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Amazon Riverboat Exploration

Earthwatch Field Report

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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 during 2018. The conservation-based research on wildlife and local people is resulting in a clearer understanding of the impacts of recent climate change in the flooded forests of the Peruvian Amazon. The flooded forests are an important landscape making up one-third of the western Amazon basin and having two-thirds of the indigenous population.

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 subsistence hunting in flooded forests. 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 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 wildlife hunting by the indigenous and campesino people. The results showed that bushmeat species, including deer, peccaries and large rodents were decimated by intensive floods, and making hunting unsustainable throughout the flooded forests. These results were used by SERFOR to decrease hunting quotas in flooded forests of Loreto and by SERNANP to limit hunting in flooded forests of Pacaya-Samiria.

Results from the upland forests of Tahuayo and Yavari showed that the non-flooded forests were not impacted as severely by recent climate change. These forests make up two-thirds of Loreto and maintained healthy populations of wildmeat species and if managed, continued to be sustainably hunted as an important socio-economic activity of the local people. These results were used by DICREL to set up wildlife management plans in regional community reserves.

The research results also show that the indigenous communities in the flooded forests have adapted to the changes in wildlife populations and that these changes in resource use agree with good management practices. When wildmeat species declined the people decreased hunting and compensated by increasing fishing. This was the correct management action. When wildmeat species began to recover, the people continued to not hunt, which again is the correct management strategy, allowing a full recovery of the species. We will continue to use this information to help develop better wildlife conservation in the Peruvian Amazon that incorporates community-based wildlife management.

From the staff of the Rio Amazonas and Clavero, the students, and me, we send our warmest regards, and thank you so much for your kind assistance with the Amazon Riverboat project.

Yours faithfully,

Richard E. Bodmer, PhD, DSc
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Director, FundAmazonia—Iquitos, Peru
Red List Authority
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Summary

Climate changes are impacting the sustainability of hunting in flooded forests, with declines in the common wildmeat species caused by intensive floods, including peccaries, deer and large rodents.

The local Cocama indigenous people have taken the correct management actions by greatly reducing hunting and compensating by increases in fishing.

Fish populations have grown during the intensive floods and the fish offtake appears sustainable.

The adaptations of the Cocama people to recent climate change concur with correct management actions and sustainable use strategies.

Goals, Objectives, and Results

The goal of this project is to help develop conservation strategies in the western Amazon that confront the current threats from climate change. The purpose is to collect wildlife monitoring data to examine impacts of climate change on wildlife and livelihoods of local indigenous people, evaluate how sustainable use of fisheries and bush meat is being affected by climate fluctuations, understand adaptations, and examine mitigations using community co-management and economic incentives.

The Population Monitoring Sustainability Model was used to evaluate the sustainability of hunting and fishing in flooded forests (Weinbaumet al. 2013). The premise of the matrix model is based on research which has shown that not all species are appropriate for wild meat hunting (Bodmer & Robinson 2004). Wildlife species, including peccaries, deer, rodents and game birds have evolved life history strategies that make them less vulnerable to overhunting than other species, and more appropriate as wild meat species. These species have faster rates of reproduction and density dependent responses that allow them to compensate for the added mortality from hunting (Mayor et al. 2017). Other wildlife taxa, such as lowland tapir and primates are more vulnerable to hunting and are not appropriate as wild meat or pelt species (Bodmer et al. 1997). These species have slower reproduction, and their populations diminish from hunting (Peres & Palacios 2007).

The matrix model helps tease apart impacts from hunting/fishing and impacts from climate change using research which has shown how terrestrial wildmeat species are vulnerable to intensive floods and fish to severe droughts that result in population declines (Bodmer et al. 2017). Arboreal species can escape the direct impacts of floods and research results show that these species do not decline in intensive floods.

The population monitoring sustainability model is based on population trends using long-term monitoring. Species are divided into 1) terrestrial species less vulnerable to hunting (peccary, deer, large rodents), 3) arboreal species less vulnerable to hunting (arboreal rodents and game birds), 3) species vulnerable to hunting (tapir and primates) and 5) aquatic species less vulnerable to overuse (fish)—Table 1.

The assumptions of the model are:

- Populations of species vulnerable to hunting will decline when an area is hunted unsustainably or is impacted by climate change
- Vulnerable species will have stable and healthy populations when an area is hunted sustainably, and not impacted by climate change.
- Populations of species less vulnerable to overhunting/overfishing will decline when an area is hunted unsustainably or is impacted by climate change
- Less vulnerable species will have stable and healthy populations when an area is hunted/fished sustainably, and not impacted by climate change.

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Table 1. Matrix of the Population Monitoring Sustainability Model

	Less vulnerable Terrestrial species Peccaries, deer & large rodents	Less vulnerable Arboreal species Arboreal rodents & game birds	Vulnerable to hunting Primates & tapir	Less vulnerable Fishing
Sustainable hunting/fishing	Healthy, stable or increasing populations	Healthy, stable or increasing populations	Healthy, stable or increasing populations	Healthy, stable or increasing populations
Non sustainable hunting/fishing	Declining populations	Declining populations	Declining populations	Declining populations
Impacts of climate change	Intensive floods cause population declines	Not impacted	Not impacted	Droughts cause population declines

Results

Water-level in 2018

2018 had an overall normal hydrological cycle (Servicio de Hidrografía 2018). There was, however, lower than normal flooding during the peak flooded period with a peak flood pulse at 116.60 m.a.s.l. with the long-term mean for all years was 117.25 m.a.s.l. putting 2018 below the average (Espinoza et al. 2013; Davidson et al. 2012) (Figure 1).

The trough in water level in 2018 was 107.57 m.a.s.l. The mean trough for all years was 108.19±1.08 m.a.s.l. putting 2018 slightly below an average year. The lowest trough in water level occurred during the dry season of 2010 (Espinoza et al. 2011) when water dropped to 105.43 m.a.s.l., and 2005 (Malhi et al. 2008) when water dropped to 106.09 m.a.s.l.

Water level in 2018 changed by 9.03 m between the peak of high water and trough of low water, which was very similar to the long-term mean change of 9.17±1.19 m (Servicio de Hidrografía 2018).

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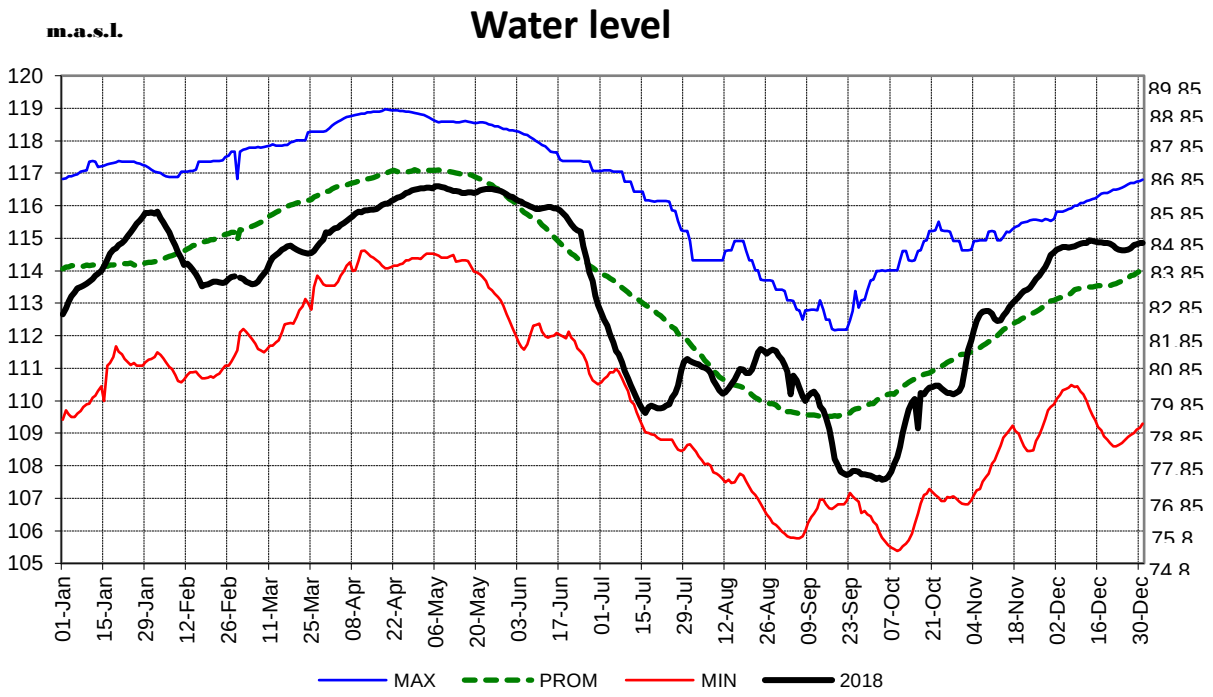

Terrestrial species less vulnerable to over hunting

Terrestrial species less vulnerable to over hunting include peccaries, deer, paca and agouti, because they have faster reproduction with density dependent responses that compensates for the added mortality from hunting and allows these populations to maintain healthy and stable populations under sustainable hunting pressure (Bodmer et al. 1997, Mayor et al. 2017). However, these same species are very vulnerable to climate change in flooded forests causing large scale population declines during years of intensive flooding (Bodmer et al. 2018). Peccary, deer, paca and agouti populations are very vulnerable to overhunting when populations become small from intensive floods. Thus, the sustainability of hunting in flooded forests is influenced more by water level than by hunting pressure. When populations are low it is essential to reduce hunting allowing species to recover (Robinson & Bodmer 1999).

The bushmeat species were decimated during the intensive floods of 2012–2015 resulting in a population decrease of over 95%. This was not caused by overhunting; the decrease was caused by the historic floods. In 2016, 2017 and 2018 the flood levels were close to the long-term average and there have been signs of recovery in some of the bushmeat species, while others are still very low.

In 2018, after three years of normal flood levels the terrestrial mammals showed signs of recovery with species recovering at different rates.

Collared peccary (*Pecari tajacu*) showed weak signs of recovery and are growing at a slow pace (camera trap photo below).

White-lipped peccary (*Tayassu pecari*) showed no signs of recovery. There were still no observations in 2017.

