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Sustainability of Hunting in Community-Based Wildlife Management in the Peruvian Amazon

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Abstract: Conservation strategies that use sustainable use of natural resources through green-labelled markets generally do not recognize the legal sale of wild meat as appropriate due to potential overexploitation and zoonotic disease risks. Wildlife hunting is important to the livelihoods of rural communities living in tropical forests for protein and income. Wildlife management plans in the Peruvian Amazon permit hunting of wild meat species for subsistence and sale at sustainable levels, that include peccaries, deer, and large rodents. These species have fast reproduction making them less vulnerable to overhunting than other species. This study assessed the sustainability of a wildlife management plan. Populations of species were estimated using camera traps and distance transect surveys, and sustainability analysis used hunting pressure from community hunting registers. Interviews were conducted to understand hunters, perceptions of the management plan. Long-term time-series showed increases in collared peccary (3.0 individual/km^2 to 5.41 individual/km^2) and white-lipped peccary (3.50 individual/km^2 to 7.00 individual/km^2) populations and short-term time series showed a decline in paca populations from 8.5 individual/km^2 to 3.01 individual/km^2. The unified harvest analysis showed permitted species populations were greater than 60% of their carrying capacities and hunted at less than 40% of their production, which shows sustainable hunting. The wildlife management plan achieved its general objective of sustainable hunting and improving livelihoods. The broader question is whether sustainable wildlife use plans that allow Amazonian communities to sell limited amounts of wild meat can be a way to change illegal wild meat trade to a legal, green labelled trade with added value.

Keywords: Peruvian Amazon; management plan; neotropical mammal species; sustainable hunting; indigenous communities; community-based conservation; wildlife population modeling; indigenous hunting practices

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1. Introduction

Community managed areas that permit traditional resources for peoples, livelihoods both for subsistence and sale are now commonly incorporated into conservation strategies, and generally include agroforestry products, fish, palm fruits, and handicrafts [1]. A green economy is emerging from community managed areas with sustainably harvested products being sold in the green-labelled markets [2]. Most of the products are accepted as appropriate by the broader international conservation community. However, the legal

commercial use of wild meat is generally not recognized as appropriate due to potential overexploitation and zoonotic disease risks [3,4].

In tropical rainforests, wildlife hunting is important to the livelihoods of rural communities as a source of protein and income, and for its social and cultural importance [5,6]. Indigenous communities have been hunting since pre-Columbian times and hunting is still practiced today [7]. Hunting in tropical forests is done mainly for subsistence or local sale and not for recreation [8]. Mammals provide wild meat for subsistence and sales, and for purchasing basic necessities, however, hunting can lead to population declines [9,10].

Unregulated hunting worldwide during the 1950s to early 1970s caused substantial population declines of wildlife, resulting in the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), national wildlife legislation, and management actions [11,12]. Peru permits subsistence hunting by Indigenous and Campesino communities in the Amazon of certain wild meat species through laws enacted in 1976 (no 21147), 2000 (no 27308) and 2011 (no 29763). Subsistence hunting is being managed in community reserves, co-managed protected areas, and Indigenous territories [13]. The subsistence hunting laws do not permit the sale of wild meat, however over the past 45 years people have been selling wild meat openly in the urban markets with only sporadic control, and 88% of the mammalian meat sold, is from deer, peccaries, and large rodents [14].

The legal sale of wild meat of deer, peccaries, and large rodents can be done if communities have a wildlife management plan authorized by the Peruvian Forestry and Wildlife Service (SERFOR) or the Peruvian Protected Area Service (SERFOR). Indigenous communities in three community co-managed protected areas in the Loreto Region of the Peruvian Amazon have obtained wildlife management plans. The plans include quotas based on hunting sustainability analysis, community agreements, wildlife habitat conservation, and source-sink areas [15].

The Peruvian Amazon of the Loreto Region is an area that has a history of wildlife use, research, and community involvement in wildlife management [11]. Overhunting during the late 20th century is now being changed to more sustainable hunting in community managed and co-managed areas [13]. The Indigenous people who manage these areas use a variety of resources including fish, palm fruits, agroforestry produce, and wild meat for subsistence use and sale. The communities prioritize collective decision-making, sustainable resource use, respect for ancestral knowledge and ecological balance, reflecting their cultural and social beliefs integral to their lifestyle [16]. Wild meat is more important as a subsistence resource and has a lower percentage sold than other resources, such as agriculture, fish and palm fruits, which have higher volumes sold in the markets [17,18].

Community reserves in the Peruvian Amazon have been working on wildlife management over the past three decades [13]. 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 [19].

Hunting is considered sustainable if, (a) harvest doesn't exceed production, (b) management goals are clearly specified and (c) biological, social and political conditions are in place allowing appropriate use and effective management [7]. In-depth monitoring of hunting is a key prerequisite for sustainable use of wildlife, avoiding population declines of species while acknowledging the rights of Indigenous peoples to food, land, traditions, and culture [20].

The wildlife management plans in Loreto use wildlife population status and community agreements to permit a limited number of species for hunting of wild meat for consumption and/or commercial sale, that include the collared peccary (*Pecari tajacu*), white-lipped peccary (*Tayassu pecari*), red brocket deer (*Mazama americana*), grey brocket

deer (*Mazama nemorivaga*) and lowland paca (*Cuniculus paca*). These species have evolved higher reproduction rates and density-dependent responses making them less vulnerable to overhunting than other species and more appropriate as wild meat species [9,21]. Quotas for commercial extraction are used for species permitted to be hunted. Hunting of mammals such as black agouti (*Dasyprocta fuliginosa*), nine-banded armadillo (*Dasypus novemcinctus*) and coatis (*Nasua* sp.) are only permitted for subsistence [15]. The plans prohibit the hunting of lowland tapir (*Tapirus terrestris*), giant anteater (*Myrmecophaga tridactyla*), giant armadillo (*Priodontes maximus*), manatee (*Trichecus inunguis*) and all species of primates, sloths and carnivores. These mammals have slower reproduction rates, and their populations decline when hunted making them vulnerable to overhunting [10].

This study examines how community led wildlife management plans that permit limited commercial sale of wild meat can conserve biodiversity and help the livelihoods of local people in the Amazon. Commercial sale of wild meat under the subsistence hunting laws is prohibited but occurs on a regular basis. The wildlife management plans that permit limited commercial sale of wild meat better reflect the reality of hunting in the Amazon. This study provides the scientific analysis of the sustainability of a wildlife management plan being implemented by Indigenous people for their subsistence hunting and legal wild meat sales. We assessed population trends and sustainability of mammal species permitted to be hunted along with understanding community perspectives towards the management plan. It is important to understand if wildlife management plans that allow subsistence and commercial use of wild meat by Indigenous communities are sustainable and have positive impacts for biodiversity conservation. The findings from wildlife population assessments and community opinions will help in understanding if limited commercial use of wild meat can help to find a solution to the widespread illegal sale of wild meat, by converting it to legal sales through sustainable hunting plans.

2. Materials and Methods

2.1. Study Area

The Tamshiyacu-Tahuayo Community Reserve (TTCR) is in northeastern Peru in the department of Loreto. It is in zone 18 of the UTM projection system between coordinates 680 075 E, 9 528 176 N and 768 162 E, 9 444 073 N with a total area of 420,080.25 ha. It is in the Tahuayo and Blanco River basins, in the upland (*terra firme*) forests dividing the Amazon and Yavari rivers. The average temperature is 26 °C, reaching 40 °C maximum and 14 °C minimum. The relative humidity is 85% with varied annual precipitation between 2800 to 3200 mm.

