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Amazon Riverboat Exploration

Earthwatch 2022 Field Report

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Message from the PI

Fundamazonia

DICE University of Kent | School of Anthropology and Conservation

Dear Earthwatch Volunteers,

It is with great pleasure to inform you of the advances of the Earthwatch project in the Peruvian Amazon in 2022. The conservation-based research on wildlife and local people is resulting in a clearer understanding of the sustainable use, community-based conservation, and impacts of climate change in the forests of the Peruvian Amazon.

Your dedicated and enthusiastic help on the project has made it possible to influence conservation policy in this region of the Amazon. The data that you collected was used to evaluate how recent changes in water level have affected the sustainability of traditional resource uses by local people. This information is being used by the Peruvian Forestry and Wildlife Service (SERFOR) to manage subsistence hunting in the Loreto Region (382,000 km2), by the Peruvian Protected Area Authority (SERNANP) to manage wildlife hunting in national reserves, and by the Regional Government (DECREL) to set wildlife management plans in community reserves.

The long-term data sets collected in the Samiria, Tahuayo, and Yavari have been analyzing fishing, hunting, and palm fruit used by the indigenous and campesino people. The results showed that integrated sustainable use is being done, leading to a green economy.

Results from the upland forests of Tahuayo and Yarapa showed that the transitional forests were an important landscape that helped species adapt to climate change. These forests allow species to move out of intensively flooded areas and maintain healthy populations.

The research results also show that the indigenous communities have adapted to climate change impacts and that these changes in resource use agree with good management practices.

From the staff of the Rio Amazonas, the biologists, and myself, we send our warmest regards. Thank you so much for your kind assistance with the Amazon Riverboat project.

Yours faithfully,

Richard E. Bodmer, PhD
Professor in Conservation Ecology
Durrell Institute of Conservation and Ecology

Director, FundAmazonia
Iquitos, Peru

Red List Coordinator
Peccary Specialist Group
IUCN

Summary

The transitional habitats linking upland and flooded forests are helping terrestrial species overcome the impacts of intensive flooding, which increases the sustainability of hunting. The research results are being used to advance a green economy in the Peruvian Amazon. Fish populations have grown during the floods, and dolphins and shorebirds have healthy populations. Caimans continue to be vulnerable to harvests by fishermen, and this local trade needs conservation measures.

Goals, Objectives, and Results

The research aims to help conserve the Peruvian Amazon of the Loreto region through field research that provides the science base for biodiversity conservation, including sustainable resource use and community-based conservation, impacts of climate change and the mega hydrovia project, and wildlife trade and recovery of endangered species.

The project's goal is to advance wildlife conservation in western Amazonia by studying the interrelation of sustainable use, climate change, and community-based conservation. The field research provides the science base for 1) sustainable resource use and community-based conservation, 2) impacts of climate change, 3) impacts of the hydrovia infrastructure project, and 4) wildlife trade and recovery of endangered species. Community-based conservation dominates the landscape of Loreto, and the project is conducting research to support the positive community-based conservation trajectory that we currently see and study how the region of Loreto is turning into a green economy (Mayor et al. 2020). Research on sustainable use provides the science for sustainable use guidelines and assessments of wildlife, fish, and palm fruit harvests (Bodmer et al. 2022).

Climate change research studies how wildlife and people have been impacted, especially in flooded forests, where the effects have been devastating (Bodmer et al. 2018). The research is also being used to study another recent threat, including the impacts on wildlife and people of the proposed dredging of the hydrovia infrastructure project (Bodmer et al. 2019). The research site on the lower Yarapa River between the Tamshiyacu-Tahuayo and Pacaya-Samiria reserves is expanding the climatic change research by including the transitional forests between upland and flooded landscapes. The research questions are based on three models: the Climate Change Matrix Model, the Hydrovia Predictive Matrix Model, and the Population Monitoring Sustainability Model. These models test the impact of climate change, the potential impacts of the proposed dredging, and the sustainability of resource use and wildlife trade. Volunteer participation allows us to build long-term data sets and study the larger issues of Amazon conservation. Data collected by volunteers on wildlife surveys continues to be the core of our research strategy.

Wildlife Surveys

The research questions use a Matrix model that uses landscape species (aquatic, terrestrial, and arboreal) and Indicator/Resource use species to study the impacts of climate change and resource uses on wildlife species. The matrix model is used to separate environmental (climate change) and human use (harvesting) impacts on wildlife populations.

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Landscape features are divided into aquatic, terrestrial, and arboreal. Indicator species are animals that people do not directly harvest, and changes in their populations are caused by environmental factors. Resource use species are animals used directly by people (hunting, fishing, collecting), and changes in their populations are from harvesting pressures or environmental factors. Environmental factors can be natural events or human-related, such as climate change, pollution, or degraded forests or rivers.

The model uses population changes in species assemblages and requires data on species population trends. Animal population trends are determined by 1) statistically significant increases or decreases and 2) non-significant stable populations, using time-series regressions of density and abundance measures.

Figure 1. Species assemblages resulting from the matrix of landscape species and indicator/resource use species.

LANDSCAPE—SPECIES TYPE	INDICATOR SPECIES	RESOURCE USE SPECIES
Aquatic	• River dolphins • Waterfowl • Fishing bats • Frogs	• Fish • Caimans • River otters—past
Terrestrial	• Terrestrial edentates • Felids	• Ungulates • Terrestrial rodents
Arboreal	• Small-bodied primates • Macaws, parrots, & parakeets	• Large-bodied primates • Game birds • Arboreal rodents

The specific research questions for the matrix models are population trends of landscape species, resource use/indicator species, and bushmeat species. Population trends will be studied for the following species:

TERRESTRIAL MAMMALS

- White-lipped peccary — *Tayassu pecari*
- Collared peccary — *Pecari tajacu*
- Red brocket deer — *Mazama americana*
- Lowland tapir — *Tapirus terrestris*
- Black agouti — *Dasyprocta fuliginosa*
- Paca — *Cuniculus paca*
- Giant anteater — *Myrmecophaga trydactila*
- Nine-banded armadillo — *Dasypus novemcinctus*
- Jaguar — *Panthera onca*
- Puma — *Puma concolor*
- Ocelot — *Leopardus pardalis*

AQUATIC SPECIES

Fish

- *Astronotus ocellatus*
- *Liposarcus pardalis*
- *Prochilodus nigricans*
- *Pygocentrus nattereri*
- *Serrasalmus rhombeus*
- *Hobilas malabaricus*
- *Hopleryhtrinus unitaeniatus*
- *Serrasalmus humeralis*
- Plus others

MACAWS

Red-bellied macaw — *Orthopsitaca manilata*
Chestnut-fronted macaw — *Ara severus*
Blue & yellow macaw — *Ara ararauna*

WATERFOWL

Neotropical cormorant — *Nannopterum brasilianum*
Great egret — *Ardea alba*
Snowy egret — *Egretta thula*
Cattle egret — *Bubulcus ibis*
Rufescent tiger heron — *Tigrisoma lineatum*
Striated heron — *Butorides striata*
Zigzag heron — *Zebrilus undulatus*

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GAME BIRDS

- Tinamous — *Tinamus* spp.
- Razor-billed curassow —*Mitu tuberosum*
- Spix's guan — *Penelope jacquacu*
- Piping guan — *Pipile cumanensis*

FROG FAMILIES

- *Aromobatidae*
- *Dendrobatidae*
- *Hylidae*
- *Leptodactylidae*
- *Microhylidae*
- *Pipidae*
- *Plethodontidae*
- *Strabomantidae*

PRIMATES

- Woolly monkey — *Lagothrix poeppigii*
- Howler monkey — *Alouatta seniculus*
- Brown capuchin — *Cebus paella*
- Saki monkey — *Pithecia monachus*
- Squirrel monkey — *Saimiri boliviensis*
- Saddle-back tamarin — *Saguinus fuscicollis*

AQUATIC MAMMALS

- Pink river dolphin — *Inia geoffrensis*
- Grey river dolphin — *Sotalia fluviatilis*
- Giant river otter — *Pteronura brasiliensis*

OTHER ARBOREAL MAMMALS

- Amazon squirrel — *Sciurus spadiceus*
- Brown-throated sloth — *Bradypus variegatus*
- Common opossum — *Didelphis marsupialis*
- Coati — *Nasua nasua*
- Tyra — *Eira barbara*

CAIMANS

- Spectacled caiman — *Caiman crocodilus*
- Black caiman — *Melanosuchus niger*
- Smooth fronted caiman — *Paleosuchus trigonatus*