Red brocket deer (*Mazama americana*) showed signs of recovery showed signs of recovery in 2017 with populations continuing to grow in 2018, and close to full recovery.

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The paca (*Cuniculus paca*) showed signs of recovery in 2017 with populations continuing to grow in 2018, but not yet reaching peak numbers.

Black agouti (*Dasyprocta fuliginosa*) showed signs of recovery in 2017 with populations continuing to grow in 2018.

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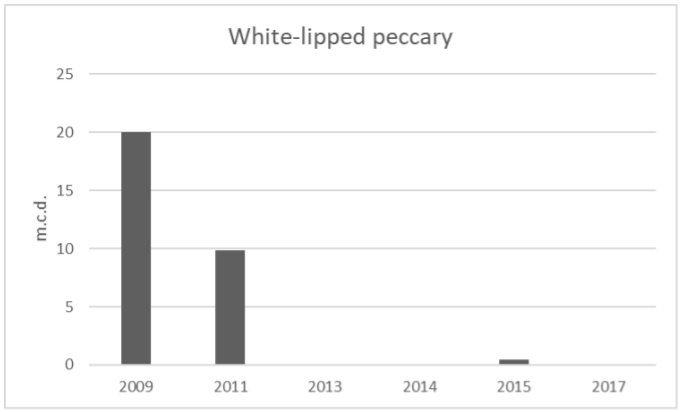
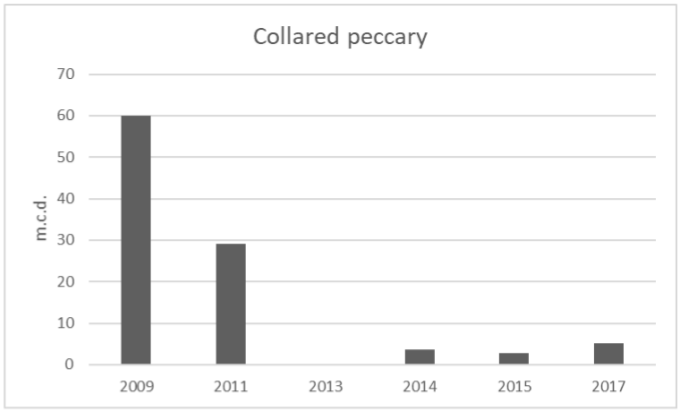
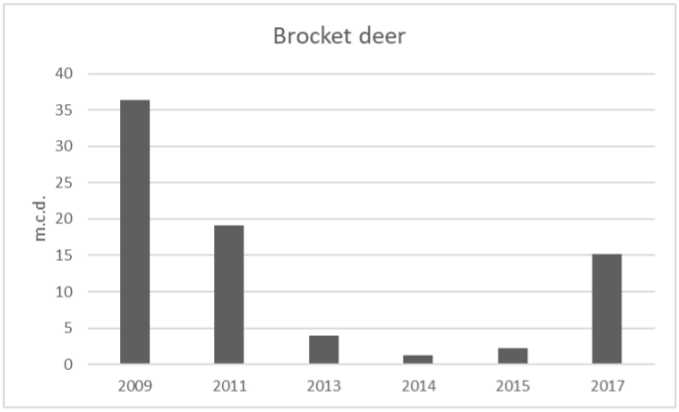
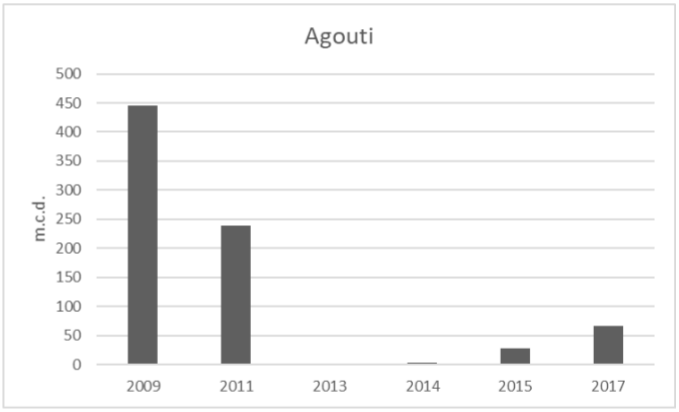
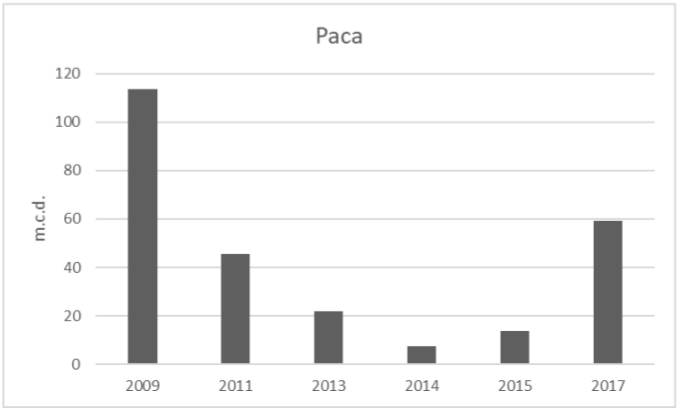
Figure 2. Population trends of terrestrial mammals measured as capture rates of camera traps, Collared peccary (*Pecari tajacu*), White-lipped peccary (*Tayassu pecari*), Red brocket deer (*Mazama americana*), Paca (*Cuniculus paca*) and Black agouti (*Dasyprocta fuliginosa*)











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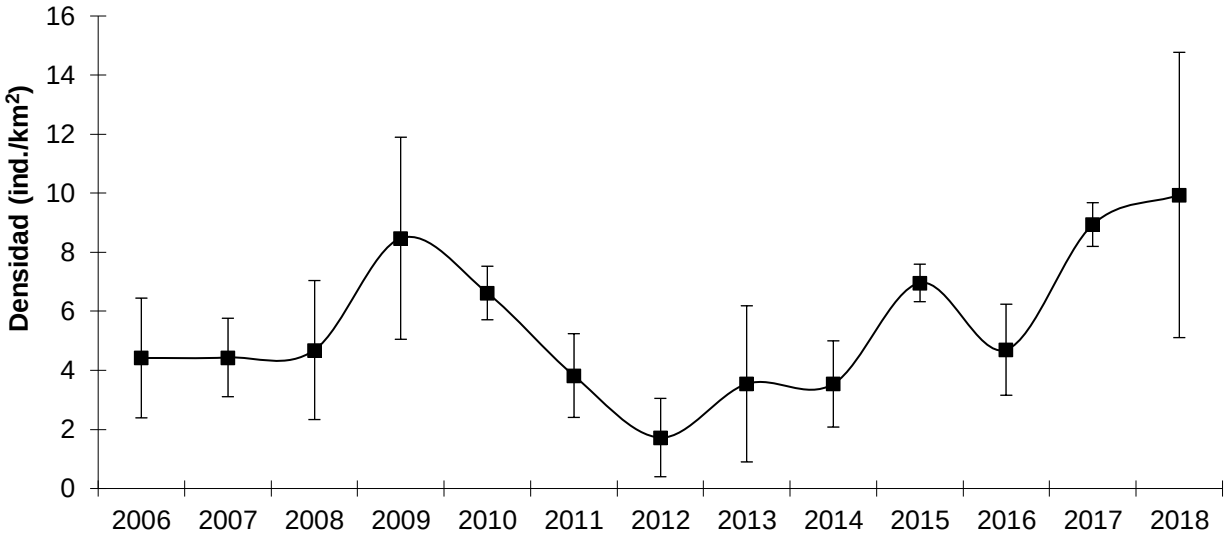
Arboreal species less vulnerable to hunting

Arboreal rodents and game birds are species that can be hunted sustainably and are less vulnerable to overhunting. They have fast reproduction and can compensate for hunting. These species were not impacted by the recent intensive floods since their arboreal habits allow them to escape flood water.

The population of the arboreal Amazon squirrel (*Sciurus spadiceus/igniventris*) has been relatively constant in the Samiria River basin from 2006 to 2018 (p=0.18, r2=0.15) (Figure 3) and in 2018 the density was 9.94 ind / km2.

Figure 3. Density of Amazon squirrel in the Samiria River basin from 2006 to 2018.



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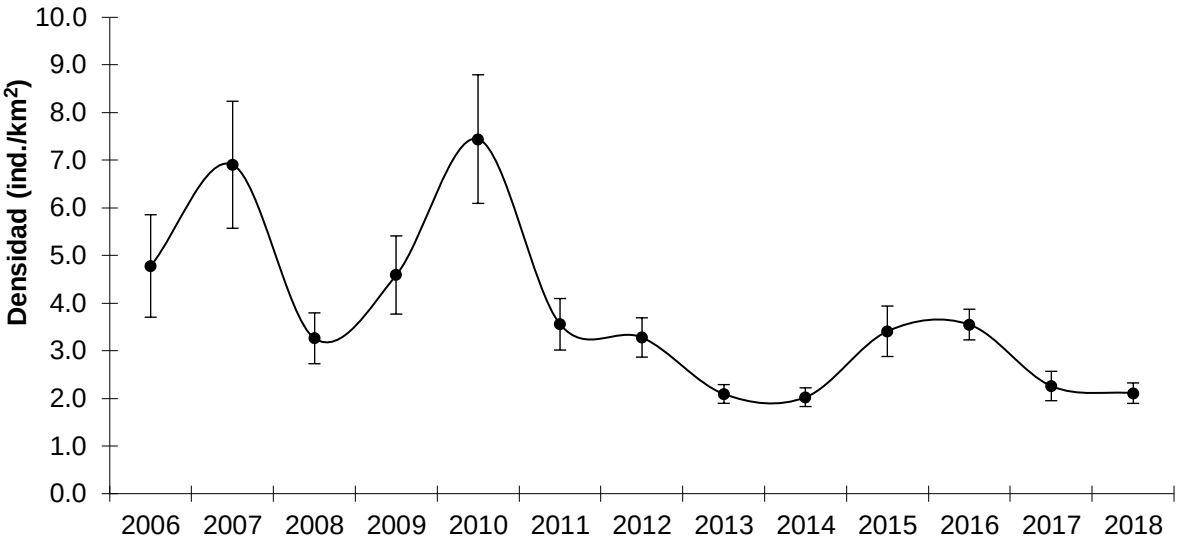
The game birds include tinamous, guans and curassows and all species can take flight allowing them to stay above inundations and total densities were stable from 2006 to 2018 (p=0.34, r2=0.38) as were densities of individual species (Figure 4).

