominent motivator for rural villagers in tropical countries (Bennett 2002, Loveridge et al. 2006, Rao et al. 2010, Velho and Laurance 2013, MacMillan and Nguyen 2014, Alfaro-Shigueto et al. 2016). We distinguish this form of recreational hunting from previous descriptions of sport or trophy hunting. Sport or trophy hunting is typically well regulated, garners income for local communities, and involves high net-worth individuals, often from the developed world or from urban centers in both developed and developing countries (Eltringham 1994, Getz et al. 1999, Harris and Pletscher 2002, Lindsey et al. 2007, Yasuda 2012). The recreational hunting described herein pertains to systems with weak to nonexistent governance and/or enforcement on hunting (El Bizri et al. 2015).

Research on recreational hunting in tropical contexts is long overdue; more than half a century ago, Harrisson (1961) already identified recreational hunting as a major threat to endangered mammals in Borneo. To date, however, the ecological impacts of recreational hunting in the tropics are little known. Recreational hunter responses to economic sanctions, diminishing game stocks, and penalties may fail to align with expectations set out by subsistence or economic principles (Cooke and Cowx 2006, Barnes-Mauthe et al. 2015). For instance, recreational angling has depleted certain fish stocks more than highly regulated commercial fisheries (Coleman et al. 2004, Cooke and Cowx 2004). It is thus possible that recreational motives may promote high levels of hunting effort that exceed both economic and biological sustainability thresholds.

This study presents a novel characterization of a community of hunters who are primarily oriented toward recreation in a rural developing country context. Collecting data on illegal hunting poses formidable challenges because of respondent concerns about legal repercussions. To overcome these challenges, we used innovative survey techniques to characterize hunter behavior without requiring respondents to admit to legal offenses. We describe how hunters in rural Yunnan Province, China, respond to regulations, changes in game populations, and their hunting practices.

Study site

Xishuangbanna Dai Autonomous Prefecture (henceforth, Xishuangbanna) is a biodiversity hotspot within Southwest China that is well suited for examining recreational hunting. Intense hunting effort has put and continues to put tremendous pressure on the avifauna and mammals of Xishuangbanna and surrounding regions (MacKinnon and MacKinnon 1986, Myers

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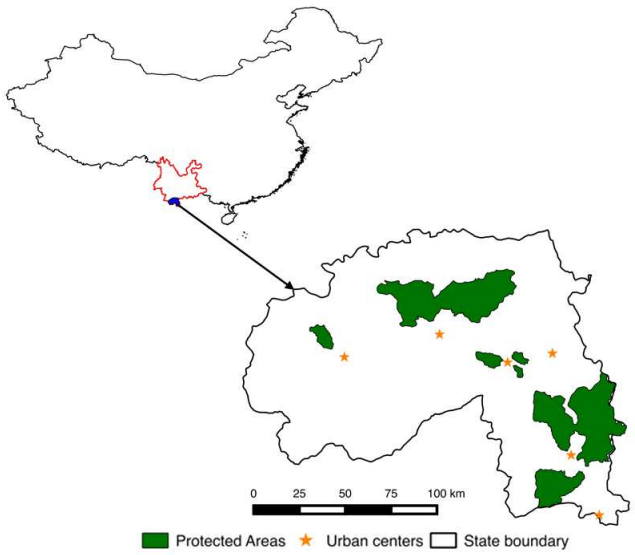
et al. 2000, Yang et al. 2004, Corlett 2007, Zhang et al. 2008, Hoffmann et al. 2010, Sodhi et al. 2010, Wilcove et al. 2013). Overhunting and forest fragmentation have driven large-bodied, economically valuable mammals and birds to extirpation; small, low-value species now dominate in abundance (Haimoff et al. 1987, Shilai et al. 1995, Harris and Shilai 1997, Luo and Dong 1998, Fan et al. 2014, Kai et al. 2014). Long before cash-crop smallholding transformed Xishuangbanna economically, researchers noted that hunting was oriented toward recreation, not subsistence, despite widespread and severe poverty (Tisdell and Xiang 1996, Xu and Wilkes 2002). More recently, Kai et al. (2014) concluded that hunting in Xishuangbanna is a leisure activity providing at most a trivial source of income or nutrition.

In rural Xishuangbanna, smallholder agriculture is the primary livelihood, employing approximately 95% of the rural population (Hammond et al. 2015). Rubber (*Hevea brasiliensis*) and tea (*Camellia sinensis*) smallholding has lifted villagers in Xishuangbanna out of poverty and into the global middle class over the past decade (Guo et al. 2002, Xu et al. 2005*a*, 2014, Yi et al. 2014). From the 1980s onward, land parcels were allocated to and managed by individual households (Xu 2006, Grumbine and Xu 2011). The main ethnic groups in this region are the Dai and Han along with smaller ethnic minority groups such as the Yao, Hani, Bulang, Jinuo, and Lahu (Xu 2006, Hammond et al. 2015).

Hunting and selling wildlife, as well as entering protected areas, are restricted under the Wildlife Protection Law of 1988 (Articles 8, 9, and 10, Chapter II; Sharma 2005, Li 2007, Xu and Melick 2007, Yu and Czarnecki 2013). Under the 1994 Hunting Firearm, Ammunition, and Equipment Administration Regulation and the 1996 Firearm Control Law, gun ownership is de facto illegal (Harris 2007, Zhou et al. 2010). However, hunters in Xishuangbanna primarily use firearms and hunt in protected areas (Santiapillai et al. 1994, Luo and Dong 1998, Kai et al. 2014). Mammals and birds are largely limited to native forest, and most remaining forests are in protected areas where hunting is prohibited; thus, by default, hunting activity in Xishuangbanna is typically illegal (Chang et al. 2013, Dayananda et al. 2016).

