# Revisiting optimal foraging theory (OFT) in a changing Amazon: Implications for conservation and management

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## Abstract

Hunter decision-making influences prey selection and is key to understanding the impacts of hunting on biodiversity. Optimal foraging theory (OFT) is often used to describe the decision-making and prey selection of subsistence hunters. We examined the behavior and game meat use of hunters in an indigenous Amazonian community and used free-listing and generalized linear mixed-effects models under the framework of OFT to assess the decision-making of individuals who hunt for economic gain and subsistence. We found that prey selection generally followed OFT, and was influenced by hunter prowess, patch choice, and characteristics of the prey encountered. Hunters preferred paca (*Cuniculus paca*), collared peccary (*Pecari tajacu*), and brocket deer (*Mazama americana*) and only partially preferred tapir (*Tapirus terrestris*) and large-bodied primates likely due to economic influences such as access to markets and prices, contrary to OFT.

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## Introduction

Tropical forests support an estimated 50% of the world's described species and many more that remain undescribed (Groombridge and Jenkins 2002). Logging and overhunting are frequently cited as drivers of biodiversity loss, particularly in the Amazon Basin of South America (Benítez-López et al. 2017; Brancalion et al. 2018; Milner-Gulland and Bennett 2003; Redford 1992; Schipper et al. 2008). Overhunting often results from commercial hunting, a consequence of local hunters selling game meat to local markets to feed demand in urban centers throughout the Amazon Basin (El Bizri *et al.* 2020; Mayor et al., 2021; Lozano and Fang 2004). While the effects of heavy hunting pressure are well studied (Benítez-López et al. 2017), the impacts of small-scale hunting on mammal populations are often confounded by other disturbances, such as habitat degradation (Peres 2001; Redford 1992, Remis and Jost Robinson 2012). Even in the absence of other disturbances, variability can still be introduced due to differences in hunting practices and behavior of individual hunters and communities. Optimal foraging theory (OFT) (Charnov 1976) is often used to describe the decision-making behavior of hunter-gatherers. OFT is a set of models which dictate the breadth and proportion of prey items that a predator should take (diet breadth model) as well as where those prey should be taken (patch choice model) (Hames and Vickers 1982).

Under the diet breadth model (Emlen 1966), prey are ranked according to the return rate afforded to the hunter, often calculated as the caloric intake gained per hour spent pursuing, killing, and processing the animal (Alvard 1993; Bettinger et al. 2015; Smith *et al.* 1983; Winterhalder 1981). As such, OFT focuses mainly on hunting for subsistence, not economic gain. A prey item is included in the diet breadth if the return rate of pursuing and killing the animal is higher than the expected mean return rate of ignoring the species and continuing to search for a higher ranked species, thereby maximizing the hunter's short-term harvesting rate (Alvard 1993; Bettinger et al. 2015; Hawkes and O'Connell 1992; Smith *et al.* 1983; Stephens and Krebs 1986). A key prediction of the diet breadth model is the zero-one rule, which states that hunters should always pursue species within the diet breadth and never pursue species outside, thereby never exhibiting "partial preferences" for prey (Bettinger et al. 2015; Levi et al. 2011a; Stephens and Krebs 1986). However, studies have shown that partial preferences could be introduced by conservation behaviors, taboos, and economic influences (Alvard 1993; Hames 2007). In the case where hunting causes declines of high-ranked species and the search time for those species increases, new, more abundant species may be added to the diet breadth (Bettinger et al. 2015; Hames and Vickers 1982; Pyke *et al.* 1977). Erosion of traditional taboos and technologies may also allow new species to be introduced to the diet breadth (Hames 2007; Hames and Vickers 1982; Hill and Hawkes 1983; Vickers 1980). Frequently, the species that provide the highest return rate are the largest bodied species, which are also vulnerable to extirpation due to low reproductive rates (Mayor et al. 2017; Redford 1992; Vickers 1991).

The patch choice model (Charnov 1976) assumes that hunters are central place foragers who exploit resources nearby the community first, eventually producing a gradient of game availability (Venkataraman et al. 2017; Winterhalder 2001). The model states that hunters will choose to hunt in patches where resource availability is highest, and therefore the return rate is highest (Bettinger et al. 2015). However, species which become rare in depleted patches are still pursued when encountered and are not dropped from the diet breadth (Bettinger et al. 2015; Hames and Vickers 1982; Winterhalder and Lu 1997). Hunters who do not change their patch choice in response to game depletion are forced to expand their diet breadth to include more abundant, less preferred species (Charnov 1976; Hames and Vickers 1982; Levi et al. 2011a).

The choices and characteristics of individual hunters or hunts may influence the effectiveness of OFT in predicting hunter behavior, including the hunter's skill (Hill *et al.* 1987), beliefs (Lemos *et al.* 2021), food preferences (Chaves *et al.* 2020) and cultural taboos (Hames 2007), the conditions of the hunt (Levi et al. 2011), the characteristics of the animal encountered, and the available technology (Bettinger 2009; Hames and Vickers 1982). Individuals may also have different goals and currencies and therefore return rates (Mithen 1989). For example, a hunter may want meat for subsistence to feed his family, for gifting to neighbors to further his social standing (Bird and Bird 1997; Hawkes *et al.* 2001), or for sale to market for economic gain (Ayres *et al.* 1991). Previous studies on the applications of OFT to human hunters have aggregated data from individual hunters to be analyzed on a community level (e.g. Hurtado, Hawkes, and Kaplan 1985; Hill, Kaplan, Hawkes, and Hurtado 1985); however, the variation due to these individual influences is then lost (Asmhyr et al. 2013; Chaves et al. 2020; Mithen 1989).

This study revisits OFT by examining hunting behavior, partial preferences, patch choice, and game meat economics in an indigenous Amazonian community that has access to the regional market. We use free-listing of hunter preferences and generalized linear mixed-effects models to assess whether OFT applies and is accurate in describing individual hunter behavior where economics influences hunter decision-making alongside subsistence pressures. Specifically, we address the following questions:

1. Which species are sold for economic gain by hunters and how much are they worth?
2. Which species do hunters prefer, and do those preferences align with what would be predicted by OFT?
3. Does OFT accurately predict individual hunter decision making upon encountering prey?

## Methods

### *Study Site*

Fieldwork was conducted in collaboration with the Maijuna (Orejón) indigenous group of the northeastern Peruvian Amazon. The Maijuna are a Western Tucanoan people with a population of approximately 600 individuals (Gilmore 2010). There are four Maijuna communities: Puerto Huamán and Nueva Vida along the Yanayacu River, Sucusari along the Sucusari River, and San Pablo de Totolla (Totoya) along the Algodón River (Fig. 1). These three river basins are part of the ancestral territory of the Maijuna and no other communities are located within this area (Gilmore 2010). The Maijuna traditionally lived in the interfluvial area between these three rivers. This residence pattern lasted until the early 1900s when the Maijuna began to slowly migrate downriver, due to influence from missionaries and *patrones* (colonists and their descendants who exploited indigenous labor to harvest forest resources), to where they eventually formed their current communities (Bellier 1993, 1994). Greater ethnographic context and a detailed ethnohistory of the Maijuna can be found in Gilmore (2010).

Fieldwork for this study was conducted in the Maijuna community of Sucusari (72.92995º W, 3.24373º S) (Fig. 1). Sucusari is approximately 126 km by river from the city of Iquitos, the commercial and political center of Loreto. However, the trip can be shortened to 70 km by crossing the thin isthmus between the Napo and Amazon Rivers by road at Mazán, a small town. The titled land of the community encompasses 4,771 hectares and adjoins the Maijuna-Kichwa Regional Conservation Area (MKRCA), a 391,040-hectare protected area that is made up of Maijuna ancestral lands and collaboratively managed by Maijuna and Kichwa indigenous communities and the regional government (El Peruano, 2015). The community has a population of 166 residents made up of both monofamilial and plurifamilial households. Of all community members, 59% are ethnically Maijuna, 35% are mestizos (individuals of mixed Amerindian and Iberian descent; Coomes and Ban 2004) and 6% are indigenous Kichwa (Roncal *et al.* 2018).

Subsistence and income generating strategies of community members include hunting, fishing, swidden-fallow agriculture, and the gathering of various non-timber forest products (Gilmore 2010). Community members sell game meat in the city of Iquitos, in towns surrounding their communities on the Napo River and in the market of Mazán (Gilmore 2020). Mean household income of Maijuna families averages about 505 USD annually (Horn *et al.* 2012, Figure 2). Game meat is also gifted, a cultural norm where a hunter who has recently killed an animal may gift a portion to neighbors, family, and friends within the community. Only men hunt in Sucusari (Roncal *et al.* 2018), hunting opportunistically from canoes, on foot and at mineral licks (Gilmore *et al.* 2020). All hunters hunt with shotguns or with machetes for slow-moving game species. Two hunters in the community use dogs to hunt. Only community members from Sucusari had hunting rights in the Sucusari titled lands and MKRCA. Our research team has been working in the Sucusari community since 1999, which has allowed us to foster strong and close relationships with hunters in the community.