Figure 4. Density of gamebirds in the Samiria River basin from 2006 to 2018.



Species vulnerable to overhunting and not appropriate for sustainable hunting:

The lowland tapir and primates are species vulnerable to overhunting and show population declines in areas of unsustainable hunting (Bodmer et al. 1997). These species have slow reproduction and cannot compensate for the added mortality from hunting (Brooks et al. 1997).

TAPIR

The lowland tapir (*Tapirus terrestris*) was the only terrestrial herbivorous mammal to have healthy and stable populations during the consecutive years of high floods (p=0.76, r2=0.02) (Figure 5). The aquatic habits of tapir allow them to withstand long periods of inundation, and their more folivorous diet reduces competition with other terrestrial species. The lowland tapir is vulnerable to overhunting and their populations are low in areas of unsustainable hunting. The healthy tapir populations in the Samiria indicates a well-managed area.

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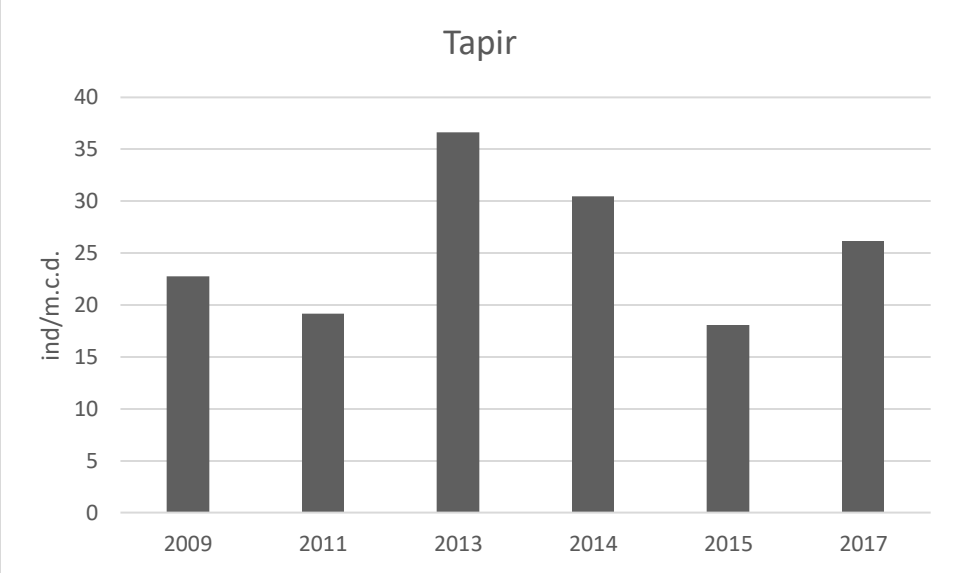
Figure 5. Camera trap abundance of tapir in the Samiria River basin.



PRIMATES

Primates of the Samiria River basin are arboreal species that are not affected by the physical inundations and are better adapted to the recent consecutive high floods than the terrestrial mammals. The total densities of primates were stable during consecutive years of high floods (r^2=0.08, p=0.85) as were densities of individual species (Figure 6).

Primates, especially the large-bodied species are vulnerable to overhunting and in areas where primates are hunted their populations are low (Peres & Palacios 2007, Puertas et al. 2017). Large-bodied primates, such as howler and woolly monkeys, have slow reproduction and they cannot compensate for mortality caused by hunting. Areas that have healthy populations of large-bodied primates indicate well managed hunting, such as the Samiria basin.

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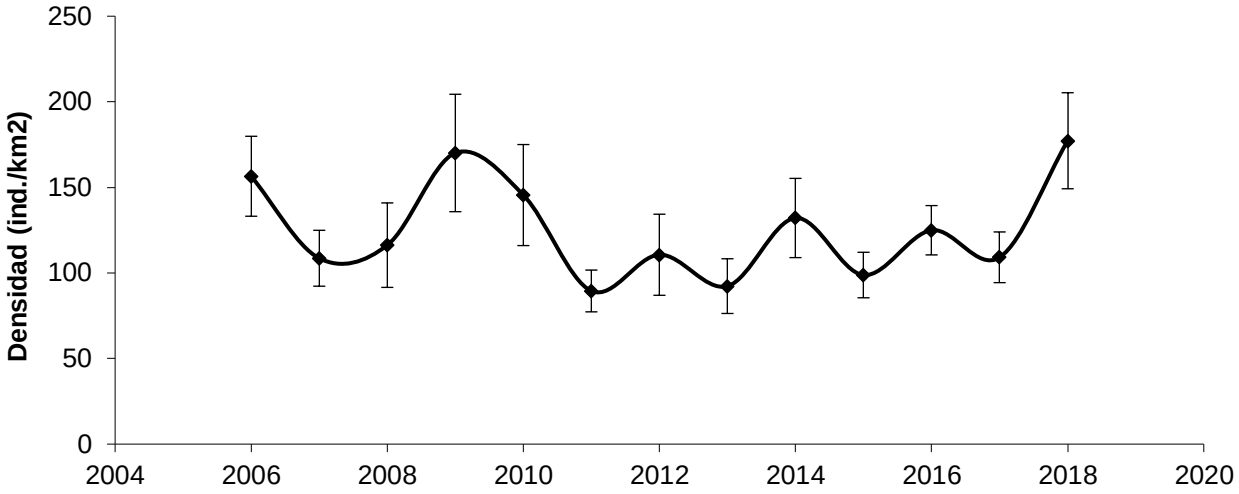
Figure 6. Primate density in the Samiria River basin from 2006 to 2018.



AQUATIC SPECIES

The aquatic species being studied include fish, wading birds, dolphins, caimans, and river otter. Research has shown that aquatic species are impacted by droughts, whereas intensive floods are advantageous for these species. The previous section showed how sustainability of hunting in flooded forests is dependent on healthy fish populations, since decreases in hunting are compensated by increases in fishing. Thus, sustainability of resource use in flooded forests must include aquatic species because of the interaction of hunting and fishing.

FISH

Fish have healthy populations in the Samiria basin and reached a peak population in 2018 with stocks in the Samiria River basin increasing from 2017 in individuals and biomass (individuals p=0.008, r2=0.65; biomass p=0.003, r2=0.75). Fish populations in the Samiria River basin are currently at a CPUE (catch per unit effort) of 20.03 ind/hour-net and a biomass CPUE of 4.45 kg/hour-net. The increase in CPUE follows five years of intensive floods and three years of average water level, with no droughts. In addition, the size class structure has been increasing in some of the most common species, including *Hobilas malabaricus, Hopleryhtrinus unitaeniatus*, *Astronotus ocellatus* and *Pygocentrus nattereri,* which is an indication of a healthier population, and a recovery from declines in 2017. Other common species did not show any change in size classes, which have been similar since 2016, including *Serrasalmus humeralis, Serrasalmus rhombeus, Prochilodus nigricans,* and *Liposarcus pardalis*.

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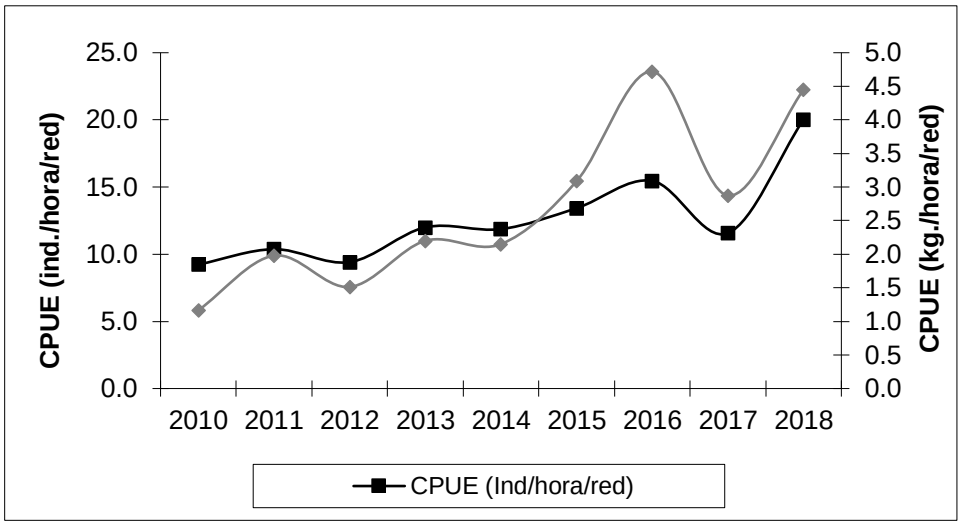
Figure 7. Population size of fish stocks in the Samiria River as Catch per Unit Effort (CPUE) of individuals (ind/net-hour) and of biomass (kg/net-hour).



WADING BIRDS

The Great Egret (*Ardea alba*) population had a substantial increase in numbers that began in 2017 and continued increasing in 2018 and is currently at 41.64 ind/km of shoreline.

The Neotropical Cormorants (*Phalacrocorax brasilianus*) had a decreasing population in 2017 and again in 2018, and is currently at 219 ind/km of shoreline, a substantial decrease from the peak in 2015 of 1,290 ind/km.

The Neotropical Cormorants are the largest consumer of fish populations. During their peak population from 2013–2015 the cormorants were estimated to consume 7,104 tons of fish annually during the low water season. In 2017–2018 this has decreased to 2,608 tons. The egret consumes much smaller amounts of fish with a mean of 216 tons annually during the low water season (Table 2).

The Neotropical Cormorant and the Great Egret appear to be in a competitive Lotka-Voltera cycle with both species consuming large amounts of the armored catfish. It appears that the Great Egret populations respond negatively to increases in the Neotropical Cormorants, and positively to decreases. The Neotropical Cormorant is the dominant species that drives the cycle, because of the large amounts of fish consumed.

