Wildlife Conservation in the Samiria River Basin of the Pacaya-Samiria National Reserve, Peru

Report for 2008

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Introduction

The Amazonian forests of Loreto, Peru are situated in the western Amazon basin and harbor some of the greatest mammalian, avian, floral and fish diversity on Earth (Puertas and Bodmer 1993, Pitman *et al.* 2003). Indeed, these forests are one of the last remaining true wilderness areas left on the planet. However, these vast expanses of pristine forest will only remain intact if conservation programs are successfully implemented (Anderson 1990, Peres et al 2006). Wildlife conservation in Loreto must incorporate landscape features (in terms of major habitat types of both flooded and upland forests), the biology of landscape species and the socio-economics of the rural people (Bodmer *et al.* 1998).

Research and conservation activities should use an interdisciplinary approach to find a balance between the needs of the indigenous people and the conservation of the animals and plants (Bodmer and Puertas 2000, Peres 2000). For example, some animals like the primates, jaguars, manatees and tapirs are very vulnerable to hunting and their populations can rapidly be depleted by overhunting (Bodmer *et al.* 1997, Peres & Palacios 2007). Other animals are more appropriate as a source of meat for local people, such as peccaries, deer and large rodents (paca and agouti)(Bodmer & Robinson 2004, Fang et al. 2008). This project is helping to conserve wildlife, not only for saving the biodiversity of the Amazon, but also as a means of helping the poor indigenous people who rely on these resources for their food and shelter (Bodmer and Robinson 2004). The project is working together with the local people, because they are the true guardians of the forest, and information provided by this research can help the indigenous people make appropriate decisions on how best to save the Amazon (Halme & Bodmer 2007). The Amazon has been abused in the past, through deforestation for timber, overhunting of animals and overfishing (Dourojeanni 1990, Peres & Nascimento 2006). Local people are taking actions in places like the Pacaya-Samiria Reserve. This areas is an examples of how things are changing; it is an example of how conservation can work in collaboration with local people, governments and NGO's (Bodmer et al 2008).

Pacaya-Samiria: a National Reserve Incorporating Local People

The Pacaya-Samiria National Reserve has gone through a major shift in its management policies over the past two decades, from an area of strict protection where local people were excluded from the reserve to an area where the local indigenous people participate with the reserve management. This drastic shift in conservation policy has led to a reduction in hunting pressure and an increase in wildlife populations (Bodmer & Puertas 2007). When the park administration changed and the reserve began to incorporate the local communities in the management of the area, attitudes of the local people also changed (Puertas et al. 2000). Local management groups were given areas to manage and were no longer considered poachers. They were able to use a limited amount of resources legally and with reserve administration approval. Many of the local people changed their attitude towards the reserve and began to see the long-term benefits of the reserve for their future. The reserve became part of their future plans and there was increasing interest in getting involved with the reserve. Many local people can now see the socio-economic benefits of the reserve and are themselves helping to conserve the area. Hunting has decreased substantially, both due to the poachers now becoming mangers, and because the local people are keeping the other poachers out of their management areas.

Research Objectives

The project is using a set of key wildlife species to evaluate the conservation success of the Samiria River basin in the Pacaya-Samiria National Reserve.

1) Ungulates are important bush meat species and were used to examine the impact of hunting by using sustainability models and long-term monitoring.
2) River dolphins were used as indicator species for the aquatic systems by incorporating long-term monitoring of the dolphin populations.
3) Macaws were used as general indicators of the terrestrial systems by evaluating changes in species numbers and composition.
4) Primate populations were monitored to determine the impact of hunting on arboreal mammals and to study ecological interactions between arboreal and terrestrial wildlife assemblages.
5) Game bird populations were monitored to determine their conservation status and impact of hunting.
6) Caiman populations were monitored to evaluate the recovery of black caiman populations and the ecological interactions between species.
7) River turtle populations were monitored to determine the success of the head-starting conservation programme in the Samiria River basin
8) Giant river otter populations were monitored to evaluate the recovery of this rare species.
9) Amazon manatee populations were monitored in the Samiria river to evaluate the conservation status of this vulnerable species.
10) The abundance, diversity and age structure of the large fish species were monitored to determine the impact of local fisheries and the effectiveness of fisheries management.

Pacaya-Samiria National Reserve

The Pacaya-Samiria National Reserve extends over an area of 2,080,000 ha in the Department of Loreto, Peru. The reserve is dominated by white water flooded forests, known in Amazonia as Varzea forests. The reserve is comprised of two major drainage basins: the Pacaya River basin and the Samiria River basin. The Samiria River basin is the largest geological and ecological feature of the reserve.

The principal habitat types of the Peruvian Amazon are a result of large scale geological changes that occurred during the tertiary and quaternary periods. The Samiria River basin is situated in the Pevas lake bed that formed after the uplifting of the Andes. When the Pevas Lake drained it left a geological depression in this area of western Amazonia, which is currently characterized by soft alluvial soils.

The wildlife of the Samiria River lives in an ecosystem that is characterised by large seasonal fluctuations occurring between the high water and low water seasons. The ecology of the aquatic and terrestrial wildlife revolves around these seasonal changes in water level.

The large seasonal inundations that annually occur along the immense floodplains of the Pacaya-Samiria rivers are a result of rainfall in the foothills of the Andes. During the summer months of October to May precipitation off of the Pacific Ocean is pushed over the Andes by the strong uplifting winds originating from Southern Ocean currents. This results in heavy rainfall on the eastern Andes that runoff into the western Amazon basin. The result is large scale flooding along the major rivers situated in the old lake bed and the high water season. In contrast, during the winter months of June to September the precipitation off the Pacific Ocean decreases and the rains in the eastern Andes is greatly reduced, resulting in the drying up of the western Amazonian rivers and the low water season.

The Amazon River is an order of magnitude greater than any other river basin on Earth. This enormous volume of water is largely a consequence of water moving from the Pacific Ocean to the Atlantic Ocean via the Amazon basin.

The rivers that originate in the eastern Andes are rich in sediments that are picked up from the recent geological formations of the Andes, giving the rivers a whitish colour. These white water rivers continually deposit and pick up sediments as they flow through the old Pevas lake bed of western Amazonia.

The white water rivers of western Amazonia are extremely dynamic and change course in a matter of a few years, with islands and channels continually forming and being washed away. This is a result of three concurrent factors, 1) the soft alluvial soil of the Pevas Lake bed, 2) the enormous volume of water that passes through the basin as a result of precipitation off the Pacific Ocean, and 3) the large quantities of sediments that are picked up and deposited as the rivers run their course.

The Pacaya-Samiria National Reserve is situated between the confluence of the two largest tributaries to the Amazon in Peru, the Ucayali and Maranon Rivers. The meeting of these two rivers actually come together to form the Amazon River proper. The Ucayali and Maranon Rivers have snaked back and fourth across the Pacaya-Samiria reserve over the millennia leaving behind an abundance of oxbow lakes, channels, levees, and other geological features. Indeed, both the Pacaya and Samiria Rivers are actually old channels. Indeed, the headwaters of the Samiria River originate principally from inflows of the Maranon River and the Samiria River drains back into the Maranon. Likewise, the Pacaya River originates from water of the Ucayali River that is drained back again at its mouth.

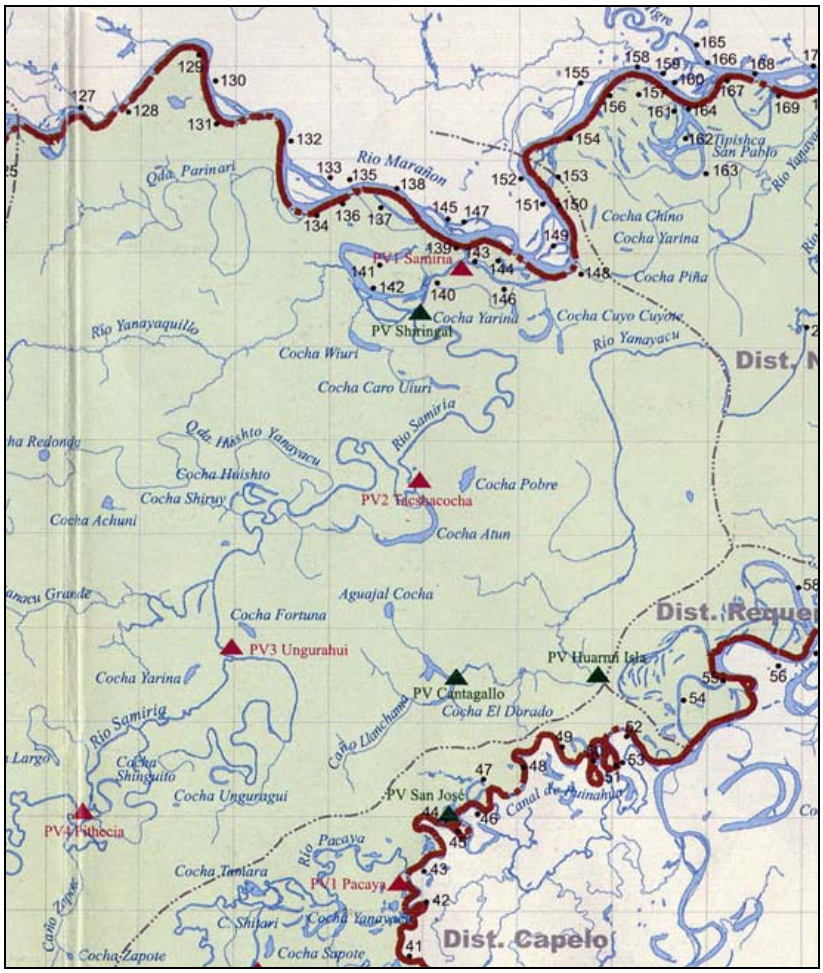
The soils of the flooded forests in the Pacaya-Samiria Reserve are rich in nutrients due to the white water rivers of the Ucayali and Maranon flowing through the forests and depositing sediments during the high water period. The Samiria River is characterised by a blackish colour during high water. This is a result of the white water from the Maranon entering the flooded forests, depositing the sediments as the currents slow during their movement through the forests, and the water picking up tannins from the leaf litter.

Whilst the soil of these Varzea forests is rich, the ecological conditions of long periods of flooding, up to 6 months, is very harsh on much of the floral and faunal community. Many plant species can not withstand the long periods of inundation and the diversity of plants in the heavily flooded areas is lower than lightly and non-flooded levees. Likewise, the terrestrial wildlife must seek out floodplain islands or levees during the high water season, which have increased competition and predation pressures. Even the arboreal wildlife is impacted by the flooding, since many of the fruit trees are quite seasonal in the Varzea forests, resulting in seasons with low food production.

The aquatic wildlife is equally affected by the large seasonal inundations. During the flooded periods the fish enter the flooded 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 floods. Indeed, many tree species fruit during this season and rely on the fish as their primary means of seed dispersal. During the flooded period many fish populations reproduce within the inundated forests. Other aquatic wildlife have a more difficult time during the floods, such as the dolphins, giant river otter and other fish predators, since their prey is more sparsely distributed throughout

the large expanses of the flooded forests. When the waters recede during the dry months, fish populations become condensed in the reduced lakes, rivers and channels with ever increasing competition and predation. During this period many fish populations migrate out of the Varzea rivers and into the larger rivers. The dolphins and other fish predators have an abundance of prey during the low water season and even follow the fish migrations down the rivers and channels.

The people who live in the flooded forests also have adapted to the seasonal fluctuations in both the use of the natural resources and their agriculture. During the high water season fishing is more difficult, since the fish are dispersed throughout the inundated forests. However, during this period hunting becomes easier with the large bushmeat species, such as deer, peccaries and tapir being trapped on the levees and islands. In contrast, during the low water season the bush meat species become difficult to hunt as they range throughout the entire forests, and the fish become easy prey being trapped in the reduced water bodies of the lakes, channels and rivers. The local indigenous people of the floodplain forests alter their hunting and fishing accordingly, with a greater emphasis on hunting during the high water season and a greater focus on fishing during the low water season.



Partial view of the Samaria river basin. The area around PV Samiria is the mouth section. The area around PV Tachacocha is the mid-section. The area around PV Ungurahui is the near up river section, and the area around PV Pithecia is the far up river section.

The agriculture of people inhabiting the flooded forests takes advantage of the rich soils from the annual deposits of sediments and the short growing period that needs to be harvested before the floods return. Traditionally, people of the flooded forests have relied on the manioc as their staple agricultural product. Manioc has a short growing period that can be planted and harvested within the low water season. Manioc flour (farainha) is produced by baking pounded. Manioc flour can be stored throughout the year and supply carbohydrates to the people during the flooded periods.

Methods

Terrestrial mammals

Line censuses along transect trails were used to conduct terrestrial mammal and game bird censuses. Censues trails between 2-5 km in length were surveyed repeatedly. Information registered on a census includes: day, site, species, number of individuals, and perpendicular distance from the individual to the transect line, habitat, time, distance travelled and weather conditions.

The method assumes that all the animals that are on the center of the line transect (0 m perpendicular distance) will be observed. The technique is based on the notion that observers do not see all the animals that are off the center of the line, and that the probability of sighting an animal depends on the distance of the animal from the line. Animals closer to the line have a higher probability of being seen than animals further from the line. The perpendicular distance of all solitary animals sighted, or the first animal sighted in a social species were recorded (Buckland *et al.* 1993). The DISTANCE estimation calculates the animals that you did not see, and includes these animals in the density estimate.

The method relies on measuring the perpendicular distance of animals before they move as a consequence of seeing the observer. That means observers must try and see the animal before they sight the observer. It also means observers must measure the perpendicular distance of the first sighting. If animals move because of the observer than the estimate will be biased. With the DISTANCE programme trails do not have to be straight, but the perpendicular distances must be measured at the correct angle of the center line. The perpendicular distance will be measured directly from the point of first sighting (Buckland *et al.* 1993).

The method assumes that animals are independently dispersed throughout the habitat. Since individual animals within a social group are not independent, but move dependant upon one another, animal groups in social species must be considered as the sampling unit. Thus, DISTANCE will calculate the density of animal groups (Buckland *et al.* 1993).

The equipment used for line transects included: a map of the area, a compass, data sheets, pens and binoculars. Trails were not placed with any pre-determined knowledge of the distribution of the animals. Censuses were done using small groups of three or four observers. Transects were walked slowly and quietly (500-1,000 m/hr) between 7am and 3pm.

Census information were analyzed using DISTANCE software (Thomas *et al*. 2002). This programme is regularly used in calculating individual or group densities (Buckland *et al*. 1993) and can estimate densities if the distribution of sightings within a transect line forms a clear probability function. When the number of sightings is deemed insufficient to determine a probability function, the method known as ‘fixed width’ was used to estimate the densities.

Censuses of caimans

To assess the population and ecology of caiman species in the ecosystem it is necessary to gain an understanding of their population size. Aquatic transects were used traveling upstream or downstream on the main river and in nearby channels or lakes. A GPS was used to determine the distance surveyed each night. All caimans seen were identified to the species level as best as possible and size of the caiman and location were noted. These data, along with data collected from captured caimans, were used to analyze the caiman population size. Caiman surveys and captures were conducted from a small boat fitted with a 15-horsepower engine. Caimans were located by their eye reflections using a 12-volt spotlight and approached to a distance where the engine was silenced and the boat paddled closer.

Noosing was used to capture caimans. The noose was made of a long pole about 2 m in length with a loop of rope that can be pulled tight over the caiman's neck. The caimans were secured with rope tied around the jaw behind the nostrils and around the neck. Total body length was measured from the tip of the snout to the tip of the tail, while head length was measured from the tip of the snout to the posterior edge of the orbital (the vent). The sex was also determined. Weight of the caiman was recorded in kilograms. A measuring tape and weighing scales was used.

