Local ecological knowledge, hunting, and game harvesting in the Peruvian Amazon

By

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Preface

This thesis is original, unpublished, independent work by the author, D. E. Zayonc.

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Acknowledgements

I arrived in Montreal with the goal of exploring a career in Amazonian conservation and to reacquaint myself with a city that I had admired from afar. As I reflect upon my time in Montreal, I am proud to say that both goals were achieved. I orchestrated a research project in the Peruvian Amazon as a conservationist, but I also gained valuable insight into Amazonian reality. Due to COVID19 and fieldwork, I never experienced the "true" Montreal summer, but my community in the "big smoke" endowed a sense of belonging and comfort that is difficult to create as a newcomer in a big city. Despite some challenges, I reflect fondly upon my M.Sc. experience. I have many people to thank for their assistance.

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Abstract

In many rural regions of Amazonia, hunting, and game meat are important sources of food and cash income but hunters who hold substantial local ecological knowledge (LEK) are often criticized for depleting wildlife. In this thesis, I examine the potential of LEK household surveys for assessing the status of Amazonian wildlife and engaging hunting communities in conservation initiatives. To assess the potential of LEK for reporting wildlife status, I compare data gathered from 37 structured household surveys conducted in a community on the Napo River in northeastern Peru for wildlife presence with data from conventional methods (487 camera trap days and 15 transect surveys). The results of the LEK household surveys are correlated with the conventional surveys and highlight the relevance of LEK for rapid wildlife inventories in Amazonia. I also explore the question of who chooses to be a hunter and the importance of game meat in rural livelihoods. Grounded in the large-scale Peruvian Amazon Rural Livelihoods and Poverty (PARLAP) Project survey of 919 communities and nearly 4000 households, I characterize hunters based on livelihood and community characteristics data. I draw upon a dataset that I collected between June and September 2019 in an Indigenous Kichwa community and a ribereño community along the Napo River (44 semi-structured hunter characterization surveys and 20 oral histories). Descriptive and quantitative analyses point to the importance of game meat for rural subsistence and identify the characteristics that drive hunting participation and harvest. By understanding the drivers of hunting, and who holds LEK about wildlife presence, large-scale surveys can identify where and how best to implement wildlife conservation initiatives in Amazonia.

Résumé

Dans plusieurs endroits de l'Amazonie, la chasse et le gibier sont essentiels pour assurer la sécurité économique et alimentaire de nombreux chasseurs. Toutefois, ces chasseurs sont souvent accusés d'être à la source de l'épuisement de la faune terrestre. Cette thèse adresse un portrait de l'importance du gibier pour soutenir les populations rurales et des circonstances qui influencent les chasseurs à dépendre du gibier. La thèse s'intéresse également aux rôles que peut jouer la connaissance écologique locale (CEL) recueillie par le biais d'enquêtes de foyers pour faire le suivit de la faune amazonienne et pour favoriser la participation des communautés rurales dans les initiatives de conservation environnementale. En me basant sur les données socio-économiques de plus 4000 foyers et de 232 communautés qui ont été collectées dans le cadre du projet PARLAP (Peruvian Amazon Rural Livelihoods and Poverty), je développe différents modèles statistiques mettant en lumière les caractéristiques des chasseurs. Dans l'objectif d'évaluer la pertinence de la CEL pour faire le suivi de la faune, j'utilise une base de données (44 sondages de caractéristiques des chasseurs semi-structurés et 20 histoires orales) que j'ai recueillie au bord de la rivière Napo entre juin et septembre 2019 dans une communauté indigène Kichwa et une communauté *ribereño*. Je compare l'information concernant la présence d'animaux obtenue par la CEL issue de 37 enquêtes de foyers avec celle obtenue par les méthodes scientifiques conventionnelles (487 jours de caméras-pièges et 15 relevés par transects) dans une communauté. La forte corrélation entre l'information obtenue par la CEL et par les méthodes conventionnelles soutient la pertinence d'utiliser les enquêtes de foyers pour mener rapidement des inventaires fauniques en Amazonie. Les analyses descriptives et quantitatives démontrent l'importance du gibier pour la subsistance en milieu rural ainsi que les nombreux facteurs qui influencent la participation à la chasse et la quantité de gibier récolté. En ayant une connaissance profonde des raisons de la chasse, et en sachant identifier les experts locaux de la faune, les sondages à grande échelle ont le potentiel de guider où et comment les politiques de conservation devraient être mis en œuvre en Amazonie.

Resumen

En varias regiones de la Amazonía, la caza y la carne de monte, juegan un rol importante al asegurar la comida y la economía, pero los cazadores también son acusados de reducir las poblaciones de la fauna local. Esta tesis explora a quién elige ser cazador y la importancia de la carne de monte en las poblaciones rurales. La tesis también evalúa la relevancia del rol de las entrevistas domiciliarias, en cuanto a lo que el conocimiento ecológico local (CEL) tiene para monitorear la fauna amazónica y para fomentar en las comunidades cazadoras la iniciativa de conservación de la biodiversidad. Fundadose en la encuesta de gran escala PARLAP (Peruvian Amazon Rural Livelihoods and Poverty Project) de 232 comunidades y casi 4000 casas, se dividieron grupos de cazadores basados en características personales, de sustento y de comunidad. También se usó un conjunto de datos (44 encuestas semiestructuradas para identificar cazadores y 20 historias orales) basados en información que se recolectó entre junio y septiembre del año 2019 en una comunidad indígena Kichwa y en una comunidad Ribereño a orillas del Río Napo. Para evaluar el rol de CEL en monitorear vida silvestre, se comparó 37 encuestas domiciliarias estructuradas para la presencia de fauna con hallazgos hechos mediante métodos convencionales (487 días de cámaras trampas y 15 encuestas de transecto) en una comunidad. Las encuestas domiciliarias de CEL para analizar la presencia de fauna son correlacionadas con los datos de las encuestas convencionales y demuestra la relevancia de las encuestas domiciliarias para hacer inventarios rápidos de fauna en la Amazonía. Los análisis descriptivos y cuantitativos muestran la importancia de la carne de monte para la subsistencia rural y las condiciones que incentivan a la participación de caza y cosecha. Al comprender a los impulsores de la caza, y a quienes son los poseedores de conocimientos locales sobre la presencia de vida silvestre, las encuestas de gran escala pueden identificar dónde y cómo implementar políticas de conservación en la Amazonía.

Chapter 1: Introduction

In many Amazonian indigenous and folk societies, hunting is an important cultural activity (Francesconi *et al.* 2018; Antunes *et al.* 2019) and game meat, when available, is a vital source of protein and micronutrients in rural diets (Sarti *et al.* 2015; Francesconi *et al.* 2018; Antunes *et al.* 2019; El Bizri *et al.* 2020a). Unfortunately, advances in technology and deforestation are threatening wildlife populations in Amazonia (Constantino 2016; Bowler *et al.* 2020). New tools (*e.g.,* guns and motors) and techniques (*e.g.,* hunting with dogs) allow hunters to access distant territories, hunt efficiently and increase their catch rates (Hames 1979; Constantino 2016). With increasing road and river networks, new hunting territories are reached within one day of travel in a motorized boat or truck, and remote wildlife populations are easily depleted (Constantino 2016; Antunes *et al.* 2016). Without abundant and diverse wildlife populations, scientists are concerned that significant changes could occur over time to the forest landscape of Amazonia (Antunes *et al.* 2016; Peres and Palacios 2007).

The Peruvian Amazon, where my thesis research takes place, faces a serious conservation challenge as elsewhere in Amazonia as modernity, contrasting ontologies and legislation affects biodiversity, local livelihoods, and forest policy (Shanee 2012; Córdova 2017). Peru is considered one of the world's megadiverse countries and includes the Tropical Andes Biodiversity Hotspot, arguably the most biologically diverse region on Earth (Myers *et al.* 2000; Rodriguez and Young 2000). Deforestation data indicate that 13% of the original primary forest cover in the Peruvian Amazonian department of Loreto has already been lost (MINAM 2011, p. 119). Although selling game meat is illegal in Peru (with few exceptions; see SERFOR (2017)), game meat is easily accessible in the large markets and restaurants of Amazonian towns and cities (Córdova 2017).

My research proposes to fill a gap between human ecology and biodiversity conservation on the subject of subsistence hunting and local ecological knowledge (LEK). Although extensive literatures exist on Amazonian livelihoods and conservation issues in Amazonia, few studies use a multidisciplinary approach to explicate hunter livelihoods (Petriello and Stronza 2020). In my thesis, I seek to understand who engages in hunting and identify the factors that influence how much game hunters harvest. The knowledge held by community members (*e.g.*, hunters, fishers, and farmers) regarding wildlife populations is compared to other conventional methods of biodiversity monitoring to assess how accurate and precise is LEK. Together, my research bridges social and natural sciences to better understand the motivations of Amazonian hunters and provide a firmer foundation for wildlife conservation policy.

1.1 Literature review

An often-overlooked component of forest degradation is overhunting, which reduces the number of "ecosystem engineers" and seed dispersers in the Amazonian system (Wilkie *et al.* 2011). Ecosystem engineers are species that have an unusually large influence on the environment compared to the other species present. For example, in the Brazilian Pantanal, the giant armadillo (*Priodontes maximus*) alters its physical surroundings through excavating, and creates habitats that are used by at least 24 different vertebrate species (Desbiez and Kluyber 2013). Tapir (*Tapirus terrestris*) and spider monkeys (*Ateles belzebuth*) play important roles as seed dispersers and are easily depleted by hunters (Peres and Palacios 2007; Antunes *et al.* 2016). If game species are reduced in forests, seed dispersal of fruiting trees is diminished and can result in tree composition changes that lead to landscape level changes affecting ecosystem services such as carbon capture and evapotranspiration; services that regulate world climate (Antunes *et al.* 2016; Strand *et al.* 2018).

Many Amazonian people are reliant on forests for food, shelter, and other ecosystem services (Dufour 1990; Strand *et al.* 2018). Although resource-reliant people provide food for their communities and families, some argue that rural groups living in Amazonia threaten the same forest that they rely upon (Terborgh and Peres 2017). Amazonians have sustained their livelihoods in the forests for millennia but technological advances since European contact provide the means to destroy the forest from within (Denevan 1992; Dufour 1990; Terborgh and Peres 2017).

To inform this study of wildlife hunting in the Peruvian Amazon, I reviewed the literature in four substantive areas of research: (1) the role of game in Amazonian forests; (2) the status of LEK surveys for monitoring wildlife; (3) modern hunting in Amazonia; and, (4) the socioeconomic dimensions of hunting.

1.1.1 The role of game in Amazonian forests

Tropical forests are considered some of the most biodiverse habitats in the world and despite their importance, the role of species interactions and their cascading effects on maintaining ecosystem services remains poorly understood (Antunes *et al.* 2016). Sixty-three to 98% of woody plant species in Neotropical wet forests produce fruit for vertebrate dispersal and yet large-bodied frugivores are often overhunted (Howe and Smallwood 1982, p. 210). The result of defaunation is an "empty forest" – which is an intact forest lacking forest vertebrates and, in turn, the ecosystem services provided by vertebrates (Harrison *et al.* 2013; Antunes *et al.* 2016). Empty forests have cascading effects on tree composition and forest function over time (Wilkie *et al.* 2011). Tree species in the Neotropics that require frugivore seed dispersal tend to have greater wood density and are among the largest trees (Antunes *et al.* 2016). If defaunation occurs to such an extent that the ecosystem begins a new steady state of wind dispersed tree domination, the niche of frugivores would be reduced (Brodie 2018). Given a new steady state, the novel Neotropical forest may not easily revert to its original state. Antunes *et al.* (2016, p. 894) project that the empty forest state can reduce above ground forest biomass by 2.5-5.8% (with some areas decreasing by 26.5-37.8%). Given such outcomes associated with defaunation and changed forest structure, forest conservation policies such as Reducing Emissions from Deforestation and Forest Degradation (REDD) should consider the role of game in neotropical forests (Antunes *et al.* 2016).

To date, empirical evidence of forest change is lacking from "empty forests" that have experienced a shift in tree species composition. A fifteen-year study of a large forest plot in Borneo did not find immediate changes in above ground biomass due to hunting (Harrison *et al.* 2013). Other studies caution about accepting findings from recent modeling studies that do not consider the ecological roles of small frugivores (Bagchi *et al.* 2018; Gardner *et al.* 2019). Paca (*Agouti paca*), agouti (*Dasyprocta fuliginosa*), tayra (*Eira Barbara*), and other rodents are small frugivores that contribute to secondary seed dispersal by moving fruits and seeds that have fallen to the forest floor (Antunes *et al.* 2016; Galetti *et al.* 2015). Further research is required to predict how defaunation may alter future tropical forests (Hazelwood *et al.* 2020).

1.1.2 Status of LEK surveys for wildlife inventories

Local ecological knowledge (LEK) is knowledge held by people about their local environment (Brook and McLachlan 2008) and conducting household LEK surveys for wildlife presence is becoming a common method to assess the status of Amazonian wildlife (Parry and Peres 2015; Camino *et al.* 2020; Coomes, Takasaki, and Abizaid 2020). LEK is related to the broader concept of Traditional Ecological Knowledge (TEK) which is defined as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, Colding, and Folke 2000, p. 1252). Both LEK and TEK among indigenous peoples are considered to be Indigenous Knowledge (IK), *i.e.,* "knowledge that is unique to a given culture or society" (Warren, Brokensha, and Slikkerveer 1991, p. 1). LEK and TEK develop dynamically as people interact with their immediate environments as they undergo social and environmental changes (Aswani, Lemahieu, and Sauer 2018). In contrast, Western knowledge is created through scientific discovery based on measured observations that test hypotheses (Agrawal 1995).

Western knowledge is often centralized and commonly associated with the state (Warren and Compton 1989). Despite different approaches for understanding the world, scholars caution about dichotomizing "Indigenous" and "Western" knowledges because often the same knowledge can be classified either way depending on the interests it serves and because, ultimately, knowledge can only be useful (Agrawal 1995). As such, there has been a push to "scientise" local knowledge and make it legible to Western science (Agrawal 2002). However, scientists should be careful when creating LEK databases because its usefulness is often specific to a certain environmental context and/or people (Agrawal 2002). Further, scientists must be aware of the entrained politics due to power relations, so that scientists may safeguard the interests of those who are already disadvantaged by Western institutions (Agrawal 1995, 2002).

As LEK, TEK, and IK become incorporated into decision making processes in wildlife conservation, there is a growing concern among Indigenous and local people(s) that those providing information are not appropriately compensated and the information may be misused by science (McCreary and Milligan 2014; Nadasdy 1999). Research conducted on Indigenous issues must be respectful and ethically sound from an Indigenous perspective to narrow the gap between various knowledge systems and research paradigms (Louis 2007). IK is rooted in personal experience and the process of knowledge creation is thus constantly tested over time (Castellano 2000). LEK reports have often identified important changes before scientific studies do and for this reason, offer the opportunity for fruitful collaboration across ontologies and epistemologies (Weatherhead, Gearheard, and Barry 2010). By providing a mechanism for Indigenous and local people(s) to participate in a research agenda that ensures communal needs are met, geographers can build ethical research relationships with local/Indigenous people (Louis 2007).

LEK surveys involve local actors and can provide more informed input for policy decisions regarding wildlife conservation. To determine the status of wildlife populations, information should be sought from the most knowledgeable people while at the same time not only maintaining, but improving scientific relations with rural people (McGregor 2011; Nadasdy 1999; Davis and Wagner 2003). Rural people often feel marginalized and forgotten by those making decisions in larger urban centers (Das and Poole 2004). By ethically incorporating local voices into decision making processes in urban centers, greater trust can be built and potentially greater ‘buy in’ from local people for effective local governance of natural resources (Turner and Berkes 2006; Louis 2007; Castellano 2000). Worldwide, there is a growing trend for including local knowledge into management practices through joint-learning, co-management and/or adaptive management (Shultis and Heffner 2016; Davies *et al.* 2013; Campos-Silva *et al.* 2018; Rotarangi and Russell 2009).

Houde (2007) describes six features of TEK: factual observations, management systems, past and current uses of the environment, environmental ethics and values, cultural identity, and cosmology. Factual observations are made by local people and include both separate empirical observations and information (*i.e.*, synthesized data) (Wenzel 1999). As such, factual observations are the feature of TEK that is most compatible with other data used for resource management (Berkes 1999). In remote areas of Amazonia, there is a need to understand baseline wildlife population dynamics, and LEK surveys using factual observation may present the greatest opportunity to conduct wildlife inventories on a large scale. Parry and Peres (2015) developed a cost-effective method in which a rapid interview survey is used to estimate the proximity of ten large-bodied vertebrate species as a proxy for local faunal depletion (Parry and Peres 2015). LEK surveys are providing scientists and Indigenous peoples throughout Amazonia the opportunity to understand the socio-economic dimensions of hunting and defaunation. The accuracy and precision of LEK surveys, however, requires validation by comparison to results from conventional techniques.

1.1.3 Modern hunting in Amazonia

Access to guns, steel tools, fishing gear, dogs, chainsaws, and motorized transport facilitates modern hunting in Amazonia (Hames 1979). When Amazonian hunting knowledge was combined in the 20th century with market access and colonist equipment, it resulted in an increase in catch per unit effort (Antunes *et al.* 2016). Today, some conservationists question whether modern hunting should be permitted in Amazonia and certain biologists even suggest that to protect the Amazonian forest, Amazonian peoples must be removed from protected reserves (Terborgh and Peres 2017; Terborgh 1999). Although wildlife populations are depleted in parts of Amazonia, other scientists argue that hunting should be permitted but with better management with an eye to conserving game species (Shanee 2012; Van Vliet *et al.* 2015b). The same scientists argue that with policy changes, more conservation initiatives and greater enforcement, Amazonian peoples will be able to maintain their cultural practice of hunting while ensuring sustainable game populations in the future (Van Vliet *et al.* 2015b; Shanee, Shanee, and Horwich 2015).

Terborgh (1999) suggests that to ensure the conservation of Manu National Park in the Peruvian Amazon, the Asháninka (known then as Matsigenka) people must be removed from the park. As "empty forests" become more common in Amazonia, Manu National Park maintains healthy populations of large frugivores like spider monkeys and tapir (Shepard *et al.* 2012). Although the perceived existential threat posed by the Asháninka people has not yet been realized, just outside the park, Piro people have locally-depleted their game resources (Shepard *et al.* 2012). Shepard *et al*. (2012) modelled local depletions of wildlife under different scenarios of hunting technology. If Asháninka people used shotguns or hunted for commercial purposes rather than hunting traditionally with bows and arrows, local wildlife would be depleted quickly. Despite rapid population growth among the Asháninka people and throughout the Neotropics, hunting technology and access to hunting grounds seems to have a stronger effect on defaunation than population density (Shepard *et al.* 2012; McSweeney 2005).

Analyses show significant wildlife depletion across the Neotropics due to hunting, especially near urban centers (Constantino 2016). As hunting efficiency increased, commercial hunting became a formidable income generating opportunity for some Amazonians (Antunes *et al.* 2016). In the 20th century, large mammals were hunted for not only their meat but also to supply the European pelt trade (Antunes *et al.* 2016). For example, an estimated 5.4 million collared peccaries (*Pecari tajacu*) were killed for hides in the Brazilian Amazon in only 65 years as were some 182 thousand jaguars (*Panthera onca*) (Antunes *et al.* 2016, p. 4). Although the 20th century offtake is disconcerting, terrestrial wildlife have fared better than aquatic wildlife and substantial populations remain in tropical forests (Antunes *et al.* 2016). Often, wildlife from inaccessible areas provide a resilient source population of forest mammals (Campos-Silva *et al.* 2017). What makes hunting in the 21st century different, however, is increased habitat fragmentation and habitat loss (Constantino 2016; Wright and Muller-Landau 2006). Although isolated communities are dispersed in remote regions throughout Amazonia, increased access to motorized vessels and roads make the entire basin more accessible, threatening source wildlife populations through habitat loss, hunting access, fragmentation, and access (Constantino 2016; Yost and Kelley 1983). Wildlife conservation must now address hunting as well as the threats posed by habitat loss, hunting access, and market expansion (Constantino 2016).

1.1.4 Socioeconomic dimensions of hunting

Subsistence hunting is an important source of protein, micronutrients and cultural practice in Amazonian rural societies (Peres 2011; Morsello *et al.* 2015; Francesconi *et al.* 2018). Some families specialize in hunting as part of a raft of resource extractive activities (Peres 2000a; Francesconi *et al.* 2018). Taboos and beliefs vary markedly for hunting of wildlife and the consumption of game meat (Ross 1978). For example, taboos of some groups prohibit the hunting of specific species, preventing game over-exploitation (Ross 1978). Cultural attitudes influence game meat demand in markets which drives game harvests (Morsello *et al.* 2015; Francesconi *et al.* 2018). Hunting is a cultural reality in Amazonian societies and wildlife management should consider the importance of local beliefs when developing conservation plans (Peres 2011).

Taboos regarding hunting can be effective informal institutions for managing wildlife (Luz *et al.* 2015; Colding and Folke 2001; Knoop *et al.* 2020). Morsello *et al.* (2015) found that taboos on hunting seasonality, species preference and offtake are more effective than legislation in Brazil and Colombia. Taboos could act as bottom-up controls on game harvests that originate through local culture for conservation management (Ross 1978). Resource habitat taboos are respected in Indigenous communities elsewhere and are effective in developing conservation ethic (Turner and Berkes 2006; Colding and Folke 2001). Colding and Folke (2001) suggest that resource and habitat taboos have functions like formalized Western institutions for nature conservation although they are often not recognized as such. By incorporating informal institutions into Western conservation management, voluntary local compliance and enforcement could achieve effective results. The incorporation of various institutions must be done carefully, and from a local perspective, to effectively engage community members.

In Amazonia, larger communities tend to deplete more game than smaller communities (Campos-Silva *et al.* 2017; Peres 2000a; Coomes, Takasaki, and Abizaid 2020). Throughout the Neotropics, communities are growing as death rates have fallen and birth rates remain high (McSweeney 2005). Even small communities can rapidly deplete wildlife with estimates that the average Amazonian smallholder requires at least 3.1 km^2 of secondary growth forest around the community to ensure a sustainable harvest of forest vertebrates (Parry, Barlow, and Peres 2009, p. 1278). As local resources are depleted, hunters must travel further and consequently expend more time and money (Abrahams, Peres, and Costa 2017). Hunters provide traditional sources of wildmeat for their families and communities, and are valuable agents in the transmission of cultural knowledge (Chicchon 1992; Siren 2012). If hunting families emigrate to urban centers for new economic opportunities such as wage labour, they may engage in less hunting (Luz *et al.* 2015; Francesconi *et al.* 2018).

Whereas outmigration from rural areas can reduce hunting pressure, sedentarism can be an important cause of local depletions of wildlife (Shepard *et al.* 2012). As communities in Amazonia become centered around health facilities and schools, the communities become more static and local people can exhaust local resources (Shepard *et al.* 2012). However, sedentary communities could eventually provide relief for game populations, as sources of wildlife far away from communities are less affected when compared to the previous seminomadic movements of many Indigenous groups (Shepard *et al.* 2012); wildlife depletion will occur but mostly locally. Further research is required to assess the basin-wide effects of sedentarization and structural depletion around nucleated settlements due to hunting.

Demand in the humid tropics for game meat is substantial particularly for people of Indigenous descent, but also for non-Indigenous rural peasants (Van Vliet *et al.* 2015b). Despite initiatives to implement sustainable use models, public environmental policies have largely resulted in the widespread criminalization of hunting and trade in game meat (van Vliet 2018). Instead of reducing impacts on the environment, trade under criminalization becomes informal and uncontrolled by governmental authorities (Christophersen and Nasi 2008). The Peruvian Amazon is an area where contrasting opinions and legislation affect biodiversity, local livelihoods and forest policy (Shanee 2012; Córdova 2017). Current policy (see SERFOR (2017)) criminalizes the sale of game meat, and yet an alternative policy could recognize game meat as an important renewable resource for Amazonians, one with high socioeconomic and cultural value (Morsello *et al.* 2015; Sarti *et al.* 2015; Van Vliet *et al.* 2015b). Under a framework of sustainable wildlife management, game meat could contribute to food security, income generation, and poverty alleviation while safeguarding ecosystem services (Sarti *et al.* 2015; Nunes *et al.* 2019; Shanee, Shanee, and Horwich 2015; El Bizri *et al.* 2020b). Including local people in wildlife monitoring can lead to timely decisions that solve key threats and empower local communities for refining sustainable-use strategies that improve their livelihoods (Danielsen *et al.* 2009; Bodmer *et al.* 2020).

1.2 Personal background and theoretical approach

I draw attention to my positionality as a descendant of the white settler population that occupies lands and watersheds in Canada. I am a trained biologist with experience in Amazonian biodiversity studies. As a member of a settler-founded society who studies subsistence strategies and Local Ecological Knowledge relating to conservation and management, I acknowledge the risk of further perpetuating colonial hegemony, co-opting Amazonian ideas and appearing to 'speak' on behalf of local Amazonian peoples. I do not wish to perpetuate these problems, instead I aim to draw attention to the value of local knowledges and the rights to self-determination. I approach the literature from a perspective of political ecology, understanding that actors of differing political powers engage with the environment, the state and each other to create their own, unique, livelihoods. It is from this perspective that I engage with the research project and in the Epilogue, I further reflect on how my perspective evolved during my graduate program.