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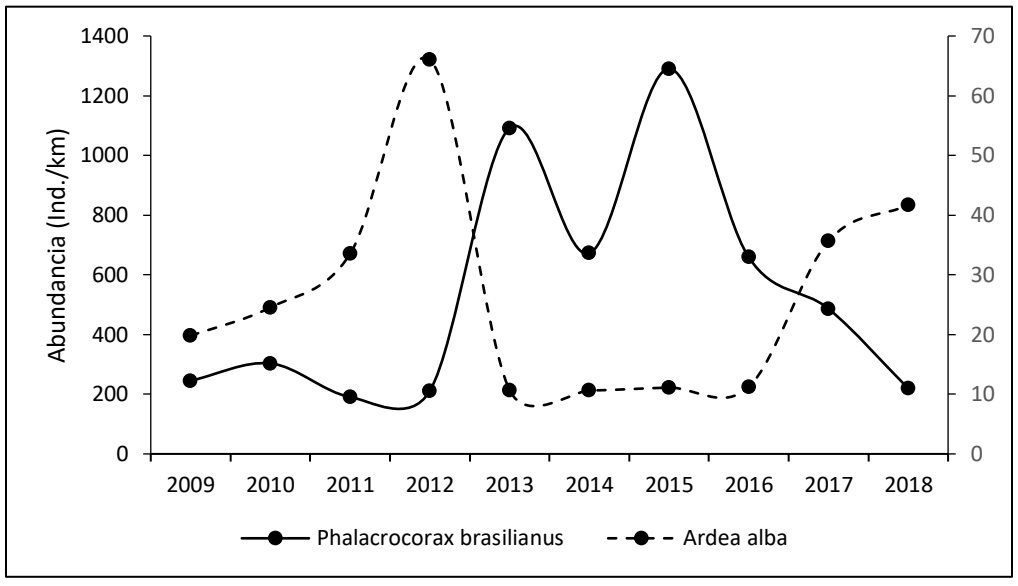
Table 2. Numbers and fish consumed by Great Egrets and Neotropical Cormorants during the low water season in the Samiria River basin from 2006–2018.

Abundance	Fish consumed	Years
Neotropical Cormorant		
234±49	1,872 tons/season	2009–2012
888±315	7,104 tons/season	2013–2016
326±188	2,608 tons/season	2017–2018
Great Egret		
32±20	256 tons/season	2009–2012
11±0.3	88 tons/season	2013–2016
38±4	304 tons/season	2017–2018

Figure 8. Populations of Great Egrets (*Ardea alba*) and Neotropical Cormorants (*Phalacrocorax brasilianus*) in the Samiria River recorded on shoreline transects as ind/km.



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The pink river dolphin (*Inia geoffrensis*) population has been relatively stable (p=0.87, r2=0.12) and peaked in 2016 with 5.79±1.44 ind/km and in 2017 and 2018 their numbers decreased to 1.61 ind/km (Figure 9). Populations of grey river dolphins (*Sotalia fluviatilis*) peaked in 2015, with decreases in 2016, 2017 and 2018. Grey river dolphins in the Samiria are currently at 0.84 ind/km.

Photo by Pablo Puertas

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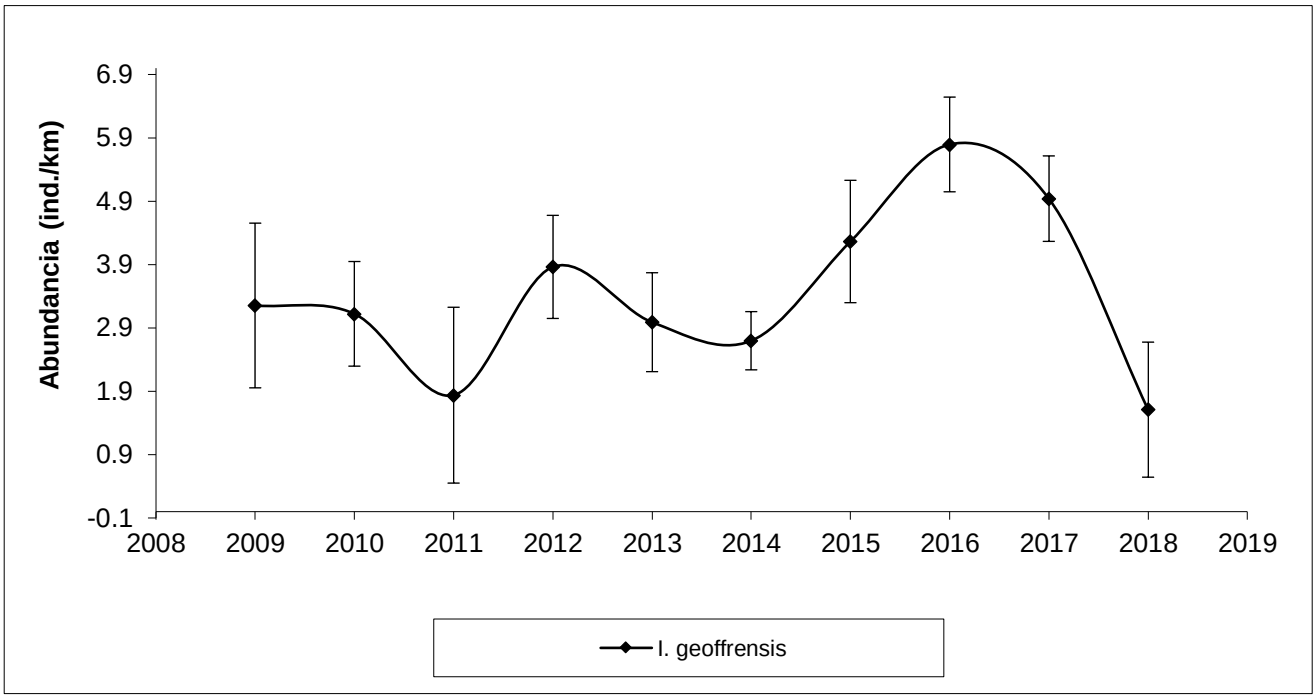
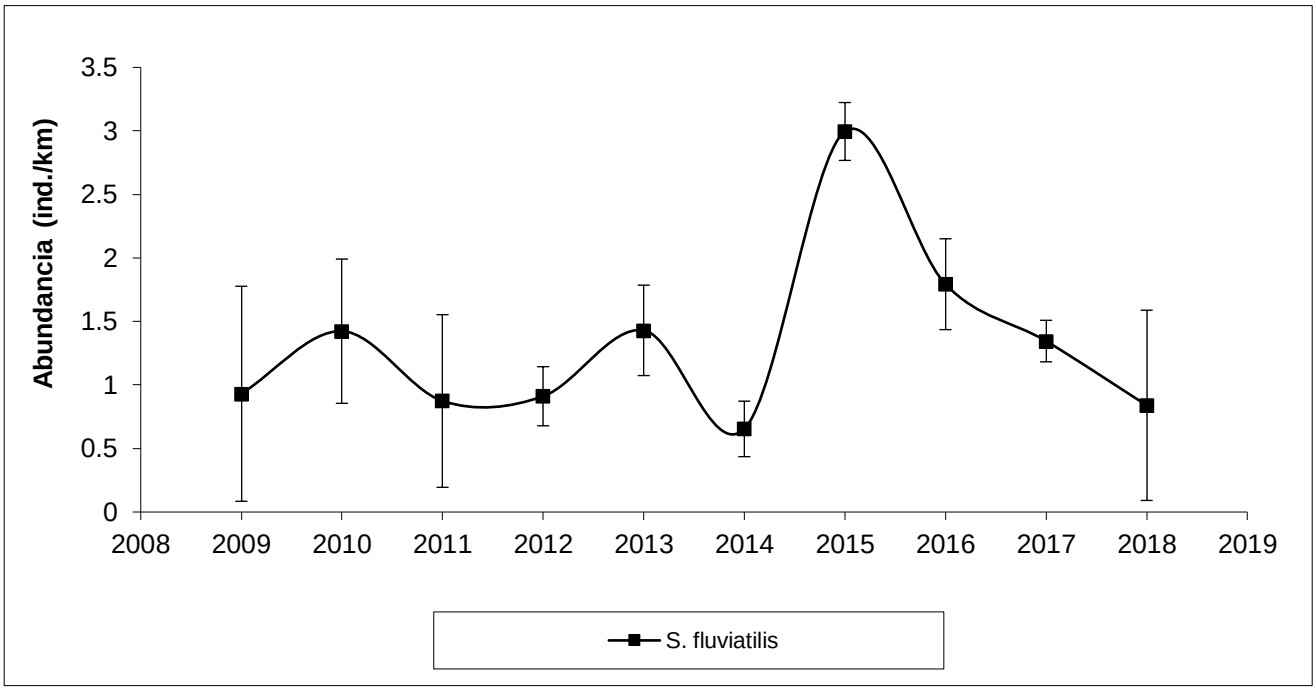
Figure 9. Pink and grey river dolphin populations in the Samiria River recorded as individuals per kilometre (ind/km).