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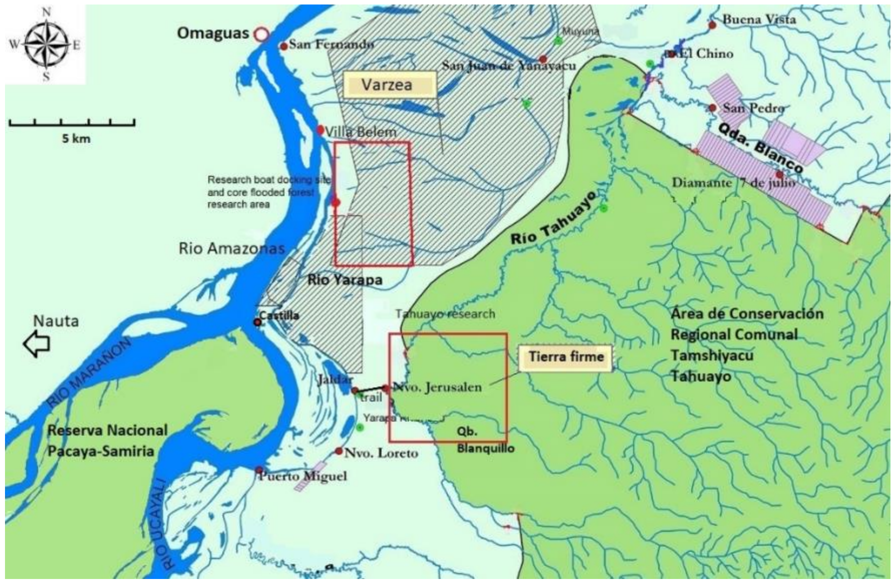
Study Area



The study area is the Lower Yarapa River basin in the buffer zones of the Pacaya-Samiria National Reserve and the Tamsiyacu-Tahuayo Regional Community Reserve located in the Marañon-Ucayali subsidence area of the Ucamara depression (Zulkafli et al. 2016). The study area is part of the largest block of várzea flooded forests in the Western Amazon and extends over an area of 2,080,000 ha in the Department of Loreto, Peru. The flooded forest in the study site has land formations with varying levels of annual flooding that are divided into six broad categories, including riverine forests, open understory flooded forests, levee forests, liana forests, tree fall gaps, and aguaje palm swamps. Aquatic formations include the Yarapa River, oxbow lakes, and channels.

The Tamshiyacu-Tahuayo community reserve 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 richness of fauna (Puertas et al. 2017). The Pacaya-Samiria National Reserve was decreed in 1982 and is currently co-managed by the Peruvian Protected Area Service and the Cocama (Kukama) indigenous people through community-based management groups (Kirkland et al. 2018). The Tamsiyacu-Tahuayo Regional Community Reserve was first decreed in 1990 and renewed in 2007.

Sustainable resource use and traditional activities are permitted within the reserves, including subsistence fishing and hunting. The people rely on small scale agriculture and fishing as their primary activities and hunting to a lesser extent. They adapt their hunting and fishing activities according to the seasonal water level and the availability of fish and wildmeat resources, with a greater focus on fishing during low water seasons and an increase in hunting during high water seasons (Bodmer et al. 2020).

The study area is situated within three Indigenous territories that belong to the communities of Castilla, Jaldar, Nuevo Jerusalen, and Villa Belen. Castiila, Jaldar and Nuevo Jerusalen are Achuar cultures and Villa Belen is Cocama.

Methods

We use wildlife surveys to study the population trends in different aquatic, terrestrial, and arboreal wildlife communities over time, according to the matrix models. The research design is based on a multiyear population analysis of species groups, and protocol has been held constant for all years from 2009–2018. Greater precision is achieved by surveying similar samples of transects over the years to maintain continuity and spacio-temporal relationships, and there are no subjective judgments or pre-determined knowledge of animal abundance for placement of surveys (Buckland et al. 2001). Species groups are surveyed independently, and surveys are conducted in all years during flooded, low water, and transition seasons, with an expected annual average of 100 survey days per year.

Survey teams include one Cocama field assistant, one Peruvian biologist fully trained in the methods, and an average of three volunteers/students (range 1–8). The team composition is held constant throughout the study and helps ensure that detection has a broad shoulder, that detection probability is constant, and that methods are consistently implemented. This is particularly important for monitoring population trends between sites and over the years (Buckland et al. 2001).

We surveyed terrestrial mammals (ungulates and terrestrial rodents), arboreal mammals (primates and other arboreal mammals), and game birds using transects. Ten trails of an average of 3 km long will be cut prior to the surveys, and each will be walked multiple times at approximately 1 km/hour. An expected average of 1000 km will be surveyed annually. We use the distance sampling method, and observers walk transects between 07:00–12:00 hours in the morning and 14:00–17:00 hours in the afternoon. When a group of animals is encountered, the number of individuals is recorded, and the perpendicular distance from the trail to the first individual sighted is measured. Clusters, such as primate troops, are considered independent units, and cluster size is used to determine the density of individuals (Buckland et al. 1993). The data are analyzed using Distance 6.0 software. Population densities are calculated as number of individuals/km² (ind/km2).

We also survey terrestrial mammals and felids with infrared and motion camera traps, Bushnell HD. Twenty cameras are set over areas of approximately 100 km2 at the study site and distributed across habitat types with an estimated annual average of 4000 camera-days. Cameras are set at 640 x 480 pix with 10-second video capture and 5-second intervals, using 8 AA alkaline batteries. Cameras are set along 1 km of transect using a width (w) of 100 m for 15-day intervals, selecting new sites on every rotation. Independent events have a minimum gap of 30 minutes for captures of the same species. Camera traps are checked weekly to determine the battery levels and general functioning of the units. Capture rates per species are calculated as independent events as the number of individuals/1,000 camera-days (ind/m.c.d.). Camera data can also be analyzed using occupancy.

We survey macaws, parrots, and parakeets using 15-minute point counts set in sampling units separated by 500 m along the shoreline of rivers, lakes, and channels. Surveys have between 6 and 9 points with 10 shoreline transects. Censuses are done in the morning (5:30-9:00h) and afternoon (16:00–18:30h) when movement is usually unidirectional from roosting to feeding sites (and vice versa). An estimated mean of 1000 points will be surveyed annually. We determine species through visual and auditory identification, and records are taken of the number of individuals in a flock and minute of observation. Population trends use the number of individuals per point (ind/pt).

We survey fish using green nylon gill nets 30 meters long, 3 meters deep, and a mesh size of 2.5 inches set for 1 hour in rivers, lakes, channels, and flooded forest habitats with weak currents. An estimated mean of 300 net-hours will be surveyed annually, equally between morning (7:00–11:00) and afternoon (14:00–18:00) surveys. Data are recorded on species, weight, standard length, and geographic coordinates. Most fish were released back into the water. Catch per unit effort (CPUE) was calculated as individuals per net-hour (ind/net-hour) and biomass per net-hour (kg/net-hour).

Fish abundance is also studied using side-scan sonar. A StarFish450 side-scan sonar set at 4500khz, and 1500 m/sec is used to determine fish abundance at shallow points (mal pasos). The sonar is attached to an auxiliary

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boat using a velocity of 3-6 km/hr. and transects of 5 km with an estimated annual average of 300 km. Fish reflect white on the sonar from oxygen held in intestines, swim bladders, and gills. The sonar also records dolphins. Our collaborators are developing pattern recognition software that can ID key species from side-scan sonar and count the fish using AI.

We survey waterfowl by shoreline transects in the morning (5:30–9:00h) and afternoon (16:00–18:30h) when flocks are generally perched, thus decreasing the chances of double counting. Ten shoreline transects of 5.0 km are surveyed along river, lake, and channel habitats with a survey speed of approximately 2 km/hour using an aluminum skiff powered by a 25 hp engine. An estimated average of 300 km will be surveyed annually. All perched or flying waterfowl are recorded. The population abundance of species is calculated as the number of individuals/km (ind/km).

We survey dolphins on 5 km diurnal aquatic transects in river, lake, and channel habitats at a velocity of approximately 2 km/hour using eight survey transects. An estimated mean of 1000 km will be surveyed annually during morning (7:00–12:00) and afternoon (14:00–16:00) transects. Dolphins are recorded visually when breaching the water surface, and the number of dolphins is determined by visual tracking. A 12 m covered launch powered by a 25 hp inboard engine is used for dolphin transects. The population abundance of species is calculated as the number of individuals/km (ind/km).

We survey caimans through visual counts at night (20:00–24:00h), traveling along 5.0 km transects at a velocity of approximately 2 km/hour on a single side of the river, lake, or large channel (>40m width) or simultaneously on both sides in smaller channels (<40 m width). An estimated mean of 500 km will be surveyed annually using six transects. We locate caimans by their eye reflections using a spotlight and approach a distance where observations can be made. Survey speed is approximately 2 km/hour, stopping when caimans are sighted. An aluminum skiff with a 25 hp outboard engine is used for caiman transects. Population abundance per species is calculated as number of individuals/km (ind/km).