1.3 Objectives

The overarching objective of this research project is to contribute to the literature on hunting and defaunation in Amazonia. The study bridges natural science approaches for biodiversity monitoring with social science perspectives on local ecological knowledge and subsistence hunting. The results of the project are presented in two substantive chapters, followed by a Conclusion and Epilogue.

My first substantive chapter (Chapter 2) addresses the validity of LEK surveys for assessing wildlife status by comparing household surveys of LEK to conventional techniques for assessing wildlife presence. This chapter has three objectives: (1) to determine the accuracy and precision of LEK surveys for wildlife presence; (2) to identify knowledge holders and determine "best practices" for conducting large-scale LEK surveys for wildlife in Amazonia; and, (3) to assess how wildlife populations are changing in the Peruvian Amazon.

In Chapter 3, I examine the drivers of hunting and game harvests in Amazonian communities. The chapter has the following three objectives: (1) to describe the community, household, and individual characteristics that influence hunters and their harvests; (2) to better understand the importance of game meat for rural Amazonian livelihoods; and, (3) to identify opportunities to reduce defaunation while respecting local livelihoods.

By exploring how hunting interacts with wildlife populations around hunting communities in the Peruvian Amazon, I contribute to an ever-growing body of literature related to Amazonian biodiversity conservation. Subsistence hunting is an important livelihood strategy for Amazonian peoples and the relationship between hunters and their environment is complex. Communities may rely on hunters for game meat (*e.g.*, though meat sharing) despite depleted populations while at the same time hunters have a duty to protect wildlife so that game meat is available in the future. With a fuller understanding of why Amazonians hunt, community-based management plans for wildlife could be more successful as they engage more effectively with resource-reliant people.

1.4 Research design

My research draws on two sources of information: (1) a large quantitative dataset derived from an extensive household and community survey conducted as part of the Peruvian Amazon Rural Livelihoods (PARLAP) Project; and, (2) a rich quantitative and qualitative dataset that I developed based on fieldwork that I conducted in the Peruvian Amazon in 2019. Together, these two datasets allow for a multiscalar and mixed methods study of hunting and local ecological knowledge in western Amazonia.

From 2012-2016, the PARLAP project conducted a survey of 919 communities, nearly 4000 households, and over 28000 individuals in four river basins in the Peruvian Amazon. These data contain socioeconomic information that link environment and rural livelihood strategies in relation to poverty, conservation, and development. This dataset forms the foundation from upon which my research is built.

I conducted my field research in two rural study communities situated along the Napo River in the Department of Loreto, Peru, between June 2019 and September 2019. The communities are located within 350 kilometers by river from the city of Iquitos, the regional capital of Loreto and the largest city in the Peruvian Amazon. Household surveys in each community solicited information on game harvest and biological inventories using household questionnaires, transects, and camera trapping yielded data on game species presence.

1.4.1 Biophysical environment

The study communities are located in the tropical rainforest (*selva baja*) of northeastern Peru. The mean annual air temperature in the region is 26°C, relative humidity levels remain between 80-100% year-round, and average annual precipitation (recorded at Iquitos) is 2600mm (IIAP 1999, p. 7). The region knows two seasons over the course of the year based on differences in the amount of precipitation, a 'wet' and 'dry' season (roughly October to April and May to September, respectively).

Both study communities are located along the Napo River (Figure 1.1), one of the largest tributaries of the Amazon River in Peru. The river is born in the high peaks of the Ecuadorian Andes and is a relatively turbulent and fast flowing river compared to other rivers in the region. At the Ecuadorian border, the Napo has already dropped to below 200 m above sea level, and it falls another 90 meters in elevation over some 650 kilometers before reaching its confluence

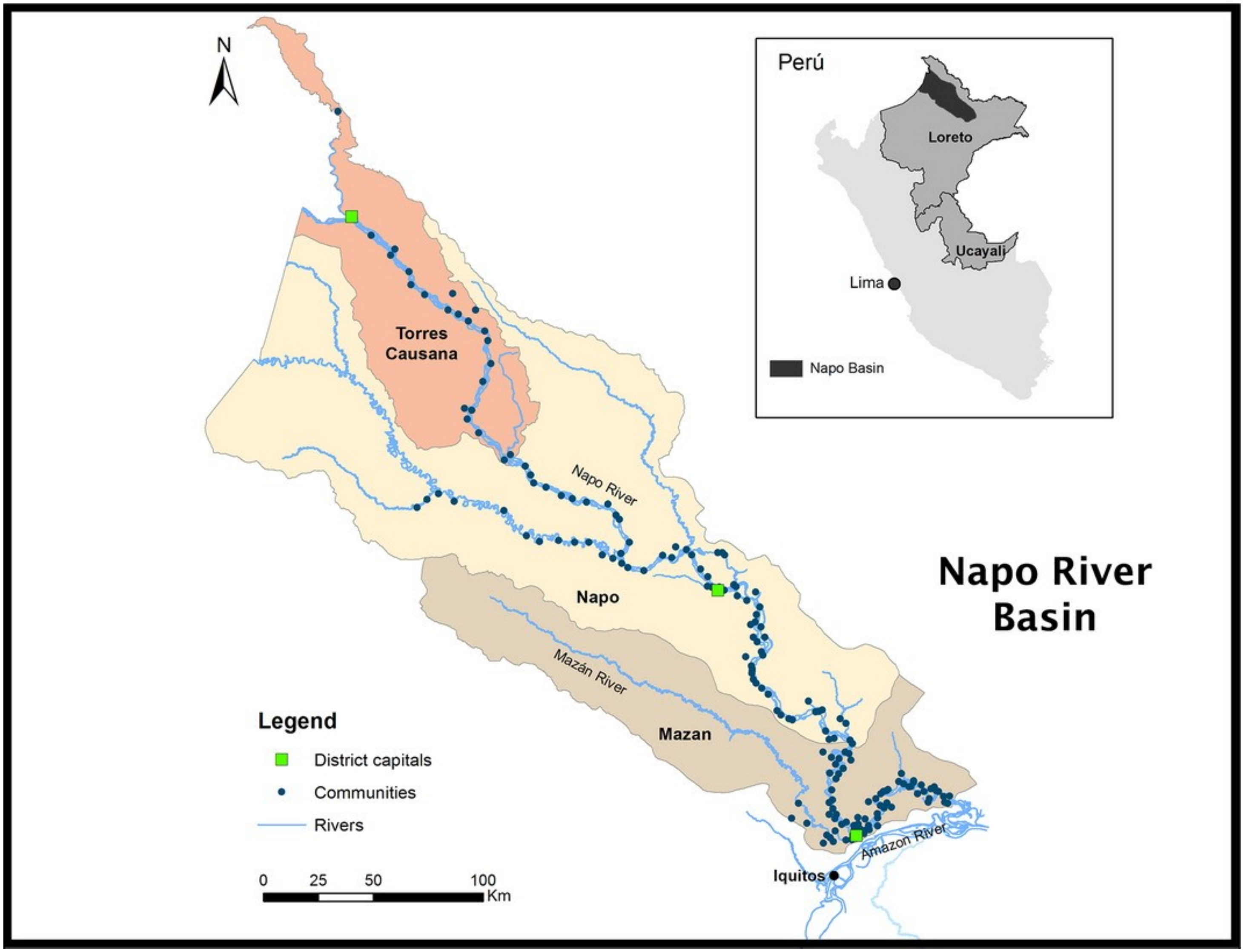


Figure 1.1 PARLAP study area (with sampled communities) in the Napo River Basin in the Department of Loreto, Peru

Note: Reproduced from Abizaid et al. (2018)

with the Amazon river downstream of Iquitos (Laraque *et al.* 2009). The Napo River width oscillates between 1500 and 3000 meters, and the 'flood' and 'low water' seasons of the Napo are offset from the annual cycle of the Amazon River, as the Napo River floods between May and July and reaches low water in November and December. The Napo basin has extensive areas of upland and roughly half of the rural communities are located on bluffs overlooking the river (Abizaid *et al.* 2018).

1.4.2 Local inhabitants and livelihoods

Most people living on the Peruvian lowlands are indigenous people and *mestizo* peasants known as *ribereños* (Chibnik 1991). Ribereños are generally of mixed Amerindian and European ancestry, often have native surnames, and have incorporated many Indigenous tools and practices into their cultivation and extraction systems (Coomes and Barham 1997). In the study area, ribereños live alongside, and may often be difficult to distinguish from indigenous Kichwa, Arabela, Maijuna, Secoya, Witoto, and Yagua people (Abizaid *et al.* 2018).

The primary economic activities among floodplain communities for meeting both cash and subsistence needs are agriculture, fishing, hunting, aquatic product extraction (*e.g.,* turtle eggs), and forest product extraction (*e.g.*, timber, non-timber forest product) (Abizaid *et al.* 2018). Households generally pursue a diversity of economic activities in order to cope with a seasonally changing and unpredictable environment as well as volatile market conditions (Coomes, Barham, and Takasaki 2004). Upland and lowland along both banks of the Napo River allow for the production and extraction of a wide variety of regional products including rice, vegetable ivory (*tagua*) but also timber and non-timber forest products (Villarejo 1988, p. 74).

Iquitos is the regional market and administrative center of Loreto and a handful of small towns serve as secondary markets and district capitals (*e.g.*, Pantoja, Santa Clotilde, and Mazán).

In the absence of roads, the river is the way of transportation and access to market. Close to markets, residents rely on canoes and small boats to bring their products to market whereas further away, residents sell to large passenger ferries (*lanchas*) or itinerant river traders, locally called *regatones* (Salonen *et al.* 2012). River transportation and accessibility are affected by seasonal variations in water levels, as well as by the velocity of river flow (Tenkanen *et al.* 2015). Many communities have access to a radiophone, a public telephone and/or cell phone coverage for communication with the city and district capitals (Abizaid *et al.* 2018).

1.5 Thesis structure

The thesis is organized into five chapters. Following this introductory chapter, I assess in Chapter 2 how socioeconomic and environmental characteristics influence hunter participation and harvest in the Peruvian Amazon. I identify, using the PARLAP data and my field data from two Napo River study communities, the community-, household-, and individual-level features that drive and constrain hunting, and assess the economic importance of hunting for the livelihoods of rural households. In Chapter 3, I assess terrestrial wildlife species richness surrounding one community along the Napo using household questionnaires, transects, and camera trapping. By comparing conventional inventory results with household survey results, I recommend best practices for collecting household survey data for rapid biological inventories for wildlife in Amazonia. In Chapter 4, I summarize my main findings and point to opportunities for future research and the conservation and development implications of my research. My thesis concludes with a personal Epilogue.

Chapter 2. Who is the expert? Evaluating local ecological knowledge for assessing wildlife depletion in the Peruvian Amazon.

2.1 Introduction

Baseline wildlife inventory data are foundational to the development of conservation plans (Danielsen *et al.* 2009). Before regulations for wildlife harvesting are created, government must first understand the underlying population dynamics in management areas (Danielsen *et al.* 2009). Although wildlife population trends are influenced by ecological factors such as suitable habitat and predator/prey dynamics, anthropogenic factors such as habitat degradation and hunting are frequently cited as being responsible for defaunation in Amazonia (Constantino 2016). In an attempt to quantify levels of sustainable harvest, Robinson (2000) estimated maximum percentage sustainable offtake values for 12 Amazonian mammals based on area, rate of reproduction, and current population. Measuring the present status of wildlife populations over large areas in Amazonia, however, is a difficult task. In this chapter, I examine the potential utility of household surveys to assess local ecological knowledge (LEK) for monitoring the status of Amazonian wildlife.

Three primary methods are used for monitoring Amazonian wildlife: line transects; camera trapping; and, household surveys (Munari, Keller, and Venticinque 2011; Danielsen *et al.* 2009; Parry and Peres 2015). Monitoring wildlife in Amazonia is challenging because the dense tropical forest cover makes detection difficult (Jenkins, Green, and Madden 2003). Natural scientists, social scientists, and policy makers generally differ in opinion as to the most effective inventory methods based on cost, sampling effort, and community involvement.

The most common method for monitoring biodiversity is the line transect by which scientists record wildlife sightings and signs of animals (feces, tracks, fur etc.) along a transect in the forest (Munari, Keller, and Venticinque 2011). Line transect data are generally accepted as being credible by biologists and surveys have been shown to empower local communities through participatory monitoring (Benchimol, von Muhlen, and Venticinque 2017). In hunting grounds, however, line transects tend to under detect wildlife because many species are cryptic and wary of human presence; the result is considerable uncertainty when assessing species presence or absence (José *et al.* 2016).

Camera trapping has become a popular and reliable method for monitoring wildlife. As technology has improved, cameras have become more durable and relatively inexpensive (Burton *et al.* 2015). Because camera trapping is a passive and non-invasive monitoring technique, it succeeds in detecting even cryptic species that are wary of humans (Burton *et al.* 2015). However, camera traps require regular monitoring over long periods which limits their application on large spatial scales (Burton *et al.* 2015). Although relatively inexpensive, camera traps still require regular, long term, sampling effort to yield scientifically acceptable results (Burton *et al.* 2015).

Conventional surveys conducted with camera traps and line transect surveys are limited in application because they involve large investments of time, equipment, and human resources (Parry and Peres 2015). For large-scale surveys, conventional surveys provide low detection probabilities of cryptic species and rapid transect sampling can lead to species misidentification and false-presences (Munari, Keller, and Venticinque 2011; Clare *et al.* 2017). Without efficient and accurate survey methods, wildlife status in remote areas is typically under-surveyed and often times unknown (Parry and Peres 2015).

In contrast to conventional methods to assess wildlife status, household surveys can solicit local peoples' knowledge held about wildlife status near their communities (Brook and

McLachlan 2008). Local ecological knowledge (LEK) is the environmental knowledge held by people that live in close contact with nature. Many remote communities are reliant on wildlife resources for food and thus have extensive knowledge on the current and historical presence of animals in forests surrounding their communities. Conducting household LEK surveys for wildlife presence is becoming a common way to assess the status of Amazonian wildlife (Parry and Peres 2015; Benchimol, von Muhlen, and Venticinque 2017; Coomes, Takasaki, and Abizaid 2020).

Household surveys of LEK can be a cost effective and efficient method of determining game presence near a community. Parry and Peres (2015), for example, developed a promising method that entails rapid interview survey to estimate the proximity of ten large-bodied vertebrate species as a proxy for local faunal depletion (Parry and Peres 2015). LEK surveys are providing scientists and local people throughout Amazonia the opportunity to better know the status of local wildlife populations and to understand the socio-economic determinants of game over-exploitation. The accuracy and precision of LEK surveys, however, requires validation using conventional techniques.

LEK surveys can be used to improve large terrestrial mammal surveys, build local capacity, and increase conservation opportunities. In a study of three peccary species in the Argentine Dry Chaco region, Camino *et al.* (2020) found that LEK surveys enhanced peccary detection compared to conventional methods (camera trap and line transect). As LEK household surveys for wildlife inventories become more commonly used, scientists must identify, in culturally appropriate ways, individuals who will provide the most accurate information. Targeting is thus a key aspect in the design of household LEK surveys. The approaches for targeting should be standardized to allow for regional, national, and international comparisons.

For wildlife inventories, researchers must identify the most knowledgeable and accessible individuals to collect survey data. Camino *et al.* (2020) found that hunters reported fewer false-presences of peccary compared to non-hunters in the Dry Chaco and as such could be considered experts regarding wildlife presence. Hunters, however, are often unavailable for surveying on a given day because hunting takes them far from the community during “working hours”. Further, hunting legislation in Amazonian countries, has created a “conspiracy of silence” whereby hunters are hesitant to engage with researchers because of a lack of clarity regarding the legality of hunting and the sale of game meat (Antunes *et al.* 2019).

In this chapter, I report on a study of the precision and accuracy of LEK compared to a wildlife inventory baseline established using conventional methods. The results of household surveys are compared with those from line transects and camera trapping used to determine wildlife presence. I hypothesize that hunters provide more accurate and precise responses compared to fishers and farmers for wildlife presence. I also assess using the household surveys, the opinion of community members as to who they think should be approached when conducting rapid inventory household surveys for wildlife. Finally, I chart the presence of wildlife through time according to household survey responses that rely on local ecological knowledge.

2.2 Study site

The ribereño study community is located along the Napo River within 200 kilometers by river from Iquitos. In February 2013, two hundred and sixty people lived in 42 households in this 90-year-old upland community. The community, unnamed for anonymity, is connected to two other nearby Kichwa communities by a 4.5-kilometer paved walkway. The community has access to a lake, a large tributary of the Napo river, a small stream and upland old growth forest that is slowly being converted to secondary forest through shifting cultivation. The Napo river, tributaries and lake provide fishing opportunities and local hunting generally occurs along the tributaries and in the upland forest. Residents extract non-timber forest products such as moriche palm fruit (*Mauritio* flexuosa) and camu-camu fruit (*Myrciaria dubia*) for sale in Iquitos.

The choice of study community was guided by the results of a large-scale survey conducted between 2012 and 2015 as part of the PARLAP project (https://parlap.geog.mcgill.ca). PARLAP data include socioeconomic information on rural livelihood strategies and the study community was chosen based on an analysis of household economic reliance on game meat in 235 communities (see Coomes, Takasaki, and Abizaid (2020)). I mapped the number of hunting households by community and analysed the amount harvested by these households. I then identified the communities with the highest number of hunting households while considering their contributions to the total amount of game. I selected a community with a rich current wildlife endowment to maximize the number of species that would be captured by camera trap and transect surveys. From PARLAP data, I know that the study community represents the 41st percentile of total game harvest and 50th percentile of current wildlife endowment. Of the 105 ribereño communities in the PARLAP dataset, the ribereño study community ranked 28th in total harvest and 33rd in current wildlife endowment.

Residents make their living along the Napo river by farming, fishing, and hunting although some households run general supply stores, work for logging companies or distill rum (aguardiente) for local sale (Abizaid *et al.* 2018). Most households practice a combination of activities that change throughout the year as the Napo floods and recedes. Large river boats provide long distance transportation multiple times per week and also provide goods, supplies, and access to market with Iquitos. The towns of Pantoja, Santa Clotilde, and Mazán serve as secondary markets and district capitals. *Rapidos*, fast boats that transport between 15 to 40 passengers three times per week, connect the study community with others between Iquitos and the Ecuadorian border. Transport to nearby communities (other than to those connected by a paved walkway) is conducted by *peque peque* – 12 to 30-foot dugout canoes propelled by small outboard motors – or by motorless canoes.

2.3 Methods

I conducted the fieldwork for the current study between July and September 2019. The research involved a camera trap survey, an upland transect survey, a river survey, and structured local ecological knowledge household surveys focused on wildlife presence. All research was approved by the McGill Research Ethics Board (File # 43-0619, Appendix A) and only passive (*i.e.,* observational) studies of wildlife were conducted.

Following initial discussions with village leaders and hunters, I set up 12 camera traps (unbaited) in the local hunting grounds following the approach of Blake and Loiselle (2018) along game trails with 12 Browning Strike Force Extreme cameras. To improve the likelihood of capturing wildlife images, I placed the camera traps near natural attractants in the upland forest such as fruiting trees, salt licks, and game trails. Cameras were located roughly 200 meters apart in a 3x4 grid pattern along newly cut trails, roughly 1.5 meters wide. I set up the camera trap survey immediately upon arrival in the community to maximize the duration of the sampling period. The cameras recorded between July 24, 2019 and September 3, 2019 and the photo record comprises 487 trap days of data (one camera had vegetation blocking the viewfinder between August 14-19, 2019). During the sampling period, the Napo river receded by more than 4 meters from seasonal highwater to low water. During the highwater season, some animals are restricted to upland forest and when the river recedes, animals are attracted to the newly exposed habitat (Beja *et al.* 2010; Bodmer 1990). I visited the camera traps twice during the sampling period to ensure functionality and to download the data.

A 4.5 km transect extended from the outskirts of the community into the intact old growth forest for the line transect survey (Figure 2.1). The transect was cut and marked within three days of setting up the camera traps. The line transect changed direction twice to avoid moriche palm swamps and common hunting trails. I trained a local hunter in transect data collection methods as described in Peres (1999). Distance from transect was not included in the data collection; instead data were collected on species encountered, number of species, marked distance along the transect and whether the species was seen, or the local assistants encountered a sign. All line transects were conducted between 06:30AM and 11:00AM at a walking pace of 1.25 km/hr.

A river survey followed the community stream for a four-hour paddle from the community (a river distance of 8.2 kilometers). Once sufficiently trained, the local hunter conducted both the land transect and river surveys with a rotating group of assistants to maximize community participation and engagement. River surveys occurred at various times of day to encounter species with differing temporal niches (including at night). The target pace for river surveys was 2 km/hr and time of day was recorded for each observation. Assistants carried GPS devices to record where observations occurred and ensure an appropriate pace. The line transect and river surveys did not occur on days (or nights) with significant rainfall (greater than 2 mm of rainfall per hour). The line transects and river surveys, together, are hereafter referred to as our “transect surveys”. Between July 29 and September 2, 2019, 10 surveys along the forest transect and 5 surveys along the river were completed.

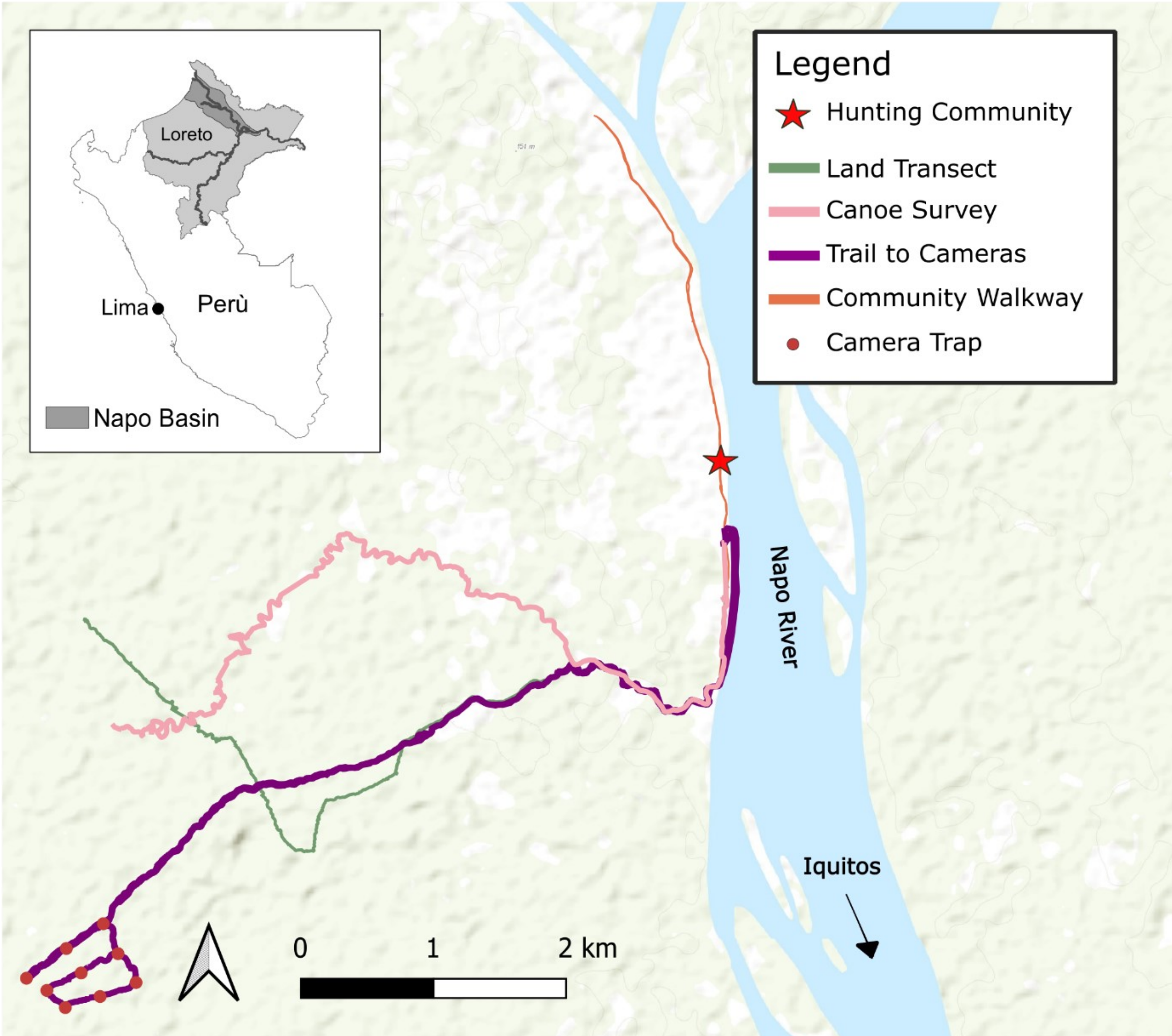


Figure 2.1: Study area with hunter tracks and conventional (camera trap and transect) survey method locations.