### *Data Collection and Analysis*

All aspects of this study were approved by George Mason University's Institutional Review Board, project #1288488-1. Prior informed consent (PIC) was obtained from the Sucusari community as well as from individual research participants before beginning the interviews for this study. We conducted weekly semi-structured interviews in Spanish (Berg and Lune 2014) with 19 hunters (90.48% of all active hunters) in Sucusari to capture decision-making processes on prey selection and the economics of hunting for a ten-month period from September 2018 to June 2019. The mean age of hunters interviewed was 41 years old, with a range of 22 to 68. Of the 19 hunters interviewed, ten were ethnically Maijuna, eight were mestizo, and one was Kichwa. If a hunter was not home when we visited his house, we made at least two more attempts during the days immediately following the initial visit. If a hunter was still not at home after three visit attempts, we gathered the data for that week during the following week's interview. During the interview, for each hunt, we first asked hunters what time they went hunting, how long the hunt lasted for, and the mode(s) of travel they used (i.e. travel by boat, canoe, or on foot). We then asked which animals they encountered during each hunt and where, asking them to indicate the location on a basemap of locally relevant points, and if they had attempted to kill the animal. If they did not try to kill the animal, we asked why they chose not to. We digitized all encounter and kill locations, extracting coordinates using ArcGIS (ESRI, 2018). We coded interview responses focused on decision-making (Berg and Lune 2014), where reasons for not shooting an animal were coded and then grouped into overall themes. These themes were "Killed", "Escaped", "Low Return", "Attack-Limited", and "Conservation", following classifications of behavior informed by Alvard (1993) and OFT (Table 1). We used these codes to calculate partial preferences based on pursuit rate, or the proportion of encounters in which the animal was killed, shot at, or pursued until it escaped.

When a hunter reported that he killed an animal, we asked how many kg of meat he sold, to whom he sold it, and at what price. Each hunter was also asked how many kg of meat he had consumed with his family and how many kg he had gifted and to whom. All hunters in the community have spring scales which they use to measure the mass of a carcass and portions to sell or gift.

We conducted separate semi-structured interviews in Spanish (Berg and Lune 2014) with 17 of the 19 hunters at the end of the study period to provide context to observed pursuit rates and relative species-specific preferences. Two hunters were not interviewed because they moved away from the community for an extended period while the survey was conducted. We asked hunters to list three species they preferred to kill while hunting (a) by canoe, (b) by land, (c) at a mineral lick, and (d) for game meat to sell. These different hunting methods (a-c) were chosen because hunters noted that they look for different species using each technique. Freelisting is an interview method that can be used to determine the salience of named species (Quinlan 2005; Roncal *et al.* 2018). In this case, it allowed us to rank species in relation to individual hunter preferences. Following Quinlan (2005), we used the following formula to determine the salience of an individual species in a hunter's list of preferences:

$$\text{Salience} = (1 + \text{length}_i - \text{position}_i)/\text{length}_i$$

where length is the total number of species listed by the hunter, and position is the numbered position at which species *i* appears in the hunter's list. We calculated the total salience of each species named at least three times for hunters in Sucusari as the mean of all salience values for that species. Species listed in free lists as preferred are considered those which hunters perceive as having the highest return rates, under OFT. Species which hunters did not list as preferred but pursued sometimes are considered species that are partially preferred (Alvard 1993).

### *Mixed-Effects Modeling*

We used generalized linear mixed-effects models to assess hunter decision-making using encounter data. Species that were encountered by hunters were aggregated into species groups because of a lack of data for some species (Table S1). Paca (*Cuniculus paca*), collared peccary (*Pecari tajacu*), tapir (*Tapirus terrestris*), and brocket deer (*Mazama americana* and *Mazama gouazoubira*) formed their own separate groups, since these were species that were preferred by hunters. Game birds were grouped together, as were large-bodied (> 1.5 kg, those which are pursued by hunters) and small-bodied primates. All other species, which were hunted but not listed as preferred (such as the agouti (*Dasyprocta fuliginosa*) and kinkajou (*Potos flavus*), were grouped into "Other Species". Encounters with carnivores (e.g. the jaguar (*Panthera onca*), puma (*Puma concolor*), and giant river otter (*Pteronura brasiliensis*)) were excluded from analyses because they were not killed during the study period. The yellow-footed tortoise (*Chelonoidis denticulata*) was also excluded from analyses because they were not killed with a shotgun.

As our primary, overarching model to evaluate hunter decision-making, we constructed a generalized linear mixed-effects model with a binomial distribution to assess the factors that contributed to whether a hunter decided to pursue an animal he encountered (Model 1). Each encounter was a sample (*n* = 1,012), and the response variable was a 0/1 based on whether the hunter pursued the animal (animal was killed, hunter took a shot at the animal unsuccessfully, or hunter pursued the animal and it escaped). We included a series of covariates formed under the framework of OFT (Table 2) and the hunter's name as a random effect to account for pseudoreplication caused by repeated samples from the same set of hunters. Only hunters who went hunting at least ten times during the study period were included in modeling (*n* = 17).

To add context to our primary model's results, we constructed three more models. The second model was created to evaluate the factors which contributed to a hunter deciding not to pursue an animal because its return rate was perceived to be too low and was therefore outside the diet breadth (Model 2). This was a generalized linear mixed-effects models with a binomial distribution. Each encounter was considered a sample (*n* = 1,012) and the response variable was a 0/1 based on whether the animal was ignored because of a reason coded as "low return". Covariates included were the same as the previous model (Table 2), with the exception of species group which was excluded due to a lack of sufficient data in each group.

Since an assumption of OFT is that species are never partially pursued, we constructed a third generalized linear mixed-effects model with a binomial distribution to assess the factors that influence when hunters choose to pursue partially preferred species and test this assumption (species in the "Other Species", "Small Primate", "Large Primate" and "Game Birds" groups, see Table S1, which were not always pursued when encountered) (Model 3). Each encounter with a partially preferred species was a sample (*n* = 652) and the response variable was a 0/1 based on whether the hunter pursued the animal (the animal was shot at, killed, or escaped before an intended shot was taken). Covariates included were the group size and mean body size of the animal, the Euclidean distance from the community, the total duration of the hunt, the hunter's overall return rate, and the consumer/producer ratio of the hunter's household, with the hunter's name as a random effect to account for pseudoreplication (Table 2).

Under the hypothesis that a partial preference for a species could be a result of increased wariness of hunters close to the community, requiring greater effort on the part of the hunter to pursue species, we constructed a final generalized linear mixed-effects model with a binomial distribution to assess the factors which contributed to preferred, major game species (paca, tapir, collared peccary, and brocket deer) escaping hunters during an encounter (Model 4). Each encounter with one of these species was a sample ($n$ = 361) and the response was a 0/1 based on whether or not the animal escaped while the hunter intended to kill it (i.e. the reason for not shooting the animal was that it escaped pursuit or a shot was taken unsuccessfully). Covariates in the model included the species group, the hunter's overall return rate, as a measure of the hunter's prowess, and the Euclidean distance from the community.

For all models, continuous covariates were scaled and checked for collinearity before including them in the model, with a correlation cutoff of 0.60 for inclusion (Dormann *et al.* 2013) before proceeding with model selection. We used a model-averaging approach to determine the optimal model, forming a candidate set of all possible combinations of relevant covariates then weighting the coefficient estimates of each model by that model's Akaike weight (Burnham and Anderson 2002). All mixed-effects models were calculated using the *lme4* (Bates et al., 2015) package and model averaging conducted using the MuMIn package (Barton 2009) in R (version 4.0.3) (R Core Team, 2020). Model fit was assessed using the theoretical pseudo-$R^2$ for mixed-effects models for the top-ranked models in each averaged candidate set (Nakagawa *et al.* 2017) and by visually examining residuals.

## Results

### *General Hunting Behavior*

We collected data on 671 hunting trips during the study period. Overall, 38.6% of hunts ($n$ = 256) were conducted over land, 31.9% ($n$ = 214) by canoe, 27.0% ($n$ = 181) opportunistically from motorboats, and 3.0% ($n$ = 20) included both a canoe and land component. During 14.3% of hunts, a hunter visited a mineral lick. However, only 1.2% of these visits to a mineral lick lasted longer than 15 minutes. Overall, 66.9% of hunts (*n* = 449) were conducted during the day, 20.3% of hunts (*n* = 136) took place at night, and 12.8% of hunts (*n* = 86) spanned both night (20.00h – 06.00h) and daylight hours (06.00h – 20.00h). On average, hunts were 6.85 hours (median 6 hours) in length, with a range of ten minutes to 27 hours.

Of all game meat harvested during the study period, by weight, hunters sold 58.2%, gifted 10.6%, and kept 31.2%. The species that were killed most frequently were paca, collared peccary, and red brocket deer (Fig. 2). The white-lipped peccary (*Tayassu pecari*) was not encountered by any hunters during the study period because the local population had experienced a population crash (e.g., see Fragoso 2004) The species that hunters sold the highest proportion of meat from were paca, collared peccary, red brocket deer, and Brazilian tapir (Fig. 2).

Hunters had highly variable overall return rates, with a mean of 0.85 (SD = 0.54) kg meat harvested/hr spent hunting and a range of 0.19 to 1.94 kg meat harvested/hr spent hunting. All hunters sold meat during the study period and return rates from sales had a mean of 5.03 soles (1.51 USD) earned/hr spent hunting and a range of 0.51 to 16.77 soles (0.15 to 5.04 USD) earned/hr spent hunting (Table S2). Overall, the paca was the most frequently reported species with 212 encounters, followed by the agouti (103 encounters) and the kinkajou (98 encounters). Hunters reported encountering animals from 0.10 km from the community to 30.82 km from the community (mean = 9.20 km, SD = 7.73 km) (Fig S1). When broken down by species group, there was some variation in the distribution of encounters by distance from the community (Fig S2). Primates in particular, both large and small-bodied, were encountered more frequently nearby the community whereas paca were generally found farther from the community compared to other groups.