Beginning in the 1980s, the Yunnan Province Forestry Bureau moved all villages outside of protected area boundaries (Lai and Wang 1998, Xu et al. 2005*b*, Allendorf and Yang 2013). Our study occurred in four villages located fewer than five kilometers from the boundaries of two Xishuangbanna National Nature Reserve protected areas (Fig. 1). The two protected areas are strict no-take areas where hunting, logging, and other extractive activities are prohibited, and together contain 1200 km^2 of lowland and montane rainforest (Santiapillai et al. 1994, Zhang and Cao 1995, Wang and Carpenter 1998, Kram et al. 2012, IUCN and UNEP-WCMC 2015). These villages, as well as surrounding villages in the county, all have running water, electricity, cell phone coverage, and paved roads providing access to the nearest urban center (Appendix 1, Table A1). The number of households per village ranged from 23 to 83 (Appendix 1, Table A1). Nearly every household in the studied region has a refrigerator, and there are currently no records of protein insecurity or malnutrition in Xishuangbanna (Hammond et al. 2015).

Fig. 1. A map of Xishuangbanna Dai Autonomous Prefecture (inset; henceforth, Xishuangbanna). In the top figure, Yunnan Province is shown with a red border,x and Xishuangbanna is filled in dark blue. In the inset map of Xishuangbanna, urban centers and protected areas are depicted.



METHODS

We surveyed active hunters using mixed methods: bag records (BR), a quantitative survey (QS), and semistructured interviews (SS). Our surveys were designed based on the lead author's ethnographic observations, informal interviews, and sustained interactions with local communities over the past three years. Given the extreme sensitivity of discussing illegal hunting, both surveys used snowball sampling wherein trusted hunter informants provided contacts to interview. Of the 50 men approached for this study (n_{BR} = 10, n_{QS} = 30, n_{SS} = 5), 5 refused to participate.

The lead author wrote all of the questionnaire instruments in Mandarin Chinese and translated the results back to English. Two local women (both of mixed Dai-Han ethnicity) were trained as enumerators and conducted all interviews in the Xishuangbanna dialect. The enumerators formerly worked for the Yunnan Tobacco Corporation and managed stock for shopkeepers in villages and rural townships; as such, they were familiar with residents in all the study villages, which increased respondent trust and helped avert nonresponse bias.

All participants were asked for verbal consent before beginning the questionnaires. We informed participants about the survey, its purpose, and potential risks. Participant names were not recorded. Unless otherwise noted, quantities are reported in terms of their means and standard errors. Permission for this study was granted by Princeton University's Institutional Review Board (#7274) and Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences (#2015.52).

Bag records
Ten hunters agreed to fill out data sheets for hunting trips taken from July 2015 to June 2016, spanning a full wet and dry season cycle. They listed hunting trip duration and the number of hunters in the party, and marked the number of individuals caught for a range of small- to large-bodied mammals and birds (Appendix 1, Table A2). A total of 57 trips taken by 10 focal hunters were recorded.

Quantitative survey
Respondents provided socioeconomic information including their age, ethnicity, marital status, sources of income, crops grown, and average monthly income (RMB) in the wet and dry seasons. Household size and the number of working adults were recorded. The QS was piloted with nine hunters in a village outside the sampling frame to ensure comprehensibility. Questions pertaining to hunting activity were phrased in the conditional tense (e.g., "If you could successfully capture two large pheasants [and nothing else] each hunting trip, would you continue hunting?") to minimize nonresponse. Thirty hunters were surveyed.

Ultimately, the QS sample was 70% Yao, 23.3% Dai, and 6.7% Han, with the ages spanning 20-70 years. Although the study region demographics are 29.8% Han, 20.7% Dai, and 6.7% Yao (Yunnan Statistical Bureau 2013), a separate large-scale study showed that the ratio of hunters among the Yao versus the Dai is 3:1, and that anywhere from 8.7% to 43.4% of the rural, adult male population had hunted at least one species of bird in the past year (C. H. Chang, *unpublished data*). As such, our sample is broadly representative of the hunting population. Below, we explain additional QS sections in greater detail.

Hunting practices
We characterized behavior on hunting trips by identifying typical trip lengths, weapon usage patterns, and consumption outcomes for captured game (Appendix 1, Table A3). We investigated whether hunters tended to interact with small and select groups of individuals based on shared identity (location, kinship, ethnicity, age). Hunters ranked the relative importance of four reasons for hunting: recreation, desire to eat bushmeat rather than domestic meat, economic concerns, and "Other," an open-ended field for any additional motivations, such as subsistence consumption.

Preference for different animal groups
Respondents ranked focal taxa in descending order from most to least desirable to hunt. The pilot study participants identified a set of nine mammals and birds that are commonly hunted (Appendix 1, Table A4). Pilot respondents indicated they would get confused assigning ranks to each of the four large-bodied bird species, and indicated that ranking only two at a time would be easier. Thus, each QS respondent ranked seven of the nine sample taxa, i.e., only two of the large bodied birds in the set at a time, and the rank scores ranged from 1 to 7 (most preferred to least preferred).