The Loreto regional government created the Tamshiyacu-Tahuayo Community Reserve (TTCR) in 1991 that was then nationally recognized in 2009 through Supreme Decree (D.S.N° 010-2009-MINAM) [22] as a Regional Conservation Area issued by the Ministry of Environment. The area has high biodiversity in upland, flooded and aquatic habitats. It was the first community reserve in Peru, providing land and management rights to the Indigenous and Campesino communities near the area [15,23]. It is governed by local communities through a management plan which is updated every five years. The plan aims to look after the environmental, economic and social aspects of the area [15]. The communities involved are Buena vista, El Chino, San Pedro, Diamente/7 de Julio and Nueva Jerusalén. These communities have an authorized wildlife management plan that establishes rules in managing the hunting of species for consumption and sales. The plan includes the number of individuals per species that can be extracted, the frequency of extraction, hunting areas, and the permitted hunting strategies [14]. This protected area has three zones: (1) a recreational zone, for tourism and settlements; (2) a zone of direct

use, designated for sustainable use of natural resources, and (3) a fully protected zone that prohibits extractive activities.

This study was in the zone of direct use within the 39,681.76 ha zone that can be used for hunting. The study site was in the upland forests of the Blanquillo stream, a tributary of the Tahuayo River in the forests managed by the community of Nueva Jerusalén which was the focal community of this study. The community is of Achuar origin and is on the banks of the upper Tahuayo River. The community practices subsistence hunting, fishing, agriculture, palm fruit collection, handicrafts, and small-scale ecotourism and is one of the five communities involved in the governance of the TTCR. Hunting in this community is done by male members of the family, and they use 16-gauge shotguns which is the only shot that can be bought from shops. The sale and licensing of guns and shots are regulated by government authorities. Hunters are required to register their shotguns with local police.

2.2. Data Collection

Field visits were made to the Blanquillo stream where Nueva Jerusalen has its hunting area to collect mammal data with camera traps and distance transects during the years 2019 to 2024. Between 16 to 22 camera traps were set up annually in the study site for an average of 75 days along transects of 3–5 km in length. Cameras were set in good locations with no pre-determined knowledge of the mammal abundance. On distance transects, mammals were recorded by sight and records were taken on their group size, location and perpendicular distance to the transect.

Visits were made to the community of Nueva Jerusalén to study their hunting preferences and views on the management plan. We interviewed 11 out of the 13 families in the community, as two of the families weren't in place at the time of our visits. We chose the hunting member of each family, to avoid any data repetition and keeping the responses unbiased and independent. We made sure that each participant was above the age of 18 and male as they are the hunting members of the family. This research study and associated interview questionnaire was ethically approved by the School of Anthropology and Conservation, University of Kent, UK (ethical approval #20241710766962600). The interviews were divided into three sections to analyze (1) what species hunters usually use, (2) how hunters value the management plan and (3) how hunters register the animals harvested (see Appendix A). All the interviews were recorded with the consent of the participant hunters for data and transcription.

2.3. Data Analyses

Camera-trap and Distance transect data were used to estimate species densities. Camera traps were analyzed using capture rates as mcd (1000 camera days) and independent observations of individuals using 24-h intervals. All individuals in a group were counted and capture rates were calculated as individual/mcd which is a measure of abundance.

Densities (individual/km^2) were calculated using factor analysis (correlation analysis that yields a factor) from 18 species/sites where camera traps were placed on the same trails as Distance transects. We assume that average camera trap detection rates between transects are proportional to differences in density. Only those species that were seen on both cameras and transects could be used. This allowed us to obtain the factor that can convert individual/mcd to individual/km^2 by comparing the individual/mcd of a species from cameras to the individual/km^2 of the same species from transects. The mean proportion of mcd to individual/km^2 gave a result of 0.08 (Supplementary Material). This factor was used to estimate the densities from camera trap as 0.08 $\times$ individual/mcd = individual/km^2.

Densities using the factor estimate were compared to the Random Encounter Model (REM) [24,25]. Previous studies of temperate mammals found REM to be higher than

other density estimates. REM estimates were greater than the factor estimates in our analysis (Supplementary Material) and we chose the factor analysis over REM, since smaller densities have less error in accepting sustainability analysis.

The mcd,s for peccaries, deer, large rodents and tapir were calculated for every 15 days to reduce variance using the formula (N/CD) × 1000, where N was the total number of individuals recorded in the camera traps and CD were the camera days (total number of cameras × 15 days). The mcd,s were used to check for statistical differences in the abundance of the mammals between the years 2019 to 2024 using one-way Analysis of Variance (ANOVA) in RStudio 2024.12.0+467. The mean densities from the factor analysis of peccaries, deer and large rodents were used for short-term time-series analysis in RStudio. For peccaries, long-term time-series used previous and newly calculated mean densities in RStudio. Primate densities were calculated using fixed-width analysis from transect data. The surveyed area (km^2) was calculated using the total transect length and pre-determined fixedwidth (0.04 km). Pivot tables on Microsoft Excel [26] were used to calculate the sum of each primate species and to calculate mean density of each species in the survey area.

Interviews were transcribed using Microsoft Word. Post transcription, content analysis was done to find quantitative (mammals hunted) information while thematic analysis was done to find qualitative (hunters' perceptions of the management plan) information using NVivo Release 14.23.3 (61). The number of hunted mammals obtained were extrapolated to 13 families for the sustainability analysis.

To assess the sustainability of the hunting, we used the unified harvest model [27] which combines the stock-recruitment model [28] and harvest model. For stock-recruitment analysis, mean densities (N) from the factor analysis were calculated using Microsoft Excel and carrying capacity (K) used densities from previous studies conducted in non-hunted areas [29] and were used to calculate the proximity of a harvested population (N) to the carrying capacity as a percentage. To evaluate sustainable hunting of faster-reproducing species (peccaries, deer and large rodents) the percentage of the hunted population was compared to estimated carrying capacity (N/K) which should be ≥60% to be considered sustainable [13]. Stock-recruitment analysis was done for collared peccary, white-lipped peccary, black agouti, red brocket deer and grey brocket deer using the equation (N/K) × 100.

The harvest analysis estimates the percentage of production hunted, using the annual rate of production and annual hunting pressure. Annual production (P) (individual/km^2) was estimated using the formula: P = (0.5D) × (Y × g). Where 'Y', is the gross reproductive productivity (number of young/number of females), 'g', is the average number of gestations per year multiplied by litter size, and '0.5D', is half of the population density assuming a 1:1 sex ratio. The gross reproductive productivity and litter size was obtained from previous studies [30,31] while density was obtained from field surveys. The annual hunting pressure (H) (individual/km^2) was obtained by number of individuals hunted (obtained from interviews and hunting registrars) × Catchment area (72 km^2 for this community [15]). The calculation for the percentage of production hunted was: (H/P) × 100. Harvest analysis was done for white-lipped peccary, collared peccary and lowland paca. The harvest rate was considered sustainable if the percentage of production hunted was ≤40% for faster-reproducing species (peccaries, deer and large rodents) and ≤20% for slower reproducing species (tapirs and primates) [13].

3. Results

3.1. Population Time-Series

Short-term time-series graph for collared peccary, white-lipped peccary (For short-term time series, the total number of groups of white-lipped peccary was considered, since

their total number of individuals was significantly more than other mammals), red brocket deer, grey brocket deer, lowland paca and black agouti was done for the years 2019 to 2024, using the mean densities obtained for each species (Figure 1a). The white-lipped peccary was found to be the most abundant mammal ($F_{5,221} = 10.12$, $p < 0.001$). Population trends observed for collared and white-lipped peccary appeared to be stable. The white-lipped peccary was more abundant than the collared peccary ($F_{1,72} = 9.13$, $p = 0.003$). Both red and grey brocket deer showed stable populations, with grey brocket deer being more abundant than red brocket deer ($F_{1,74} = 48.7$, $p < 0.001$). Black agouti population trends appeared stable and more abundant than the lowland paca ($F_{1,74} = 4.468$, $p = 0.038$). The population of lowland paca showed a weak but significant decline from 2019 to 2024 ($y = 1944.36 - 0.96x$, $r^2 = 0.24$, $p = 0.001$).