### *Game Meat Economics*

Game meat was frequently sold within the community to neighbors and friends, to communities nearby Sucusari on the Napo River (labeled as "Napo" in Fig. 3), and to the regional market in the town of Mazán or the city of Iquitos. Game meat was typically sold salted or salted and then smoked. Four species made up 63.2% of total meat sales by mass: paca, collared peccary, red brocket deer, and tapir. On average, meat from each of the most commonly sold species sold for the most money at the regional market, at S/. 12.12 (3.64 USD) for paca meat, S/. 11.94 (3.59 USD) for collared peccary, S/. 8.92 (2.68 USD) for red brocket deer, and S/. 9.80 (2.94 USD) for tapir per kg (Fig 3). Meat sold for less in nearby communities along the Napo River and went for even lower prices in the community itself (Fig. 3).

Hunters also frequently gifted game meat that they harvested to extended family, friends, and neighbors (10.6% of all meat harvested, by mass). The most commonly gifted species were the yellow-footed tortoise (36.36% by mass), grey brocket deer (29.55% by mass), South American coati (*Nasua nasua*) (18.60% by mass), and common woolly monkey (*Lagothrix lagotricha*) (17.65% by mass) (Fig. S3). All of these species were sold relatively infrequently (Fig. 2).

### *Hunter Preferences*

During interviews at the end of the study period, we asked hunters to list three species they prefer to kill while hunting on trails, by canoe, and at mineral licks and three species they prefer to kill when hunting for economic gain. The collared peccary and the paca were the most preferred species, with overall salience indices of 0.80 and 0.76, respectively (Table 3). The collared peccary was the most preferred species targeted on land with an index of 0.95 but was less preferred than other species by canoe or at mineral licks. The paca was the most preferred species targeted from canoes, with an index of 0.99, but was also less preferred than other species on land and at mineral licks. The white-lipped peccary and Brazilian tapir were the most preferred species targeted in mineral licks, with indices of 0.83 and 0.79 respectively, but were not preferred prey on land or in canoes. The collared peccary and paca were also the most highly preferred species when hunting for meat to sell, with salience indices of 0.88 and 0.72 respectively while the white-lipped peccary and red brocket deer were similarly ranked at 0.42 and 0.43 respectively. The tapir was never listed as a species that was targeted for sale. While the red brocket deer was listed repeatedly by hunters, it was the least preferred species overall compared to the other four species (Table 3).

### *Partial Preferences of Species*

We used hunter-reported encounter data and the reasons the hunter gave for not shooting an animal during an encounter to assess partial preferences of species groups. The paca, collared peccary, and brocket deer were almost always pursued upon encounter, each with a pursuit rate of over 96.0% (Table 4). The tapir and game birds were usually pursued when encountered, at a rate of 76.2% and 73.5%, respectively. However, when the tapir was not pursued it was typically for an attack-limited reason (14.3% of encounters), while the reason game birds were not pursued was typically for a perceived low return rate (23.5% of encounters). The species in the "Other Species" category, which were species not listed as preferred species by hunters, were killed at least once during the study period, and were not encountered frequently enough to form their own group, were also partially preferred at a pursuit rate of 52.5% of encounters (Table 4). Large primates were also partially preferred at a pursuit rate of 42.8% of encounters, but were often ignored for a perceived low return rate (33.1% of encounters) and for attack-limited (13.8% of encounters) and conservation reasons (10.3% of encounters). Small primates were almost never pursued (3.50% of encounters), typically for a perceived low return rate (65.9% of encounters) or for conservation reasons (22.0% of encounters) (Table 4).

### *Mixed-Effects Modeling*

We used generalized linear mixed-effects models to assess the factors that influenced whether hunters decided to pursue an animal that they encountered while hunting (Model 1). The averaged model of hunter decision-making included species group and body size of the animal as significant covariates (Table 5). In general, predicted probabilities of pursuit followed stated pursuit rates (Table 4), with the paca, deer, and collared peccary almost always pursued (Fig. 4). Model results showed that as the hunter's overall return rate increased, the probability of pursuit decreased (Fig 4). Probability of pursuit increased with the body size of the animal and group size, and decreased with distance from the community and consumer/producer ratio (Table 5).

Model results for Model 2 showed that mean price was the most important factor in determining whether a hunter did not pursue a species because of a perceived low return rate (Table 5). As distance from the community increases, hunters are more likely to ignore species with cheaper meat prices, particularly for species worth less than about six Peruvian soles (1.81 USD) per kg (Fig 5). Model results for Model 3 showed that species body size and mean price were the most important covariates (Table 5). Hunters were more likely to shoot at larger partially preferred species and those that were worth more economically (Table 5). Model results for the probability of a preferred species group (paca, collared peccary, tapir, and deer) escaping during an encounter (Model 4) showed that both the hunter's overall return rate (a measure of hunter prowess) and the distance from the community were important factors (Table 5). As distance from the community and the hunter's overall return rate increased, the probability of an animal escaping decreased (Fig 6, Table 5). There was no correlation between the hunter's overall return rate and the distance from the community (0.048). Parameters of model subsets for all averaged models (Models 1-4) are given in Table S3.

## Discussion

### *Diet Breadth Model*

Results from hunter preference data indicated clear preferences for some species over others. Interestingly, the white-lipped peccary and tapir had lower preference indices in comparison to the paca and collared peccary, even though these species are reported to be among the most commonly hunted species in Amazonia (de Andrade Melo *et al.* 2015; El Bizri *et al.* 2020; Mayor *et al.* 2021). These results match game meat prices, where paca and collared peccary are the species most likely to be sold and the most valuable. Accordingly, the paca and collared peccary were the most commonly sold species by proportion of total meat sales. Some hunters remarked that the tapir was often not killed because of its large body size, with monetary rewards not matching the effort required to process and carry the meat to market. These results indicate that hunters consider both economic and subsistence return rates when they are hunting, challenging the theory that the largest species provide the highest return rates to hunters (Alvard

1993; Bettinger *et al.* 2015). The relatively low salience for the paca from land-based hunting can likely be partially attributed to the nocturnal nature of the species (Griffiths *et al*. 2020) or differential habitat preferences (El Bizri *et al*. 2018). Several hunters noted in their interviews that they did not like to hunt by land at night because they were afraid of being bitten by snakes. It's also possible that the paca is more commonly found in riparian areas at night, leading hunters to target them by canoe rather than by land.

Hunter preferences found here did not line up with previously reported results from other communities, such as those reported by Bodmer (1995), where tapirs and white-lipped peccaries were the most preferred species. It's possible that since the white-lipped peccary was not encountered by hunters during the study period, hunters' listed preferences were conflated, placing the white-lipped peccary lower on the preference list than it would be if it were still abundant.

Evaluation of hunter pursuit rates for species groups revealed that hunters in Sucusari do not follow the predicted zero-one rule of the diet breadth model (Bettinger et al. 2015; Stephens and Krebs 1986), similar to what was reported by Alvard (1993) where Piro hunters frequently exhibited only partial preferences for some species. The measured pursuit rates we present showed that paca, collared peccary, and brocket deer were in the optimal diet breadth of all hunters, and were almost always pursued, a result that is directly in line with free-listed preferences. Since these species were almost always pursued, it's likely that these species yield the highest return rate for hunters. The currency of the return rate (Winterhalder 1981) in this case is likely a mixture of economic gain and subsistence, where the most preferred species are not only relatively large-bodied but also economically valuable.

The tapir was only a partially preferred species, pursued only on 76.2% of encounters, even though it is the largest game species. Given the reasons for not pursuing tapirs on some occasions (9.5% low return, 14.3% attack-limited), it's possible that hunters are not willing to invest the time needed to transport and process the tapir, a significant task given its size, since that handling time precludes time that could be spent searching for other smaller and more economically profitable species (Bettinger *et al.* 2015; Chaves *et* al., 2020; Smith *et al.* 1983; Winterhalder and Lu 1997). It also should be noted that tapir often could not be effectively killed with a shotgun without getting close or using a special lead slug that some hunters carry. In some cases, hunters may have encountered tapir without having a slug with them, increasing the probability of attack limitation (Levi *et al*. 2011). Tapir also had a high preference index (0.79) to be hunted at mineral licks, but only 14.31% of hunts during the study period included a visit to a mineral lick. This result lends evidence to the idea that while hunters know where to find tapir, which frequently visit mineral licks in the region (Griffiths *et al.* 2020), they choose not to hunt them in favor of other species. Large-bodied primates were also partially preferred and were frequently ignored because of a perceived low return rate (33.1% of encounters) or for conservation reasons (10.3% of encounters). The prevalence of conservation-based reasons for ignoring primates while hunting contrasts with results presented by (Alvard 1993, 1995), which showed that Piro hunters targeted species only with short-term maximization of harvest in mind and not long-term conservation. Levi *et al.* (2009; 2011b) estimated a kill rate for another large-bodied primate, the spider monkey (*Ateles chamek*) at 0.90, much larger than the 0.119 we report here. Tapir and large primates perform key ecosystem functions, including seed dispersal (Brodie *et al.* 2009; Effiom *et al.* 2014; Galetti *et al.* 2001; Tobler 2008) and are crucial to the health of the broader ecosystem. The partial preference results indicate that hunters were not going to the forest to look for these species specifically, which may result in lower offtake levels and a lower risk of overexploitation of those species in our study area than others across the region (Peres 1990) if the population of the community stays low (Alvard *et al.* 1997). In contrast, the relatively high pursuit rate and preference for the paca compared to the tapir has conservation implications since the paca is a rodent with a much higher reproductive rate than that of the tapir and is therefore more resistant to population decline (Bodmer *et al.* 1997; El Bizri *et al.* 2018). However, our data did show fewer encounters with paca nearby the community, suggesting that some local defaunation or behavioral avoidance may be occurring.