Exit scenarios: how would hunters respond to changes in catch success?
To determine how hunters may respond to reductions in catch success (corresponding to declines in animal populations), we created hypothetical catch scenarios. In each scenario, hunters were asked to state if they would continue to hunt or stop hunting (a decision to exit the system permanently). By interviewing a pilot group of hunters (n = 9), we determined typical trip length and baseline catch rate (animals/trip) for three categories of prey: large mammals, large birds, and small birds (Appendix 1, Table A3). The pilot interviews indicated that the typical trip length was two days and provided baseline catch rates per hunting trip: one boar or muntjac, two large birds, or five small birds. The pilot respondents stated that the typical trip usually yielded only one type of game mammals only, large birds only, or small birds only. The baseline trip lengths and catch rates were used to create the hypothetical catch rates.

For each prey category, the hypothetical catch rates were 50%, 20%, or 10% expected catch success relative to the baseline. Because the typical catch per trip was so low for all prey categories, these scenarios were presented as successfully obtaining the baseline catch for each prey category once per 2, 5, or 10 trips. This method of assessing exit willingness was preferred to fractional catch (e.g., 0.4 large birds per trip in the 80% reduction case) because it more accurately reflects the reality of hunting in this and other degraded systems. Hunters are not assured of catching anything on a given trip, and measure success in terms of the proportion of trips that yield game (Kai et al. 2014).

Semistructured interview
To elucidate hunter attitudes toward regulation and to examine hunting behavior in more detail, we used semistructured interview prompts (Appendix 2). Respondents reflected on hunting regulations and enforcement, as well as environmental conditions. Five respondents (three Yao and two Dai) were interviewed across the four villages, none of whom participated in the QS survey or the BR data collection. The interview findings are either summarized or paraphrased.

Data analysis
Recorded catches (BR), prey preference scores, exit scenario responses, and hunter social interactions (QS) are reported in terms of the mean ± standard error of the mean. We used a linear model to regress prey preference against body mass, and local regression (LOESS) to characterize the different exit scenarios in the quantitative survey.

RESULTS

Bag records
The mean trip length was 1.9 ± 0.02 days (n_{BR} = 57 [range: 1, 5]). Hunting parties averaged 2.3 ± 0.04 hunters (n_{BR} = 39). Among the recorded trips, 61.5% were group hunts, and 38.5% were solo trips.

Only one type of game was usually caught per trip, i.e., mammals, large birds, or small birds. On only 5 trips out of the 57 records (8.8%) were more than one group of prey captured together (large birds and large mammals, n_{BR} = 4; large birds and small birds, n_{BR} = 1). The average catch per trip for each group of prey was 0.25 ± 0.01 boar and muntjac, 0.47 ± 0.01 large-bodied birds (phasianids, Imperial Pigeons [*Ducula badia*], Great Barbet [*Psilopogon virens*]), and 0.56 ± 0.03 small-bodied birds (passerines and near-passerines, primarily bulbuls in genus *Pycnonotus*). This would translate to catching one boar or muntjac once every four hunting trips, and catching one bird (large or small) once every two hunting trips.

Quantitative survey results

Demographic characteristics
The mean household annual income was USD $4354 ± $113, with an average annual per capita income (including children) of USD $1172.16 ± $42.48 ($n_{QS}$ = 29). The mean number of residents per household was 4.7 ± 0.05 individuals. All respondents were farmers, and 80% of respondents were rubber smallholders. Apart from rubber, respondents grew 1.2 ± 0.03 crops (e.g., sugarcane, n_{QS} = 30). Most members (*c*; 64%) of the household farmed the family landholding. The rest were typically children in school.

Reported per capita annual incomes were slightly higher than the Xishuangbanna state average ($1096) (Hammond et al. 2015). 76% of interviewed households had per capita annual incomes above China's poverty line (RMB 2500/USD $375). Families whose per capita incomes fell below the national poverty line were equally distributed across the four surveyed villages. Before the price of oil crashed, rubber sold at four times its current value, and fewer households in the study region fell below the national poverty line (Fox 2014). Among the surveyed households, 83% had agricultural incomes above tropical developing country averages (Angelsen et al. 2014).

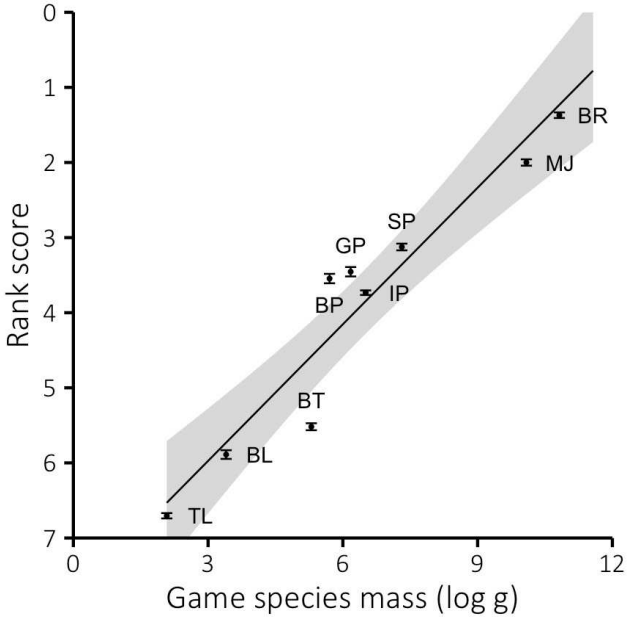
Hunter motivations
The possible range of ranks that could be assigned to each type of motivation was 1 to 4. Respondents ranked leisure as the primary motivation to hunt (1.3 ± 0.03, n_{QS} = 21 [range: 1, 3]) followed by the desire to eat bushmeat over domestic alternatives (1.8 ± 0.03, n_{QS} = 25 [range: 1, 3]). Economic motivations came in last place (2.3 ± 0.07, n_{QS} = 16 [range: 1, 4]). All of the respondents using the "Other" category (n_{QS} = 5) said they hunted because it was a fun activity.

