Project Las Piedras

A socio-ecological investigation into the impact of illegal logging activity in Las Piedras, Madre de Dios, Peru.

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1. Contents

2. Summary

We investigated the ecological consequences, as well as socio-economic drivers, of illegal logging activity and associated subsistence hunting, on large mammals, along the Las Piedras river, Madre de Dios, Peru.

A series of 107 structured and semi-structured interviews, conducted with timber personnel, provided socio-economic information on illegal logging in Las Piedras. From this, we created a profile of loggers including information such as education, place of birth and salary. The total number of timber camps in Las Piedras was estimated as 231 camps, of which 176 camps were situated inside areas protected for un-contacted Indians. The estimated total number of loggers in Las Piedras was 2021. Of the interviewed loggers, 17.3% had encounters with un-contacted Indians highlighting the threat the Indians face by the invasion of loggers into their natural habitat. We recorded the transportation of 6,074.4 m^3 of bigleaf mahogany (*Swietenia macrophylla*) to the market in Puerto Maldonado, worth an estimated US$ 5,148,643.3 in the local market. We estimated that during the month prior to the investigation 2301 mammals and 2112 birds were consumed in logging camps in Las Piedras. The monthly harvest of bushmeat equalled 41,282.7 kg.

Standard un-bounded line-transect census techniques were used to assess relative abundance and community structure at six sites. In total, 1104 km were censused. Logging and hunting history at each site was assessed using information obtained from timber personnel and information collected at the sites. Sites were subsequently grouped into two categories, active and not-active, i.e. sites were logged during the field period and logging activity terminated a minimum of three years prior to the investigation, respectively. A strong impact of logging and hunting activity was recorded for the long-haired spider monkey (*Ateles belzebuth*), red howler monkey (*Alouatta seniculus*), equatorial saki monkey (*Pithecia aequatorialis*) and the two deer species (*Mazama americana* & M. *gouazoubira*). No substantial impact was found for any of the other investigated mammals. Most birds were recorded with lower abundance at the active sites than at not-active sites. Razor billed curassow (*Crax mitu*) was close to extinction at the active sites

The impact of small scale selective logging activity on the forest ecosystem is discussed and compared with the impact of less selective mechanised timber extraction. Recommendations concerning research crucial to the sustainable management of timber concessions in Madre de Dios are presented.

3. Introduction

3.1. Illegal loggers

In recent years Las Piedras has experienced a strong inflow of illegal loggers, due to the increased market value of mahogany (*S. macrophylla*). The price per board foot at the time of the investigation was US$ 1.86[1] in Puerto Maldonado. With an approximate mean amount of 4.7 m^3 per mahogany tree, the economic value of a single tree was no less than US$ 3,840. This was a huge lure for the local population who on the whole lack alternative work opportunities. Unofficial estimates regarding the number of people working in Las Piedras varied, but the commonly stated figure was in the order of 5000.

In 1999, the Peruvian government signed the "International Tropical Timber Agreement" of the ITTO[2] and therewith agreed to prevent the export of tropical timber, such as mahogany, from unmanaged areas by the year 2000. In 2000 a new forest and fauna law (No. 27308)[3] was passed by congress, which outlawed the extraction of tropical timber outside managed timber concessions. In order to apply to INRENA[4] for a timber concession, loggers had to unite and form small companies. The law is a new approach to formalising timber extraction and provide incentives for sustainable management via ensuring property rights over an areas as large as 40,000 ha for 40 years.

The timber concessions were assigned across Peru in 2002 to local and national logging companies, including more than 30 in Madre de Dios. In this region, police were used to force illegal loggers out of these new concessions and protected areas. However, many loggers were unprepared for the abrupt change in natural resource policy and did not apply for concessions, which made them criminals over night. In June and July 2002 these illegal loggers organised a strike in Puerto Maldonado, which virtually paralysed all economic and civic activities for several weeks. Many official buildings, including those of INRENA were destroyed. In November 2002 the leader of the illegal loggers was elected as President of Madre de Dios, reversing progress made by conservationists and human rights activists. Illegal logging both in timber concessions and protected areas in Madre de Dios is still rife.

3.2. Importance of mammals

Large mammals provide vital ecological services and play an important role in forest ecology through seed dispersal and predation, pollination, folivory and frugivory[5]. Strong evidence exists that even in areas where forest is still intact, hunting can lead to local extermination of large mammal populations[6]. Indeed, overhunting has been found to cause an ecological inversion of mammalian biomass and can lead to landscape-level changes in habitats and faunal assemblages[7].

No rigorous mammal population censusing has been carried out to date along the Las Piedras river. The only existing investigation into the status of mammals in this area was relatively minor and consisted of an exploratory trip in 1996 in search for giant river otters[8] and a pilot study of logging impact on mammal species[9]. The conclusion of this latter study was that a maximum of 86.016 wild animals, including 54,190 long-haired spider monkeys (*Ateles belzebuth*) and red howler monkeys (*Alouatta seniculus*), were likely killed by timber personnel in Madre de Dios in 1999. Local extinction is inevitable for some species if this rate of extraction is maintained.

3.3. Un-contacted Indians

Madre de Dios is one of the last places in the world where indigenous Indian groups can be found living a relatively unaltered lifestyle, that is to say without any physical or social contact with the civilised world. These groups are locally referred to as "voluntarily isolated Indians". Indians rely on bushmeat for their

[1] US$1 = 3.55 Nuevo Soles (July 2002)
[2] International Tropical Timber Organisation (www.itto.or.jp)
[3] the law can be read (in Spanish) online http://www.elaw.org/resources/text.asp?ID=556
[4] National Institute of Natural Resources in Peru
[5] *e.g.* Terborgh 1983
[6] Alvard *et al.* 1997; Bodmer *et al.* 1994; Peres 2000
[7] Cullen *et al.* 2001; Rylands *et al.* 1997
[8] Groenendijk *et al.* 1996
[9] Velasquez 2000

protein intake (Stearman 1995). A strong impact of loggers on game species deprives native people of their dietary needs and poses a serious threat to their livelihood (Stearman 1995). These Indians do not share the same diseases with people who live in civilisation and, therefore, their immune system cannot deal with viruses transmitted for example by illegal loggers or other intruders. In the last decade many Indians died in their natural habitat after having encountered loggers or oil prospectors[10]. A reserve for un-contacted Indians (Reserva del Estado para Indigenas en Aislamiento Voluntario) in the middle reaches of the Las Piedras and Los Amigos rivers has recently been created in 2000. A further reserve was established in the upper reaches of the Las Piedras (Zona Reservada Alto Purus) in 2002. The urgent need for this second reserve became obvious after reports of sightings of "calatos" (naked people) by loggers in the upper parts of Las Piedras and on the border to Brazil increased, areas that are presumably used as a refuge for those people[11].

The problems Madre de Dios is facing at the moment are based around a large number of illegal loggers who have invaded the forest of Las Piedras in search for precious mahogany. The supposition is that the invasion is causing unknown amounts of environmental impact and destroying the basis of the life of the World's last un-contacted Indian populations.

[10] Alfredo Garcia Altamirano, personal communication
[11] Alfredo Garcia Altamirano, personal communication

4. Objectives

4.1. Socio-economic investigation into illegal logging activity in Las Piedras

- Investigate the position and number of logging camps in Las Piedras.
- Estimate the number of timber personnel working in Las Piedras.
- Investigate the timber extraction processes and machinery used in Las Piedras.
- Estimate the extraction of *S. macrophylla* in Las Piedras.
- Investigate the socio-economic environment of illegal timber extraction in Las Piedras.
- Investigate hunting pattern of loggers and their food preferences.
- Investigate the animal species hunted and the biomass harvest.

4.2. The impact of logging activity and associated subsistence hunting on large diurnal mammals

- To provide the first mammal inventory for Las Piedras.
- Investigate the development of mammal populations after the cessation of logging activity and associated subsistence hunting.

5. Methodology

Data collection was carried out from the 9th of May until the 21st of September 2002. The project consisted of two parts. Part I was a socio-economic investigation of illegal timber extraction in Las Piedras, including the conduction of interviews in illegal timber camps and the monitoring of timber transportation on the Las Piedras river. Part II was an ecological investigation into the impact of timber extraction and associated subsistence hunting on large diurnal mammals, consisting of a mammal census at sites of different logging activity.

5.1. Socio-economic investigation of illegal timber extraction in Las Piedras

Conduction of interviews in illegal logging camps

Structured and semi-structured interviews with timber personnel were conducted between the 9th of May and 21st of June 2002 in logging camps and ports along the Las Piedras river. Hereafter, "Las Piedras" will be used to describe the Las Piedras river including its tributaries, whereas "Las Piedras river" refers to the actual river and "tributaries" will be used for the tributaries of the Las Piedras river. The interviewers consisted of two loggers, a student from Puerto Maldonado and B. Schulte-Herbrüggen, who supervised the data collection process for the first two weeks. Additional interviews were collected by B. Schulte-Herbrüggen while travelling on boats with loggers and whenever loggers visited the project camp during the mammal census.

B. Schulte-Herbrüggen familiarised himself with the problems of illegal logging in Las Piedras during discussions with local NGOs in Puerto Maldonado and conversations with loggers, who were frequently encountered in Puerto Maldonado and were happy to talk about their work. A questionnaire was developed with the help of Alfredo Manuel Garcia Altamirano, an experienced anthropologist who works for the Tambopata Reserve Society (TReeS) in Puerto Maldonado and has conducted interview studies in the past with native people in the Las Piedras area. We also asked interested NGOs such as FENAMAD[12] to contribute questions and to comment on the questionnaire. Training in the conduction of the interviews was undertaken prior to the start of the data collection with the help of Alfredo Manuel Garcia Altamirano and Chris Kirkby (TReeS). Potential problems and difficulties were discussed. Several trial interviews were conducted with friends of the two loggers in the team and the results analysed to improve the questionnaire.

The interviews were conducted by two people on a rotation basis. The questions were read from a standardised sheet, in order to standardise data collection across people. One person read the questions and one person recorded the answers. Hunting for commercial purposes was an illegal activity, therefore interviews could potentially give biased results, as the loggers might have feared disclosure of their activities. Yet to our knowledge, no person had been penalised for illegal hunting and previous experience with interviews suggested such bias would be negligible[13]. We therefore considered this approach as useful and valuable. The team of interviewers travelled with a 12m boat and a 16HP (peke-peke) motor upstream the Las Piedras river as far as the confluence with the Bolognesi stream, approximately 14 days of non-stop travelling from Puerto Maldonado. Having reached this point the team returned to Puerto Maldonado due to the low water level in the river, which made it extremely difficult to manoeuvre the boat. Tributaries of the Las Piedras river were not entered due to the low water level typical of the dry season. Other than in logging camps, the questionnaire was also conducted at the native community Montesalvado, logging communities such as Puerto Nuevo, the logging port of Curiacu and whenever timber personnel were encountered while travelling on the river. The native communities close to Puerto Maldonado, of which most logged the forest in their direct neighbourhood, were not entered since we concentrated on the illegal extraction of mahogany and the species had already been depleted in these areas several years ago. Besides those, every encountered logging camp, up to the native community of Montesalvado was entered and the loggers present were asked if they agreed to participate in a formal interview. Beyond Montesalvado the team worked without the project leader and not all camps were visited. However, the time and date when the boat passed a camp was always recorded and signs of recent activity, *e.g.* boat or intact camp (mostly visible from the water) were used to distinguish between active and in-active logging camps. To the loggers the work was explained as an independent research project that aimed to describe the reality in the logging camps and the environmental

[12] a non-governmental organisation called Federacion Nativa de Madre de Dios y Affluentes
[13] Victor Velasquez, personal communication

impact of logging activity. When feasible, the nights were spent in logging camps and data collection started after one hour of socialising. The two loggers in the team encountered many friends in the camps, which improved the atmosphere and facilitated data collection. Most loggers asked whether we were working for INRENA and were satisfied when we denied this. B. Schulte-Herbrüggen encountered only one person who did not want to be interviewed during the course of 40 interviews.

The group spent three days at the new logging port of Curiacu. We encountered approximately 60 loggers who used the shops to re-supply or who were waiting for the water level to rise in order to enter the small tributaries by boat. Our presence was a welcomed distraction and many loggers approached us for an interview in the evenings. We were allowed to take pictures of the loggers while hunting and eating, *e.g. A. belzebuth*, and often spent many hours with them, discussing local issues.

The positions of the logging camps were recorded with a standard GPS (Garmin Etrex). Unfortunately, problems aroused in the use of the GPS after the departure of B. Schulte-Herbrüggen and not all positions were obtained for the area above Montesalvado.

Special attention was paid to avoid the conduction of more than one interview per camp without knowing about it. This was made clear during the initial conversation when loggers were asked about who they worked with and if they had heard of us already having been in their camp.

Number of camps and timber personnel in Las Piedras

Timber personnel stated the approximate position (i.e. Las Piedras river or tributary and travelling time from known location such as tributary mouth) of their camp during the interviews, which enabled us to calculate the proportion of interviewees who worked in the Las Piedras river and its tributaries. By knowing the proportional distribution of timber camps in Las Piedras and the exact number of camps along the Las Piedras river, we calculated the number of camps inside the tributaries. The estimation of total number of camps and the mean number of timber personnel in the investigated camps was then used to calculate the total number of timber personnel working in Las Piedras during the time of the investigation. The large number of interviews conducted at the logging port Curiacu (the commercial centre of Las Piedras at the time of the investigation, where loggers from all parts of Las Piedras bought new supplies and sold their wood) in addition to the interviews conducted with loggers who travelled on the Las Piedras river, ensured that the collected data were representative for Las Piedras as a whole.