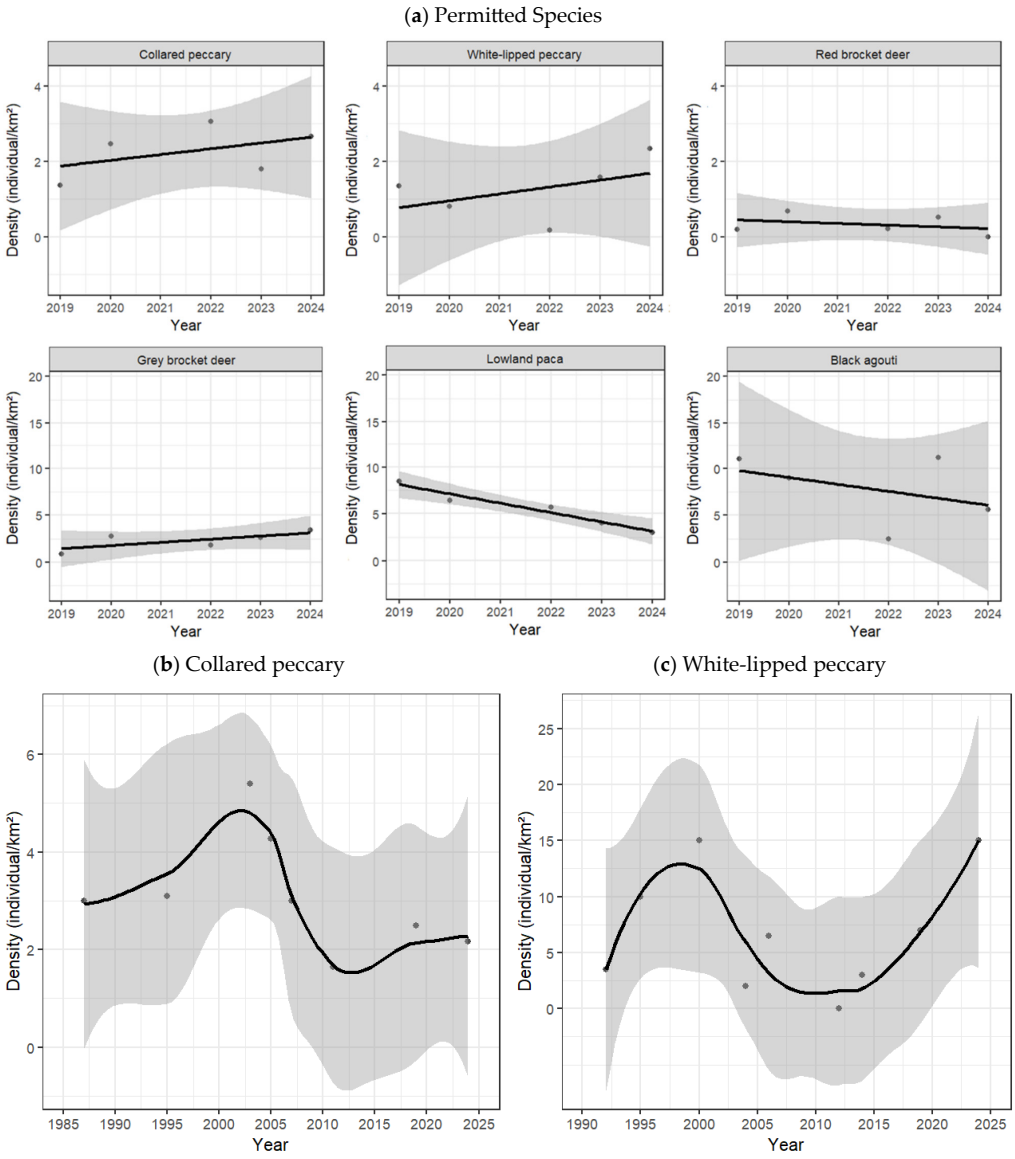

Figure 1. Population time-series graphs with dots showing the annual densities, and the lines showing mean trends. The population trends of mammalian densities (individual/km^2) were of (**a**) collared peccary (*Pecari tajacu*), white-lipped peccary (*Tayassu pecari*), lowland paca (*Cuniculus paca*), black agouti (*Dasyprocta fuliginosa*), red brocket deer (*Mazama americana*) and grey brocket deer (*Mazama nemorivaga*) from 2019 to 2024, (**b**) collared peccary from 1985 to 2024 and, (**c**) white-lipped peccary from 1992 to 2024, after the implementation of the management plan in 1991 with the grey shaded area representing a 95% confidence interval (CI).

Long-term time series of population densities of collared peccary from 1987 to 2024 and white-lipped peccary from 1992 to 2024 showed an increase in population density of both species post-implementation of the community reserve in 1991 (Figure 1b,c). Since then, the populations have fluctuated over multiyear periods, but over the long term the fluctuations have been stable. In both short-term and long-term time series when white-lipped peccary populations decreased, collared peccary populations increased and vice versa. For instance, this was seen in 2022 for short-term time series and in 2004 for long-term time series.

3.2. Content Analysis

Content analysis using NVivo and Microsoft Excel of interviews of 11 participants showed that the hunters preferred to hunt white-lipped peccary, lowland paca, collared peccary and black agouti. None of the hunters hunted any non-permitted species including primates, tapirs, manatees, felines or river otters. The mammal that was hunted and sold the most was the white-lipped peccary (58 hunted and 41 sold) followed by the lowland paca (49 hunted and 32 sold) (Figure 2). Collared peccary and black agouti were hunted infrequently, and only one red brocket deer was hunted and no grey brocket deer. The total cash income from wild meat sales was USD 1,566. Hunters sold wild meat in the markets of the town of Nauta and in markets and restaurants of the city of Iquitos. Hunting locations were both distant from the village of Nueva Jerusalén like the Blanquillo stream area and closer to the village on the Tahuayo River.

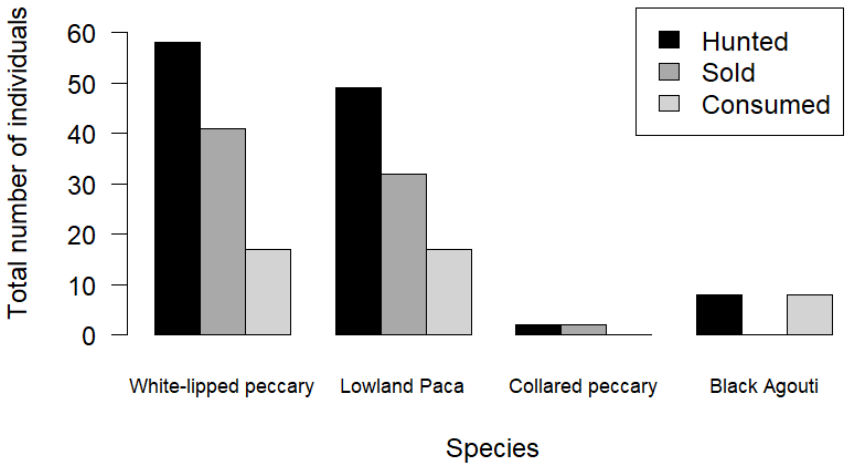

Figure 2. Bar graph of total number of mammal species hunted, sold, and consumed by the communities in the year 2023 and April 2024 observed from the interviews indicating the hunting preferences of the community members of Nueva Jerusalen.

3.3. Unified Harvest Model

The unified harvest analysis used stock-recruitment and harvest analysis to determine if hunting was safe and sustainable. Stock-recruitment analysis used mean densities at the hunted site and carrying capacities from previous studies done in non-hunted areas of the same forests [29]. Both white-lipped peccary and collared peccary had populations above 60% of carrying capacity, which is considered safe. Grey brocket deer and black agouti had populations greater than their estimated carrying capacities, which suggests they are at a high point in their multiyear population fluctuations. The red brocket deer was below 60% of the carrying capacity, which is at a greater risk than other species and suggests that this species is at a low point in its multiyear population cycles (Table 1).

Table 1. The proximity of collared peccary (*Pecari tajacu*), white-lipped peccary (*Tayassu pecari*), red-brocket deer (*Mazama* americana), grey-brocket deer (*Mazama nemorivaga*) and black agouti (*Dasyprocta fuliginosa*) to their carrying capacities (K). This was determined using mean density (N) from 2024 and defined carrying capacity (K) from previous studies [29].