Interactions between hunters
Respondents shared information often (57.1%) or sometimes (17.9%) with other hunters (n_{QS} = 28). All respondents joined group hunts; 22.2% often, 29.6% sometimes, and 48.1% rarely hunted with others (n_{QS} = 27). The results for group hunting and information sharing were similar.

Respondents tended to interact with their own ethnic group; 70% solely interacted with their own ethnic group, 19% with their own and other ethnicities, and 11% with other ethnic groups only. Friends were always consulted but not necessarily family; 21% solely associated with their friends, and 79% with friends and family. This trend was not necessarily because of age similarity in friendship groups; 76.9% of respondents communicated with hunters of all age groups. However, the respondents overwhelmingly associated with members of their own village (70.3% with an additional 14.8% that included other villages); only 14.8% solely interacted with hunters from other villages.

Game preferences and hunting practices
The respondents significantly preferred hunting larger-bodied game over smaller-bodied species (Fig. 2, $F_{1,7} = 77.6$, $p < 4.9 \cdot 10^{-5}$, $R_{adj}^2 = 0.91$, $n_{QS} = 30$). Grey Peacock-Pheasant (*Polyplectron bicalcaratum*) and Bar-Backed Partridge (*Arborophila brunneopectus*) were more preferred than the predicted relationship between rank score and mass. Hunters preferred Barbet (*Psilopogon* spp.) less than would be expected from the rank-body mass relationship.

Fig. 2. Hunters preferred larger game species. A linear model was fit between rank score and the focal taxa's mass (log-transformed), and the grey band corresponds to the 95% confidence interval. The points and associated error bars show the average rank (and standard error of the mean) for the focal taxa. The game species masses are provided in Appendix 1, Table A4. The abbreviated labels represent the following: BR, boar; MJ, muntjac; SP, Silver Pheasant (*Lophura nycthemera*); GP, Grey Peacock-Pheasant (*Polyplectron bicalcaratum*); IP, Imperial Pigeon (*Ducula* spp.); BP, Bamboo Partridge (*Arborophila* spp.); BT, Barbet (*Psilopogon* spp.); BL, Bulbuls (family Pycnonotidae); and TL, Tailorbird (*Orthotomus* spp).



Generally, captured game was not sold, but instead was eaten at home or shared with friends and family (Table 1). Respondents typically used generalist gear, chiefly guns (67%) and snares (32%). There was no indication that hunters tended to specialize on one type of weapon over others; hunters who used snares or mist nets also reported using guns.

Exit decisions
The exit scenario responses exhibited three clear thresholds for exiting the system: (1) after pigs and muntjac were extirpated (an early exit); (2) after large birds were extirpated (midway exit), and (3) declining to exit even when the catch was limited to small birds (late exit). We explored whether or not richer households tended to exit earlier or later. Typically, respondents who exited early (strategy 1) had higher per capita incomes than those who would exit later, but some of the lowest-income respondents would also exit early (Fig. 3).

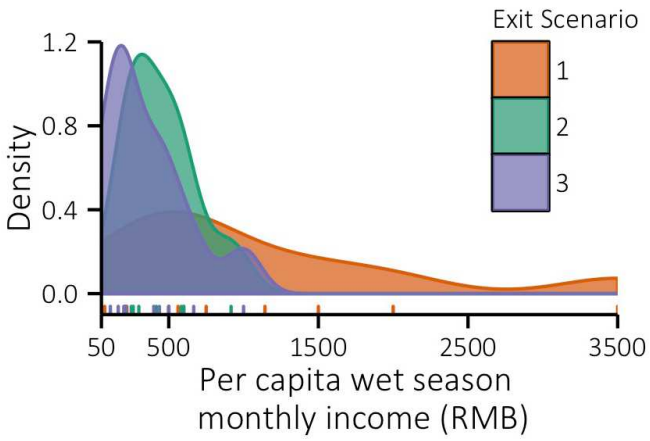
Indeed, many respondents reported they would continue hunting notwithstanding major reductions in the expected catch for mammals and birds (Fig. 4). Even when the expected catch was limited to small birds, as many as 36.7% of respondents said they would continue hunting. However, small birds had the lowest

preference rankings (Fig. 2), which should have led to high exit willingness. And even when the expected catch rate for small birds was extremely low (one successful trip out of ten), 16.7% of respondents stated they would still not exit.

Table 1. Frequency of usage for various weapons (Weapon) and consumption pathways (Game Consumption) for hunted game. Snares and guns are widely used. Most captured game is shared with friends (Share) or consumed at home (Home), rather than being sold at market (Sell). Frequency of usage denotes respondents who never, rarely, sometimes, or often engage in a particular activity.