Our decision-making model and partial preference results showed that species were pursued based on hunter and species-specific characteristics, showing that individual hunters have different diet breadths that are influenced by their own beliefs (e.g. propensity to ignore primates for conservation reasons) (Lemos *et al.* 2021), and their own skill at hunting (Hill *et al.* 1987). These results support arguments made by Hames and Vickers (1982) and Mithen (1989), who stated that individuals vary in their behavior and return rates and therefore their diet breadths, and studies assessing hunter behavior should examine individual choices rather than aggregating data for analysis at the group level.

### *Patch Choice Model*

The importance of distance from the community in all decision-making models indicated that hunters are making decisions about potential return rates based upon the patch that they enter, consistent with the patch choice model (Charnov 1976) and results presented by Hames and Vickers (1982), where hunters will choose to enter patches further from the community for preferred species or will accept a wider variety of species closer to the community. Levi *et al.*

(2011a) also showed an effect of distance from the community on diet breadth, where hunters expanded their diet breadth as distance increased to avoid the risk of returning empty-handed. Our model results indicate preferred species were more likely to escape encounters closer to the community, indicating that those animals are more wary of hunters closer to the community and exhibit a behavioral response to humans that enables them to escape more often. The probability of escape was much lower farther from the community and when facing a more skilled hunter. Since there was no correlation between hunter skill and distance from the community of encounter locations, it can be assumed that this result is not due to more skilled hunters choosing patches farther from the community. The wariness of species closer to the community likely has a large effect on hunter return rate, since hunters would need to spend more time pursuing preferred species when they are encountered close to the community. This result supports the patch choice theory, where hunters who are hunting closer to the community likely have to accept a wider range of species than those hunting farther away (Hames and Vickers 1982). However, the patch choice theory has focused on depletion of game following the central place foraging theory causing a decline in return rate in patches closer to the community, not a behavioral response by animals (Charnov 1976; Pyke *et al.* 1977; Winterhalder 2001). Our results for increased wariness nearby the community add greater context to the expansion of diet breadth predicted by the patch choice model.

### *Conclusions*

We suggest that the behavior of Amazonian hunters who have access to markets but also still depend on hunting for subsistence is still largely explained by the optimal foraging theory and its applications, the diet breadth model and the patch choice model. With greater access to technology and markets, it's likely that other Amazonian communities which previously hunted only for subsistence now hunt for both subsistence and economic gain, and that these results of prey selection are generalizable to those communities. The results of this study indicate that the influence of the market may drive preference towards valuable species such as the paca and collared peccary, and away from tapir and large primates which have been shown to be well within the diet breadth of subsistence hunters in other communities (Alvard 1993). The partial preference for these keystone (Paine 1995) seed dispersers compared to species such as the paca suggests that indigenous communities engaged in small-scale commercial and subsistence hunting may have a lesser effect on biodiversity than has been previously suggested by other studies showing tapir and primates as preferred species (Alvard 1993; Hames and Vickers 1982; Ojasti 1984). These results also suggest that future fluctuations in market prices could alter these preferences and further endanger these species or continue to further reduce their preference by hunters.

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## Compliance with Ethics Statement

All aspects of this study were approved by George Mason University's Institutional Review Board, project #1288488-1. Prior informed consent (PIC) was obtained from the community as well as from individual research participants before beginning this study.

## Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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## Data Availability Statement

The datasets generated during and/or analyzed during the current study are not publicly available since specific hunters are identifiable by the information in interviews but are available from the corresponding author on reasonable request.

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## Figure and Table Captions

Table 1. Themes of reasons hunters gave for not shooting at an animal during an encounter, grouped according to Alvard (1993) and the optimal foraging theory, in an indigenous community in the Peruvian Amazon.

Table 2. Hypotheses for inclusion of covariates in generalized linear mixed-effects models, formed under the framework of the optimal foraging theory, a description of how metrics were calculated, and mean and standard deviation of continuous covariates.

Table 3. Salience indices by species from semi-structured interviews with hunters in Sucusari, Peru, showing preferred species. Only species listed more than ten times by hunters are shown.

Table 4. Proportions of encounters that resulted in pursuit or not shooting at the animal because of a perceived low return rate, attack-limited reasons, or conservation reasons by species group. Species that were killed, were shot at unsuccessfully, or escaped are classified as pursued.

Figure 1. Study area, including the Maijuna community of Sucusari and the Maijuna-Kichwa Regional Conservation Area (MKRCA).

Figure 2. Proportions of total meat by mass that was sold, number of animals killed, and number of animals encountered broken down by species and ordered by number of kills. Only species that were killed more than five times during the study period are shown.

Note: * indicates a preferred game species, as determined by salience indices.

Figure 3. Average price per kilogram of meat sold of the four most frequently sold species for sales within the community of Sucusari, Peru, to other communities nearby on the Napo River, and to the regional markets in either Mazán or Iquitos. Only species for which more than 30 kilograms were sold during the study period are shown. Species are shown in descending order of frequency of kills. Descriptive error bars show ranges.

Figure 4. Generalized linear mixed-effects model results predicting the probability of a hunter pursuing an animal that is encountered versus the hunter's overall return rate and species group of the encountered animal. Other covariates held at the mean value for display, and hunter chosen for display represents the median intercept of the random effects of the optimal model.

Figure 5. Generalized linear mixed-effects model results of the predicted probability of a hunter not pursuing an animal upon encounter versus distance from the community and the mean price per kg of the meat of the species encountered. Hunter chosen for display represents the median intercept of the random effects of the optimal model. Mean price values chosen for display represent quartiles and mean of mean price.

Figure 6. Generalized linear mixed-effects model results of the predicted probability of a preferred species escaping a hunter during an encounter versus distance from the community and the hunter's overall return rate (a measure of hunter prowess). Hunter chosen for display represents the median intercept of the random effects of the optimal model.

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Table 1.

| Code | Explanation | Sample Interview Responses |
|---|---|---|
| Killed | The animal was killed without the use of a shotgun | I chased it into its hole and killed it with my machete |
| Escaped | The hunter intended to kill the animal and may have pursued it, but the animal escaped | It ran away and left me behind |
| | | It escaped from me |
| Low Return | Killing the animal would have been too much effort for the return it gave | It was too small |
| | | It was too hard to get to |
| Attack-Limited | The hunter is restricted in the number of kills he can make, and a shot would have precluded a later kill | I did not want to make any noise |
| | | I did not have enough cartridges |
| Conservation | The hunter gave up a short-term gain to avoid killing certain species/sexes/age groups | It had young with it |
| | | I don't eat monkeys |

Table 2.

| **Fixed Effects** | **Hypothesis for Model 1** | **Reference** | **Calculation** | **Mean** | **SD** |
|---|---|---|---|---|---|
| Distance from Community (km) | Hunters may seek patches farther from the community for a greater return rate (patch choice theory) | Charnov 1976; Alvard 1994 | Euclidean distance from encounter to community center | 9.13 | 7.70 |
| Hunt Duration (hr) | When a hunt lasts longer unsuccessfully, hunters may be more apt to shoot less preferred species so they do not come home empty handed | Alvard 1993; Levi et al. 2011 | Total duration of hunt in which hunter was actively searching for or pursuing prey | 6.85 | 4.48 |
| Group Size (# individuals) | Hunters may be more likely to shoot at larger groups, when the chances of success are higher | Alvard 1993 | Estimated group size of animals | 4.65 | 9.13 |
| Hunter's Overall Return Rate (kg/hr) | Variation in hunter skill may drive variation in diet breadth | Hill et al. 1987 | Total kg harvested over entire study period / total hours spent actively hunting | 0.85 | 0.54 |
| Hunter's Household Consumer/Producer Ratio | Hunters with larger households may have a wider diet breadth since food is needed more often | Alvard 1993 | Total number of people in hunter's household / total number of hunters in the household | 0.29 | 0.12 |
| Body Size (kg) | Larger species may be more likely to be in the diet breadth of hunters because they provide a greater return rate | Alvard 1993 | Estimated body size of species, from the literature, in kg | 10.59 | 23.26 |
| Species Group | Hunters may prefer some species over others due to factors such as taste | Alvard 1993 | - | - | - |
| Distance from Community : Mean Price | Hunters may seek patches farther from the community specifically to target species that are more economically valuable (patch choice theory) | Charnov 1976; Alvard 1994 | Mean price calculated as the mean number of Peruvian soles received per kg for all sales within that species group during the study period | - | - |
| Hunter's Overall Return Rate : Mean Price | Hunters that are more successful may be more likely to sell game meat, and less skilled hunters may be more willing to accept less valuable species | - | | - | - |

Table 3.

| Species | Hunting Method | | | Sale | Overall Mean |
|---|---|---|---|---|---|
| | Land | Canoe | Mineral Lick | | |
| *P. tajacu* | 0.95 | 0.89 | 0.48 | 0.88 | 0.80 |
| *C. paca* | 0.56 | 0.99 | 0.77 | 0.72 | 0.76 |
| *T. terrestris* | 0.53 | 0.50 | 0.79 | - | 0.60 |
| *T. pecari* | 0.63 | 0.25 | 0.83 | 0.42 | 0.53 |
| *M. americana* | 0.62 | 0.49 | 0.56 | 0.43 | 0.52 |

Table 4.