Species	English Name	Mean Density ± SD (N) (Individual/km^2)	Estimated Carrying Capacity (K) (Individual/km^2)	$\frac{N}{K} \times 100$	Conclusion
Pecari tajacu	Collared peccary	2.17 ± 0.60	3.00	72.33	Safe
Tayassu pecari	White-lipped peccary	14.99 ± 11.07	15.00	99.93	Safe
Mazama americana	Red brocket deer	0.36 ± 0.18	0.70	51.43	At risk
Mazama nemorivaga	Grey brocket deer	2.17 ± 0.79	0.43	504.65	Safe
Dasyprocta fuliginosa	Black agouti	8.46 ± 0.67	2.91	290.72	Safe

The percentage of production hunted was determined in the species most frequently hunted, collared peccary, white-lipped peccary and lowland paca. The percentage of production hunted for all the species was less than 40%, which suggests a safe harvest (Table 2). This percentage was lower for peccaries compared to the paca. Both the stock-recruitment and harvest analysis showed that white-lipped peccary, collared peccary and lowland paca were hunted at safe levels and had safe populations close to their carrying capacities, which suggests sustainable hunting in the unified harvest analysis.

Table 2. Percentage of production hunted for collared peccary (*Pecari tajacu*), white-lipped peccary (*Tayassu pecari*) and lowland paca (*Cuniculus* paca) in the direct use zone of Nueva Jerusalén in the TTCR. Data are from field census, interviews and previous studies [30,31].

Species	*Pecari tajacu*	*Tayassu pecari*	*Cuniculus paca*
Gross production (Y)	0.76	0.57	0.62
Average gestations per year/Litter-size (g)	2.00	1.65	1.02
0.5 × Density	1.08	7.49	3.04
Annual production (P)	1.64	7.04	1.92
Individuals hunted	8	51	40
Annual Hunting pressure (H)	0.11	0.71	0.56
% production hunted	6.70	10.08	29.17

3.4. Thematic Analysis

Thematic analysis used NVivo to understand hunters, perspectives on the management plan. All the participant hunters said that the management plan is important to them. Figure 3 (All figures were created using RStudio, however analysis was done on NVivo) shows the percentage response to what the hunters value in the management plan. (a) All of the hunters said the management plan was important to them because it regulates hunting. (b) Hunters said that the management plan is working for them, firstly for the conservation value, secondly for the subsistence meat value, and thirdly for the income. (c) Hunters said that both large and small mammals were favored by the management plan. (d) Hunters said that peccaries were the most important mammals for the management plan followed by the paca and brocket deer.

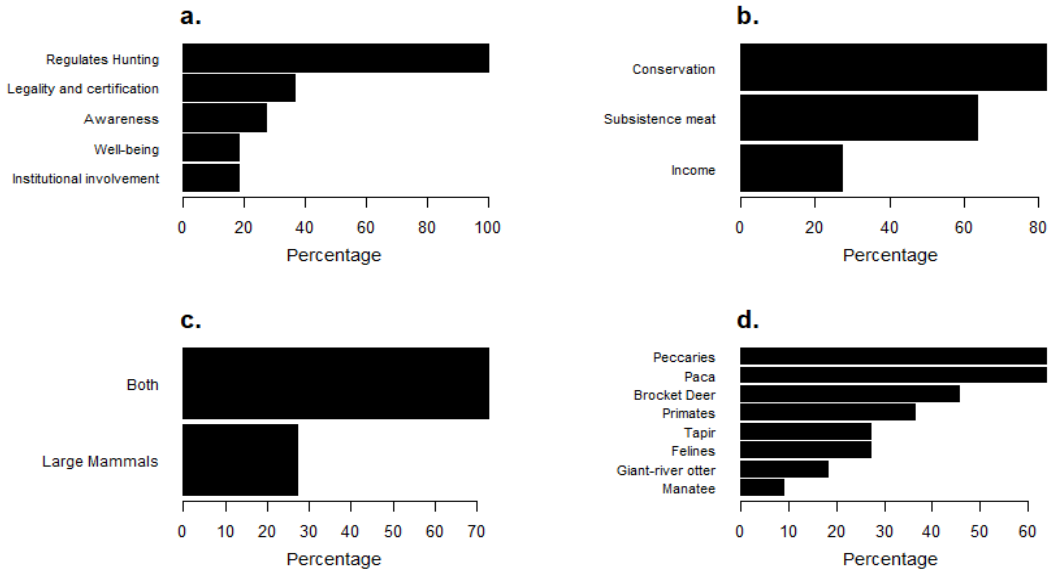

Figure 3. Horizontal bar graphs showing percentage responses of hunters to (**a**) why the management plan is important to them? (**b**) In what way is the management plan working for them? (**c**) whether small, large or both mammals are favored by the management plan, and (**d**) which mammal is the most important for the management plan.

The wild meat sales have increased from USD 2.14–USD 2.67 per kg before the plan when meat was sold illegally in the markets to USD 8.01–USD 10.68 per kg after the plan where meat is sold legally in markets and to restaurants. All the participant hunters registered the animals they hunted, however two of them registered only those that they sold. Hunters usually go in groups of two to three people, travelling a full day by motorized canoe to the hunting areas.

The information on the register used by the hunters included: name of hunter, dates of departure/return, distance travelled, number and species hunted, sex, location hunted, date of hunt, hunting method, animals sold, place sold, and animals consumed (Figure 4). The section that was most complete was the number and species hunted that had 90.91% register. Hunters pay a fee to the community for each animal they hunt. For large animals including collared and white-lipped peccary and red-brocket deer they pay USD 0.80 to the community while for grey-brocket deer and paca hunters pay USD 0.53. This payment is used by the community for education and other social and health services.

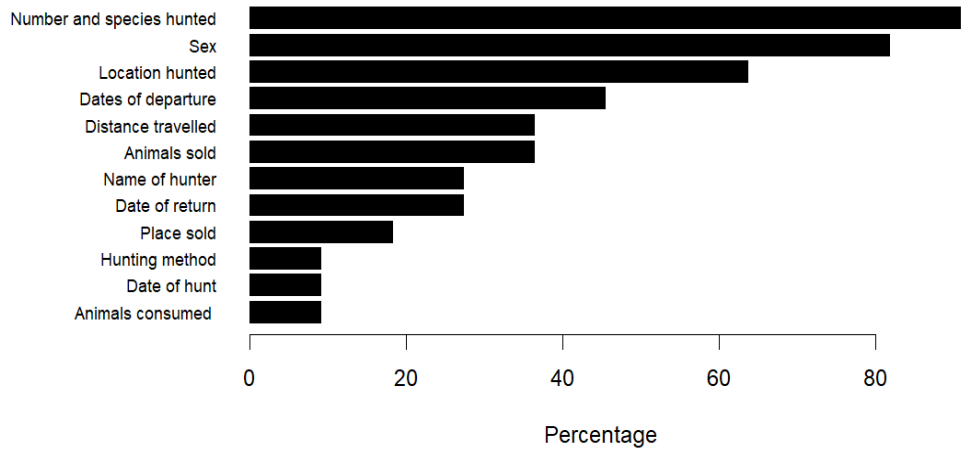

Figure 4. Horizontal bar graph indicating percentage responses of hunters to what hunters from the community of Nueva Jerusalen register in their hunting registrars, which is important for wild meat certification and sales purpose.

3.5. Tapirs and Primates

Hunting of tapir and primates are not permitted in the management plan and were studied to see if these species are benefitting from the plan. Mean density of the lowland tapir (1.18 ± 0.41) showed a large population that was greater than the estimated carrying capacity of tapir from previous studies. Mean densities of primates were calculated using fixed-width analysis from the line transect data. The densities of primates showed some species to be above their estimated carrying capacities, and others below, with the area having healthy populations of primates relative to their carrying capacities (Table 3). Furthermore, interviews revealed that the tapirs and primates have greater tourism value, and the hunters are discouraged from hunting them.