Amphibians are a good biological indicator and are often thought to be one of the first taxa to react to environmental degradation and climate change. To determine the differences between natural fluctuations and more extreme events, we must conduct long-term monitoring of these species. Floating meadow surveys are used to determine the density and diversity of frogs in the floating vegetation. Abundance can be calculated using CPUE, and density can be estimated using fixed width. Floating meadow surveys will be conducted at night from 8:30–10:30 pm as this is when amphibians are active in this habitat. Available floating vegetation can be surveyed for frogs along the rivers, lakes, and channels. Floating meadow frog surveys should be spaced at roughly 100m intervals. First, slowly drive the boat (10 m aluminum skiff) into the vegetation. Do not drive past the engine, or it will be difficult to get back out. The following variables should be recorded for each survey: start time, end time, weather variables, location, GPS waypoint, max and min temp, and humidity. As soon as the boat stops moving the survey commences. 15 minutes are spent by Earthwatch volunteers searching for amphibians within a 2m radius around the edge of the boat. All individuals should only be recorded once. The following variables should be recorded for each individual sighted: frog species, plant species, height from water, male/female, temperature, humidity, time of observation/capture, distance from the tree line, and any other information.

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Results

PRIMATES

Nine species of primates were recorded on the distance transects. The squirrel monkey (*Saimiri macrodon*) was the most abundant species with a density of 129 ind/km2 followed by the brown capuchin monkey at 16 ind/km2. Primate densities were generally higher in 2022 than in 2019, showing a positive trend in primate numbers at the study site.

DENSITY (IND/KM^2)		
PRIMATE SPECIES	**2019**	**2022**
Howler monkey — *Alouatta seniculus*	0.31	0.51
Nancy Ma's night monkey — *Aotus nancymae*	1.89	13.54
Coppery titi monkey — *Callicebus cupreus*	1.94	1.28
Pygmy marmoset — *Cebuella pygmaea*	0.18	10.86
Marañón white-fronted capuchin — *Cebus yuracus*	0.06	2.48
Monk saki — *Phitecia monachus*	0.41	0
Saddle-back tamarin — *Saguinus fuscicollis*	7.07	3
Ecuadorian squirrel monkey — *Saimiri macrodon*	88.48	129.34
Large-headed capuchin — *Sapajus macrocephalus*	5.09	16.44

SLOTHS AND ANTEATERS

Sloths (*Bradypus variegatus*) are quite common in the Yarapa study area with a density of 1.14 ind/km^2. The tamandua (*Tamandua tetrodactyla*) had a density of 0.70 ind/km^2.

UNGULATES

The camera trap data showed how ungulate species were using the landscapes of upland and flooded forests. The average annual camera trap effort was 3,130 camera days (9,390 camera days in total), with 1,750 camera days per year in upland forests (5,270 in total) and 1,370 per year in flooded forests (4,120 in total). The study site is at the boarder of these distinct habitats.

White-lipped peccary used both habitats and took advantage of the high food production in flooded forests and refuge in upland forests during the annual flooded season. White-lipped peccary had the highest terrestrial mammal density and greatest mammalian biomass 278 kg/km2 clearly showing their ecological dominance.

Camera traps in the upland forest of Blanquillo showed a higher abundance of white-lipped peccary during the high-water season (220 ind/mcd) and a lower abundance during the low-water season (40 ind/mcd). In contrast, the cameras in flooded forests recorded good numbers of white-lipped peccary during the low-water season, and none were recorded in the high-water season. These results indicate that white-lipped peccary is moving between the tierra firme upland forests and the adjacent varzea flooded forests. The white-lipped peccary can take advantage of the nutrient-rich and food-abundant flooded forests in the low-water season and then move to non-flooded upland forests during the high-water season.