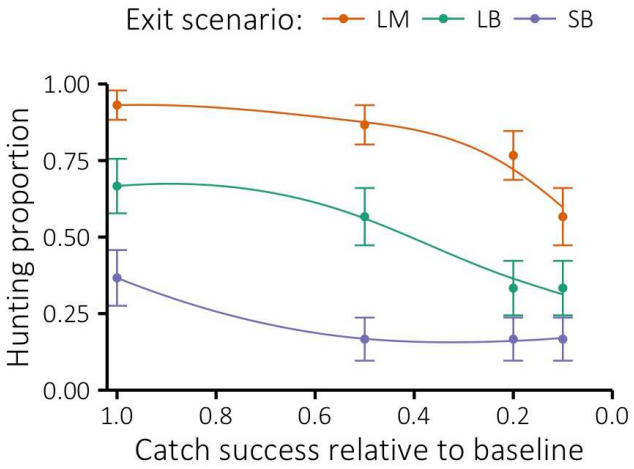
	Frequency of usage			
	Never	Rarely	Sometimes	Often
Weapon				
Mist net	0.93	0.07	0	0
Snare	0.68	0.21	0.04	0.07
Gun	0.33	0.24	0.03	0.4
Game Consumption				
Share	0.04	0.14	0.1	0.72
Sell	0.88	0.12	0	0
Home	0.32	0.04	0.07	0.57

Fig. 3. The distribution of per capita monthly incomes associated with those respondents that would exit early (1; after the extirpation of large mammals), midway (2; after the extirpation of large birds), or late (3; after the extirpation of small birds, or refusal to exit in all conditions). The tick marks below the density plots show the individual responses observed for each exit threshold. Respondents who would exit late (that is, they expressed willingness to continue hunting when the prey base solely comprised small passerines and expected catch was low) had lower incomes on average than early exiters.



Discrepancies between stated and revealed preferences can complicate the interpretation of exit scenario data. One cause for concern would be if the hypothetical exit scenarios substantially diverged from reality. The bag records revealed low catch rates for all three of the prey groups (mammals, large birds, and small birds), consistent with the exit scenarios.

Fig. 4. The proportion of respondents who would continue to hunt in different scenarios of catch success. The first point for each group of game corresponds to the baseline level of catch for each group on a typical hunting trip; the other points correspond to 50%, 20%, and 10% of the baseline catch success. Hunters were prompted to imagine that they could only hunt large mammals (LM), large birds (LB), or small birds (SB) within each set of scenarios. A LOESS curve (span = 1.15) was fit for the proportion of hunters who would continue hunting for each category of game (LM, LB, and SB).



In addition, the respondents felt that the nine focal taxa were less common in the past year compared with a decade ago and that larger-bodied game had declined more severely than smaller species. The proportion of respondents perceiving a decline in abundance for the focal taxa were 92.9% for muntjac; 86.7% for Silver Pheasant (*Lophura nycthemera*) and Imperial Pigeon, 77.8% for Grey Peacock-Pheasants, Bamboo Partridges (*Arborophila* spp.), and pigs, 69.6% for Barbets, and 15.4% for Bulbuls (family Pycnonotidae) and Tailorbirds (*Orthotomus* spp). There was a strong association between perceived decline and body mass (Spearman's $\rho = 0.82$).

Semistructured interview

Qualitative perceptions of hunting

All respondents ($n_{SS} = 5$) indicated that hunting in this landscape does not provide many material benefits. One illustrative example was a respondent's assertion that "there aren't really any [benefits from hunting]. Mostly it's fun and occasionally you get to eat wild meat.... Now that [hunting] is illegal,...if they (hunters) see something they'll shoot it." Four of the five interviewees explicitly stated that hunting was and continues to be entertaining. For instance, one of the SS respondents stated that "[People continue to hunt because it] is their hobby. Going into the forest to hunt is fun and sometimes you get to enjoy wild meat."

The interviewees noted that hunting weapons (mainly guns) have "become more advanced" in the past 20 years. All respondents ($n_{SS} = 5$) reported that catch rates have plummeted, and attributed the decline to overhunting and habitat degradation. "Many

forests have been cleared for agriculture, and there are fewer animals in the forest.... Before, the forest grew very thick, so there were more wild animals. But now the forests are very damaged, so there are many fewer animals." Hunters also noted that forest fragmentation and advances in technology have made accessing the forest easier; "there are roads and cars so you don't have to walk everywhere."

Hunter opinions on enforcement

Antihunting and arms-restriction enforcement has ramped up in the past decade. All of the quantitative survey and semistructured interview respondents were aware of the national firearms ban and believed that no birds or mammals can be legally harvested, which is, in fact, more restrictive than the law actually is. Of the nine focal taxa presented in the ranking activity, only Silver Pheasant, Imperial Pigeon, and Grey Peacock-Pheasant are actually protected by law.

Hunters deploy a variety of tactics to avoid penalties for illegally owning guns and hunting. Rangers patrol too infrequently to catch hunters at significant rates, and villagers know when patrols have arrived in a particular location. One interviewee issued the prescriptive that one should "[b]e like a mouse with the cat; when the cat comes, the old mouse hides," and then bluntly stated, "[y]ou can't be punished if you don't get caught."

The hunter interviewees resented the fact that the forestry police rely on informants. Only one of the respondents felt positively about informants, stating that they are "pretty grateful [to informants], maybe someday I can change my ways.... Most people should feel the same, but some might not get it." All of the other interviewees reported that they disliked informants and would retaliate. One stated, "[I think about] getting even. If you report me this time, then when you go up [into the mountain to hunt], I'll report you. I think most people would have the same idea." As a result, it is "riskier to report a local [for illegal hunting] over an outsider." Devolving regulation to or copolicing hunting activity with village committees may be more palatable to villagers. One respondent stated, "We are more afraid of the forestry police. But we respect the village committee more because they work for us, so we believe in them more."

Nonetheless, the interviewees expressed their belief in the state's legitimacy to regulate hunting and firearms, despite their enjoyment of hunting and regular disregard of these laws. One respondent stated that "People have to follow the country's laws. You can only go into the forest to play [euphemism for hunting] when it's not illegal.... If there weren't restrictions [on hunting] then local people would be very happy, [but] we have to follow the laws." Others elaborated that "We [villagers] wouldn't demand [to change the law], we can only respect the law."

