

Chapter 10

Management of Subsistence Hunting of Mammals in Amazonia: A Case Study in Loreto, Peru



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Abstract Subsistence hunting of mammals by rural people has been permitted in the Peruvian Amazon since 1976. Research has shown that the brocket deer, peccaries, and large rodents can be hunted sustainably in *terra firme* (non-flooded) forests, whereas the slower reproducing tapir and primates are vulnerable to overhunting and should not be hunted. Hunting of terrestrial species in flooded forests (*varzea*) is less sustainable due to annual flooding that reduces populations of deer, peccaries, and large rodents, making them more vulnerable to overhunting especially during recent intensifications of weather conditions due to climate change. In the Peruvian Amazon of Loreto, people manage subsistence hunting in regional community conservation reserves, national community comanaged reserves, and Indigenous territories through a set of guidelines that include limits on hunting of non-vulnerable species, cessation of hunting on vulnerable species, wildlife habitat management, and source-sink areas. Currently, 60% of the Peruvian Amazon of Loreto includes some form of community conservation that incorporates management of subsistence hunting.

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Resumo A carne de grandes mamíferos silvestres é um componente importante da economia local de muitos povos amazônicos, tanto para consumo quanto para venda. A caça de subsistência desses mamíferos por populações rurais é permitida na Amazônia peruana desde 1976. Pesquisas mostram que o veado-catingueiro, os porcos-do-mato e os grandes roedores podem ser caçados de forma sustentável em florestas de terra firme (não alagadas), enquanto a anta e os primatas, de reprodução mais lenta, são vulneráveis à alta pressão de caça e não devem ser caçados. Em florestas inundáveis (várzea), a caça de espécies terrestres não é sustentável devido às inundações anuais que reduzem as populações de veados, porcos e grandes roedores, tornando-os mais vulneráveis à caça excessiva, especialmente durante os períodos de intensificação das condições climáticas, que estão mais frequentes devido às mudanças do clima. Ao longo de três décadas na Amazônia peruana, os sistemas de manejo comunitário da fauna silvestre foram desenvolvidos por meio de pesquisa e participação da população local, resultando na caça sustentável de várias espécies de mamíferos. A década de 1990 foi um período experimental em que estratégias restritas de proteção foram testadas contra as de uso sustentável baseadas nas populações humanas locais. Estratégias essas que foram bem sucedidas na conservação da paisagem socioeconômica e cultural da Amazônia, onde peixes, produtos florestais não madeireiros e carne de animais silvestre são tradicionalmente utilizados. Hoje, os habitantes de Loreto, Peru, administram a caça de subsistência em reservas regionais de conservação comunitária, que são reservas nacionais cogeadas por comunidades rurais e por indígenas em seus territórios. A caça é administrada por meio de um conjunto de diretrizes que incluem limites à caça de espécies menos vulneráveis, proibição da caça de espécies vulneráveis e manejo do habitat em áreas fonte-sumidouro. Atualmente 60% da Amazônia peruana de Loreto inclui alguma forma de conservação comunitária de manejo da caça de subsistência. Este tipo de manejo também foi desenvolvido em outras regiões da Amazônia e apresentou sucesso semelhante ao de Loreto. As Conferências Internacionais sobre Manejo da Vida Selvagem na Amazônia e na América Latina têm sido importantes para o intercâmbio de ideias, experiências, resultados científicos e envolvimento da comunidade, visto que têm sido implementadas em diferentes países amazônicos. Em contraste, o Brasil difere desses países porque a legislação de caça é contraditória e muitas vezes sujeita a interpretações arbitrárias. Por exemplo, populações locais que vivem fora de áreas protegidas não podem implementar oficialmente programas de uso sustentável da fauna silvestre. Já aqueles que vivem dentro de algumas categorias de áreas protegidas podem gerenciar o uso de seus recursos de forma susten-

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tável, como nas Reservas de Desenvolvimento Sustentável Mamirauá e Amanã. A caça, no entanto, não faz parte das permissões, as quais se concentram em pesca, agricultura sustentável e produtos florestais madeireiros e não madeireiros. De fato, a caça sem controle no país levou ao uso excessivo, comércio indiscriminado e declínio populacional de algumas espécies de animais silvestres. Em contraste, o uso desses animais é permitido dentro dos territórios indígenas, onde muitos povos praticam sistemas tradicionais de caça que conservam populações saudáveis de espécies e habitats, apresentando uma biodiversidade semelhante às áreas de proteção integral.

Keywords Subsistence hunting · Amazon · Sustainable use · Community-based wildlife management

10.1 Introduction

Indigenous people of Amazonia have been hunting mammals since pre-Colombian times and mammals continue to be hunted throughout the Amazon basin by Indigenous and Campesino people (Robinson and Bennett 2000). Over the past three decades, research, management, and conservation efforts have focused on understanding how species respond to hunting and developing management and conservation strategies for sustainable use and species recovery (Silvius et al. 2004).

Agriculture, fisheries, timber, non-timber extraction, and wildmeat harvests have traditionally been the major resource uses by Indigenous people (which includes traditional Campesino people) in the Amazon (Padoch 1988; Endo et al. 2016). Mammals have historically provided wildmeat, which is an important source of subsistence protein and income from market sales to purchase necessities (Bodmer et al. 2004).

The massive unregulated extraction of mammal pelts during the 1950s, 1960s, and early 1970s created a backlash that resulted in the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) national wildlife legislation and management actions (Grimwood 1968; Antunes et al. 2016). Different countries in Latin America took different directions in relation to hunting of mammals in Amazonia after the implementation of CITES in 1974. Peru, through laws enacted in 1976 (n° 21,147), 2000 (n° 27,308), and 2011 (n° 29,763), allowed subsistence hunting of certain wildmeat species by Indigenous hunters, whereas Brazil prohibited hunting of mammals outside of legally demarcated Indigenous territories. Bolivia, Colombia, French Guiana, and other Amazonian countries also permitted subsistence hunting. Countries that permitted subsistence hunting had no management protocols to manage subsistence hunting, other than listing permitted species and limiting sale of wildmeat (Grimwood 1968; Bodmer et al. 1988).