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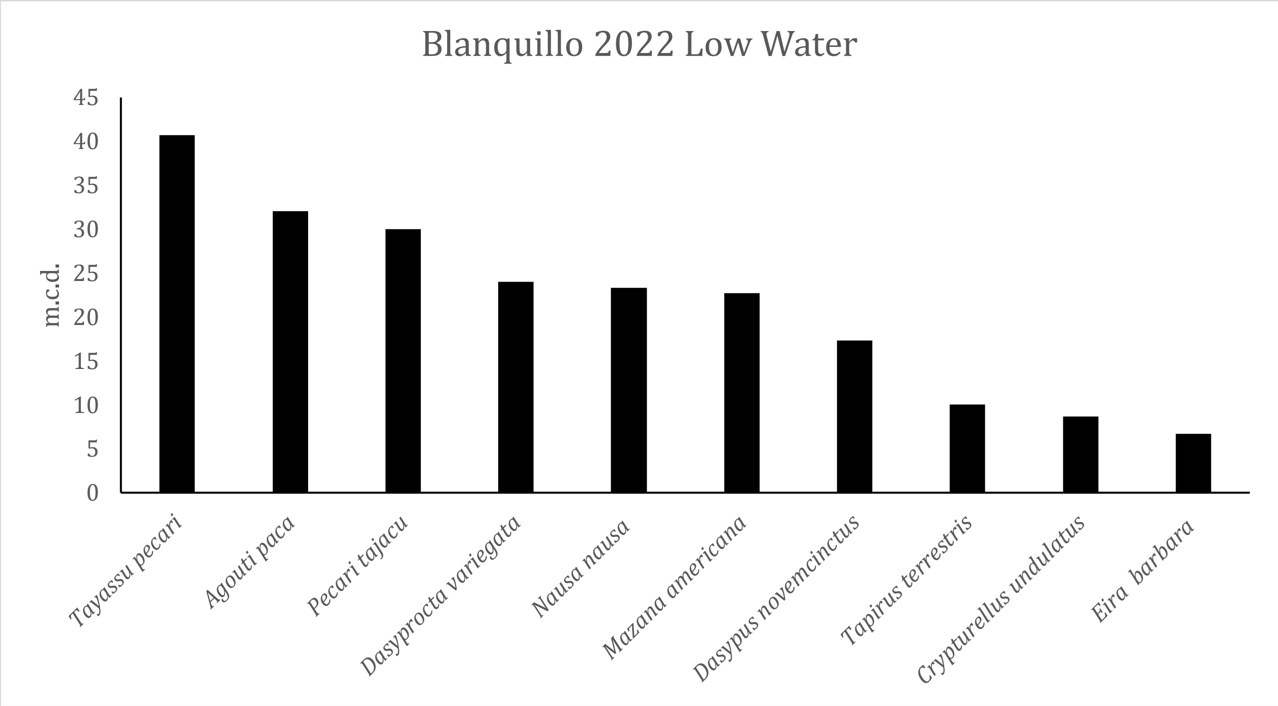
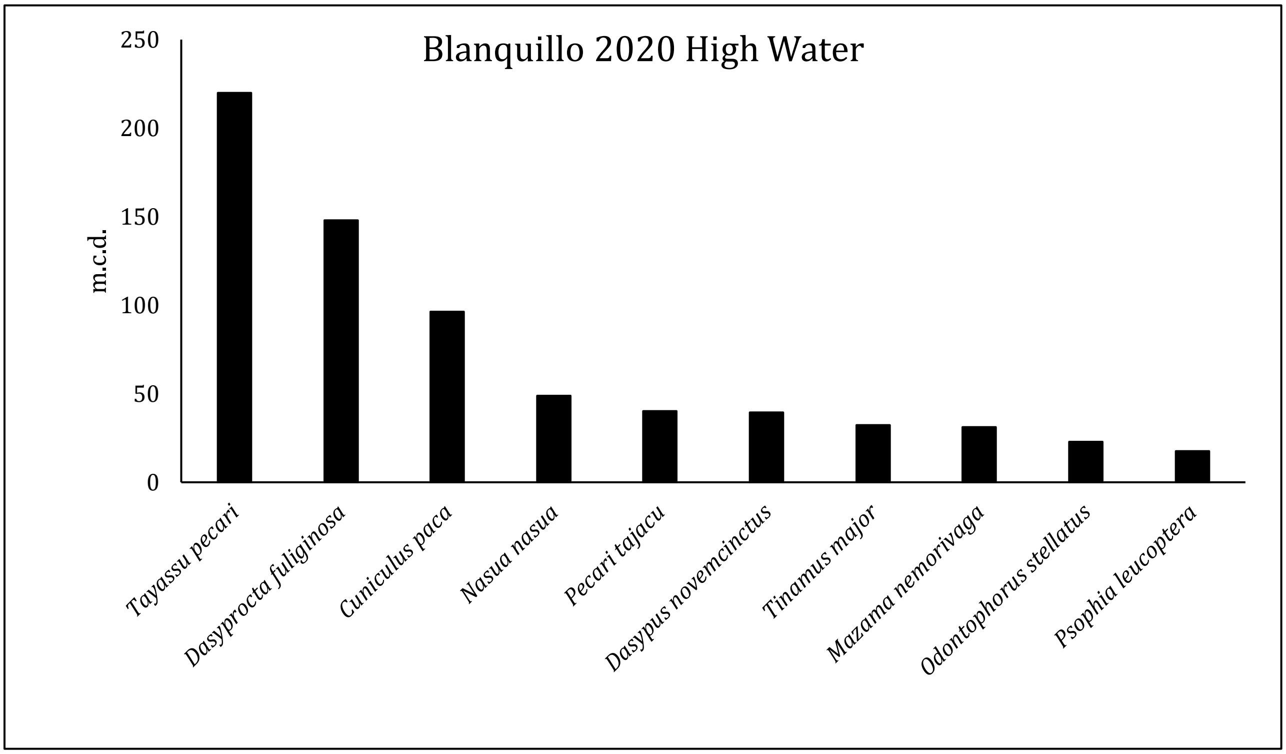
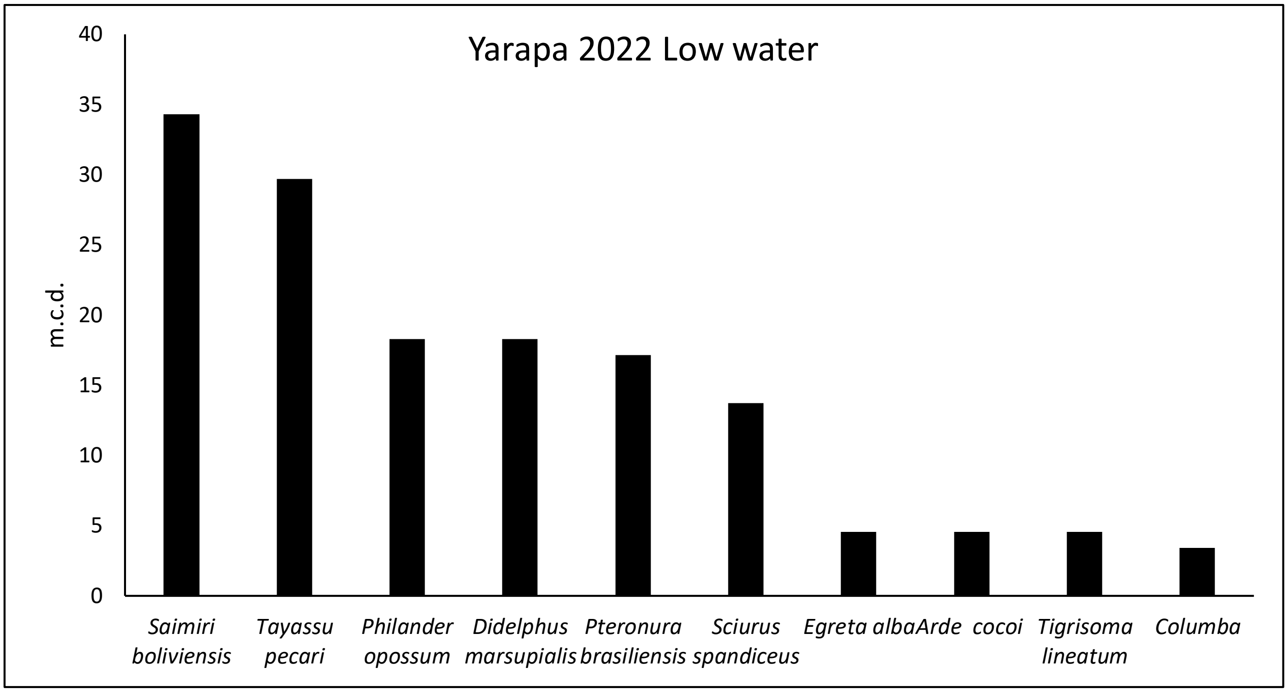
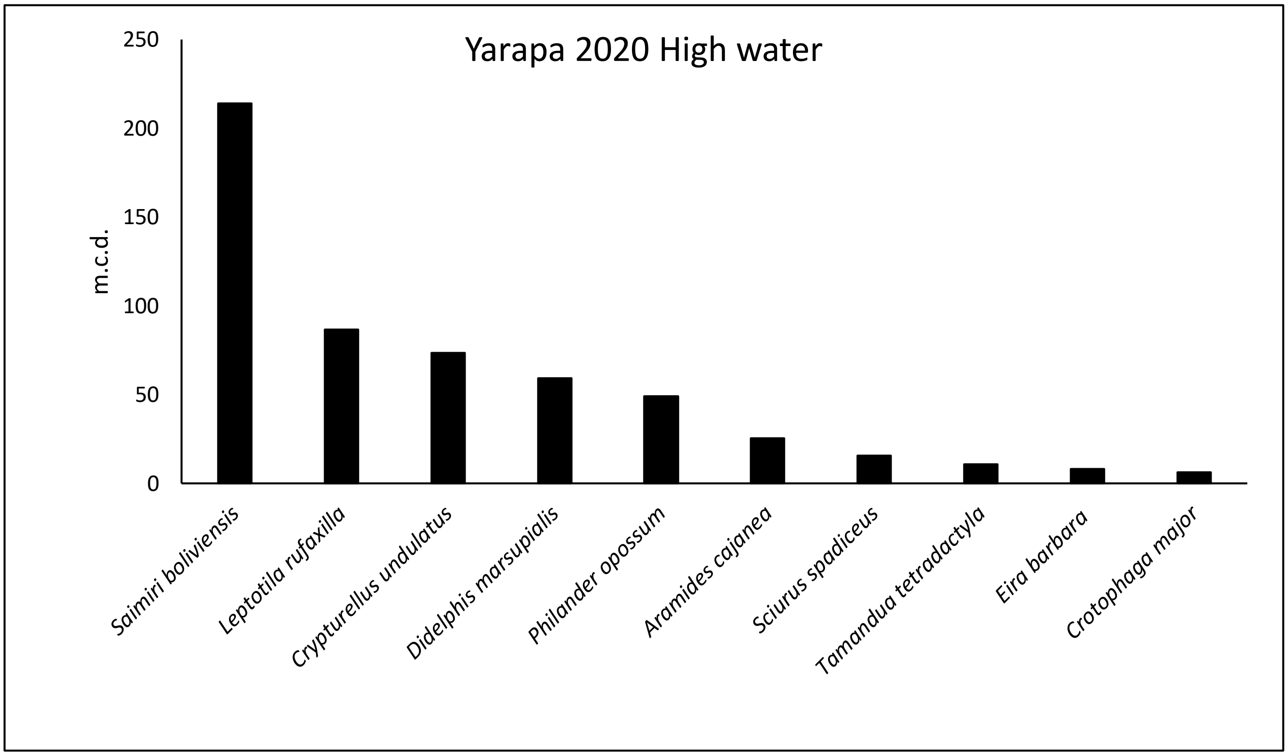
Collared peccaries have consistent populations and maintain stable populations. Collared peccaries are more abundant in tierra firme forests than in flooded forests.

In the graphs below, the Blanquillo site is in tierra firme upland forests, and the Yarapa is in flooded varzea forests.






Yarapa 2022 Low water
m.c.d.
40
35
30
25
20
15
10
5
0
Saimiri boliviensis
Tayassu pecari
Philander opossum
Didelphus marsupialis
Pteronura brasiliensis
Sciurus spandiceus
Egreta alba
Arde cocoi
Tigrisoma lineatum
Columba


Yarapa 2020 High water
m.c.d.
250
200
150
100
50
0
Saimiri boliviensis
Leptotila rufaxilla
Crypturellus undulatus
Didelphis marsupialis
Philander opossum
Aramides cajanea
Sciurus spadiceus
Tamandua tetradactyla
Eira barbara
Crotophaga major

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Peccary Density Estimates

Densities from camera trap data were calculated using the proportional method combining distance transect and camera trap capture data. The proportional method uses densities of selected species calculated with the Distance method and camera trap capture rates to calculate the density of a species (y) as follows:

Species density (y) = $[D_{spp} / mcd_{spp}] \times mcd_{spy}$

Species (y) is the density of the species that is calculated in ind/km2

D_{spp} is the average density of the selected species calculated with distance transects in ind/km2

mcd_{spp} is the average capture rate of the camera traps of the selected species calculated in ind/m.c.d.

mcd_{spy} is the capture rate of the species (y) calculated from the camera traps in ind/m.c.d.

The selected species are those species that are observed at similar frequencies both in distance transects and in camera traps. In this study, the selected species included *Sciurus spadiceus* (Squirrel), *Tamandua tetradactyla* (Shiwi), *Nasua nasua* (Achuni), *Mazama nemorivaga* (Gray deer), and *Pecari tajacu* (Sajino) (Table).