Basemap from January 14, 2021 ESRI world topographic map imagery accessed through the Quick Map Services plugin in QGIS on January 15, 2021. Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

I conducted 37 structured LEK household interviews with community members. The household survey instrument (Appendix B) prompted community members to report on the presence or absence of 31 specific animal species within a 2 hour walk/paddle and within a day walk/paddle from the community at three points in time: at the time of household formation; at the arrival of a local logging company in 2007; and, at the time of survey. The questionnaire also collected household livelihood information, and respondents were asked to recommend who visiting scientists should target when collecting household survey data for rapid wildlife inventories. The survey instrument prompted respondents to state whether they hunted and whether they currently held a leadership position in the community (*e.g.,* community president). The survey instrument also prompted households to rank their livelihood reliance on hunting, fishing, and farming. The response data collected distinguishes household categories for analysis. I conducted interviews after having obtained the informed consent of household members and the community authorities. Data were collected and compiled for wildlife presence into three separate datasets, according to survey method used. Only explicit sightings of animals and animal signs were included for transect surveys. Photos from camera trap records that did not include an animal or the animal was not identifiable (*i.e.,* too far away for reliable identification) were not included. To distinguish how survey responses differ among community members and how LEK survey responses compare to conventional methods, I analyzed the LEK data through three steps.

First, I use a Principal Component Analysis (PCA) to determine which responses for the 31 animal species listed in the household survey varied most. I selected the 10 species with the largest eigenvalues in the first principal component to determine how responses varied between three comparison groups: hunters and non-hunters; leaders and non-leaders; and farmers, fishers, and hunters. The subset of ten animals identified in the PCA analysis are referred to as "PCA animals".

Second, to understand how LEK responses compare to conventional methods, I conducted a Spearman correlation test to assess association among household survey responses, camera trap survey data, and transect data for wildlife inventories. I used three one-way analyses of variance (ANOVA) to determine how survey responses varied among the comparison groups for animals encountered with conventional methods.

To assess the quality of LEK responses, I evaluate how accurate and precise LEK responses are relative to conventional methods. "Accuracy" is defined as the "closeness of agreement between [the] measured quantity value and a true quantity value of a measurand" whereas the "precision" refers to the "closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same … object" (JCGM 2012, pp. 21-22). In this study, I consider the presence of an animal (the measurand) to be defined by presence in the conventional method survey. I evaluate the accuracy of LEK responses by the size of measurement error, or when respondents reported false absences. Overall survey response precision is determined by the standard error of grouped responses: the smaller the standard error, the greater the response precision. For specific species, precision is determined by the spread of responses for the presence or absence of the animal. For example, for jaguar, the closer binary survey responses are to 0% or 100% as being present, the more precise are household responses; whereas the closer survey responses are to 50%, the less precise responses are for jaguar.

Third, I use linear regression models to predict determinants of wildlife presence using year and distance category (2 hour and 1 day) as covariates.

$$A_i = \beta_0 + \beta_1 Year_i + \beta_2 Distance_i + e_i$$

Where:

- A_i is the animal presence index, or the total integer value of reported animals present near the community at household formation. There are four indices: PCA index is a 10 animal subset of the animals which varied most in household survey responses; large, medium, small, and vulnerable indices are based on the category listed in Table 2.1.
- Year is the year of household formation
- Distance is the binary hiking/paddle distance category (1 = one day: 0 = two hour)
- β_0 is the y-intercept
- e_i is the error term

As a final step, I allocated species into three different size categories: large animals (greater than 5.5 kilograms); medium (between 2 and 5.5 kilograms); and, small animals (less than 2 kilograms). I also classified animals according to vulnerability based on the IUCN Red List (IUCN 2020; see Table 1) and by the variation in household presence/absence responses from the PCA. Using LEK household survey data for animals present at household establishment, I use five one-way analyses of covariance (ANCOVA) to determine how animal presence (PCA, large, medium, small, and vulnerable) varied in time at different distances from the community. I plotted the number of animals reported as being present in time with a linear regression model, and a LOESS line was fit through the data. I completed all statistical analyses using the statistical program R version 4.0.0 (R Core Team 2020).

2.4 Results

Twenty of the 31 animal species listed in the household survey appeared in the conventional method survey (*i.e.,* camera trap and transect surveys) and serve as the baseline measure for comparison with LEK responses (Table 1). LEK survey responses are positively correlated with species observed during the conventional survey ($\rho = 0.44$, $P = 0.01$). On average, LEK responses from non-hunters and hunters identified 18.1 and 18.9 of the 20 animals, respectively, found using the conventional methods, although the difference is not statistically significant ($F_{(1,35)} = 1.3847$, $P = 0.25$; Table 2). There was no statistical difference in reported animal presence among the primary livelihood strategy categories (means: Farmers = 18.6, Fishers = 18.67, Hunters = 17.67; $F_{(2,32)} = 0.2901$, $P = 0.75$; Table 2) or between leaders and non-leaders ($F_{(1,35)} = 0.0112$, $P = 0.92$; Table 2). The most common animal to be reported as a false absence is *Tapirus terrestris* followed by *Panthera onca* (Figure 2.2, Table 2.1).

Camera trap and transect surveys are positively correlated for species presence or absence among the 31 household survey animals ($\rho = 0.81$, $P < 0.01$). Household survey results were positively correlated with the transect surveys ($\rho = 0.44$, $P = 0.01$) as with the camera trap survey ($\rho = 0.40$, $P = 0.03$).

The ten animals with the largest eigenvalues in the first principal component for presence/absence responses were (in order of greatest variance): Brazilian tapir, white-lipped peccary (*Tayassu pecari*), collared peccary, woolly monkey (*Lagothrix lagotricha*), jaguar, Salvin's curassow (*Crax salvini*), common caiman (*Caiman crocodilus*), black caiman (*Melanosuchus niger*), Arrau river turtle (*Podocnemis expansa*) and giant armadillo. The ten animal subset is hereafter used to represent "PCA animals" or "PCA responses". I observe no

Table 2.1. Animals included in LEK structured interview that appeared in conventional surveys and the percentage of respondents who stated the animal could be encountered within two hours from the community.

English Name	Scientific Name	Transects	Cameras	Interviews	Body Mass (g)[1]	IUCN Status
Brazilian Tapir	Tapirus terrestris	Yes	Yes	62%	125800	Vulnerable
Jaguar	Panthera onca	Yes	Yes	73%	90000	Near Threatened
Capybara	Hydrochaeris hydrochaeris	No	No	95%	33710	Least Concern
White-lipped peccary	Tayassu pecari	No	No	76%	32000	Vulnerable
Giant anteater	Myrmecophaga tridactyla	Yes	Yes	95%	31000	Vulnerable
Giant armadillo	Priodontes maximus	Yes	Yes	95%	30000	Vulnerable
Collared peccary	Pecari tajacu	Yes	Yes	78%	20430	Least Concern
Brocket deer	Mazama spp.	Yes	Yes	97%	20230	Data Deficient
Black caiman	Melanosuchus niger	No	No	32%	19410	Needs Updating
Red howler monkey	Alouatta seniculus	Yes	Yes	100%	7020	Least Concern
White-bellied spider monkey	Ateles belzebuth	No	No	11%	6800	Endangered
Paca	Agouti paca	Yes	Yes	100%	6710	Least Concern
Yellow-tailed woolly monkey	Lagothrix lagotricha	No	No	46%	5790	Vulnerable
Agouti	Dasyprocta fuliginosa	Yes	Yes	100%	5500	Least Concern
Yellow-footed tortoise	Geochelone denticulata	No	No	95%	5150	Vulnerable
Common caiman	Caiman crocodilus	Yes	No	81%	4500	Least Concern
Nine banded armadillo	Dasypus novemcintus	Yes	Yes	100%	4430	Least Concern
Yellow spotted Amazon river turtle	Podocnemis unifilis	Yes	No	95%	4330	Vulnerable
Arrau river turtle	Podocnemis expansa	No	No	62%	3500	Needs Updating
Salvin's curassow	Crax salvini	No	No	16%	3140	Least Concern
South American coati	Nasua nasua	Yes	Yes	89%	3050	Least Concern
White fronted capuchin monkey	Cebus albifrons	Yes	Yes	97%	2880	Least Concern
Dusky titi monkey	Callicebus spp.	Yes	No	100%	1130	Least Concern
Spix's guan	Penelope jacquacu	Yes	Yes	100%	1070	Least Concern
Trumpeter	Psophia spp.	Yes	Yes	95%	1040	Near Threatened
Tinamou	Tinamus spp.	Yes	Yes	97%	1020	Near Threatened
Common squirrel monkey	Saimiri boliviensis	Yes	Yes	100%	940	Least Concern
Amazon red squirrel	Sciurus spp.	Yes	Yes	100%	680	Least Concern
Tamarin monkey	Saguinus spp.	Yes	Yes	100%	510	Least Concern
Pygmy marmoset	Cebuella pygmaea	No	No	100%	150	Vulnerable

[1] Body mass data from Mena *et al.* (2000); Peres (2000b); Nowak and Walker (1999)

statistically significant differences in household survey PCA responses between hunters and non-hunters ($F_{(1,35)} = 2.4338$, $P = 0.1277$); leaders and non-leaders ($F_{(1,35)} = 0.0201$, $P = 0.888$); or, by household primary livelihood category ($F_{(2,32)} = 1.3038$, $P = 0.2855$), Table 2). Responses where animals were declared as being present by households but which did not appear in the conventional surveys are deemed "incorrect". Some animals may be present around communities ephemerally (conventional surveys may not have occurred during the appropriate season) or have niches that make them unlikely to be observed by conventional methods (*e.g.,* arboreal species for camera trap surveys and aquatic species in line transects through upland forest).

Responses to our LEK survey, suggest that animal presence around the study community has decreased and especially since the arrival of a logging company in 2007 (Figure 2.3). The presence of large animals (greater than 5.5 kilograms) decreased more than medium (between 2 and 5.5 kilograms) and small animals (less than 2 kilograms) (Table 2.3; Figure 2.4). Many of the animals that declined in presence are listed as "vulnerable" or "endangered" by the IUCN (2020) Red List (Figure 2.4, Table 2.1). Although wildlife presence decreased locally, many animals that disappeared within 2 hours of the community are reported as being present within a one-day hike or paddle from the community (Figure 2.3 and 2.4). In fact, of the ten species identified in the PCA with the greatest household response variability, animal presence declined over time ($\beta_1 = -0.09$, $P < 0.001$), but less so in the 1-day zone ($\beta_2 = 1.41$, $P < 0.01$).

Villagers recommended that visiting scientists ask local authorities (19 of 36 responses) and hunters (14 of 36 responses) regarding wildlife presence around a community. Other responses included community elders, women leaders, and anybody.

Table 2.2. Survey responses by livelihood designations

Top table (A) represents correct responses in relation to baseline of conventional surveys based on hunting engagement, community leadership, and primary livelihood categories. All animals were found to be present in either camera trap or transect surveys. An ANOVA found no statistical difference between categories (Hunting engagement: $F_{(1,35)} = 1.3847$, $P = 0.25$; Community leadership: $F_{(1,35)} = 0.11$, $P = 0.92$; Primary livelihood: $F_{(2,32)} = 0.29$, $P = 0.75$). The bottom table (B) represents "Correct" responses (PCA) in relation to baseline of conventional surveys based on hunting engagement, community leadership, and primary livelihood categories. Several PCA animals did not appear in either camera trap or transect surveys. An ANOVA found no statistical difference between categories (Hunting engagement: $F_{(1,35)} = 2.43$, $P = 0.13$; Community leadership: $F_{(1,35)} = 0.02$, $P = 0.89$; Primary livelihood: $F_{(2,32)} = 1.30$, $P = 0.29$).

A.

		Subset Survey Responses		
		Correct Response (/20)	**Standard Error**	**N**
Hunting Engagement				
	Non-Hunter	18.12	0.63	16
	Hunter	18.9	0.32	21
Community Leadership				
	Non-Leader	18.59	0.37	29
	Leader	18.5	0.76	8
Primary Livelihood				
	Farmer	18.61	0.46	23
	Fisher	18.67	0.58	9
	Hunter	17.67	1.33	3

B.

		PCA Survey Responses		
		"Correct" Response (/10)	**Standard Error**	**N**
Hunting Engagement				
	Non-Hunter	7	0.45	16
	Hunter	6.24	0.26	21
Community Leadership				
	Non-Leader	6.59	0.27	29
	Leader	6.5	0.63	8
Primary Livelihood				
	Farmer	6.78	0.33	23
	Fisher	6.44	0.47	9
	Hunter	5.33	0.33	3

Figure 2.2 Brazilian tapir (*Tapirus terrestris*) and jaguar (*Panthera onca*) captured in camera trap survey.

2.5 Discussion

I analyzed data collected by household surveys for LEK of wildlife presence, camera trap survey and transect surveys to assess the accuracy and precision of LEK surveys for collecting wildlife inventory data in remote regions of Amazonia. My results suggest that LEK surveys are an accurate method for collecting wildlife inventory data. Specifically I find that: (1) LEK household surveys are consistently correlated with conventional surveys for wildlife presence; (2) there is no statistical difference in survey responses between hunters and non-hunters, by leadership status, or by household primary livelihood strategy; and, (3) local residents indicate that visiting scientists should consult with community authorities and then hunters to assess wildlife presence around their community. Through carefully conducted LEK surveys, not only are scientists able to acquire a synoptic view of current wildlife presence, but also, can look back in time and visualize how wildlife populations are changing in Amazonia.

2.5.1 LEK household surveys for wildlife are accurate but are variable in precision

Of the 20 animals that were encountered during the conventional survey, there were no statistically significant differences were found between hunters and non-hunters in reporting false-absences. The most common animal to be reported as a false-absence is *Tapirus terrestris* followed by *Panthera onca*. Both species have large home ranges and are relatively cryptic (Quigley *et al.* 2017; Varela *et al.* 2019). Brazilian tapir are a popular game species because of their large biomass and abundant fat that is used for cooking. Around hunting communities, tapir are one of the first animals to be extirpated and their loss could have cascading effects on forest structure due to their role as large seed dispersers (Antunes *et al.* 2016). Scholars have hypothesized that due to historical depletion of tapirs, indigenous people along the Xingu river developed a resource taboo on tapir that limits its harvest (Ross 1978). Tapir are wary of human

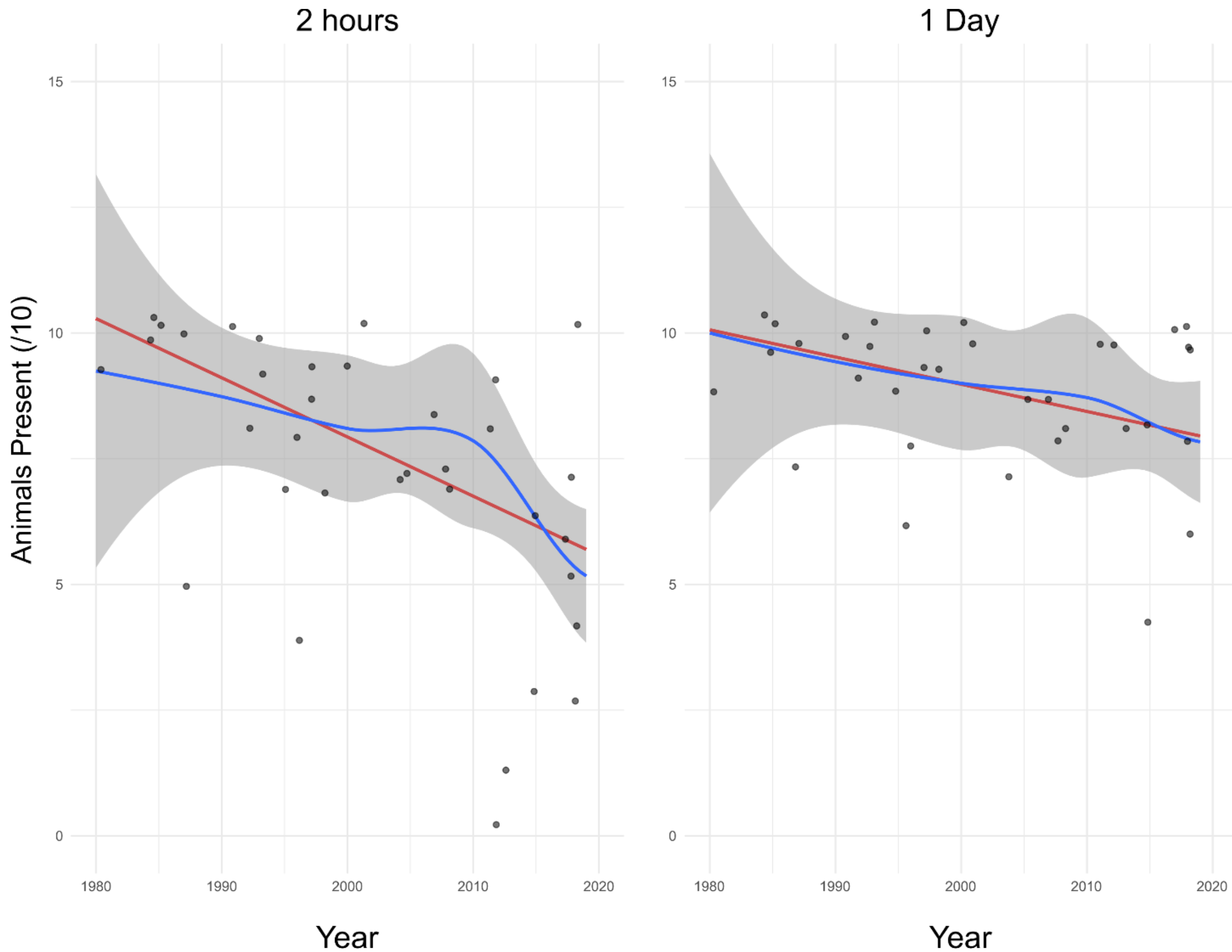


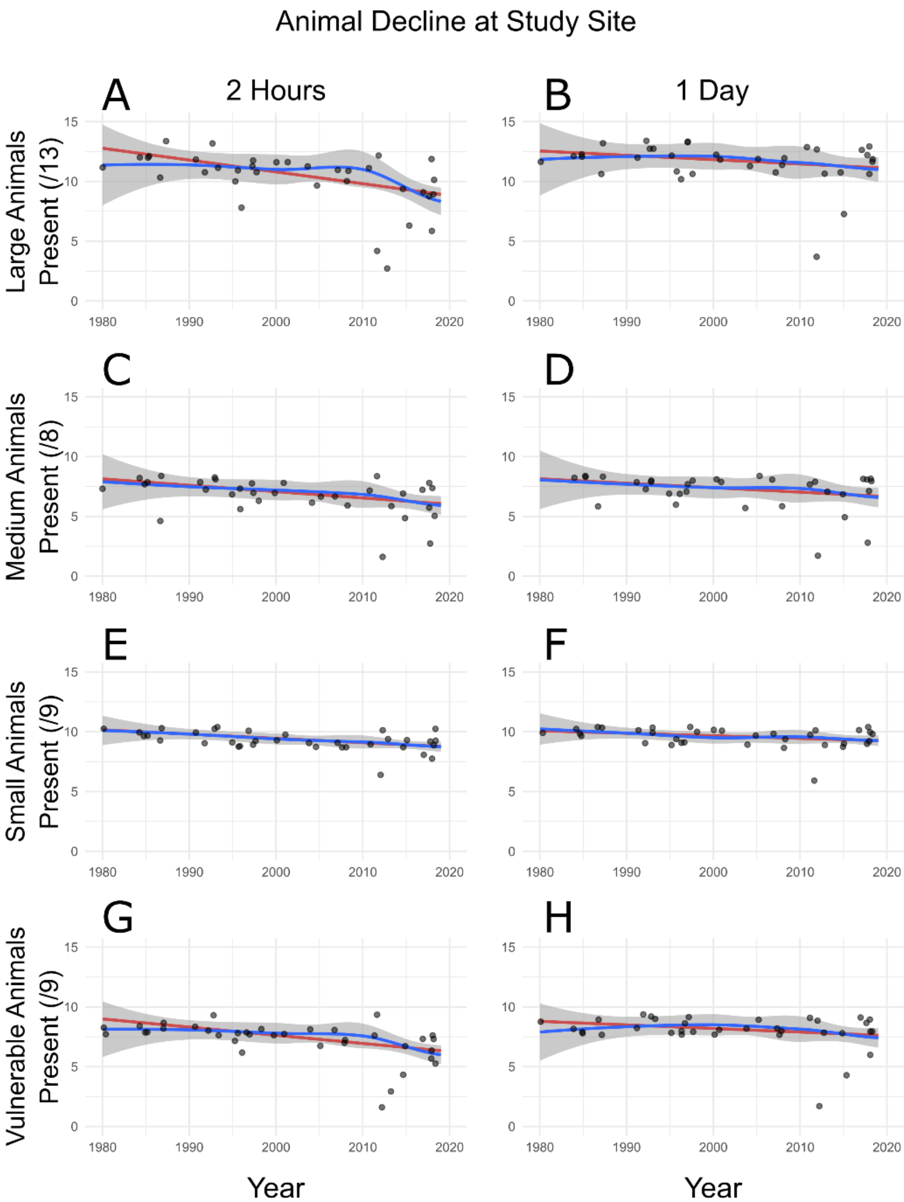
Figure 2.3 PCA animal presence around study community. 1980 – 2019.

Blue LOESS line (and 95% confidence interval) through presence/absence data of animals (within 6 km) upon household formation year based on household survey data. Red line represents linear regression for animal presence using year as the covariate ($Two\ Hour\ (PCA)_i = 10.28 - 0.12Year_i$, $R^2 = 0.26$, $P < 0.001$; $One\ Day\ (PCA)_i = 10.06 - 0.05Year_i$, $R^2 = 0.07$, $P = 0.06$).

Table 2.3. Results of analyses of covariance (ANCOVA) for animal presence data by year and by distance designation.

(β = Regression Coefficient; SE = Standard Error; df = Degrees of Freedom, SS = Sum of Squares, MS = Mean Square, F = F-score, P = P value)

PCA Animals							
	β	SE	Df	SS	MS	*F*	*P*
Year	-0.09	0.02	1	73.27	73.27	15.95	< 0.001
Distance	1.41	0.50	1	36.54	36.54	7.95	< 0.01
Residuals			71	326.14	4.59		
Large Animals							
Year	-0.07	0.02	1	45.21	45.21	12.82	< 0.001
Distance	1.38	0.44	1	35.15	35.15	9.97	< 0.01
Residuals			71	250.30	3.53		
Medium Animals							
Year	-0.05	0.01	1	20.17	20.17	11.63	< 0.01
Distance	0.42	0.31	1	3.12	3.12	1.80	0.18
Residuals			69	119.69	1.73		
Small Animals							
Year	-0.03	0.01	1	8.07	8.07	15.95	< 0.001
Distance	0.30	0.17	1	1.63	1.63	3.23	0.08
Residuals			71	35.93	0.51		
Vulnerable Animals							
Year	-0.05	0.01	1	23.92	23.92	12.88	< 0.001
Distance	0.78	0.32	1	11.36	11.36	6.12	0.02
Residuals			71	131.87	1.86		



<u>Figure 2.4 Animal presence around study community, 1980 – 2019.</u>

Blue LOESS line (and 95% confidence interval) through presence/absence data of animals (within 6 km) upon household formation year based on household survey data. Red line represents linear regression for animal presence using year as the covariate ((A) $Two\ Hour\ (Large)_i = 12.78 - 0.10Year_i$, *$R^2$=0.24, P < 0.01;* $(B) One\ Day\ (Large)_i = 12.55 - 0.04Year_i$, *$R^2$ = 0.03, P = 0.14; (C)* $Two\ Hour\ (Medium)_i = 8.13 - 0.05Year_i$, *$R^2$ = 0.18, P < 0.01;* $(D)\ One\ Day\ (Medium)_i = 8.14 - 0.04Year_i$, *$R^2$ = 0.07, P = 0.06;*
$(E)\ Two\ Hour\ (Small)_i = 10.16 - 0.04Year_i$, *$R^2$ = 0.26, P < 0.001;*
$(F)\ One\ Day\ (Small)_i = 10.08 - 0.02Year_i$, *$R^2$ = 0.08, P = 0.05;*
$(G)\ Two\ Hour\ (Vulnerable)_i = 9.00 - 0.07Year_i$, *$R^2$ = 0.25, P = 0.001;*
$(H)\ One\ Day\ (Vulnerable)_i = 8.79 - 0.03Year_i$, *$R^2$ = 0.04, P = 0.13).*

presence, and thus are difficult to detect in transect surveys but are often captured through sign surveys and camera trap surveys (Trolle *et al.* 2008). Although they are the largest mammal in Amazonia, their relatively low abundance makes it unlikely that people who do not venture far into the forest would be aware that tapir is present nearby. Nonetheless, 62% of all households reported that tapirs are present within two hours of the community suggesting that if interviews were conducted as a focus group, tapirs would likely be considered to be present within six kilometers of the community.

Jaguar are another large, cryptic mammal. Visual encounters are rare and most wildlife inventory surveys report the presence of jaguars based on camera trap or sign surveys (Silver *et al.* 2004) but LEK surveys are becoming popular (Petracca *et al.* 2018). When jaguars are observed near communities, news spreads quickly because community members fear for their livestock and families. Considering the extensive range of jaguars it can be difficult to obtain accurate results for their presence (Silver *et al.* 2004; Petracca *et al.* 2018). In my study, 73% of households reported that jaguars are present within six kilometers of the study community. If data are collected through focus group interviews, it seems reliable responses for jaguar presence could be secured.