The biannual International Conferences on Managing Wildlife in Amazonia and Latin America that began in 1992 helped to facilitate a relatively coordinated effort by researchers, NGOs, and governments to find appropriate ways to manage subsistence hunting (Silvius et al. 2004). Projects throughout the Amazon found overwhelmingly that community-based approaches to wildlife management resulted in greater success than strict protection or other forms of management (Bodmer et al. 2008). This led to an expansion in the number of community-managed areas in the form of Indigenous territories, community-run protected areas, and community comanaged protected areas (Mayor et al. 2020). Indigenous communities wanted community-managed areas for hunting mammalian wildmeat species for subsistence food, especially ungulates and large rodents (Townsend 2000).

Over three decades in the Peruvian Amazon, community-based wildlife management systems have been developed through research and community participation resulting in sustainable hunting of wildmeat mammal species (Silvius et al. 2004). In this chapter, we will show how wildlife management of subsistence hunting is being used as a strategy that conserves mammals, forests, and traditional cultures and livelihoods of Amazonian people.

10.2 Wildlife Management of Subsistence Hunting

Community-based conservation began in the 1980s with the Chico Mendes movement and the creation of extractive reserves in the Brazilian Amazon. During this same period, community reserves were being developed in the Peruvian Amazon, and work began on community-based wildlife management (Bodmer et al. 1997b). The 1990s was an experimental era where strict protection strategies were tested against community-based sustainable use strategies (Terborgh 1999). However, community-based strategies were successful at conservation in the socioeconomic and cultural landscape of the Amazon where fish, non-timber forest products, and wildmeat are traditionally used (Nolte et al. 2013).

Wild meat from large mammals is an important part of the local economy of many Amazonian people, both for consumption and sale, and these people value the long-term socioeconomic importance of wild meat (Van Vliet et al. 2015b). Here, we will examine wildlife management of mammals in Loreto, Peru, as an example of a strategy to manage subsistence hunting and conserve mammals, habitats, and livelihoods of local people. Loreto is the largest administrative region in Peru, spanning over 362,000 km² of western Amazonian tropical rainforest.

The mammals most commonly hunted for wildmeat in Loreto include the collared peccary (*Pecari tajacu*), white-lipped peccary (*Tayassu pecari*), red brocket deer (*Mazama americana*), gray brocket deer (*Mazama nemorivaga*), lowland tapir (*Tapirus terrestris*), lowland paca (*Cuniculus paca*), black agouti (*Dasyprocta fuliginosa*), capybara (*Hydrochoerus hydrochaeris*), woolly monkey (*Lagothrix lagotricha*), and howler monkey (*Alouatta seniculus*). There are also a range of other species that are hunted less frequently including felids, procyonids like *Nasua nasua*, edentates like *Dasybus novemcinctus*, marsupials, other primates like

Sapajus apella, the manatee (*Trichechus inunguis*), and smaller rodents. Some species are generally not hunted by most people, and these include giant river otter (*Pteronura brasiliensis*), pink river dolphin (*Inia geoffrensis*), and gray river dolphin (*Sotalia fluviatilis*).

Loreto has two major landscape features that have very different resources, sustainability, and Indigenous cultures and in turn have different resource management and economies, one being the upland forests (*terra firme*) and the other the flooded forests (*várzea*) (Asner et al. 2014). Management of subsistence hunting differs between these landscapes.

Terra firme forests are relatively constant habitats across the year, whereas flooded forests are highly seasonal habitats. The relatively constant temperatures, rainfall, and solar inclination make the western Amazonian *terra firme* forests one of the most aseasonal areas on Earth (Higgins et al. 2015). These forests are regulated more by intrinsic biological mechanisms, such as predation and inter- and intraspecific competition (Fragoso and Reo 2013). In contrast, the physical effects of flooding make the flooded forests very seasonal, with marked differences between the flooded period and the dry period; consequently, these forests are more extrinsically regulated by physical water levels (Ayres 1993).

The two major formations of *terra firme* and flooded forests are very distinct in terms of wildlife density and diversity and require different wildlife management and conservation strategies. Flooded forests are volatile ecosystems driven by river water level variations and pulses that can cause droughts and floods that directly impact wildlife species (Espinoza et al. 2013). Flooded forests are, in turn, vulnerable to climate intensifications which have resulted in mammal die-offs during recent historically high floods (Bodmer et al. 2018).

Hunting is more sustainable in upland *terra firme* forest than the flooded forests, because common wildmeat species, including peccary, deer, and large rodents generally have larger and more stable populations in upland forests, and lower and more volatile population densities in flooded forests (Antunes et al. 2016; Bodmer et al. 2018). It is easier to achieve sustainable hunting in areas with greater density, greater productivity, and greater stability of mammal species. In areas with greater fluctuations, hunting levels need to change and adapt to fluctuating mammal densities to avoid becoming unsustainable. Thus, in flooded forests wildlife management needs to be dynamic and track mammal populations (El Bizri et al. 2018; Bodmer et al. 2020).

Intensive floods cause high mortality from increased inter- and intraspecific competition, increased predation and drowning as levees (restingas) shrink with rising water levels throughout western Amazonian flooded forests. Under such circumstances, terrestrial mammal populations may undergo severe local declines; indeed, such events occurred in western Amazonia during the historic floods of 2012 and 2015, resulting, for example, in a 95% decrease in wildmeat species populations in the Pacaya-Samiria National Reserve in western Amazonia (Bodmer et al. 2018).

The intensification of flooding, not hunting pressure, is the cause of decreasing wildmeat species numbers in flooded forests of western Amazonia. For example, prior to the floods, there were healthy peccary, deer, and large rodent populations in

the Samiria River of the Pacaya-Samiria National Reserve (Aquino et al. 2001). However, the historic floods of 2012 and 2015 caused the wild meat species to crash from around 16 animals per km² to 0.8 animals per km², or a mortality of 15.2 animals per km² (Bodmer et al. 2020).

10.3 The Wildlife Management Model

Terrestrial mammals can be hunted more sustainably in upland *terra firme* than in flooded forests. For this reason a community-based wildlife management model was developed for the *terra firme* forests of Loreto based on a set of guidelines that communities follow to manage subsistence hunting (Fang et al. 2008). Research conducted in the 1990s was used to develop and test the guidelines in the 2000s and the model was adopted by more communities and in more protected areas in the 2010s. The process involved governmental sectors including INRENA, SERNANP and SERFOR, and NGOs including WCS, Fundamazonia, G & B Moore Foundation, among others.