Table. Species selected for the calculation of D_{spp} and mcd_{spp}.

SPECIES		IND/KM^2	IND/M.C.D.
Southern Amazon red squirrel — *Sciurus spadiceus*	Ardilla	3.57	8.7
Southern tamandua — *Tamandua tetradactyla*	Shiwi	0.31	6.01
South American coati — *Nasua nasua*	Achuni	0.06	9.71
Amazonian brown brocket deer — *Mazama nemorivaga*	Venado gris	0.18	12.49
Collared peccary — *Pecari tajacu*	Sajino	0.15	15.72
	D_{spp} / mcd_{spp}	D_{spp}	mcd_{spp}
AVERAGE	**0.80**	**0.85**	**10.52**

White-lipped peccary density—Blanquillo

2019 7.10 ind/km^2

2020 17.6 ind/km2

2022 3.28 ind/km2

Average: 9.29 ind/km2

Collared peccary density—Blanquillo

2019 1.27 ind/km^2

2020 3.2 ind/km2

2022 2.4 in/km2

Average: 2.29 ind/km2

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LARGE RODENTS

The terrestrial rodents had large populations in the upland forests, with a density of paca (Agouti paca) at 2.6 ind/km2 and a density of agouti (*Dasyprocta variegate*) at 1.9 ind/km2. However, in flooded forests, paca was scarce, and agouti populations were low, with a density of 0.01 ind/km2. Squirrels (*Sciurus spadiceus*) were abundant in flooded forests (5.5 ind/km2), as were the bushy-tailed rats (*Isothrix bistriata*) (10.2 ind/km2).

CARNIVORES

Short-eared dogs were observed on cameras in the Blanquillo upland forests on numerous occasions. The pack size was estimated at five individuals.

Giant river otters were observed on transects and cameras. A pack of 6 individuals was recorded on the camera, and a female sub-adult was observed on the transects in the focal study site. The transect density was 0.3 ind/km2.

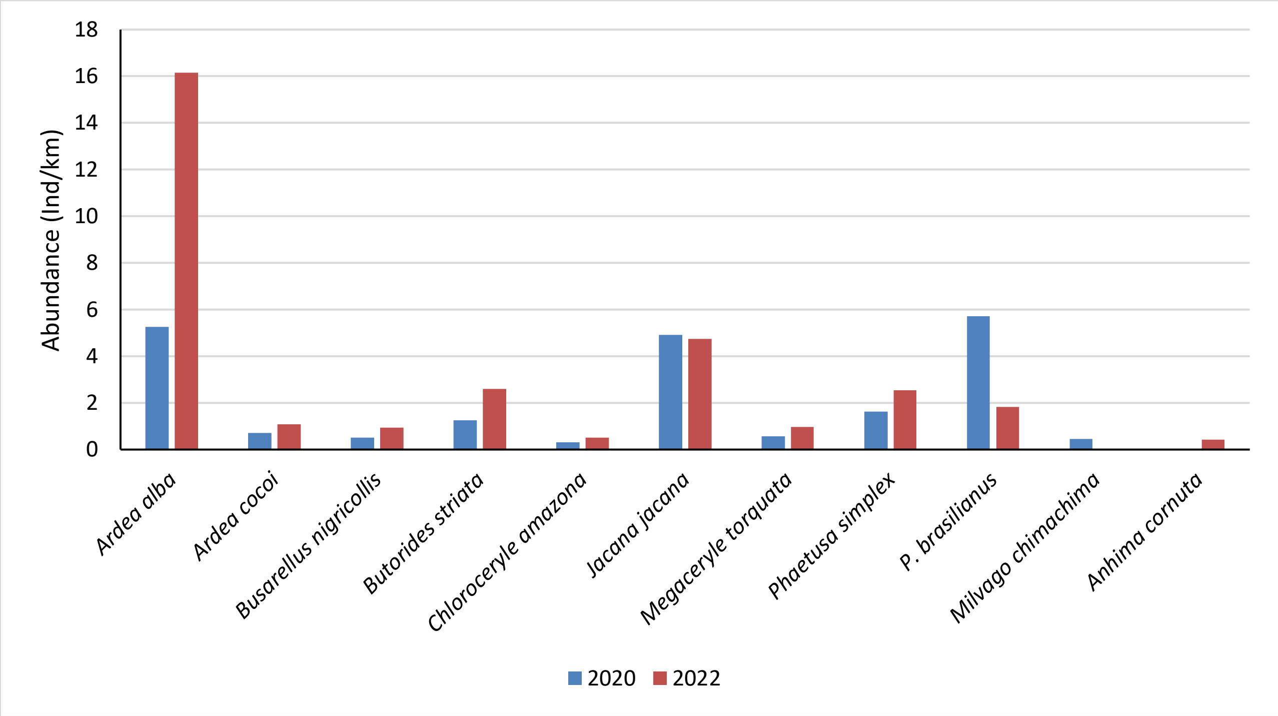
A female jaguar with cubs was observed and jaguars were recorded on cameras with an abundance of 0.10 ind/km2 or one individual every 10 km2. Likewise, pumas, ocelots, margays, and jaguarundis were recorded on the camera traps.

SHOREBIRDS

Shorebirds continue to be abundant in the study area, reflecting good aquatic habitats and healthy fish production. The great egret (*Ardea alba*) was the most abundant species, with over 6,000 individuals sighted, and they were more abundant in 2022 than in 2019.

Other abundant species included cocoi heron (*Ardea cocoi*), Black-collared hawk (*Busarellus nigricollis*), striated heron (*Butorides striata*), jacana (*Jacana jacana*), large-billed tern (*Phaetusa simplex*), and Neotropical cormorant (*Nannopterum brasilianum*).

	ABUNDANCE	
SPECIES	**2019**	**2022**
Great egret — *Ardea alba*	5.25	16.15
Cocoi heron — *Ardea cocoi*	0.71	1.09
Black-collared hawk — *Busarellus nigricollis*	0.51	0.95
Striated heron — Butorides striata	1.24	2.60
Amazon kingfisher — *Chloroceryle amazona*	0.31	0.50
Wattled jacana *Jacana jacana*	4.90	4.74
Ringed kingfisher *Megaceryle torquata*	0.58	0.96
Large-billed tern *Phaetusa simplex*	1.64	2.55
Neotropical cormorant — *Nannopterum brasilianum*	5.71	1.84
Yellow-headed caracara — *Milvago chimachima*	0.44	0.00
Horned screamer — *Anhima cornuta*	0.00	0.44