Subsistence hunting by loggers

In order to assess the scale of hunting, timber personnel were asked to state species and the number of animals hunted during the month prior to the investigation. Total monthly harvest of animals and biomass were calculated for all investigated timber camps as well as the data extrapolated to the estimated total number of timber camps in Las Piedras. The body mass for adult animals was calculated from FAO (1996), Peres (1997), Peres (1999), Peres (2000), Robinson *et al.* (1986), Robinson *et al.* (1986b) and Terborgh *et al.* (1990). Consecutively, loggers stated their five preferred mammals and three preferred birds. Those named were ranked according to the number of times the species was stated as one of the preferred species as well as the number of times the species was ranked as the most preferred species.

Monitoring the boat and balsa traffic on the Las Piedras river

The extraction of *S. macrophylla* in Las Piedras was investigated from 9th of May until 20th of September 2002. Data collection was carried out at a total of 118 days. Gaps in the data set were filled by extrapolation of daily average values, which were obtained for each month. During May and June (interview study) data was recorded while travelling in the boat. During July, August and September, sightings were recorded from two camps (mammal census) in the lower part of the Las Piedras river. Data collection started at 5:30am and terminated at 4:30pm. This period coincided with sunrise and sunset, respectively, and was assumed to be the main travelling time of loggers. Before and after this time no data collection was possible due to lack of light. Motor sounds that were heard outside this period were recorded. The amount of wood transported with one balsa was estimated by counting the number of *tramos* (subunits of a balsa). One *tramo* was assumed to consist of 1.2m^3 (500 board feet)[14] of wood. This assumption was tested several times during conversations with loggers who transported wood to the market. The market value of the recorded mahogany was

[14] 1 board foot is a unit of measurement represented by a board of 1 foot long, 1 foot wide and 1 inch thick, and equalled 0.00236m^3. We used 423.8 as the conversion factor; hence 423.8 board feet = 1 m^3.

calculated. The price per Cubic Metre on the market on Puerto Maldonado equalled approximately US$ 847.6[15] and US$ 1150 on the US market[16]. For one observation the following data was collected on a standardised data sheet: time, number of boats, number of balsas and the amount (board feet) of wood transported, direction of travel, number of men, women and children on the vehicle, number and type of motor on the vehicle, number of cylinders on the vehicle, and additional information like guns, bushmeat, food or tourists. Observations were aided by a binocular.

5.2. The impact of logging activity and associated hunting on large diurnal mammals

Site identification

Six study sites (see chapter 6.1 for a map of the study sites) situated along a gradient in logging history were identified during May and June 2002. Information obtained from timber personnel during the interview study (see above) proved to be invaluable for the selection of these sites. Where possible we spoke with people who had worked in the area and interviewed them regarding the logging history at sites that we considered appropriate for the census. The sites of investigation and the available information on human impact are displayed in chapter 6.2.

Site classification

Because of the difficulty in assessing precise logging regimes and extraction rates, hunting history and rate of game recovery, and varying habitat productivity[17] the sites were roughly classified into active and not active sites. Two sites that were experiencing logging-related impact during the time of the field study (sites B & E) were compared with four sites which loggers had abandoned at least three years ago (A, C, D & F). Confirmation of the preliminary assigned impact categories or indices was reconsidered during the field period using the following techniques: interviews with loggers, direct evidence of hunting activity, state of decay of felled trunks and stumps, and recovery of vegetation close to logged canopy openings. Special attention was paid to information necessary to refine the impact categories, *e.g.* duration of impact, presence of brazil-nut collectors and machinery used.

All sites were chosen in terra firme (non-inundated) forest in order to minimise the differences in soil and forest structure between sites, which can alter patterns of mammal assemblage[18]. Although, this factor cannot be excluded, we assume that the presence of loggers is the dominant factor influencing species composition, since the species under investigation had broad ecological tolerances[19]. The transects did not cross different habitat types or run parallel to physical or biological boundaries (*e.g.* streams), to avoid skewed and unrepresentative data respectively.

Stakeholder groups such as FENAMAD and FEPEFMAD[20] were informed about the study from the beginning and their co-operation obtained to ensure good relations during the course of the investigation.

Transect Preparation

Assessments of the impact of loggers on diurnal mammal species was conducted using standardised un-bounded line transect census techniques[21]. Two transects per site were utilised, one on each side of the river, in a random direction. Due to difficult terrain transects D & E incorporated sections of previous logging trails. This was justified, given the non-significant difference of perpendicular distance of encountered mammals, such as *A. belzebuth* groups (Mann-Whitney test, n=151, z=-0.743, p= 0.458) between transects cut by the investigators and transects that had been cut by timber personnel for logging and hunting purposes. None of the tested species showed a significant difference.

[15] July 2002, personal observation
[16] Tropical Timber Market Report: 1-15th September 2002, ITTO
[17] Peres 1999
[18] Emmons 1984
[19] Eisenberg 1989 & Emmons 1984
[20] Federacion de Pequenos Extractores Forestales con Manejo Sostenible de Madre de Dios
[21] Bodmer *et al.* 1997 & Peres 1999

Very few animals were first detected on the basis of their alarm calls; instead most detections were made after hearing movement, other calls than alarm calls and olfactory cues. Interesting, therefore that the perpendicular distance at which mammal groups were encountered showed a general avoidance pattern with less encounters made on the transect and close by than in five to ten meters distance from the transect. Animals appeared to be aware of the trails and might have avoided them due to the threat that was connected to them when loggers inhabited the sites.

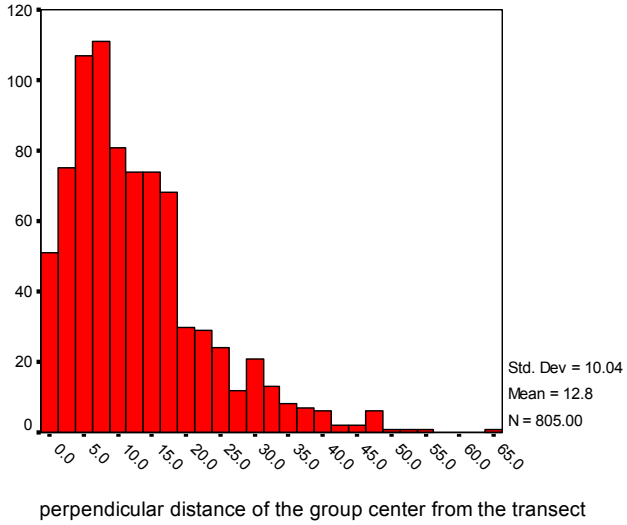


Figure 5-1 Showing the frequency distribution of perpendicular distance for all recorded mammal sightings at the six transects.

The comparison of sites with different logging history appeared to be problematic due to supposedly different visibility at the sites of different regeneration stages, which would have influenced the detection probability. However, we argue that the patchiness of the distribution of mahogany stands and therefore logged sites does not support this argument. The encounter probability, as mirrored in the perpendicular distance at which the animals were encountered, was not significantly different between the sites (Kruskal Wallis test for large primates grouped: df=5, chi-square=8.256, p=0.143, all tested individual species p>0.05).

Transects were prepared during July 2002 using a standardised technique, following White (2000) and Peres (1999). A minimum of four people were involved. One person walked in front cutting the trail, guided by a second person who carefully monitored the linear development of the approximately 5 km long transect using a compass. The two following people completed the trail cutting and cleaned the trail. Slight detours around natural obstacles like fallen trees and dense regenerating undergrowth had to be passed, due to time constraints. However, Peres (2000) states that this method does not change the overall objectives of the survey as long as the original compass bearing is resumed immediately after the obstacle is passed. This was the case. The transects were measured with a 50-m foresters tape and marked with coloured tape every 50 m for distance localisation during the census. Fallen litter was removed during the initial cleaning and some censuses to avoid unnecessary noise and disturbance. Time needed to cut one transect of 5 km varied, depending on the habitat, but a good approximation is three days. Transects were not used the day after they had been cut to allow for the effects of disturbance to die down. Where logging trails were used for the census, they were checked for their general linearity and special attention paid to whether or not the loggers had followed animal trails, in order to avoid biased data collection.

Census Technique

Transect censusing involved two observers (one guide and one student), for safety reasons and also to ensure that all data during contact with desired species was collected efficiently. Data collection was carried out in both directions, i.e. on the outbound and inbound stretches. The outbound stretch was censused between 6:00 am and 11:30 am. On return the inbound stretch was censused between 1:00 pm and 4:00 pm. This approach was successful in avoiding times of decreased mammal activity and therefore encounter probability, as the statistical tests showed. No significant difference was found between data collected in the morning and the afternoon. Mann-Whitney test was performed on *A. belzebuth* (n=151, z=-0.930, p=0.352), *C. apella* (n=211, z=-1.264, p=0.206) and *S. fuscicollis* (n=118, z=-0.843, p=0.399). The two data sets could be merged.

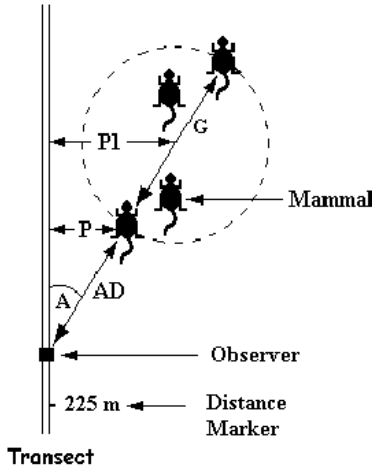


Figure 5-2 schematic picture of the data collection. An observer is walking on a transect, encounters a group of animals and measures the perpendicular distance (PD) from the transect to the centre of the group, plus the group width and the distance on the transect.

Daily rotation of observer and sites minimised observer dependent bias. Observers walked slowly and quietly along the centreline of a transect at a rate of approximately 1-1.5 km/h. They stopped every 100 m for 10 sec to listen for animals and to ensure that they were aware of any animals before they themselves were noticed. During an encounter, up to 5 min, or until visual contact was lost, were spent recording the following data using a standardised recording sheet: species; number of individuals encountered; perpendicular distance (± 1 cm) to the first animal seen and the animals at the extremes of the group; number of juveniles; behaviour: *e.g.* eating, playing etc.; time of day; general visibility; principal detection method (visual, auditory or smell); signs of human activity: *e.g.* logging. Only accurate counts of animals were considered for analysis.

Despite the problems associated with line transect surveying, it is generally considered as the best methodology for evaluating large diurnal rainforest mammal communities. A variety of methods have been developed for the calculation of mammal densities using line-transect methodology[22] and successfully been applied[23]. However, the large number of observations necessary for meaningful analysis and associated costs, make them prohibitive for most monitoring programmes. During this study, the recommended minimum number of 40 encounters was obtained only for *C. apella* on one transect. After pooling sufficient encounters were recorded for *A. belzebuth*, *A. seniculus* and *C. apella*. Due to the large variation in calculated densities resulting from small sample sizes, relative estimates of animal abundances were more appropriate for comparing differences between mammal populations at sites of different logging history. Species-specific encounter rates per ten walked kilometres (hereafter referred to as relative abundance) were calculated for all recorded species.

Training

A preliminary week of orientation, first aid training and familiarisation, including species identification by sight and sound, paired with the species behaviour and escape response, training of rapid counts of individual animals and standardisation of measurements, provided all participants with the same level of experience. By the end of this process, everybody in the team could identify animals (by sight and sound) and habitat types reliably and consistently. The local guides were invaluable during this period as they had lived in the forest for many years and had great experience in encountering and identifying animals.

[22] Brockelman *et al.* 1987 & Buckland *et al.* 2001

[23] *e.g.* Bodmer *et al.* 1997, Carrillo *et al.* 2000, Chapman *et al.* 2000, Peres 2000 & White *et al*. 2000

6. Site description

The study sites were situated along the Las Piedras river (13º08´S, 69º36´W) 50 to 100 km northwest of Puerto Maldonado in the department Madre de Dios. With 80.000 people living in the department and over half of the living in Puerto Maldonado the population density on a whole is about 1/sqkm and about 0,4/sqkm in rural areas. At approximately 200 m above ground level, lowland rainforest is the dominating vegetation type with variation due to different hydrological regimes found in the seasonally flooded alluvial flood plains along the river, and undulating terra firme hills, which characterise the adjacent higher landscape. Rapid changes in temperature are common during the dry season (April-October), with a minimum of 8 ºC a maximum of 34 ºC. The annual mean temperature is 24 ºC. Precipitation varies considerably from year to year (mean 2,400 mm).