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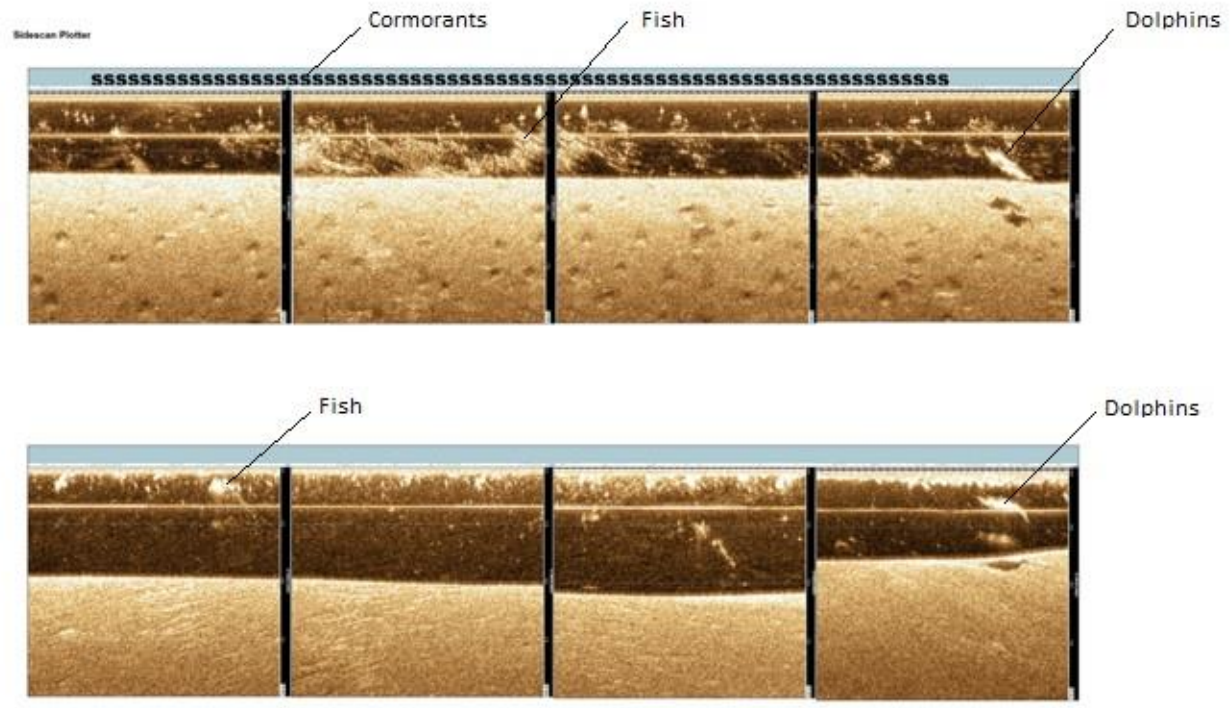
SHALLOW AREAS—MAL PASOS

Mal pasos are shallow areas of the river that occur mainly during the low water season. The hydroscape at the mouth of the Samiria River has three shallow areas that were studied, one at the confluence of the Samiria and Maranon rivers, another in the lake of San Martin, and a third at the island of Bolivar. These shallow areas are important for a variety of aquatic species including fish, dolphins and cormorants.

Side-scan sonar was used to study the relationships between fish abundance and dolphin and cormorant numbers. The shallow areas of the Samiria have very high fish numbers and are important feeding areas for dolphins and cormorants (Figure 10).

Figure 10. Side scan sonar images of cormorant and dolphin feeding sites in shallow areas in the hydroscape at the mouth of the Samiria River.



DOLPHIN NURSERY

One of the shallows (mal pasos) is a dolphin nursery area where infant and juvenile dolphins congregate and are accompanied by several adult dolphins. On all hydrophone recording days the area had greater numbers of infant and juvenile dolphins than adults with 71% of the pod on average being young dolphins. Behaviors included feeding, resting and playing with infants and juveniles observed playing together. The hydrophone recordings demonstrate the high activity of dolphin sounds at the nursery and shows the importance of shallow areas for dolphin reproduction (Figure 11).

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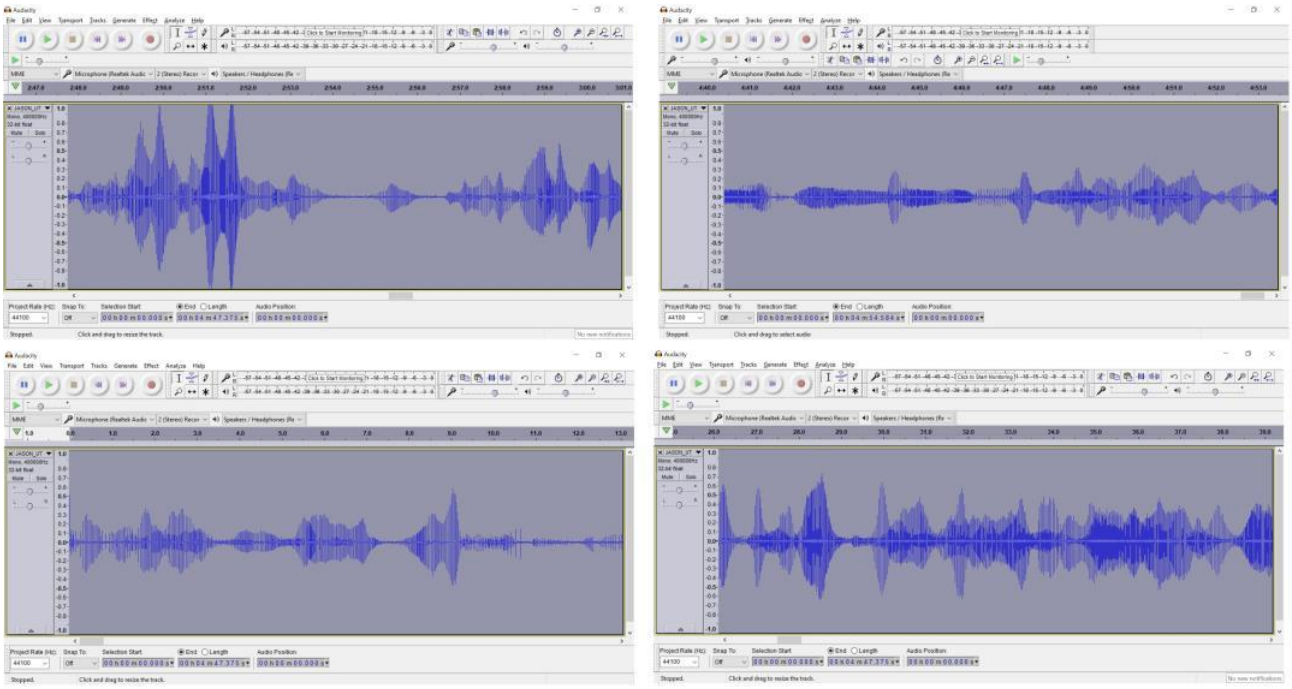
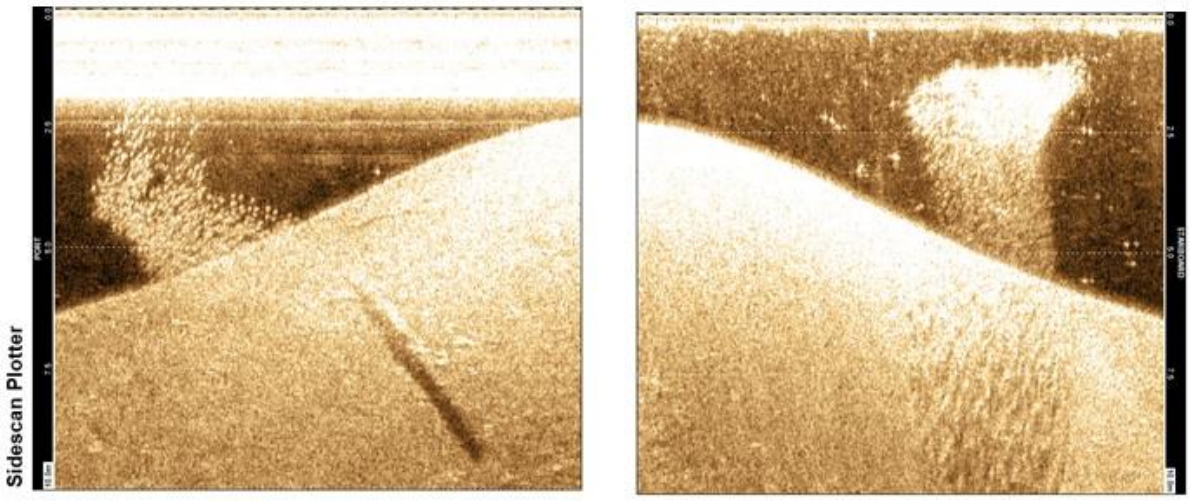
Figure 11. Hydrophone recordings of pink river dolphins at the nursery site.



The shallow areas are important fish habitats with large schools of fish concentrating at the mal pasos in the Samiria River (Figure 12).

Figure 12. Large fish schools at the mal paso of the San Martin Lake taken with side scan sonar.



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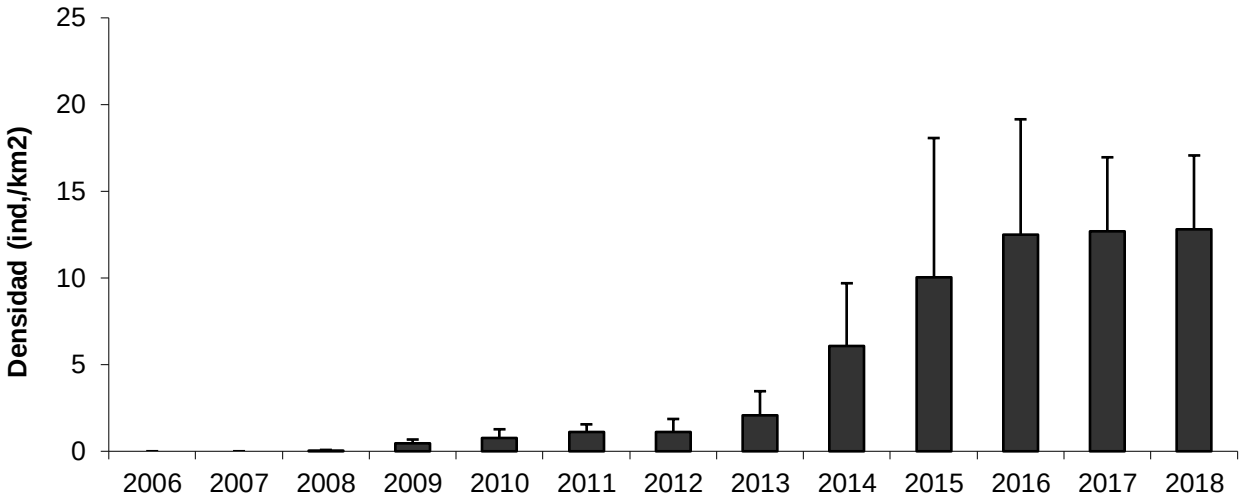
Giant river otter (*Pteronura brasiliensis*) continued to have healthy and increasing numbers in the Samiria River basin and the population was high during 2018. (p=0.0001, r2=0.81). The rapid increase in giant river otters in the Samiria over the past 10 years shows healthy ecological conditions, such as increasing fish stocks, that allow otters to have high reproductive rates.