The population abundance of each species was calculated using the formula N/L, where N= the number of individuals and L= the distance travelled in kilometres. The results indicate the number of individuals per kilometre.

Censuses of macaws

Point counts were used to monitor macaws. Between eight and nine points was established in each sampling unit separated by 500m. A GPS was used to measure the distance between points.

Fifteen minutes was spent at each point. Censuses were carried out twice a day in the morning (5:30-9:00h) and afternoon (16:00-18:30). The censuses usually lasted longer in the morning than in the afternoon.

Within the 15-min counts, all macaw species either perched or flying were noted. The distances of the birds from the observer were estimated where possible. A motorized boat was used to travel to each point.

Abundance data were calculated in each sampling zone. This was done by adding the total number of sightings and dividing this number by the number of points. Thus, abundance is expressed as the number of individuals per point.

Census of turtles and the nesting programme

The censuses of the river turtles, in particular *Podocnemis uniflis*, was carried out in the Samiria River basin. The method consists of travelling with the current of the river on a boat and registering the number of individuals sited, either sunbathing or swimming. The 'fixed width' method was used to estimate turtle abundance, where the fixed width was the width of the river.

The censuses was carried out using a boat and following an imaginary line across the middle of the river between the hours of 11:00 and 13:00, collecting data on: the perpendicular distance, the number of individuals, the location of the boat, the activity of the species and any other information deemed relevant. To facilitate the observations, binoculars were used when individuals were

sunbathing more than 50 m away from the boat. The classification of the microhabitat was recorded. Beaches at were used to collect turtle eggs from nests as part of the head starting programme.

Turtle eggs were collected from the nests and placed in an artificial beach constructed next to the park guard posts. After 60 days the turtles hatch and were released back into the main river.

Preparation of the artificial beach

The artificial beach was prepared by turning over the sand which had been carefully selected and free from organic remains and insects. The artificial beach was encircled by a barrier created from palm tree wood, in order to keep in the sand and to facilitate drainage whilst avoiding the loss of nests during the incubation process. The size of the palm frame is dependent upon the number of nests planted; in this case a frame of 5 by 6 metres was used.

Collection of eggs

The nests were located by gently probing the ground with a small stick; or by simply pressing the ground very gently with one's heel when the footprints are not clear enough or had been washed away by rain.

Transport of eggs

Once the nests are found, they were carefully excavated out of the soil using ones hands. Eggs were extracted, one by one, and placed very gently on a tray with a layer of sand. Care was taken to maintain the original position of the egg and not to turn them around during handling in order to make sure that the growth rate of the embryo remains intact. Every nest in the tray was labelled with the number of eggs collected and the number of eggs that were not viable. The latter were covered up with sand and separated with leaves.

Selection of eggs

The eggs were taken to the artificial beach built next to the guard post where they were incubated. Eggs considered viable are those that develop a whitish spot 24 hours after they have been laid. Cracked shells render eggs inviable. Eggs that were not considered viable due to cracks in their shells, fungus, abnormal size, or appearing flaccid, were discarded.

Nesting

A hole was dug by hand in the sand similar to that of a natural nest. The depth of the hole depends on the number of eggs that were placed in the nest. One by one, the eggs were placed inside the whole, in the same position in which they had been found, and the nest was then be covered up with sand and lightly patted to create a little mound of sand about 5cm high. The distance left between each nest was 20 cm, whilst 30 cm of space was left between each row.

Information on the number of nests, the number of eggs, the percentage of inviable eggs as well as the date of collection and incubation was recorded.

Censuses of dolphins and manatees

Dolphin censuses were carried out at both sites. Five kilometres was travelled daily from 9:00 to 14:00 h along the centre of the river using a boat. Information collected included: species, group size, group composition, behaviour (travelling, fishing, playing), time, and any additional observations.

Data were analysed using fixed width: $$D = \frac{N}{2AL}$$

Where:

D= Density
N= Number of individuals
A= River width
L= Distance travelled
2= Number of margins sampled

Aquatic surveys were used to census dolphins. A GPS (Global Positioning System) was used to determine the length of each aquatic census. Dolphin transects usually take three to four hours to complete depending on the speed at which the river is flowing.

A motorized boat was used to carry out the census. Any dolphins seen coming to the surface for air, swimming with their heads above water, sunbathing or swimming just below the surface of the water (i.e. no deeper than 5 cm) were recorded. Care was taken not to double count any dolphin sightings. Behavioral information on the dolphin activity was also recorded along with the size class of each dolphin sighting. For each transect the weather conditions and the start and finish times were recorded.

Censuses of fish

Censuses were carried out at both sites. During the censuses green gill nets of 3.5'' were used in lakes and channels with weak currents and white gill nets in the river. Fishing points were located on shores or banks where there is aquatic vegetation or shrubs, although meanders are the preferred areas. Individuals were identified, measured and weighed. Catch per unit effort was calculated by the number of individuals per species caught and the effort spent fishing at each zone.

Habitats were also compared (lake, channel, river) and diversity indices were used. Productivity of fish was shown in terms of catch per unit effort, using the 'biomass captured per effort' method. The CPUE method is a robust indicator over time for the level of abundance, density and pressure fishing in a given zone (Queiroz 2000). The length-frequency analysis helps to predict biological impacts of fisheries. A harvest focused on juveniles, for example, causes greater impact than a harvest of adult fish not in their breeding period.

Giant River Otter

Censuses were conducted for two months intervals. Sample counts were used to compare relative abundance between censuses rather than absolute counts which would have required identification of all individuals. Censuses were conducted by by boat, scanning with binoculars and listening for otter calls. We recorded group sizes and locations using a handheld Global Position System (GPS), which we also used to calculate the length of each transect. Double counting was avoided by keeping a constant boat speed and where possible by identifying groups by the unique throat markings of individuals. The total length of each transect was recorded, along with the width and type of the body of water.

Sample Sizes

The following table presents the sample sizes of aquatic and terrestrial transects used during the three year study.

Activity	Samiria			Lago Preto		
	2006	2007	2008	2006	2007	2008
Terrestrial censuses (km)	540	820.87	1068.65	507.1	601.3	196.2
Dolphin censuses (km)	217	259.47	442.15	24	119.78	137.76
Caiman censuses (km)	189.23	124.62	252.8	50.1	132.7	189.6
Macaw counts (Points)	331	622	383	139	84	130
Fish surveys (hours)	307	175.3	135.45	166	221.01	120
Turtle censuses (km)	101.95	24.95	193.69			

Results

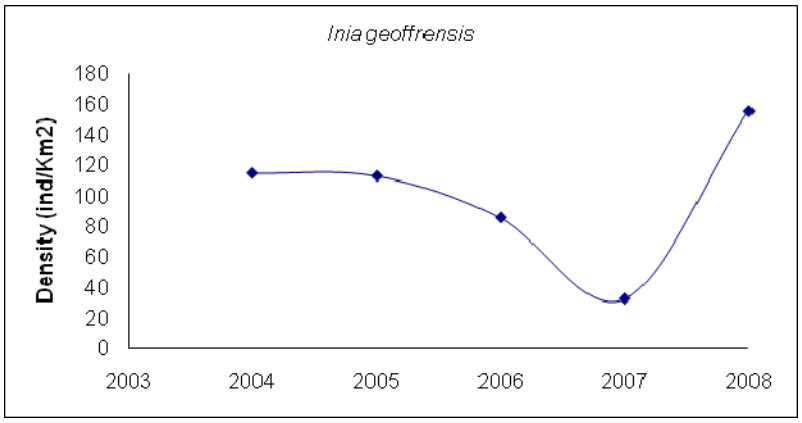
River dolphins were used as indicator species for the aquatic systems by incorporating long-term monitoring of the dolphin populations.

The pink river dolphin (*Inia geoffrensis*) and the grey river dolphin (*Sotalia fluviatilis*) were used as indicator species for the aquatic hydroscape. These species are appropriate as indicator species because 1) they are top predators of the hydroscape, 2) they are not intentially killed by people due to strong taboos, 3) they can move in and out of river systems over short periods of time, and 4) they are easy to count and observe. The dolphin's ability to move widely means that changes in dolphin populations within a river system will be caused more by dolphins leaving an area or immigrating into an area rather than a result of mortality or reproduction. Thus, if a hyrdoscape is going through negative changes, such as pollution or overfishing, the dolphin numbers in the system will be observed rapidly. Likewise, if a river system becomes healthier than surrounding hydroscopes dolphin numbers would increase from dolphins moving into the area.

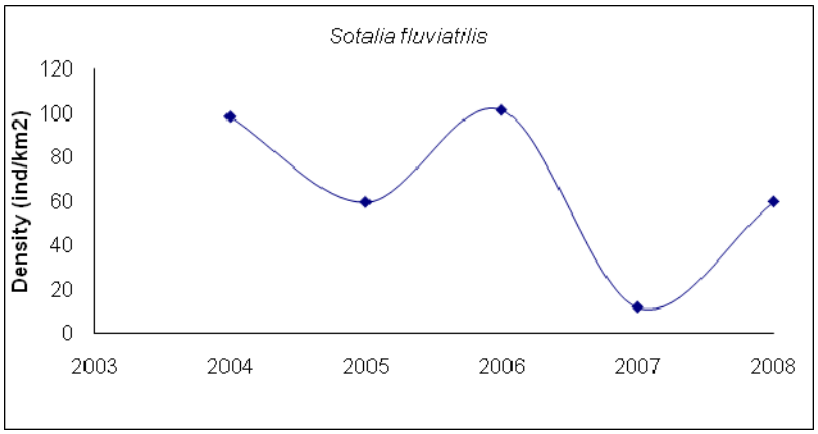
Dolphin densities in the Samiria River basin are some of the greatest recorded throughout Amazonia, with densities often well above 100 ind/km2. Overall, pink river dolphins in the Samiria River are greater than the grey river dolphin. Between 2004 and 2008 there have been variations in the density of both species, with the greatest densities occurring in 2008.
In the Samiria River, pink river dolphins have greater densities at the mouth section and lower densities in the mid-river and up-river sections. There is a strong correlation between the abundance of commercial fish, measured as CPUE, and pink river dolphins. This indicates that pink river dolphins focus their feeding on similar sized fish as local fishermen. The mouth of the Samiria River has a concentration of commercial fish, especially during the low water periods when fish migrate out of the Samiria River and into the main channel of the larger Maranon River.

In contrast, grey river dolphins have generally greater densities in the mid-river and up-river sections and lower densities at the mouth. Grey river dolphins do not show a correlation between commercial fish abundance. Grey river dolphins appear to feed on the smaller, less commercial fish species that are more abundant up river from the mouth of the Samiria River.

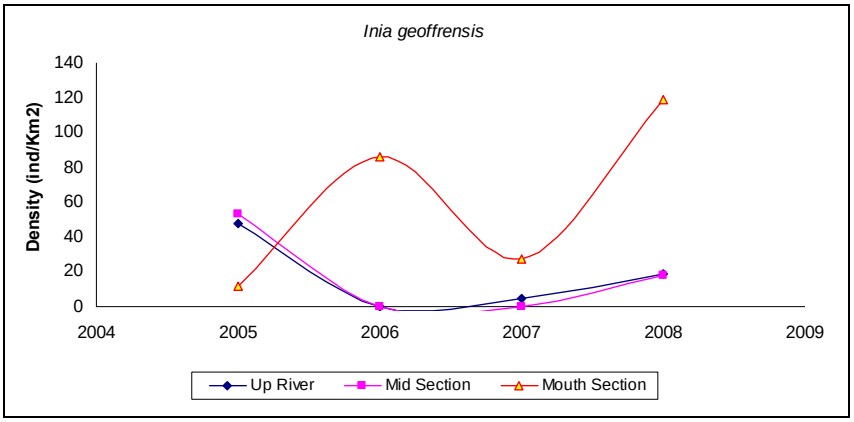
There appeared to be an influx of dolphins into the Samiria River in 2008. This might be due to the increase in petroleum exploitation and increased fishing activities outside the reserve. The increase in oil prices and commodities led to greater resource extraction in areas outside the reserve. The conservation management inside the reserve might have led to a generally healthier hyroscape and an influx of dolphins in 2008, compared to areas outside the reserve.



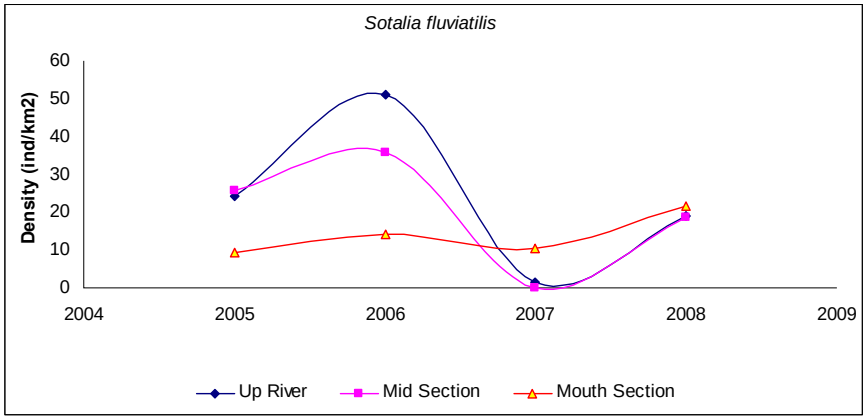
Density of pink river dolphins in the Samiria river



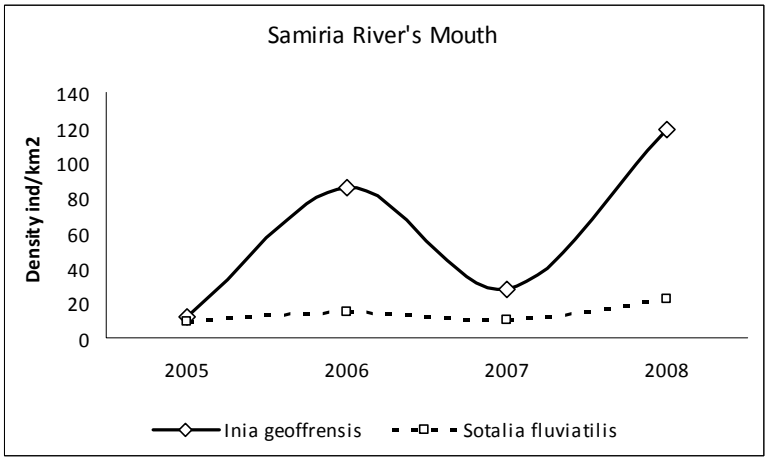
Densities of grey river dolphins in the Samiria River



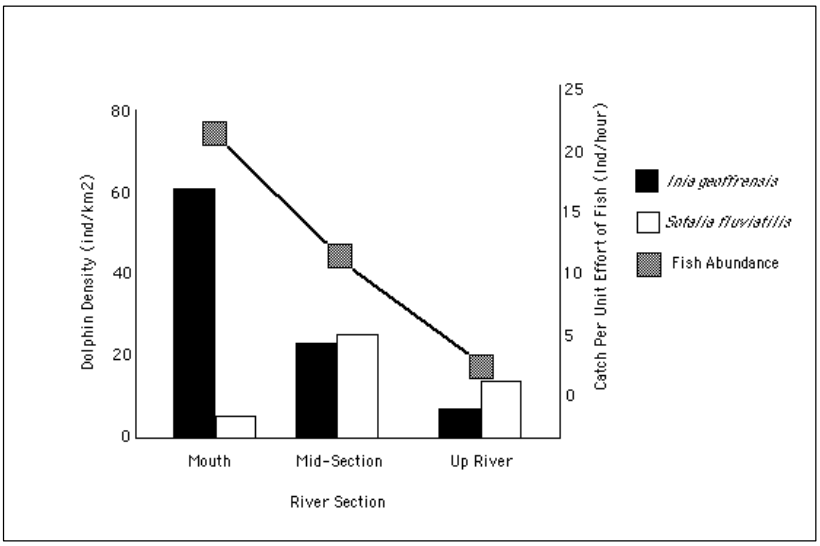
Densities of pink river dolphins in the different sections of the Samiria River



Densities of grey river dolphins in different sections of the Samiria River



Densities of river dolphins at the mouth of the Samiria River



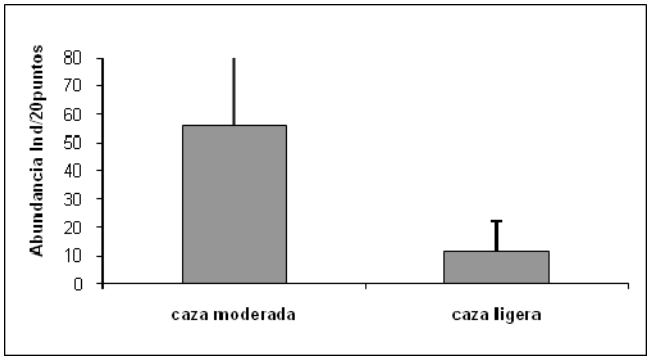
Correlation between river dolphins and commercial fish abundance, measured as CPUE in different sections of the Samiria River

Macaws were used as general indicators of the terrestrial systems by evaluating changes in species numbers and composition.