The guidelines are as follows:

1. Develop community-based wildlife management plans that are culturally and socioeconomically acceptable to the rural communities, and based on the actual hunting systems.
2. Focus wildlife hunting on non-vulnerable wildmeat species (peccaries, deer, and large rodents).
3. Prohibit or drastically reduce hunting of species vulnerable for hunting (mainly tapir, primates, and carnivores).
4. Set initial hunting levels using sustainability models, including the production model (Robinson and Redford 1991), harvest and unified harvest model (Robinson and Bodmer 1999), among others (Weinbaum et al. 2013).
5. Monitor hunting using catch-per-unit effort (CPUE) and hunting registers.
6. Maintain intact wildlife habitat and sustainable palm fruit harvesting.
7. Include non-hunted and hunted areas as source-sink hunting systems.

Community-based wildlife management is more successful if management plans concur with the cultural and socioeconomics of the communities, and plans need flexibility (Manfredo et al. 2008). Conservation programs in the Peruvian Amazon have demonstrated that rural communities can successfully set up community-based wildlife management which is an important precondition (Palacio 2003).

Research has shown that only a limited number of mammal species are appropriate for wild meat hunting in tropical forests (Robinson and Bennett 2000). Species including peccaries, deer, and large rodents have evolved life history strategies that make them less vulnerable to overhunting than other species, and more appropriate as wild meat species (Robinson and Redford 1991). These species have high rates of reproduction, and density-dependent responses that, in combination, allow them to compensate for added mortality from hunting (Bodmer et al. 1997a; Mayor et al.

2017). Other wildlife taxa, such as lowland tapir, primates, and carnivores, are more vulnerable to hunting, and are not appropriate as wild meat or pelt species (Puertas and Bodmer 2004; Peres and Palacios 2007). These species have slower reproduction, and their populations diminish when hunting occurs (Peres 2000; Mayor et al. 2017).

Mammal species vary in their populations independent of hunting, and these population fluctuations influence sustainability. For example, the white-lipped peccary (*Tayassu pecari*) has been shown to go through boom-and-bust cycles, and subsistence hunters take peccaries in accordance with their availability (Fragoso et al. 2022). When white-lipped peccaries are abundant, they are the most frequently hunted species and make up the greatest proportion of wildmeat, but when their populations are low, hunters stop harvesting this species (Hawkes et al. 1982).

White-lipped peccaries can reach densities exceeding 16 ind/km² with herd sizes above 500 individuals in western Amazonia (Salovara et al. 2003). Average adult body weight is around 33 kg. When white-lipped peccary numbers are high, they dominate the terrestrial Amazon ecosystem with biomass figures in excess of 500 kg/km², far greater than any other species. These high numbers of peccaries cause extensive changes to the understory vegetation through their characteristic rooting behavior (Beck 2006). White-lipped peccaries are seed predators, and the composition of saplings is altered by high peccary numbers (Beck et al. 2010).

In contrast, when white-lipped peccary populations crash, their numbers can be so low that they are not recorded on linear transect and camera trap surveys, or on hunting registers (Richard-Hansen et al. 2013; Mayor et al. 2015). The absence of the white-lipped peccary then results in greater sapling growth in the forests and a denser understory in the vegetation. The boom-and-bust populations cycles of the white-lipped peccary impact the forest structure and the entire gamut of animal and plant diversity (Beck 2006).

In contrast to white-lipped peccary, the collared peccary (*Pecari tajacu*) has more constant populations in upland forests (Perez-Peña et al. 2018). Hunters prefer the collared peccary for their meat quality, body size (33 kg), and pelt. Peru permits the export of collared peccary pelts if they originate from subsistence hunters, and it is the only country that maintains a peccary pelt trade (Fang et al. 2008). Peccary pelts are legally sold by subsistence hunters in the Peruvian Amazon, and are considered a by-product (less than 10% of meat value). Peccary pelts are exported under CITES Appendix II regulations and Peruvian authorities adjust regional export quotas depending on scientific wildlife monitoring (Fang et al. 2008).

Population studies and sustainability models have shown that subsistence hunting of collared peccary is usually sustainable in upland forests, but not sustainable in flooded forests (Fang et al. 2008). The collared peccary has density-dependent responses that increase reproductive productivity to compensate for added mortality from hunting (Gottdenker and Bodmer 1998). Long-term populations of collared peccary have been relatively stable and hunting pressure has decreased significantly from 145,000 pelts pre-CITES to 20,000 post-CITES (Fang et al. 2008).

The red brocket deer (*Mazama americana*) (30 kg) is hunted more frequently than the smaller gray brocket deer (*Mazama nemorivaga*) (15 kg), reflecting the

greater preference by hunters. Studies have shown brocket deer to be hunted sustainably with density-dependent responses and fast recovery so it is a non-vulnerable wildmeat species if limits are set (Hurtado-Gonzales and Bodmer 2006; Mayor et al. 2011a).

The lowland paca (*Cuniculus paca*) (12 kg) is often the most commonly hunted species and is hunted more during the high-water season when access to upland forest streams is possible (El Bizri et al. 2018). The paca is hunted along the streams at night using torches (flashlights) that reflect off of the large eyes of these nocturnal rodents. Paca populations can recover quickly and the paca has been the first species to recover from the historic floods in 2012 and 2015 (Bodmer et al. 2020). Paca reproduction is linked to fruit production, with a greater percentage of females pregnant when fruit production is high during higher levels of river water (El Bizri et al. 2018). When the white-lipped peccary crashed, paca populations began to increase, as did paca hunting (Mayor et al. 2015), suggesting that decreased competition from the white-lipped peccary allows the paca to increase numbers with greater food availability.

The agouti (*Dasyprocta* spp.) (5 kg) is a diurnal, fast reproducing caviomorph rodent hunted for subsistence throughout the Amazon. Agouti are usually hunted sustainably and often found in agricultural plots and fallows (Mayor et al. 2011b). They were impacted in flooded forests by high floods, but recovered quickly, demonstrating their resilience by bouncing back from population decline (Bodmer et al. 2020).

The lowland tapir (*Tapirus terrestris*) is the largest of the native terrestrial mammals in the region, with adults weighing around 200 kg. Tapirs have been found to be vulnerable to hunting and their populations decrease in areas where the species is hunted (Bodmer et al. 1997a). Tapirs have slow reproduction (Mayor et al. 2017), and cannot compensate for the added mortality from hunters, who often wait at salt licks to hunt them (Montenegro 2004). Tapirs are not common prey for the large felids, because of their large body size and large tusks used for defense, so hunters can cause greater mortality for tapirs than predators.