Species response precision, determined by percentage of households that reported in the household LEK survey a species as being present, varies by species but when responses are aggregated, the results appear to be accurate. The PCA identified five species that varied most in survey responses: tapir, white-lipped peccary, collared peccary, woolly monkey, and jaguar. All species are, or were historically, preferred hunting species susceptible to defaunation. Forty-six percent of respondents claimed that woolly monkeys and 62% of respondents claimed that tapirs and Arrau river turtles are present within two hours of the community. In the interest of protecting animals most susceptible to hunting pressure, interviews should maximize survey precision for the species that vary most in survey responses. Individually, responses for certain species lacked precision but 73% of the study species had less than 20% variation among respondents. If interviews are conducted in focus groups, greater precision can be achieved.

The positive correlation between results from conventional and LEK methods for collecting wildlife inventory data suggests that not only do the survey methods complement each other, but that LEK household surveys yield accurate responses for wildlife presence. For some species, household surveys may lack precision among respondents. For large-scale surveys limited by time and budget, organizing a focus group discussion in multiple communities could provide promising data for understanding local population dynamics of key species in Amazonia.

2.5.2 Who are the experts and why might LEK surveys be more effective than conventional methods?

I observed no statistically significant difference in household survey responses between hunters and non-hunters; leaders and non-leaders; or by primary livelihood strategy. Appropriate targeting for household surveys is crucial to obtain reliable data and hunters are generally considered in the literature to be those with the most accurate understanding of wildlife presence (Davis and Wagner 2003). Hunters often travel far from their households and have keen eyes for animal signs and animal habitat (Camino *et al.* 2020; Luzar *et al.* 2011). In contrast to other studies, my research finds no differences in survey responses between hunters and non-hunters (cf. (Camino *et al.* 2020). The community in which the current study occurs, however, may be an outlier from other communities because of the relatively high local endowment of wildlife and hunter harvests when compared to other ribereño communities in the PARLAP dataset.

Although no significant statistical differences were found for the PCA responses, hunters may report fewer "correct" responses than non-hunters ($F_{(1,35)} = 2.43$, $P = 0.13$). Responses were considered "incorrect" if they differed from results from the conventional method survey. The most common "incorrect" responses were for white-lipped peccary, Arrau river turtle and woolly monkey – animals that may be present in the study area, but only ephemerally.

2.5.3 LEK as a complement to conventional methods

While this chapter has thus far used camera trap and transect data as the measurand against which to assess the accuracy of LEK, LEK surveys alone may have advantages in identifying species over conventional methods. Indeed, during fieldwork, I heard stories of a white-lipped peccary herd passing through the community each year to cross the Napo River. The herds are difficult to monitor using conventional methods (Ohl-Schacherer *et al.* 2007; Norris *et al.* 2011) and were not captured in my conventional survey despite 76% of households stating that they are present near the community. In fact, during the last week of my field research, a herd of about 80 white-lipped peccaries passed through the community to cross the river. Previous accounts describe transiting herds of greater than 100 individuals that the entire community as well as passing transport will harvest (Field Notes 2019). LEK surveys are well suited for not only assessing species presence, but also, potentially, the abundance of specific species such as white-lipped peccary.

Arrau river turtle populations have declined throughout the Amazon basin (dos Santos and Fiori 2020) but during breeding season they will haul out on exposed Napo River beaches to lay their eggs. Although their ecological role may be diminished, they are present and identifying areas where Arrau river turtles are laying eggs through LEK surveys may be essential for conservation measures aimed at maintaining healthy river turtle populations. Populations are especially at risk because most eggs discovered by rural Amazonians are collected to be either consumed locally or sold to market (Pearse *et al.* 2006; Pineda-Catalan *et al.* 2012). Providing alternative subsistence opportunities and creating conservation policies together with rural Amazonian communities may be the only way to prevent the extirpation of Arrau river turtles in the Napo River. In Brazil, community conservation projects aimed at protecting beaches from egg poaching resulted in significant ecological and social benefits (Campos-Silva *et al.* 2018).

Woolly monkeys are another keystone species vulnerable to overhunting (Levi *et al.* 2011). When woolly monkeys are abundant, they are easily hunted because they are loud and travel in large troops and are one of the first species to disappear from around a community (Levi *et al.* 2011). Ecologically, woolly monkeys play an important role in long distance seed dispersal of carbon dense trees (Antunes *et al.* 2016). During my conventional survey, Woolly monkeys were not observed suggesting that they may be locally extirpated, but 45% of respondents reported that the monkeys are present. If the monkeys are absent, they may have only recently been extirpated and subpopulations further in the forest may move towards new habitat closer to communities.

It is interesting to note that hunters report fewer "correct" responses for the ten-animal subset identified in the PCA analysis. Data gathered using conventional methods cannot be used to refute household survey responses as false presences. Certainly, species that are ephemeral in the area, aquatic species or species at low abundances may not appear in conventional surveys. In contrast LEK surveys can capture the presence of such species while allowing comparisons to be made between current and historical animal populations.

2.5.4 Conducting large-scale LEK surveys for wildlife inventories in Amazonia

LEK surveys may offer the best approach to wildlife inventories in remote regions on a large-scale (Parry and Peres 2015). LEK surveys involve local actors who can provide informed input for policy decisions for wildlife conservation. To understand wildlife populations, it is important to solicit information from the most knowledgeable people but it is also important to not only maintain, but improve, relations with rural people (McGregor 2011; Nadasdy 1999; Davis and Wagner 2003). Rural people often feel marginalized and forgotten by those making decisions in larger urban centers (Das and Poole 2004). By ethically incorporating rural voices into decision making processes occurring in urban centers, greater trust can be built and potentially greater "buy in" garnered from rural people for effective local governance of natural resources (Turner and Berkes 2006; Louis 2007; Castellano 2000).

In my study, local people recommended that visiting researchers speak with community authorities and hunters regarding wildlife presence in forests surrounding communities. Although residents generally found the conventional surveys interesting, they felt that they already had a good understanding of where animals were because they know their local forests. Indeed, some residents viewed the conventional surveys as being unnecessary. Sometimes, however, people do not wish to be interviewed regarding wildlife presence and community authorities must manage community visitors (*e.g.,* scientists). Although no significant differences in LEK survey responses were found between leaders and non-leaders, I suggest that visiting scientists – out of respect – organize standardized focus group discussions with community leaders and hunters to collect data ethically, efficiently, and effectively.

2.5.5 Applications: visualizing wildlife decline throughout the Amazonian basin

Not only can LEK surveys provide a useful snapshot of current wildlife populations but with careful sampling, LEK surveys can be used to assess the status of how wildlife populations change over time (Coomes, Takasaki, and Abizaid 2020). My research shows that wildlife populations are declining around the study community – particularly large and vulnerable animals. Wildlife is scarcer surrounding the study community today than in the past and especially since the arrival of a logging company ten years ago. Community members are concerned that despite employing sustainable logging practices and having strict regulations against wildlife harvesting, the logging company is scaring wildlife away from the community. Although people do acknowledge that hunting depletes wildlife, deforestation, habitat degradation, habitat fragmentation, and noise could be reducing game resources. Hunters are concerned about how external actors may be contributing more to wildlife decline than does hunting.

Like other intertemporal studies reliant on LEK, my results may be limited by the cognitive bias referred to as ‘rosy retrospection’, where respondents recall historical environmental conditions more favourably than current conditions (Thurstan *et al.* 2016; Papworth *et al.* 2009). Importantly, however, this study relies on relative contrasts of presence/absence data and therefore reduces retrospection bias (Coomes, Takasaki, and Abizaid 2020). If future research aims to measure population level changes over time with LEK methods, researchers should use robust survey instruments employing appropriate recall periods to inform conservation action and management plans for specific species that could be difficult to monitor using conventional methods (Nash, Wong, and Turvey 2016; Golden, Wrangham, and Brashares 2013).

By asking households to list wildlife that are present or absent around their community at a key moment in community history and currently, communities themselves document changes that are relevant to their interests. Perhaps for species with extensive home ranges, multiple household interviews should be conducted to describe how overall populations have changed over time. For example, population studies of herd animals like white-lipped peccary would benefit from the use of LEK surveys because rural people could describe the relative change in herd size over time. White-lipped peccary are preferred game species because when they are present, they can be stalked, and many peccaries can be killed from the herd at one time. As a white-lipped peccary herd moves from one community to the next, hunting pressure continues to reduce herd size and population recovery can only occur far from communities in upland forests. Clearly, wide ranging species require collaborative efforts among various communities for conservation. Through LEK surveys of white-lipped peccary population dynamics, greater insight may be gathered for these vulnerable and ecologically important species.

2.6 Conclusion

LEK household surveys are an accurate method for collecting baseline wildlife inventory data in Amazonia. Surveys are well suited for large-scale rapid wildlife assessments and could be reproduced across river basins to capture a fuller understanding of vulnerable wildlife populations far from urban centers. I found that LEK survey results are correlated with a conventional survey measurand (*i.e.,* transect and camera trap surveys) and may outperform conventional surveys for aquatic, ephemeral, and cryptic species. Further, rapid LEK surveys can be used for retrospection to visualize on a large-scale how wildlife populations are changing through time. I recommend the use of LEK surveys for wildlife inventories in remote regions of Amazonia with careful attention to collecting data ethically with a community-focused approach.

Local people should stand to benefit, not be criticized, for the data that they voluntarily provide for Western science.

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Chapter 3: Got game? Characterizing hunters in the Peruvian Amazon

3.1 Introduction

Hunting is an important livelihood strategy for rural Amazonians that provides both cash income and food (Nunes *et al.* 2019; Van Vliet *et al.* 2017; Ponta *et al.* 2019; Rao and McGowan 2002) but is considered by conservationists to be a serious threat to biodiversity, forest composition, and even the world climate system (Benitez-Lopez *et al.* 2017; Brodie 2018; Antunes *et al.* 2016). Discordant world views among local people, conservationists, and social scientists, coupled with vague and rapidly changing legislation have created a conflictive context that endangers rural livelihoods and limits the efficacy of conservation efforts (Antunes *et al.* 2019; Van Vliet *et al.* 2015b). In this chapter, I examine the socioeconomic and environmental drivers that shape hunter livelihoods to identify opportunities for biodiversity conservation. Conservation policy must consider local perspectives and realities (Petriello and Stronza 2020; Antunes *et al.* 2019). I argue that formalizing small-scale hunting for cash income could be an effective solution for protecting forests, wildlife, and people in Amazonia.

Conservationists are concerned about progressive defaunation of Amazonian forest and rivers, referring to them as "empty forests" and "empty rivers" (Wilkie *et al.* 2011). Models suggest that with fewer seed dispersing animals, landscape level changes could occur in forest composition that could alter the world carbon cycle (Antunes *et al.* 2016; Brodie 2018). In addition to reduced habitat due to deforestation and forest fragmentation, hunting is villainized in the Amazon for creating functionally empty forests (Parry and Peres 2015; Constantino 2016; Peres 2001). Still, studies that assess the importance of hunting for rural livelihoods find that game meat is a critical source of food for impoverished forest people (van Vliet *et al.* 2019).

The debate over Amazonian hunting policy recently turned to address how hunting can be leveraged to protect biodiversity through sustainable hunting policies that respect local wellbeing (van Vliet *et al.* 2019). "Sustainable harvest" is defined by Robinson and Bennett (1999) by four guiding principles: (1) populations cannot show consistent declines in numbers; (2) harvested populations cannot be reduced to densities that are vulnerable to local extinction; (3) harvest populations cannot be reduced to densities where the ecological role of the species or ecosystem is impaired; and, (4) harvested populations cannot be reduced to densities where they cease to be a significant resource to human users. Sustainability indices for harvest however vary and often do not consider source populations of wildlife far from human settlements (Robinson 2000; Antunes *et al.* 2016; Milner-Gulland and Akcakaya 2001; Joshi and Gadgil 1991). Despite massive international demand, and defaunation in the 20th century for animal pelts, terrestrial wildlife harvest continues to be substantial in Amazonia today (Antunes *et al.* 2016).

Many studies report on community wildlife harvests because scientists are interested in maximum sustainable harvest, noting that harvests can be substantial. In studying festival hunting, Siren (2012, p. 41) found total annual wildlife harvests of 33,439 kg/year in 1999-2001 and 33,339 kg/year in 2008-2009 in the Kichwa community of Sarayaku, Ecuador. If the average Angus Black Bull weighs 850 kilograms, the equivalent yearly harvest in Sarayaku for cattle is nearly 40 bulls. With over 1000 inhabitants, if the harvests were spread between community members evenly, everyone would consume nearly 34 kilograms of game meat per year – roughly equivalent to one small goat or capybara (*Hydrochaeris hydrochaeris*) per person.

Game meat consumption can vary considerably among communities or households and some hunters harvest much more than others. In a study of contemporary urban hunters in the Três Fronteiras region of the Brazilian Amazon, van Vliet *et al.* (2015a, p. 4) reported a total harvest of 11,600 kilograms of game meat, mostly destined for market, collected by four hunters over a 60 day monitoring period. Peres (2000a, p. 247) estimates conservatively that 89,224 tons of game meat is consumed each year by the rural population in Brazil, and da Silva *et al.* (2020) measured 209,866 kg of game meat hunted for subsistence and cultural purposes by 20 Fulni-ô people in northeastern Brazil between June 2015 and July 2016. Many studies in Amazonia conclude that local subsistence hunting is unsustainable and the response to defaunation by government has been strict and confusing legislation (Zapata-Rios, Urgiles, and Suarez 2009; Antunes *et al.* 2019; Aquino *et al.* 2015; Bodmer, Eisenberg, and Redford 1997).

To create effective legal reforms for sustainable harvest policies that account for the realities of hunters and hunting communities, scientists must first identify who hunts and what drives the choice of hunting as a livelihood strategy (Francesconi *et al.* 2018). The scientific literature points to two hunter categories in Amazonia: specialized and opportunistic hunters. Regardless of whether hunters are specialized or opportunistic, the relationship between subsistence livelihoods and the market must be better understood to guide the development of reasonable management programs that benefit local people while protecting ecological integrity

A raft of studies report on specific community, household, and individual characteristics that influence hunting. Petriello and Stronza (2020, p. 11) conclude that the main social drivers of hunting and harvest are the need for subsistence and cash income whereas the main constraints originate from state and protected area hunting regulations, communal rules, and individual disinterest, disapproval, and the desire to protect wildlife. Hunting is more likely in forested areas, especially near urban centres (Torres *et al.* 2018). Although people living in remote, forested areas are most dependent on game meat, actors living in populous, peri-urban areas are perhaps contributing most to total hunting efforts (Torres *et al.* 2018). Other studies show that hunting ability increases with age until physical health impairs harvest ability (Walker *et al.* 2002; Francesconi *et al.* 2018). Older and more successful hunters are more likely to engage in food sharing within their villages, strengthening social bonds and ultimately enhancing food security (Nunes *et al.* 2019). The effects of wealth on game consumption are unclear and vary depending on the environment and social setting (Demmer *et al.* 2002; Francesconi *et al.* 2018; Fa *et al.* 2009). Game meat consumption may be driven more by cultural attitudes than economic factors (Morsello *et al.* 2015) and researchers suggest that indigenous communities harvest more than colonist communities (Redford and Robinson 1987). Indigenous hunters and non-indigenous hunters are portrayed differently in the literature despite overlapping geographies and economies in rural areas (Petriello and Stronza 2020). More studies focus on indigenous than non-indigenous hunting although campesinos now represent the largest group of hunters in Latin America (Petriello and Stronza 2020). Some researchers suggest that with more formal education, the demand for game meat will be reduced (Luz *et al.* 2015).

Although previous studies identify the potential drivers of hunting, the relative importance of different drivers at multiple scales remains little studied. Specifically, studies have yet to identify the factors that have the greatest effect on the choice of hunting as a livelihood strategy and on the amount that someone hunts. Literature that characterizes hunters generally examines the effects of specific variables are on hunter harvest. In this chapter, I seek to identify and explicate the most significant drivers of hunting in the Peruvian Amazon. To do so, I will develop a characterization of hunters that considers community, household, and individual level variables. Such a characterization is needed for more effective conservation programs and to identify where and with whom the programs will be most productive.

3.2 Methods

This study is based upon a large-scale quantitative dataset that is complemented by a rich quantitative and qualitative dataset from fieldwork that I conducted in 2019. Together, the datasets allow for a multiscalar and mixed methods approach to the study of hunting in Amazonia.

3.2.1 PARLAP project

Data were gathered as part of the Peruvian Amazonian Rural Livelihoods and Poverty (PARLAP) Project, an international collaboration aimed at advancing our understanding of rural poverty among folk and indigenous peoples in western Amazonia. A community survey was undertaken by two field teams from December 2012 through March 2014 along four major rivers – the Amazon, Napo, Pastaza, and Ucayali – selected to capture a diversity of ecological conditions, economic activity, history, and ethnic groups over a large geographical area (117,680 km^2). Along each river, the teams were guided by maps from the Peruvian *Instituto Nacional de Estadística e Informática* (INEI) for the 2007 census (INEI 2009), the *Instituto del Bien Común* (IBC) for their census of indigenous communities (Smith *et al.* 2003; Benavides 2010), and Google Earth imagery, supplemented by local enquiries by the teams to identify unmapped settlements. A total of 919 communities was visited over 19 months, which PARLAP researchers estimate represents between 84% and 97% of all communities in each of the six study sub-basins – Napo, Amazon, Pastaza, Lower Ucayali, Middle Ucayali, and Upper Ucayali (Figure 3.1). Between August 2014 – July 2016 the PARLAP teams returned to a stratified sample of 235 communities and interviewed nearly 4000 households on livelihood activities, welfare, and

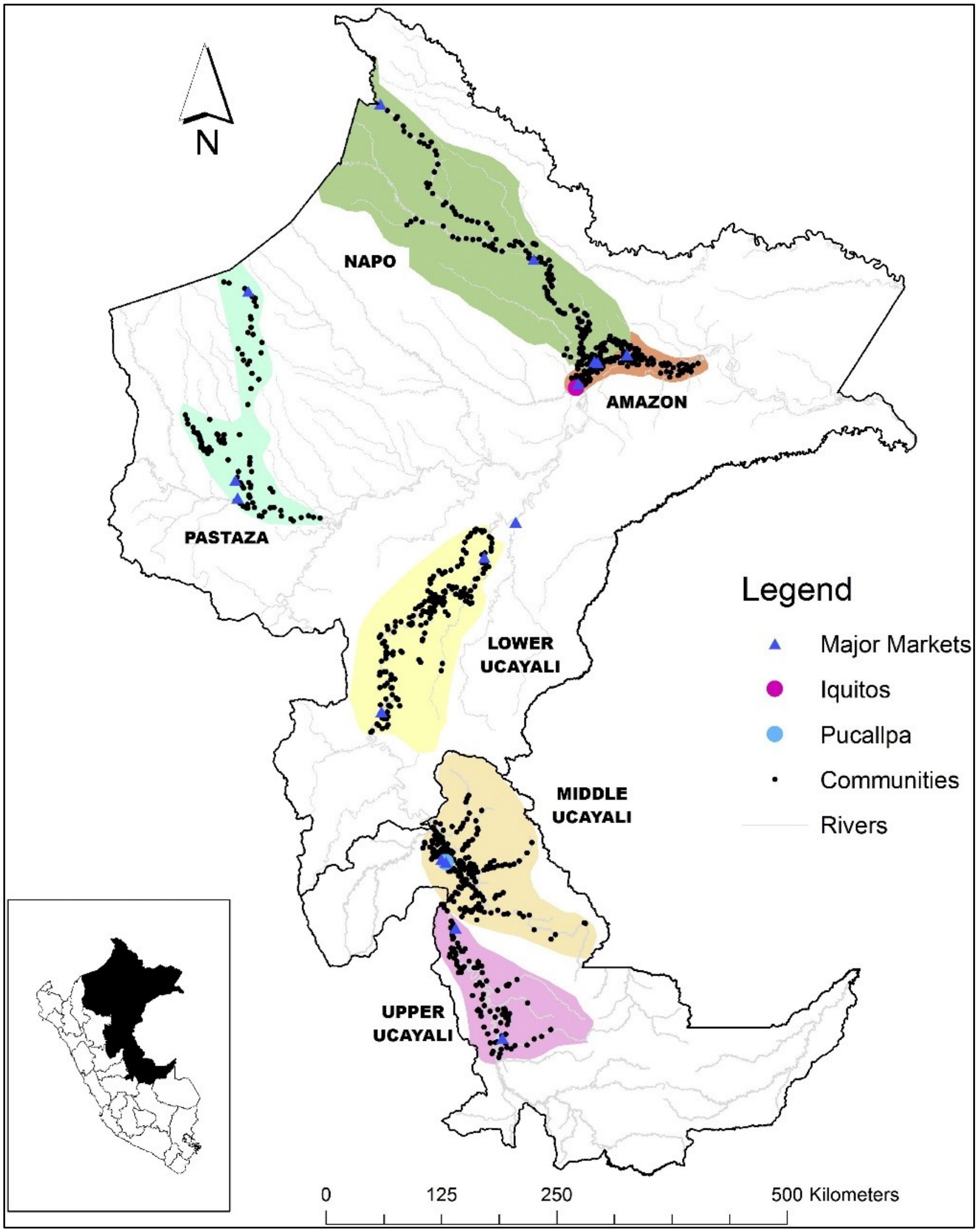


Figure 3.1. Study area of PARLAP survey with sampled communities.

Note: Reproduced from Coomes et al. (2016)

resource perceptions that were then used for the validation of the data collected by the community survey.

In the PARLAP study, communities self-defined as either colonist, ribereño or Indigenous. Colonist communities are only allowed to conduct sport hunting – it is illegal for colonists to conduct subsistence hunting (SERFOR 2017, p. 40). I exclude colonist communities from the analysis because there were few observations (n = 3 communities in the stratified subsample) and colonists generally have lower reliance on game meat. Although the term "campesino" is legible to state governments, I use the term "ribereño" in this chapter – unless in direct reference to other Amazonian studies of campesinos. Ribereños are mestizo peasants of generally mixed Amerindian and European ancestry (Chibnik 1991) who often have native surnames, and who use indigenous tools and practices into their agriculture and forest extraction systems (Coomes and Barham 1997). Some scholars highlight a cultural merging between indigenous and ribereño communities, pointing to the fluidity between distinct categories in the study area (Francesconi *et al.* 2018).

PARLAP study communities are located primarily along the major rivers or tributaries and range in size from 5-13,098 individuals (mean: 46 households and 299 individuals). Forty-seven percent of communities self-identified as being indigenous. Settlements were founded between 1522 and 2012 with an average age since establishment in the current location of 38 years, and 36% of communities had relocated since first foundation. River boat service (*lancha*) was available in 49% of communities and 39% had access to a public telephone at the time of the community survey. The mean distances along the rivers to the nearest neighbouring settlement, market town, and major urban centre (*i.e.*, Iquitos or Pucallpa) are 4.1 km (std dev: 3.8 km, Euclidean), 81.9 km (std dev: 77.1 km, river network), and 261 km (std dev: 227.2 km, river network), respectively, and were based on the geo-referenced location of each community (see (Coomes, Takasaki, and Abizaid 2020, pp. 2-4; Webster *et al.* 2016)).

3.2.2 Field study

Quantitative and qualitative data of hunter harvest and household livelihoods were collected through fieldwork conducted in two PARLAP study communities between June 2019 and September 2019. The two study villages were chosen by analyzing game meat reliance in the stratified subsample of 235 PARLAP communities that occurred between August 2014 – July 2016. The household surveys solicited game harvests and with those data, communities were sorted by total game harvest and by the number of hunting households. I identified and mapped communities with the most hunting households while considering their contribution to game harvest. An important logistical consideration was to ensure that both communities be located within the same river basin. The Napo river basin, where the fieldwork was conducted, had high reported game harvests and is also relatively accessible from Iquitos. Another consideration was to capture different hunting backgrounds and cultures. The two study communities (one ribereño[2] and one indigenous Kichwa) along the Napo River were selected because the PARLAP survey data indicated both high numbers of hunters and high game harvests (Figure 3.2 and 3.3). From our PARLAP and field data, we know that the Kichwa community represents the third percentile of total game harvest whereas the ribereño community represents the 41st percentile. Of the 105 ribereño communities in the PARLAP dataset, the ribereño study community ranked 28 in total harvest.

[2] At the time of the PARLAP survey and the present study, the community self-identified as a ribereño community. In December 2019, however, the community gained indigenous status as an indigenous Kichwa community. The community is formed by a mixture of households that identify as ribereño, Kichwa, and Yagua but was originally founded as ribereño. At a community assembly in October 2019, community members voted to be recognized officially as a Kichwa community.