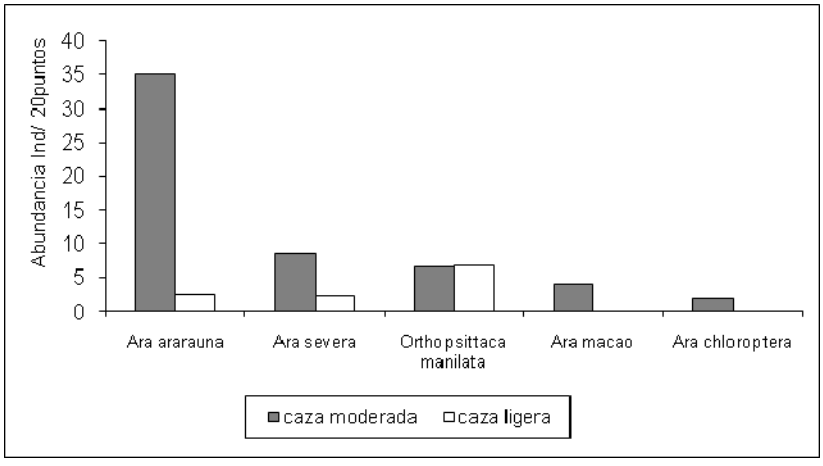
The macaw populations were used as indicator species of the terrestrial forest landscape. However, it appears that competitive interactions with other frugivore assemblages, especially the primates, might be influencing macaw abundance. Results in both the Samiria River basin and the Lago Preto Conservation Concession show that macaw populations decrease when primate populations increase.

In the Samiria River basin the macaw populations were compared between the moderately hunted zone (caza moderada) and the lightly hunted and non hunted zones (caza ligera). The moderately hunted zone had substantially greater abundances of macaws than the slightly hunted zone. In 2008, the dominate species in the moderately hunted zone was *Ara ararauna*. Howver, there is considerable variation between years, and in 2007 *Orthopsittaca manilata* was dominant in the moderately hunted zone. Macaws are very mobile species and these variations might reflect movement patterns.

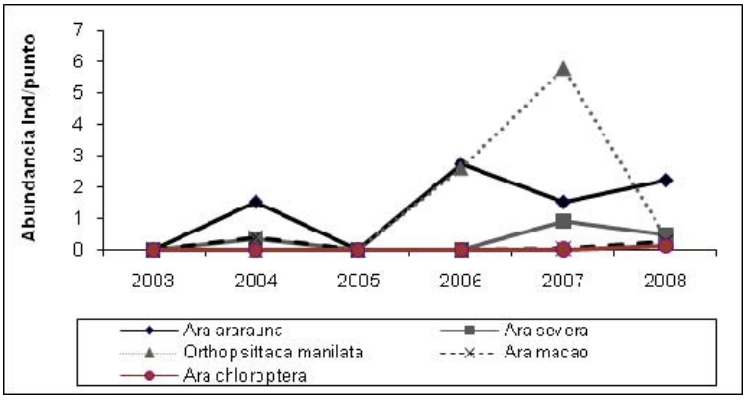
In the lightly hunted zone, *Orthopsittaca manilata* was dominant in 2008. Similar to the moderately hunted zone there is considerable variation between years. Previous to 2007, *Ara ararauna* was consistently dominant in the lightly hunted zone.



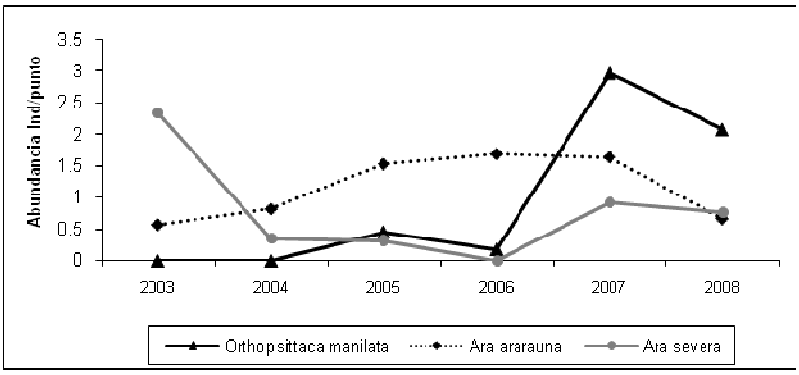
Overall macaw abundance in the Samiria River between the moderately hunted zone (caza moderada) and the lightly hunted zone (caza ligera), data are from 2008.



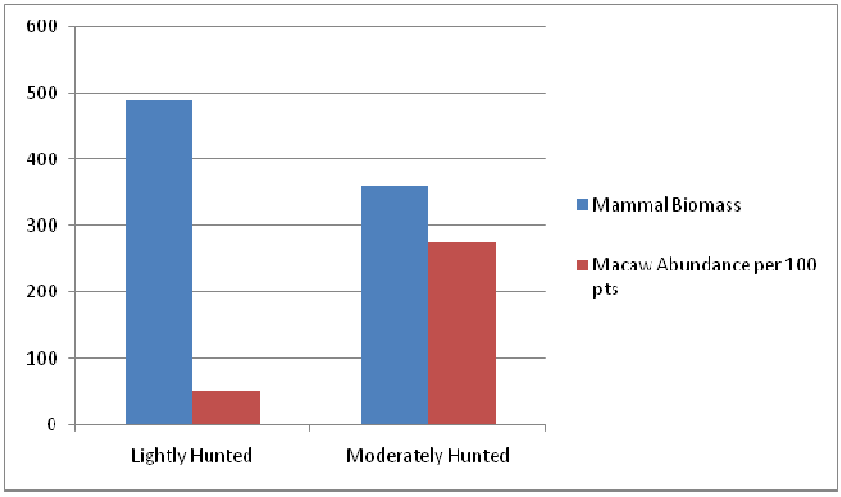
Macaw abundance by species in the Samiria River between the moderately hunted zone (caza moderada) and the lightly hunted zone (caza ligera), data are from 2008.



Macaw abundance in the moderately hunted zone of the Samiria River basin.



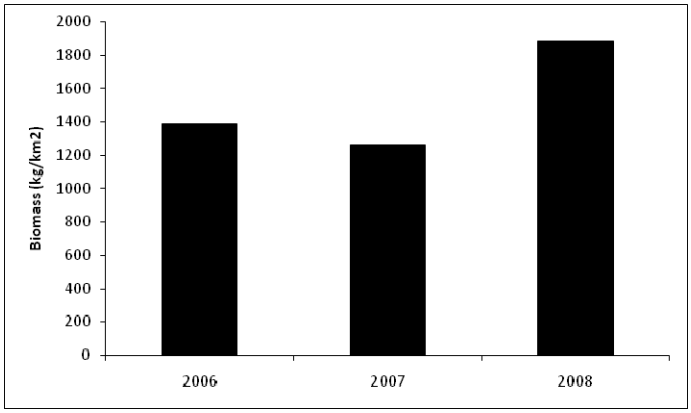
Macaw abundance in the moderately hunted zone of the Samiria River basin.



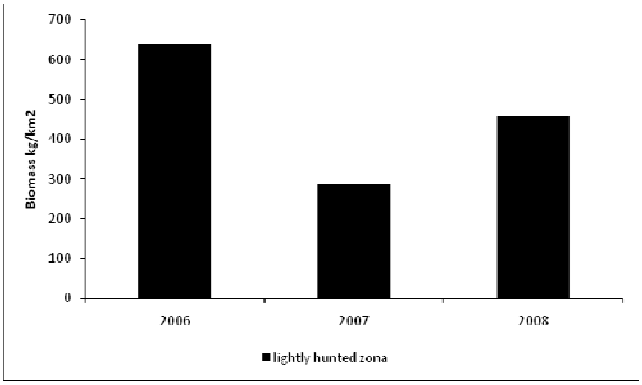
Relationship between mammal biomass and macaw abundance in the Samiria River basin.

Primate and terrestrial mammal populations were monitored to determine the impact of hunting on arboreal mammals and to study ecological interactions between arboreal and terrestrial wildlife assemblages.

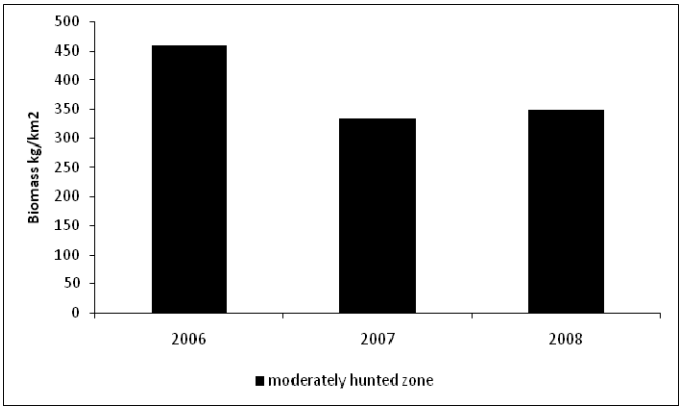
The terrestrial mammals of the Samiria River have shown healthy populations during the past three years. Overall, the heavily hunted zone has shown the greatest increase, measured as biomass (kg/km2), which was largely due to increased sightings of white-lipped peccary. The lightly hunted and moderately hunted zones have shown some variation, and overall have shown relatively constant mammalian biomass.



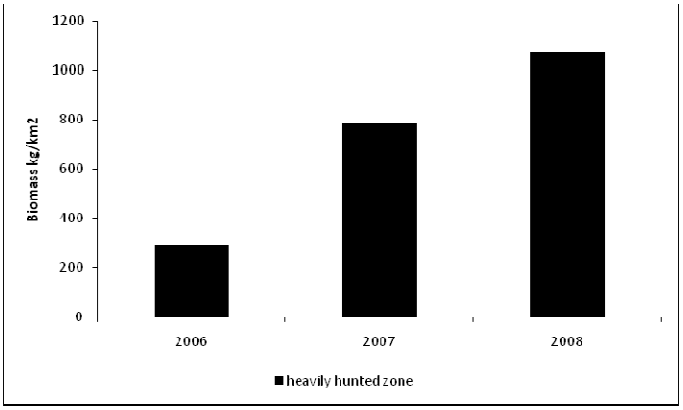
Cumulative biomass of mammals from 2006-2008 in the Samiria River



Overall Biomass of mammals from 2006-2008 in the lightly hunted zone

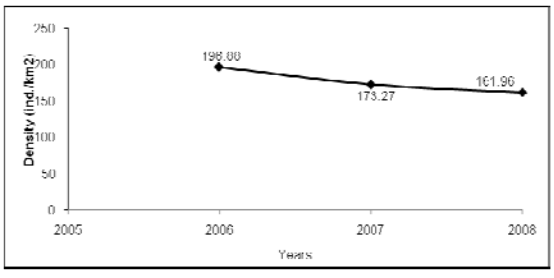


Overall Biomass of mammals from 2006-2008 in the moderately hunted zone

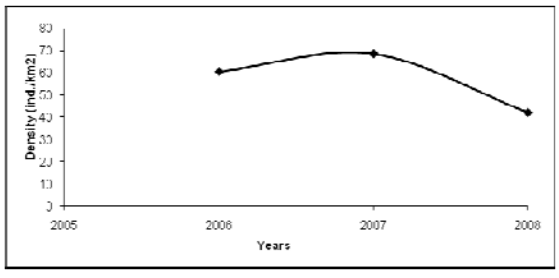


Overall Biomass of mammals from 2006-2008 in the heavily hunted zone

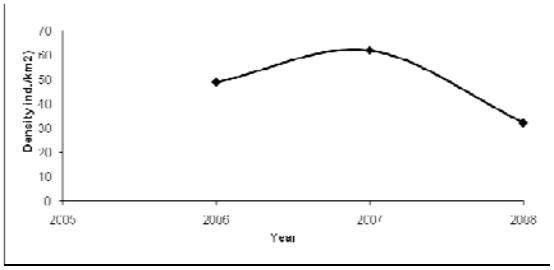
The primates have generally maintained their population levels in the Samiria River. The densities in 2008 were slightly lower overall than 2007, except for the woolly monkey which showed an increase for 2008. The greatest decline was in the populations of saddled-back tamarin, *Saguinus fuscicollis,* which is a small-bodied primate not used by hunters. It is likely that competition from the larger primates is driving down the populations of the smaller tamarins.



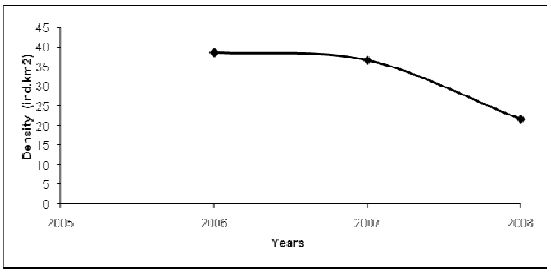
Density of *Saimiri boliviensis*



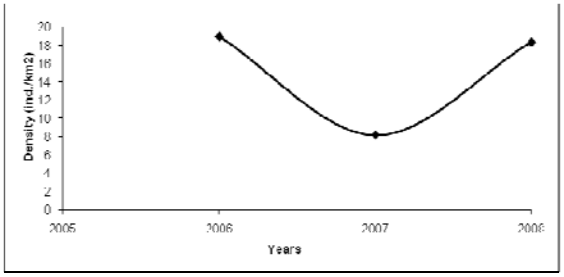
Density of *Cebus apella*



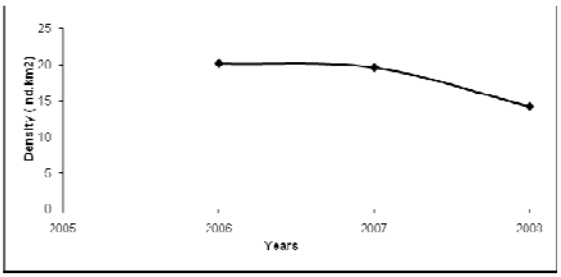
Density of *Alouatta seniculus*



Density of *Saguinus fuscicollis*

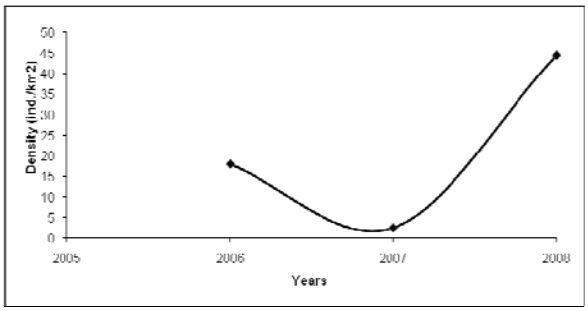


Density of *Lagothrix poeppigii*

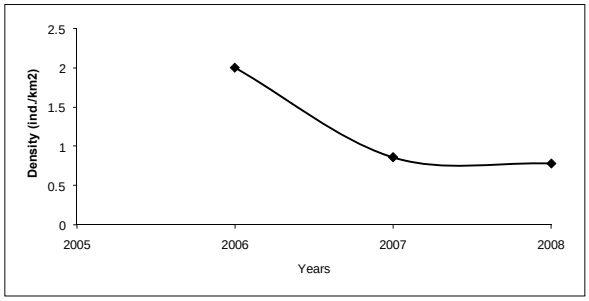


Density of *Pithecia monachus*

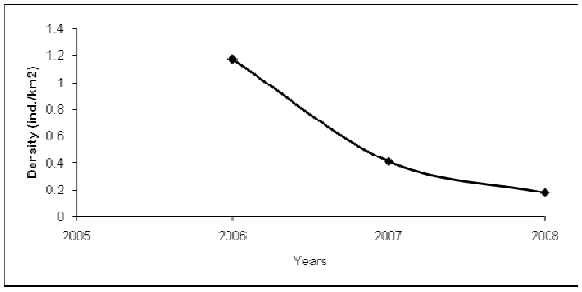
The densities of the terrestrial mammals showed considerably greater variation than the arboreal primates. White-lipped peccary(*Tayassu pecari)*, , lowland tapir (*Tapirus terrestris)*, and coati (*Nasua nasua)* showed the greatest increases during the three year period. In contrast, red brocket deer (*Mazama Americana)*, collared peccary (*Tayassu tajacu)*and sloth (*Bradypus variegates)* showed the largest decreases. The agouti (*Dasyprocta fuliginosa*) and tamandua (*Tamandua tetradactyla)* showed relatively stable populations.