Tapir meat is not preferred by local people, because it is dark and oily and so can be difficult to digest (Mayor et al. 2021). Tapir meat is the lowest priced wildmeat in the markets, reflecting its low quality. However, tapirs have large quantities of meat. In well-managed subsistence hunting systems, tapirs should not be hunted (Fang et al. 2008).

Large-bodied primates have been shown repeatedly to be vulnerable to overhunting (Peres and Dolman 2000; Levi et al. 2011; Bowler et al. 2014). Commonly hunted species include woolly (*Lagothrix lagothricha*), howler (*Alouatta* spp.), and spider monkeys (*Ateles* spp.), as the large-bodied (8–12 kg) species traditionally hunted by native Amazonians (Puertas et al. 2017). There are a range of medium-bodied species that are also hunted, especially close to villages where larger species are absent. These include such species as saki (*Pithecia* sp.), uakari (*Cacajao calvus*), capuchin (*Cebus* sp. and *Sapajus* sp.), and titi monkeys (*Plecturocebus* sp. and *Cheracebus* sp.) (Bowler et al. 2008a). Primates have relatively slow rates of reproduction (Bowler et al. 2014; Mayor et al. 2017), and are not common prey species

due to their arboreal habits and alarm communications (Bowler et al. 2008b). In non-hunted areas, primates can reach their carrying capacity with slow reproduction and low predator predation rates. Primates cannot compensate for the added mortality from hunters, and this results in population declines in hunted areas. In well-managed areas, primates should not be hunted, or rarely hunted (Puertas et al. 2017).

Jaguars (*Panthera onca*) are occasionally hunted as a result of human-wildlife conflict when the cats have preyed on dogs and pigs. Pumas (*Puma concolor*) are rarely hunted, and rarely seen by hunters. Subsistence hunters will also take a wide range of other mammal species on occasion or in moderation, including Amazon squirrels (*Sciurus* spp.), armadillos (Dasypodidae), coati (*Nasua nasua*), ocelots (*Leopardus* spp.), and tayra (*Eira barbara*).

Non-mammalian terrestrial species that are commonly used as wildmeat include the game birds (guans—Penelopinae, curassows—Cracinae, tinamous—Tinamidae, and trumpeters—Psophiidae), yellow footed tortoise (*Chelonoidis denticulata*), and spectacled and black caiman (*Caiman crocodilus* and *Melanosuchus niger*, respectively) (Begazo and Bodmer 1998). The giant river otter is generally not hunted but was drastically overhunted during the pelt trade era during the 1950s to 1970s. However, populations have recovered in many areas throughout the Amazon, which was a result of CITES and national wildlife legislation (Recharte and Bodmer 2009), as well as local belief systems in some areas (Pimenta et al. 2018).

Evaluating the sustainability of wildlife hunting is a key component of guidelines for effective and sustainable management. Considerable effort has been devoted to evaluating the sustainability of wild meat hunting in Loreto using population harvest models, such as the unified harvest model and production model (Bodmer and Robinson 2004) and Catch-Per-Unit-Effort (CPUE) analysis by looking at the number of animals hunted in relation to the hunting effort (Puertas and Bodmer 2004).

10.4 Implementing the Guidelines

Implementing the wildlife management guidelines of the community-based model will ensure that wildlife populations are not overhunted, so that subsistence hunting is sustainable, and economic and subsistence benefits that wildlife provides to local communities are maintained. Implementing the guidelines will also ensure that wildlife habitat is kept intact. This will conserve not only the wildmeat species, but the entire range of biodiversity. We will now look at a case study from the Tamshiyacu-Tahuayo Regional Community Reserve (TTRCR) to show how sustainable subsistence hunting is being implemented in the Peruvian Amazon.

The TTRCR is situated in the upland forests that divide the Amazon Valley from the Yavarí Valley in Loreto. Its *terra firme* forests harbor high biodiversity and great faunal richness. In 1991, the regional government of Loreto created the Tamshiyacu-Tahuayo Community Reserve, an area covering a total of 322,500 ha. To bring its status in-line with new legislation, the regional government created the TTRCR in

2007, an act which was recognized on a national level in 2009 through Supreme Decree (D.S. N° 010-2009-MINAM) issued by the Ministry of Environment, which increased the area to its current size of 420,080 ha.

The TTRCR was the first community reserve established in Loreto and was created out of a desire from the local communities to have management rights in their traditional lands and includes people of the Cocama, Ashuar, and Campesino cultures (Newing and Bodmer 2003). The community reserve status allowed the people to manage their traditional resources of fish, wildmeat, and non-timber plants, including palm fruit, leaf, and fiber. The people of the community reserve worked with biologists and conservationists who helped develop community-based wildlife, fisheries, and palm fruit extraction (Bodmer et al. 1997b).

Operated by local communities through the management committee of the TTRCR, and with support from the Wildlife Conservation Society (WCS), the program continues to this day (ACRCTT 2022).

Within the TTRCR, four communities in the Tahuayo-Blanco Rivers currently hunt using the wildlife guidelines: El Chino, San Pedro, Nuevo Jerusalen, and Diamante/7 de Julio. These communities have set up community-based wildlife management schemes by putting in place the following actions: (1) reduce hunting of animals vulnerable to hunting, such as primates and tapirs, and set limits on hunting of animals more resilient to overhunting including peccaries, paca, agouti, and deer, (2) keep hunting registers, (3) have local biologists trained in the use of sustainability models evaluate harvest limits, and (4) conserve wildlife habitats including the *Mauritia flexuosa* palm trees, a key fruit producer for arboreal and terrestrial vertebrates (ACRCTT 2022). Hunting limits were evaluated by looking at the sustainability of premanagement hunting levels on non-vulnerable species (deer, peccaries, and large rodents). If the hunting was sustainable then the hunting limits were set at that level. If they were not sustainable then hunting levels would need to be reduced. All of the non-vulnerable species were hunted sustainably premanagement (Bodmer and Robinson 2004). The communities set their hunting limits by the number of animals permitted for each family per month, with a limit on large animals (peccaries and deer) and another slightly higher limit for small animals (paca and agouti) (ACRCTT 2022).

Data were available for the periods before (1991 and 1994–1996) and after (2011–2013) the implementation of wildlife management protocols, allowing for a temporal comparison of hunting pressure and densities of species in these timeframes. The measures used to evaluate the effectiveness of management of wildlife under subsistence hunting in TTRCR were: (1) hunting pressure analysis, (2) vulnerable species analysis, (3) abundance analysis using CPUE, and (4) density comparisons.