Table 3. Percentage production rates of lowland tapir (*Tapirus terrestris*) and primates sighted namely bald-headed uakari monkey (*Cacajao calvus*), coppery titi monkey (*Callicebus cupreus*), white-fronted capuchin (*Cebus yuracus*), woolly monkey (*Lagothrix lagothricha*), monk-saki monkey (*Pithecia monachus*), moustached tamarin (*Saguinus mystax*), squirrel monkey (*Saimiri* sp.), brown capuchin (*Sapajus apella).* The rate is determined using mean density (N) from 2019 to 2024 and defined carrying capacity (K) from previous studies [29].

Species	English Name	Mean Density ± SD (N) (Individual/km^2)	Estimated Carrying Capacity (K) (Individual/km^2)	$\frac{N}{K} \times 100$
Order: Perissodactyla				
Tapirus terrestris	Lowland Tapir	1.18 ± 0.41	0.31	380.65
Order: Primates				
Cacajao calvus	Bald-headed Uakari	8.19	4.94	165.78
Callicebus cupreus	Coppery Titi monkey	4.37	11.84	36.90
Cebus yuracus	White-fronted capuchin	3.82	5.58	68.45
Lagothrix lagothricha	Woolly monkey	14.2	24.50	57.95
Pithecia monachus	Monk-saki monkey	5.73	10.51	50.42
Saguinus mystax	Moustached Tamarin	11.47	30.49	37.61
Leontocebus nigrifrons	Saddled-back Tamarin	7.65	22.63	33.67
Saimiri sp.	Squirrel Monkey	18.3	45.90	39.86
Sapajus apella	Brown Capuchin	28.32	10.20	277.64
Total primates		102.05	166.59	61.25

4. Discussion

The specific objective of the Tamshiyacu-Tahuayo Community Reserve (TTCR) management plan is to carry out hunting of collared peccary, white-lipped peccary, red brocket deer, grey brocket deer and lowland paca through management rules that help ensure their sustainable use [15]. The broader aim is to have sustainable wildlife use plans that allow Amazonian communities to sell a limited amount of wild meat which aligns with the reality of hunting by Amazonian people and investigate whether illegal wild meat trade can be converted to a legal, green labelled trade that increases the economies of local communities through added value.

The Loreto Region spans over 382,000 km^2 of the western Amazon and this region has implemented community-based protected areas and Indigenous territories in over 60% of the area [13]. These community managed areas use traditional resources for peoples, livelihoods both for subsistence and sale, and generally include agroforestry products, fish from managed lakes, palm fruits collected by climbing, turtles from head-starting programs, handicrafts made by the women, and wild meat from managed wildlife use areas. An Amazon green economy is emerging from the community managed areas with products

being sold in the green labelled markets. The broader international conservation community accepts most of the products as appropriate. However, due to potential overexploitation and zoonotic disease risks the legal commercial use of wild meat is generally not recognized as appropriate [32–34]. Thus, wildlife regulations in Amazonian countries prohibit the sale of wild meat, except in the Loreto Region, where there are three areas permitting wild meat sales through approved management plans.

Community-based wildlife management is more successful if it aligns with the cultural and socioeconomics of the communities along with flexibility [35]. Our findings showed that the plan has been successful in achieving sustainability towards hunting and resource use. Population time-series and unified harvest models for the permitted species indicate stable and sustainable populations. Species not permitted in the plan have large and healthy populations. Interviews with the hunters showed that the management plan is respected and adhered to.

4.1. Population Trends of Mammals

The population trends for collared peccary, white-lipped peccary, black agouti, red brocket deer and grey brocket deer indicated stable populations as observed from short-term time series, while paca showed a weak decline. The population of white-lipped peccary and collared peccary increased post-implementation of the management plan as observed from the long-term time-series. Both species have a sympatric association in the Amazonand have dietary overlap [36]. In certain years, it was observed that collared peccary populations decreased when white-lipped peccary populations increased and vice versa, which could be due to spatial or temporal competition between the species happening [37] due to different diel periods as seen in Northern Pantanal, Brazil [38]. White-lipped peccaries tend to outperform collared peccaries at acquiring resources and sometimes kill infant collared peccaries because of interspecific aggression as reported by Carrillo and Fuller [39] in Costa Rica. Heterospecific aggression, being common in animals, has a strong relationship with resource overlap suggesting a form of interference competition [40]. Similar observations were reported by Kiltie and Terborgh [41] in Peru, and white-lipped peccaries occupy greater areas than collared peccaries due to different seasonal movement patterns as observed in Southeastern Brazil [42]. White-lipped peccaries are more susceptible to food shortage and habitat disturbance [43] showing greater reliance on high value food resources like fruits and seeds compared to the more omnivorous collared peccary [40,44,45]. This may explain why white-lipped peccary were more abundant than collared peccary from 2019 to 2024.

The decline of the lowland paca in 2024 could be due to the ongoing Amazonian drought and interspecific competition with white-lipped peccaries along with hunting. Paca reproduction increases during high-water levels when fruit production is high [46]. Furthermore, indirect-interspecific competition for food between paca and white-lipped peccary can affect the populations and the larger white-lipped peccary populations may result in decreased food availability for the paca. However, paca populations can recover quickly as observed from the aftermath of the historic floods in 2012 to 2015.

The population of black agouti had high numbers. Red and grey brocket deer populations were stable with the grey brocket deer being more abundant than red brocket deer. The red brocket deer appears to be at a low point in its population whilst grey brocket deer and black agouti appear to be at high population levels. Like the collared peccary and paca, the red brocket deer might have direct competition with the high populations of white-lipped peccary, being of similar body size and having a frugivorous diet. In contrast, the smaller grey brocket deer and black agouti that have smaller body sizes might have less direct competition with the white-lipped peccary resulting in large populations.

4.2. Sustainability of Hunting and the Wildlife Management Plan

The unified harvest analysis showed that hunting appeared sustainable for the peccaries, deer and large rodents in the management plan area of the TTCR. White-lipped peccary was the most abundant mammal (2019 to 2024), and the most hunted species. The large populations and high reproductive rate of the white-lipped peccary means that the species can compensate for the hunted mortality.

Paca was the large rodent hunted the most and its meat is usually sold by hunters because of its market price. The paca appears to be hunted sustainably as its percentage of production hunted was below 40%. However, compared to the peccaries, this percentage was closer to the 40% limit used in the model. The paca has seasonal reproductive patterns [47,48], which might remain, even when population sizes reduce due to unknown climatic effects and highly seasonal food availability. The ongoing Amazonian drought in the past few years has resulted in low fruit availability, and high fruit availability is required by female pacas during pregnancies [46]. Unlike peccaries that consume invertebrates and small vertebrates when fruit is less available, or deer that can consume leaves, the paca relies heavily on fruits [49]. Thus, climate change being one of the contributing factors to the Amazonian drought, can negatively affect the seasonal reproduction of paca, making its population vulnerable to declines.

Black agouti was the second most hunted large rodent and showed a safe population. Compared to the paca, the agouti has a faster rate of reproduction. The red brocket deer had a smaller population than its estimated carrying capacity, which was risky while that of the grey brocket deer was safe. Intensive hunting inside forestry concessions or small Indigenous territories might deplete brocket deer populations [50–53]. Increased hunting within sustainable limits was observed in 1991 to 1998 [54] which might be one of the reasons along with historic floods [55] for a decrease in population. However, from the interviews, no significant hunting of red or grey brocket deer was observed. In places like the southern Brazilian Amazon, the brocket deer faces threats from habitat conversion [53] which is not the case in Peruvian Amazon as the community managed areas are not being deforested. Red brocket deer are likely to recover as they have fast reproduction rates and intrinsic rates of population increase [13,54].