Figure 13. Giant river otter population in the Samiria River.



CAIMAN

The spectacled caiman (*Caiman crocodilus*), black caiman (*Melanosuchus niger*) and smooth fronted caiman (*Paleosuchus trigonatus*) use the aquatic/terrestrial interface habitats. There has been a gradual decrease in common caiman and black caiman and this trend continued in 2018 (black caiman p=0.005, r2=0.48; common caiman p=0.002, r2=o.68). The smooth-fronted caiman has had more stable populations (p=0.34, r2=0.11), but is the least common with a 2018 abundance at 0.012 ind/km, whereas black caiman were at 0.26 ind/km and common caiman at 0.23 ind/km.

Photo by Pablo Puertas

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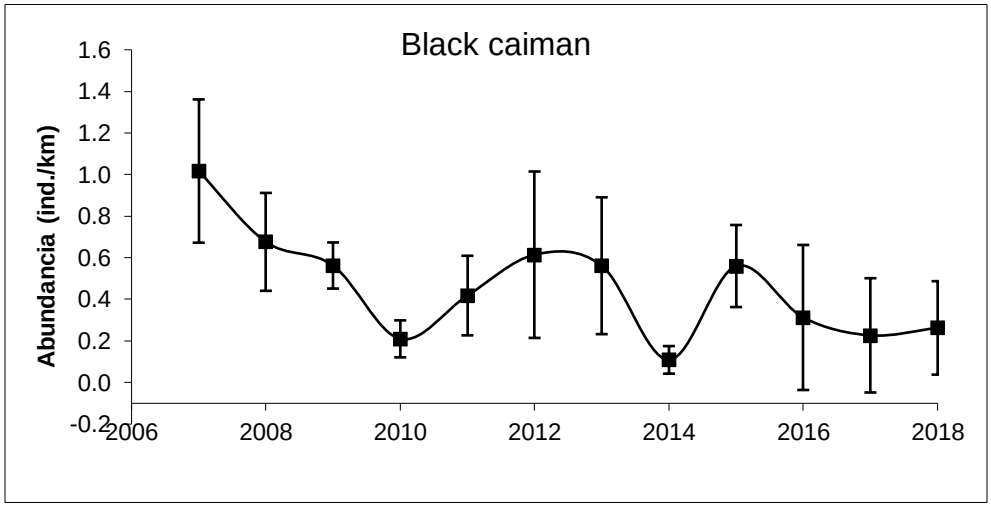
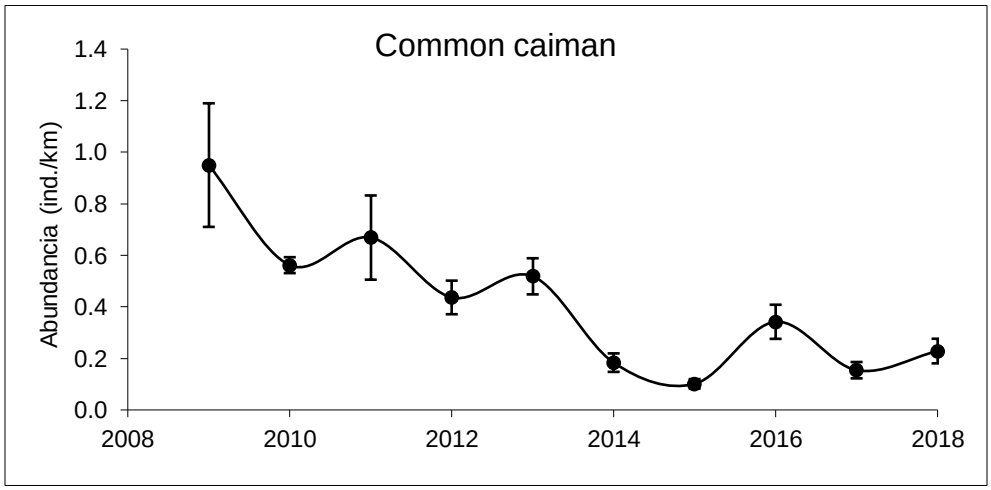
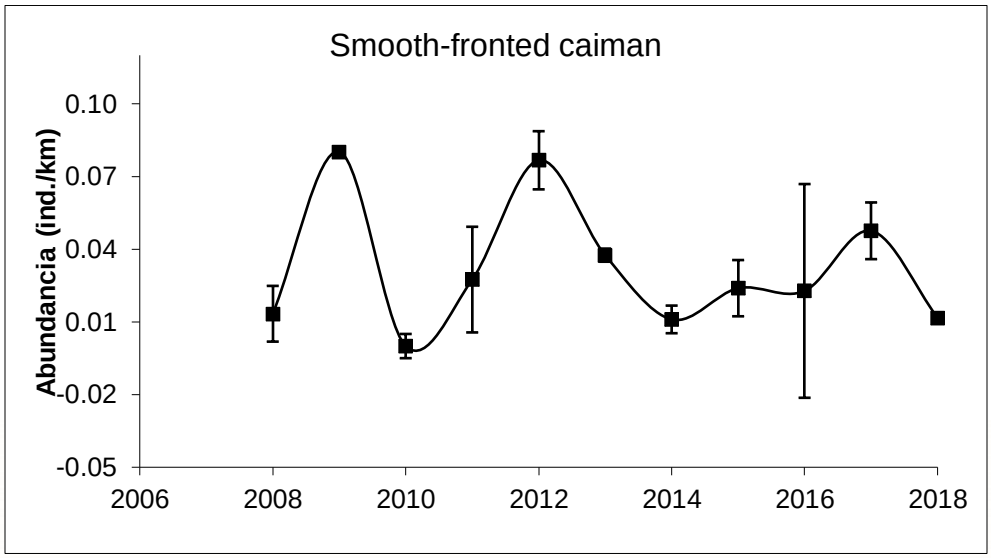
Figure 14. Black, common, and smooth-fronted caiman abundance in the Samiria River.







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Conclusion of the model

The Samiria River basin currently does not show signs of unsustainable hunting and fishing, and current hunting and fishing levels appear sustainable. The vulnerable species, such as primates and tapir have healthy and stable populations and do not show signs of unstainable hunting. The arboreal wildlmeat species including game birds and arboreal rodents have healthy and stable populations, indicating sustainable use. The major bushmeat species, including peccary, deer, paca and agouti were decimated by intensive floods and are in various stages of recovery. Most of the species have increasing populations. Fish populations have been increasing and are currently at peak numbers (Table 3).

Table 3. Matrix of the Population Monitoring Sustainability Model for the Samiria River

	Less vulnerable Terrestrial species Peccaries, deer & large rodents	Less vulnerable Arboreal species Arboreal rodents & game birds	Vulnerable to hunting Primates & tapir	Less vulnerable Fishing
Sustainable hunting/fishing	Recovering populations	Healthy & stable populations	Healthy & stable populations	Healthy & increasing population
Non sustainable hunting/fishing	X	X	X	X
Impacts of climate change	Recovering after declines caused by floods	Not impacted	Not impacted	Last drought was in 2010

X: No signs of declining populations

Hunting and Socio-economic results

The major species hunted for wild meat in Loreto are peccaries, deer, tapir, and large rodents (Fang et al. 2008). Recent years of consecutive high floods in flooded forest have caused a dramatic decline in these species, resulting in fewer animals to hunt and hunting becoming less sustainable.

The Cocama of the Samiria River have reduced hunting over the past five years as bushmeat mammals have become scarce. Hunters who still go out are less successful and state that “it is no longer worthwhile going hunting, there are no game animals.” The decline of wild meat species has made Cocama rely more on fishing during the high-water season. The Cocama of the Samiria must now fish in the high-water season when fish are more dispersed and fish returns are lower. Local people state that during the high water they must fish for longer periods to meet the daily fish intake of their families (Kirkland et al 2018). A similar pattern has been seen in other areas where hunting returns have declined (Rowcliffe et al. 2005). Fortunately, fish numbers are overall high in the Samiria River basin and can support the increased fishing.

Household surveys of villages at the mouth of the Samiria showed how Cocama indigenous people increased fishing and decreased hunting because of declining bushmeat populations. Fishing has increased to 100% whilst hunting has decreased to only 11% of households (Figure 15). Fish meat is the most important animal protein consumed by people with an average extended family fishing 4,251±2,329 kg annually, whereas the average annual wild meat was only 135±267 kg. Annually the 240 households at the mouth of the Samiria are fishing 1,020 tons, which is less than the 3,860 tons of fish consumed by the Neotropical cormorant.