Hunters began recording harvests in 1991 in the Tahuayo-Blanco area as part of the participatory involvement of community-based wildlife management. Hunter participation relies on building interest in community-based wildlife management by having researchers work with hunters when evaluating the impact of harvests (Puertas and Bodmer 2004). Hunting registers involve hunters and their family in data collection. This participatory method helps researchers, extension workers, and

hunters find common ground to discuss wildlife issues. Hunting registers included information about the number of animals hunted, the species, sex, location of the kill, and dates of hunter departure and return. This last item was used to determine hunting effort as number of hunter days, and CPUE was calculated as number of individuals hunted per hunter-day (Puertas and Bodmer 2004).

The annual hunting rate of mammals and the biomass of wildmeat extracted from the Tahuayo-Blanco area decreased substantially between 1991 and 2013, from 1278 individuals (22,126.9 kg) to only 479 individuals (5331.7 kg) (Table 10.1). The number of species hunted also decreased. At least 35 mammal species were harvested in 1991, while only 14 were harvested in 2013. In particular, the harvest rates of vulnerable species, which include the lowland tapir and primates, have decreased dramatically from an annual total of 373 individuals (6735.8 kg)

Table 10.1 The harvest rates of mammals and biomass extracted from the Tamshiyacu-Tahuayo Regional Community Conservation Area in 1991 and 2013

Species	English name	Number of individuals		Biomass extracted (kg)	
		1991	2013	1991	2013
Artiodactylas					
Tayassu pecari	White-lipped peccary	166	2	5312	66
Pecari tajacu	Collared peccary	165	50	4125	1250
Mazama spp.	Brocket deer	88	9	2540	216
Perissodactylas					
Tapirus terrestris	Lowland tapir	38	0	5320	0
Primates					
Saguinus spp.	Tamarins	11	0	5.5	0
Cebuella pygmaea	Pygmy marmoset	1	0	0.1	0
Saimiri spp.	Common squirrel monkey	9	0	7.2	0
Cebus albifrons	White-fronted capuchin	20	0	60	0
Sapajus apella	Brown capuchin	46	2	161	7
Plecturocebus cupreus	Titi monkey	76	0	91.2	0
Aotus nancymae	Night monkey	4	0	3.2	0
Pithecia monachus	Monk saki monkey	57	0	114	0
Cacajao calvus	Red uakari monkey	23	0	92	0
Alouatta seniculus	Red howler monkey	22	0	187	0
Ateles paniscus	Black spider monkey	8	1	62.4	7.8
Lagothrix lagotricha	Common woolly monkey	58	0	632.2	0
Rodents					
Coendou bicolor	Bicolor-spined porcupine	8	0	40	0
Hydrochoerus hydrochaeris	Capybara	10	6	300	180
Cuniculus paca	Paca	174	379	1531	3411
Dasyprocta fuliginosa	Black agouti	97	17	446	85

(continued)

Table 10.1 (continued)

Species	English name	Number of individuals		Biomass extracted (kg)	
		1991	2013	1991	2013
<i>Myoprocta pratti</i>	Green acouchy	13	0	9.8	0
<i>Sciurus</i> spp.	Squirrels	15	0	12	0
Marsupials and edentates					
<i>Didelphis marsupialis</i>	Common opossum	25	1	17.5	3
<i>Myrmecophaga tridactyla</i>	Giant anteater	5	0	157.5	0
<i>Tamandua tetradactyla</i>	Collared anteater	17	1	78.2	4.5
<i>Bradypus variegatus</i>	Three-toed sloth	4	0	16	0
<i>Priodontes maximus</i>	Giant armadillo	1	0	30	0
<i>Dasybus novemcinctus</i>	Nine-banded armadillo	19	4	110	20
Carnivores					
Canidae	Free-ranging dogs	2	0	20	0
<i>Nasua nasua</i>	South American coati	49	4	151.9	22
<i>Potos flavus</i>	Kinkajou	4	0	12	0
<i>Eira barbara</i>	Tayra	14	0	67.2	0
<i>Lutra longicaudis</i>	Southern river otter	1	0	10	0
<i>Leopardus pardalis</i>	Ocelot	25	2	180	14.4
<i>Puma concolor</i>	Puma	3	1	225	45
Total		1278	479	22,126.90	5331.70

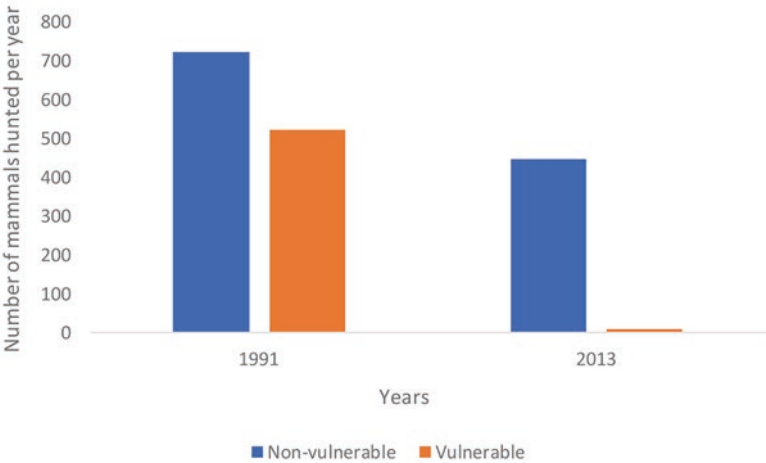


Fig. 10.1 Annual hunting pressure of mammals in the Tamshiyacu-Tahuayo Regional Community Conservation Area in 1991 prior to wildlife management, and in 2013 after implementation of subsistence hunting management