Stock-recruitment analysis indicated a large population of tapirs and primates. Interviews suggested that hunters did not hunt any of the non-permitted species. Tapir meat is dark and oily and not preferred by the local people as it is difficult to digest [13,14]. Additionally, adult tapirs can weigh around 200 kg making it difficult to carry the hunted animals back home. Primates were prohibited from subsistence hunting and market sales in the 1976 wildlife law [14], but were still hunted until the implementation of the management plan. The hunters now acknowledge that primates are more vulnerable to hunting and should be protected. Furthermore, mammals like tapirs, primates, felines and river otters are considered charismatic species that have ecotourism value, and helps with the small-scale ecotourism of the communities. In contrast, peccaries, deer and large rodents have less ecotourism value because they are illusive and difficult to see and being prey species have good hiding abilities.

Interviews indicated a positive perception of hunters on the management plan. Communities are aware of the management plan and their responsibilities in conservation and sustainable hunting within the permissible limit. Thematic analysis showed that hunters think the most important mammals for the management plan are peccaries, deer and large rodents as they provide food and income.

The financial value for wild meat has increased twofold under the management plan with a significant added value, since wild meat is legally sold with a green label, authorization from the Forestry and Wildlife Service. Hunters acknowledged the importance of

the management plan and registering the animals hunted, which is needed for verification. Income generated by sales is used by the families, and the community charge is used for community activities. Under the plan, the biological, social and political conditions are met indicating clear management goals of community-based conservation.

Although the plan has helped in achieving sustainability, there are some aspects that should be considered. Hunting of the paca should be monitored closely due to its decreased density and harvest rates comparatively closer to the 40% limit. The ability of different prey to withstand various levels of harvest without depletion varies with the population dynamics of the species [56]. Paca is a high-valued meat in the wild meat markets [14], and our results showed that it was sold more than it was consumed. Paca populations recover more quickly from floods compared to droughts [46] and paca might be particularly vulnerable to climatic intensifications.

Intensifications in annual flood cycles due to climate change is a greater threat to mammalian populations than hunting [20,55]. During historically high floods populations of paca, peccaries, and deer deceased by 90% in flooded forests which was a magnitude greater than hunting impacts. Arboreal mammals were not impacted by the floods, including primates, since they could physically escape the water, and lowland tapir were able to overcome the floods due to their more aquatic nature [55].

Hunting by Amazonian people is a pre-Columbian activity that continues to this day throughout the Amazon basin. Studies have shown at archaeological sites in Loreto that biodiversity was maintained over thousands of years and pre-Columbian resource uses did not negatively impact the rainforest biodiversity [57]. However, over the years this practice has seen changes in methods as well as in management. For instance, subsistence hunting is legal in Peru along with Bolivia, Colombia and French Guiana, but it is still prohibited in Brazil [11]. A shift in management has been observed from simply listing permitted species in the past to now working with Indigenous communities on management plans [58]. Beyond the Neotropics, community-based management plans are observed in different forms. In Alaska, community-based subsistence hunting by the Indigenous Inupiat communities is carried out under the Alaska National Interest Lands Conservation Act (ANILCA) which permits hunting of whales, polar bears and seals only for self-consumption [59]. In Canada, the First Nations based near the Peace River region are permitted hunting for venison for self-subsistence under Treaty 8 of 1898 [60]. In Australia (South, Western and Northern Territory), Aboriginal people have substantially unrestricted access to pastoral land in order to hunt for food [61,62].

What makes the TTCR wildlife management plan unique is that it incorporates limited wild meat sales. Incorporating limited commercial use of wild meat does not result in overhunting, but quite the opposite, it results in more robust community-based conservation with benefits to biodiversity and local people. Our study shows how traditional hunting practices used today can be managed by local people according to an official wildlife management plan that encourages sustainable hunting levels and maintains high diversity intact rainforest. In the community-based protected areas people keep the forests intact to maximize wildlife populations which in turn conserves the entire biodiversity.

5. Conclusions

Conservation strategies that use sustainable use of natural resources by local people in tropical forests include agroforestry products, fish, palm fruits, and handicrafts which is part of an emerging green economy through green-labelled markets. However, the legal commercial use of wild meat is generally not recognized as appropriate due to potential overexploitation and zoonotic disease risks. Wildlife hunting is a traditional activity important to the livelihoods of rural communities living in tropical forests as a source

of subsistence protein and income. This study evaluated a wildlife management plan in the Loreto region of the Peruvian Amazon that permits a limited number of wild meat species for subsistence hunting and commercial sale. The Tamshiyacu-Tahuayo Community Reserve (TTCR) wildlife management plan has been successful in achieving its general objective of sustainable hunting and improving the quality of community life. The broader question is whether sustainable wildlife use plans that allow Amazonian communities to sell a limited amount of wild meat can help change illegal wild meat trade to a legal, green labelled trade with added value. Population trends of permitted species were stable, and peccary populations increased post-implementation of the management plan. Hunting was done within sustainable limits and only of permitted species as observed from the unified harvest analysis and interviews.

Many countries in the tropics have successfully implemented different management plans. Loreto has had wildlife management within community reserves for decades and the wildlife management plan of the TTCR has been effective in conserving the populations of permitted (peccaries, deer and large rodents) and non-permitted (tapirs and primates) species while providing added value in legal meat sales to the hunters. However, these plans can be negatively affected by legislations not acknowledging Indigenous hunting and by impacts from climate change on species. Wildlife management plans should be implemented taking Indigenous traditions into consideration and working with communities.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su17030914/s1, Table S1: Species selected for the calculation of Dspp and mcdspp; Table S2: Comparison of the Factor and REM methods for estimating density of ungulates and large rodents.

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Appendix A Interview Questionnaire

Section A: Based on Hunting preferences:

(a) Which animals did you hunt last month, and how many of each kind did you hunt?
(b) Which animals did you hunt last year, how many of each kind, and in which month?
(c) How much meat did you sell and how much did you eat? How much do you earn from selling the meat, and where do you sell it?
(d) Which places do you usually hunt small animals, and where do you hunt big animals? How many hours does it take to get there by boat (*pequepeque*)?

Section B: Based on Management plan:

(a) Do you think the wildlife management plan is working for you? Why do you think that it is important to you?
(b) If yes, then in what terms? Like subsistence meat, income, conservation and/or traditional use?
(c) Do you think the management plan favors more towards small animals or large animals?
(d) What species do you think are most important for the management plan?
(e) Does the meat you sell have more value under the management plan or was it before?

Section C: Based on Hunting registrars:

(a) Do you register the animals that you hunt?
(b) Do you register all the animals you hunt or just the ones you sell?
(c) Do you only register the animals only mentioned in the management plan or all the animals?
(d) What type of information do you register in your registrar?
(e) How does the hunting the register work in terms of who records it?
(f) Is there a community payment on selling animals?

References

1. Agrawal, A.; Ostrom, E. Collective Action, Property Rights, and Decentralization in Resource Use in India and Nepal. *Politics Soc.* **2001**, *29*, 485–514. [CrossRef]
2. Edwards, D.; Laurance, S. Green Labelling, Sustainability and the Expansion of Tropical Agriculture: Critical Issues for Certification Schemes. *Biol. Conserv.* **2012**, *151*, 60–64. [CrossRef]
3. Fa, J.E.; Funk, S.M.; Nasi, R. *Hunting Wildlife in the Tropics and Subtropics*; Cambridge University Press: Cambridge, UK, 2022.
4. Van Vliet, N.; Mesa, M.P.Q.; Cruz-Antia, D.; de Aquino, L.J.N.; Moreno, J.; Nasi, R. The Uncovered Volumes of Bushmeat Commercialized in the Amazonian Trifrontier between Colombia, Peru & Brazil. *Ethnobiol. Conserv.* **2014**, *3*, 7. [CrossRef]
5. East, T.; Kümpel, N.F.; Milner-Gulland, E.J.; Rowcliffe, J.M. Determinants of Urban Bushmeat Consumption in Río Muni, Equatorial Guinea. *Biol. Conserv.* **2005**, *126*, 206–215. [CrossRef]
6. El Bizri, H.R.; Morcatty, T.Q.; Valsecchi, J.; Mayor, P.; Ribeiro, J.E.S.; Vasconcelos Neto, C.F.A.; Oliveira, J.S.; Furtado, K.M.; Ferreira, U.C.; Miranda, C.F.S.; et al. Urban Wild Meat Consumption and Trade in Central Amazonia. *Conserv. Biol.* **2020**, *34*, 438–448. [CrossRef]
7. Robinson, J.; Bennett, E.L. *Hunting for Sustainability in Tropical Forests*; Columbia University Press: New York, NY, USA, 2000.
8. Bennett, E.L.; Nyaoi, A.J.; Sompud, J. Saving Borneo's Bacon: The Sustainability of Hunting in Sarawak and Sabah. In *Hunting for Sustainability in Tropical Forests*; Robinson, J.G., Bennett, E.L., Eds.; Columbia University Press: New York, NY, USA, 1999.
9. Robinson, J.; Redford, K. Sustainable Harvest of Neotropical Forest Mammals. In *Neotropical Wildlife Use and Conservation*; University of Chicago Press: Chicago, IL, USA, 1991; pp. 415–429.
10. Peres, C.A. Effects of Subsistence Hunting on Vertebrate Community Structure in Amazonian Forests. *Conserv. Biol.* **2000**, *14*, 240–253. [CrossRef]
11. Grimwood, I. Endangered Mammals in Peru. *Oryx* **1968**, *9*, 411–421. [CrossRef]