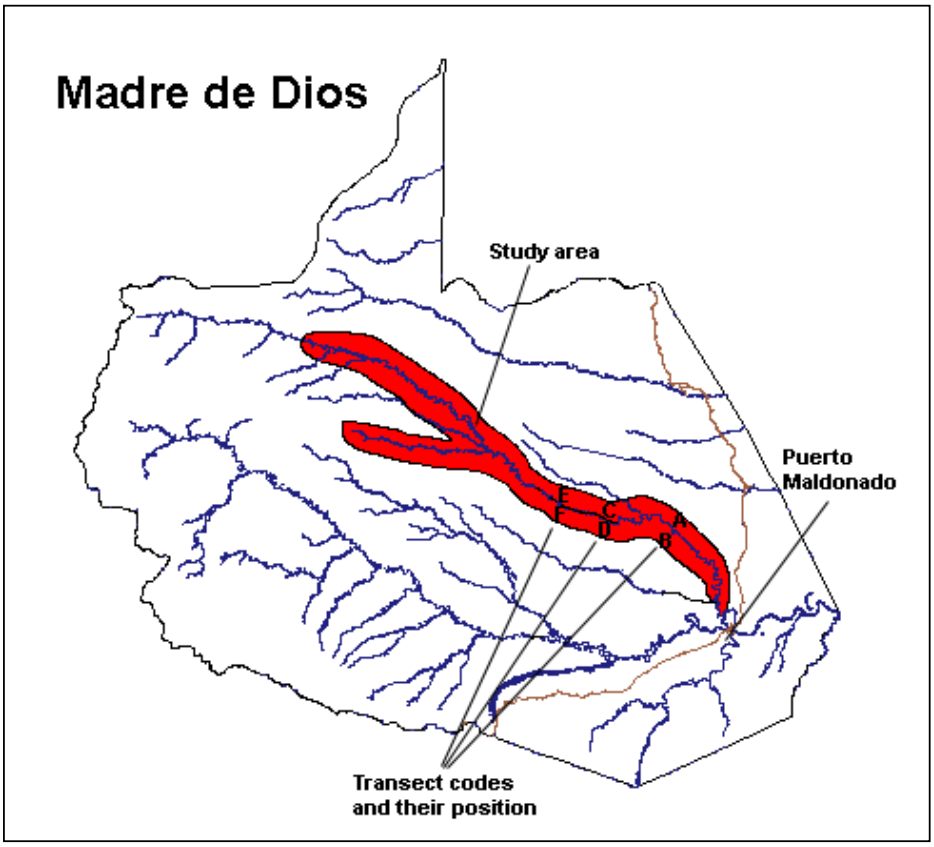
With 18 different ethnic groups of Amazon Indians, Madre de Dios is one of the cultural capitals of the world. However, their numbers are strongly declining and today's population of around 10,000 is only a fraction of their numbers at the beginning of the 20th Century; since the start of the rubber boom in the 1890s, their populations have been decimated by disease, slavery and murder[24].

The area lies in close proximity to protected areas, well known for their biological diversity, such as Manu National Park, Bahuaja Sonene National Park, and the Tambopata National Reserve. Due to the favourable ecological location within the transitional zone between humid tropical and subtropical rainforest, a great variety of different ecosystems can be found and contribute to an exceptional level of biodiversity. Biological inventories, undertaken since 1976, have revealed that the department is arguably one of the richest hotspots on the Planet. More than 1230 butterfly species, approximately 7% of the world's bird species (~600), and up to 4% of the world's mammal species (~160), including endemics and vertebrates that are considered highly endangered by IUCN[25], *e.g.* giant river otter (*Pteronura brasiliensis*), giant anteater (*Myrmecophaga tridactyla*) and yellow-spotted side-necked turtle (*Podocnemis* spp) have been recorded. Madre de Dios exceptional botanical diversity has long been recognised and led to its nomination as World Centre for Plant Diversity by the IUCN and WWF[26].

Economic development of the region has been slow. Since the early 20th century exploitation of natural resources, including rubber (*Hevea brasiliensis*), brazil-nut (*Bertolletia excelsa*), and hardwood (*e.g.* Meliacea), has been reported in Madre de Dios. Commercial exploitation of gold began 1940. Until the late 1980s governmental support for the conversion of forest into pasture for cattle, combined with the encroachment of human settlements around Puerto Maldonado, has been a major threat to the areas intact forest ecosystems and native Indian populations. The major industries of Madre de Dios at present include tropical timber (mainly *S. macrophylla*), alluvial gold mining, brazil-nut, tourism, and commerce[27].

[24] Castillo 2002
[25] The World Conservation Union (www.iucn.org)
[26] The World Wildlife Fund (www.panda.org)
[27] Groom 1991

6.1. Maps of the study sites



Map 6-1 The location of the sites of investigation in Madre de Dios, Peru.

6.2. Land-use history of investigated sites

Site A – not active

A brazil-nut collector (*castanero*) had worked in the area for three months per year from 1993 until 2000. The *castanero* was interviewed by B. Schulte-Herbrüggen in Puerto Maldonado regarding the land use history of the site and his hunting behaviour. He stated that he had hunted 10 *Tayassu pecari*, 6 *Tayassu tajacu* and 3 *Mazama* spp. per month. Several other species were hunted at very low frequency, *e.g.* one Tapirus terrestris in eight years. From 1995 until 1999, the forest was part of a large timber concession that was logged with a tractor and heavily impacted. "No animals could be found after the loggers had left" (castanero). At the time of the investigation the area was part of a tourism concession owned by Juan Julio Durand and Emma Hume (Tambopata Expeditions). Logging and hunting in the area had been prevented by staff for the last three years. The *castanero* said that he did not hunt after the loggers had left.

Site B – active

The site was heavily impacted at the time of the investigation by farmers and loggers. For more than 22 years a family of seven people had lived in the forest. They made their living out of collecting brazil nuts and sporadic logging of approximately 12,000 board feet (*Cedrela odorata* and *Cedrelinga catenaeformis*) per year. The investigated area was logged in January and February 2002. In the month prior to our investigation the family had hunted 2 *T. pecari*, 2 *T. tayacu*, 2 *A. belzebuth*, 2 *D. variegata*, 3 *P. jacquacu* and 3 *Ara* spp. No tractor had been used. Several logging camps existed two kilometres further upstream and *rumbiadors*[28] were encountered in the forest during the fieldperiod.

Site C – not active

Timber extraction had occurred with the help of a tractor at the site from 1993 until 1998. Since 1999, this area has been part of a tourism concession, held by Jungle Odyssey, and hunting has been prevented by staff. No further information is available for this site.

Site D – not active

The forest at this site has not been logged since 1999. A small farm was discovered close to the logging camp indicating that the timber personnel had worked at the site for several years. Tractor tracks were found and dated back to approximately 1994. One km further downstream a different logging camp was discovered that was abandoned approximately three to four years prior to the investigation. Tractor tracks were found.

Site E - active

This site had been logged until May 2002. B. Schulte-Herbrüggen interviewed the concessionaire in May 2002 when he was about to leave the camp. During the time of the investigation a new camp was set up 2 km further downstream and chainsaw noise was heard. An extensive trail system was discovered that reached as far as the adjacent tributary (Huasca). The forest had been logged for more than ten years by at least ten people at a time. Several camps existed inside the forest that loggers had hired from the concession owner, increasing the total number of loggers working in the area to approximately 50. Tractors had been used. *Castaneros* worked in the area.

Site F – not active

On one of the trees along the logging trail the date 06.05.1998 could be read. Our guides told us that this was commonly done when loggers abandon a camp. This information was confirmed by one of our guides, who passed the camp in late 1998 and did not observe any activity at the site. Two small camps were found. One at the river and the second 45min walking distance inside the forest. We estimated that a minimum number of 5 people had worked in the area. No tractor tracks were found.

[28] people searching the forest for valuable trees, such as mahogany

7. Results

7.1. Socio-economic investigation of illegal timber extraction in Las Piedras

Position of timber camps in Las Piedras

A total of 107 interviews were collected, representing individual logging camps that were positioned in Las Piedras. In total, 71 active logging camps were encountered along the Las Piedras river, of which 58 (81.7%) were positioned in areas protected for native communities. Of the 107 questioned timber personnel, only two claimed to work in a timber concession, and the remaining worked illegally.

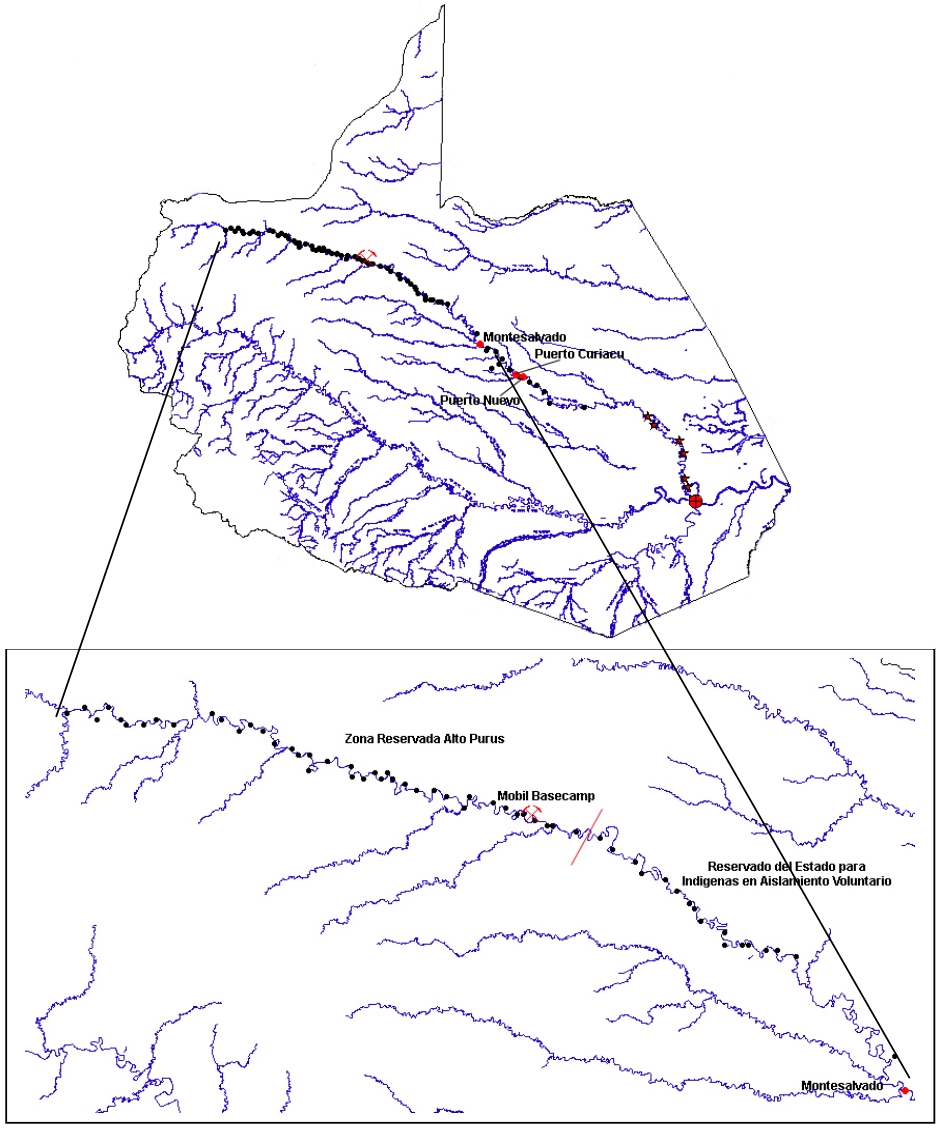


Figure 7-1 The department of Madre de Dios with logging camps (black spots) encountered along the Las Piedras river. Settlements of loggers are shown as red dots. Communities in the lower reaches of the Las Piedras river that harvest timber but not mahogany are shown as red stars. The site where the Mobil Base Camp was positioned is shown as a red cross. Puerto Maldonado at the confluence of the Las Piedras river with the Madre de Dios river is shown by a red dot with black cross inside. The red line in the bottom figure shows the border between the Zona Reservada Alto Purus and the Reservado del Estado para Indigenas en Aislamiento Voluntario.

The camp position was obtained from 104 interviewees. Of those 72 (69.2) worked in camps inside tributaries of Las Piedras and only 32 (30.8%) worked in the Las Piedras river. The number of timber camps situated in tributaries of the Las Piedras river was estimated as 160. Hence, the total number of logging camps in Las Piedras was calculated to be 231.

Of the interviewed loggers who worked in tributaries, 92.2% worked inside areas protected for un-contacted Indians (see Table 7-1). Applying this information to the above-calculated total number (196) of timber camps in tributaries yielded a total of 181 illegal camps inside protected areas. Including the number of observed timber camps along the Las Piedras river (43), a total of 224 timber camps were positioned inside protected areas. The four camps stated as positioned close to the native community "Montesalvado" were not considered as inside protected areas, since the community lies on the border to the reserve and therefore, the status of the timber camps could not be described unambiguously. Twelve interviews were not allocated to any geographical area and were excluded from this analysis.

Table 7-1 Interviewed loggers stated the approximate position of their camp.
The raw data is displayed as well as the number of camps inside protected areas.

Area	Number of timber camps in Las Piedras	Number of timber camps inside protected areas
Las Piedras river		
Roughly allocated	20	8
Montesalvado	4	4
7 islas	7	7
Sub-Total	**31**	**19**
Tributaries of the Las Piedras river		
Ceticayo	2	2
Chanchamayo	6	6
Curiacu	9	9
Huasca	5	0
Panguana	5	5
Pingachari	7	7
Pumayacu	2	2
Ronsoco	16	16
Ronsoquito	1	1
San Francisco	4	4
Panguamayo	2	2
Shahuana	5	5
India	1	1
Sub-Total	**64**	**59**
Unknown position	12	---
Total	**107**	**78**

Encounters between loggers and un-contacted Indians

17.3% of all interviewed timber personnel had experienced visual contact with voluntarily isolated Indians. This is equivalent to 18 independent encounters, which has to be seen as a minimum estimate, since most contacts had occurred in tributaries (see Table 7-2). Interviewing a greater number of people working in those areas would most likely have resulted in a higher number of encounters.

Table 7-2 Visual encounters between loggers and un-contacted Indians. It was stressed that we did not ask for camps or traces but actual visual sightings of people. Frequency and percentage data is presented.