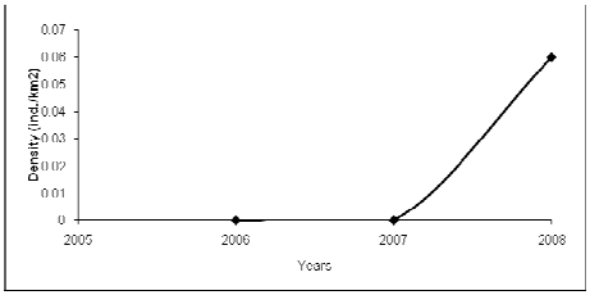
Density of *Tayassu pecari*



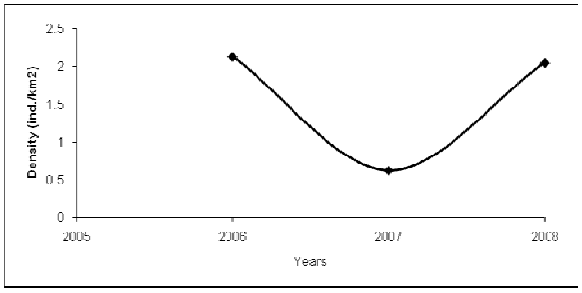
Density of *Tayassu tajacu*



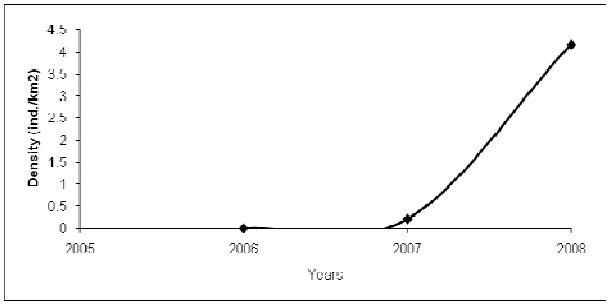
Density of *Mazama americana*



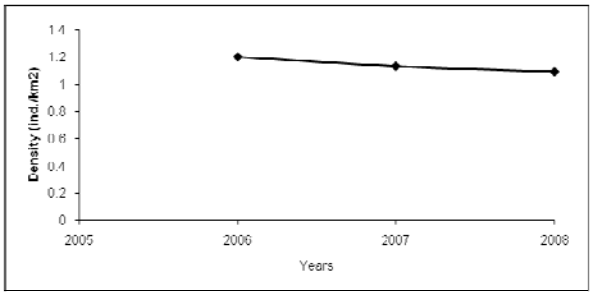
Density of *Tapirus terrestris*



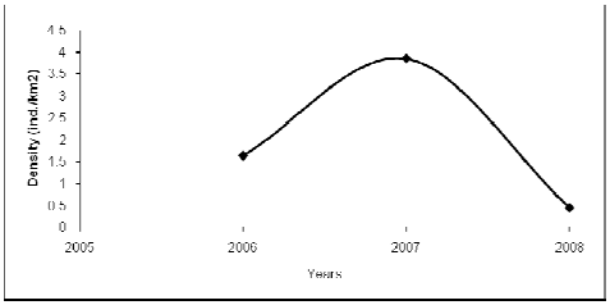
Density of *Dasyprocta fuliginosa*



Density of *Nasua nasua*



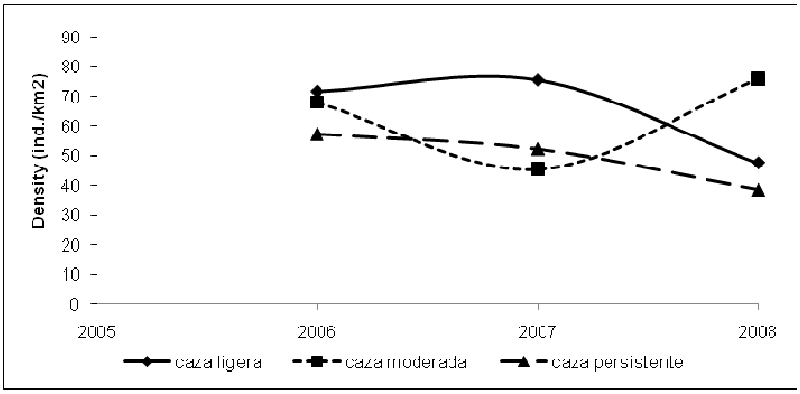
Density of *Tamandua tetradactyla*



Density of *Bradypus variegates*

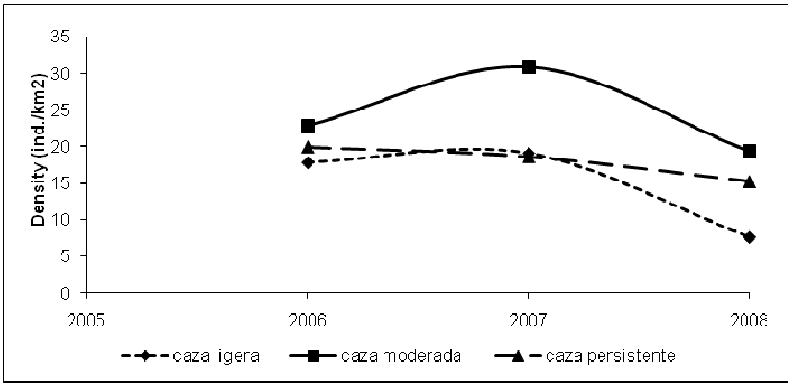
Densities of arboreal and terrestrial mammals were compared between the lightly hunted (caza ligera), moderately hunted (caza moderada) and heavily hunted (caza persistente) sites of the Samiria River basin. While sampling variance may account for some of the fluctuations, the overall trends are an important indication of management actions.

The squirrel monkey (*Saimiri boliviensis)* showed similar densities between the three hunting zones. This is the most abundant primate in the Samiria River basin.



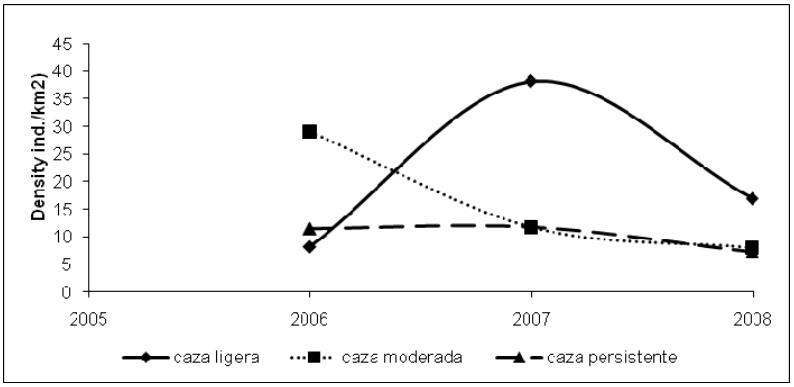
Density of *Saimiri boliviensis* by year from 2006-2008 for the Samiria river

The brown capuchin monkey also showed similar densities and population trends between the three hunting zones over the past three years. The lightly hunted site showed the greatest decline in 2008, which suggests that this was due more to natural fluctuations than by hunting.



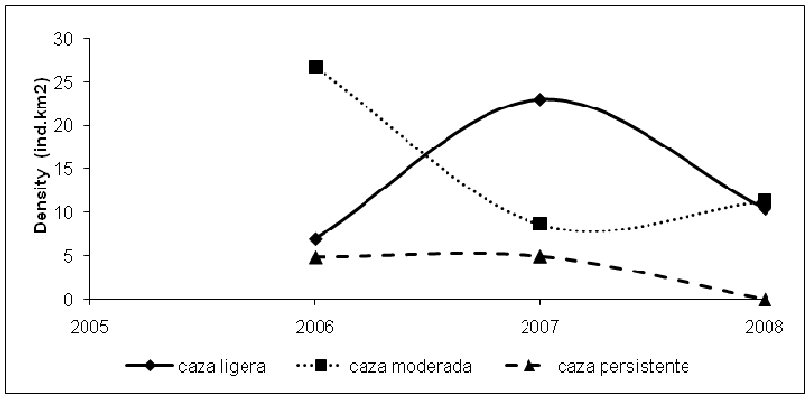
Density of *Cebus apella* by year from 2006-2008 for the Samiria river

The howler monkey showed considerable variation in sightings between the three hunting zones. Over the past two years the howler monkey was most abundant in the lightly hunted sites. It also showed a decrease in sightings between the moderately hunted sites between 2006 and 2007.



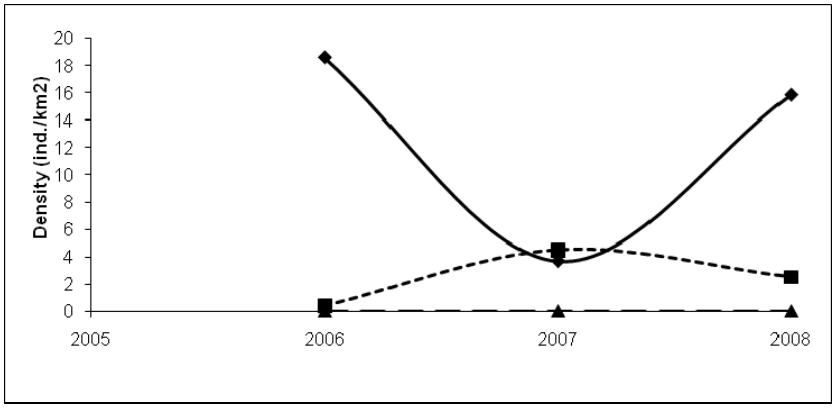
Density of *Alouatta seniculus* by year from 2006-2008 for the Samiria river

The saddled-back tamarin has also shown considerable variation over the past three years. The heavily hunted site has shown the greatest decline. This might be due to competition from larger-bodied primates as their populations increase. Tamarins are not hunted and it is unlikely that this decline was caused by hunting.



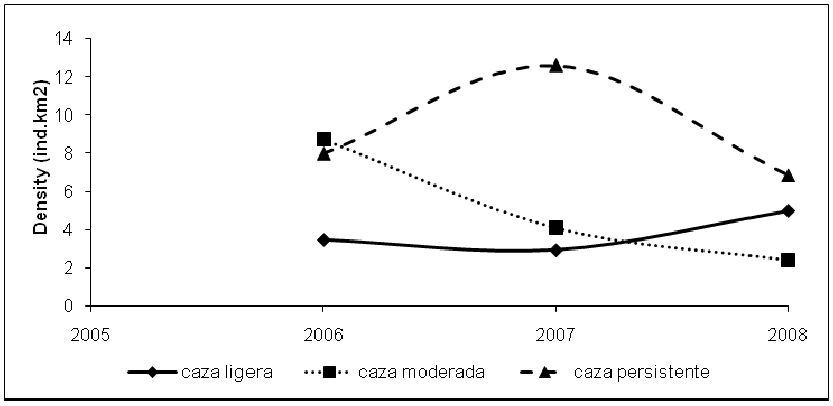
Density of *Saguinus fuscicollis* by year from 2006-2008 for all the Samiria River

The woolly monkey has generally shown healthy populations in the lightly hunted and moderately hunted zones, and is still very uncommon in the heavily hunted sites. There was a dip in sightings in the lightly hunted site in 2007, but this might have been due to sampling variations.



Density of *Lagothrix poeppigii* by year from 2006-2008 for the Samiria river

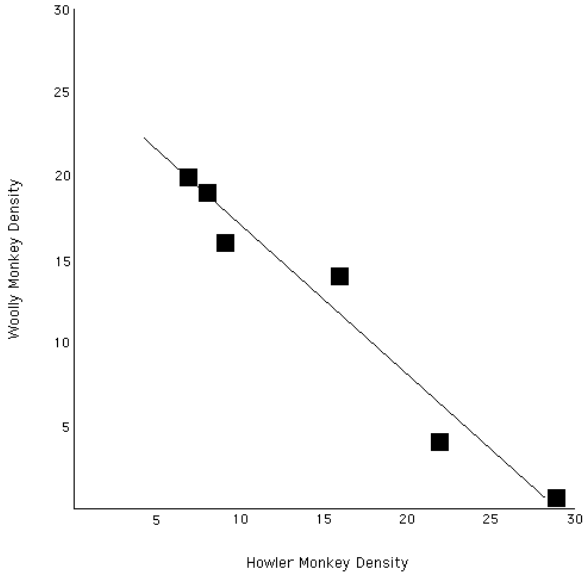
The saki monkey had a greater number of sightings in the heavily hunted sites, compared to the lightly hunted and moderately hunted sites. This species is used for bush meat in the Peruvian Amazon and its relative abundance in the heavily hunted site is encouraging. The sightings in the lightly hunted and moderately hunted sites are similar.



Density of *Pithecia monachus* by year from 2006-2008 for the Samiria river

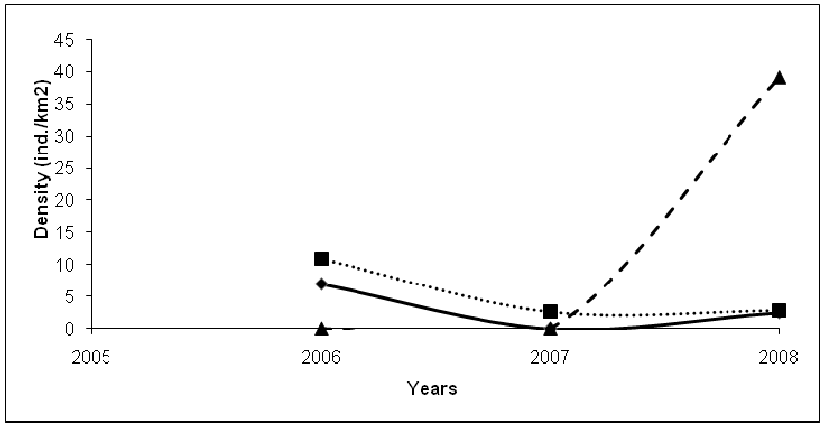
Competition appears to be a major factor determining the primate communities along the Samiria river basin. Whilst squirrel monkeys are the most abundant species in all three sections of the Samiria basin, biomass reflects ecological dominance. Howler monkeys and capuchin monkeys have similar biomasses in the mouth region, whereas howler monkeys dominate the mid-section and woolly monkeys (*Lagothrix lagotricha*) dominate up river (Fig. 2). Using censuses it is clear that the howler monkeys and woolly monkeys are in a Lokta-Volterra competitive interaction, with woolly monkeys winning up river and howler monkeys winning in the mid section ($r= 0.98$, $p<0.001$)(Fig. 3). The total K of both species appears to be around 30 ind/km2. Other species also appear to have Lokta-Volterra interactions, but sample sizes do not currently show significant relationships.