DISCUSSION

We found that recreation was ranked as the main force driving hunting in both the quantitative surveys and semistructured interviews in our rural study area in tropical Southwest China. Most hunting catch was shared or eaten at home rather than being sold at market, reinforcing our finding that profit does not seem to be a primary motivation. We presented a novel questioning technique, exit scenarios, to measure how hypothetical reductions in game availability would affect the rate of hunting, and found that hunting activity in Xishuangbanna was surprisingly resilient to reductions in catch. Respondents repeatedly opined that the degraded landscape of monoculture agriculture with scattered forest preserves harbored very few game species, which was confirmed by the low catch rates reported on the bag records. Semistructured interviewees asserted that on a typical hunting trip, one could almost be assured of returning empty handed. However, most interviewees expressed an eagerness to continue hunting even if game populations declined more precipitously, which supported the quantitative survey exit scenario results.

The entertainment value of hunting may, in fact, be widespread but heretofore overlooked in rural developing world settings (Harrison et al. 2016). Although this study focused on hunters living in relatively wealthy and comfortable conditions, previous research has described poverty-stricken hunters who nonetheless prize the thrill of the chase. For poor subsistence hunters in Vietnam, the enjoyment of hunting was itself a major reward, with one hunter stating, "Even if I can get enough food for living from other livelihoods I still like to go to the forest to hunt until my health would not be strong enough for trapping...I like trapping" (MacMillan and Nguyen 2014). Alfaro-Shigueto et al. (2016) observed poor artisanal fishermen in Peru shooting endangered Waved Albatross (*Phoebastria irrorata*) for sport, with no obvious material gains. Just as cultural and social values are recognized as important dimensions of wildlife exploitation (Barnes-Mauthe et al. 2015, Oleson et al. 2015), so too should the entertainment or recreational value of hunting be considered more broadly, especially if it attenuates decisions to stop hunting in response to dramatic game population crashes.

Another driver for sustained hunting behavior is a cultural or gustatory preference for wild meat even when domestic alternatives are readily available (Fa et al. 2002, Zhang et al. 2008, Lee et al. 2009, Scheffers et al. 2012, Morsello et al. 2015). Respondents in the quantitative and semistructured interviews indicated a preference for wild meat over domestic poultry or pork. Local villagers are largely well nourished with ample access to domestic poultry and livestock (Hammond et al. 2015). The low catch rates from the bag records indicate that hunting would not provide a stable source of food, similar to the findings of Kai et al. (2014).

Expecting hunters to reduce hunting effort in response to declining catch may not be realistic if hunting is a form of leisure; if the entertainment value of hunting is not strongly linked to successfully catching prey, then the pleasure of pursuit could sustain hunting activity even when game become increasingly rare and elusive. The combination of body size preference and reluctance to stop hunting promotes hunting-down-the-web defaunation; there is no reduction in hunting effort as valuable game species become rarer, thereby preventing any natural recovery of overexploited species (Pauly et al. 1998, Cowlishaw et al. 2005, Wilkie et al. 2011).

Respondents exhibited a strong preference for large game, and larger body size was strongly correlated with a greater perception of decline, similar to global patterns of mammalian endangerment (Cardillo et al. 2005, Davidson et al. 2009). Although the hunter respondents preferred large prey, they were nonetheless willing to continue hunting even when catch rates were vanishingly small and limited to low-value taxa, as shown by the trip records and the quantitative survey. They tended to

use generalist weapons such as rifles that can target volant and nonvolant vertebrates. Such generalist gear permits high levels of overall extraction (Rao et al. 2005, Van Vliet and Nasi 2008, Abernethy et al. 2013). In Xishuangbanna, these hunting dynamics may explain the regional extirpation of large-bodied birds and mammals such as Green Peafowl (*Pavo muticus*) and Sambar deer (*Rusa unicolor*; Luo and Dong 1998, Han et al. 2009, Kai et al. 2014).

Persistent willingness to continue exploiting wildlife stocks despite low catch has been documented in regions mired in deep poverty as well as relatively wealthy communities with market access (Cinner et al. 2009). To our knowledge, our examination of hunter exit decisions is novel, but the artisanal fisheries exit decision literature echoes our results. Rural poor fishers in the Philippines would opt to continue fishing even if they were offered buy-outs that exceeded their monthly expenditures by 150% (Muallil et al. 2011). At the other end of the economic spectrum, relatively well-off households in rural East Africa would continue to fish despite anticipated catch declines of 50% or more (Daw et al. 2012).

The late exiters (those that would continue hunting even when their catch was limited to low-biomass prey such as passerines) had the lowest mean and median incomes, presenting a potential caveat to our study. However, domestic poultry and livestock and refrigeration are readily available for even the poorest villagers in the focal landscape (Hammond et al. 2015; Chang, *unpublished data*). Leisure was also the top ranked motivation for the poorest respondents. We believe that the income difference in exit thresholds did not manifest a livelihood poverty trap, but was rather a result of the fact that lower-income respondents lived in rural, high mountain villages where alternative leisure activities such as karaoke are limited.

Noncompliance with hunting regulations is a major cause for concern (St John et al. 2011, 2013, Nuño et al. 2013). The appropriate scale for regulation is subject to debate between top-down and bottom-up perspectives. Currently, Chinese laws and regulations regarding wildlife and exploitation are centrally determined and enforced at state and county levels (Grumbine and Xu 2011). China is exceptional in the degree of public trust invested in the law and the widespread belief that the government need not consult its citizens when setting laws (Shi 2001, Li 2004). As such, there is typically acknowledgment of the law's legitimacy, even on the part of inmates (Zhang et al. 1999). China extensively disseminates its laws, resulting in high rates of legal awareness (Li 2004).