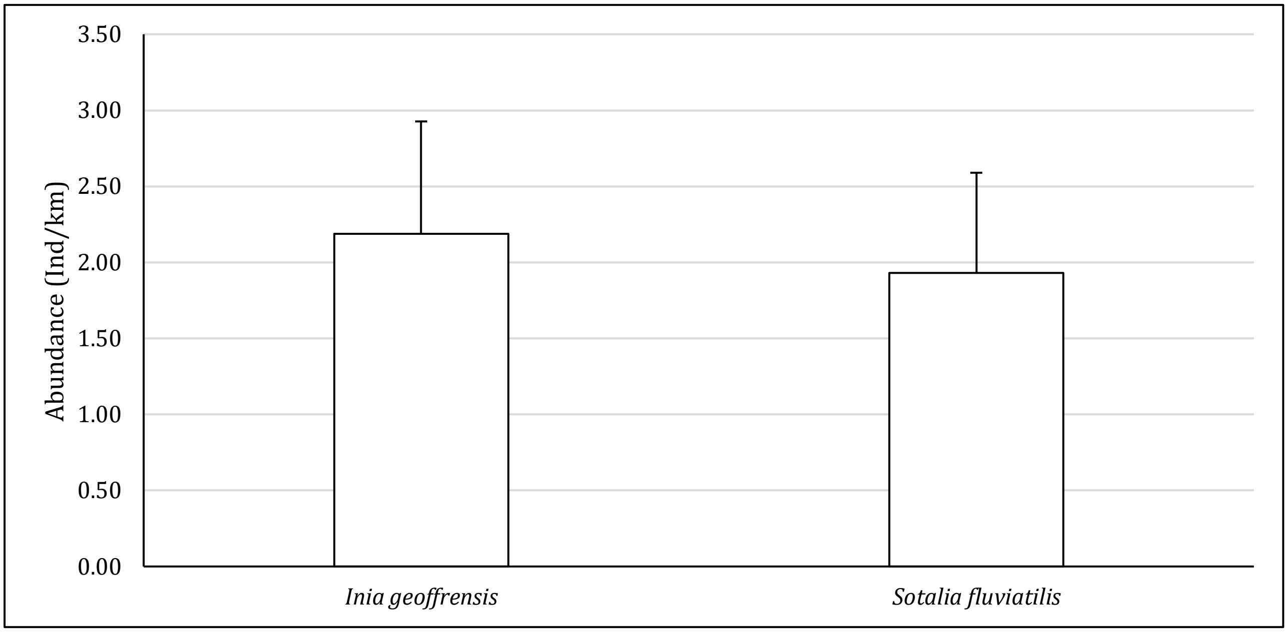


DOLPHINS

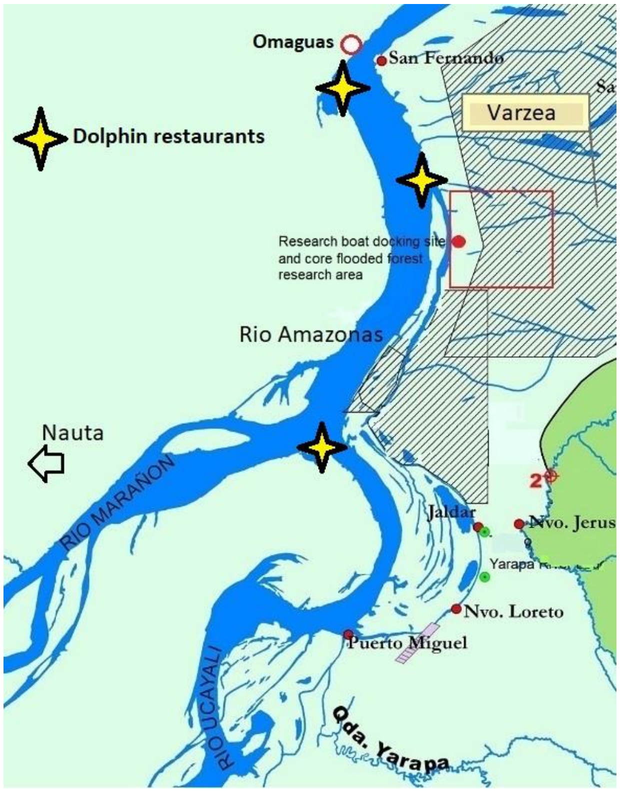
The pink (*Inia geoffrensis*) and grey (*Sotalia fluviatilis*) river dolphins were studied in the main Amazon River hyroscape and in the Yarapa River. Dolphins concentrate in areas of confluences, either of rivers meeting or lakes flowing into rivers. These areas have a higher abundance of fish and are termed dolphin restaurants. The dolphins switch between feeding behavior and resting at the restaurants, interspersed with play and mating bouts. Nurseries with 5–10 young and juvenile dolphins are also occurred at the larger restaurants, with a few adults swimming around the nursery. Pink and grey dolphins share the restaurants and we have observed interspecific interactions. Pink dolphins communicate at higher frequencies than grey dolphins and during interspecific interactions pink dolphins reduce their frequency and grey dolphins increase their frequency. On one occasion a grey river dolphin pod left an infant at a pink dolphin nursey as they went off fishing. Dolphins sighted in river sections between restaurants are often observed traveling. The smaller Yarapa River is only used by dolphins in the high-water season and solitary individuals, or small pods use the river. The areas identified as dolphin concentrations include the confluence of the Ucayali and Maranon Rivers, the confluence of the Yarapa and Amazon Rivers and the confluence of the Puritania lake with the Amazon River.

The Ucayali-Maranon area of dolphin concentrations is the largest and most constant. Typically, there will be between 20–30 dolphins of both species. The Yarapa and Puritania restaurants are more seasonal with dolphin numbers greater in the high-water than in the low-water season. The two dolphin species occur at similar abundances.

Figure showing dolphin abundances.



Map showing the areas of dolphin concentrations.



MACAWS, PARROTS, AND PARAKEETS

The white-winged parakeet was the most abundant species on the riverine point counts and in 2022 had an abundance of 56.2 ind/point. The abundance of white-winged parakeets was greater in 2019 than in 2022. Riverine points work well for the parrots and parakeets at the study site.

The Blue and yellow macaw (*Ara ararauna*) was more commonly seen on the terrestrial transects than the riverine points, were they had a high density of 10 ind/km2. The macaws in this area stay in the forest are rarely fly over the river and for this reason the terrestrial transects are better at recordings macaws than the riverine points. Scarlett macaws (*Ara macao*) were seen less frequently and had a low density of 0.2 ind/km2.

POINT COUNTS	ABUNDANCE	
SPECIES	**2019**	**2022**
White-winged parakeet — *Brotogeris versicolurus*	85.2	56.2
Cobalt-winged parakeet — *Brotogeris cyanoptera*	3.9	4.2
Dusky-headed parakeet — *Aratinga weddellii*	0.9	2.5
Southern mealy Amazon parrot — *Amazona farinosa*	2.4	2.4
Orange-winged Amazon parrot — *Amazona amazonica*	1.3	1.3
Tui parakeet — *Brotogeris sanctithomae*	1.3	1.1
White-eyed parakeet — *Psittacara leucophthalmus*	1.2	1.1
Yellow-crowned Amazon parrot — *Amazona ochrocephala*	0.8	0.9
Short-tailed parrot — *Graydidascalus brachyurus*	0.4	0.7
Red-bellied macaw — *Orthopsittaca manilata*	3.6	0.6

FISH

Fish populations were similar between 2019 and 2022, however the species composition was very different. For example, *Pygocentrus nattereri* was the most common species in the high-water season in 2019, but in 2022 it was not caught in the high water and *Liposarcus pardalis* was the most common species. It is not yet clear why we see these differences at the study site. The fish move through the Yarapa from the Ucayali to the Amazonas Rivers, so the lower Yarapa is more like a channel than a river and would have fish moving through, whereas a river will have greater resident fish species.

2019			
SPECIES	**HIGH WATER**	**SPECIES**	**LOW WATER**
Pygocentrus nattereri	29.63	*Pygocentrus nattereri*	51.22
Triportheus angulatus	14.26	*Serrasalmus humeralis*	15.96
Serrasalmus humeralis	9.82	*Auchenipterus nuchalis*	9.46
Calophysus macropterus	9.19	*Pimelodus sp.*	3.27
Tetragonopterus argenteus	4.91	*Tetragonopterus argenteus*	3.15

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Pimelodus blochii	4.59	*Triportheus angulatus*	2.38
Triportheus albus	3.96	*Mylossoma albiscopum*	2.26
Pimelodus sp.	3.80	Pterygoplichthys pardalis	2.14
Serrasalmus rhombeus	2.69	Hoplias malabaricus	1.07
Hydrolycus scomberoides	1.90	Piaractus brachypomus	0.95
	84.7860539		91.8999404

2022			
SPECIES	**HIGH WATER**	**SPECIES**	**LOW WATER**
Liposarcus pardalis	26	*Pygocentrus nattereri*	97.5
Curimatella meyeri	16.5	*Liposarcus pardalis*	62.5
Leporinus trifasciatus	13.5	*Brycon melanopterus*	17
Schizodon fasciatus	9.5	*Hoplias malabaricus*	17
Brycon amazonicus	9	*Squaliforma emarginata*	15
Brycon melanopterus	5	*Serrasalmus humeralis*	10
Callophysus macropterus	3	*Tetragonopterus argenteus*	6.5
Metynnis sp.	2.5	*Triportheus albus*	6.5
Myleus sp.	2.5	*Brycon erythropterum*	5.5
Roeboides myersii	2	*Schizodon fasciatus*	3.5
	89.5		241

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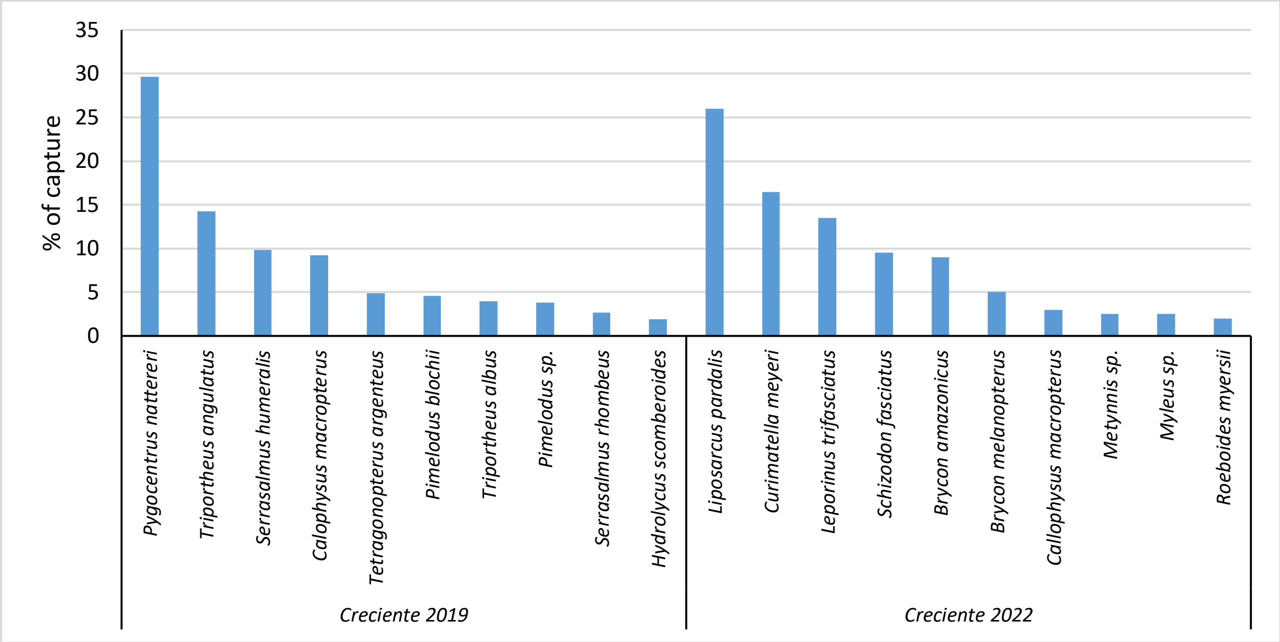