These results have important implications for conservation strategies and management policies. The conservation actions of reducing hunting clearly are helping to increase the populations of large bodied primates, but at the expense of small bodied species. Also, the dominance of one species will impact the population of other species. For example, if woolly monkeys or howler monkeys begin to dominate an area of the Samiria basin, this will decrease the population of the competing species.



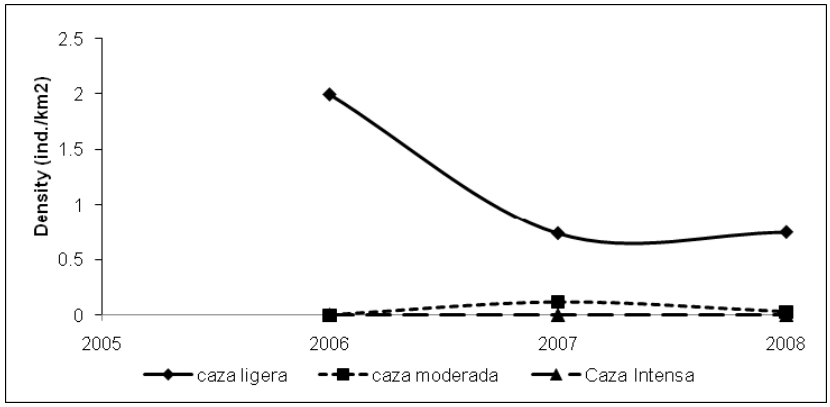
Lotka-Volterra relationship between the woolly monkey and howler monkey in the Samiria river basin.

Sightings of the white-lipped peccary have increased substantially in the lightly hunted site and remained at relatively low levels in the moderately hunted and lightly hunted sites. The white-lipped peccary is one of the most important bush meat species and increased sightings in the lightly hunted site demonstrates the positive impact of wildlife management in the reserve. The white-lipped peccary ranges over wide areas of forest and can move into the heavily hunted areas over short time periods.



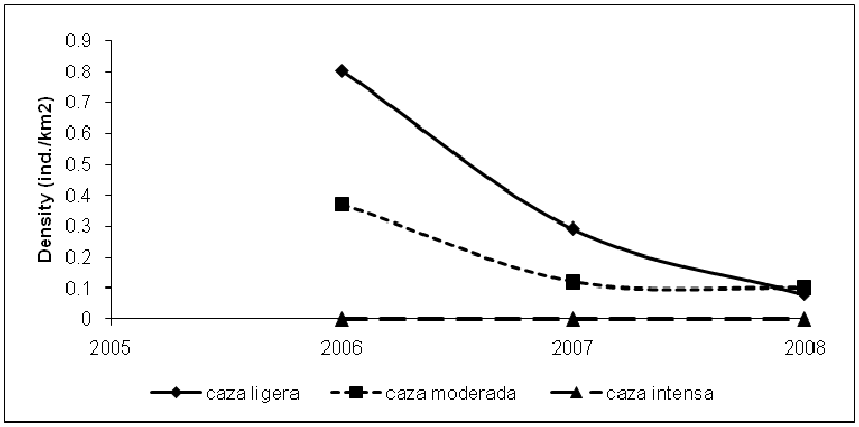
Density of *Tayassu pecari* by year from 2006-2008 for the Samiria river

The collared peccary is sighted consistently more in the lightly hunted sites. In the heavily hunted and moderately hunted sites the collared peccary has very few sightings. The collared peccary is more sedentary that the white-lipped peccary and does not generally move over large distances, which would make its repopulation of the heavily hunted sites take long periods of time.



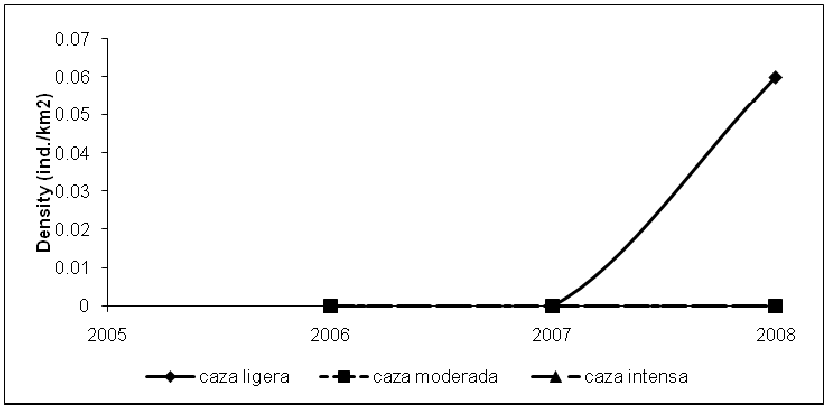
Density of *Tayassu tajacu* by year from 2001-2008 for the Samiria river

The red brocket deer has shown decreases in sightings in the lightly hunted and moderately hunted sites. Sightings in the heavily hunted site has been consistently low. It is unclear what might be causing these declines.



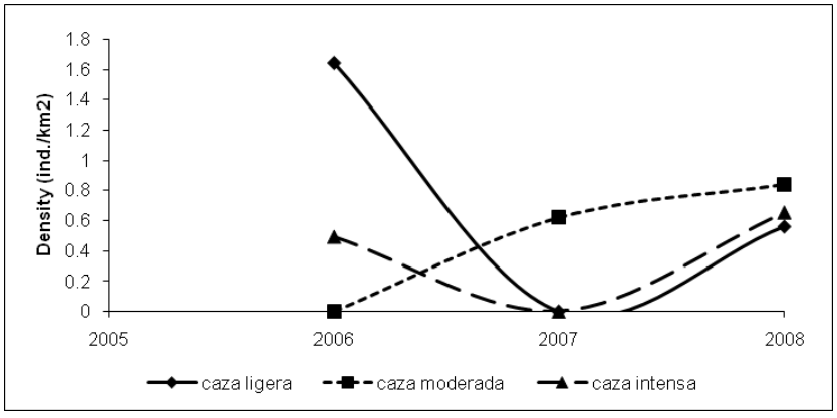
Density of *Mazama 23mericana* by year from 2006-2008 for the Samiria river

The lowland tapir has shown increase in sightings in the lightly hunted sites, especially during 2008. This species has been generally low in the Samiria River basin due to overhunting in the past. Lowland tapir abundance in the moderately hunted and heavily hunted sites is still very low.



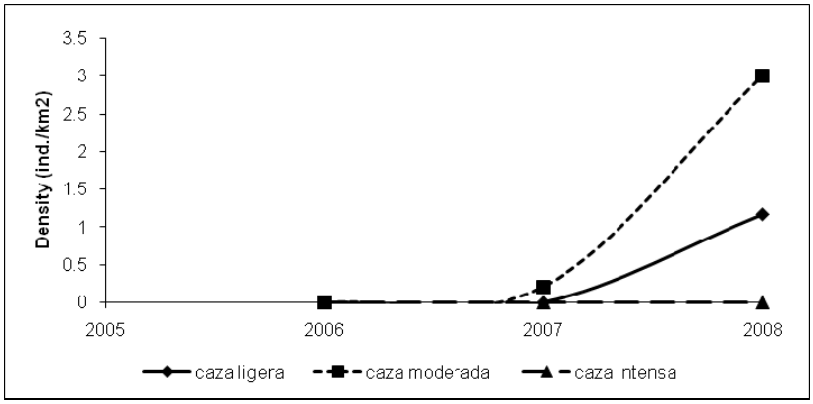
Density of *Tapirus terrestris* by year from 2006-2008 for the Samiria river

The agouti has shown considerable variation in sightings over the past three years between the sites. Overall, sightings in all three sites were most similar during 2008, with all three zones increasing from 2007.



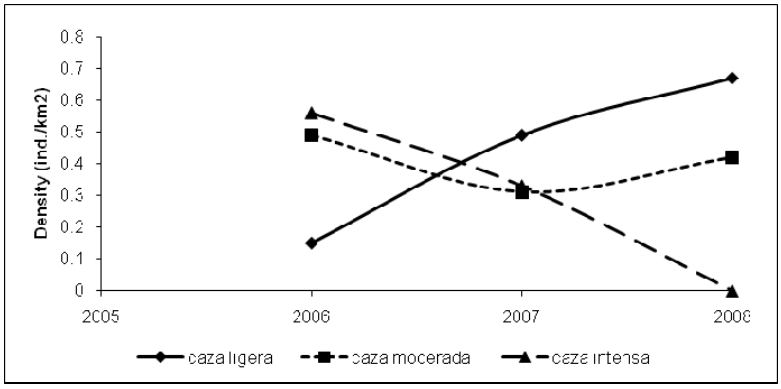
Density of *Dasyprocta fuliginosa* by year from 2006-2008 for the Samiria river combined

The coati has shown substantial increases in sightings in the lightly hunted and moderately hunted sites during 2008. The abundance of coati in the heavily hunted site has been consistently low.



Density of *Nasua nasua* by year from 2006-2008 for the Samiria river

The tamandua also has shown considerable variance in its sightings between the three hunting zones. The greatest abundance during 2008 were in the moderately and lightly hunted zones, with a general decrease in the heavily hunted zone. This is not a common bush meat species, so it is unlikely that this decrease was a result of hunting, but is more likely a natural fluctuation or a result of sampling variance.

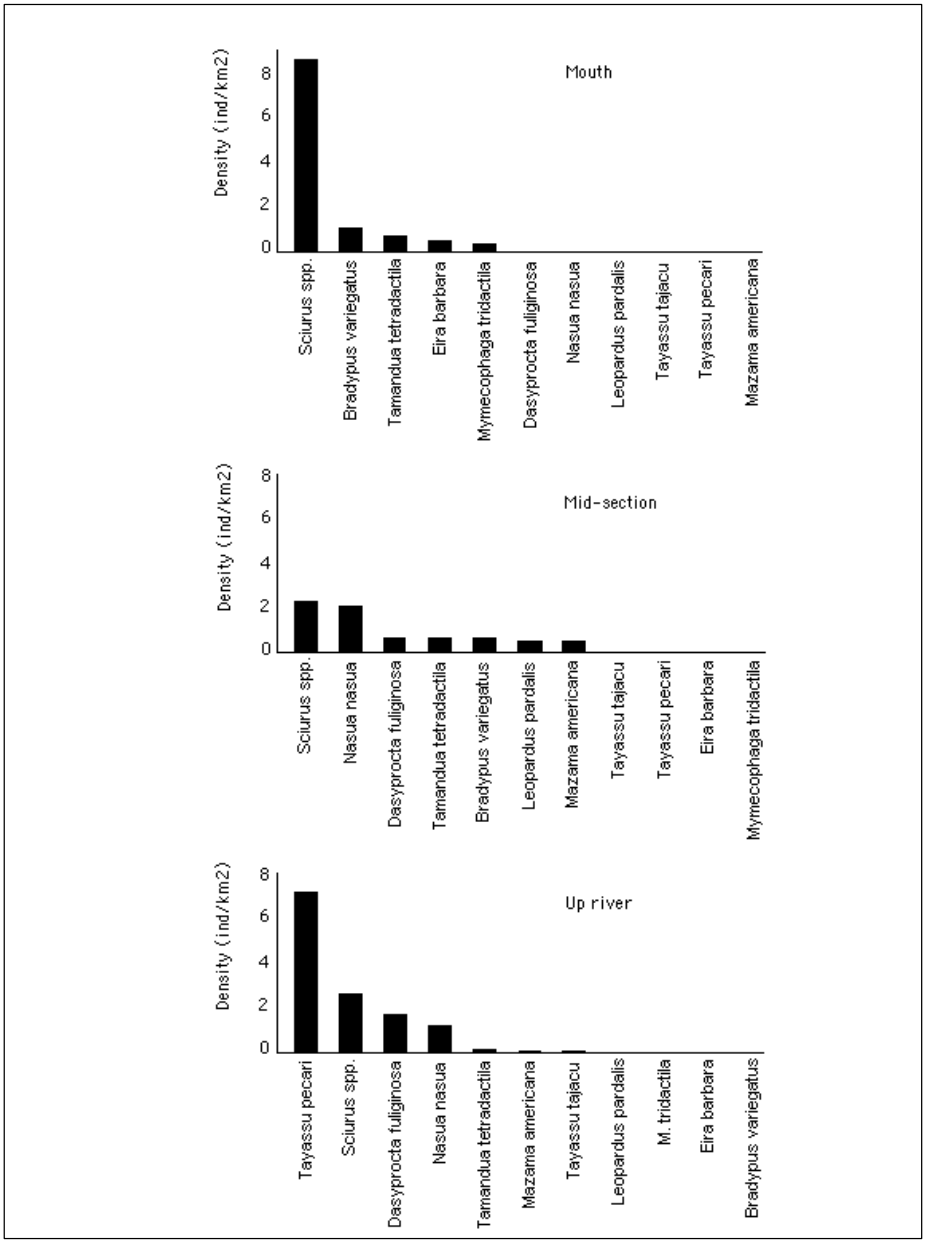


Density of *Tamandua tetradactyla* by year from 2006-2008 for the Samiria river

The populations of terrestrial mammals in the Samiria basin is confounded by both hunting and habitat types. The area around the mouth of the Samiria is flooded more intensively than the forests in the mid section, and up river is flooded the least. There is also greater hunting of terrestrial mammals closer to the mouth and less hunting up river. The terrestrial mammals show a clear relationship with distance from the mouth, and species have greater densities and biomasses further up river. For example, terrestrial mammals had a total density of 2.4 ind/km2 at the mouth, 4.2 ind/km2 at the mid section and 10.2 ind/km2 up river and their populations in an 100km2 area are greater in the up river sections of the basin (X^2=595, p<0.001). Similar to previous surveys very few ungulates occur in the mouth region and have increasing populations further up the basin. The peccary biomass dominates the up river sections of the Samiria river.

In contrast, the aboreal Amazon squirrels (*Sciurus* spp.) have a greater density at the mouth (8.5 ind/km2), compared to the mid and upper sections (2.2 and 2.5 ind/km2 respectively). Likewise, the arboreal sloth (*Bradypus variegatus*) has greater densities at the mouth (1.1 ind/km2) compared to the mid section (0.5 ind/km2). This species was not observed up river.

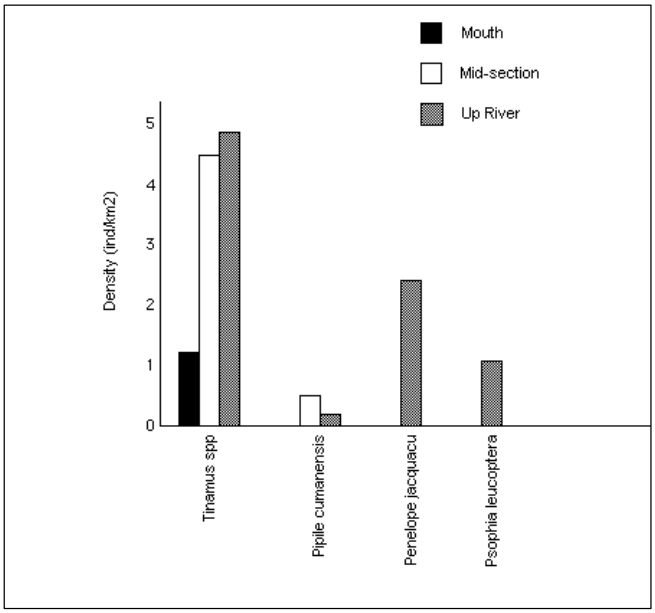
These results suggest that the extensive flooding around the mouth of the Samiria river basin is limiting the populations of terrestrial mammals. During high water periods terrestrial mammals retreat to levees or floodplain islands to wait out the floods. Levees are more common up river and in turn these areas support greater populations of terrestrial mammals.