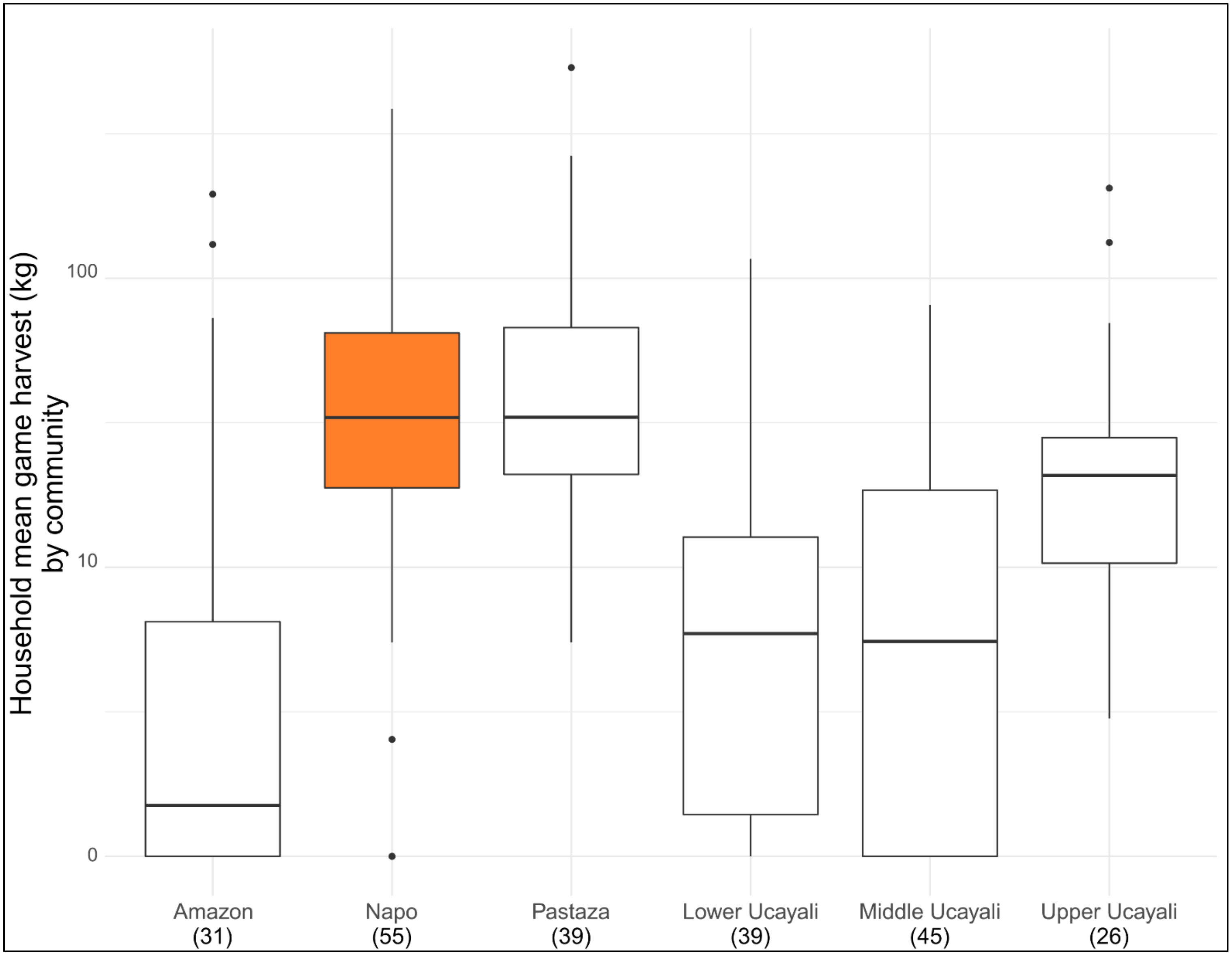


Figure 3.2. Average hunting household game harvest (kg) by community in river sub-basin.

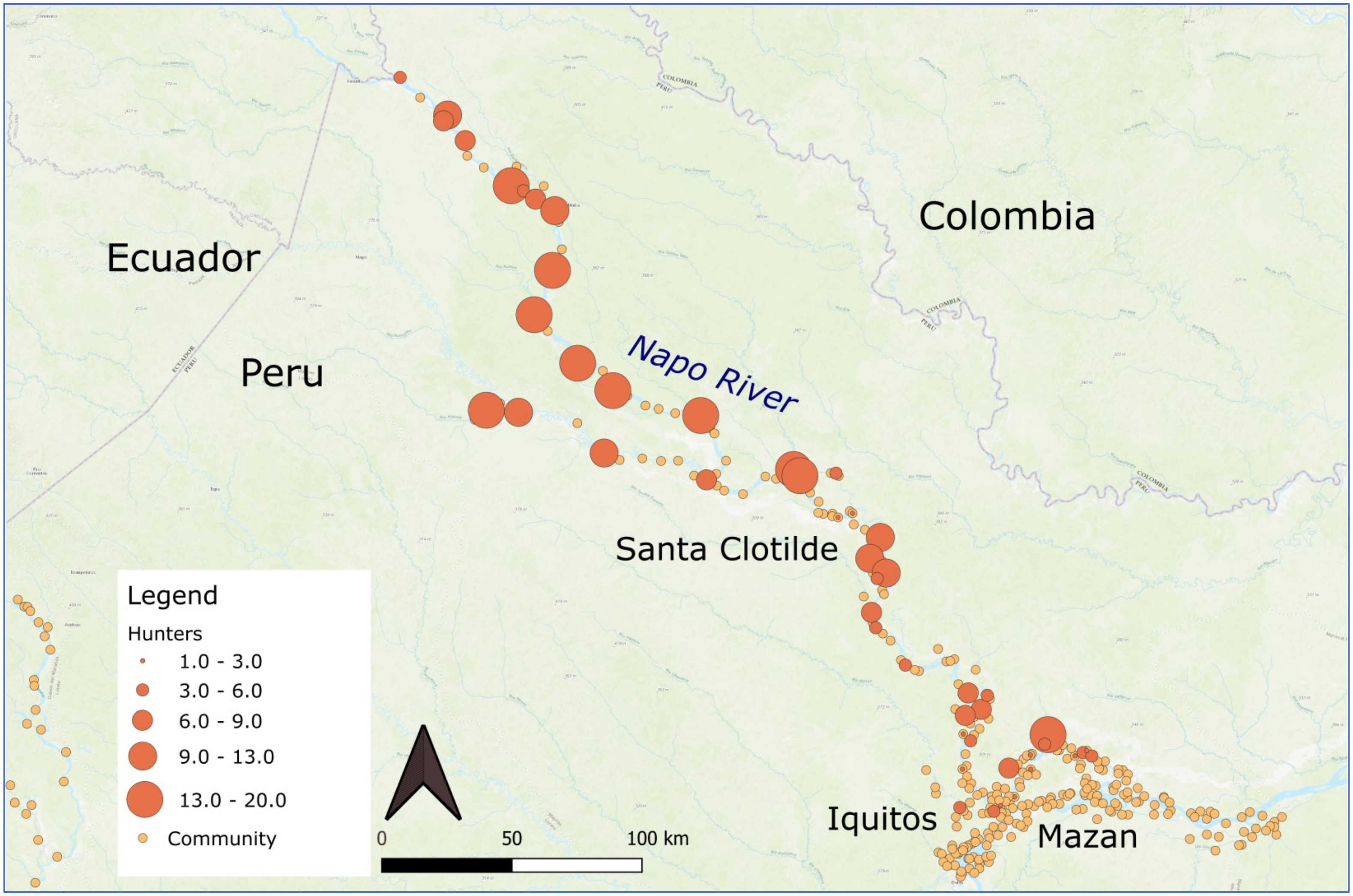


Figure 3.3. Number of hunting households in communities along the Napo river where PARLAP household surveys were completed (August 2014 – July 2016).

Note: Basemap accessed on October 09, 2020 from ESRI World Topographic Map layer obtained from the QuickMap Services plugin in QGIS.

Although selling game meat is illegal in the Peruvian Amazon, harvesting for market is common and thus of interest to the study. To protect community, household, and individual wellbeing and trust, I do not provide community names or locations; instead, I distinguish between communities as “Kichwa community” and “ribereño community”. Within each study community, semi-structured household surveys for game harvest and household information were conducted (Appendix C), oral history surveys (Appendix D) and participant observation to complement the PARLAP data on hunter livelihoods. By merging the PARLAP project and the extended in-person surveys, I aim to better understand hunting and local livelihoods from multiple perspectives.

3.2.3 Qualitative analysis

Semi-structured surveys ($N = 46$) and oral history surveys ($N = 20$) of hunter harvests and livelihoods were conducted in the 2019 study communities. The semi-structured surveys provided rich data for characterizing hunters. Hunters were identified for the semi-structured surveys with the help of a key informant, re-interviewing households from the previous PARLAP study, and randomly selected households complete the sample frame. Oral histories provide contextual background as to why people adopt hunting as a livelihood strategy and the role of hunting in the community. Individuals selected for the oral histories were the oldest household heads and other well-informed household members identified by other key informants. Before beginning an interview, I explained to participants the research aims and that their participation was voluntary, that they could withdraw at any time and that information would be used anonymously. I then obtained verbal consent from all individuals who were willing to participate. I did not ask for written consent because most people are illiterate. Handwritten notes were made during each interview and transcribed upon my return to Canada to a password protected backup computer and USB stick. Qualitative data from the 2019 field survey are used to help explain and support quantitative findings from the large-scale PARLAP survey analysis in the Discussion section of this chapter.

3.2.4 Livelihood analysis

In the analysis of the livelihood portfolios of hunter households from the PARLAP dataset, I first examine hunting reliance by determining hunting participation rates and estimating hunting incomes within four river basins (Napo, Amazon, Pastaza, and Ucayali). Household game harvest is endogenously related to current income generation and wealth indices, and therefore wealth data cannot be included as variables in the statistical modeling for game harvest. I descriptively analyze harvest and wealth data by dividing PARLAP hunters by quartile of game harvest and reporting their mean incomes, land assets, and non-land assets (See Appendix E for more information on how variables were created for the livelihood analysis). I demonstrate the relative importance of game as food but also for income generation through percentile rank of game harvest plots that compare the percentage of game harvest sold and game harvest consumed. Game income was determined by multiplying annual game harvest (kilograms) with the local market price of game meat (USD/kg). To better understand the importance of hunting income and how hunting may be related to household income, the top ten percent of hunting households were split into percentile ranks by game harvest, and livelihood incomes (agriculture, fishing, hunting, and other subsistence activities) are plotted to visualize income portfolios.

3.2.5 Quantitative analysis

I modelled total household game harvest (log values) as the dependent variable. Independent variables were selected *a priori* based on the relevant literature and included the following: percent forest cover within 5 kilometres; initial terrestrial wildlife endowment of the community

(PCA); indigenous community; percent Holocene soils around community; river distance to Iquitos/Pucallpa (log km); river distance to major market (log km); number of households; community age (log decades); community location on main channel or tributary; community access to lake; household head age; household head age (squared); household head education; place of birth; indigenous family; number of male workers present in household; number of female workers present in household; number of dependants present in household; initial assets of household; and, initial landholdings of household (See Appendix F for more information on the means, standard deviations, and observations of variables used for the quantitative analysis). To account for factors that were common among 6 river sub-basins (for example, remoteness, topography, forest conversion; Amazon, Napo, Pastaza, Lower Ucayali, Middle Ucayali, and Upper Ucayali), I included dummy variables to represent the river sub-basin. To account for the lack of independence in sampling across the whole PARLAP study region of 232 communities, I clustered observations by community to allow for robust standard error estimations.

I evaluated the covariates for total household game harvest using Cragg's double-hurdle model (Cragg 1971). A double-hurdle model separates the total game harvest of a household into two parts: a selection equation (probit model) that estimates the decision to engage in hunting as a livelihood strategy; and a truncated lognormal regression (linear model) that estimates the total game harvest by a household. The model was originally developed to analyze zero-inflated dependent variables where there may be differences between the decision to engage in an activity (for other livelihood examples see Carter et al. 2020; Robinson 2016) and the amount of activity conducted (Wooldridge 2010, p. 536); such is the case with hunting in our study context as 72% of households surveyed did not harvest any game. .

For the dependent variable, I considered a binary variable Q indicating whether household i hunts or not. When a household transitions to engage in hunting ($Q = 1$), $t_{ij} = t^*_{ij}$. To represent the amount a hunter harvests, household i in community j appears to follow $t_{ij} = Qt^*_{ij}$ where t^*_{ij} is a continuous latent variable. Thus, the observed total harvest variable, t, is a limited dependent variable that is censored at 0 kg for households that do not hunt. Households that do hunt take on 'true' values greater than 0 kg.

In practical terms, the selection equation of the double-hurdle model estimates $P(Q = 1 \mid \theta)$, the probability that $Q = 1$ (that a household collected any game meat) conditional on an observed set of covariates θ. Taking engagement in hunting into account, I then estimated $H(t \mid \theta, t^* > 0)$ using a truncated lognormal regression model (where H is the estimated game harvest). An assumption of this two-part model is that Q and t^* are independent, conditional on explanatory variables θ. Regardless of the strength of this assumption, one can include all variables θ in both the first- and second-stage equations while allowing the parameters on those variables to freely vary between equations, making the assumption less burdensome (Wooldridge 2010). I considered θ to contain the individual-, household-, and community-factors previously listed and employed a probit specification to estimate the probability of hunting as a function of these variables. The probit regression coefficients are not as directly interpretable as they would be from a linear regression model. We can interpret a positive coefficient to indicate that an increase in the variable (or a state other than the reference state) is associated with an increase in the predicted probability of the outcome. Conversely, a negative coefficient would indicate that a decrease in the variable is associated with a decrease in the predicted probability of the outcome. For the selection equation, I modelled variables that could directly inhibit (or act as a hurdle) a household from harvesting game (*e.g.*, a person may be too old to hunt).

3.3 Results

3.3.1 Participation in hunting and game harvest

Of the 235 communities included in the PARLAP household survey, 80% reported some wildlife harvest. Among basins there is variation in the amount of game harvested and the percentage of households that participate in hunting (Table 1). For example, although the hunting participation rate in the Napo river basin is more than five times greater than hunting participation along the Amazon river, the mean harvests per hunter is about 103 kilograms less. Overall, game production from the average Napeño hunting household is 125.1 kilograms valued at over 1100 USD and nearly ten percent of hunting household income. Household game production could be used to support nuclear families (subsistence) or sold within the community or to boats headed for larger markets (cash income). Accordingly, of the 125.1 kg hunter harvest along the Napo River, nearly half of the harvest is sold.

The income generated from selling game is used to buy farming, material, and educational goods that are rarely produced locally. Game meat is an expensive commodity and supplements the income generated from agricultural or fishing (Castro, Revilla, and Neville 1976; Takasaki, Barham, and Coomes 2001). As hunters' harvests increase, so does the percentage of game meat sold, indicating not only the importance of selling game meat but also the opportunity to sell large quantities for significant profit (Figure 3.4). On average, households harvesting more than 160 kilograms of game meat sell more than half of their harvest whereas households harvesting less than 30 kilograms sell less than a quarter of their harvest. My fieldwork observations revealed that most hunting households sell small quantities of game meat to large passenger ferries that travel upstream to the Ecuadorean border and downstream to

Table 3.1. Descriptive statistics for hunting livelihoods in PARLAP survey by river sub-basin.

	Napo (1003)	**Amazon** (525)	**Pastaza** (587)	**Lower Ucayali** (703)	**Middle Ucayali** (698)	**Upper Ucayali** (413)
Participation Rate (%)	42.3%	7.8%	50.6%	12.5%	14.8%	34.4%
Total Game Harvest (kg)	53053	9384	32980	9395	7885	10400
Mean Harvest per Hunter (kg)	125.1±8.2	228.9±19.1	111.0±7.0	106.8±9.7	76.6±3.6	73.2±9.5
Sold (%)	47.2%	56.7%	52.4%	68.2%	20.0%	17.1%
Income from hunting (US$)	1105±133	2013±508	635±45	568±124	825±72	549±131.2
Income share from hunting (%)	9.8%	16.4%	4.5%	6.8%	8.3%	5.6%
Number contracted	36	16	3	22	44	39

Note: N values in brackets for each basin.

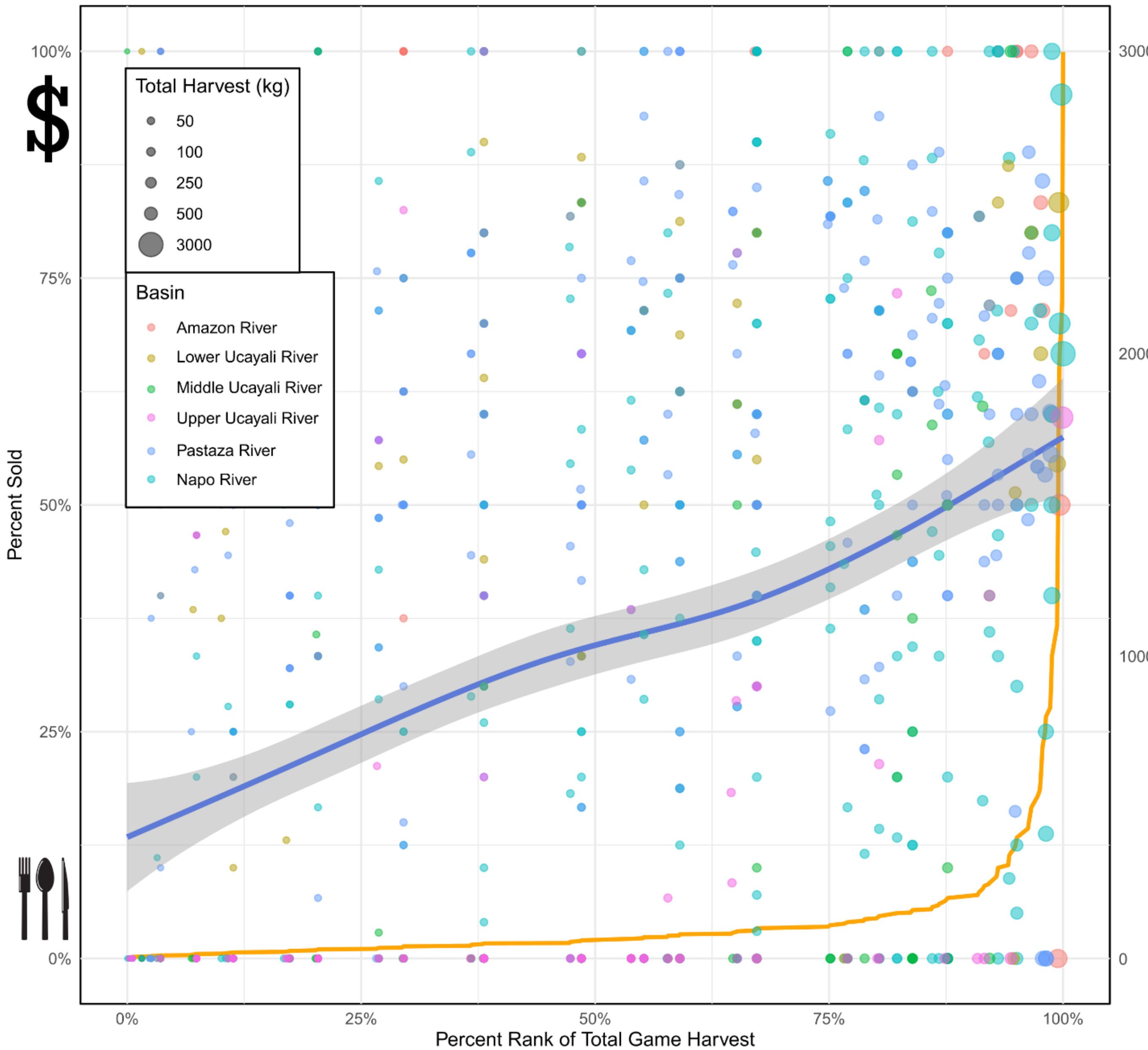


Figure 3.4. Percent of game meat sold by household percentile rank of total harvest by all hunting households (PARLAP data).

Notes: Blue line represents LOESS line through percentages sold (with 95% confidence interval) and yellow line represents the total harvest in relation to percentile rank (n = 1095).

Iquitos. A commercial hunter must bring at minimum 1.5 tons of game meat to Iquitos to profit given the costs and risks (*e.g.,* confiscation, fines, and detainment) associated with bringing large quantities of meat to market.

Twenty-eight percent of PARLAP households reported game harvest and hunting households varied markedly in the amounts harvested. When hunting households are divided into quartiles by total harvest, those who hunt more appear to have higher overall incomes ($P < 0.0001$), are more land rich ($P < 0.001$) but poorer in non-land assets ($P < 0.001$) (Table 3.2 and 3.3). Households that harvest the most meat tend to have diverse livelihood portfolios except for the top two percent of hunting households in the PARLAP dataset. The top two percent of households take in 43% of the game meat in the survey which contributes to over a third of the total income (Figure 3.5 and 3.6). The top two percent of hunting households harvest more than 270 kilograms of game meat per year. All households in the indigenous Kichwa community collected game whereas 23% of households in the ribereño community did not and a natural break in PARLAP household hunter harvest occurs at 270 kg where the LOESS line intersects the scatterplot data (Figure 3.5). Within the 2019 study communities, specialized hunters identified by key informants each harvested more than 270 kg of game meat (Figure 3.7).

3.3.2 Determinants of hunting and harvests

The double-hurdle model for hunter harvest included 12 covariates in the first stage probit equation and 19 covariates in the second stage truncated log normal equation ($R^2 = 0.16$). Community size (number of households), community age (decade established), family indigeneity, household composition (number of females, males, and dependants), hunter education and place of birth were included only in the second stage because they are characteristics that do not inhibit (or act like a hurdle) the likelihood that someone hunts but may

Table 3.2. Mean and standard deviation for hunting households using PARLAP data (quartiles of game harvest).

	Low	Low/Mid	Mid/High	High
No. of Observations	291	298	233	273
Game Income (NS)	150.0± 88.2	360.0±138.3	664.0±264.9	2369.1±3591.4
Percent Income from Hunting	1.5%	3.6%	5.8%	16.4%
Total Income (NS)	9724.2±12037.8	10136.7±9046.4	11489.5±8102.4	14437.8±11273.6
Total Land	4.48±6.79	6.67±19.95	6.10±9.90	5.88±11.88
Asset Index (z-scores)	-0.14±0.92	-0.28±0.81	-0.17±0.93	-0.39±0.81
Number Contracted	14	23	11	13

Table 3.3. Spearman rank correlation (ρ) between total game harvest and endogenous wealth variables (total income, land assets, and non-land assets).