	Frequency	Percentage
Yes	18	17.3
No	86	82.7
Total	104	100

The majority of reported encounters (58.8%) occurred in Las Piedras between January and May 2002. With 10 encounters in five months in 2002 and only four encounters in 2001, the number of encounters had increased by 600% between 2001 and 2002. The dramatic increase in the number of encounters poses a lethal threat to the Indians life and culture.

Table 7-3 Location and time of encounters between loggers and un-contacted Indians

Location	Date	Number of Indians encountered
Las Piedras		
Chanchamayo	May 2002	12
San Francisko	April 2002	1
San Francisko	April 2002	4
Curiacu	March 2002	6
Curiacu, 6 days upstream	March 2002	15
Curiacu	February 2002	40
Curiacu	February 2002	80
Pingachari	February 2002	7
7 islas	January 2002	1
Ceticayo	20 January 2002	300
Ronsocco	August 2001	50
Unspecified	August 2001	4
Communidad 1900	July 2001	400
Communidad Montesalvado	16 July 2001	300
Unspecified	1999	40
Compania Petrolera	1999	14
Santa Elena	1993	2
Los Amigos	April 2002	7

The working structure of illegal logging camps in Las Piedras

The total number of loggers who worked in the investigated camps was 929. On average, 8.76 loggers worked in one camp. Applying the above estimate of total number of timber camps in the Las Piedras river and its tributaries, we calculated that 2021 timber personnel worked in the area during the time of our investigation, of which 1971 worked in protected areas. The maximum number of loggers encountered in any camp was 24, although up to 19 people were commonly employed on top of the standard work force, when wood, which was often cut many kilometres inside the forest, had to be carried to the river for transportation to Puerto Maldonado. Those *cargadores* normally did not stay for more than one month but added substantially to the number of timber personnel. There numbers were not included in the analysis, due to insufficient data.

Table 7-4 Distribution of tasks in the investigated logging camps. The data displayed for "loggers", refers to the total number of people working in the camps. The rows below refer to loggers with individual tasks. In those, maximum for example refers to the highest number of people in any camp that had a certain task. The number of interviews that included this specific information is stated as N.

	N	Min.	Max.	Sum	Mean	Std. Dev.
Loggers	**106**	**2**	**24**	**929**	**8.76**	**4.35**
Motosierristas	98	0	4	136	1.39	0.77
Cortador_Castillo	102	0	3	49	0.48	0.91
Cortador_Disk	99	0	12	360	3.63	2.67
Cooks	105	0	4	112	1.07	0.70
Rumbiador	90	0	3	96	1.07	0.58
Cargador	29	0	19	48	1.66	3.88

Table 7-5 Machinery used in logging camps and the percentage distribution of the number of item per camp.

	N	0	1	2	3	4	5	6	Mean
Chainsaw (%)	106	0	40.6	41.5	10.4	4.7	0.9	1.9	1.90
Castillo (%)	105	77.1	22.9	0	0	0	0	0	0.23
Circular saw (%)	105	15.2	66.7	10.5	5.7	1.9	0	0	1.12
Tractor (%)	105	92.4	7.6	0	0	0	0	0	0.08

All logging camps utilised at least one chainsaw, a result that does not surprise. Most camps had one or two *motosierristas*[29] who cut trees and if available cut boards with a *castillo*[30]. The use of *castillos* is illegal, due to supposed greater wastage. If a tree was cut using a *castillo* the boards had to be processed in a sawmill in Puerto Maldonado for the price of US$ 36.3 per Cubic Metre in order to be sold. The additional price generally limited the use of *castillos* to steep terrain that could not be reached with a circular disk and to loggers who could not afford a circular disk, the latter being represented by the 15.2% of camps that did not use a circular saw. However, we learned that large quantities of branch-wood were commonly discarded since the curved shape of tree branches limited the length of boards that could be cut using a circular saw. Boards of less than three meters could only be sold to carpenters in Puerto Maldonado and yielded a low price of approximately US$ 0.57 per board foot, which discouraged the harvest of these parts when new trees were available. The greater flexibility of *castillos* allowed even curved tree branches to be cut into long boards and we learned that by doing so, the harvest could be increased by up to 60%. Disks were most commonly used in the visited logging camps. Three people were required to operate a circular saw: a *cortador*[31], a *carapero*[32] and an *aquatero*[33]. The circular saw was either set up at a strategic place inside the forest, in order to minimise the transportation distance of wood from the logged sites to the circular saw, or directly at the logged site. *Madereros*[34] who could afford to utilise several saws processed trees at different sites simultaneously and thereby increased the harvest. Those camps employed up to 12 people who were responsible for operating the saws. Only 7.6% of all camps utilised a tractor.

[29] timber personnel working with a chainsaw
[30] metal frame including two chainsaws that are connected via one chain and used to cut boards from felled trees
[31] timber personnel operating a castillo or circular saw
[32] an assistant to the *cortador*
[33] assistant responsible carrying water used for cooling the circular saw
[34] camp owners

Camp owners, on average earned the highest salary, followed by *cortadors* and *motosierristas*. Their salary depended on the number of trees cut, the time needed to transport the wood to the market, the market price and his expenditures, which explain the high variability in the data. Instead of a fixed salary, *motosierristas* and *cortadores* were commonly paid 10-15% of the value of the wood that they processed. The amount of wood gained from a certain tree heavily depended on the skills of the *cortador*. This form of payment aimed to encourage the personnel and maximise the benefit for the logger and camp owner.

Rumbiadores often worked independently, selling their information to *madereros* at a high price. Values recorded during the field period ranged from US$ 140 for a mahogany tree with 11.8m^3 to 20% of the wood, which corresponded to 2.4m^3 worth US$ 2,000 in Puerto Maldonado. However, they were frequently employed by *madereros*, in order to guide the other *obreros*[35] and search for more trees in the area. In this constellation they had a fixed salary of US$ 5.7 – 7.1 plus approximately US$ 57 for every new mahogany tree that they encountered.

The native community of Montesalvado consisted of 80 people that belonged to 10 families. Most male members worked in logging camps in the Las Piedras tributary San Franzisco and earned a standard salary of US$ 171 per month. The surplus gain from selling the timber was used for general purposes within the community and enabled them for example to install a light system that worked until 9:00 p.m.

Timber personnel worked six days a week, Sundays were used for resting, but were paid for seven days. While visiting the logging port Curiacu we encountered several groups of loggers who had been caught at the port for several weeks due to the low water level in the tributaries, preventing them from returning to their camps. During May the water level of the tributary Curiacu was not higher than 50cm at its mouth. While waiting at the port the loggers did not receive any payment and had to pay high prices for subsistence.

The only women encountered in timber camps were the camp cooks. They received a relatively low salary of approximately US$ 86 per month although their work started early in the morning and did not finish until late in the night. Prostitution was part of daily life. It was reported on several occasions that prostitutes either travelled independently from camp to camp or the camp's cook offered her body for approximately US$ 8.6 per night.

Table 7-6 Monthly salary (in Nuevo Soles) of loggers according to their working position

	N	Min.	Max.	Mean	StDev
Camp owner	9	500	5,000	1,966.7	1,468.8
Motosierrista	16	450	5,000	1,115.6	1,108.4
Cortador	24	500	5,000	1,172.9	1,103.1
Organiser	10	600	3,000	1,070.0	741.0
Rumbiador	7	600	1,000	714.3	157.4
Assistant	28	400	800	610.0	89.6
All tasks	3	500	750	616.7	125.8
Cook	1	300	300	300.0	0
Average	99	300	5,000	1,004.34	926.93

Demography of loggers

The average age of timber personnel in Las Piedras was 35.2 years. The *rumbiadores* and camp organisers on average were the oldest. Their work required most working experience, therefore camp owners rather relied on someone who had spent many years in the forest than a "newcomer". Interestingly, the average age of the camp owners was the second lowest and they had received the best education. None of the interviewed *rumbiadores* and organisers had attended a university. A fact obviously influenced by their higher age and the lower number of educational institutions in Puerto Maldonado in the past. The displayed information does not take into account the large number of young people who worked on a less formalised basis. We encountered several children (16 years and less) who worked *e.g.* for shops at the port of Curiacu or as assistants to *balseros*[36]. A twelve-year-old boy assisted a Brazil-nut collector for several months, since his parents could not afford to send him to school and worked themselves as loggers in Las Piedras. When the police prevented the loggers from passing Curiacu in August 2002 and hundreds of loggers had to stay upstream for several weeks we heard reports of fourteen-year-old prostitutes at the Curiacu port.

[35] loggers employed by a camp owner
[36] people specialised in transporting balsas from logging camps to the local market

Loggers could roughly be grouped into three groups according to their age and education. The a) experienced, relatively old and less educated *rumbiadores* and camp organisers, the b) relatively well educated medium aged *motosierristas*, *cortadores* and assistants, and c) the camp owners, who on average were younger and better educated than any of the other groups.

Table 7-7 Age and education of timber personnel according to their working position as stated by the interviewed loggers.

	Age of loggers					Education			
	N	Min.	Max.	Mean	StDev	N	Primary (%)	Secondary (%)	University (%)
Camp owner	9	19	51.0	32.0	0.42	10	0	60	40
Motosierrista	16	17	54	33.31	9.98	17	17.6	52.9	29.4
Cortador	21	18	59	36.19	10.66	25	0	80	20
Rumbiador	8	37	62	48.75	8.49	8	37.5	62.5	0
Organiser	8	24	48	41.50	7.76	10	10	90	0
Assistant	23	18	50	31.35	10.11	28	3.6	75	21.4
All tasks	0	---	---	---	---	3	33.3	33.3	33.3
Average	**88**	**17**	**62**	**35.22**	**11.09**	**103**	**8.7**	**69.9**	**21.4**

Today's loggers: caoba-rush or traditional family business

The majority (64.1%) of questioned timber personnel stated that their place of birth was in Madre de Dios. 15.3% of the people were born outside Madre de Dios but in similar areas, i.e. rainforest. People native to the Andes comprised 16.4% of all interviewees. 93% of all loggers lived in Puerto Maldonado at the time of the investigation.

Table 7-8 Place of birth and current address of the interviewees.

	Place of birth		Current address	
	Frequency	Percentage	Frequency	Percentage
Madre de Dios				
Puerto Maldonado	54	58.1	93	93
Tahumanu	4	4.3	0	0
Puerto Nuevo in LP	1	1.1	2	2.0
Montesalvado	0	0	5	5.0
Rainforest outside Madre de Dios				
Ucallaly	9	9.7	1	1.0
Iquitos	2	2.2	0	0
Andes				
Cusco	9	9.7	0	0
Arequipa	3	3.2	0	0
Puno	3	3.2	0	0
Quillabamba	2	2.2	0	0
Urubamba	1	1.1	0	0
Lima	3	3.2	0	0
Venezuela	1	1.1	0	0
Bolivia	1	1.1	0	0
Total	93	100	101	100

The period of time the interviewees had worked as loggers ranged from as few as one week to 30 years. The majority of loggers (52 %) had not worked in the logging industry for more than three years and 74.8% had not worked for more than eight years. 21% of the interviewees had been loggers for less than 1 year.

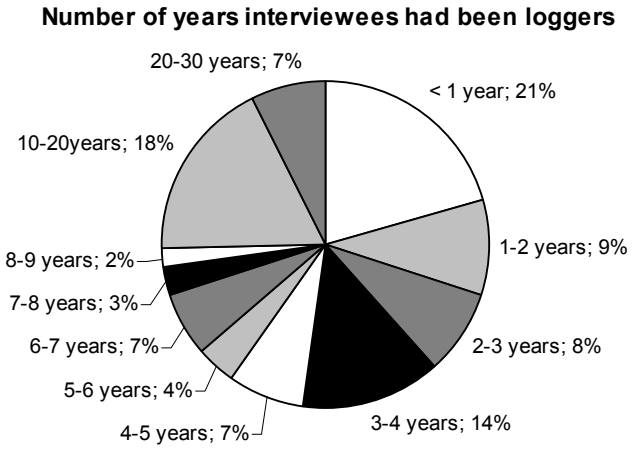
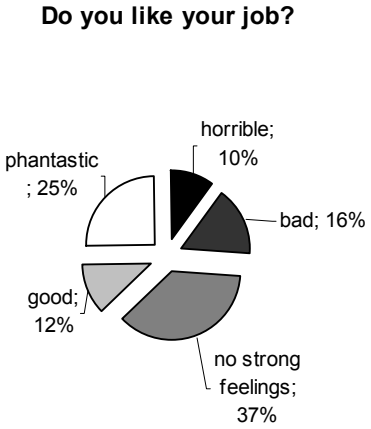


Figure 7-2 Percentage distribution of years interviewees had worked as loggers

Attitude towards their work

Do you like your job and do you want your son to become a logger?

The frequency distribution of the grouped statements, positive (fantastic & good), negative (horrible & bad) and no strong feelings was not substantially different, however with 37% of the interviewees stating a positive attitude and only 26% a negative attitude, there was a slight trend. When taking into account their vehement response towards the prospect of their sons becoming loggers, the lack of strong opinions concerning their own work was striking. The vast majority (84%) of timber personnel strongly objected the idea of their sons becoming loggers. Only a small fraction of 7% supported this idea.