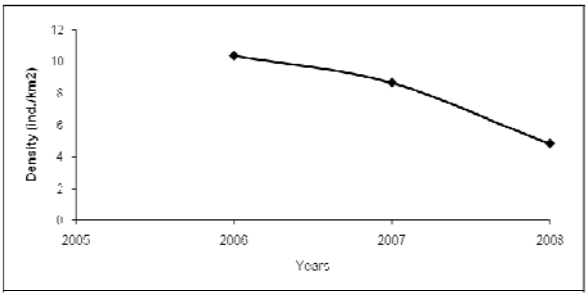
Densities of terrestrial mammals in different sections of the Samiria river basin.

Game bird populations were monitored to determine their conservation status and impact of hunting.

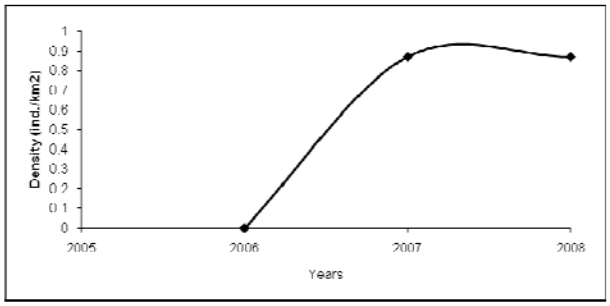
Game birds become increasingly more common from the mouth of the Samria to the up river sections. Game birds are generally rare at the mouth, with only the *Tinamus* spp. sighted along the transects. In the mid-section the *Tinamus* spp. became even more abundant and the *Pipile cumanensis* were also sighted. The up river section has the greatest density and species richness for the game birds. The game birds have not recovered to the same extent as the primates, and are still at relatively low numbers, especially around the mouth of the basin.



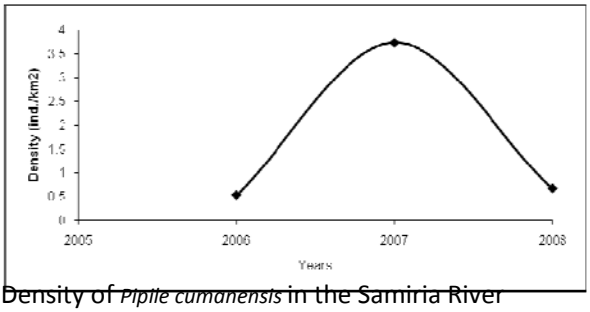
Density of game birds in different sections of the Samiria river basin.



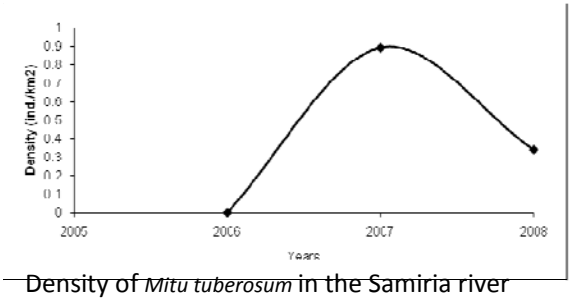
Density of *Tinamus sp .* in the Samiria River



Density of *Crypturellus sp.* In the Samiria River



Density of *Pipile cumanensis* in the Samiria River



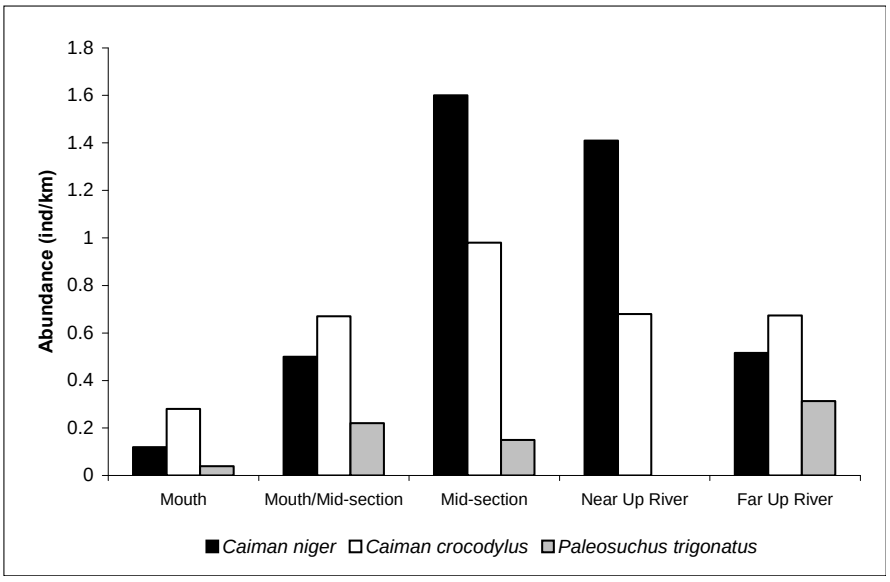
Density of *Mitu tuberosum* in the Samiria river

Yearly fluctuations in the sightings of game birds in the Samiria River basin

Caiman populations were monitored to evaluate the recovery of black caiman populations and the ecological interactions between species.

Three species of caimans occur in the Pacaya-Samiria National Reserve, the black caiman (*Caiman niger*), the common caiman (*Caiman crocodylus*) and the dwarf caiman (*Paleosuchus trigonatus*). The black caiman was intensively overhunted during the 1950's – 1970's and has been recovering in the Samiria river over the past decades.

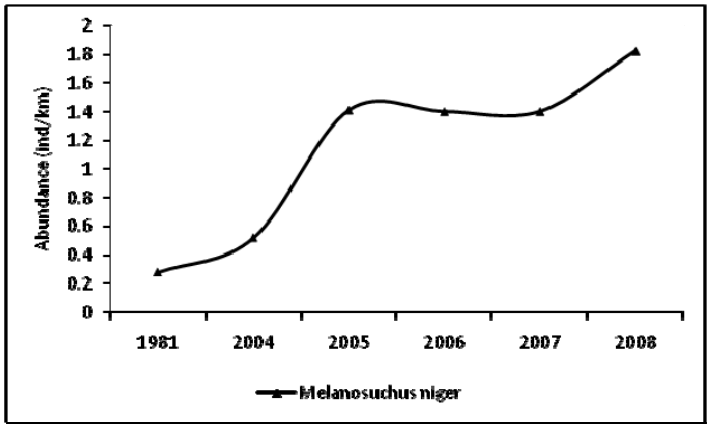
The abundance of caimans varies along the Samiria river basin. All three species were rare around the mouth of the Samiria river (0.4 ind/km) and were more common in the intermediate zone between the mouth and the mid-section (1.4 ind/km). Caimans were most abundant at the mid section (2.7 ind/km) and the beginning of the up river section (2.2 ind/km), and then decreased at the upper reaches of the Samiria (1.4 ind/km)(X^2=18, p<0.001).



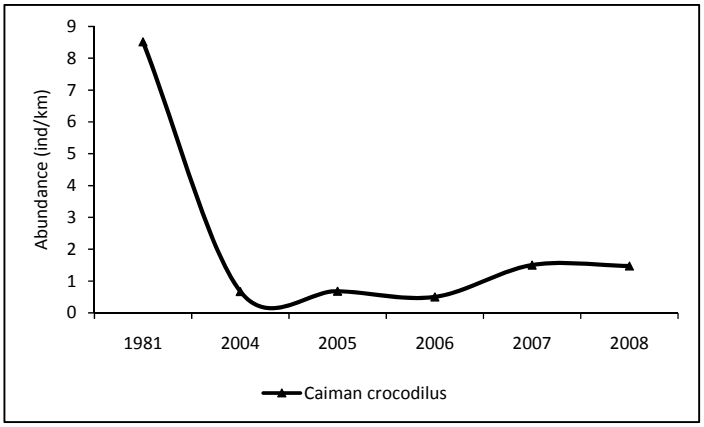
The abundance of caimans in different sections of the Samiria river.

The population of black caiman increased slowly between 1981 to 1996 with an er of 1.02 and an r of 0.02. Between 1996 and 2004 the population increased slightly faster with an er of 1.08 and an r of 0.08. The black caiman population has increased considerably faster since 2004 e^r of 1.64 and an r of 0.49.

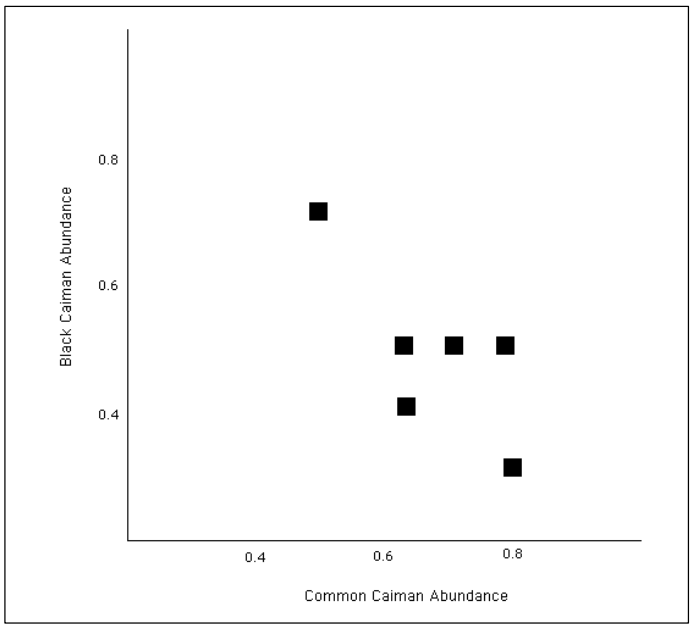
The black and common caiman appear to be in a Lotka-Voltera competitive interaction, with the black caiman winning over the common caiman. Indeed, the common caiman was very abundant in 1981 with over 8 ind/km, but has been decreasing as the black caiman populations have increased (r=.55, p=0.03). Therefore, the conservation actions to recover the black caiman populations have led to a decrease in common caiman numbers over the years.



Population trends of black caiman in the Samiria River

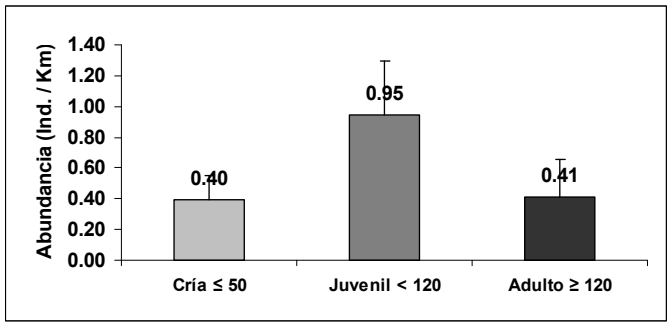


Population trends of common caiman in the Samiria River

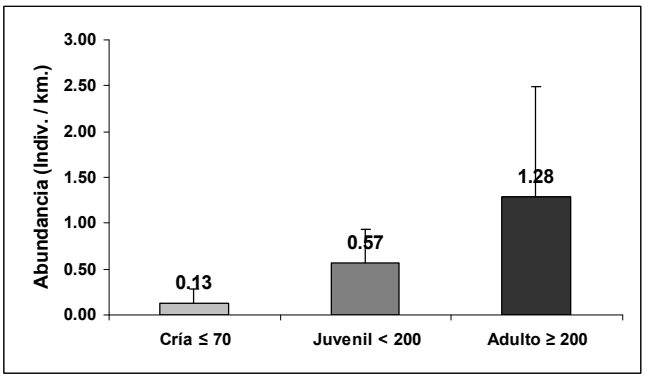


Lotka-Volterra relationship between black and common caiman in the Samiria River basin.

The age structure of the common and black caiman differs considerably in the Samiria River basin. The common caiman has a greater proportion of the juvenile age class, whilst the black caiman has a greater proportion of adults. The change in the populations of common and black caiman may be related to these differences in demography. The competitive interactions of the black caiman appear to be decreasing the adult common caimans, and decreasing the number of juvenile common caiman surviving to the adult stage.



Age structure of common caiman *Caiman crocodilus* in the moderately hunted zone of the Samiria River.



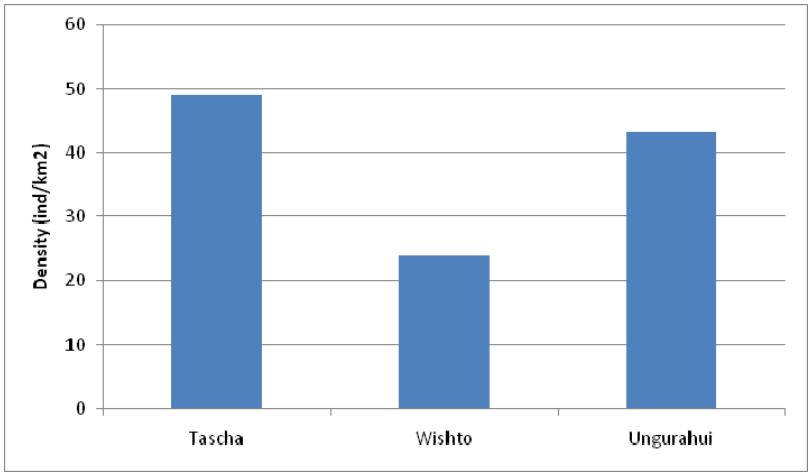
Age structure of black caiman *Melanosuchus niger* in the moderately hunted zone of the Samiria River.

River turtle populations were monitored to determine the success of the head-starting conservation programme in the Samiria River basin

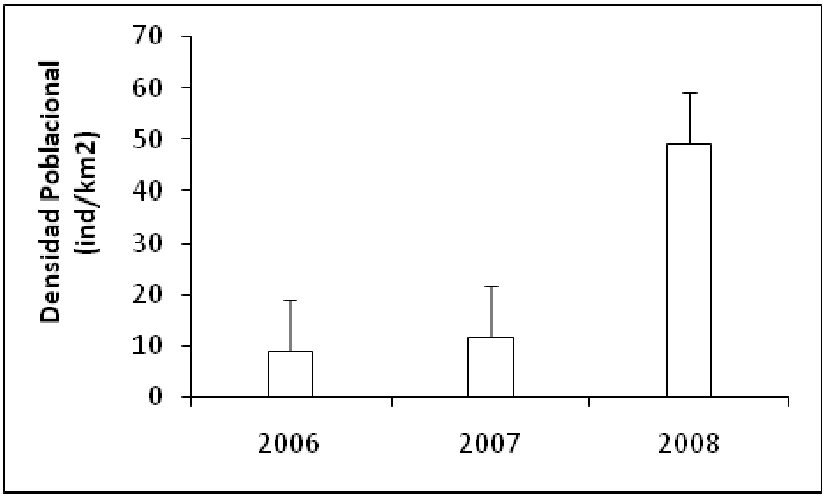
The Pacaya-Samiria National Reserve has implemented a turtle conservation program based on head starting for a number of years, where eggs of Yellow-spotted Amazon River Turtle (*Podocnemis unifilis*) and Giant Amazonian River Turtle (*Podocnemis expansa*) have been removed from their wild nests, replanted at guard stations, hatched, and released back into the river. This conservation strategy has been set up to overcome the intensive poaching of turtle eggs during the laying season. River turtle numbers are recovering along the Samiria river basin as a result of the head starting program.