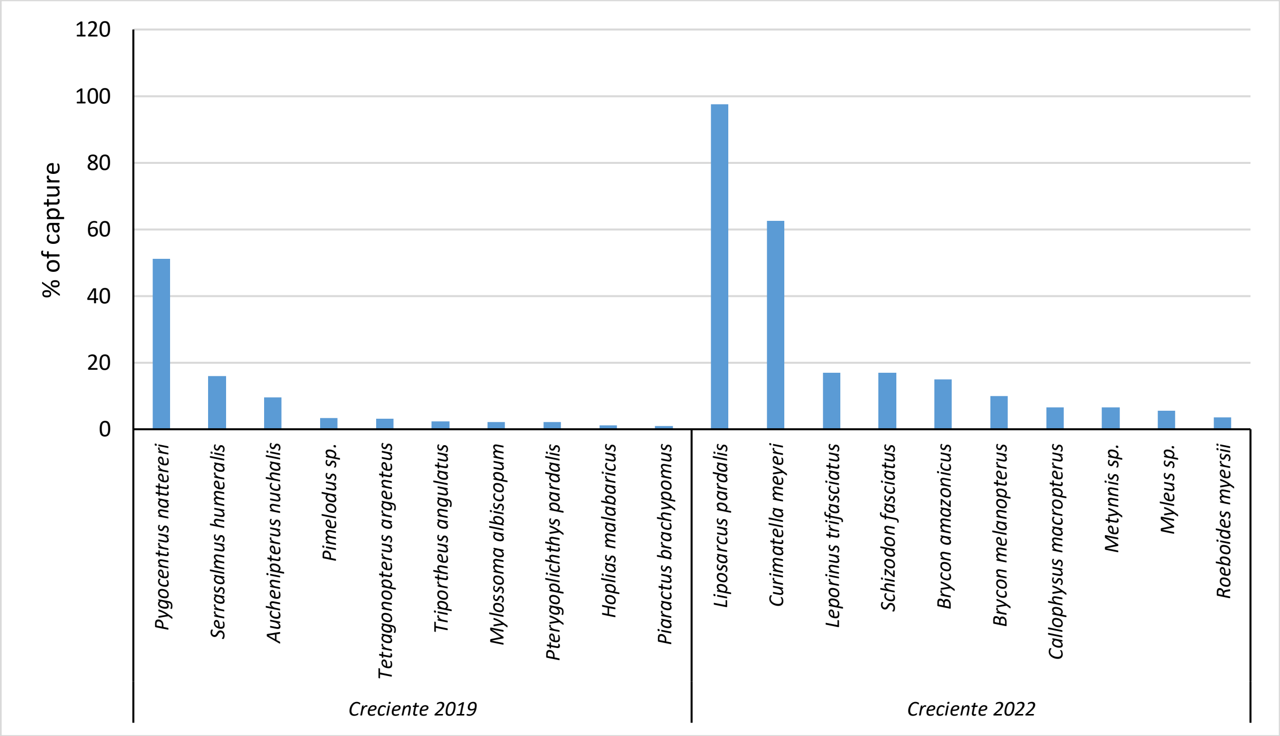

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CAIMANS

Caimans continue to be vulnerable to harvests by fishermen, and abundances throughout Loreto are low along navigable rivers, lakes, and channels.

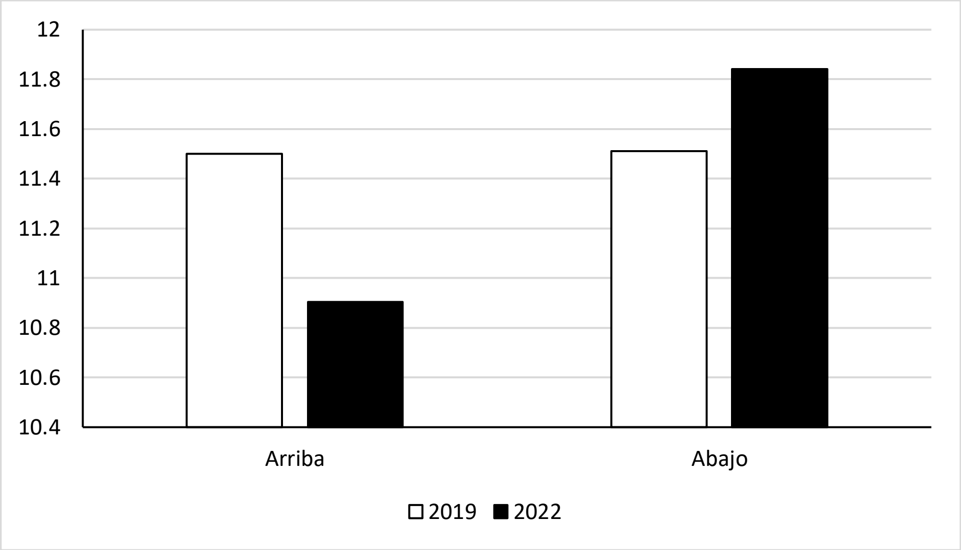
Caimans along the Yarapa River are generally low, and young individuals dominate the composition. Larger caimans live in the lakes inside the forests where fishermen do not set nets. When they set nets, they look for caimans while they wait for their net catch, and the large number of fishermen in Loreto has resulted in overharvesting. The caimans that live in isolated lakes are an important source population. Young caimans come out of these lakes and into the rivers.

In the Yarapa River, three species of caimans were observed. The most abundant species was the common caiman (*Caiman crocodilus*) followed by the black caiman (*Melanosuchus niger*), and lastly, the dwarf caiman (*Paleosuchus trigonatus*).

ABUNDANCE IND/KM					
SPECIES	YOUNG	JUVENILE	ADULT	TOTAL	DS
Caiman crocodilus	0.557	0.082	0.000	0.639	0.27707398
Melanosuchus niger	0.055	0.035	0.000	0.090	0.03040768
P. trigonatus	0.041	0.000	0.041	0.082	0.0236522

FISHING BATS

Fishing bats showed stable populations with a difference between up river (arriba) and down river (abajo) in 2022.



	2019	2022
Up	11.49	10.90
Down	11.50	11.84

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FROGS

The frog surveys on the floating meadows were dominated by *Boana punctata, Dendropsophus Triangulum, Boana lanciformis, Dendropsophus haraldschultzi*, and *Sphaenorhynchus dorisae*. The study site has 64 confirmed species of frogs.

	TRANSECTO		
SPECIES	**UP**	**DOWN**	**TOTAL GENERAL**
Boana punctata	40	23	63
Dendropsophus triangulum	24	19	43
Boana lanciformis	7	9	16
Dendropsophus haraldschultzi	8	6	14
Sphaenorhynchus dorisae	10	1	11
Sphaenorhynchus lacteus	5	4	9
Dendropsophus leali	3	5	8
Dendrosophus bifurca	2	3	5
Sphaenorhynchus sp.	3	1	4
Dendropsophus leucophyllatus	2	2	4
Dendrosophus leali	2	2	4
Boana fasciata		3	3
Pristimantis luscumbei	2		2
Dendropsophus leucoplueleotes		2	2
Boana cinereus		1	1
TOTAL GENERAL	**122**	**89**	**211**

Discussion

HOW IS THE RESEARCH ANSWERING THE QUESTIONS?