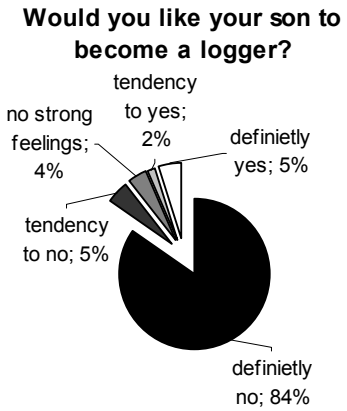


Figure 7-3 (left) The percentage distribution of interviewees statements regarding their attitude towards their job; N=96. **Figure 7-4** (right) The loggers response towards the prospect of their sons becoming loggers; N=94.

After the interviewees had stated their attitude towards their job, they were asked about the reasoning behind their statement. Multiple answers were allowed and recorded. A slim majority of the interviewees (51.8%) stated financial reasons for the positive evaluation of their job (19.4% high salary, 1.1% easy money, 23.7% the only paying work, 6.5% the most lucrative work and 1.1% stated that it was secure work), however only 2.1% complained about the low salary. The hard working conditions were criticised by 63.5% (39.8% work is very hard, 23.7% work is dangerous) of the loggers. Remarkably, only 9.7% stated that they liked the work. 1.1% said that it was family tradition. The loggers were well aware of the dangers of their work and many suffered under the intense physical work. Most interviewees lacked alternative job opportunities in the town and were lured into the forest by the prospect of high financial gain in short time.

When the interviewees were asked why they did not want their sons to become loggers, 83.5% stated that they wanted them to live a better life than their parents (56.2% to get a proper job, 12.0% to study at the University, 12.0% to become better than they were and 3.3% to serve society) and 29.3% explained their decision with the harshness and dangers of their work. Future problems with the government were stated by 3.3% of all interviewees. The only reason for becoming loggers was the good salary and was stated by 5.4%.

Interestingly, the interviewees argued differently when asked about their job and the future perspectives of their sons (see Figure 7-5). For most loggers their work was a dangerous necessity, which they had to do in order to support their family. Only one person explicitly stated that he was looking for a different job. They seemed to have got used to their situation and did not consider major changes in their lives. However, for their sons the situation was completely different. The vast majority of loggers did not want their sons to become a logger but to seek a proper job in the city. During not documented discussions with the loggers we learned that a general pessimistic atmosphere existed and most loggers anticipated changes in the land-use policies.

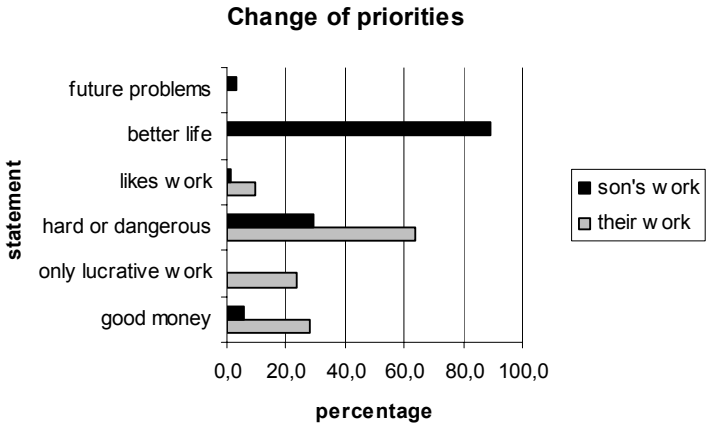


Figure 7-5 Displays the change in argumentation between justifying their statement regarding their own work and whether they wanted their sons to become loggers. The data was calculated after grouping of individual statements that showed similar intention, *e.g.* better life = sum of "become a professional", "study at university" and "have a better future".

Timber concessions

Considering the problems regarding the introduction of the concessions scheme in Madre de Dios, i.e. strike of the loggers, it was very surprising that 80.8% of all interviewed loggers confirmed that they considered working in a timber concession. This value was relatively constant between the different groups of loggers. Only the assistants and loggers with no specified work were less willing to work inside a concession. In general, these people had not worked for long periods in logging camps and many did not intend to stay for more than a few weeks or months, which would explain their "lack" of interest in timber concessions.

Table 7-9 Did loggers consider working inside timber concessions?
The answers are displayed according to the working position of the interviewees.

	N	Yes	Percentage
Camp owner	10	8	80
Motosierrista	17	15	88.20
Cortador	25	22	88.0
Rumbiador	8	7	87.5
Organiser	10	9	90
Assistant	27	19	70.4
All tasks	3	2	66.7
Average	**104**	**84**	**80.8**

Puerto Curiacu in May 2002

The port at the mouth of the Las Piedras tributary "Curiacu" was the centre of the timber trade in Las Piedras during the time of the investigation. We counted 15 temporary camps in which approximately 60 loggers stayed. New camps were set up on a daily basis and other taken down, as new loggers arrived and others left. We were told that the weekend before our arrival up to 100 loggers had been at the port to refresh their supplies in one of the seven shops (see

Table 7-10 for example prices). New wood arrived most of the days and balsas left frequently to Puerto Maldonado. An estimated amount of 118 m^3 of mahogany, worth US$ 100,000 on the market in Puerto Maldonado, was always piled up at the port. During the night the loggers gathered in front of the shops and watched TV or video films or spent the night drinking and dancing. The guide who accompanied B. Schulte-Herbrüggen actually complained about the loud music and that he could hardly sleep while at the port. A group of health workers set up their camp at the port for one day while travelling to the native community Montesalvado. They described the living conditions of the loggers as unacceptable and complained about their mis-use of antibiotics; due to the high price of medication loggers commonly did not take the full treatment but stopped after one or two doses, paving the way for the evolution of resistant bacteria. Two unconfirmed cases of malaria were reported.

Table 7-10 Selection of prices for the most commonly purchased goods at shops at the port of Curiacu

Item	Price	
Multi-pack of cigarettes (x10)	S/. 30.0	(US$ 8.57)
Beer 24x 0.33 litre	S/. 120.0	(US$ 34.29)
T-shirt	S/. 20.0	(US$ 5.71)
Beans (1kg)	S/. 5.0	(US$ 1.43)
Dry juice powder	S/. 1.5	(US$ 0.43)
Potatoes (1kg)	S/. 3.0	(US$ 0.86)
Milk powder for 0.5 litre	S/. 5.0	(US$ 1.43)
Oil (5 litre)	S/. 36.0	(US$ 10.29)
Canned tuna (x1)	S/. 3.0	(US$ 0.86)
Rice (50 kg)	S/. 150.0	(US$ 42.86)
Radio use (5 minutes)	S/. 3.0	(US$ 0.86)
Fuel (1 gallon)	S/. 12.0	(US$ 3.43)
1 tablet Ampicillin (antibiotics)	S/. 2.0	(US$ 0.57)
1 cartridge for a shotgun	S/. 3.0	(US$ 0.86)

Timber extraction in Las Piedras

In total, 1429 boats and 444 balsas were recorded. The estimated total amount of mahogany that floated down the Las Piedras river was 6,074.4 m^3, worth US$ 5,148,649.2 in Puerto Maldonado and US$ 6,985,543.4 on the US market.

Table 7-11 Extraction of mahogany in Las Piedras for May until September 2002. Gaps in the data set were filled by scaling up from the daily estimates.

	Boats	*Balsas*	*Mahogany (Cu. m)*	*Market value in Puerto Maldonado (US$)*	*Men*	*Women*	*Children*
May (observed 22 days)	186	70	784.6	665,000	806	83	45
daily average (observed)	8.5	3.2	35.7	30,227.3	36.6	3.8	2.0
extrapolated (31 days)	263.5	99.2	1,105.5	937046.3	1134.6	117.8	62
June (observed 21 days)	221	48	534.5	453,000	904	91	18
daily average (observed)	10.5	2.3	25.4	21,571.4	43.0	4.3	0.9
extrapolated (30 days)	315	69	763.5	647,133	1290	129	27
July (observed 25 days)	379	128	1,272.5	1,078,600	1700	200	96
daily average (observed)	15.2	5.1	50.9	43,144.0	68.0	8.0	3.8
extrapolated (31 days)	471.2	158.1	1,577.9	1,337,464.0	2108	248.0	117.8
August (observed 31 days)	346	91	857.7	727,000	1428	156	82
daily average (observed)	11.2	2.9	27.7	23,451.6	46.1	5.0	2.6
extrapolated (31 days)	346	91	857.7	727,000	1428	156	82
September (observed 19 days)	297	107	1,120.8	950,000	1230	129	59
daily average (observed)	15.6	5.6	59.0	50,000.0	64.7	6.8	3.1
extrapolated (30 days)	468	168	1,769.7	1,500,000	1,941	204	93
total (extrapolated)	**1863.7**	**585.3**	**6,074.4**	**5,148,643.3**	**7,901.6**	**854.8**	**381.8**
monthly average (extrapolated)	**372.7**	**117.1**	**1,214.9**	**1,029,728.7**	**1,580.3**	**171.0**	**76.4**
daily average (extrapolated)	**12.2**	**3.8**	**39.7**	**33,651.3**	**51.6**	**5.6**	**2.5**

The average amount of mahogany transported by one balsa was 10.4 m^3. We recorded 6068 men, 659 women and 300 children travelling on the Las Piedras river from May until September 2002. The strongest boat traffic was observed during July and September 2002. The underlying reasons for this pattern were due to the method of data collection and the political circumstances.

The data collection in May and June 2002 was carried out while travelling with a boat on the Las Piedras river during the interview study. The investigators travelled as far upstream as Alto Purus and therefore could not record the boats and balsas leaving from camps positioned further downstream, hence most traffic was not recorded and the presented results underestimate the real traffic. This geographical problem, inherent in the methodology continued during the mammal census period. During this time the observers were positioned in the lower reaches of the Las Piedras river (see Map 6-1), however, still beyond two tributaries (Pariamanu & Huasca), in which supposedly a great number of loggers worked.

Illegal loggers had entered two reserves for un-contacted Indians in the middle reaches ”Reserva del Estado para Indigenas en Aislamiento Voluntario” and upper reaches ”Zona Reservada Alto Purus” of the Las Piedras river. Police helicopter were recorded passing the project camp for the first time at the 13th of August. Police entered the forest with the objective of preventing loggers from passing the demarcation line (UTM 343 E) of the Indian reserve. Police were positioned at the native community of Montesalvado, which lies on the border to the reserve, approximately five days upstream from Puerto Maldonado, and the mouth of the tributary Curiacu, which flows in a westerly direction and therewith directly into the reserve. The police stopped all balsas from floating downstream, since timber extraction inside the reserve was illegal and it still had to be decided whether the wood would be confiscated. Interestingly, despite these drastic measures, the amount of mahogany that floated to Puerto Maldonado was still more than 50% of the July amounts. We were told that loggers could pass the police post at night for the price of US$ 57 per balsa with 4.7 m^3, worth US$ 4000 in Puerto Maldonado. The police left the control post in Las Piedras at the 20th of September for unknown reasons. The presented data are minimum estimates and the real extraction was likely to be higher for the above stated reasons.

Timber extraction in Las Piedras

87% of all interviewees stated that they would only harvest mahogany. Spanish cedre (*Cedrela odorata*) and mahogany were cut in 10% of the camps. Hence, mahogany was cut in 97% of all camps. The camps that harvested other species than mahogany and spanish cedre were found close to Puerto Maldonado, *e.g.* native community Luzerna, where the mahogany stands had already been depleted many years ago.

Table 7-12 Timber selection by loggers in Las Piedras.

	Frequency	Percentage
Mahogany	87	87
Mahogany & spanish cedre	10	10
Others	3	3
SUM	**100**	**100**

In total, 109.5 balsas left the investigated camps during the month prior to the interviews. Those balsas transported a total of 1108.4m^3 of mahogany and 28.1m^3 of spanish cedre to Puerto Maldonado. The extraction of spanish cedre represented 2.5% of the total timber extraction. On average 1.2 balsas were constructed per camp and month and transported 9.5m^3 of timber. For the above estimated total number of timber camps (231) the monthly extraction of mahogany summed up to 2587m^3 or US$ 2,192,910,7 on the market in Puerto Maldonado.

Table 7-13 Number of balsas and amount of wood leaving the investigated logging camps per month. N refers to the number of interviews collected that contain relevant information.

	N	Min.	Max.	Sum	Mean
Balsas	94	0	5	109.50	1.2
Mahogany (m^3)	99	0	51.9	1108.4	11.2
Spanish cedre (m^3)	98	0	7.1	28.1	0.3
Sum Mahogany & spanish cedre				**1136.5**	

An average amount of 4.7 m^3 per mahogany tree was commonly stated. Applying this number to the calculated amount of mahogany extracted in the 99 camps that stated to harvest mahogany, yielded a monthly harvest of 236 trees. Including the conservative figure of 50% (80% was often heard) for the trees felled but not processed due to rotten wood inside the tree resulted in a minimum monthly amount of 472 felled trees. For the estimated total number of 231 timber camps in Las Piedras this figure increased to 1101 trees per month.

Interestingly, when calculating the total number of timber camps in Las Piedras from the monthly estimates of mahogany floating to Puerto Maldonado and the calculated average number of balsa leaving one timber camp per month, the estimate did not match with the result obtained from the interview study. Even when choosing the highest recorded amount of mahogany floating towards Puerto Maldonado (September), the estimated number of timber camps did not exceed 158 although we earlier calculated a total number of timber camp of 231. Hence if the result obtained from the interview data were correct, we should have observed more mahogany floating downstream. We argue that the same reasons as stated above for the differences in monthly traffic on the Las Piedras river apply, in addition to extraction procedures characteristic to the timber harvest of selective logging in Madre de Dios. The data collection was carried out during the dry season and the tributaries, which we showed held most timber camps, did not have sufficient water levels for transporting balsas. Timber extraction that relies on the river for transportation of the wood has a seasonal pattern[37]. The dry season was not commonly used for transportation of timber to the market but for the felling of trees and preparation of boards in order to facilitate transportation during the wet season, when manoeuvre would be easier and safer on the river. We encountered camp owners who had approximately 89.3m^3 of mahogany lying cut in the forest, prepared for the first rising of the river.