Source	**ρ**	***P***
Total Income	0.315	< 0.0001
Land Assets	0.110	< 0.001
Non-Land Assets	-0.103	< 0.001

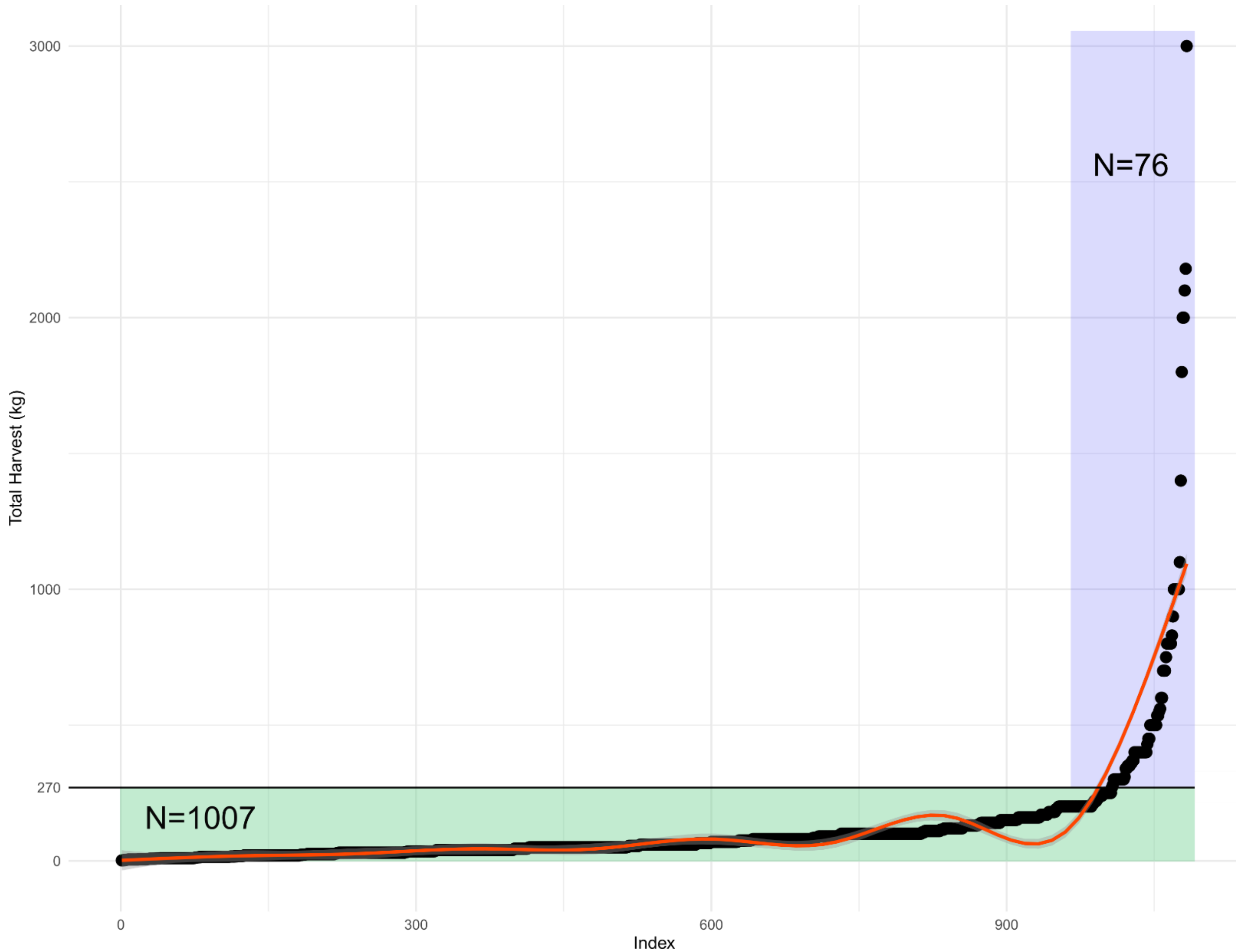
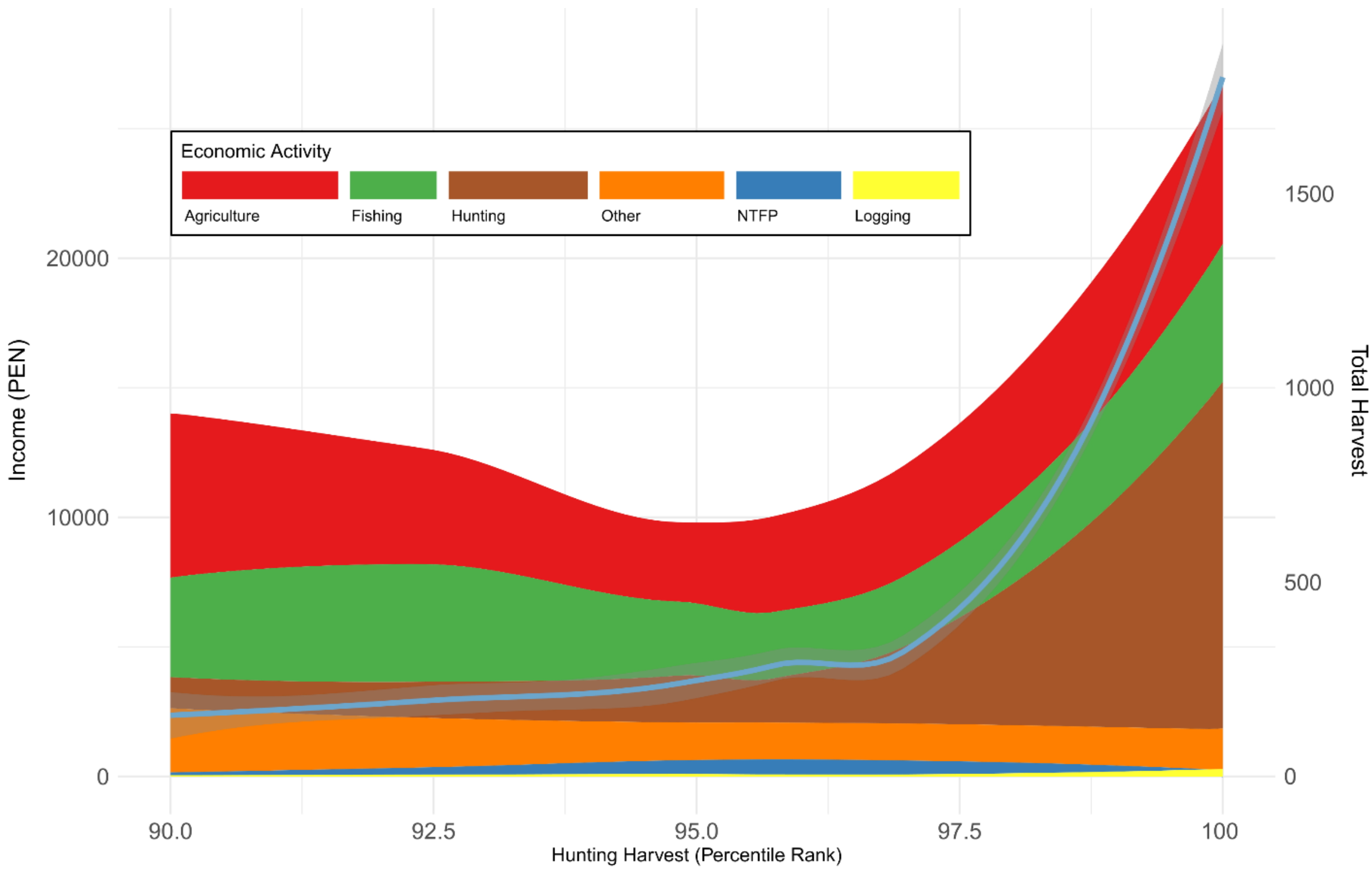


Figure 3.5. Scatterplot representing total hunting harvest (kg) of hunting households (PARLAP data).

Notes: LOESS line (red) was fit to the data. Black line represents natural break (jenks = 6) in the data at 270 kg.



<u>Figure 3.6. Household mean incomes for each economic activity and total harvest by rank of game harvest</u>

Note: Stacked smooth lines representing income sources of top ten percent of hunting households (PARLAP data; 179 hunters collected > 150 kg). Blue line represents LOESS line of total harvest (kg) with 95% confidence interval).

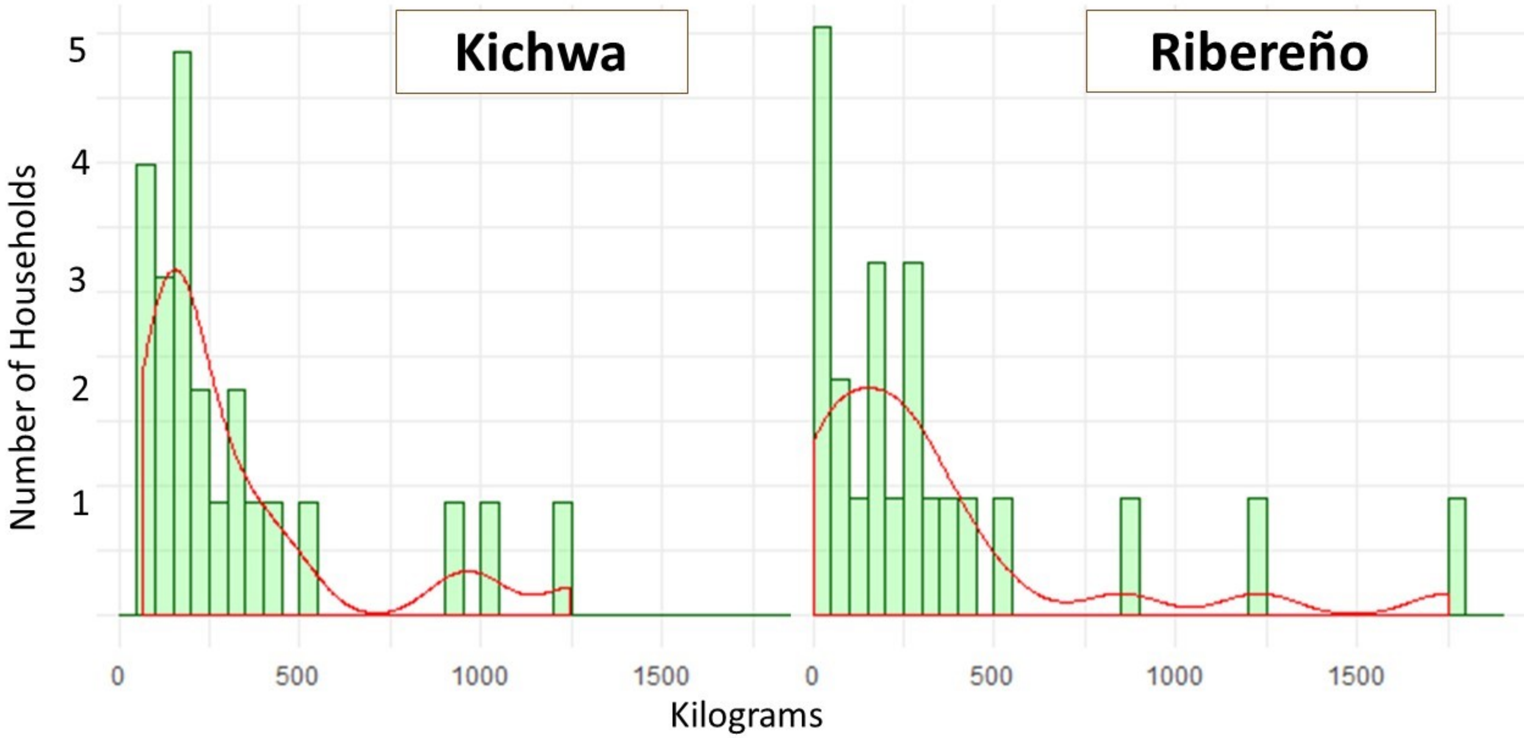


Figure 3.7. Histogram of household game harvest (kg) with LOESS line (red) in study communities (2019).

Note: All Kichwa households surveyed reported game harvest whereas 23% of households in the ribereño community reported no game harvest.

influence the amount someone hunts. In contrast, community indigeneity was only included in the first stage along with the remaining covariates, that were included in both stages, (*i.e.,* forest cover, distance to city, distance to market, initial wildlife endowment, location on main channel, percent of Holocene soils, household initial assets, household initial land assets, and hunter age). Covariates were included in the selection equation if they could theoretically inhibit someone from hunting at all. Certain fundamental community characteristics were included as controls (*e.g.,* location and identity) to help understand drivers of hunting (*e.g.,* forest cover, education, livelihoods, and demography). Seventy-two percent of households surveyed reported no game harvest and the determinants of whether a household harvested game meat differed from the determinants for the amount that a household harvested (Table 3.4 and 3.5).

The first stage of the hurdle model assesses which factors are associate with the livelihood decision to hunt. Households in communities with greater forest cover and that are located further from major cities are positively associated with hunting. Indigenous communities are also more likely to have households engaged in hunting. In contrast, households in communities with a greater percentage of Holocene soils (a proxy for more fertile land in the floodplain for farming) are less likely to engage in hunting. Similarly, households located along the main channel of rivers and with access to a lake are less likely to hunt (Table 3.4). Households with more initial land assets and older heads of household are more likely to hunt but the likelihood of participating in hunting begins to decrease after the age of 37 (Table 3.4).

The second stage of the hurdle model provides estimates for the determinants of game harvest, controlling for the community- and individual-level variables that influence the decision as to whether or not to hunt. Distance to market (P = 0.067) and hunter age (P = 0.061) are positively albeit weakly related to the quantity of game harvested. Households located on a main

Table 3.4. Determinants of household participation in hunting.

Cragg hurdle regression (first stage)	Number of obs	=	3,865
Log pseudolikelihood = -3236.4675	Wald chi2(24)	=	93.96
(Std. Err. adjusted for 232 clusters in UBIGEO)	Prob > chi2	=	0.0000
	Pseudo R2	=	0.1591

Selection Equation

Variable	Coefficient	Std.Err.	Z-score	*P*
Forest Cover	1.773	0.470	3.770	0.000
Distance to City	0.510	0.089	5.750	0.000
Distance to Market	0.031	0.062	0.490	0.621
Indigenous Community	0.237	0.077	3.090	0.002
Wildlife Endowment	0.071	0.055	1.300	0.193
Lake Presence				
Yes	-0.240	0.095	-2.540	0.011
Community on Main Channel				
Yes	-0.303	0.079	-3.830	0.000
Percent Holocene Soils	-0.345	0.171	-2.020	0.043
Household Assets	-0.034	0.039	-0.870	0.386
Household Land Assets	0.014	0.005	2.720	0.006
Hunter Age	0.039	0.011	3.390	0.001
Hunter Age (squared)	-0.001	0.000	-4.660	0.000

Note: The table reports the modelled, first-stage coefficients for each variable (zero-hurdle model: binomial with probit link). While an increase in the probability of the outcome attributable to a one-unit increase in a given independent variable in the probit regression is dependent on the values of all other independent variables and their initial conditions, we can interpret a positive (negative) coefficient to indicate that an increase (decrease) in the variable, or a state other than the reference state, is associated with an increase (decrease) in the predicted probability of the outcome.

Table 3.5. Determinants of amount of game harvested (kg) by hunting households.

Cragg hurdle regression (second stage)	Number of obs = 3,865
Log pseudolikelihood = -3236.4675	Wald chi2(24) = 93.96
(Std. Err. adjusted for 232 clusters by community)	Prob > chi2 = 0.0000
	Pseudo R2 = 0.1591

Amount Equation

Variable	Coefficient	Std.Err.	Z-score	*P*
Forest Cover	0.573	0.663	0.860	0.387
Distance to City	-0.035	0.106	-0.330	0.742
Distance to Market	0.100	0.055	1.830	0.067
Wildlife Endowment	0.024	0.127	0.190	0.850
Community Size	-0.057	0.067	-0.850	0.397
Community Age	0.081	0.099	0.820	0.411
Lake Presence				
Yes	-0.023	0.128	-0.180	0.860
Community on Main Channel				
Yes	-0.312	0.130	-2.390	0.017
Percent Holocene Soils	0.105	0.246	0.430	0.670
Indigenous Family				
Yes	0.044	0.097	0.460	0.647
Household Assets	0.070	0.048	1.470	0.141
Household Land Assets	-0.001	0.004	-0.230	0.815
Male workers present	-0.040	0.036	-1.130	0.257
Female workers present	-0.056	0.059	-0.960	0.336
Dependants present	-0.002	0.020	-0.080	0.936
Hunter Age	0.033	0.018	1.870	0.061
Hunter Age (squared)	-0.000	0.000	-1.500	0.134
Hunter Education	-0.013	0.012	-1.080	0.279
Hunter born in community	0.120	0.064	1.890	0.058

Note: The table reports the modelled, second-stage coefficients for each variable.

channel collect less game than those located on tributaries to main channels ($P = 0.017$) (Table 5).

The overall model provides marginal effects estimates on game harvest at the mean of the data (Table 3.6; Figure 3.8; Figure 3.9). Increased forest cover is the most significant positive driver of household game harvest. In fact, for a one percent increase in forest cover, the model predicts that household hunter harvest will increase by 1.96 kilograms but the magnitude is lower as percentages are less than 30% and the magnitude is higher as percentages approach 100% (Figure 3.9). Other community level characteristics positively associated with game harvest are distance to city and indigenous community. For a one-kilometer increase in distance from city, a household may harvest 0.5 kilograms more game meat with perhaps even greater harvests in communities located more than 150 km away from major cities (Figure 3.9). Households in indigenous communities collect 24 kilograms more game meat in a year than a household in ribereño communities. Being located on the main channel is the most significant constraint for game harvest and the presence of a community lake is also negatively correlated with hunting harvest. Households located on the main channel collect 41 kilograms less game meat per year than households located on tributaries to main channels. Households that have access to a community lake collect 26 kilograms less game meat than households that do not have lake access.

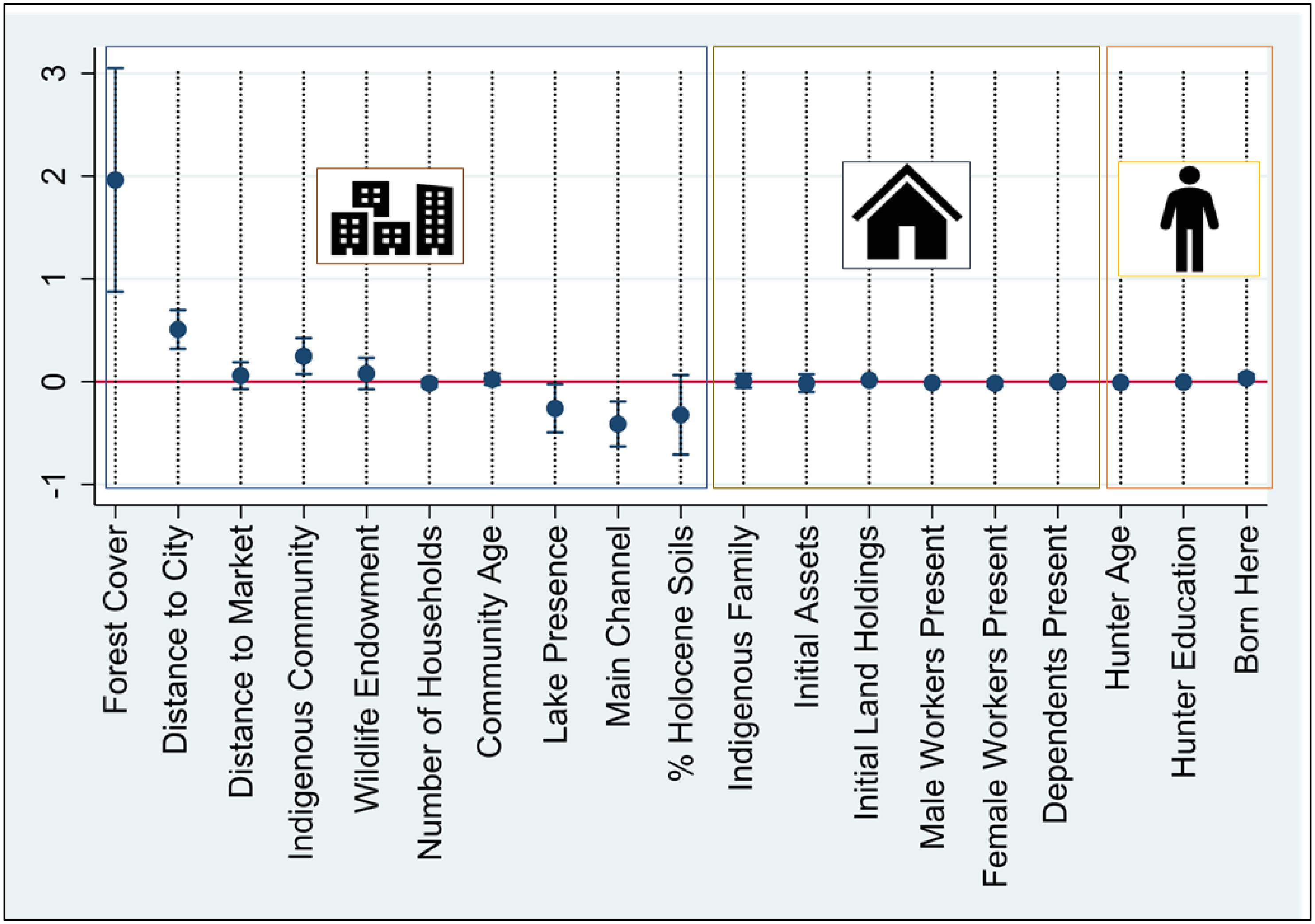
Households with more initial household land assets harvest more game whereas at the mean of the data, older hunters secure less game (Figure 3.8; Figure 3.9). The effect sizes, however, of household and individual characteristics are much smaller than the community level variables.

Table 3.6. Marginal effects of overall double-hurdle model on game harvest.

Average marginal effects
Expression : Conditional mean estimates of dependent variable, predict()
(Std. Err. adjusted for 231 clusters by community)

Unconditional
Number of obs = 3,865

	dy/dx	**Std.Err.**	**z**	***P(z)***
Forest Cover	1.963	0.555	3.540	0.000
Distance to City	0.509	0.095	5.330	0.000
Distance to Market	0.059	0.067	0.890	0.376
Wildlife Endowment	0.079	0.077	1.020	0.308
Community Households	-0.016	0.019	-0.840	0.399
Community Age	0.023	0.028	0.820	0.413
Lake Presence				
Yes	-0.259	0.120	-2.170	0.030
Community on Main Channel				
Yes	-0.412	0.111	-3.700	0.000
Percent Holocene Soils	-0.322	0.197	-1.640	0.101
Indigenous Family				
Yes	0.012	0.027	0.460	0.648
Household Assets	-0.015	0.044	-0.350	0.727
Household Land Assets	0.014	0.005	2.530	0.012
Male workers present	-0.011	0.010	-1.150	0.252
Female workers present	-0.016	0.016	-0.960	0.338
Dependants present	-0.000	0.006	-0.080	0.936
Hunter Age	-0.008	0.002	-3.660	0.000
Hunter Education	-0.004	0.003	-1.090	0.275
Hunter born in community	0.034	0.018	1.860	0.063
Indigenous Community	0.241	0.079	3.040	0.002



<u>Figure 3.8. Marginal effects of variables for average household from the complete double-hurdle model (PARLAP data).</u>

Note: Sample includes both hunters and non hunters. Variables are separated into community, household and individual categories as indicated by icons.

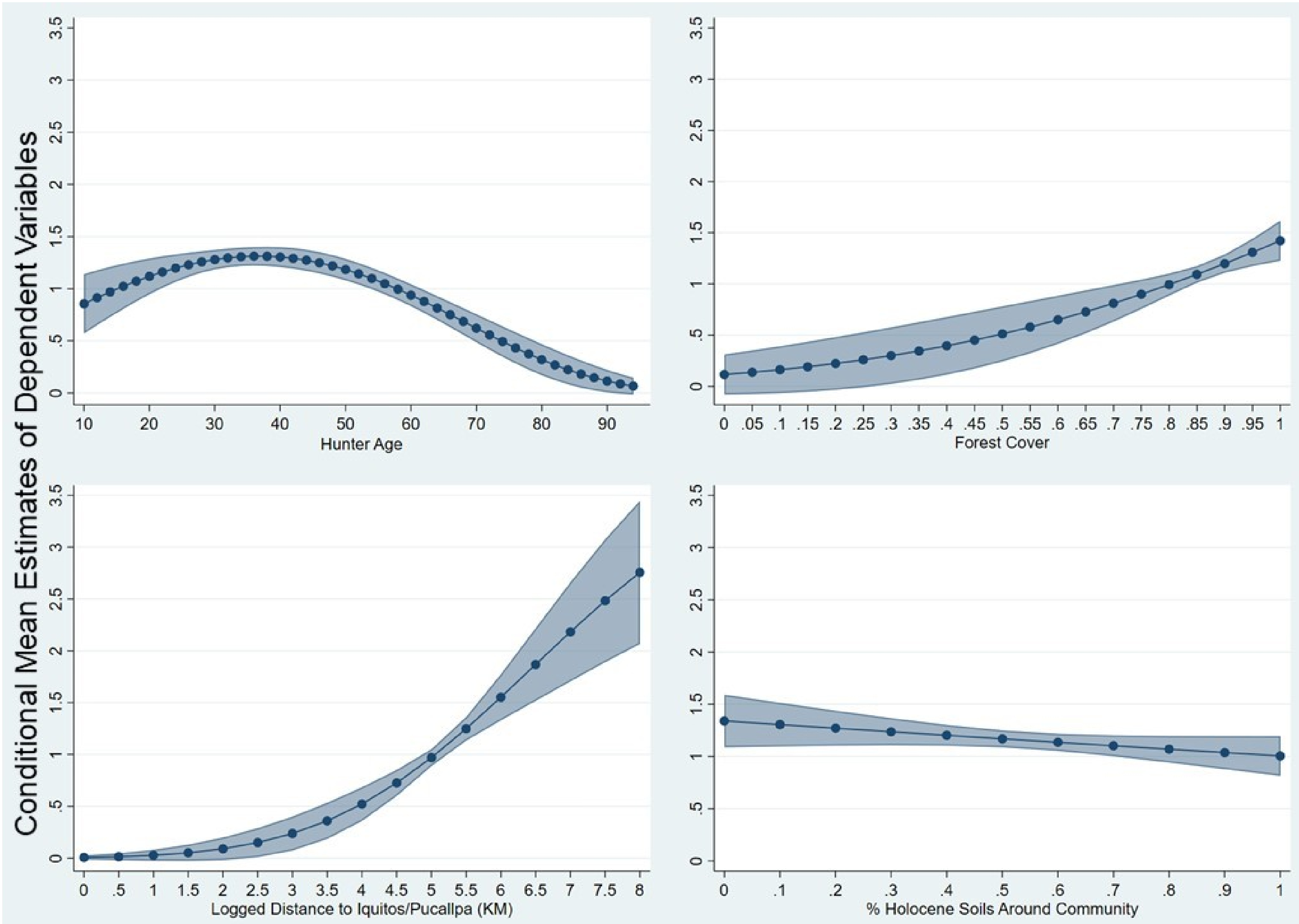


Figure 3.9. Marginal effects with 90% confidence interval for key variables influencing the amount game harvested by hunters (PARLAP data).

Notes: Top left - hunter age, top right - forest cover, bottom left - distance to city, and bottom right - percentage of Holocene soils

3.4 Discussion

Drawing quantitative and qualitative findings from my 2019 field study and a robust quantitative analysis of the large-scale PARLAP, I present a rich characterization of hunters in western Amazonia. Recall that I chose my two field study communities because of their high levels of game harvest relative to all other PARLAP communities, and as such my field data do not reflect conditions in a 'typical' community in the Peruvian Amazon. The qualitative results do point to drivers and consequences for the top hunters. Throughout the discussion, I highlight two key findings: 1) community characteristics drive hunting in the Peruvian Amazon; and, 2) most hunters collect game for subsistence and cash income, and a small number for significant for commercial profit.

In this section, I begin by discussing the factors that drive hunting in the Peruvian Amazon. Community level factors drive the hunter characterization model but certain individual and household characteristics such as hunter age and initial household land asset holdings are influential. I then describe how hunting is part of a diverse livelihood portfolio for both indigenous and ribereño communities, suggesting that rural Amazonians could be useful allies for protecting biodiversity from excessive hunting. Finally, I argue for an expanded definition of "subsistence hunting", one that allows for hunters to earn some monetary income to promote social security and encourages local protection of natural resources from "commercial hunting".

3.4.1 Hunters and game harvesting

Community factors drive hunting participation in the Peruvian Amazon, but individual traits are helpful for identifying hunters. Community-level covariates have the largest effects on game harvest suggesting that environmental conservation programs should initially consider communities rather than individuals or households when developing conservation policy. Certain household and individual characteristics of hunters though do have a small but significant influence on the amount of game harvested.