| | | | | | | Proportion of Encounters: Reasons for No Pursuit | | |
|---|---|---|---|---|---|---|---|---|
| Species Group | Number of Encounters | Proportion Pursued* | Proportion Killed | Proportion Shot At Unsuccessfully | "Escaped" | "Low Return" | "Attack-Limited" | "Conservation" |
| Paca | 212 | 0.972 | 0.726 | 0.042 | 0.203 | 0.009 | 0.019 | 0.000 |
| Collared Peccary | 78 | 0.962 | 0.526 | 0.038 | 0.397 | 0.000 | 0.038 | 0.000 |
| Deer | 50 | 0.960 | 0.540 | 0.040 | 0.380 | 0.020 | 0.020 | 0.000 |
| Tapir | 21 | 0.762 | 0.381 | 0.286 | 0.095 | 0.095 | 0.143 | 0.000 |
| Game Birds | 34 | 0.735 | 0.353 | 0.088 | 0.294 | 0.235 | 0.029 | 0.000 |
| Other Species | 304 | 0.526 | 0.234 | 0.056 | 0.237 | 0.280 | 0.069 | 0.125 |
| Large Primate | 143 | 0.420 | 0.119 | 0.105 | 0.196 | 0.336 | 0.140 | 0.105 |
| Small Primate | 171 | 0.035 | 0.012 | 0.012 | 0.012 | 0.661 | 0.088 | 0.216 |

*Proportion pursued is the sum of proportions killed, shot at unsuccessfully, and "escaped"

Table 5. Generalized linear mixed-effects model results of hunter decision-making. Coefficient estimates of averaged models shown with standard error in parentheses. NA indicates that fixed effect was not tested in the model due to convergence issues, and a dash indicates that fixed effect was not tested because of the hypotheses of the model. Reference species group for species group fixed effect is the collared peccary. Statistically significant estimates shown in bold.

| | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
|---|---|---|---|---|
| **Response Variable (0/1)** | Whether an animal is pursued | Whether an animal is not pursued for perceived low return rate | Whether a partially preferred species is pursued | Whether an animal escapes pursuit by a hunter |
| **Sample of encounters** | All | All | Partially preferred species | Preferred species |
| **Sample Size (n)** | 1,012 | 1,012 | 651 | 361 |
| **Fixed Effects** | | | | |
| Group Size | 0.022 (0.074) | -0.005 (0.043) | -0.142 (0.134) | - |
| Body Size | **1.948 (0.775)** | -0.071 (0.166) | **3.062 (1.036)** | - |
| Distance from Community | -0.073 (0.113) | -0.067 (0.122) | -0.164 (0.198) | **-0.635 (0.146)** |
| Hunt Duration | -0.122 (0.131) | 0.003 (0.056) | -0.166 (0.153) | - |
| Hunter's Overall Return Rate | -0.144 (0.188) | -0.021 (0.128) | -0.283 (0.267) | **-1.019 (0.260)** |
| Hunter's Consumer/Producer Ratio | -0.021 (0.109) | 0.005 (0.111) | 0.024 (0.124) | - |
| Species Group (Paca) | **2.057 (0.909)** | NA | NA | -0.256 (0.367) |
| Species Group (Deer) | -0.134 (0.945) | NA | NA | 0.110 (0.326) |
| Species Group (Tapir) | **13.100 (4.563)** | NA | NA | 0.111 (0.410) |
| Species Group (Game Birds) | -0.331 (1.064) | NA | NA | - |
| Species Group (Other Species) | -1.403 (0.915) | NA | NA | - |
| Species Group (Large Primate) | **-2.082 (0.955)** | NA | NA | - |
| Species Group (Small Primate) | **-4.750 (1.100)** | NA | NA | - |
| Mean Price | NA | **-1.631 (0.142)** | **1.002 (0.246)** | - |
| Mean Price:Distance from Community | NA | -0.203 (0.180) | -0.171 (0.236) | - |
| Mean Price:Hunter's Overall Return Rate | NA | -0.012 (0.056) | -0.170 (0.218) | - |
| **Random Effect** | Hunter Name | Hunter Name | Hunter Name | Hunter Name |

| | | | | |
|---|---|---|---|---|
| **Marginal $R^2$*** | 0.630 | 0.444 | 0.248 | 0.278 |
| **Conditional $R^2$*** | 0.670 | 0.534 | 0.360 | 0.397 |

*$R^2$ values calculated based on the top-ranked model of each averaged model, by Akaike weight


Legend
● Maijuna Communities
Road
Maijuna Titled Lands
MKRCA
Algodón River
San Pablo de Totolla
Nueva Vida
Puerto Huáman
Apayacu River
Sucusari
Napo River
Mazán
Amazon River
Iquitos
N
0 5 10 20 Kilometers
Colombia
Peru
Iquitos
Brazil

Figure 1.

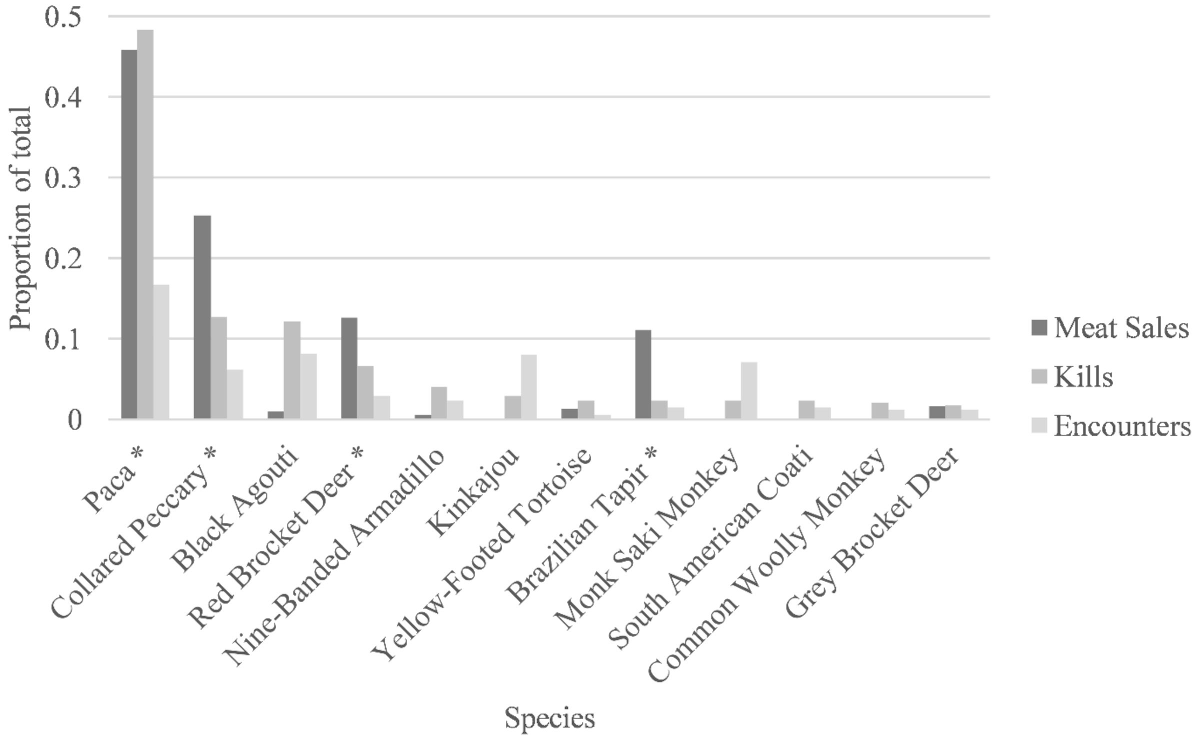

0.5
0.4
0.3
0.2
0.1
0
Proportion of total
Paca *
Collared Peccary *
Black Agouti
Red Brocket Deer *
Nine-Banded Armadillo
Kinkajou
Yellow-Footed Tortoise
Brazilian Tapir *
Monk Saki Monkey
South American Coati
Common Woolly Monkey
Grey Brocket Deer
Species
Meat Sales
Kills
Encounters

Figure 2.

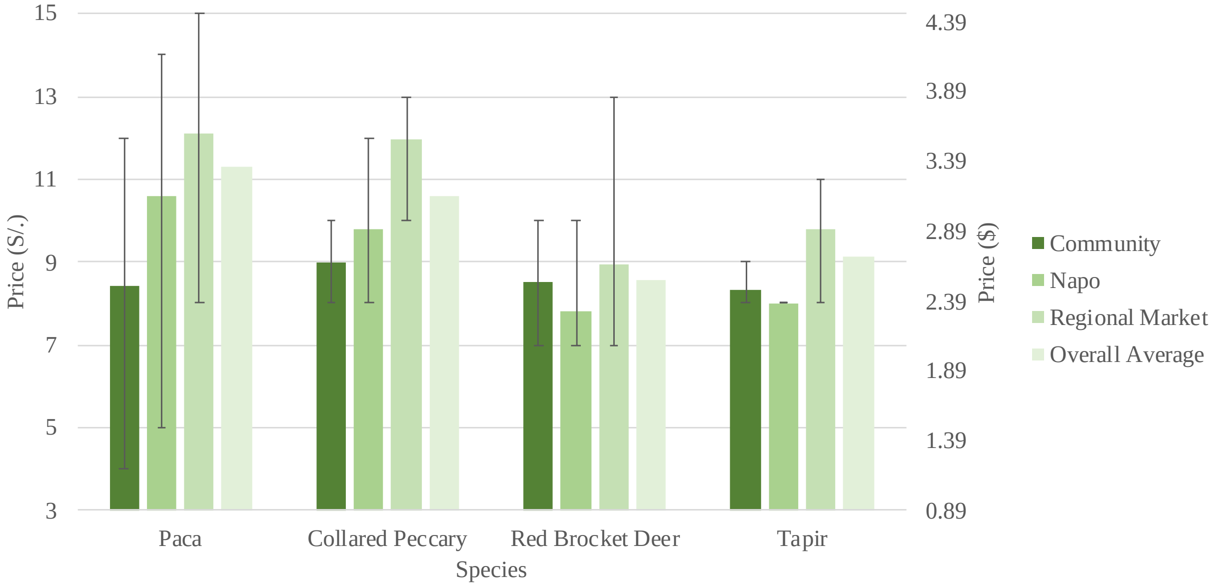

15
13
11
9
7
5
3
Price (S/.)
4.39
3.89
3.39
2.89
2.39
1.89
1.39
0.89
Price ($)
Paca
Collared Peccary
Red Brocket Deer
Tapir
Species
Community
Napo
Regional Market
Overall Average

Figure 3.