12. Antunes, A.P.; Fewster, R.M.; Venticinque, E.M.; Peres, C.A.; Levi, T.; Rohe, F.; Shepard, G.H. Empty Forest or Empty Rivers? A Century of Commercial Hunting in Amazonia. *Sci. Adv.* **2016**, *2*, e1600936. [CrossRef] [PubMed]
13. Bodmer, R.E.; Puertas, P.; Fang, T.; Antúnez, M.; Soplín, S.; Caro, J.; Pérez, P.; El Bizri, H.R.; Arenas, M.; Nieto, J.C. Management of Subsistence Hunting of Mammals in Amazonia: A Case Study in Loreto, Peru. In *Amazonian Mammals: Current Knowledge and Conservation Priorities*; Springer Nature: Cham, Switzerland, 2024; pp. 275–297.
14. Mayor, P.; El Bizri, H.; Morcatty, T.; Moya, K.; Bendayán, N.; Solís, S.; Vasconcelos Neto, C.F.; Kirkland, M.; Arevalo, O.; Fang, T.; et al. Wild Meat Trade over the Last 45 Years in the Peruvian Amazon. *Conserv. Biol.* **2022**, *36*, e13801. [CrossRef] [PubMed]
15. ACRCTT. *Plan de Manejo de Fauna Silvestre Orientado al Aprovechamiento Comercial de Animales de Caza en el Área de Conservación Regional Comunal Tamshiyacu Tahuayo, Loreto-Perú*; Comité de Gestión del Área de Conservación Regional Comunal Tamshiyacu Tahuayo: Iquitos, Peru, 2022.
16. Chirif, A. *La Historia Del Tahuayo Contada Por Sus Moradores*; Wildlife Conservation Society: Lima, Perú, 2012.
17. Coomes, O.T.; Barham, B.L.; Takasaki, Y. Targeting Conservation–Development Initiatives in Tropical Forests: Insights from Analyses of Rain Forest Use and Economic Reliance among Amazonian Peasants. *Ecol. Econ.* **2004**, *51*, 47–64. [CrossRef]
18. Coomes, O.T.; Abizaid, C.; Takasaki, Y.; Rivas Panduro, S. The lower Ucayali River in prehistory: Cultural chronology, archeological evidence and a recently discovered pre-Columbian site. *Geogr. Rev.* **2021**, *111*, 145–167. [CrossRef]
19. Silvius, K.M.; Bodmer, R.E.; Fragoso, J.M.V. *People in Nature: Wildlife Conservation in South and Central America*; Columbia University Press: New York, NY, USA, 2004. [CrossRef]
20. Kirkland, M.; Eisenberg, C.; Bicerra, A.; Bodmer, R.E.; Mayor, P.; Axmacher, J.C. Sustainable Wildlife Extraction and the Impacts of Socio-Economic Change among the Kukama-Kukamilla People of the Pacaya-Samiria National Reserve, Peru. *Oryx* **2020**, *54*, 260–269. [CrossRef]
21. Bodmer, R.E.; Eisenberg, J.; Redford, K. Hunting and the Likelihood of Extinction of Amazonian Mammals. Caza y Probabilidad de Extincion de Mamiferos Amazonicos. *Conserv. Biol.* **1997**, *11*, 460–466. [CrossRef]
22. Peruvian Law Supreme Decree on Forestry and Wildlife Regulations D.S.N° 010-2009-MINAM. Decreto Supremo. N° 010-2009-MINAM, Lima, Peru. 2009. Available online: https://www.minam.gob.pe/wp-content/uploads/2013/09/ds_010-2009-minam.pdf (accessed on 11 January 2025).
23. Newing, H.; Bodmer, R.E. Collaborative Wildlife Management and Adaptation to Change: The Tamshiyacu Tahuayo Communal Reserve, Peru. *Nomadic Peoples* **2003**, *7*, 110–122. [CrossRef]
24. Rowcliffe, J.M.; Field, J.; Turvey, S.T.; Carbone, C. Estimating Animal Density Using Camera Traps without the Need for Individual Recognition. *J. Appl. Ecol.* **2008**, *45*, 1228–1236. [CrossRef]
25. Palencia, P.; Rowcliffe, J.M.; Vicente, J.; Acevedo, P. Assessing the Camera Trap Methodologies Used to Estimate Density of Unmarked Populations. *J. Appl. Ecol.* **2021**, *58*, 1583–1592. [CrossRef]
26. Create a PivotTable to Analyze Worksheet Data—Microsoft Support. Available online: https://support.microsoft.com/en-gb/office/create-a-pivottable-to-analyze-worksheet-data-a9a84538-bfe9-40a9-a8e9-f99134456576 (accessed on 11 January 2025).
27. Weinbaum, K.Z.; Brashares, J.S.; Golden, C.D.; Getz, W.M. Searching for Sustainability: Are Assessments of Wildlife Harvests behind the Times? *Ecol. Lett.* **2013**, *16*, 99–111. [CrossRef]
28. McCullough, D. The Theory and Management of Odocoileus Populations. In *Biology and Management of the Cervidae*; Wemmer, C., Ed.; Smithsonian Institution Press: Washington, DC, USA, 1987; pp. 535–549.
29. Salovaara, K. Diversity and Abundance of Mammals in the Yavari Valley. In *Perú: Yavari—Rapid Biological Inventory*; Pitman, N., Ed.; The Field Museum: Chicago, IL, USA, 2003.
30. Fang, T.G.; Bodmer, R.E.; Puertas, P.E.; Perez Peña, P.; Mayor, P.E.; Hayman, D. *Certificación de Pieles de Pecaríes (Tayassu Tajacu y Tayassu Pecari): Una Estrategia Para La Conservación y Manejo de Fauna En La Amazonía Peruana*; Fundamazonia: Lima, Peru, 2008.
31. Guimarães, D.A.d.A.; Bastos, L.V.; Ferreira, A.C.S.; Luz-Ramos, R.S.; Ohashi, O.M.; Ribeiro, H.L. Características reprodutivas da paca fêmea (*Agouti paca*) criada em cativeiro. *Acta Amaz.* **2008**, *38*, 531–538. [CrossRef]
32. Karesh, W.B.; Cook, R.; Bennett, E.L.; Newcomb, J. Wildlife Trade and Global Disease Emergence. *Emerg. Infect. Dis. J.* **2005**, *11*, 1000–1002. [CrossRef] [PubMed]
33. Gluszek, S.; Viollaz, J.; Mwinyihali, R.; Wieland, M.; Gore, M.L. Using Conservation Criminology to Understand the Role of Restaurants in the Urban Wild Meat Trade. *Conserv. Sci. Pract.* **2021**, *3*, e368. [CrossRef]
34. Kadigi, R.M.J.; Mgeni, C.P.; Kangile, J.R.; Aku, A.O.; Kimaro, P. Can a Legal Game Meat Trade in Tanzania Lead to Reduced Poaching? Perceptions of Stakeholders in the Wildlife Industry. *J. Nat. Conserv.* **2023**, *76*, 126502. [CrossRef]
35. Manfredo, M.J.; Vaske, J.J.; Brown, P.J.; Decker, D.J.; Duke, E.A. *Wildlife and Society: The Science of Human Dimensions*; Island Press: Washington, DC, USA, 2008.
36. Desbiez, A.L.J.; Santos, S.A.; Keuroghlian, A.; Bodmer, R.E. Niche Partitioning among White-Lipped Peccaries (*Tayassu pecari*), Collared Peccaries (*Pecari tajacu*), and Feral Pigs (*Sus scrofa*). *J. Mammal.* **2009**, *90*, 119–128. [CrossRef]
37. Ferreguetti, A.C.; Davis, C.L.; Tomas, W.M.; Bergallo, H.G. Using Activity and Occupancy to Evaluate Niche Partitioning: The Case of Two Peccary Species in the Atlantic Rainforest, Brazil. Hystrix It. *J. Mamm.* **2018**, *29*, 168–174. [CrossRef]