3.4.1.1 Community factors drive hunter participation

Community characteristics that increase livelihood opportunities appear to both decrease the likelihood and the amount that people hunt. More Holocene soils generally results in better agricultural output in the Peruvian Amazon, but it is also indicative of the amount of lowland present. Hunting could therefore be influenced by upland forest availability or increased farming potential. The negative and stable (see Figure 3.9) association between Holocene soils and hunter harvest could be due to alternate livelihood opportunities. Rural Amazonians perhaps are not as reliant on hunted protein when they can farm effectively and/or fish efficiently. When Amazonians travel to their agricultural fields (*chacras*), they will typically bring the firearm along with them (if they own one) because wildlife is sometimes encountered. Opportunistic hunting can occur while working at the household chacra or while traveling near home whereas a hunting expedition will see the hunter venture into the upland forest. The small positive relationship between initial land assets by household suggests that land is important for hunting. Indeed, previous studies have shown that households will attract game to their gardens by planting fruiting trees and tubers (Smith 2005) and hunters from larger communities hunt over smaller catchment areas that could be a result of an increased density of manioc-associated game species (Nunes *et al.* 2020).

The presence of a lake for fishing was associated with reduced hunting participation in the study. Fishing is an important source of income and acts as a safety net that Amazonians can rely upon when crops fail (Takasaki, Barham, and Coomes 2010). Fishing is an activity with few barriers to entry; nets are easily acquired or shared and the activity can be done passively in contrast to hunting, which can requires significant investment in firearms, ammunition, and fuel if hunters seek to access hunting grounds far from human population by boat. Hunting requires active pursuit where the hunter must stay alert: tracking game or awaiting it at a strategic location. Although hunting could act as an investment strategy for the accumulation of financial capital, it is not as universally relied upon like fishing or agriculture. Unsurprisingly, fishing opportunities (*i.e.*, lake presence) appear to reduce the reliance or likelihood that a household will hunt.

One might expect *a priori* that community location along a river's main channel would be associated with increased hunter participation and harvest. Being located on a main channel improves access to market and therefore more game meat could be sold to large passenger and product ferries (*lanchas*) that pass by their community. However, I find that people in communities along on main channels were *less* likely to hunt, and if they did hunt, they hunt less. Although market access is better, communities along a main channel have greater fishing opportunities and other livelihood opportunities for income generation. Additionally, communities located up tributaries and away from main channels may have access to forests with more abundant wildlife.

Remoteness, Holocene soils, lake presence, and presence on main channels are inherent community properties that act as controls in the analysis. The control characteristics are useful for identifying communities that could be empowered to protect local resources like wildlife and safeguard forests for their community.

Increased forest cover was associated with a greater likelihood that people hunted and had the largest marginal effect for higher game harvest in the PARLAP dataset. For forest cover values below 30%, there is little change in hunter harvest however as forest cover increases from

30 to 100%, the positive relationship between forest cover and hunter harvest increases substantially (Figure 3.9). Distance to city (akin to remoteness) was the second largest driver for increasing the likelihood someone hunts and the amount they harvest. The results corroborate some of the findings by Torres *et al.* (2018) who argue that forest cover defines game availability and that remoteness may determine game meat reliance for food. In contrast to Torres *et al.* (2018), I found that hunting decreases with proximity to urban centres. Unlike their study which relies on a series of general linear mixed models with different covariates of remoteness and forest cover, I use a two-stage statistical model that accounts for whether someone hunts (probit), the amount someone hunts (OLS) and given that someone hunts, the amount that they hunt (truncated model). The authors acknowledge that the remoteness results may not be strong because their coefficient standard error encompasses zero. My study finds that the households located furthest from cities (with river distance to Iquitos or Pucallpa greater than 150 km) drive the positive marginal effects of game harvest (Figure 3.9) whereas the maximum distance for remoteness in the Torres *et al.* (2018) study is 117 km. Finally, Torres *et al.* (2018) studied recent and long term in-migrants from various regions of Brazil and focused on landscape characteristics without including cultural or socioeconomic characteristics. The authors conclude by highlighting the importance of studying the interactions between landscape, socioeconomic and cultural factors because their study, and most studies on hunting and game meat consumption, study the drivers of extraction in isolation (Torres *et al.* 2018; Godoy *et al.* 2010; Rentsch and Damon 2013). A recent article from Coomes, Takasaki, and Abizaid (2020) considers environmental and socioeconomic controls in their analysis of wild resource use in the Peruvian Amazon and find that remoteness has a significant positive relationship with wildlife harvests.

The finding of distinct drivers for hunting adoption and for household game harvest has policy implications. In the second stage of the double-hurdle model, the effect of distance to city appears to have no conclusive effect on hunter harvest whereas distance to market nears significance. The results suggest that for *hunters*, the amount one harvests is more dependent on distance to market towns rather than an urban center. If a hunter is located near a market, they will harvest less game compared to hunters who are further away. Perhaps forests close to markets have been overharvested or there are stricter controls near markets. Regardless, my study reports that remoteness is a statistically significant driver for hunter harvest.

3.4.1.2 Indigenous and ribereño communities

My results suggest that more hunting occurs in indigenous communities. Similarly, Redford and Robinson (1987) found that indigenous people(s) took more game (in quantity and species) than colonists. Geographically, indigenous communities in the PARLAP study are often located further from urban centres and at the margins of the market. In the model, I control for remoteness and forest characteristics and still find that indigenous communities tend to engage more in hunting than ribereño communities – at least for this large-scale study in the Peruvian Amazon.

Both the PARLAP and 2019 surveys, however, show no indication that indigenous households harvest more than ribereño households. A recent study by Francesconi *et al.* (2018) found no difference between indigenous and ribereño hunting rates and suggests that harvest could be influenced by cultural merging within river basins (Francesconi *et al.* 2018). Certainly, in the Kichwa community where I studied, nearly every household engaged in hunting (except for households where physical impairments inhibited the activity) whereas the ribereño community had greater livelihood specialization at the household level (See Figure 3.7). Within each community, there were also household specialized in hunting that took more than 270 kilograms of dressed game meat in the previous calendar year. Considering that indigenous households are more likely to participate in hunting but not necessarily harvest more, the overall impact of indigeneity *per se* on local wildlife biomass may be insignificant. Still, given the importance of engaging in hunting for a livelihood and their relative remoteness, indigenous communities may be well placed to, and already, act as stewards for forest conservation far from state resources.

Although indigenous communities may be well situated to protect forests, those forests could already be depleted to some degree of wildlife (Coomes, Takasaki, and Abizaid 2020). Indeed, the harvest of prey could be more influenced by the local availability of wildlife stocks rather than cultural aspects (Jerozolimski and Peres 2003). De Thoisy, Richard-Hansen, and Peres (2009) detected no differences in prey harvest based on ethnic background of hunters in French Guiana. However, the current status of wildlife stocks is endogenously related to hunting pressure – the more a person hunts, the more wildlife will decline; and the less animals are present, the less a hunter will harvest. In this study, I use forest cover as a proxy for game availability and initial wildlife endowment to control for current wildlife abundance. This approach is especially practical for two reasons: forest cover can now be easily measured through remote sensing and thus be used on a larger scale, and we can better understand change in wildlife structure from around a community at founding.

3.4.1.3 Characteristics of hunters

Although individual and household level variables were found to be less influential in my study for game harvest, these variables are important because they can be used to assist in targeting of conservation policy. In other studies, individual characteristics like age, education, and place of birth have been linked to hunter participation and hunting success. Luz *et al.* (2015) found that formal education influences hunting activity in the Bolivian Amazon. The study suggests that as education increases, hunting yields decrease and provide relief to at-risk wildlife species. More educated people may earn more income through wage labour which may decrease their reliance on activities like agriculture, fishing, and hunting. My model found no association between education and hunting activity although I do acknowledge that alternate livelihood practices may influence whether someone hunts or not. Some households indicated that hunting income provided the means to put their children through school and even send some children to university. The relationship between education and hunting harvest remains unclear and should be further explored. Currently, educational and religious institutions (especially the Catholic Church) are promoting increased conservation practice in Amazonia which could influence local perceptions and use of wildlife (Francis 2015; Knoop *et al.* 2020). My study, however, indicates that education levels do not influence hunter harvests or participation.

The only individual characteristic that I found to significantly influence hunting participation and harvest statistically was hunter age. Older people, mostly men, are more likely to engage in hunting and older hunters reported harvesting more game than younger hunters. However, hunting efficiency peaked at thirty-seven years of age, corroborating other Amazonian studies (Figure 3.9). Despite peak physical ability occurring during a hunter's twenties, skill and knowledge take years to develop – approximately 25-30 years. A young hunter may not know when to practice patience and let an animal come to a better location. Hunting families begin teaching children how to hunt at as early as 10 years of age and anecdotes from my oral history surveys highlight the importance of pedigree for developing hunter ability. In the study communities, it is not uncommon for children to miss school to go hunting when the hunting conditions in the nearby forest are propitious. The balance between hunting experience and physical ability is found in other Amazonian indigenous groups: peak hunting occurs at 35 for Hiwi, 40 for Machiguenga and Piro, and 37-42 among Ache peoples (Gurven and Kaplan 2006; Kaplan 1994; Kaplan *et al.* 2000). Although age influences hunting ability, I conclude that individual and household characteristics are less important than community characteristics for understanding wildlife harvest in the Peruvian Amazon. The results suggest that hunters may be more a product of their local environment rather than their upbringing, an issue that should be further explored.

3.4.2 Hunter livelihoods – opportunistic and specialized hunters

Hunters have diverse livelihood portfolios and wildlife can contribute significant cash income and provide sustenance for their families and communities. The literature points to two types of hunters in Amazonia: specialized and opportunistic. In the two study area communities on the Napo river – selected for being 'hunting' communities – I estimated that 23,080 kg of wildlife biomass was harvested across 45 households in the previous calendar year. The PARLAP survey, which is dominated by opportunistic hunters, reports 121,267 kg of game harvest across 3865 households; specialized hunters collected 43% of the total game harvest amounting to over 51.6 tons of game meat among 79 households. Regardless of whether hunters are opportunistic or specialized, the relationship between subsistence livelihoods and the market must be better understood to develop reasonable management programs that benefit local people while protecting ecological integrity. Realistically, people will extract what they can to support themselves and their families.

Opportunistic hunters hunt sporadically during the year, when game is plentiful or concentrated, whereas specialized hunters tend to harvest large quantities of game – often for market. I distinguish specialized hunters as harvesting the top two percent of game meat in the large-scale PARLAP survey (all collected more than 270 kg of game meat). In the two study communities, individuals identified by key informants as the best hunters all collected more than 270 kg of game meat (Figure 3.7). van Vliet *et al.* (2015a, p. 4) report that specialized hunters in the Três Fronteiras region sold 81% of the game meat they harvested to wholesalers in the city, significantly more than the diversified (analogous to opportunistic) hunters who sold 21% of the total harvest to family or friends. In my study, specialized hunters generally sold more than half of their game meat harvest whereas opportunistic hunters often sold between one quarter to one half of their harvest. Game meat is an important subsistence resource but is also a useful source of income for all hunters.

Hunters, especially specialized hunters, are often underrepresented in studies because they are frequently absent from study communities when interviews take place. Hunters are often absent because they are away hunting, and ambiguous legislation and enforcement have lead to a "conspiracy of silence" where hunters are unsure what their hunting rights are and whether their livelihood activity is legal or not (Antunes *et al.* 2019). In fact, van Vliet *et al.* (2015a, p. 6) found that 73% of commercial hunters identified in their study had been penalized at least once by environmental and/or territorial authorities. In turn, building trust is essential to understand what characteristics are shared between hunters and what factors influence a hunter to engage in the livelihood strategy opportunistically or as a specialized activity

The PARLAP study did not specifically focus on local livelihoods (*i.e.,* agriculture, fishing, timber extraction along with hunting) rather than hunting and hunters, and therefore may underestimate the total amount of game harvested. Interestingly, the top quartile of hunting households in the study had the least amount of non-land assets and appears to have less land than hunting households in the middle two quartiles (see Table 2). Game income could initially be used to clear land for future agriculture but those who hunt the most may have limited time to clear land and farm. Game income does not appear to be used to accumulate non-land assets in the PARLAP survey. During 2019 fieldwork, income from hunting was reportedly used primarily for subsistence (consumption of the meat, and purchase of household goods like soap), education, or alcohol consumption. Further research should explore where game income is invested.

3.4.3 Hunters and their potential role in conservation

I argue for a scalar distinction between small-scale and large-scale hunting in contrast to the current hunting categories of commercial or subsistence. Legal frameworks in the Amazon generally allow for subsistence hunting but the definition of subsistence does not allow selling meat for cash (Antunes *et al.* 2019). Where game meat consumption is culturally accepted and is present as a menu item in the Amazonian cities such as Iquitos and Pucallpa, local people sell valuable game meat to be able to purchase household goods such as soap and gasoline (Córdova 2017; van Vliet *et al.* 2019). Hunting income also provides the means to pay for educational supplies for children and even university educations. Game meat is a lucrative commodity and provides impoverished rural Amazonians in remote areas with a crucial source of income. In other parts of the world, a mixed-economy allows for income generation because in broad subsistence terms, money is necessary to subsist (Wenzel and Natcher 2019). The sale of game harvested from small-scale hunting could be formalized to protect a traditional resource while formally incorporating the good into the market ('t Sas-Rolfes 2017). However, I argue that large-scale hunting as a commercial enterprise is problematic. According to my field notes, a commercial hunter must bring a minimum 1.5 tons of game meat to market to cover supply costs and the associated risks associated with bringing large quantities of meat to market. Costs include shotguns (140 USD each), ammunition (1.1 USD per shotgun cartridge), flashlights, provisions, salt, and fuel whereas risks are confiscations, fines and even detainment. The costs and risks are often assumed by contractors (*habilitadores*) who have connections and access to larger markets.

Contractors who supply the tools, funds, and transportation to facilitate large-scale hunting, often employ local hunters to harvest game in territories far from the influence of state or even local authorities. The system used to employ local hunters takes advantage of impoverished people who get a small benefit compared to the earnings of the *habilitador*. The system is rooted in debt-peonage (*habilitacion*) relations spawned to extract rubber during the rubber boom period of the late 19th century (Barham and Coomes 1996). These contracted commercial hunting expeditions into remote regions deplete important source populations of wildlife that provide a healthy supply of valuable wildlife to riverine communities. Over the short term, rural hunters gain quick income but at the detriment of their future hunting resources. If rural people were able to gain a fair income for game meat without risking criminal sanctions, they may be motivated to protect upstream rivers and forests from large-scale hunting activities.

Social scientists now advocate for legal frameworks that empower rather than criminalize hunters for wildlife harvests (van Vliet *et al.* 2019). Certainly, rules that criminalize hunting practices, which could be considered subsistence activities, lead to uneasy relationships among hunters, conservationists, and government. Indeed, I suggest that hunters may be in the best position, and the most motivated, to protect forests – and wildlife – from commercial activity. Today, certain hunting communities along the Napo River have already closed their local tributaries to illegal gold mining, commercial fishing, commercial logging, and commercial hunting. Although the goal is to safeguard resources for their own community use, by closing their tributary, communities have essentially created large national reserves that are as yet not recognized by the state. If hunting communities were empowered by the state to recreate this strategy throughout the Amazonian basin, Amazonian conservation initiatives related to wildlife conservation could be advanced by local people to protect their local resources.

My model for hunter characterization emphasizes that community characteristics should be the main indicators for targeting of conservation initiatives by environmental nongovernmental organizations and government agencies. Thanks to improvements in transportation, and therefore access to market, local opportunities to generate income are increasing and so is the agricultural and commercial frontier. If environmental NGOs and government policy focus on communities, rather than people to safeguard at-risk environmental resources, effective solutions could materialize. For example, in the Yucatan, opportunities created through economic incentives and productive alternatives (*i.e.,* commercialization of other non-timber forest products) favour lower hunting pressure (Santos-Fita, Naranjo, and Rangel-Salazar 2012). Local people are in the best position to protect valuable forests and ecosystem services, but they must have personal motivations to counteract commercial hunting. By scaling the definition of subsistence hunting, commercial practices could be reduced as communities work to protect their own natural resources. In an ecosystem where habitat change threatens a crucial component of the world climate system, targeting specific local communities may provide the best solution, ethically and practically, to protect against defaunation in the Amazon.

3.5 Conclusion

Government and nongovernmental organizations must consider socioeconomic and ecological interactions on multiple scales when developing conservation policy. Overhunting is an serious threat to biodiversity in Amazonia but criminalizing impoverished people in remote regions endangers peoples' well-being and is counterproductive for empowering community-oriented conservation. In this study from the Peruvian Amazon, I show that community characteristics drive engagement in hunting and hunter harvest over individual and household characteristics. Hunting not only provides nutritious food for Indigenous people(s) and ribereños but also a valuable source of cash income that helps pay for household goods and education. I recommend that the definition for subsistence hunting be expanded to include the ability to sell small quantities of game meat for income. I suggest that environmental NGOs and government focus on communities rather than households or individuals for targeting local resource management opportunities. By targeting communities rather than individuals, watershed level conservation projects could be fostered in remote regions far from state influence. For conservation to work, rural people must be encouraged, not criminalized, to take care of their wildlife resources. Broadening the definition of subsistence hunting is an appropriate first step for reconciling relations between the state and rural Amazonians.

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Chapter 4 - Summary and conclusion

I undertook this study of local ecological knowledge (LEK), hunting, and game harvesting in Peru to better understand the threat hunting poses to Amazonian wildlife. My thesis assessed which survey methods are best suited for large-scale and rapid inventories of wildlife in rural areas of Amazonia. I conducted a field study in an Indigenous community along the Napo River, and compared data from 487 days of camera trapping, 10 line transect surveys, 5 river surveys, and 37 structured LEK household interviews. I assessed the factors influencing the choice of hunting as a livelihood strategy with data collected in the PARLAP survey, a study of 919 communities and nearly 4000 households across four river basins, and my own fieldwork data collected through 46 semi structured interviews and 20 oral history surveys in two Napo River communities. This concluding chapter summarizes my key research findings and discusses their implications for conservation and development.

4.1 Summary of key findings

I compared data on LEK of wildlife gathered from household surveys with data I gathered using conventional survey methods for assessing the local status of wildlife. The three main findings of my research into the accuracy and precision of LEK wildlife surveys (Chapter 2) are as follows.

1. Household survey data are highly correlated with conventional method data and can provide an accurate and precise way of assessing wildlife presence on a large-scale in tropical forests.
2. I observed no significant differences for responses among categories: between hunters and non-hunters; between leaders and non-leaders; and among hunters, fishers, and farmers. For large-scale wildlife inventories, it is important to engage with not only

hunters but community authorities and other people familiar with the local environment, together, to ensure accuracy and precision in survey responses.

3. Wildlife populations are declining, especially nearer to communities, and household interviews provide a means to better understand how populations are changing around communities and among communities. For species that are rare, cryptic or ephemerally present, household interviews may be the best method to be used.

The main findings of my hunter characterization study, reported in Chapter 3, are also threefold.

1. Diverse factors influence hunter participation and harvest levels. Community-level factors including forest cover, remoteness, indigeneity, percentage of Holocene soils, location on main channel, and lake access have the greatest effect on both, but age and initial assets are influential individual- and household-level factors.
2. Despite the illegal nature of selling game meat, hunting income is an important component of rural livelihood portfolios for many rural households in the Peruvian Amazon. Specialized hunters harvest more than 270 kg of game meat per year and collected more than 43% of the game meat reported in the PARLAP dataset. The total harvest of specialized hunters amounts to over 51.6 tons of game meat of which more than half is sold whereas opportunistic hunters may only sell a quarter. Small-scale hunters are perhaps better situated to be aware of hunting pressure because they are geographically situated where overhunting is occurring and personally motivated to protect their local resources.
3. Marked differences exist in the quantities of game harvested by hunters. Commercial hunting, which involves collecting more than 1500 kg of game meat for market, is practiced by few but could have profound effects on forests far from state oversight.

4.2 Implications for conservation and development

Hunting in tropical forests is a controversial livelihood activity. Conservationists view hunting as an activity that jeopardizes important ecosystem functions while often failing to recognize the economic, social, and cultural realities of Amazonian life (van Vliet 2018). Game meat is a valued source of protein and micronutrients in areas far from markets (Rao and McGowan 2002) and families engage in hunting as well to provide cash income to meet basic needs and help put their children through school. Hunting can act as an investment strategy for the accumulation of financial capital and provide a safety-net for households when experiencing environmental shocks. Although substantial commercial hunting through the twentieth century impacted wildlife, the fact that many terrestrial mammal populations are relatively healthy points to opportunities where terrestrial game can be sustainably managed while respecting local cultures and worldviews (Hurtado-Gonzales and Bodmer 2004; Antunes *et al.* 2016; Bodmer *et al.* 2020).

Social scientists are advocating for legal frameworks that aim to empower rather than criminalize wildlife harvests and alienate hunters (van Vliet *et al.* 2019; Ingram 2020). Rules that criminalize game harvesting for subsistence needs lead to uneasy relationships among rural people, conservationists, and government. Indeed, previous responses to the "game meat crisis" in Amazonia could be viewed as "cultural imperialism" in conservation practice (van Vliet 2018; McGregor 2005). I suggest that hunters may be in the best position, and be the most motivated, to protect local forests – and wildlife – from commercial activity. Today, certain communities along the Napo River have already closed their local tributaries to illegal gold mining, commercial fishing, commercial logging, and commercial hunting. By doing so, the communities have essentially created a large nature reserve, as yet unrecognized by the state. If hunting communities were empowered by the state to replicate this strategy throughout the basin, Amazonian conservation initiatives aimed at enhancing wildlife populations could be advanced with the help of local people.

LEK surveys for wildlife are an opportunity to bring together conservationists, rural Amazonians, and government for more effective wildlife management and conservation. As wildlife populations are hunted throughout Amazonia, there is an urgent need to understand why and where animal populations are declining. My study shows that LEK surveys are a valid approach for assessing the status of wildlife which, as others have demonstrated (Coomes, Takasaki, and Abizaid 2020; Parry and Peres 2015), can be used on a large scale. Although my findings do not support the hypothesis that hunters had more accurate responses than fishers or farmers, the finding supports the use of LEK surveys with all resource reliant community members. By engaging communities through LEK surveys, wildlife inventories can be used as a means to bring together conservationists, rural Amazonians, and state governments.

Rural people living in remote regions of Amazonia will continue to hunt regardless of governmental legislation, and conservation policies need to work with communities to find ways to effectively manage wildlife. A growing number of scientists recognize that the current legal framework in Amazonian countries endangers the livelihoods of impoverished forest peoples and are not realistic (Peres and Lake 2003; van Vliet *et al.* 2019). If environmental NGOs and government policy focus on communities rather than people to safeguard at-risk environmental resources, effective solutions could be found. For example, in the Yucatan, opportunities created through economic incentives and productive alternatives (*i.e.,* commercialization of other non-timber forest products) meant to reduce hunting pressure (Santos-Fita, Naranjo, and Rangel-Salazar 2012). By allowing that subsistence hunting includes the right to sell small quantities of game meat, governments and conservation organizations are more likely to get ‘buy-in’ from communities. Determining just how much game meat should be allowed to be sold would depend on the local status of specific wildlife populations, and enforcement in remote areas is likely to remain a challenge. But by targeting local communities where hunting is common because of the abundance of wildlife and empowering them to protect wildlife from non-local commercial hunters, the incentives would be better aligned to conserve wildlife and reduce defaunation in Amazonia.

4.3 Implications for future research

After investigating the strengths of different methods for collecting baseline wildlife inventory data in the Amazon and characterizing what drives Amazonian people(s) to adopt hunting as a livelihood strategy, I identify opportunities for future research that could provide valuable insight for wildlife conservation policy in Amazonia.

I suggest that animal ecologists examine the prospects for using LEK focus group interviews for assessing the presence of ephemeral, rare, and cryptic species such as the white-lipped peccary and the short-eared dog (*Atelocynus microtis*). Findings from my research suggest that LEK surveys have the potential to quickly identify where further studies using conventional methods should be conducted while also engaging local people in wildlife monitoring. These data would provide valuable information for the IUCN to determine the status of threatened Amazonian wildlife.

I showed in Chapter 3 that community characteristics are good predictors for increased hunter participation and harvests. By identifying such characteristics, scientists can identify communities for closer future study, ones that could be candidates for supporting local efforts to protect their upstream watersheds from commercial activities. Individual-level characteristics identified in this study also can guide conservationists identifying additional opportunities among hunters themselves to protect forests and rivers from damaging commercial practices.

Further work is needed to better understand how income generated from wildlife harvest is invested by households, and how best to promote alternate income opportunities for people in remote regions. A key issue that remains is whether hunting is an effective path for rural poverty alleviation through investment, for example, in education of children or diversification into other economic activities. What incentives could ensure that income generated from hunting creates a positive feedback loop, one that protects forests, wildlife, and social wellbeing?

Together, these future avenues for research embrace the importance of engaging local Amazonian people in wildlife conservation while respecting their autonomy. Such research would encourage people living in remote areas, far from the reach of the state, to protect wildlife resources from outsiders and also help guide where research and conservation initiatives for animal conservation should be targeted in Amazonia.