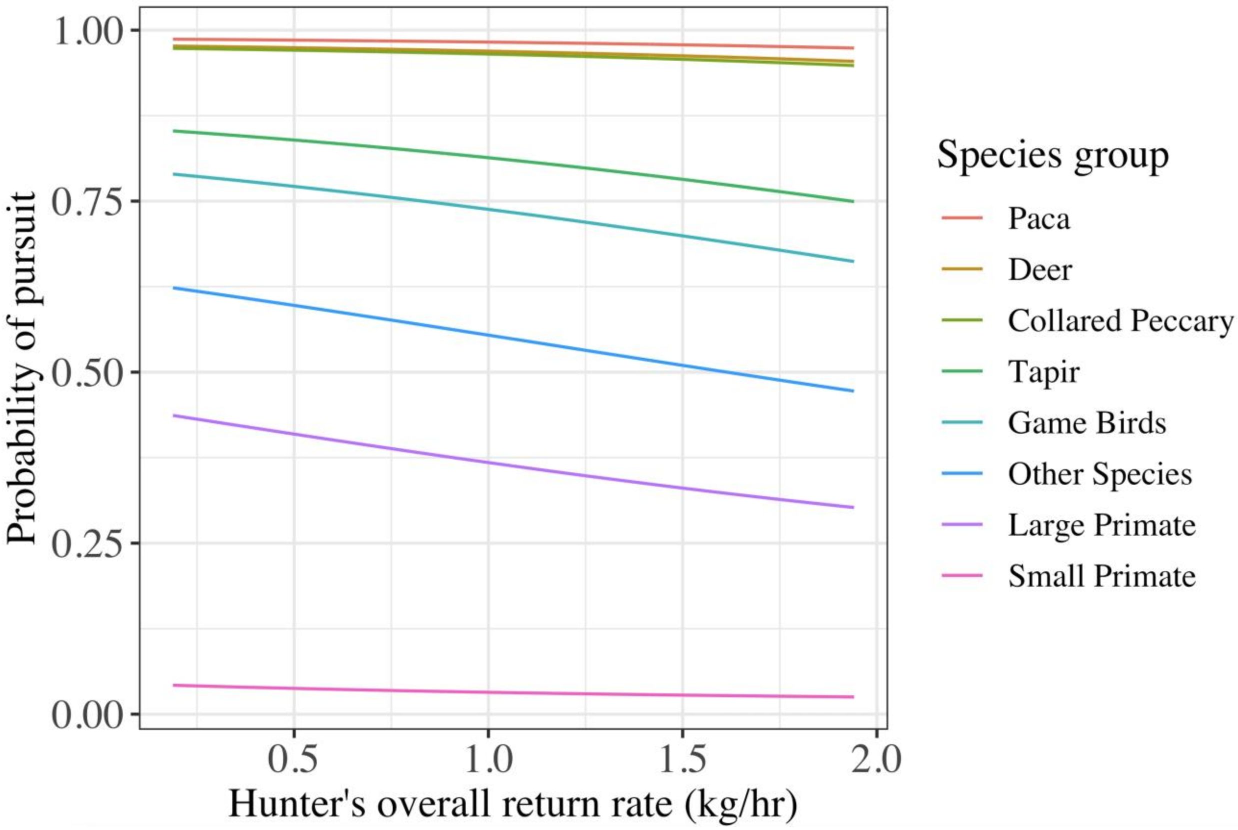

1.00
0.75
0.50
0.25
0.00
Probability of pursuit
0.5
1.0
1.5
2.0
Hunter's overall return rate (kg/hr)
Species group
Paca
Deer
Collared Peccary
Tapir
Game Birds
Other Species
Large Primate
Small Primate

Figure 4.

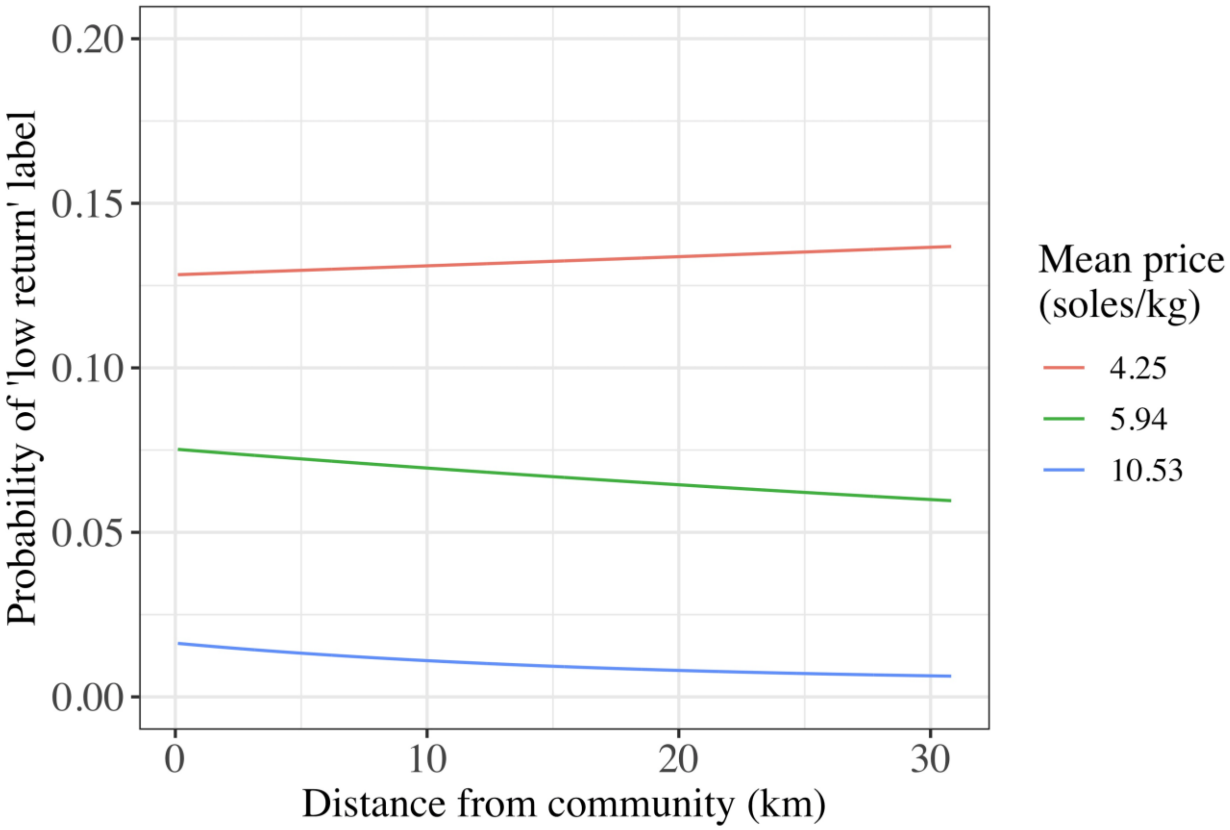

0.20
0.15
0.10
0.05
0.00
Probability of 'low return' label
0
10
20
30
Distance from community (km)
Mean price (soles/kg)
4.25
5.94
10.53

Figure 5.