Respondents to our quantitative and semistructured surveys were aware of laws governing hunting and expressed a surprising degree of acceptance. In fact, our interviewees believed that all species are banned for hunting, which is stricter than the law. The perception that all birds and mammals are protected from harvest may be because of two factors: (1) restricted access to protected areas, because there are no large forest patches outside of protected lands (Xu et al. 2014), and (2) the firearms ban, because hunters in this region typically use guns. Respondents did not argue that they should be permitted to hunt, nor did they invoke ancestral rights, sovereignty, or self-determination, as has been the case in other rural tropical contexts (Colchester 2000, Perreault 2003, El Bizri et al. 2015). All of the respondents stated that the state was morally correct in setting and enforcing laws to protect wildlife.

However, acknowledging the law does not guarantee compliance, and we assert that top-down hunting and firearm restrictions has provoked defiance in Xishuangbanna. Although inadequate patrolling has permitted hunting to continue in Xishuangbanna, the perception that enforcement relies on unfair tip-off and forced interrogation tactics has encouraged bottom-up cooperation against the state. It is thus challenging to conduct research on the efficacy of state intervention; enforcement has succeeded in making public conversation about hunting highly sensitive, especially with outsiders, but has not curbed excessive hunting effort.

Strong kinship ties and shared ethnic identity reinforced by the traditional Chinese system of *guanxi* (interpersonal connections) may be a powerful guarantor of confidentiality and deterrent to reporting one's neighbor for illegal hunting violations (Hwang 1987, Wang et al. 2008). Our results on the interactions between hunters and their confederates suggest that there is some degree of ethnic homophily at play (Barnes-Mauthe et al. 2013, Barnes et al. 2016). This is most likely because hunters tend to associate with members of their own villages, or those nearby.

For a diffuse and relatively invisible behavior such as hunting, village-level enforcement in rural settings may be powerful and more effective than top-down control (Ostrom et al. 1994, 1999, Gibson et al. 2005). The semistructured interviewees preferred that regulation of hunting be devolved to individual villages rather than county- and state-level forestry and environmental protection bureaus. Community programs can produce rapid and marked changes in the rates of illegal hunting. In Thailand, village interventions led to increased tiger (*Panthera tigris*) abundance and reduced illegal hunting (Steinmetz et al. 2014). Similarly, village committees in Cambodia were able to enforce protection for the critically endangered Giant Ibis (*Thaumatibis gigantea*), fostering a local ethic of protecting habitats and nesting sites (Clements et al. 2010). Future work in Xishuangbanna should verify the appropriate scale for regulating hunting and identify potential interventions that could curb hunting behavior or direct it in a more sustainable fashion. One method would be to incorporate enforcement instruments or hunting legislation into exit scenarios to assess how different interventions could curtail excessive hunting effort.

Managing natural resources succeeds or fails based on the motivations of human users. We found that hunting in Southwest China is largely driven by a desire for outdoor recreation. Discounting the recreational component of hunter motivations can lead to inaccurate expectations about the impact of particular interventions. When catch rates and recreational utility are decoupled, regulation must use additional levers to shift behavior toward desired trajectories.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/9072

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Erratum: The original publication of this manuscript contained the wrong appendix. This correct Appendix 1 was added on 30 March 2017.

Appendix 1: **Additional information on the study location and interview question design**.

Village	Households	Distance via road to nearest urban center (km)	Percent of access road to urban center that is paved
NP	23	8.84	74%
SJ	50	35.1	80%
YQ	83	25.3	100%
XM	60	3.2	100%

Table A1: The characteristics of the focal villages. The names of the villages are represented using symbols to protect respondent anonymity.

Group	Common name	Local name	Species name
Large mammals	Wild boar	Ye zhu or Dong	*Sus scrofa*
	Muntjac	Ji zi	*Muntiacus muntjak*
Large birds	Grey peacock-pheasant	Guang gui or He hua	*Polyplectron bicalcaratum*
	Partridge *spp*.	Tuan ji	*Arborophila* spp.
	Silver pheasant	Bai xian	*Lophura nycthemera*
	Wild junglefowl	Ye ji	*Gallus gallus*
	Chinese francolin	Ma ji	*Francolinus pintadeanus*
	Mountain bamboo-partridge	Zhe gu	*Bambusicola fytchii*
	Hornbill *spp*.	Da zui qiao	Primarily *Anthracercos albirostris* and *Anorrhinus austeni*
	Great barbet	Zha lu	*Psilopogon virens*
Small birds	Smaller barbet spp.	Gu du lu ke or Nuoc'bao	Primarily *Psilopogon asiatica*
	Dove spp.	Jiu	Primarily *Chalcophaps indica*,
	Woodpeckers	Zhuo mu niao	Primarily *Chrysocolaptes* spp.
	Laughingthrush	Shan fu	*Garrulax* spp.
	Bulbul	Hei tou gong	Primarily genera *Pycnonotus*,
	Unidentified small bird	Xiao niao	—

Table A2: The list of species provided on the hunting trip data sheets. Common name denotes the species or genus of interest.