4.4 Conclusion

My research on hunter livelihoods in the Peruvian Amazon advances our understanding of the drivers of defaunation in Amazonia. My findings will help inform conservation and management policies that acknowledge the realities of rural life. Hunting is an important livelihood activity for rural Amazonians, and hunters, along with other community members, are an important source of local ecological knowledge. By incorporating local knowledge of wildlife populations, basin-wide studies on defaunation can further engage Indigenous and folk peoples in protecting resources from outsiders. If small-scale hunting is formalized to allow for a mixed economy of subsistence and cash income, hunters would not be ostracized in Amazonian conservation; instead, they could be engaged as leaders and custodians of primary forest and its fauna. In doing so, we can develop together conservation and development initiatives in Amazonia that better reflect the realities faced by local resource users.

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Epilogue

I arrived at McGill to explore my interest in Amazonian defaunation that developed while working at the Tiputini Biodiversity Station in the Ecuadorian Amazon. At the research station, I gained an appreciation for the biodiversity present in the western Amazon. The Tiputini Biodiversity Station showcases an Amazonian environment protected from human use. It is located across the river from Yasuní National Park and is not easily accessed by visitors. In fact, visiting researchers must travel two hours by motorboat on the Napo, drive along the Maxus Road for two hours before finally travelling another two hours, again by motorboat, to the research station. There is no hunting allowed at the research station and numerous conservation projects ensure that wildlife generally do not consider people as predators (at least on the station grounds). As a biologist, the biodiversity station was the epitome of conservation – an area where stacks of yellow spotted Amazon river turtles (*Podocnemis unifilis*) could be seen sunning themselves on partially submerged branches and primatologists are able to study the natural behaviours of Amazonian monkeys because the monkeys are unafraid of humans. During my M.Sc. degree at McGill, however, I came to realize that the Amazonia I felt impassioned to protect is not "real".

Humans are the greatest ecosystem engineers today. We have a lasting impact on the lands we inhabit for generations and scientists are discovering that much of "untouched" and "virgin" Amazonia are human modified landscapes. After European colonization, disease, and genocide reduced Indigenous populations and provided a predator release opportunity for Amazonian wildlife. Perhaps the "virgin" rainforests of Amazonia are unnatural landscapes where human impacts are reduced. The "real" Amazonia today is a resource reliant landscape that includes local Amazonians who work with the forest to provide subsistence livelihoods far from state resources.

During my M.Sc. fieldwork, I was saddened to not see a single adult *Podocnemis unifilis* over my three months stay. It was strange to neither see nor hear signs of the largest monkey species, white-bellied spider monkey (*Ateles belzebuth*), around the communities. However, the reality occurring throughout the Peruvian Amazon is that people will do what they must to provide for themselves and their families. Tropical biologists and conservationists must understand the realities of daily Amazonian life to create conservation policy that local people can engage with. Protected areas must be large, ecologically intact, and well monitored to prevent environmental destruction. In Amazonia, however, it is unrealistic for state governments to monitor an area roughly the size of the continental United States. Local people, though, are eager to protect their community resources from outsiders and ensure generational supplies of fish, game, and non-timber forest products *if* they can provide enough for their families.

Consider the following scenario. You have been hiking for hours searching for an animal to provide protein or income for your family. Before dusk, you see a troop of woolly monkeys along a hillside. What do you do? Hunting is a controversial subject; hunting depletes wildlife, yet locals rely on hunting to support their families. Hunters can also face harsh consequences for selling the meat of a vulnerable species. For many, the need to provide outweighs the risk. BANG.

You took the shot. Your family will sell some meat to buy school supplies for your sister while the woolly monkey remains listed as a vulnerable species by the International Union for Conservation of Nature (IUCN). The photo serves as a reminder of both human and animal vulnerability in the Amazon (Figure 5.1).

Figure 5.1. Woolly monkey shot during hunting expedition.

I have come to understand that for conservation to occur, policies must be put in place that empower local people to safeguard resources from large-scale operations that generally do not benefit rural communities. Small-scale activities such as hunting, fishing, farming should be formalized to repair relations between state governments, conservationists, and rural peoples who often feel marginalized. Greater communication and education between the social sciences and natural sciences will ensure that both disciplines work towards mechanisms that account for both ecological protection and consider the livelihoods of marginalized people.

Appendices

Appendix A – Ethics approval and renewal

McGill

Research Ethics Board Office
James Administration Bldg.
845 Sherbrooke Street West. Rm 325
Montreal, QC H3A 0G4

Tel: (514) 398-6831
Fax: (514) 398-4644
Website: www.mcgill.ca/research/research/compliance/human/

Research Ethics Board 1
Certificate of Ethical Acceptability of Research Involving Humans

REB File #: 43-0619

Project Title: Got game? Assessing the role of local knowledge for Amazonian wildlife conservation.

Principal Investigator: Daniel Zayonc

Department: Geography

Status: Master's Student

Supervisor: Prof. Oliver Coomes

Approval Period: **June 14, 2019 to June 13, 2020**

The REB-1 reviewed and approved this project by delegated review in accordance with the requirements of the McGill University Policy on the Ethical Conduct of Research Involving Human Participants and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

Deanna Collin
Senior Ethics Review Administrator

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* Approval is granted only for the research and purposes described.
* Modifications to the approved research must be reviewed and approved by the REB before they can be implemented.
* A Request for Renewal form must be submitted before the above expiry date. Research cannot be conducted without a current ethics approval. Submit 2-3 weeks ahead of the expiry date.
* When a project has been completed or terminated, a Study Closure form must be submitted.
* Unanticipated issues that may increase the risk level to participants or that may have other ethical implications must be promptly reported to the REB. Serious adverse events experienced by a participant in conjunction with the research must be reported to the REB without delay.
* The REB must be promptly notified of any new information that may affect the welfare or consent of participants.
* The REB must be notified of any suspension or cancellation imposed by a funding agency or regulatory body that is related to this study.
* The REB must be notified of any findings that may have ethical implications or may affect the decision of the REB.

McGill University
Research Ethics Board Office (REB-1, 2, 3, 4)
RENEWAL REQUEST/STUDY CLOSURE FORM

For Administrative Use

Signature of REB Chair or designate: Deanna Collin (Digitally signed by Deanna Collin DN: cn=Deanna Collin, o=McGill University, ou=Research Ethics Board, email=deanna.collin@mcgill.ca, c=CA Date: 2020.06.01 14:10:48 -04'00') Date: ____________

Approval Renewal Period: 14 June 2020 to 13 June 2021

The researcher is responsible for ensuring that all other applicable approvals/renewals from other organizations are obtained before continuing the research.

Appendix B – LEK survey for local wildlife presence

Nombre de comunidad.................................... UBIGEO:……………………………… Fecha:………………………..

HH ID: ………………………………………. Nombre...................................... Sexo (M/F): …………………………………..

Se dedica: Cazado …… Pescador: ………. Agricultor ……………. Otra: ……………… Líder? ……… Monteraz? ………

B. Historia de vida y identidad

B1. Su familia se identifica como indígena?

No ……. Sí ……. Sí? Cual grupo indígena? Kichwa .... Otra (cuál?) ....

B2. Naciste en esa comunidad (S/N)? ………….. Si no, donde naciste? ………………

B3. Desde que tenías 18 años, cuantos lugares has vivido (por al menos 6 meses)?

………… lugares

B4. Cuantas generaciones ha vivido su familia en esa comunidad? ………… generaciones

B5. ¿Cuantos años ha vivido tu casa en esa comunidad? ………… años

C. Extracción de recursos naturales

C1. Tú u otras personas en tu casa participan en iniciativas comunitarias para proteger recursos naturales?

(*Toca todos que aplican por 'Sí'. Pregunta considerando las respuestas del focus groups actividad)*

	Pez	Presa
Miembro de una comisión o asociación comunitaria		
Participa con ONG de protección de recursos naturales		
Participa en vigilancia de recursos		
Siga restricciones por uso de recursos (e.g., tipos de equipos, protege mientras estaciones de crianza)		
Protege unos especies (e.g., paiche)		
Pagan impuestos por recursos tomados		
Ninguna de las opciones		

D. Comida y nutrición

D2. Cuantas veces por semana comes pescado o carne de monte por su almuerzo?

[*Nota: máximo de almuerzos por semana es 7*]

	Creciente	Vaciente
Almuerzo con pescado por semana		
Almuerzo con carne de monte/semana		
Almuerzo con pollo u otro carne		

C2. ¿Cuáles de las próximas especies pude encontrar cuando por primera vez estableció su casa aquí, inmediatamente antes de la empresa y hoy?

[*Toca todas que aplican si 'Sí'*]

Especies	**Pudo encontrar cuando movieran o cuando establecieran su casa aquí?***		**Pudo encontrar inmediatamente antes de Empresa**		**Puedes encontrar ahora?**	
	En menos de 2 horas caminando o por canoa	**En menos de 1 día pero más de 2 horas caminando o por canoa**	**< 2 horas caminando o por canoa**	**< 1 día y > 2 horas caminando o por canoa**	**< 2 horas caminando o por canoa**	**< 1 día y > 2 horas caminando o por canoa**
Presa						
Sachavaca						
Huangana						
Sajino						
Ronsoco						
Majaz						
Venado						
Mono Coto						
Mono Choro						
Maquisapa						
Añuje						
Carachupa						
Perdiz						
Paujil						
Pucacunga						
Lagarto Blanco						
Lagarto Negro						
Ardilla						
Achuni						
Charapa						
Taricaya						
Motelo						
Otorongo						
Carachupa Mama						
Oso Hormiguero						
Trompetero						
Mono Pichico						
Machin Blanco						
Leoncito						
Mono Tocon						
Mono Fraile						

Cuanto tiempo para la pista (del local hasta el río)? ……………………………………………………

Cuantos cartuchos compras en un mes? ……………………………… **En un año?** ………………………………

A quien debería preguntar este entrevista en la comunidad?……………………………………………………

Appendix C – Structured household survey instrument

Esta entrevista quiere clasificar quien es un cazador con datos cuantitativas. Se puede relacionar con el último estudio de PARLAP. Con este estudio, personas interesadas pueden dar más información sobre sus prácticas de caza en historias orales. Estos datos serian cualitativos que complementa la entrevista semi-estructurado.

Entrevista semi-estructurado por campesino, cazadores y monteraces
30/04/19

Nombre de comunidad... Fecha:…………………………….

UBIGEO:…………………………………… ; Nombre: .... , Nombre de esposa: …...................................

Nivel de caza: Monteraz …………… Cazador ……………. No caza ……………..

Household ID:…………. Entrevista de casa structurada? (Y/N): ……………………

B. Demografía [*Completa tabla de demografía en la siguiente página y regresa aquí*]

C. Historia de vida y etnicidad

C1. ¿Su familia se identifica como indígena?

No ……. Sí ……. Sí? ¿Cual grupo indígena?

Kichwa .... Yagua ...... Maijuna …… Otra (cuál?) ....

C2. Naciste en esa comunidad (S/N)? …………… Si no, ¿donde naciste? ……………….

C3. Desde que tenías 18 años, ¿cuantos lugares has vivido (por al menos 6 meses)?

……….. lugares

C4. ¿Cuantas generaciones ha vivido su familia en esa comunidad?

……….. generaciones

C5. ¿Cuantos años ha vivido tu casa en esa comunidad?

……….. años

B. Demografía

B1. Por cada miembro de la casa (presente, no presente at tiempo de la entrevista; vivo o muerto).

[Empieza con el jefe (ID 1), esposa, si presente (ID2); y después con los niños de mayor edad y finalmente otros adultos**]**

ID de personaje	**Nombre y Apellidos**	**Sexo (M/F)** M=1 F=2	**Relacion al jefe***	**Nacido aquí? (Sí/No)**	**Está vivo?**		**Edad *****	**Mas alto nivel de educación al fecha ******	**Esta persona vive en casa ahora?***** (S/N)**	**Esta persona caza por carne de monte?****** (S/N)**
					(Sí/No)	**Edad al muerto****				
1 (Jefe)			-----------------							
2										
3										
4										
5										
6										
7										
8										

*1=esposa/compañero; 2=hijo/hija; 3=hijastro/hijastra; 4=nieto/nieta; 5=hermano/hermana del jefe; 6=yerno/nuera; 7=madre/padre del jefe; 8=suegro/suegra; 9=tía/tío del jefe; 10=primo del jefe; 11=tía/tío de la esposa; 12=primo de la esposa; 13=no relación; 14=otra relación. ** Si murió antes de edad 1, pon "0". ¿Si la persona está muerta, cual edad tendrian hoy si estuviera vivo?

Si edad es <1 año, pon edad como "0". ****códigos de educacion: 0=ninguno; 1-6=Grado 1-6 (pon grado); 7-11=Secundario; 12=Tecnologico/Centro de Educacion Ocupacional (CEO);13=Universidad** Quien vive aquí al menos 6 meses por año. ******0=No caza, 1= cazador, 2= monteras **[*Regresa a "C", pagina 1*]**

D. Historia de la casa en la comunidad

D1. ¿Formaran tu casa en la comunidad o movieron aquí como una casa?
[*Nota: Formación de casa refiere a cuando una familia está formada y vive en su propia casa y los novios son independiente de sus padres*]

Formaron su familia aquí: ……… Vinieron de otro lugar: …………….

(i) ¿Si la casa era formada aquí en la comunidad, cuantos años han vivido aquí recién como una familia en esta comunidad? (i.e., no hubieron salido por más de un año)

……….. años

Cuantas generaciones de familia directo (padres/abuelos/bisabuelos/etc.) han vivido en esa comunidad?

Jefe …………. (generaciones; esa generacion=1; muchas generaciones=8; no sabe=9)

Esposa …………. (generaciones)

(ii) Si movieron aquí como casa, cuando llegaron? ……. (año)

¿Porque eligieron moverse a esa comunidad?
[*Lee la tabla de opciones abajo y despues toca todos los que aplican. NB: Quiero saber porque llegaron aquí NO porque salieron de la anterior comunidad*]

Razon(es)	**Sí (toca)**
Jefe y/o esposa nacido aquí	
Familia o familiares aquí	
Amigos aquí	
Buscando educación por sus niños	
Buscando tierra por trabajar	
Buscando recursos por sacar	
Caucho (caucho/jebe/shiringa)	
Madera	
Pescado	
Carne de monte	
Otro	
Buscando oportunidades de contrato (to be habilitado)	
Buscando oportunidades de contrato (to habilitar others)	
Para formar una comunidad indigena (CCNN)/pueblo	
Para estar con el mismo grupo etnico	

Razones religiosas	

D2. Dotación familiar. Cuantos de las próximas parientes tienes ahora viviendo en esa comunidad (15 años of mas, que no viven contigo en esa casa):

Parientes viviendo aquí	**Numero**	
	Jefe	**Esposa**
Hermanos		
Hermanas		
Madre		
Padre		
Tias*		
Tios*		
Primos**		

*Hermanos o hermanas de la madre o padre del jefe o de la esposa de la casa

**Hijos o hijas de hermanos o hermanas del jefe o de la esposa de la casa

D3. ¿Has tenido o ha tenido tu esposa algunos de los próximos puestos como líderes en esa comunidad?

Posición	**Ahora (Sí/No)**	**Antes (Sí/No)**
Tte Gobernador		
Apu/Jefe de la comunidad		
Agente Municipal		
Presidente de la Asociación de Padres de Familias		
Presidente del Club de Madres		
Coordinador del Vaso de Leche		
Líder de la iglesia u otra religión		
Presidente de la Rondas de Vigilancia		
Presidente de la Seguridad Cuidadana		

E. Ingresos de casa de la carne de monte

E3. ¿Cuántos de los siguientes animales has cazado en el año pasado?

Especies	**Número de animales muertos**		**Numero de kilogramos**		**¿Menos de 2 horas caminando o en canoa?**
Presa	Vaciente	Creciente	Vaciente	Creciente	**(Sí, no o por estación)**
Sachavaca					
Huangana					
Sajino					
Ronsoco					

Majaz					
Venado					
Mono Coto					
Mono Choro					
Maquisapa					
Añuje					
Chupacara					
Motelo					
Paujil					
Guan					
Ardilla					
Otros aves					
Otros mamiferos					
Pescado					
Paiche					
Tambaqui					
Red-bellied pacu					
Peacock bass					
Wolf fish					

¿Cuál era las “otras” aves? ……..

¿Cuál era las “otras” mamíferos? …………………………………………………………………………………………….

¿Qué métodos de caza usas? ……………………………………………………………………………………………………

Cuantos veces por semana vas a cazar? ………………….. Por cuantos horas? ……………………………….

E1. Produccion en el mes pasado

Pescado – fresco	Kgs			
Pescado – salado	Kgs			
Carne del monte	Kgs			

E2. Produccion desde el día de San Pablo 2018/día de independencia de Perú

Pescado – fresco – low water	Kgs			
Pescado – fresco – high water	Kgs			
Pescado – salado – low water	Kgs			
Pescado – salado – high water	Kgs			
Carne del monte – low water	Kgs			
Carne del monte – high water	Kgs			

F. Credito y habilitación

F1. Estuviste o alguien más de tu casa habilitado por cazar carne de monte desde el anterior feriado (San Pablo por San Carlos; Dia de independencia para Santa Teresa)?

Sí ……. No ……… [*si no, siga a F2*]

Si sí, ¿por cuales animales?

……………………………………………………………………………

G. Bienes del hogar

G2. Tenencias de tierras

Como familia aquí en esa comunidad, tienes:

Chacra(s) Sí……. No……

Purma(s) del bosque Sí……. No……

Parcela(s) Sí……. No……..

[*Nota: una parcela es un pedazo de tierra que pertenece a un individuo que puede ser titulado o que tiene una certificación de posesión o del estado o la persona cree que la tierra pertenece a él sin embargo que tal vez no lo ha trabajado*]

Si tienes, cuantas parcelas tienes?: ………….. (parcelas)

Parcela no.	Dimensiones (m x m)	¿Tienes título? (Sí/No)	¿Tienes certificado de posesión? (Sí/No)	¿Tienes certificado de uso? (Sí/No)
1				
2				
3				
4				

¿A ver cuantos chacras tienes? [*Si casa no tiene campos, siga a G3*]

Tipo de tierra y campo	Uso de campo*	Dimensiones (m x m)	Campo esta dentro/fuera de la parcela? (D/F)
Chacras, frutales, purmas, pastos, y monte alto en la Altura (Upland) [pregunta sobra cada categoría, empieza con chacras]			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
Chacras de restinga			
Chacras, frutales and purmas en Restinga Alta (High Levee) [pregunta sobra cada categoría, empieza con chacras]			
1.			

2.			
3.			
4.			
5.			
Chacras, frutales and purmas on Restinga Alta/Bajial (Low Levee) [pregunta sobra cada categroria, empieza con chacras]			
1.			
2.			
3.			
4.			
5.			
Barreales/barrizales and playas (arrozal, chiclayal, manial, sandial)			
1.			
2.			
3.			

*Codigos de campo por altura: 1=chacra; 2=verduras; 3=purma; 4=frutal; 5=pasto; 6 = monte alto; 7 =otra.

Codigos por restinga alta: 1=chacra; 2=verduras; 3=purma; 4=frutal; 5=pasto; 6=monte alto; 7=other.

Codigos por restinga baja: 1=chacra; 2=verduras; 3=purma; 4= frutal; 5=pasto; 6=monte alto; 7=other.

Codigos por barreal/barizales y playas: 1=arrozal; 2=chiclayal; 3=manial; 4=sandia; 5=verduras; 6=gramalote/caña

brava/otro

G2. Posesiones: Hoy en día y al tiempo de establecimiento en la comunidad

Posesión capital	**Posado cuando casa fue establecido * (Sí/No)**	**Ahora posado (Sí/No)**
Celular/teléfono de casa		
Escopeta		
Canoa		

Peque-peque		
Bote		
Motor fuera de borda		
Refrigerador/congelador		
Estufa de propano		
Sierra de cadena		
Red de pesca - tarrafa		
Red de pesca – trampa		
Red de pesca – hondera		
Red de pesca – arrastradora		
Red de pesca – mallon		

*Por casa que movieran aquí, mientras su primer año en la comunidad; por casas que han formada su casa aquí, durante su primer año como pareja independiente en su hogar. Pregunta sobre los bienes que llevaron o adquieran durante su primer año en su propia casa aquí.

H. Extracción de recursos naturales

H2. Eres parte o alguien más en tu casa es parte de una iniciativa comunitaria para proteger los recursos naturales locales

[*Toca todas que aplican por 'sí'. Pregunta esas preguntas considerando los resultados de la encuesta de grupos de enfoque*]

	Pescado	Carne de Monte
Miembro del comité o asociación		
Participa con ONG para proteger recursos		
Participa en vigilancia de recursos		
Sigue restricciones por el uso del recurso (e.g., tipos de equipos, protejan mientras la crianza)		
Protege algunos especies (e.g., paiche)		
Paga impuestos por algunos recursos		
Ninguno de las opciones		

¡Gracias por su participación! v. 17/04/19

Appendix D – Oral history survey instrument

Esta entrevista quiere clasificar quien es un cazador con datos cualitativos.

Entrevista semi-estructurado por campesino, cazadores y monteraces **30/04/19**

Nombre de comunidad.. Fecha:…………………………

UBIGEO:…………………………………… ; Nombre: .... , Nombre de esposa: …………...........................

Nivel de caza: Monteraz ………….. Cazador ……………. No caza …………….

Household ID:…………. ¿Entrevista de casa semi-estructurada? (Y/N): ……………………

B. Caza en la comunidad

1. Descríbame como la caza ha cambiado en esa comunidad desde que naciste
2. ¿Qué hacen diferente los cazadores de hoy?
3. ¿Puedes obtener tanta carne de monte que anteriormente?
4. ¿Cómo ha cambiado las poblaciones de animales desde que era joven?
5. ¿Crees que la gente usa la carne de monte diferentemente hoy en día comparando a cuando era joven?
6. ¿Para dónde va la carne que cazas?

……

……

……

……

……

……

C. Ética de conservación

1. ¿Cómo aprendiste a cazar?
2. ¿Hay algunas especies que no cazas? ¿Porque?
3. ¿Tienes algunas maneras de prevenir la sobreexplotación de la carne de monte?
4. ¿No cazas a algunas especies durante temporadas específicos?
5. ¿Qué sabes sobre los reglamentos de la ley forestal?
6. ¿Cómo le afecta los reglamentos de la ley forestal?
7. ¿Has participado en algunas iniciativas comunales para proteger la carne de monte?
8. ¿Qué quieres decir a los biólogos de conservación y la policía de recursos naturales?
9. Cuál es la mejor manera de conservar la carne de monte y guardar las costumbres de caza en la comunidad

……

……

……

……

……

……

………

………

………

C. Bienes de caza

1. ¿Qué te asiste practicar la caza como obra de vida? Enfoque sobre temas de terrenos
2. ¿Cómo viajas para cazar? ¿Para dónde vas?
3. ¿Cuál es la historia de tu escopeta, tu fusil, tus balas, tu canoa?

………

………

………

………

………

………

D. Seguridad de comida

1. ¿Las personas están preocupadas para tener comida en la casa? ¿Más o menos que anteriormente?
2. ¿Me puedes describir un momento cuando su familia era preocupado por no tener bastante comida?

………

………

………

………

………
……………………………………………

Appendix E – Livelihood analysis variable creation

Variable	Description
Game Income (NS)	Total income from game meat. Quantity sold multiplied by the market price of the nearest major market. If there was no local market, value was imputed by the mean value of all the markets in the same district, if still missing then to basin level and if still missing to all community's level
Percent Income from Hunting	Game income divided by total income.
Total Income (NS)	Total income from both earned and unearned income.
Total Land	Household total land holdings in hectares including upland forest.
Asset Index (z-scores)	Current household assets based on short model of 8 assets: housing materials, phone, outboard motor, motorcycle, generator, television, refrigerator and stove. Does not include land.

Appendix F – Variables

Variable	Description	Mean	St.Dev	N
Total Harvest (ln)	Logged Yearly Household Harvest (KG)	1.146	1.924	3890
Forest Cover	Forest Cover w/i 5 KM	.819	.16	4579
Distance to City (ln)	Logged Distance to Iquitos/Pucallpa (KM)	5.105	1.121	4579
Distance to Market (ln)	Logged Distance to Major Market (KM)	3.951	1.008	4579
Wildlife Endowment	Initial Terrestrial Wildlife Endowment (community)	.445	.78	4568
Community Households (ln)	Number of Households	3.673	.774	4579
Community Age (ln)	Community Age (decades)	1.572	.614	4579
Lake Presence	Does Community Have Access to a Lake	.822	.383	4579
Community on Main Channel	Community Located on Main Channel	.67	.47	4566
Percent Holocene Soils	Percent Holocene Soils Around Community	63.2	30.3	4579
Indigenous Community	Indigenous Community	.533	.499	4566
Indigenous Family	Indigenous Family	.498	.5	3892
Household Assets	Initial Assets of Household	-.285	.707	3894
Household Land Assets	Initial Landholdings of Household	1.804	4.801	3894
Male workers present	Number of Male Workers Present in Household	1.344	.889	3898
Female workers present	Number of Female Workers Present in Household	1.179	.746	3898
Dependents present	Number of Dependents Present in Household	2.544	1.793	3898
Hunter Age	Household Head Age	45.324	14.501	3895
Hunter Education	Household Head Education	6.297	3.137	3893
Hunter Born in Community	Born in Community	.439	.496	3896