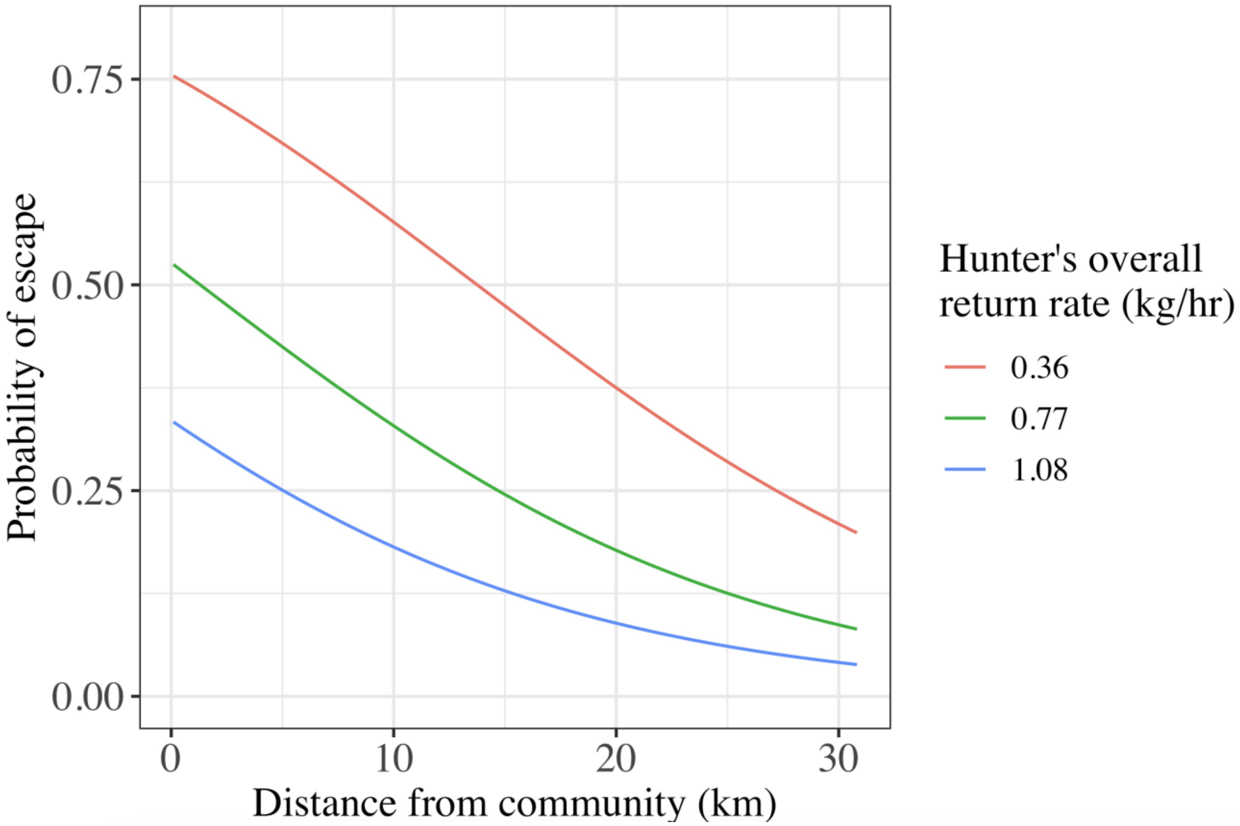

0.75
0.50
0.25
0.00
Probability of escape
0
10
20
30
Distance from community (km)
Hunter's overall return rate (kg/hr)
0.36
0.77
1.08

Figure 6.

## Supplementary Information

Table S1. Species included in generalized linear mixed-effects models, along with the species group they were placed in, the value for mean body size and mean price used for the species/species group, and the reference from which mean body size values were taken.

| **Class** | **Scientific Name** | **Common Name** | **Species Group** | **Mass (kg)** | **Mean Price (Soles/kg)** | **Reference** |
|---|---|---|---|---|---|---|
| Mammal | *Pecari tajacu* | Collared Peccary | Collared Peccary | 25.00 | 10.58 | Bodmer et al., 2004 |
| Mammal | *Mazama americana* | Red Brocket Deer | Deer | 33.00 | 7.96 | Bodmer et al., 2004 |
| Mammal | *Mazama gouazoubira* | Grey Brocket Deer | Deer | 17.35 | 7.96 | Robinson & Redford, 1986 |
| Mammal | *Lagothrix lagotricha* | Common Woolly Monkey | Large Primate | 11.00 | 4.25 | Bodmer et al., 2004 |
| Mammal | *Alouatta seniculus* | Red Howler Monkey | Large Primate | 6.19 | 4.25 | Robinson & Redford, 1986 |
| Mammal | *Cebus albifrons* | White-fronted Capuchin | Large Primate | 2.01 | 4.25 | Robinson & Redford, 1986 |
| Mammal | *Pithecia monachus* | Monk Saki Monkey | Large Primate | 1.80 | 4.25 | Robinson & Redford, 1986 |
| Mammal | *Hydrochoerus hydrochaeris* | Capybara | Other Species | 30.00 | 5.25 | Bodmer et al., 2004 |
| Mammal | *Myrmecophaga tridactyla* | Giant Anteater | Other Species | 27.00 | 5.25 | Robinson & Redford, 1986 |
| Mammal | *Dasyprocta fuliginosa* | Black Agouti | Other Species | 5.00 | 5.25 | Bodmer et al., 2004 |
| Mammal | *Tamandua tetradactyla* | Southern Tamandua | Other Species | 4.56 | 5.25 | Robinson & Redford, 1986 |
| Mammal | *Choloepus didactylus* | Linnaeus's Two-toed sloth | Other Species | 4.15 | 5.25 | Robinson & Redford, 1986 |
| Mammal | *Nasua nasua* | South American Coati | Other Species | 3.88 | 5.25 | Robinson & Redford, 1986 |
| Mammal | *Dasypus novemcinctus* | Nine-banded Armadillo | Other Species | 3.54 | 5.25 | Robinson & Redford, 1986 |
| Mammal | *Potos flavus* | Kinkajou | Other Species | 2.49 | 5.25 | Robinson & Redford, 1986 |
| Mammal | *Cuniculus paca* | Paca | Paca | 9.00 | 11.32 | Bodmer et al., 2004 |
| Mammal | *Callicebus moloch* | Dusky Titi Monkey | Small Primate | 1.17 | 0 | Robinson & Redford, 1986 |
| Mammal | *Callicebus lucifer* | Yellow-handed Titi Monkey | Small Primate | 1.00 | 0 | Robinson & Redford, 1986 |
| Mammal | *Aotus vociferans* | Spix's Night Monkey | Small Primate | 0.87 | 0 | Robinson & Redford, 1986 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mammal | *Saimiri sciureus* | Common Squirrel Monkey | Small Primate | 0.69 | 0 | Robinson & Redford, 1986 |
| Mammal | *Leontocebus nigricollis* | Black-mantled Tamarin | Small Primate | 0.36 | 0 | Robinson & Redford, 1986 |
| Mammal | *Tapirus terrestris* | Brazilian Tapir | Tapir | 160.00 | 9.11 | Bodmer et al., 2004 |
| Bird | *Mitu salvini* | Salvin's Curassow | Game Birds | 3.06 | 0 | Begazo & Bodmer, 1998 |
| Bird | *Pipile cumanensis* | Blue-throated Piping Guan | Game Birds | 1.30 | 0 | Begazo & Bodmer, 1998 |
| Bird | *Penelope jacquacu* | Spix's Guan | Game Birds | 1.28 | 0 | Begazo & Bodmer, 1998 |
| Bird | *Nothocrax urumtum* | Nocturnal Curassow | Game Birds | 1.25 | 0 | Kattan et al. 2016 |
| Bird | *Tinamidae sp.* | Tinamou | Game Birds | 1.10 | 0 | Dunning, 2007 |
| Bird | *Psophia crepitans* | Grey-winged Trumpeter | Game Birds | 1.03 | 0 | Dunning, 2007 |
| Bird | *Ortalis guttata* | Speckled Chachalaca | Game Birds | 0.50 | 0 | Begazo & Bodmer, 1998 |

Table S2. Return rates of 17 hunters in Sucusari, Peru, measured by different metrics based on the outcomes of the meat each hunter harvested during the study period. Return rate of total kg/hr was used as the covariate for "hunter return rate" in generalized linear mixed-effects models.

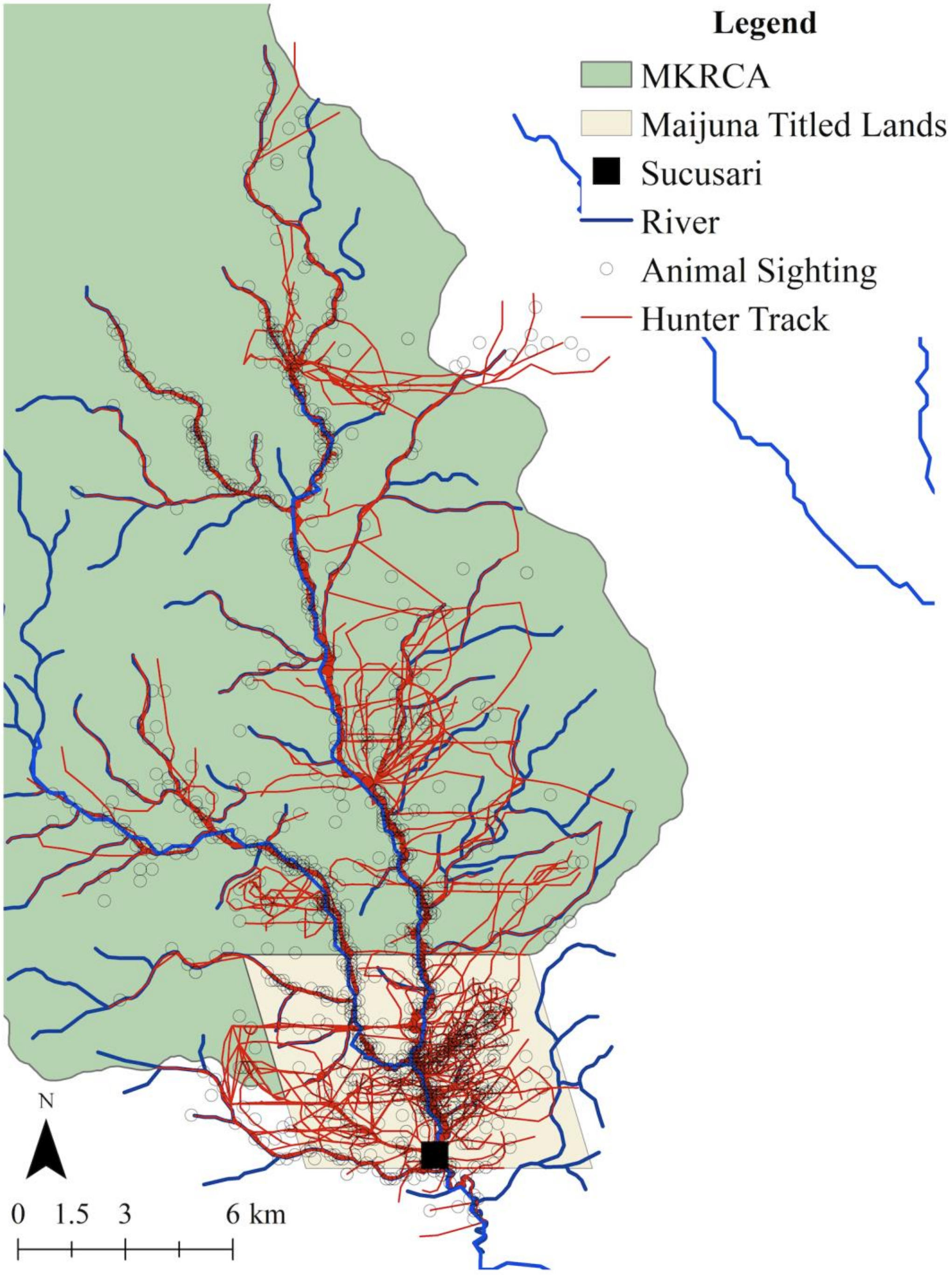
| Hunter | Total kg/hr | Soles Earned/hr | kg Sold/hr | kg Gifted/hr | kg Kept for Consumption/hr |
|---|---|---|---|---|---|
| 1 | 0.188 | 0.511 | 0.060 | 0.049 | 0.079 |
| 2 | 0.196 | 0.664 | 0.061 | 0.070 | 0.065 |
| 3 | 0.319 | 1.570 | 0.171 | 0.005 | 0.142 |
| 4 | 0.324 | 1.317 | 0.131 | 0.086 | 0.107 |
| 5 | 0.360 | 1.696 | 0.173 | 0.027 | 0.160 |
| 6 | 0.408 | 3.929 | 0.350 | 0.032 | 0.025 |
| 7 | 0.505 | 2.322 | 0.200 | 0.037 | 0.269 |
| 8 | 0.680 | 1.593 | 0.202 | 0.030 | 0.449 |
| 9 | 0.856 | 5.910 | 0.528 | 0.056 | 0.272 |
| 10 | 0.882 | 1.658 | 0.153 | 0.284 | 0.444 |
| 11 | 1.042 | 9.636 | 0.910 | 0.056 | 0.075 |
| 12 | 1.080 | 0.966 | 0.094 | 0.055 | 0.931 |
| 13 | 1.195 | 2.648 | 0.257 | 0.421 | 0.517 |
| 14 | 1.252 | 9.323 | 1.007 | 0.120 | 0.126 |
| 15 | 1.520 | 16.769 | 1.483 | 0.000 | 0.036 |
| 16 | 1.616 | 10.947 | 1.181 | 0.006 | 0.429 |
| 17 | 1.941 | 14.118 | 1.412 | 0.000 | 0.529 |
| Mean | 0.845 | 5.034 | 0.493 | 0.079 | 0.274 |
| SD | 0.536 | 5.161 | 0.498 | 0.111 | 0.245 |