[37] Eckersley 2003 & personal observation

A typical timber extraction process by pequenos madereos (summer 2002)

The following describes a commercial, highly selective timber extraction process by *pequenos madereros* in the Las Piedras river in 2002. The process was observed while visiting logging camps and the information regarding logging activity collected in semi-structured interviews and informal socialising with loggers and project guides. Although a different harvesting regime has been described by Proyecto Sepahua (Eckersley, *et al.* 2002), for the neighbouring department Ucayali, we assume, due to the large body of collected information the following description is based on, that this logging activity was representative for Las Piedras.

Along the Las Piedras river most logging camps were owned by *pequenos madereros*, who run a camp with on average eight people, without the help of large machinery, *e.g.* tractors. Some *madereros* owned more than one camp and very few loggers ran several large camps that automated the timber extraction by means of large tractors. The latter were likely to be connected to international timber companies.

Locating trees and preparing a trail system

The first step in the process of selective timber extraction is to locate the valuable trees, mainly mahogany. This information was commonly gathered prior to the arrival of the main working group by one or two *rumbiadores*. They were paid by a *maderero* to identify suitable sites for timber extraction, i.e. close to mahogany trees, that made the creation of a camp economically viable. A commonly heard minimum number was 10-15 trees. However *madereros* who were about to set up their first timber camp were likely to utilise as few as 2-3 trees, whereas "established" loggers would search for more profitable sites. Some *rumbiadores* worked independently and sold the information on suitable sites in Puerto Maldonado. Subsequently, they often continued working in the camp as a guide for the *obreros*, as well as continuing searching for more mahogany trees. If several trees were found a main trail was cut, which enabled fast transportation of the wood from the forest to the river. Smaller trails connected the main trail with the logged sites. Whereas the main trail was around three meters wide, the smaller trails were not wider than 1m, covering only the minimum area needed to walk with a large board on ones back.

The logging process

The trees were felled by a *motosierrista* using a chainsaw, commonly "Stihl 070", and the trunk cut into quarters along the centre line. These quarters were processed with a mobile circular saw or a castillo into boards. A circular saw consisted of a metal disk, approximately 1m in diameter, two metal rails with a wooden cart on top, and a peque-peque motor that drove the saw. Three to four people were necessary to run a saw: a *motosierrista* (who cut the trunk into quarters), a *cortador* (who was responsible for cutting the quarters into boards), a *carapero* (assisting the *cortador*) and a *aquatero* (who carried water from a tributary to cool the disk). The saws were expensive, costing around US$ 1000, and hard to move in steep terrain. Loggers who could not afford a saw or who worked in steep terrain used a *castillo*. A *castillo* consisted of a metal frame with two chainsaws attached to it. The two chainsaws powered one chain. In contrast to the saw it was cheaper, i.e. the chainsaws could be used for different work as well, were easier to transport and also cut the wood faster. However, since the width of the chain was greater than the width of the circular saw it had been declared illegal by INRENA. Wood cut by a circular saw had a different surface structure than wood cut by a *castillo*, which made them easy to distinguish and therefore hard to sell on the market in Puerto Maldonado. Loggers using a *castillo* had to process their wood in a sawmill in Puerto Maldonado (S/. 0.30 or US$ 0.09 per board foot), which smoothed the surface and made it indistinguishable from wood cut with a circular saw. This was an open secret and did not cause any problems.

Transportation of the wood to the market

Once the boards had been cut, they were transported to the river. If a tributary with sufficiently high water level was close to the logged site, the boards were carried to the stream and floated down to the main river. Great attention was necessary, since small streams were unpredictable and often rose more than a meter over night, washing away any wood lying on the river bank. In this case, the loggers had to try to catch it before it reached the main river and floated away. The losses were great and many people were injured when trying to secure the wood in a flood. If no tributary could be found, the wood was carried to the main river either on the loggers back or on a small wooden cart, which was pulled by the loggers. The maximum amount of wood that could be transported by the wooden cart was approximately 300 board feet. Due to the difficulties of

pulling a heavy cart up a steep hill and the associated dangers, carts were generally not used in steep terrain. In such a forest, heavy boards of up to 90kg were carried in rotation with light boards (40kg) along a chain of people with a distance of 100m in between them. This work continued for up to eight hours. However, this time varied since the eight hours of daily work included the time needed to walk in-between the camp and the logged site.

At the river, two to three *balseros* spent approximately one day to construct a balsa of 22.3 m^3 out of the boards. Chains and strong ropes were used to join the boards and stabilise the balsa while floating to Puerto Maldonado. Loggers who cut wood twelve days upstream (with 16 HP motor) the Las Piedras river from Puerto Maldonado, needed approximately 30 days to float their balsa to the town. Many of the encountered *pequenos madereros* said that they could not effort to pay *balseros* for transportation of the wood and tried to maximise their benefit by cutting as many trees as possible and sell the wood to shops along the river. The price per board foot at the mouth of Curiacu was US$ 1.0 and probably decreased with increasing distance from Puerto Maldonado, however no data is available to prove this. *Balseros* employed by the shop owners floated the wood to Puerto Maldonado where it was sold for US$ 2.0 per board foot. A simple calculation shows the benefit shop owners were able to gain during this high time of logging activity in Las Piedras. Let us assume that six people were needed for transporting a balsa of 5,000 board feet to the town. The journey from Curiacu to Puerto Maldonado was likely to take around ten days. A well-paid *balsero* earned US$ 11.4 per day plus US$ 4.3 per day for food. Fuel cost and uncertainty add US$ 571.4, including a "return ticket" to Curiacu. 11.8 m^3 of mahogany yielded US$ 10,000 in Puerto Maldonado minus the cost of purchase in Curiacu US$ 5,000 and the transportation US$ 1,231.4 leaving a benefit of US$ 3,768.6 for the shop owner.

Puerto Maldonado

Balsas that reached the port in Puerto Maldonado were deconstructed in the river into individual boards by *balseros* and *estibadores* and lifted with a crane to the port itself. *Estibadores* piled up the boards and presented them to potential customers. Once the wood had been bought, the boards were carried to a truck that transported the wood to Lima, from where it was sent by ship to the markets abroad.

7.2. The impact of logging activity and associated hunting on large diurnal mammals

Hunting associated to logging activity in Las Piedras

The total monthly harvest of bushmeat including mammals and birds in all 231 timber camps in Las Piedras was estimated as 4,414 animals or 41,282.7 kg. In terms of number of animals hunted, mammals and birds were equally strong impacted; mammals contributed 2,301 (52.4%) and birds 2,112 (47.6%) to the total harvest. However, the vast majority 37,349.0 (90.5%) of extracted biomass came from mammals and only a small percentage 3,933.7 (9.5%) was contributed by birds.

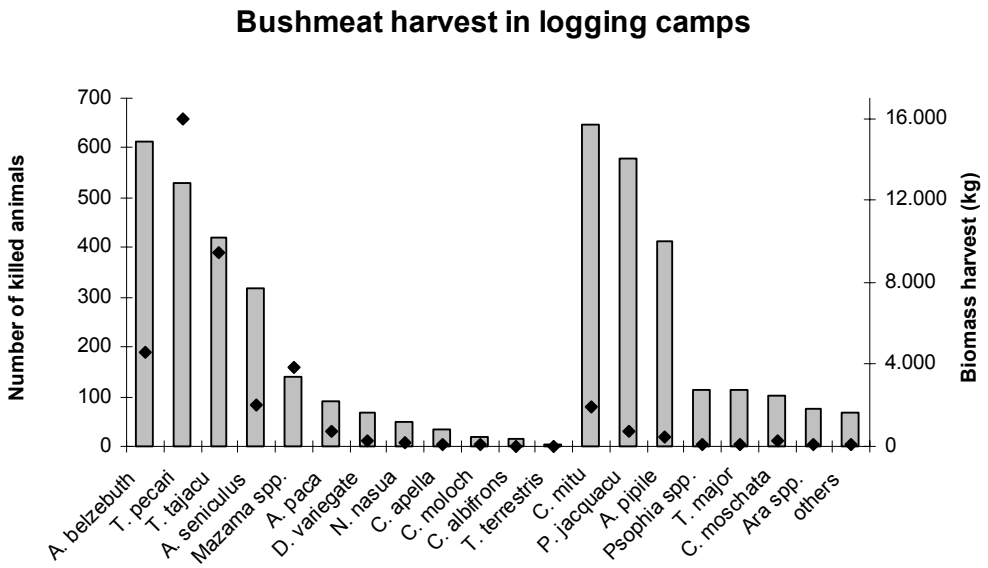


Figure 7-6 Number of killed mammals and birds (bars) and corresponding biomass harvest (dots) for a one month period and 231 timber camps. The species were grouped into mammals and birds and ranked according to the number of animals killed.

The investigated timber camps contributed 960 mammals or 15,872.1 kg. Each logger consumed 313.2 g of edible meat per day (Table 7-14). The hunted species were roughly allocated into two groups of different hunting pressure, separated by the bold line in Table 7-14. The most commonly hunted mammal species were *A. belzebuth* (254), followed by *T. pecari* (220), *T. tajacu* (177) and *A. seniculus* (132). They comprised 81.6% and 84.2% of the total harvest in terms of numbers of animals and biomass respectively. The species hunted with less intensity were led by *M. americana* (58). The greatest biomass harvest experienced *T. pecari* with 41.9% of the total harvest followed by *T. tajacu* with 25.1%.

Table 7-14 Mammals hunted in the investigated logging camps in Las Piedras during the 30 days prior to the interviews. The minimum and maximum data refer to the lowest and highest stated values respectively in any camp. The total hunted biomass, as calculated from the number of animals killed and their mean body mass, and the average amount of bushmeat consumed per logger per day are shown. The amount of fresh edible meat consumed was calculated using 0.5 as conversion factor[38]. The total number of loggers that worked in camps for which data is available was 841 for *A. seniculus* and *T. pecari* and 850 for the remaining.

Species	*N*	*Min.*	*Max.*	*Sum*	*Mean*	*Std. Dev*	*Mean body mass (kg)*	*Biomass harvest (kg)*	*Consumption per person per day (g)*
A. belzebuth	96	0	15	254	2.65	3.10	7.50	1,905.0	37.8
T. pecari	96	0	15	220	2.29	2.39	30.25	6,655.0	131.9
T. tajacu	97	0	10	177	1.82	1.92	22.50	3,982.5	78.1
A. seniculus	96	0	15	132	1.38	2.28	6.27	831.6	16.4
M. americana	96	0	5	58	0.60	0.95	28.05	1,626.9	31.9
A. paca	96	0	6	38	0.40	1.17	8.11	308.2	6.0
D. variegate	96	0	10	29	0.30	1.24	4.10	113.1	2.3
N. nasua	96	0	5	21	0.22	0.67	3.49	73.3	1.4
C. paella	96	0	10	15	0.16	1.05	3.05	44.3	0.9
C. brunneus	95	0	5	8	0.08	0.55	1.11	8.4	0.2
C. albifrons	96	0	5	6	0.06	0.52	2.36	14.7	0.3
T. terrestris	97	0	1	2	0.02	0.12	152.97	305.9	6.0
SUM				**960**				**15,872.1**	**313.2**

In addition to the above-described harvest of mammals, 887 birds were killed per month in the investigated logging camps. This was equivalent to 1,651.83 kg of biomass or 32.40 g of edible meat per person per day. *C. mitu*, *P. jacquacu* and *A. pipile* were most severely hunted and comprised 77.4% of all killed birds and 88.6% of the total biomass harvest. Extrapolation of this data for all logging camps in Las Piedras resulted in a monthly harvest of 2396 birds and 4461.6 kg biomass.

Table 7-15 Birds hunted in the investigated logging camps during the 30 days prior to the interview. The mean body mass for "others" was assumed to be equal to the mean of all other hunted species. Minimum, maximum and mean refer to individual interviews (camps), the sum refers to the total number of animals shot in all investigated camps. The standard deviation is given. The total number of loggers that worked in camps for which data is available was 849,72 for all species but "others". N refers to the number of interviews collected that contain relevant information.

Species	*N*	*Min.*	*Max.*	*Sum*	*Mean*	*Std. Dev*	*Mean body mass (kg)*	*Biomass harvest (kg)*	*Consumption per person per day (g)*
C. mitu	97	0	20	271	2.79	3.681	3.06	829.26	16.3
P. jacquacu	97	0	24	243	2.51	3.854	1.28	311.04	6.1
A. pipile	97	0	15	173	1.81	2.655	1.20	207.60	4.1
P. leucoptera	97	0	8	48	0.50	1.414	0.99	47.52	0.9
Tinamus spp.	97	0	8	48	0.50	1.205	1.17	56.16	1.1
C. moschata	97	0	15	43	0.44	1.656	3.00	129.00	2.5
Ara spp.	97	0	8	32	0.33	1.167	1.13	36.16	0.7
Others	53	0	10	29	0.55	1.916	1.21	35.09	0.7
SUM				**887**				**1,651.83**	**32.40**

[38] FAO 1996

Food preference

The most preferred mammal was *A. paca*. 74.12% of the interviewed timber personnel stated the species as one of the five tastiest mammals and of those, 75.5% ranked *A. paca* as the tastiest mammal of all. Other highly preferred mammals were *M. americana*, the two peccary species and *A. belzebuth*, all of which suffered under high hunting pressure (see Table 7-14). Interestingly *A. belzebuth* experienced the strongest harvest in numbers of animals of any of the species but was only the fifth most preferred species. The low number of *A. pacas* actually consumed in the logging camps was likely to be due to the species nocturnal activity. A total of 35% of the interviewed loggers voted *C. mitu* as the tastiest bird species. Other highly valued species were *A. pipile*, *P. jacquacu* and *T. major*. Of minor preference were for example *C. moschata* and *Ara* spp.. Most birds were prepared with soup and did not constitute a major contribution to the daily protein household.