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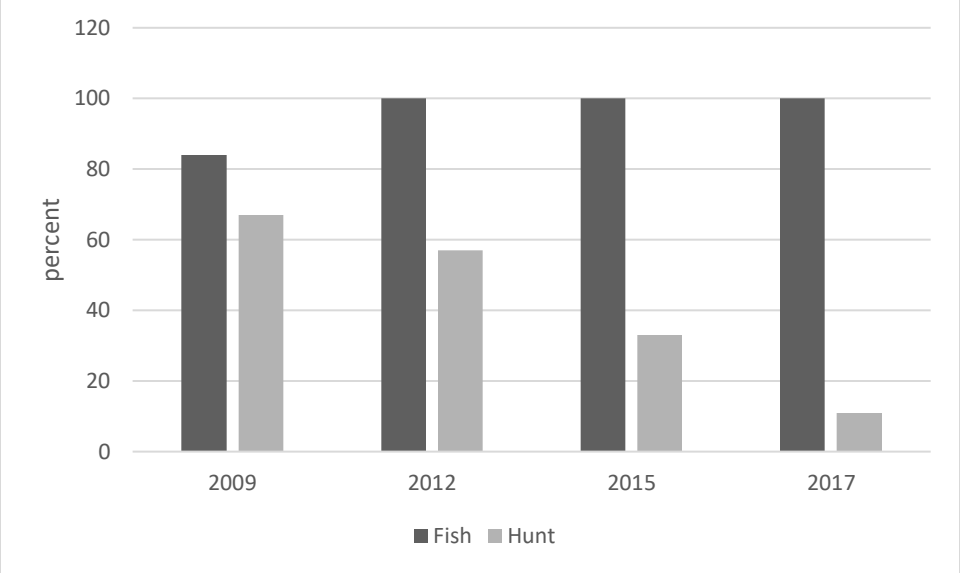
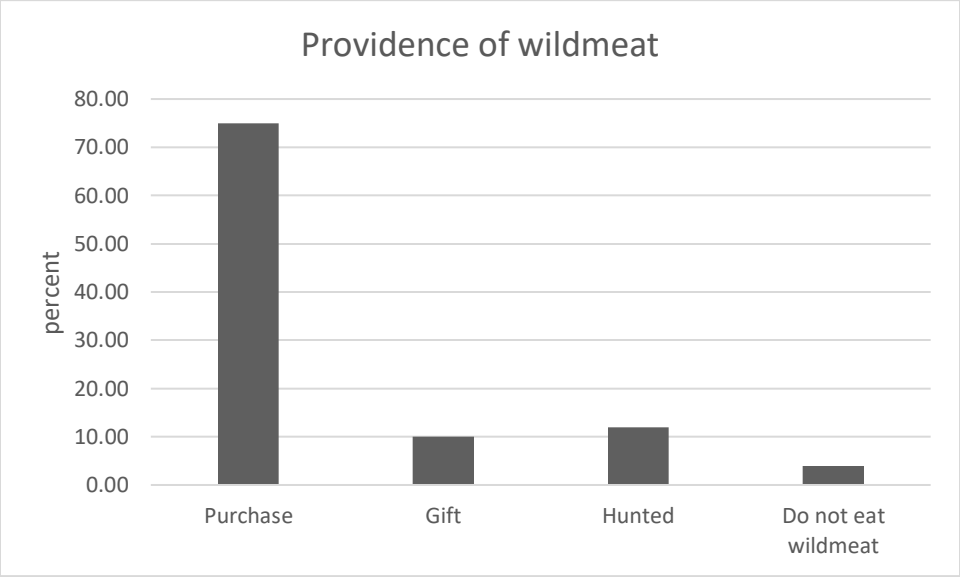
Figure 15. Percentage of families hunting and fishing in the communities at the mouth of the Samiria River.



The villages of the Samiria consume fish virtually every day, whilst bushmeat is only eaten an average 26 days a year. Chicken is eaten more than bushmeat on average 70 days of the year. Fish is the least expensive protein with an average price of S/3.88 per kilo, whilst bushmeat and chicken are around S/10-12 per kilo. Most of the bushmeat consumed by families of the Samiria is purchased (75%) or given as a gift (10%). Hunting by people of the Samiria only makes up 12% of the bushmeat consumed (Figure 16). The species hunted most frequently in the Samiria is the paca and is the most frequently eaten species making up 47% of bushmeat consumed in Samiria. Peccary meat makes up 33% of bushmeat consumed, but virtually all the peccary meat is purchased or given as a gift. Most of the peccary meat eaten in the Samiria comes from the Chambira river and the Santa Rita market. The Chambira river is in upland forests where peccary populations were not impacted by the floods and bushmeat hunting remains an important resource use activity.

Figure 16. Providence of wildmeat in the communities at the mouth of the Samiria River.



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On average an extended family in Samiria consumes 81kg of paca meat and 54kg of peccary, or approximately 8 pacas and 2 peccaries per year. Of this, only about half of a paca is from the Samiria, the majority is from upland forests outside of the reserve. There are approximately 240 families living in villages at the mouth of the Samiria, including Nuevo Arica, San Martin, Bolivar, Leoncio Prado and Santa Clara. Therefore, there are around 125 paca hunted annually in the Samiria by the communities living at the mouth. Virtually no peccaries are hunted in the Samiria.

The intensification of flooding is the cause of decreasing bushmeat numbers, not hunting pressure, which is minimal. For example, during periods of healthy peccary, deer, and large rodent populations the local people in Samiria were hunting an estimated one animal per km2 in the hunting zone. In contrast, the historic floods of 2012 and 2015 caused the bushmeat population to crash from around 16 animals per km2 to 0.8 animals per km2, or a mortality of 15.2 animals per km2. The current low hunting pressure is estimated at less than 0.1 animals per km2 in the hunting zone, the majority being paca.

Discussion

The principal cause of fluctuating bushmeat populations in flooded forests is the water level during peak flooding. Intensive floods cause high mortality from increased inter and intra specific competition, increased predation and drowning as levees (restingas) shrink with raising water levels. Bushmeat populations can become decimated, which occurred during the historic floods of 2012 and 2015 resulting in a 95% decrease in bushmeat species populations (Bodmer et al. 2018).

The intensification of flooding is the cause of decreasing bushmeat numbers, not hunting pressure, which is minimal. For example, during periods of healthy peccary, deer, and large rodent populations the local people in Samiria were hunting an estimated one animal per km2 in the hunting zone. In contrast, the historic floods of 2012 and 2015 caused the bushmeat population to crash from around 16 animals per km2 to 0.8 animals per km2, or a mortality of 15.2 animals per km2. The current low hunting pressure is estimated at less than 0.1 animals per km2 in the hunting zone, the majority being paca.

The Cocama people of the Samiria River have adapted to the decimated bushmeat populations by greatly reducing hunting. The costs to supply a hunting trip are currently greater than the return in bushmeat because there was virtually no bushmeat found. When the people reduced hunting they increased their fishing activity, which compensated for the decreased hunting, which fell by 81%. The decrease in hunting by the Cocama was the correct management action, be it on purpose or by default.

The reduced hunting pressure is allowing peccary, deer, and large rodent populations to increase during years of normal flood levels. It is very important not to hunt excessively during the period of recovery, and that is exactly what the Cocama are doing, again taking the correct management actions.

The Monitoring Sustainability Model showed how the current low hunting levels appear sustainable. The vulnerable species such as primates and tapir have healthy and stable populations, which is only possible when people are hunting sustainably. The game bird populations are also healthy and stable, which again demonstrates that current hunting levels appear sustainable. The bushmeat species are in recovery, which is only possible under sustainable hunting levels. The Monitoring Sustainability Model showed how the current low hunting levels appear sustainable. The vulnerable species such as primates and tapir have healthy and stable populations, which is only possible when people are hunting sustainably. The game bird populations are also healthy and stable, which again demonstrates that current hunting levels appear sustainable. The bushmeat species are in recovery, which is only possible under sustainable hunting levels.

The results from the research are being used by the Peruvian Protected Area Service and the Regional Government for management plans and actions. The Loreto region is currently going under a transition from an oil-based economy to a greener economy. The protected areas and indigenous territories will be an important part of the region's future and results from this project are being used to help incorporate wildlife conservation and indigenous people in the transition.

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Project Impacts

Increasing Scientific Knowledge

TOTAL CITIZEN SCIENCE RESEARCH HOURS

Provide an estimate for the number of hours per day that volunteers spent collecting data, being trained to collect data in the field, and performing data entry:

8 hours per day per volunteer

Average of 8 survey days and 1 community support day or 9 workdays. There were 92 volunteers, which comes to 8x9x95 = 6,624 hours

PEER-REVIEWED PUBLICATIONS PUBLISHED

- Bodmer, R., P. Mayor, M. Antunez, K. Chota, T. Fang, P. Puertas, M. Pittet, M. Kirkland, M. Walkey, C. Rios, P. Perez-Peña, P. Henderson, W. Bodmer, A. Bicerra, J. Zegarra and E. Docherty. 2018. Major shifts in Amazon wildlife populations from recent intensification of floods and drought. Conservation Biology,32(2):333–344. doi: 10.1111/cobi.12993.
- Kirkland, M., Eisenberg, C., Bicerra, A., Bodmer, R. and P. Mayor. 2018. Sustainable wildlife extraction and the impacts of socio-economic change among the Kukama-Kukamilla people of the Pacaya-Samiria National Reserve, Peru. Oryx. 10.1017/S0030605317001922.
- Rafael dos Santos de Andrade, Barros Monteiro, F.O., Rocha El Bizri, H., Pantoja, L., Bodmer, R., Valsecchi, J. and P. Mayor (2018). Embryonic and fetal development of the white-lipped peccary (*Tayassu pecari*). Theriogenology 119: 163–174, doi.org/10.1016/j.theriogenology.2018.07.006

Note: *All the papers cite Earthwatch Institute in the acknowledgements.*

PEER-REVIEWED PUBLICATIONS IN REVIEW

- Mayor, P., El Bizri, H., Moya, K., Solis, S., Queiroz Morcatty, T. and R. Bodmer (In review). Assessing the minimum sampling effort to reliably monitor wild meat trade in urban markets.
- Bodmer, R. et al. (In press). Modelamiento de las Consecuencias Previsibles del Dragado de los Principales Ríos Amazónicos Sobre la Fauna Silvestre y la Gente de los Bosques Inundados de Loreto, Perú. Folia Amazonica

NON-PEER REVIEWED PUBLICATIONS:

Technical reports, white papers, articles, sponsored or personal blogs:

- Bodmer, R., Mayor, P., Antunez, M., Chota, K. and T. Fang (2008). Evaluación de la sostenibilidad de la caza en el rio Samiria, Reserva Nacional Pacaya-Samiria. Report FundAmazonia/SERNANP-MINAM.
- Bodmer, R.E. y T.G. Fang. 2018. Evaluación de Pecaríes en la Amazonia Peruana de Loreto para las Cuotas Máximas Sostenibles 2018. Report submitted the Department of Forestry and Wildlife, SERFOR, CITES, Peru.
- Certifying Peccary Pelts in Peru. (2018). Darwin Initiative Newsletter, Feb. 2019, p. 23–24.
- Bodmer, R. and P. Henderson. 2018. Effects of Motorized Boats on Aquatic Ecosystems of an Amazonian Flooded Forest: Samiria River Basin, Pacaya-Samiria National Reserve, Peru. Report FundAmazonia/SERNANP-MINAM.