Variable	Measure
Behavior on trips	
Long hunt trip duration	Days
Short hunt trip duration	Hours
Weapon usage	Frequency (0-3)
Consumption outcomes for hunted game	Frequency (0-3)
Information sharing and group hunting	
Family members that also hunt	Checklist
Participation frequency	Frequency (0-3)
Topics for discussion	Checklist
Ethnicity of confidants and trip participants	Checklist
Age of confidants and participants	Younger, Same, Older
Whether confidants and participants are friends, family, or both	Yes/No
Whether confidants and participants reside in same village as respondent	Yes/No

Table A3: Questions regarding hunter behavior on trips and interactions with other hunters. The "frequency" 0-3 score corresponds to never, rarely, sometimes, and always. For checklists, the respondent indicated whether each item was or was not relevant (e.g. "Ethnicity of confidants and participants" checklist would have check boxes for each of the ethnic groups).

Common name	Species depicted	Local name	Mass (g)	Card ID	Image source
Tailorbird	*Orthotomus atrogularis*	Feng ye ying	8	B	MacKinnon *et al*. (2000)
Bulbul	*Alophoixus pallidus*	Hei tou gong	30	B	MacKinnon *et al*. (2000)
Barbet	*Psilopogon virens*	Gu du lu ke or Nuoc'bao	200	B	MacKinnon *et al*. (2000)
Silver pheasant	*Lophura nycthemera*	Bai xian	1500	1	del Hoyo *et al*. (2015)
Hill partridge	*Arborophila spp*.	Tuan ji	300	1	del Hoyo *et al*. (2015)
Grey peacock-pheasant	*Polyplectron bicalcaratum*	Guang gui/He hua	480	2	MacKinnon *et al*. (2000)
Imperial pigeon	*Ducula badia*	Da hang ban	670	2	MacKinnon *et al*. (2000)
Wild boar	*Sus scrofa*	Ye zhu or Dong	50000	B	Smith *et al*. (2010)
Muntjac	*Muntiacus muntjak*	Ji zi	24000	B	Smith *et al*. (2010)

Table A4: The set of animals that the respondents ranked. Field guide images of each taxon were printed onto laminated card-stock (11" x 14"). There were two cards: A and B that the enumerators switched between using a coin toss. Common name denotes the species or genus of interest. For cases where a genus was the example (e.g. tailorbird), a representative species was chosen to include on the card. Card ID indicates if the taxon was shown on both (B), the first (1), or second (2) cards. 16 respondents ranked the first card (A) and 11 ranked the second (B). **Sources:**

del Hoyo, J., A. Elliott, J. Sargatal, D. A. Christie, and E. de Juana, editors. 2015. *Handbook of the Birds of the World Alive*. Lynx Edicions, Barcelona, Spain. [online] URL: http://www.hbw.com/

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Appendix 2.
Semistructured interview guide.

Section 1: Why hunters hunt in an era of high risk (perception)

1. What recreation options do local people have?
2. What livelihood options do local people have?
    a. What crops do farmers grow?
    b. How does this differ from the situation twenty years ago?
3. What thoughts do local people have regarding hunting?
4. Why do people continue to hunt now?
5. What are the upsides of hunting, if any?
    a. Before, what did people feel the benefits of hunting were?
6. What are the downsides of hunting?
7. What has made it easier to be a hunter in the past 20 years?
8. What has made it harder?
    a. Can you describe how the forest and animals have changed since you started hunting as a youth?
    b. Has the regulation of hunting changed since your youth?
9. Have any of these changes affected your or others decisions to hunt?
10. Many respondents have stated that young people (post-90s) hunt much less than their elders. What is causing this trend?
11. How do you feel about this trend where young people are hunting less and less?
    a. What is good about it?
    b. What is bad about it?

Section 2: Enforcement and leakage

1. Are all forests equally protected?
    a. Is it more or less risky to hunt in certain areas?
    b. What about different distances to villages?
2. How do people select which places they want to go hunt?
    a. Do they think differently about 国有林 (nationalized forest), farmland, 集体林 (community forest), and protected areas?
    b. Are there any trade offs in terms of risk and reward?
3. What precautions can hunters take to avoid punishment?

Section 3: Enforcement and reasons for hunting

1. In the interview, lots of people have mentioned that hunting is really tightly enforced now.
    a. What are the laws?
    b. What is protected? / What is illegal to do?
    c. Historically, were there local rules in your community about getting pigs, muntjac, and other prized animals?
    d. Are there any local rules in the community about getting animals now?
2. How does the local village committee enforce these laws?
    a. How do forestry rangers in villages enforce these laws?
    b. How do the forestry police at the county, state, or provincial level enforce the law?
3. How does the forestry police get information about people hunting?

4. How do local people feel about this?
    a. How do they feel about the way the policies get this information?
    b. How do they feel about people who provide this information?
5. What risks, if any, do people face when they report people in their village for hunting? What about if they report outsiders from the village? What about outsiders who know or are related to people in the village?
6. What if the village forest/protected area ranger reports that a local person is illegally hunting? What risks and rewards might he receive?
    a. What if they report an outsider? Would they face the same level of risk? Would they gain the same level of benefits?
7. Do people generally respect local institutions (village committee) more than centralized ones (county/state/provincial level)? Are people more afraid of local institutions than centralized ones?

Section 4: Enforcement and interviews

1. What do you worry about when participating in this interview?
    a. We know each other well. How do you think the general population would respond to my last interview? To this interview?
    b. What would other people worry about when participating in this interview, particularly people who do not know us well?
2. What are the potential repercussions of responding to this interview?
    a. What about the previous interviews that I have done?
3. Do you think these repercussions are likely to happen?
4. Would people have responded differently to this interview a decade ago?
    a. What has caused people to respond differently?