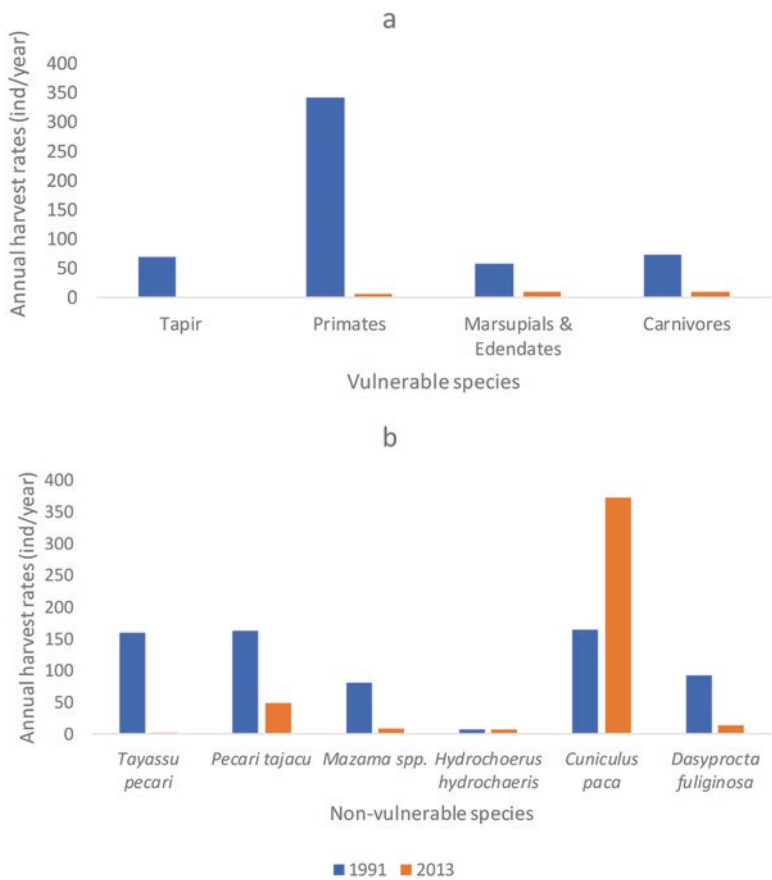


Fig. 10.2 The harvest rates of (a) vulnerable and (b) non-vulnerable or appropriate species in the Tahuayo-Blanco region of the Tamshiyacu-Tahuayo Regional Community Conservation Area in 1991 and 2013

belonging to 13 species in 1991 to three individuals (14.8 kg) from two species in 2013 (Fig. 10.1).

The hunting of marsupials, edentates, and carnivores has also decreased. In 1991, 71 individuals (409.2 kg) from 6 different species of marsupials and edentates were hunted annually, whereas in 2013 only six individuals (27.5 kg) from three species were hunted. Likewise, 98 individuals (666.1 kg) from at least seven different species of carnivore were hunted in 1991, while in 2013 only seven individuals (81.4 kg) from three species were hunted. The proportion of vulnerable species that make up total harvests has decreased from 42.41% to 3.34%. This is interesting when compared to the harvest rates of the non-vulnerable species (Fig. 10.2). In particular, the harvest rate of the paca has increased from 174 individuals (1531 kg) hunted in 1991, to 379 individuals (3411 kg) in 2013.

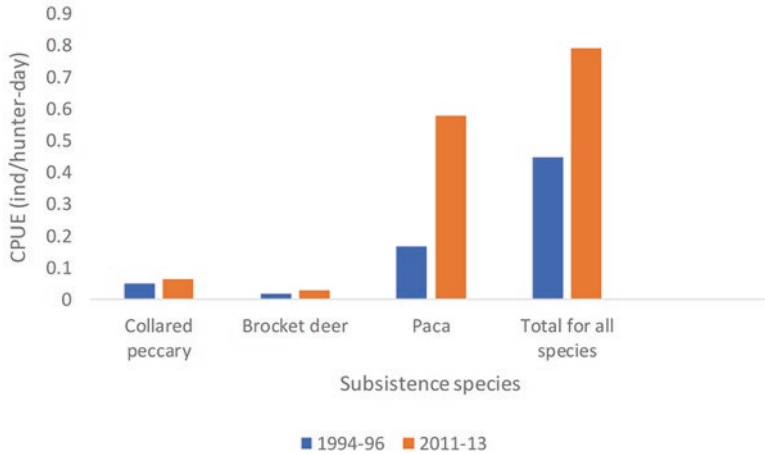


Fig. 10.3 Abundance of mammals in the Tamshiyacu-Tahuayo Regional Community Conservation Area measured by catch-per-unit-effort (CPUE) in 1994–1996 and 2011–2013

The CPUE of game species is used as a measure of overall abundance. Comparisons of this metric in the Tahuayo-Blanco area over the last 20 years (between the period of 1994–1996 and 2011–2013) found that, overall, mammal species had a mean of 0.46 ind/hunter-day in 1994–1996, which had increased in 2011–2013 to a mean of 0.81 ind/hunter-day, reflecting an increase in the populations of mammal species. The CPUE of the paca was relatively high across all years and increased from a 1994–1996 mean of 0.17 to a 2011–2013 mean of 0.58 ind/hunter-day. The mean CPUE for collared peccary was consistently low over the years with 0.07 in 1994–1996 and 0.08 ind/hunter-day in 2011–2013. Likewise, the mean brocket deer CPUE remained similar over the years, and was 0.03 in 1994–1996 and 0.04 ind/hunter-day in 2011–2013 (Fig. 10.3).

These results indicate that overall subsistence hunting in the community reserve is sustainable. An increase in CPUE over time reflects a growing population of mammals and in turn a growing population indicates sustainable use. The paca has increased more than other species in their population size.

Densities of terrestrial mammals were compared between the premanagement period using transect data from 1992 to 1996 and after implementation using data from 2019 to 2022 camera trap surveys in the TTRCR. The density comparisons showed similar results to the CPUE analysis. Densities of white-lipped peccary in the 1990s ranged between 6.6 and 13.1 ind/km², which is similar to the 2019–2022 densities of 7.10–17.6 ind/km². Collared peccary had a density of 1.4–1.6 ind/km² in the 1990s which is similar to the recent density of 1.2–3.2 ind/km², and likewise brocket deer density in the 1990s was 0.94 ind/km², similar to the recent surveys of 1.5 ind/km². The paca currently has a large population with 12.8 ind/km², and agouti with 9.4 ind/km². These comparisons show stable terrestrial mammal populations with healthy densities and indicate sustainable use. Likewise, a recent analysis

using a different data set also concluded that the wildmeat hunting is sustainable in the TTRCR using occupancy models (ACRCTT 2022).

Hunting of lowland tapir was greatly reduced after the implementation of the guidelines, and this was reflected in an increase in tapir densities from 0.1 ind/km² in the 1990s to 1.1 ind/km² in the 2019–2022 surveys. This shows that the communities respect the guidelines, resulting in the recovery of species that were over-hunted in the past.