38. Hofmann, G.S.; Coelho, I.P.; Bastazini, V.A.G.; Cordeiro, J.L.P.; de Oliveira, L.F.B. Implications of Climatic Seasonality on Activity Patterns and Resource Use by Sympatric Peccaries in Northern Pantanal. *Int. J. Biometeorol.* **2016**, *60*, 421–433. [CrossRef] [PubMed]
39. Carrillo, E.; Fuller, T.K. Heterospecific Infanticide among Sympatric Peccaries in Costa Rica. *Biotropica* **2022**, *54*, 284–288. [CrossRef]
40. Whitworth, A.; Beirne, C.; Basto, A.; Flatt, E.; Tobler, M.; Powell, G.; Terborgh, J.; Forsyth, A. Disappearance of an Ecosystem Engineer, the White-Lipped Peccary (*Tayassu pecari*), Leads to Density Compensation and Ecological Release. *Oecologia* **2022**, *199*, 937–949. [CrossRef]
41. Kiltie, R.A.; Terborgh, J. Observations on the Behavior of Rain Forest Peccaries in Perú: Why Do White-Lipped Peccaries Form Herds? *Z. Für Tierpsychol.* **1983**, *62*, 241–255. [CrossRef]
42. Keuroghlian, A.; Eaton, D.P.; Longland, W.S. Area Use by White-Lipped and Collared Peccaries (*Tayassu pecari* and *Tayassu tajacu*) in a Tropical Forest Fragment. *Biol. Conserv.* **2004**, *120*, 411–425. [CrossRef]
43. Thornton, D.; Reyna, R.; Perera-Romero, L.; Radachowsky, J.; Hidalgo-Mihart, M.G.; Garcia, R.; McNab, R.; Mcloughlin, L.; Foster, R.; Harmsen, B.; et al. Precipitous Decline of White-Lipped Peccary Populations in Mesoamerica. *Biol. Conserv.* **2020**, *242*, 108410. [CrossRef]
44. Altrichter, M.; Carrillo, E.; Sáenz, J.; Fuller, T.K. White-Lipped Peccary (*Tayassu pecari*, Artiodactyla: Tayassuidae) Diet and Fruit Availability in a Costa Rican Rain Forest. *Rev. Biol. Trop.* **2001**, *49*, 1183–1192.
45. Reyna-Hurtado, R.; Chapman, C.A.; Calme, S.; Pedersen, E.J. Searching in Heterogeneous and Limiting Environments: Foraging Strategies of White-Lipped Peccaries (*Tayassu pecari*). *J. Mammal.* **2012**, *93*, 124–133. [CrossRef]
46. El Bizri, H.R.; Fa, J.E.; Bowler, M.; Valsecchi, J.; Bodmer, R.E.; Mayor, P. Breeding Seasonality in the Lowland Paca (*Cuniculus paca*) in Amazonia: Interactions with Rainfall, Fruiting, and Sustainable Hunting. *J. Mammal.* **2018**, *99*, 1101–1111. [CrossRef]
47. Mayor, P.; Guimarães, D.A.; López, C. Functional Morphology of the Genital Organs in the Wild Paca (*Cuniculus paca*) Female. *Anim. Reprod. Sci.* **2013**, *140*, 206–215. [CrossRef] [PubMed]
48. Bowler, M.; Anderson, M.; Montes, D.; Pérez, P.; Mayor, P. Refining Reproductive Parameters for Modelling Sustainability and Extinction in Hunted Primate Populations in the Amazon. *PLoS ONE* **2014**, *9*, e93625. [CrossRef] [PubMed]
49. Dubost, G.; Henry, O. Seasonal Reproduction in Neotropical Rainforest Mammals. *Zool. Stud.* **2017**, *56*, e2. [CrossRef]
50. Zapata, G.R. Sustentabilidad de la cacería de subsistencia: El caso de cuatro comunidades quichuas en la Amazonía nororiental ecuatoriana. *Mastozoología Neotrop.* **2001**, *8*, 59–66.
51. Townsend, W.; Rumiz, D.; Solar, L. El Riesgo de La Cacería Durante Las Operaciones Forestales: Impacto Sobre La Fauna Silvestre En Una Concesión Forestal En Santa Cruz. *Rev. Boliv. Ecol.* **2002**, *11*, 47–53.
52. Townsend, W.; Rumiz, D. La Importancia de La Fauna Silvestre Para Las Comunidades Indígenas de Las Tierras Bajas de Bolivia. In *Biodiversidad: La Riqueza de Bolivia*; Editorial FAN: Santa Cruz, Bolivia, 2003; pp. 305–310.
53. Varela, D.M.; Trovati, R.G.; Guzmán, K.R.; Rossi, R.V.; Duarte, J.M.B.; Duarte, J. Red Brocket Deer Mazama Americana (Erxleben 1777). In *Neotropical Cervidology*; Funep: Tokyo, Japan, 2010; pp. 151–159.
54. Hurtado-Gonzales, J.L.; Bodmer, R.E. Assessing the Sustainability of Brocket Deer Hunting in the Tamshiyacu-Tahuayo Communal Reserve, Northeastern Peru. *Biol. Conserv.* **2004**, *116*, 1–7. [CrossRef]
55. Bodmer, R.; Mayor, P.; Antunez, M.; Chota, K.; Fang, T.; Puertas, P.; Pittet, M.; Kirkland, M.; Walkey, M.; Rios, C.; et al. Major Shifts in Amazon Wildlife Populations from Recent Intensification of Floods and Drought. *Conserv. Biol.* **2018**, *32*, 333–344. [CrossRef]
56. Caughley, G. *Analysis of Vertebrate Populations*; John Wiley & Sons: London, UK, 1977.
57. Kelly, T.J.; Lawson, I.T.; Roucoux, K.H.; Baker, T.R.; Honorio-Coronado, E.N.; Jones, T.D.; Rivas Panduro, S. Continuous Human Presence without Extensive Reductions in Forest Cover over the Past 2500 Years in an Aseasonal Amazonian Rainforest. *J. Quat. Sci.* **2018**, *33*, 369–379. [CrossRef]
58. Terborgh, J. *Requiem for Nature*; Island Press: Washington, DC, USA, 1999; Volume 256.
59. Huntington, H.P. Management and Regulation of Local Subsistence Hunting in North Alaska. Ph.D. Thesis, University of Cambridge, Cambridge, UK, 1991. [CrossRef]
60. Natcher, D.; Ingram, S.; Bogdan, A.-M.; Rice, A. Conservation and Indigenous Subsistence Hunting in the Peace River Region of Canada. *Hum. Ecol.* **2021**, *49*, 109–120. [CrossRef]
61. South Australian Legislation. *National Parks and Wildlife Act 1972*; South Australian Legislation: Adelaide, Australia, 2002.
62. Western Australia Legislation. *Wildlife Conservation Act 1950*; Western Australia Legislation: West Perth, Australia, 2016.