Table 7-16 The preferred mammal and bird species in logging camps. The species were roughly allocated to ranked preference groups (group one being the most preferred) according to the number of times they were stated as one of the five tastiest mammal or three bird species. Species of the first group were further ranked according to the greatest percentage for any taste category (1-5, 1-3 for mammals and birds respectively, with 5 being the most preferred. In some timber camps a second person was interviewed regarding food preference, explaining the high number of collected interviews.

Ranked Category	*Species*	*N*	*% of times species were included in list of preferred animals*	*Most commonly stated preference category*
	Mammals			
	A. paca	143	74.12	5
	M. americana	143	69.23	4
1	*T. tajacu*	143	71.33	3
	T. pecari	143	63.63	2
	A. belzebuth	143	38.46	1
	D. novemcinctus	143	18.18	
2	*A. seniculus*	143	17.48	
	D. variegata	143	15.38	
	T. terrestris	143	11.2	
3	Remaining			
	Birds			
	C. mitu	143	65.03	5
1	*A. pipile*	143	53.85	5
	P. jacquacu	143	46.85	4
	Tinamus spp.	143	38.46	2
	C. moschata	143	10.5	
	Ara spp.	143	6.3	
2	*O. guttata*	143	1.4	
	C. undulatus	143	1,4	
	P. leucoptera	143	1.4	

The number of animals hunted was positively correlated with the species average body mass, however not significantly (Pearson Correlation: r=0.539, N=10, p=0.108 for mammals and r=0.333, N=8, p=0.420 for birds). The unfortunate distribution of adult weight in birds questioned any meaningful analysis. *T. terrestris* was excluded from this analysis since the low number of animals killed was most likely due to the species nocturnal activity, loggers rarely hunted, during the night, and not due to preference, which we tested here. Of the hunted mammals *Callicebus brunneus* (1.11kg) had the lowest body mass.

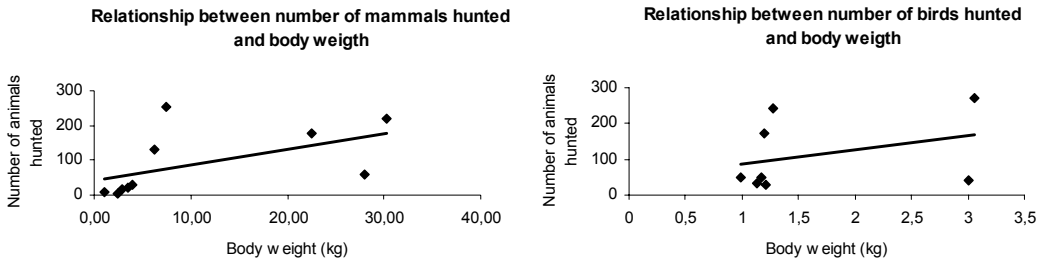


Figure 7-7 Number of mammals killed and **Figure 7-8** number of birds killed versus bodyweight.

Food preferences reflected hunting behaviour. Of the six most commonly hunted species five were stated as highly preferred (group one) and only one, *A. seniculus*, was grouped into the second preference group. The most preferred mammal, *A. paca*, was not frequently hunted, supposedly due to its nocturnal activity. The same observation was made for birds. All four species of preference group one were highly sought after by the loggers, as reflected in their harvest.

A typical hunt

Hunting in a logging camp with eight *obreros*, which was typical for Las Piedras in 2002, was a matter of opportunity encounters. Most kills occurred along the logging trail and rarely followed an active search in the forest. When animals were heard close to the trail the loggers entered the forest and the kill normally followed within minutes. Loggers concentrated on their work rather than the hunt.

Nearly all camps had at least one gun (shot gun), which was commonly carried by one of the loggers during the normal working hours. Larger camps (> 12 people) either had a professional hunter or a *rumbiador* who spent the day walking in the forest and searching for valuable trees and bushmeat. For loggers hunting on their own the animals weight and position of the encounter were crucial to the decision making, since, *e.g.* a *T. terrestris* with up to 250kg was basically to heavy for one person to carry. *T. pecari* with only 40kg were beheaded before carried to the camp. We were told that one person was rarely willing to carry a *T. pecari* for longer than one hour.

When the investigators stayed in a logging camp for two days, we were able to join a "hunt". A *P. jacquacu* was shot from the trail, 500m from where the loggers had cut a tree using noisy chainsaws only minutes earlier. This harvest was sufficient for a soup for five people that was served for dinner. Most camp owners said that they had no time for hunting and rather paid for expensive canned tuna than allocating one person for a day towards the hunt.

Mammal census

From the 15th of July until the 21st of September 2002, six transects were censused in order to investigate the development of mammal populations after the cessation of logging and associated hunting activity. Sampling effort on each transect varied from a minimum of 130 km (transect D) to a maximum of 232 km (transect E). Total effort was 1,104 km. A total of 27 mammal species were recorded, comprising six orders, Artiodactyla (4), Carnivora (6), Perissodactyla (1), Primates (9), Rodentia (4) and Xenarthra (3). The size-classes ranged from 0.22 kg (*S. ignitus*) to 153 kg (*T. terrestris*). The highest and lowest number of mammal species recorded (visual and auditory encounters, tracks & faeces) at any transect were 23 and 15 respectively (see chapter 14).

Relative abundance for individual species

The mean relative abundance of *A. belzebuth* was substantially higher (67.7%) at the not-active than at the active sites. The lowest abundance was recorded at the heavily impacted site B. The results suggested a strong impact of human activity on the species and gave evidence for recovery of the populations after cessation of the impact. Within treatment variation was large.

A clear trend was found for *A. seniculus*. The relative abundance of the species was 181.8% greater at the not active sites with none of the active sites reaching the abundances recorded at the not active sites. Within site variability was substantial with the maximum relative abundance at the not active sites being 172% greater than the smallest recorded abundance.

Of the three large primates, *C. apella* was the most frequently encountered species. The lowest number of encounters was recorded at the heavily impacted site B. The encounter frequency was 45% lower than at site C were the species was most frequently encountered. The average encounter rate was 11% higher at the not-active sites than at the active sites.

The average relative abundance of *C. albifrons* did not change substantially between the two treatments. The abundances at individual sites were highly variable with the lowest recorded number of animals at site F, which appeared to have suffered under less intense logging impact than other investigated sites (see chapter 6.2 for further information on the variation on logging history).

P. aequatoriales was not encountered at any of the active sites plus one not-active site. Where the species occurred, it was infrequently encountered compared with other primates.

C. brunneus occurred in higher relative abundance at the not-active sites than at the active sites, but was not encountered or heard at site D.

On average, *S. boliviensis* was encountered at active and not-active sites with the same frequency. However the within treatment variability was large and the high number of encounters at the active site B strongly increased the average value for the active sites. Hence no clear trend could be identified.

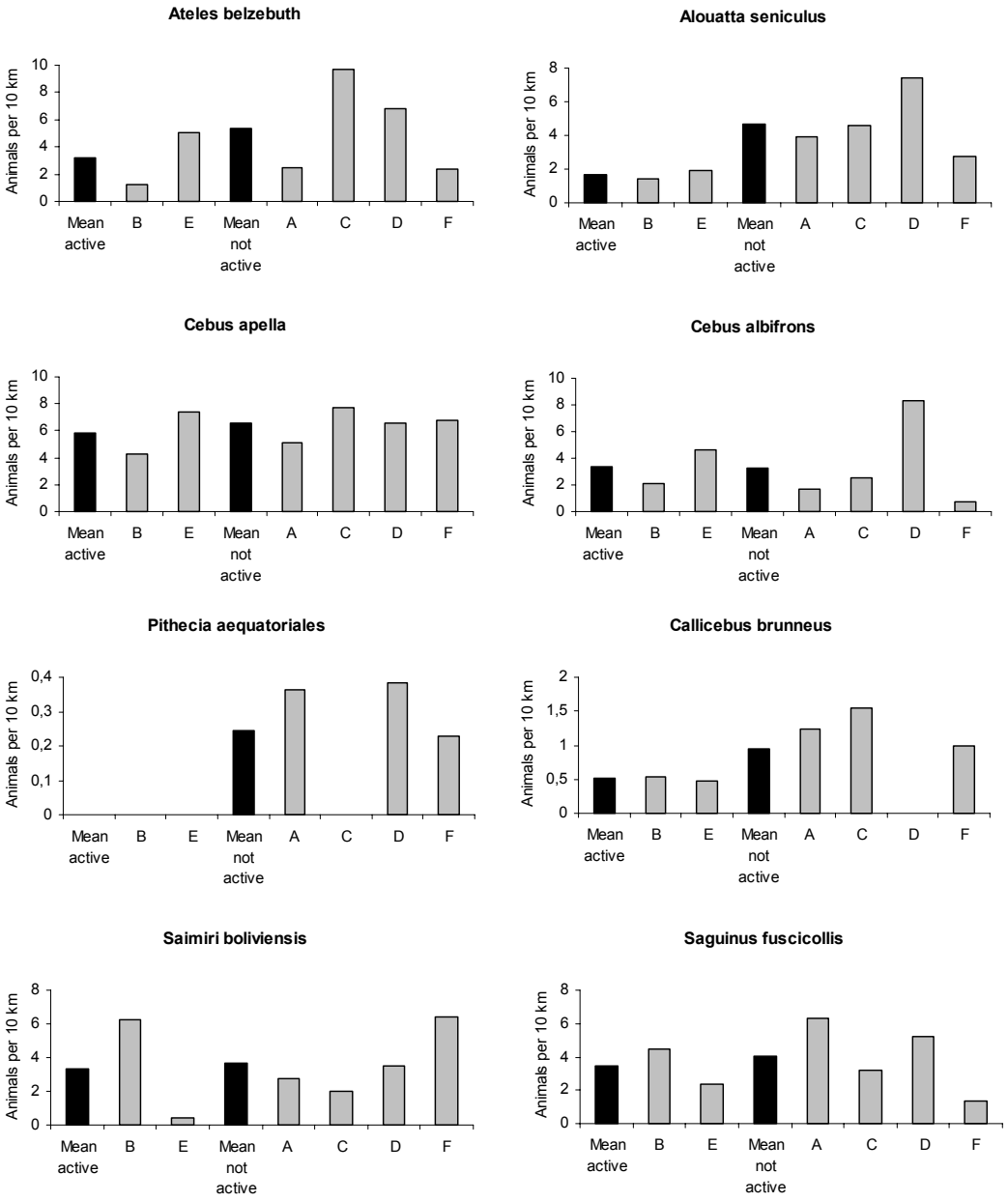


Figure 7-9 The development of mammal populations after cessation of human impact. Data are presented for eight primate species that were recorded during the mammal census. Black bars show the average relative abundance for each treatment and grey bars the data for individual sites.

M. americana was more frequently encountered than *M. gouazoubira*. None of the species were recorded at the active site E. *M. gouazoubira* was not recorded at the not-active site C. None of the species were encountered at site F but tracks were recorded. The mean abundances of both species were relatively low at all sites but increased substantially after cessation of the logging impact. The percentage increase in animal encounters between the active sites and the not-active sites was 188% for *M. gouazoubira* and 265% for *M. americana*. Due to the species shyness and vigilance, 0.155 and 0.076 animals per 10km walked could not be identified to the species level at site A and D, respectively, and were excluded from the analysis.

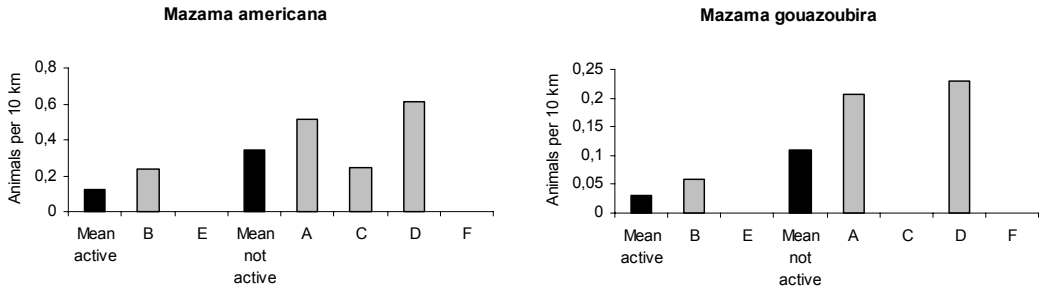


Figure 7-10 Relative abundance of censused deer species at sites logged and hunted during the time of the investigation and sites that had not been logged for at least three years.

T. tajacu and *T. pecari* both suffered from intense hunting pressure by the logging community. It was therefore interesting that both species showed declining relative abundance in the absence of loggers compared with the active sites. However, none of the species was extinct at any of the sites. Fresh tracks of *T. pecari* were recorded at site F. Large groups of 70 counted animals but with an estimated real number of up to 200, were encountered within of 2km of active logging camps.