The results from the TTRCR show how wildlife management of subsistence hunting is successfully conducted by local communities. This is an Amazonian model developed in the region over three decades, where local people are managing their own subsistence hunting, and where sustainable use is the norm, with biodiversity and traditional cultures being conserved.

10.5 Final Considerations

Since the first Natural Protected Area officially approved in Peru in 1961, 15 Natural Parks and 16 National Reserves have been created. The first Regional Community Reserve was recognized in 2009, and by 2021, 12 years later, 21 Regional Conservation Areas (RCAs) have been recognized protecting 3.59 million ha (Fig. 10.4). In Peru the Natural Parks total 10.36 million ha, the National Reserves 4.65 million ha, and Communal Reserves 2.17 million ha; the RCAs constitute 17.3% of the national territory protected with these categories, and in the region of Loreto account for 26.7% (2.19 million ha).

Thus, community-based regional reserves have been created in Peru, and especially in Loreto region, with Indigenous people developing sustainable management programs for wildlife, fisheries, turtles, and palm products (Benavides 2010). Some

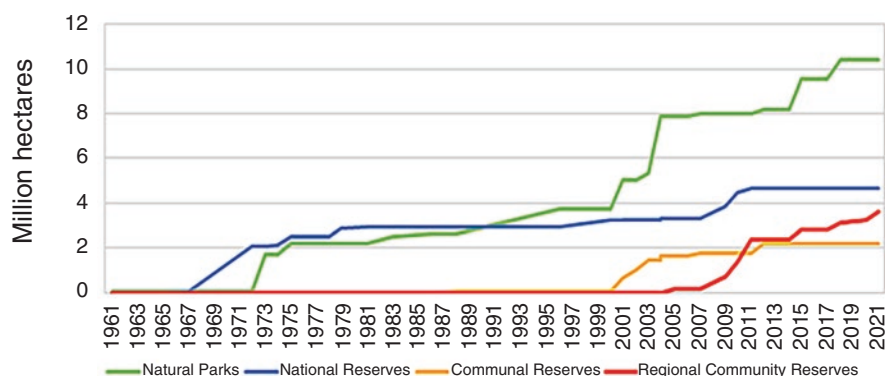


Fig. 10.4 Evolution of the territory protected (in millions of hectares) by the state of Peru as Natural Parks, National Reserves, Communal Reserves, and Communal Regional Areas since the creation of the first Natural Protected Area in 1961. We considered the year in which the Supreme Decree is issued as the legal basis of the national protected areas

of these sustainable use programs involve regulated international wildlife trade, such as the peccary pelts and the Yellow-spotted river turtle (*Podocnemis unifilis*) management involving CITES, custody chains, certification, and verification (Fang et al. 2008). Local people are also involved with national trade, such as a certified wildmeat trade from Indigenous comanaged areas sold to high-end restaurants in Lima (SERNANP 2015).

Local trade in wildmeat, fish, and palms are important, and many Indigenous people depend on local trade for their household economy (Kvist et al. 2001; Kirkland et al. 2018). These resources are now being managed, and shown to be sustainable in community reserves, comanaged reserves and Indigenous territories (Nolte et al. 2013; Blackman et al. 2017). Indigenous people manage their forests for hunting and their lakes for fish; they climb palm trees to collect fruits, and they have started the management of turtle hatcheries.

Community-based conservation began in the 1980s in the Amazon region with IUCN a major player in this early stage. The interest in working with Indigenous and Campesino people who wanted to manage resources on their traditional lands was a major reason for creating the initial community-based areas (Western and Wright 1994; Townsend 2000). During the 1990s, Indigenous people and wildlife biologists developed sustainable use and management and the International Conferences on Wildlife Management in Amazonia and Latin America was a forum for wildlife researchers and Indigenous people to develop community wildlife management throughout the Amazon and Latin America (www.comfauna.org) (Silvius et al. 2004). Over 25 years, the conferences have helped expand wildlife management of subsistence hunting through community-based strategies.

The unsustainable resource exploitation of the twentieth century is being substituted by sustainable resource use by community-based management in the twenty-first century. This is a complete paradigm shift in the rural economy, driven by the desire of Indigenous people to manage and conserve resources on their traditional lands, and not overuse resources for a market-based economy (Mayor et al. 2020).

In Loreto, there are three types of community areas where people manage subsistence hunting: community Regional Conservation Areas, comanaged National Reserves and Indigenous territories. The regional and national governments have been very supportive in the creation of these community-managed areas, and they continue to create new areas (Mayor et al. 2020). Currently, around 60% of Loreto is in one of these three community and comanaged areas where people are managing subsistence hunting (Fig. 10.5).

In the flooded forests, people are currently impacted by climate change and need to adapt to climatic intensifications. Floods kill terrestrial mammals and drought kills off fish, and recent historic floods and droughts have resulted in many die-offs (Bodmer et al. 2017). Mammal populations can be reduced under such circumstances, and, indeed, this occurred during the historic floods of 2012 and 2015, resulting in a 95% decrease in wildmeat species populations in flooded forests (Bodmer et al. 2018).

When wildmeat species populations crashed because of intensive floods, the Cocama Indigenous people of the flooded forests in the Pacaya-Samiria National