The three research questions were addressed during the 2022 field season—sustainable use, climate impacts, and community conservation. The sustainable use questions looked at wild meat, fish, and palm fruits. Wildmeat populations had healthy populations dominated by the white-lipped peccary. The results showed that flooded forests with connectivity to transitional and upland forests have greater numbers of peccaries and deer than pure flooded forests. This makes the sustainable use of wild meat species (deer, peccaries, and large rodents) more sustainable in the flooded forests connected to transitional forests. The community of Nuevo Jeruselen in the upland study site is part of an official wildlife management plan that limits hunting to sustainable levels. The results of the camera traps showed high populations of hunted and non-hunted species. This helps confirm that the management plan is working, benefiting both the biodiversity and local people.

Fish are an important resource for both subsistence protein and market sales. The communities manage lakes in their territories as the focus of their fisheries management. Rivers have greater open access from fishermen from outside. Fish are very abundant in the Yarapa River channel, which connects the Ucayali to the Amazonas rivers. Results indicated a relatively constant number of fish between years but with considerable species composition differences. The fish in the Yarapa River move between the large rivers on one side and coming out of lakes on the other. Because of the influx of fish from the large rivers, the Yarapa is more likely to have greater variance in fish species than rivers that have their own headwaters.

The fishermen from other areas, especially the towns of Nauta and Omaguas, use the Yarapa fish at sustainable levels. However, at night, they will capture caimans when they see them, which negatively impacts the caiman populations in the rivers. Caimans have a healthy population in the lakes where the adults take refuge. The young they produce come out to the river and become vulnerable to being captured by the fishermen. Fishing nets sometimes capture anaconda as a bycatch. In 2022, one anaconda was rescued, and two were killed by fishermen who often fear the snake and will kill it rather than release it. They do not use the anaconda and leave it rotting on the riverbank.

The results from the Tamshiyacu-Tahuayo community reserve show how local communities successfully manage wildlife subsistence hunting (Fang et al. 2008). This is an Amazonian model developed in the region over three decades where local people manage their subsistence hunting, and sustainable use is the norm, with biodiversity and traditional cultures being conserved (Mayor et al. 2020). Surprisingly, this model expanded throughout the Amazon region, especially in Loreto. The Tamshiyacu-Tahuayo community reserve was the first community reserve established in Loreto in the early 1990's. It was created out of a desire from the local communities to have management rights in their traditional lands (Bodmer et al. 1990). This included their major resource uses of fish, wild meat, and non-timber plants, including palm fruit, leaf, and fibre. 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. 1997).

Other community-based regional reserves have been created in Loreto, and indigenous and campesino people are developing wildlife, fisheries, turtle, and palm sustainable management programs (Benavides 2010). Some of these sustainable use programs involve regulated international wildlife trade, such as the peccary and taricaya 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 co-managed areas to high-end restaurants in Lima (SERNANP 2015).

Local trade in wild meat, fish, and palm are important, and many indigenous people depend on local trade for their household economy (Kirkland et al. 2018, Kvist et al. 2001). These resources are used through indigenous management, which has been shown to be sustainable in community reserves, co-managed reserves, and indigenous territories (Nolte et al., 2013; Blackman et al., 2017). Indigenous people manage their forests for hunting, their lakes for fish, climb palm trees to collect fruits, and head-start turtle nests. All these resource uses are based on models of sustainable use, not the past models of over-exploitation.

Community-based conservation began in the 1980s in the Amazon region, with IUCN being a major player in these early stages. The interest in indigenous people wanting to manage resources on their traditional lands was a major reason for creating the initial community-based areas (Western & Wright 1994, Townsend 2000). During the 1990s indigenous people and wildlife biologists developed sustainable use and management with the International

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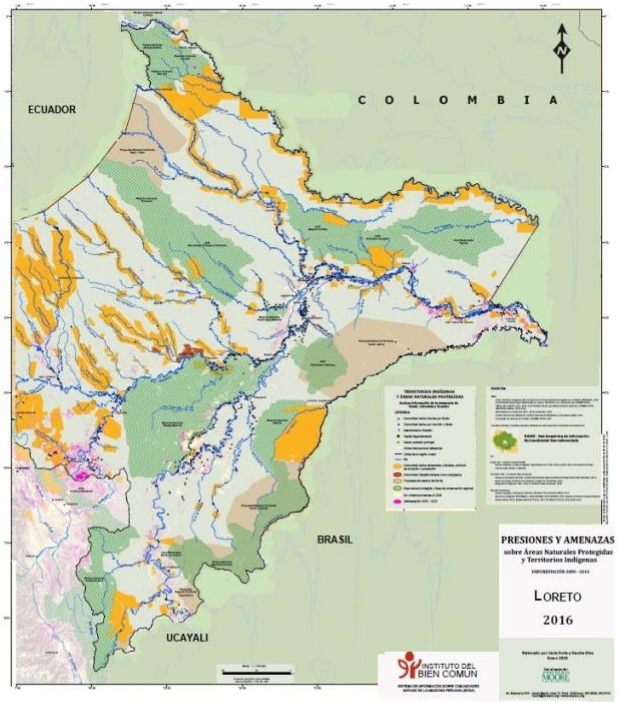
Conferences on Wildlife Management as a forum for wildlife researchers and indigenous people to develop community wildlife management throughout the Amazon and Latin America (comfauna.org). Over 25 years, the conferences have helped expand wildlife management of subsistence hunting through community-based strategies.

The unstainable resource exploitation of the 20th century is being substituted by sustainable resource use by community-based management in the 21st century. This is a complete paradigm shift in the rural economy, driven by the desire of indigenous and campesiono people to manage and conserve resources on their traditional lands and not overuse resources for a market economy (Mayor et al. 2019).

In Loreto, there are three types of community/indigenous areas where people manage subsistence hunting: community regional conservation areas, co-managed national reserves, and indigenous territories. The regional and national governments have been very supportive of the creation of these community-managed areas, and they continue to create new areas (Benavides 2010). Currently, around 50% of Loreto is a community/co-managed/indigenous area where people manage subsistence hunting (Map).



Map of Loreto showing community Regional Conservation Areas and co-managed National Reserves (green) and indigenous territories (orange).

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Recent Publications

1. Amanda Bélanger, Andrew J. Wright, Catalina Gomez, Jack D. Shutt, Kimberlyn Chota, and Richard Bodmer (2022). River dolphins (*Inia geoffrensis* and *Sotalia fluviatilis*) in the Peruvian Amazon: habitat preferences and feeding behavior. Latin American Journal of Aquatic Mammals. 2236-1057 Vol. 17 No. 1
2. Bodmer, Richard, Pablo Puertas, Tula Fang, Miguel Antúnez, Sandro Soplín, Jonathan Caro, Pedro Pérez, Hani El Bizri, Marco Arenas, José Carlos Nieto, Maire Kirkland and Pedro Mayor (in press). Management of subsistence hunting of mammals in Amazonia. IN: Research and Conservation Priorities of Mammals in Amazonia. Editor: Adrian Barnett, In Press, Springer-Brazil.
3. Rojas, R.R.; Mora, W.V.; Lozano, E.P.; Herrera, E.R.T.; Heymann, E.W.; Bodmer, R. 2021. Ontogenetic skull variation in an Amazonian population of lowland tapir, *Tapirus terrestris* (Mammalia: *Perissodactyla*) in the department of Loreto, Peru. Acta Amazonica 51: 311-322.
4. Fragoso, J.M.V, Antunes, A.P., Silvius, K.M. , Constantino P.A.L., Zapata-Ríos G., El Bizri, H.R, Bodmer, R.E., Camino, M., de Thoisy, B., Wallace, R.B., Morcatty, T.Q. Mayor, P., Richard-Hansen, C, Hallett, M.T., Reyna-Hurtado, R.A., Beck, H., de Bustos, S., Keuroghlian, A., Nava, A., Montenegro, O.L., Painkow Neto, E., Altrichter, M. (2022). Large-scale population disappearances and cycling in the White-lipped peccary, a tropical forest mammal. PLOS-ONE.
5. Mayor P., El Bizri H. R., Morcatty T., Moya K., Bendayán N., Solis S., Vasconcelos Neto C., Kirkland M., Arevalo O., Fang, T., Pérez-Peña P., & R. Bodmer 2021. Wild meat trade over the last 45 years in the Peruvian Amazon. Conservation Biology: 1–13. https://doi.org/10.1111/cobi.1380
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7. Bodmer, R., P. Mayor, M. Antunez, T. Fang, K. Chota, T. Ahuanari Yuyarima, S. Flores, B. Cosgrove, N. López, O. Pizuri & P. Puertas (2020). Wild Meat Species, Climate Change, and Indigenous Amazonians. Journal of Ethnobiology, 40: 220-235.
8. Mayor P, Álvarez J, Garcia J, Bodmer R (2020) Pueblos Indígenas de la Amazonía Peruana, 2nd ed. CETA/Fundamazonia, Iquitos, Peru

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