NON-PEER REVIEWED PUBLICATIONS:

Books and book chapters: N/A

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Presentations

- Adaptaciones de la Fauna Silvestre y la Gente a Cambios Climáticos Multianuales en la Reserva Nacional Pacaya Samiria, Perú. National Conference on Research in Protected Areas, SERNANP, Lima, Peru, Sept. 2018
- Fluctuaciones de poblaciones de aves acuáticas (Phalacrocorax brasilianus y Ardea alba) y impactos del cambio climático. National Onothology Conference, Iquitos, Peru, July 2018
- Cyclical Responses of Wildlife to Climate Fluctuations in Amazon Flooded Forests. Latin American Wildlife Conference (CIMFAUNA), Paraguay, May 2018

Mentoring

GRADUATE STUDENTS

List graduate students doing thesis work on the project:

Name	Surname	Title	Degree	Completed
Jamie	Gray	Temporal changes in avian diversity, distribution and abundance in relation to habitat use and river level fluctuation in the Peruvian Amazon.	MSc	2018
Rhianna	Goble	Anuran Abundance and Diversity in the Pacaya-Samiria National Reserve: Microhabitat Usage and Climate Change Impacts	BSc	expected 2019
William	Corver	Cats in the Pacaya Samiria National Reserve, Peru	BSc	expected 2019
Rishane	Colas	An analysis of ecological factors influencing tucuxi (*Sotalia fluviatilis)* and boto (*Inia geoffrensis)* river dolphin behavior and habitat use in the Pacaya-Samiria National Reserve, Peru	Bsc	expected 2019

COMMUNITY OUTREACH

Provide details on how you have supported the development of environmental leaders in the community in which you work:

Name of school, organization, or group	Education level	Participants local or non-local	Details on contributions/ activities
Samiria Management Groups	Secondary	local	Workshops on certification
Villages of San Martin, Nuevo Arica, Bolivar, Leoncio Prado, San Jose	Secondary	local	Workshops on climate change and adaptation, and camera traps
Reserve staff	BSc	local	Climate change and wildlife conservation
UNAP and UCP Universities, Iquitos	BSc	local	Field courses on wildlife conservation, community-based conservation, sustainable use, protected areas and climate change

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PARTNERSHIPS

List your current active professional partnerships that contribute to your project and indicate the type of support these partners provide:

Partner	Support Type(s)[1]	Years of Association (e.g., 2006–present)
FundAmazonia	Technical	2005–present
AmazonEco	Logistical	2004–present
DICE, University of Kent	Academic	2000–present
SERNANP-Ministry of Environment	Collaboration and Permits Inter-institutional agreement since 2015	2000–present
SERFOR-Forestry and Wildlife Service	Collaboration	2000–present
UNAP & UCP Universities	Academic	2000–present
Ministry of Culture, Regional Office	Cultural	2010–present
Peruvian Navy	Historical conservation	2015–present
WCS	Funding	2001–2016
CIFOR	Funding	2012–2016
Operation Wallacea	Funding	2007–present
Operation Earth	Funding	2012–present

1. *Support type options: funding, data, logistics, permits, technical support, collaboration, academic support, cultural support, other (define)*

CONTRIBUTIONS TO MANAGEMENT PLANS OR POLICIES

List the management plans/policies to which your project contributed this year

Plan/Policy Name	Type[2]	Level of Impact[3]	New or Existing?	Primary goal of plan/policy[4]	Stage of plan/policy[5]	Description of Contribution
Pacaya Samiria National Reserve	Management plan	regional	renewed	Biodiversity conservation	In progress	Scientific research, monitoring protocols, dynamic baseline and co-management policy
Peccary Subsistence Hunting Annual Plan	Annual quotas	national	annual	Sustainable use	adopted	Scientific results, sustainable use analysis, evaluation of quotas
River turtle certification plan	Management plan	regional	annual	Implementation of certification	In progress	Coordination
Peccary Pelt certification plan	Certification plan	national	existing	Consolidating certification	adopted	Coordination

1. *Type options: agenda, convention, development plan, management plan, policy, or other (define)*
2. *Level of impact options: local, regional, national, international*
3. *Primary goal options: cultural conservation, land conservation, species conservation, natural resource conservation, other*
4. *Stage of plan/policy options: proposed, in progress, adopted, other (define)*

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Conserving natural and sociocultural capital

CONSERVATION OF TAXA

List any focal study species that you did not list in your most recent proposal:

Species	Common name	IUCN Red List category	Local/regional conservation status	Local/regional conservation s tatus source
N/A				

In the past year, has your project helped conserve or restore populations of species of conservation significance? If so, please describe below:

Species	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source	Description of contribution	Resulting effect[6]
Pteronura brasiliensis	Endangered	Endangered	Department of Biodiversity, MinAm	Monitoring and research	Population increase
Lagothrix lagotricha	Vulnerable	Vulnerable	Department of Biodiversity, MinAm	Monitoring and research	Stable population
Tapirus terrestris	Vulnerable	Vulnerable	Department of Biodiversity, MinAm	Decrease hunting	Stable population
Priodontes maximus	Vulnerable	Vulnerable	Department of Biodiversity, MinAm	Monitoring	Population weakened from climate change
Myrmecophaga tridactyla	Vulnerable	Vulnerable	Department of Biodiversity, MinAm	Monitoring	Population weakened from climate change
Panthera onca	Near threatened	Vulnerable	Department of Biodiversity, MinAm	Monitoring and research	Stable population
Podocnemis unifilis	Vulnerable	Near threatened	Department of Biodiversity, MinAm	Headstarting certification	Increased reproduction
Podocnemis expansa	Vulnerable	Near threatened	Department of Biodiversity, MinAm	Headstarting	Increased reproduction
Trichechus inunguis	Vulnerable	Endangered	Department of Biodiversity, MinAm	Monitoring and research	Stable population
Tayassu pecari	Near threatened	Near threatened	Department of Biodiversity, MinAm	Monitoring	Population weakened from climate change

6. Resulting effect options: decreased competition, improved habitat for species, range increased, population increase, improved population structure, increased breeding success, maintained/enhanced genetic diversity, other

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CONSERVATION OF ECOSYSTEMS

in the past year, has your project helped conserve or restore habitats? If so, please describe below.

Habitat type	Habitat significance[7]	Description of contribution	Resulting effect[8]
Flooded forests	Breeding grounds	research and monitoring	Extent maintained

ECOSYSTEM SERVICES

Indicate which ecosystem service categories you are directly studying in your Earthwatch research and provide further details in the box below:

☒Food and water ☐Flood and disease control
☐Spiritual, recreational, and cultural benefits ☐Nutrient cycling

DETAILS

Fisheries reproduction in inundated forests. The project is helping to conserve the largest fisheries reproduction area in the Peruvian Amazonia, the 20,000 km2 Pacaya Samiria National Reserve. During high water periods 90% of the reserve floods, literally becoming an inland sea. During floods fish enter the water laden forests and feed on the abundance of vegetative and animal production, especially the abundance of fruits, invertebrates and other living organisms trapped in the annual. The abundance of food improves the condition of fish and in turn allows for high reproductive rates with many fish populations reproducing within the inundated forests.

CONSERVATION OF CULTURAL HERITAGE

Provide details on intangible or tangible cultural heritage components that your project has conserved or restored in the past year:

Cultural heritage component[9]	Description of contribution	Resulting effect
Artifacts, history	Museum of Amazonian Indigenous Cultures	Circa 8,000 annual visitors
Ships, history	Amazon Historic Boat Museum	Circa 12,000 annual visitors

9. Cultural heritage component options: traditional agriculture, artifacts, building(s), hunting ground or kill site, traditional ecological knowledge and practices, monument(s), oral traditions and history, spiritual site, traditional subsistence living

Research Plan Updates

Report any changes in your research since your last proposal/annual report. For any 'yes' answers, provide details on the change in the 'Details' box.

1. Have you added a new research site or has your research site changed? ☒Yes ☐No

2. Has the protected area status of your research site changed? ☐Yes ☒No

3. Has the conservation status or a species you study changed? ☐Yes ☒No

4. Have there been any changes in project scientists or field crew? ☐Yes ☒No

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DETAILS

Provide more information for any 'yes' answers. Provide details on any changes to your objectives, volunteer tasks, or methods, include reason for the change:

New site: Lower Yarapa River

Mooring location: 4º24'41"S -73º24'52"W at 110 masl

The new study site is close to the confluence of the lower Yarapa and Amazonas rivers. The lower Yarapa River is a 50 km long channel that originates in the Ucayali River and discharges into the Amazonas River. The Yarapa River also originates in the forests of the Tamshiyacu-Tahuayo Community Reserve.

The new site continues to be in the same landscape that we have always worked in, known as the Samiria-Yavari landscape by WCS. This landscape includes the Pacaya-Samiria National Reserve/the Yarapa River/Tamshiyacu-Tahuayo Community Reserve/the Yavari-Miri River and the Lago Preto Conservation Concession. We are currently working in all these areas and have done so since the early 1990's.

The Yarapa study site will be on the landmass that connects the Pacaya-Samiria National Reserve and the Tamshiyacu-Tahuayo Community Reserve. These two protected areas almost touch each other, so the new site is nicely positioned within the protected area complex.

The flooded forest habitat at the Yarapa site is the same type as the Samiria, consisting of varzea habitat with riverine, open understory, levee, liana, and palm swamp forests. These are high nutrient ecosystems with heavy sediment water flowing through the understory during the high-water season.

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As the PI I would like to thank the following biologists and support staff for their hard work on the project in 2017: Kimberlyn Chota, Tula Fang, Pablo Puertas, Pedro Mayor, Tino Vela, Osnar Pizuri, Miguel Antunez, Natalie Lopez, William Bodmer, Oscar Fang, Emma Docherty, Joseph Zagarra and Wendy Juarez.

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We would like to thank Earthwatch Institute, FundAmazonia, DICE, WCS-Peru, the Pacaya Samiria National Reserve Authority (SERNANP), the Ministry of the Environment, the Peruvian Forestry and Wildlife Service (SERFOR), UNAP, UCP, the Gordon & Betty Moore Foundation, USAID, DICE – University of Kent, the Ministry of Culture and the Peruvian Navy for their financial and institutional support of the project.

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