Table S3. Generalized linear mixed-effects model results of hunter decision-making showing the covariates of the top-ranked models of each model series, number of parameters (K), ΔAIC, and Akaike weight (*w*) used in model averaging. All candidate models within 2 AIC points of the top-ranked model are shown.

| **Model** | **K** | **ΔAIC** | ***w*** |
|---|---|---|---|
| *Series 1* | | | |
| Body Size + Hunt Duration + Species Group + Success Rate | 12 | 0.00 | 0.095 |
| Body Size + Hunt Duration + Species Group + Success Rate + Distance from Community | 13 | 0.49 | 0.074 |
| Body Size + Hunt Duration + Species Group | 11 | 0.50 | 0.074 |
| Body Size + Hunt Duration + Species Group + Distance from Community | 12 | 0.96 | 0.059 |
| Body Size + Species Group | 10 | 1.20 | 0.052 |
| Body Size + Species Group + Distance from Community | 11 | 1.29 | 0.050 |
| Body Size + Species Group + Success Rate | 11 | 1.56 | 0.043 |
| Body Size + Species Group + Success Rate + Distance from Community | 12 | 1.62 | 0.042 |
| Body Size + Species Group + Success Rate + Group Size | 13 | 1.71 | 0.040 |
| Body Size + Species Group + Success Rate + Consumer/Producer Ratio | 13 | 1.83 | 0.038 |
| *Series 2* | | | |
| Distance from Community + Mean Price + Distance from Community:Mean Price | 5 | 0.00 | 0.106 |
| Body Size + Distance from Community + Mean Price + Distance from Community:Mean Price | 6 | 1.11 | 0.061 |
| Success Rate + Distance from Community + Mean Price + Distance from Community:Mean Price | 6 | 1.96 | 0.040 |
| Group Size + Distance from Community + Mean Price + Distance from Community:Mean Price | 6 | 1.97 | 0.039 |
| Hunt Duration + Distance from Community + Mean Price + Distance from Community:Mean Price | 6 | 1.99 | 0.039 |
| Consumer/Producer Ratio + Distance from Community + Mean Price + Distance from Community:Mean Price | 6 | 1.99 | 0.039 |
| *Series 3* | | | |
| Distance from Community + Hunt Duration + Group Size + Mean Price + Success Rate + Distance from Community:Mean Price + Mean Price:Success Rate | 10 | 0.00 | 0.068 |
| Hunt Duration + Group Size + Mean Price + Success Rate + Mean Price:Success Rate | 8 | 0.00 | 0.068 |

| | | | |
|---|---|---|---|
| Distance from Community + Hunt Duration + Mean Price + Success Rate + Distance from Community:Mean Price + Mean Price:Success Rate | 9 | 1.10 | 0.039 |
| Distance from Community + Hunt Duration + Group Size + Mean Price + Distance from Community:Mean Price | 8 | 1.29 | 0.036 |
| Hunt Duration + Group Size + Mean Price | 6 | 1.34 | 0.035 |
| Distance from Community + Hunt Duration + Group Size + Mean Price + Success Rate + Distance from Community:Mean Price | 9 | 1.39 | 0.034 |
| Hunt Duration + Group Size + Mean Price + Success Rate | 7 | 1.46 | 0.033 |
| Hunt Duration + Group Size + Mean Price + Success Rate + Distance from Community + Mean Price:Success Rate | 9 | 1.55 | 0.031 |
| Group Size + Mean Price + Success Rate + Distance from Community + Distance from Community:Mean Price + Mean Price:Success Rate | 9 | 1.66 | 0.030 |
| Group Size + Mean Price + Success Rate + Mean Price:Success Rate | 7 | 1.78 | 0.028 |
| Hunt Duration + Mean Price + Success Rate + Mean Price:Success Rate | 7 | 1.80 | 0.027 |
| Consumer/Producer Ratio + Distance from Community + Hunt Duration + Group Size + Mean Price + Success Rate + Distance from Community:Mean Price + Mean Price:Success Rate | 11 | 1.84 | 0.027 |
| Consumer/Producer Ratio + Hunt Duration + Group Size + Mean Price + Success Rate + Mean Price:Success Rate | 9 | 1.85 | 0.027 |
| *Series 4* | | | |
| Distance from Community + Success Rate | 4 | 0.00 | 0.539 |
| Distance from Community + Success Rate + Species Group | 7 | 0.33 | 0.458 |

Figure S1. Map of interview results and reported encounter locations with 17 hunters in Sucusari, Peru.



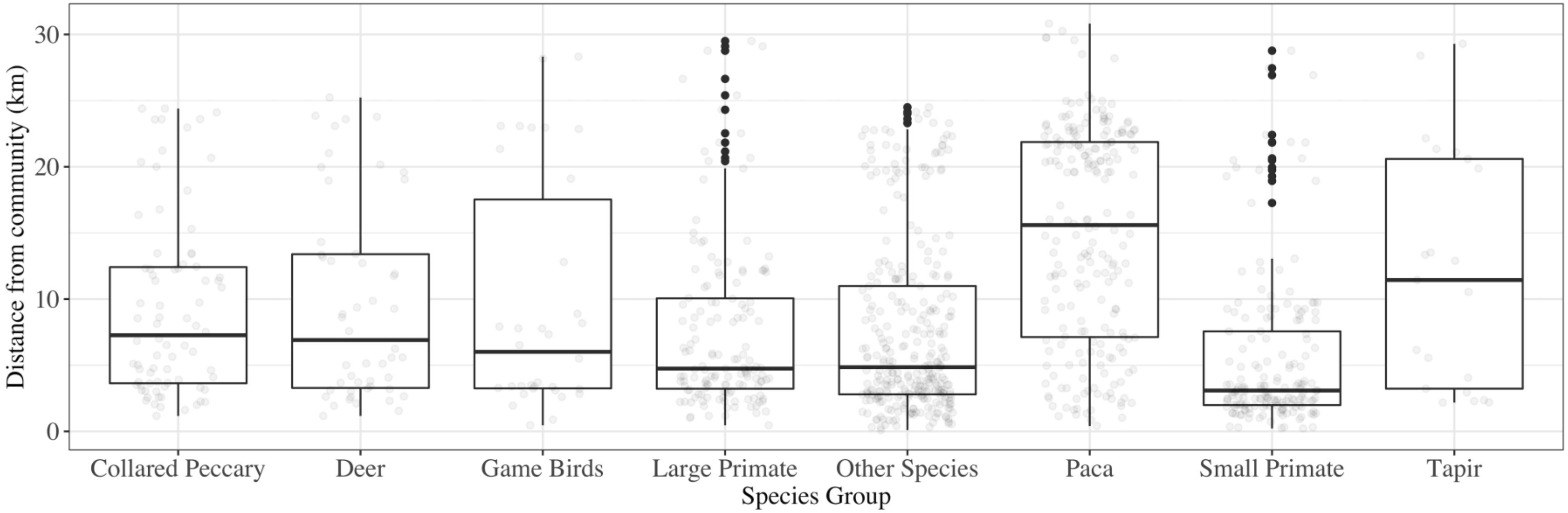


Figure S2. Boxplot of distribution of encounter locations' distance from the community by species group. Raw data shown by grey points.

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