The abundance of *Podocnemis unifilis* was determined by turtles sunning along the riverbanks, whereas *Podocnemis expansa* does not sun along the banks and was not censused. Very few turtles were sighted around the mouth of the Samiria river basin. The density of *Podocnemis unifilis* ind/km was greatest at the Tascha Cocha and Ungurahui zones, which are in the mid section of the Samiria River. Wishto had the lowest densities of river turtles. This difference appears to be related to park guard vigilance, since both the Tascha and Unguurahui sites have permanent park guard stations, which are not present at the Wishto site. During turtle egg collection at the Wishto site there were numerous eggs poachers observed in the area.

The numbers of turtle sightings has increased substantially since 2006 and clearly shows the success of the turtle programme in the Samiria River. The expectation is that it takes between 8 to 10 years for turtle hatchlings to become adults and start sunning themselves. Since 1996 a total of around 865,864 turtle hatchlings have been released in the head starting program, with an annual average of 73,507 *Podocnemis unifili* and 16,348 *Podocnemis expansa*. The hatchling numbers are in accord with the increasing turtles sunning along the Samiria River.

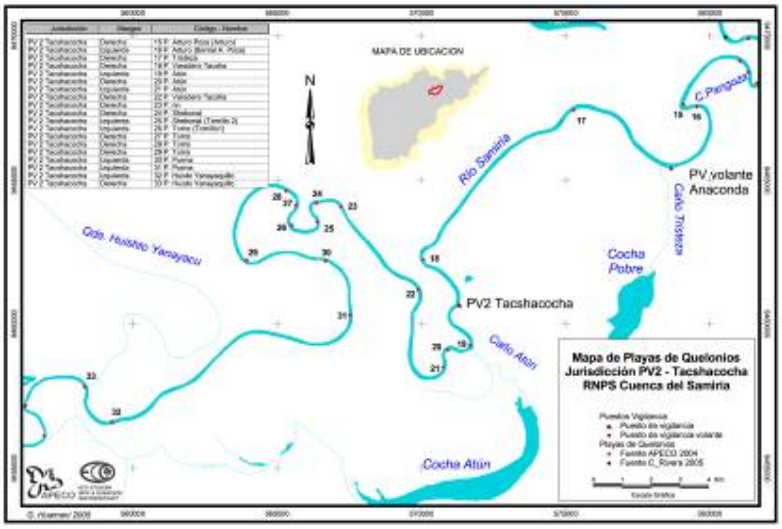


Abundance of *Podocnemis unifilis* in the Samiria River.

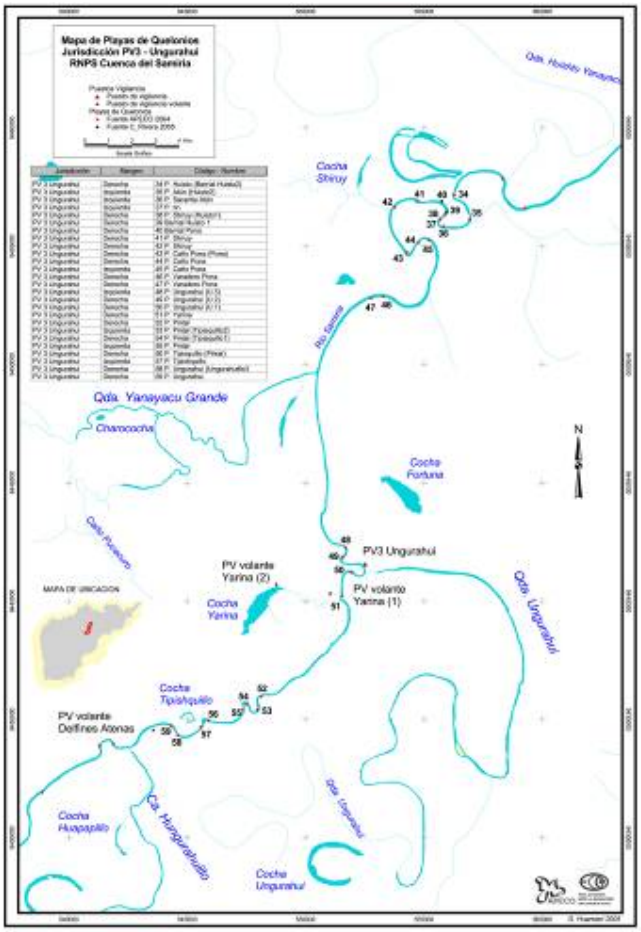


Density of *Podocnemis unifilis* in the Samiria River.

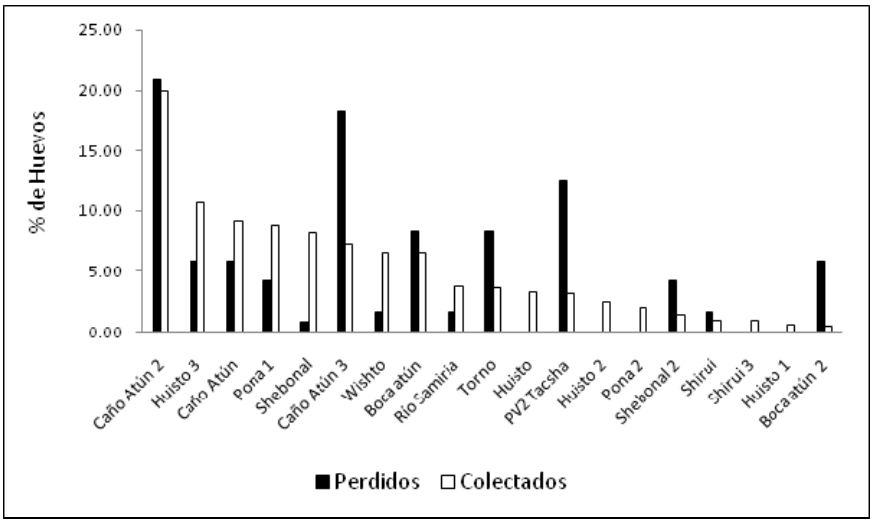
Beaches used by turtles along the mid section of the Samiria River were identified and the number of eggs collected at the beaches were recorded. This information will be used to set up vigilance programmes for the head starting initiative and to evaluate fluctuations in turtle nests and egg numbers between years, especially as the turtle populations grow.



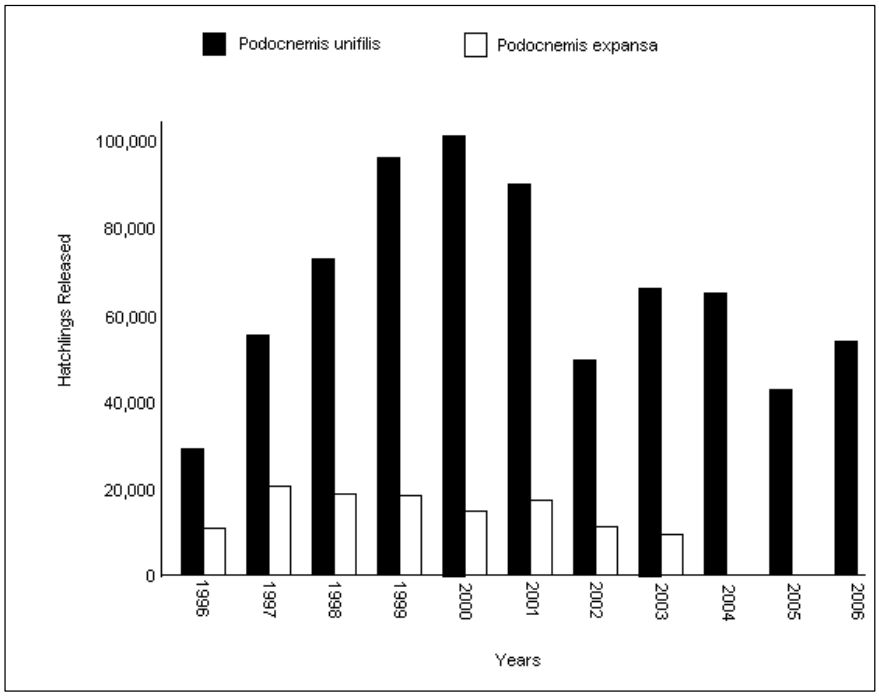
Map of the turtle egg laying beaches at the Tascha site.



Map of turtle egg laying beaches at the Wishto and Ungurahui sites



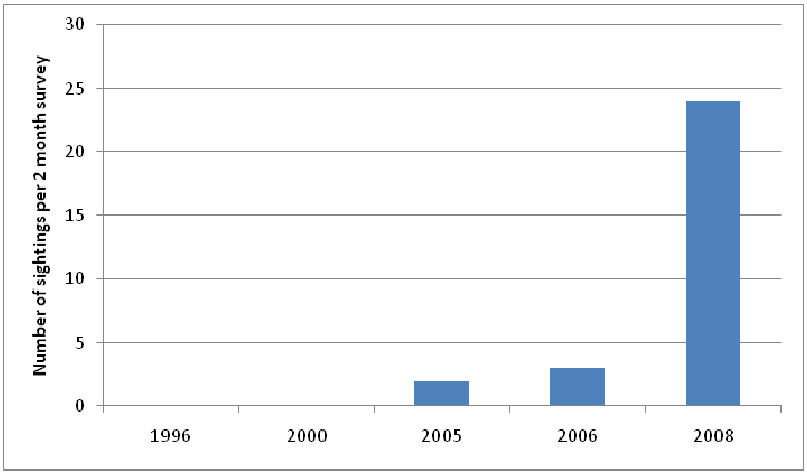
Percent of eggs collected from the different turtle egg laying beaches



The number of hatchling turtles resealed during the head starting program.

Giant river otter populations were monitored to evaluate the recovery of this rare species.

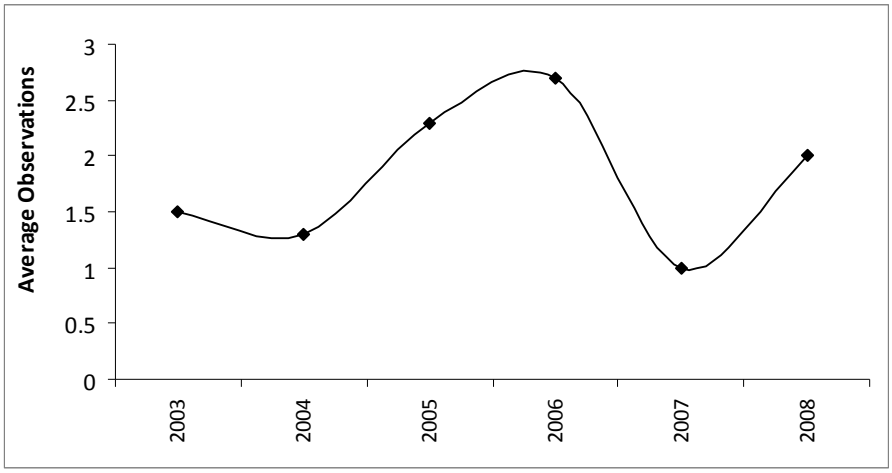
The giant otter is endemic to South America and has shown a marked decline due to excessive pelt hunting during the 1940's to 1970's with many pollutions becoming extirpated. By the end of the 1970s, the giant otter was nearly extinct. Studies of giant otter are a high priority for the IUCN and long-term conservation efforts for this critically endangered flagship species are needed. Today, the giant otter is beginning to show a slow recovery in population size in many areas of its former range in the Amazon, including the Samiria River basin and the Lago Preto Conservation Concession. The sightings of giant river otter have increased substantially in the Samiria River basin in 2008.



Abundance of giant river otter along the Samiria River.

Amazon manatee populations were monitored in the Samiria river to evaluate the conservation status of this vulnerable species.

The manatee (*Trichechus inunguis*) population along the Samiria River has been relatively stable over the years. This species is still occasionally hunted by local people, often killed when mistaken for Piache fish. The Samiria River basin continues to be a stronghold for the species in Loreto, but further conservation efforts are required.



Abundance of manatees along the Samiria River

The abundance, diversity and age structure of the large fish species were monitored to determine the impact of local fisheries and the effectiveness of fisheries management.

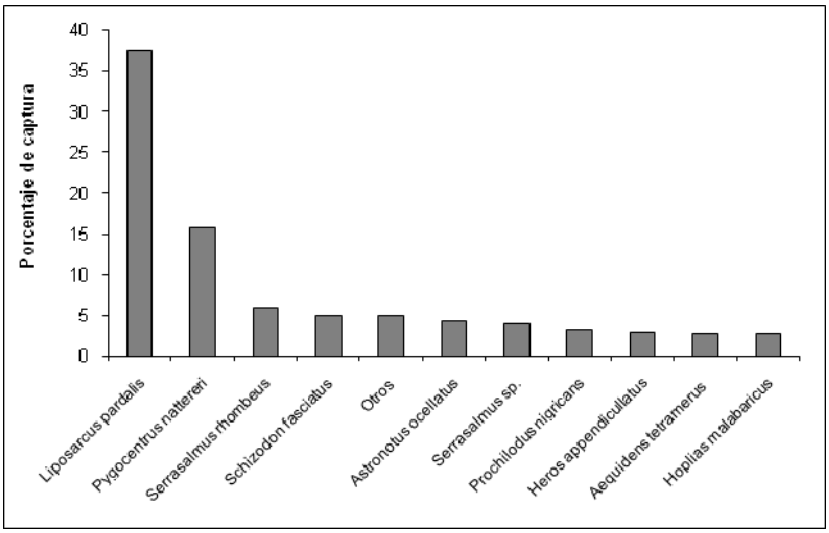
There were 56 species belonging to 14 captured during the surveys in the Samiria River basin.

Most common species surveyed in the Samiria River basin

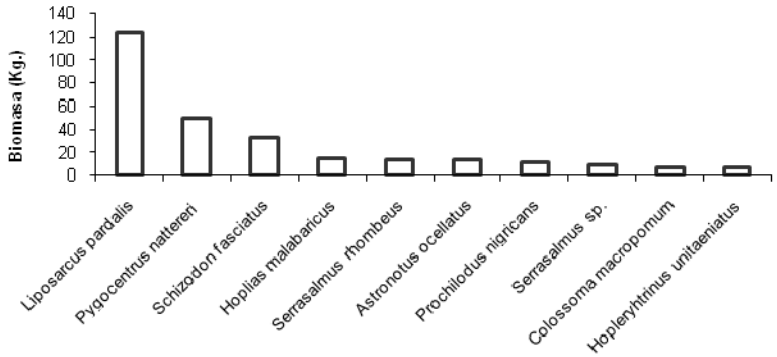
Familia	Nombre científico	Nombre común
Potamotrygonidae	*Potamotrygon motoro* (Naterrer, 1841)	Raya
Osteoglossidae	*Osteoglossum bicirrhosum* (Vandelli, 1829)	Arahuana
Curimatidae	*Potamorhina latior* (Spix, 1829)	Llambina
Prochilodontidae	*Semaprochilodus amazonensis* (Fowler, 1906) *Prochilodus nigricans* (Agassiz, 1829)	Yaraqui Boquichico
Anostomidae	*Schizodon fasciatum* (Spix, 1929)	Lisa
Erytrhinidae	*Hoplias malabaricus* (Bloch, 1794)	Fasaco
Cynodontidae	*Hydrolicus scomberoides* (Cuvier, 1817)	Chambira
Characidae	*Triportheus elongatus* (Spix, 1829)	Sardina
Serrasalmidae	*Captopryon* sp. *Serrasalmus elongatus* (Kner, 1860) *Serrasalmus* sp. *Pygocentrus nattereri* (Linnaeus, 1766) *Serrasalmus rhombeus* (Linnaeus, 1766) *Mylossoma duriventris* (Cuvier, 1818) *Mylossoma* sp. *Myleus rubripinnis* (Müller y Troschel, 1845) *Colossoma macropomum* (Cuvier 1818) *Piaractus brachypomus* (Cuvier 1818)	Piraña Piraña alargada Piraña Piraña roja Piraña blanca Palometa Palometa Curuhuara Gamitana Paco
Doradidae	*Oxiydoras níger* (Valenciennes, 1833)	Turushuqui
Pimelodidae	*Pseudoplatystoma fasciatum* (Linaeus, 1766)	Doncella

Familia	Nombre científico	Nombre común
Loricariidae	*Ancistrus sp.*	Carachama ancistrus
	Hypostomus emarginatus (Valenciennes, 1840)	Carachama
	Liposarcus pardalis (Castelnau, 1855)	Carachama
	Liposarcus sp.	Carachama
	Loricariia sp.	Shitari
Cichlidae	*Astronotus ocellatus* (Agassiz, 1831)	Acarahuazú
	Cichla monoculus (Spix, 1829)	Tucunaré
	Aequidens tetramerus (Heckel, 1840)	Bujurqui
	Heros appendiculatus (Castelnau, 1855)	Bujurqui azul
	Chaetobranchus flavescens (Heckel, 1940)	Bujurqui vaso

The most common fish species in the Samiria River basin was Common Pleco (*Liposarcus pardalis)*, followed by Red-Bellied Piranha (*Pygocentrus nattereri*) and the White Piranha (*Serrasalmus elongatus)*. Likewise, the biomass of fish was dominated by the Common Pleco, followed by Red-Bellied Piranha and the Lisa (*Schizodon fasciatum)*.