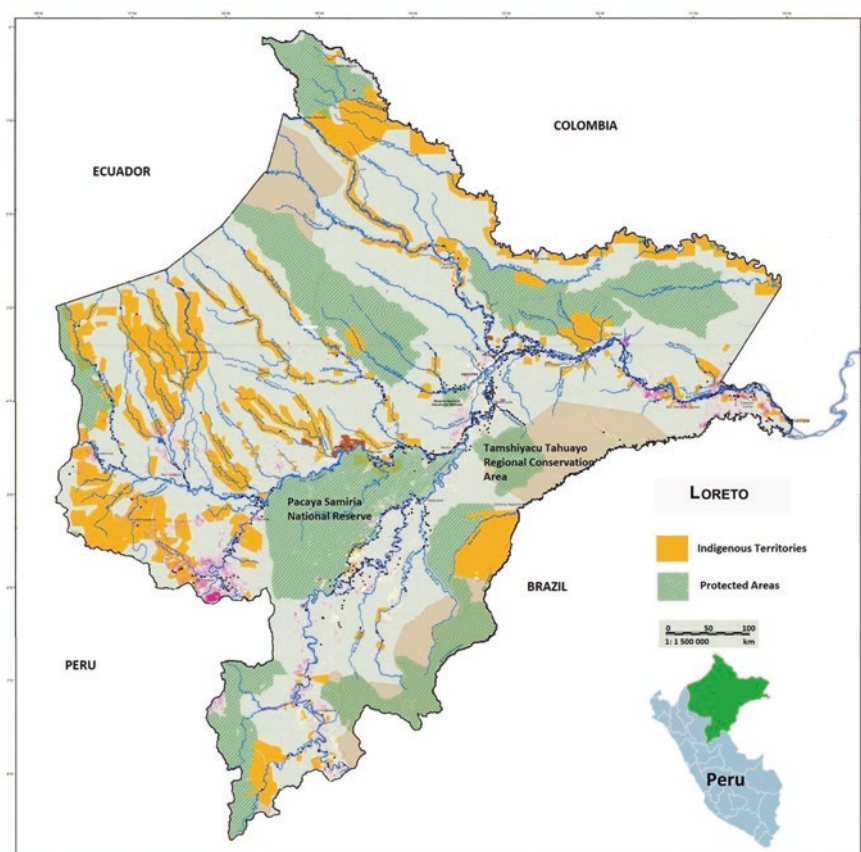


Fig. 10.5 Map of Loreto showing community Regional Conservation Areas and comanaged National Reserves (green), and Indigenous territories (orange) based on Soria and Rios (2016)

Reserve adapted to wildmeat population reductions by reducing their hunting because terrestrial mammals became scarce (Bodmer et al. 2020). When the people reduced hunting, they compensated by increasing their fishing activity since the intensive flooding resulted in increased fish populations (Rowcliffe et al. 2005). The decrease in hunting by the people was, therefore, an appropriate adaptive management action and the fish were harvested sustainably due to their increased populations.

The reduced hunting pressure by the Cocama allowed peccary, deer, and large rodent populations to increase during years of normal flood levels (Bodmer et al. 2020). It was important that the people did not hunt excessively during this period of recovery, and that is what the people did, again taking another appropriate adaptive management action. Both of the adaptive management actions were a combination of traditional resource use practices, and related to the peoples' concern about the decreased terrestrial mammal populations.

Well-established traditional knowledge systems and governance practices of Indigenous and Campesino peoples provide their conceptual basis to act as environmental stewards of their lands (IPBES 2019). A global assessment demonstrated the importance of Indigenous peoples' lands for biodiversity conservation. For threatened species, 26% of species have >50% of their habitat on Indigenous peoples' lands, and for threatened mammals, $\geq 10\%$ of their territorial range are found Indigenous peoples' lands, which show low human pressure (O'Bryan et al. 2021). Equally, the appropriate management actions taken by Indigenous people are probably linked to pre-Colombian cultural roots. The ancestral beliefs that go back to pre-Colombian times are consistent with the sustainable resource use of wildmeat species (Mayor et al. 2021). In contrast, the market driven economy of the twentieth century did not consider sustainable use and resulted in overexploitation. When Indigenous people became involved with resource management in community reserves and Indigenous territories, they were able to incorporate their traditional cultural practices, which created the current sustainability of subsistence hunting.

Wildlife management for subsistence hunting in other parts of the Amazon was also developed around community-based strategies and has had similar success as in Loreto. The International Conferences on Wildlife Management in Amazonia and Latin America has been important for the interchange of ideas, experiences, scientific results, and community involvement as these community-based wildlife strategies have been implemented in different countries.

The Indigenous territorial management strategy in the Madidi landscape of Bolivia has resulted in wildlife species and habitat conservation, and an increase in the economic benefits for the Indigenous people (Wallace et al. 2020). In French Guiana subsistence hunting is being included as part of the sustainable resource use and food security initiatives of Indigenous communities (Richard-Hansen et al. 2019). Likewise, in the Colombian Amazon Indigenous communities are managing wildlife resources using traditional use strategies and finding ways to manage market sales of wildmeat (Van Vliet et al. 2015a). All these countries, like Peru, permit subsistence hunting and have found that some form of community-based management has been successful in conserving the wildlife and habitats and improve local economies and traditional cultures.

Brazil differs from other Amazonian countries because hunting legislation is contradictory and oftentimes subject to arbitrary interpretation (Van Vliet et al. 2019). Non-Indigenous people, although permitted to register themselves as subsistence hunters and own guns, are only allowed to hunt when they are in a state of necessity, to quench their or their family's hunger. There is no definition in the law of what subsistence hunting means, and these undefined regulations leave hunters at the mercy of law enforcement and wildlife agents who interpret their "state of necessity." In fact, many agents tend to treat any form of hunting as a crime and penalize even local people living in inner parts of the Amazon with little access to urban goods. In addition, local people living outside protected areas cannot officially implement sustainable wildlife use. Those living inside some categories of protected areas can manage their resource use sustainably as shown in the Mamirauá and Amanã Sustainable Development Reserves; however, hunting is not part of the

permitted uses, which focus on fish, sustainable agriculture, and timber and non-timber forest products (Lima and Peralta 2017). Indeed, this unmanaged hunting has led in some cases to overuse, indiscriminate wildlife trade and species population declines (Peres 2000). In Brazil, wildlife use is allowed inside Indigenous territories and many Indigenous people practice traditional hunting systems that conserve healthy populations of species and intact habitats and have similar biodiversity as fully protected areas (Qin et al. 2023).

The prohibition of hunting is based on a protectionist strategy using control and vigilance, whereas sustainable use of wildlife is based on science and traditional use. The scientific method is characterized by being more deductive, empirical, systematic, controlled, and based on hypotheses, with established protocols agreed to test a consistent model through control of a limited number of factors and representing a discontinuous fraction of reality (Sillitoe 2017). In contrast, traditional use is based on ancestral knowledge and a conceptual understanding of the forest. Local ecological knowledge (LEK) is an epistemological construction, as valuable as scientific knowledge (Braga-Pereira et al. 2021). LEK has direct practical concerns and is considered more inductive, subjective, and tacit (Sillitoe 2017). LEK is built from the spontaneous assessment of a world that changes irregularly during daily experiences, and dialogue with others. All the experiences that connect the local population with nature are analyzed and systematized as a holistic, complementary, and indivisible vision of the world, being dynamic, adaptive, and a product of local-global interactions (Braga-Pereira et al. 2021). These parallel approaches when combined lead to the same outcome: subsistence hunting can be managed through community-based approaches.

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