Percent of captures of fish in the Samiria River basin



Biomass of fish in the Samiria River basin

In the varzea of the Samaria River basin fish move into the flooded forests during the high water period from December to June. This is a very productive period for the fishery with abundant food in the forests, including insects, fruits and forest debris. During the low water period from July to November the fish move into the lakes, channels and main river. Competition is greater during low water and many species migrate out of the Samiria and into the larger Maranon River. This difference is reflected in the CPUE of high and low water periods.

Variation in the capture, biomass and CPUE between high and low water seasons in the Samiria River basin.

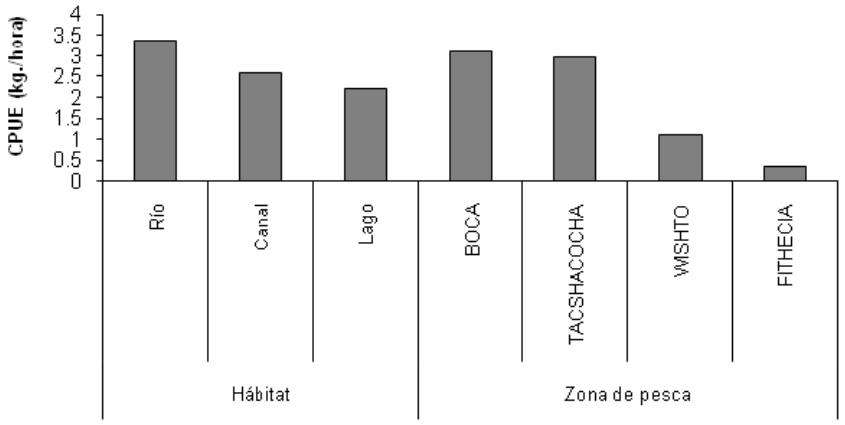
	High Water	**Low Water**
Number of Captures	128	1988
Time (hours)	26.15	109.30
Biomass (kg)	18.261	328.400
CPUE	**4.89**	**18.18**

The diversity of fish was greatest in the lower reaches of the Samiria River and decreased further up river. Tascha Cocha had the greatest diversity and is situated in the lower mid section of the river. Diversity at the mouth was was slightly less than Tascha Cocha, due to a greater dominance of several species. The diversity of fish decreased at the Wishto site in the upper mid section, and further decreased at the Pithecia site in the upriver section.

Overall, the diversity between the main river, channels and lakes was similar, with the channels having the greatest diversity, followed by the lakes. The main river channel of the Samiria River had the lowest diversity.

Diversity of fish in the Samiria River basin.

	Habitat			**River Sections Upriver-Mid river-Mouth**			
	Río	**Canal**	**Lago**	**Pithecia**	**Wishto**	**Tacshacocha**	**Boca**
Diversity Index (H')	2.5403	2.8874	2.6485	1.3168	1.6933	3.1443	2.2942

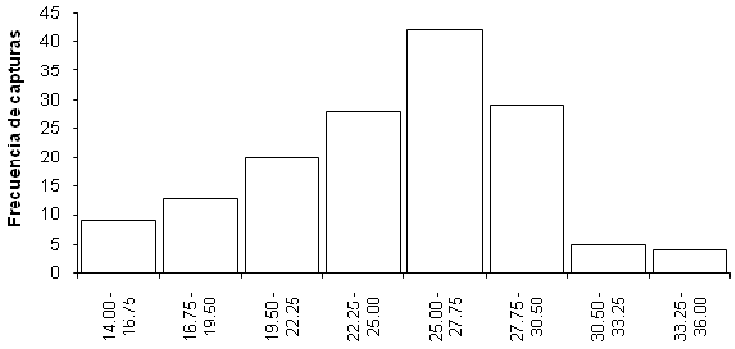


CPUE of biomass of fish along the Samiria River basin.

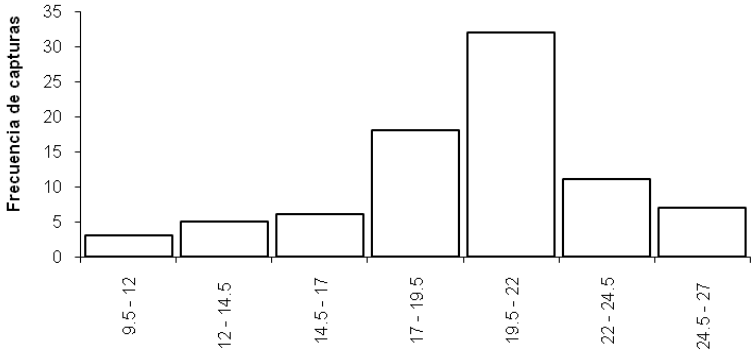
The frequency distribution of body lenth was used to compare commercial fish surveyed with standars developed by the Peruvian Ministry of Fisheries. The results showed that *Astronotus ocellatus* and *Prochilodus nigricans* in the Samiria basin had healthy age structures that correspond to a strong fishery. However, *Colossoma macropomum* showed a younger age structure than found in lightly fished areas. Further analysis is required, especially for *Colossoma macropomum.*

Legal limits of size classes of three commercially important species in the Samiria River basin

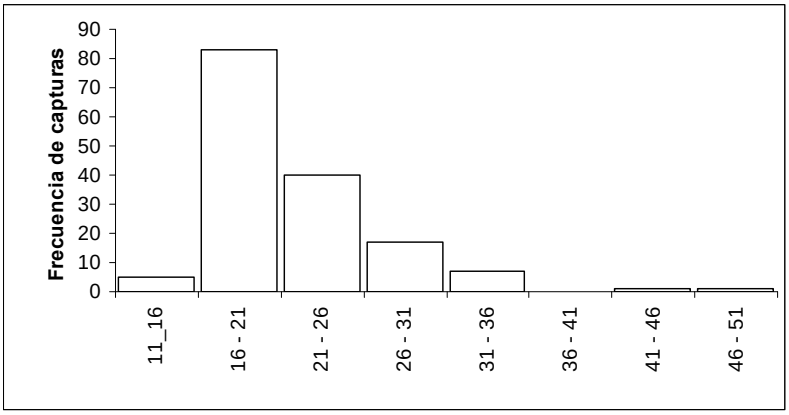
Species	Length(cm)				Legal Reference
	N	Mín.	Máx.	Media	
Astronotus ocellatus	60	13.7	27	20.3	20 cm INDERENA, Colombia.1987
Colossoma macropomum	130	15	42	28.5	45 cm. R.M Nº 147-2001-Pe
Prochilodus nigricans	136	10	36	23	25 cm R.M Nº 147-2001-Pe



Frequency distribution of body length of boquichico *(Prochilodus nigricans).*



Frequency distribution of body length of *Astronotus ocellatus*



Frequency distribution of body length of *Colossoma macropomum.*

Discussion

Populations of the terrestrial mammals are at healthy levels in the Samiria River basin. The primates were, by far, the animals with the greatest population numbers, followed by the rodents, birds, and ungulates. Twelve species of primates occur in the reserve although only 8 species were actually recorded during this study. The red howler monkey was the species with the highest density in the basin. White-lipped peccary was the ungulate with the highest population, and it can live in large groups of up to about 200 individuals. Piping guans, spix guans and the razor-billed curazao were the most common game birds in the river basin.

The abundance of dolphins is very healthy in the Samiria River with the Pink River Dolphin having a higher density than the Grey River Dolphin. The Samiria River basin has one of the greatest densities of dolphins found anywhere in the Amazon basin. Results showed that both species are often sighted alone, or in pairs, and sometimes in pods larger than four.

The Amazonian Manatee is difficult to sight, but with the limited sightings it is clear that the Samiria River is one of the last refuges of manatees in the Peruvian Amazon. The lower basin had very few sightings possibly as a result of human disturbance. The local people say that they often see them close to their villages.

The Pacaya-Samiria Reserve has one of the greatest populations of black caimans in the Peruvian Amazon. This species was overhunted in the 1940's-1970's because of the value of its leather. The conservation of the Samiria River basin has allowed the black caiman to recover. However, the common caiman is decreasing in the basin, apparently from competition from the black caiman. The smooth-fronted caiman is generally rare in the Samiria, but can occasionally be sighted.

Amongst the macaws, the blue & yellow and the red-bellied macaws were the most abundant species in the study zones. Both species make their nests in dead palms, although the former also takes advantage of hollows made by other birds. The other less abundant species are scarlet macaw and red & green macaw that nest in relatively soft trees. In the study areas there are large patches of palm swamps which are key habitats of the macaw species. Conservation of palm swamp will be very important and changes in macaw abundance are likely to correlate to changes in the fruit production within the palm habitats.

The density of the yellow spotted river turtles in the study zone is at a healthy level. The turtle head starting recovery programme appears to be successfully helping to increase the turtle populations. The incubation of eggs in artificial nests is directly correlated to the increase in turtle numbers. The time between infant turtles to adult turtles is estimated at around eight years and the turtle nesting programme started 10 years ago. Therefore, it is predicted that turtle numbers should increase dramatically during the coming years.

The two most abundant species of fish in the study sites were Common Pleco, followed by Red-Bellied Piranha and the White Piranha. The Piranha feeds on bleeding or sick individuals, and helps to clean the ecosystem and serve an important ecological function. The Common Pleco is abundant in its preferred habitat of shallow waters. In general the diversity of fish recorded during in the Samiria River basin is high because of the variety of habitats.

In conclusion, conservation activities produce the best results when professionals, institutions, local communities and the reserve authorities work together. The monitoring activities conducted by the Earthwatch expedition helped to collect information on a variety of wildlife populations, which can help to determine whether the current conservation strategies are being successful and if the best

decisions are being taken. Understanding fluctuations in wildlife populations over time is extremely important in relation to conservation and management strategies of the reserve. These fluctuations can be influenced by natural events or induced by human impacts. Thus, only through long-term monitoring can the true impact of conservation be determined. It is therefore very important that monitoring of wildlife in the Pacaya-Samiria National Reserve is continued and research records fluctuations in population densities. This information is extremely useful to the reserve authorities and local communities and for the conservation of natural resources in the Pacaya Samiria National Reserve.

The Pacaya-Samiria National Reserve is a refuge for the high diversity assemblages of aquatic and terrestrial wildlife, including large populations of river dolphins, recovering populations of manatees and giant river otter, 12 species of primates, and a wide range of terrestrial rainforest mammals (Aquino et al. 2001). Macaws, wading birds, and game birds are abundant (Gonzalez 2004), as are populations of caimans and river turtles. The hyrdoscape of the reserve has a great diversity of fish and abounds with economically important species.

The Pacaya-Samiria National Reserve has approximately 95,000 people living in villages and towns along its boundary (INRENA 2000). Some of the villages lie just inside the reserve, however there are no human settlements within the core area. Most of the inhabitants are Cocama-Cocamilla Indians (Puertas et al. 2000). The Cocama-Cocamilla people are renowned for their mobility with families continually moving between villages (Newing & Bodmer 2004). They have always adapted well to other societies and integrated well with the influx of European customs beginning with the missionaries, and then through the rubber boom and twentieth century.

The Pacaya-Samiria National Reserve has gone through a major shift in its management policies over the past two decades, from an area of strict protection where local people were excluded from the reserve to an area where the local indigenous people participate with the reserve management. This drastic shift in conservation policy has led to a reduction in hunting pressure and an increase in wildlife populations (Bodmer & Puertas 2007). When the park administration changed and the reserve began to incorporate the local communities in the management of the area, attitudes of the local people also changed (Puertas et al. 2000). Local management groups were given areas to manage and were no longer considered poachers. They were able to use a limited amount of resources legally and with reserve administration approval. Many of the local people changed their attitude towards the reserve and began to see the long-term benefits of the reserve for their future. The reserve became part of their future plans and there was increasing interest in getting involved with the reserve. Many local people can now see the socio-economic benefits of the reserve and are themselves helping to conserve the area. Hunting has decreased substantially, both due to the poachers now becoming mangers, and because the local people are keeping the other poachers out of their management areas.

Many animal populations are recovering in the Samiria river basin during the past decade. The results of this report document how the population dynamics, community structure and land/hyroscape use of the wildlife is being affected by the successful conservation actions of the reserve. A range of terrestrial and aquatic wildlife taxa were monitored to understand the changes, including mammalian, avian, reptilian and fish species.

The results of the research show that many animal populations have recovered along the Samiria river basin over the past decades. This has been due in large part to the change in management policy of the Pacaya-Samiria National reserve, from an area of strict protection to an area that incorporates local indigenous people in the reserve management. The level of poaching was much greater during the period of strict control and hunting pressure was considerably greater. Local

people saw no future in the reserve and considered the reserve administration as an enemy who took away their access to natural resources in their traditional lands.

In the late 1990's the strict policies of the reserve were changed and local people became involved with reserve management. This has permitted them to change their views of the reserve and move from being poachers to managers. With the decrease in poaching activities and an increased involvement of local people in the management of the reserve the animal populations have increased. There are now larger populations of most of the wildlife species than in the recent past.

The success of the reserve has seen recovering populations of key wildlife species, such as the large-bodied primates, the blue and gold macaws, the Amazonian river turtles, and the black caiman. However, the research clearly shows that species are often in Lotka-Volterra competitive interactions, and recovery of one species will actually impact the population of other species. For example, large-bodies primates appear in competition with each other, and outcompete smaller species. As the blue and gold macaw numbers increase, the chestnut fronted macaw is in decline. Likewise, the recovery of the black caiman is resulting in a decline of common caiman. The local management policies of the reserve need to take into account the results of being successful. It may lead to an increase in the species being conserved, and in turn lead to a change in the animal community structure and a decrease in competing species.

The Pacaya-Samiria National Reserve is the largest protected area in the north eastern Peruvian Amazon and is key to biodiversity conservation of the western Amazon basin. The results of this study clearly show that the reserve is conserving biodiversity. The results also show that having a reserve administration that involves local people in park management has a positive effect on biodiversity conservation.

The Peruvian Amazon is a mega-diverse rainforest that harbors one of the greatest, if not the greatest, assemblages of biodiversity on Earth. The project in Loreto has been developing and implementing a conservation strategy for the mega-diversity of the Samiria-Yavari landscape by showing the national government, regional government, international community and other actors that protected areas in Loreto can be successful both socially and for biodiversity conservation, and by increasing the on-the-ground capacity of local professional to insure that protected areas in Loreto will be successfully implemented in the long-term.

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