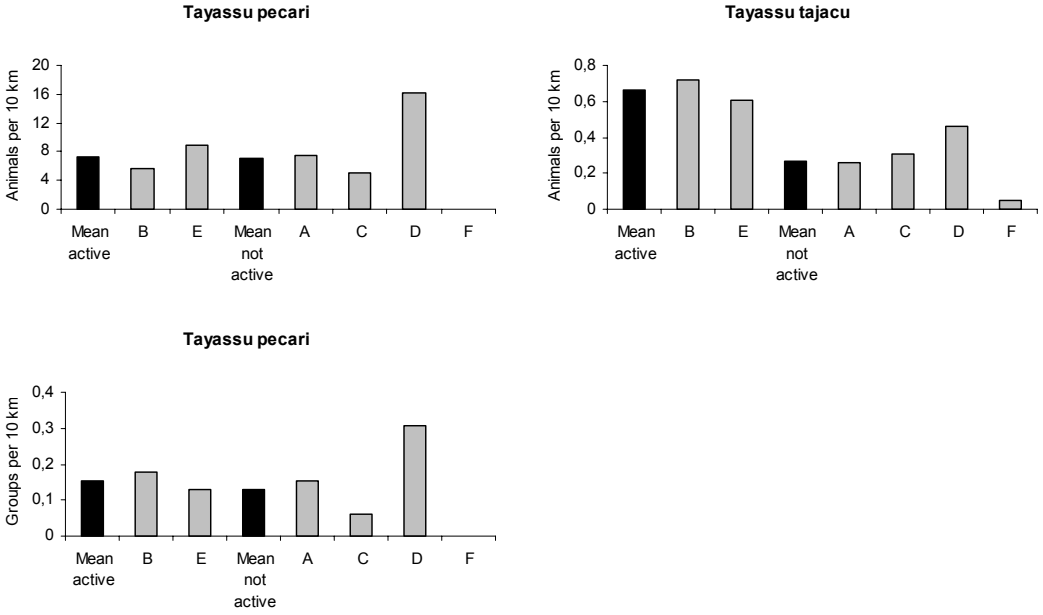


Figure 7-11 Shows the encounter rate per 10 walked km for *T. pecari* and *T. tajacu*. The large group size of *T. pecari* did not allow accurate counts and the number of encountered groups displays a more realistic picture.

The most frequently encountered rodent species were *S. pyrrhinus* and *D. variegata*. Both species occurred at higher mean abundances at the not-active sites. *S. ignitus* and *M. pratti* decreased after cessation of logging. *M. pratti* was the only species that was extinct at any of the sites.

S. pyrrhinus occurred at 120% and 240% greater relative abundance than *S. ignitus* at the active and not active sites respectively. *S. ignitus* increased slightly in abundance after cessation of the impact and *S. pyrrhinus* decreased slightly. None of the species showed a substantial response towards the change in land use.

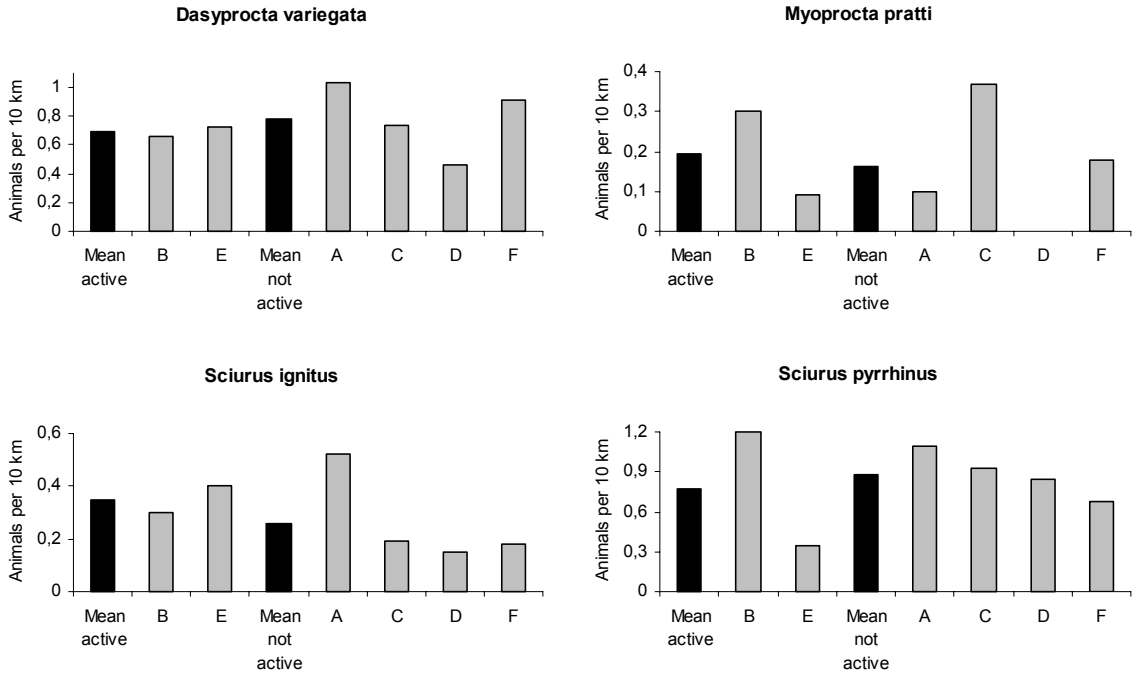


Figure 7-12 Relative abundance of censused rodents at sites logged and hunted during the time of the investigation and sites that had not been logged for at least three years.

We censused five bird species that were intensively hunted by timber personnel. All species were recorded with higher relative abundance at the not-active sites than at the active sites. *A. pipile* was the most infrequently encountered species, followed by *C. mitu*. Both were severely hunted by loggers (see above). However, *C. mitu* increased by 189% and *A. pipile* only by 10% in abundance after cessation of the human impact. Both were locally extinct or close to extinction at least one site. *P. jacquacu* was the second most hunted species but could easily sustain the high hunting pressure. Besides trumpeters (site F), none of the species was extinct at any of the sites; *C. mitu* was not encountered but heard at site F.

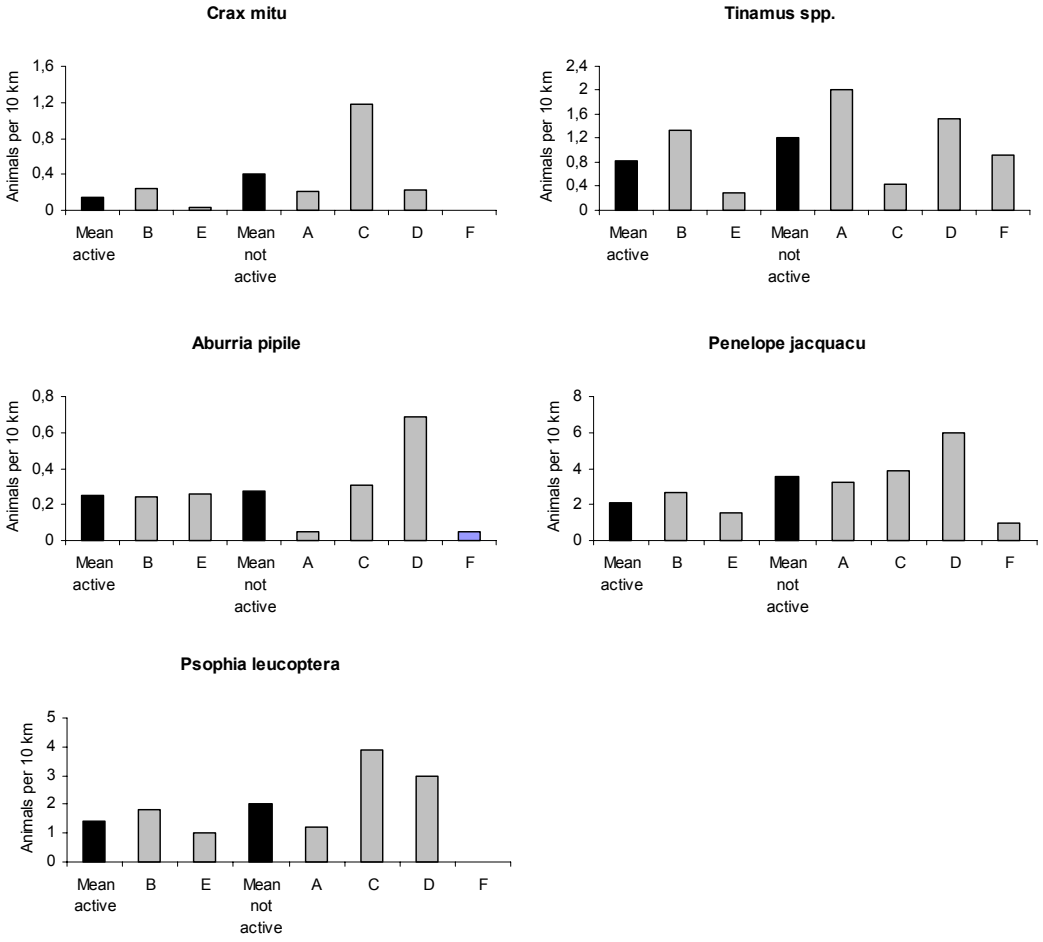


Figure 7-13 The relative abundance of five bird species in the study area is displayed.

Biomass allocation in mammal community

Mammals with more than 3000g bodyweight comprised 95.5% of the total biomass at the active sites and 96.7% at the not-active sites. *T. pecari* was the most abundant species and contributed more than 70% of the total biomass of the mammal community. However, when excluding *T. pecari* from the analysis large mammals still comprised 84.5% and 88.2% at the active and not actives sites, respectively, of the total community biomass. Due to the large herd-size of *T. pecari* we were not able to record the exact number of animals. We assume that the proportion of the total biomass was even higher than displayed in this report. The second most important species in terms of biomass contribution at the active sites was *A. belzebuth* (7.6%, when *T. pecari* was included), followed by *C. apella* (5.5%) and *T. tayacu* (4.7%). *C. albifrons* was one of the most abundant species at the active sites and gained due to its relatively high body mass (2450 g) the dominant position in terms of biomass in the group of small mammals.

8. Discussion

8.1. The Impact

The most urgent question that arose by the sight of hundreds of loggers passing our camp was concerned with their impact on indigenous people and the environment.

Indians

Native communities in Las Piedras suffered devastating impacts after encounters with oil prospectors in 1999, which caused the death of approximately 100 Indians[39]. The death was caused by ordinary flu which our immune system so easily copes with but is potentially lethal to the Indians. An increasing number of sightings of Indians at the border to Brazil in early 2002 gave rise to speculations about illegal loggers invading the territories of the Indians[40]. However, this could not be confirmed until direct observations were presented. Our data clearly showed that illegal loggers had invaded the reserves for Indians in Las Piedras and were still present when this report was written[41]. Close contact is required by most diseases for transmission but most interviewees stated that they had seen Indians at great distance or stumbled over them while searching for bushmeat. Most loggers fled at the sight of Indians. Due to the fact that we did not enter tributaries, where most encounters had occurred, our estimates are far from precise and present only an idea of the potential danger of current land use.

Environment

Forest structure

The impact of illegal logging activity on the environment was manifold. The vast majority of logging camps in Las Piedras consisted of a handful of loggers who did not use large machinery for their work but relied on their own body strength. To our knowledge this type of timber harvest has so far not been described in the scientific literature. The existing publications[42] concentrated on the impact of timber concessions that use large machinery and are less selective, i.e. extract more trees per area. Although we did not evaluate the impact of the observed timber extraction in a quantitative manner, direct observations at the sites and discussions with loggers suggest that the impact on forest structure was less than it has been described in the literature for other sites. Due to the highly selective harvest of mahogany and the naturally low density of the tree species[43] the number of impacted sites was relatively low. The trail system connecting the sites was kept to a minimum size (see page 27), in order to save resources, and was commonly overgrown by regenerating vegetation within of three years. However, since the species is distributed very patchily and no "reduced impact logging" techniques were applied the impact on a small scale was potentially large[44].

Mahogany

S. macrophylla has suffered from immense logging pressure during the last decades and is now commercially extinct in most of its range due to unsustainable logging practices[45]. After years of battles between range countries and conservation organisations, the species was included in CITES appendix II[46] in November 2002. Natural regeneration of mahogany requires environmental conditions that result from rare large-scale disturbances, such as hurricanes, fires or flooding[47]. The gaps in the forest canopy caused by selective logging are not considered sufficient for successful natural regeneration of the logged species, leading to their local extinction in most impacted forests[48].

[39] Survival International: http://www.survival-international.org/yoraup0901.htm
[40] Alfredo Garcia Altamirano, TReeS, personal communication
[41] Andres Vera, logger, personal communication
[42] *e.g.* Chapman *et al*. 2000, Thiollay 1997, Uhl *et al*. 1989, Verissimo *et al*. 1995
[43] 0.1-0.3 trees per ha with a patchy distribution (CITES 2002, Gullison *et al.* 1996, Zimmerman *et al*. 2001)
[44] Pereira *et al*. 2002 & Pinard *et al.* 1996
[45] UNEP-WCMC 2000
[46] The Convention on International Trade in Endangered Species of Wild Fauna and Flora
[47] *e.g.* Snook 1993, Balée and Campbell 1990 & Gullison *et al.* 1996
[48] Verissimo *et al.* 1995

The high logging pressure depleted local populations and forced loggers to search for trees deeper in the forest or further upstream, where mahogany could still be found close to the river. The enormous profit margins of mahogany extraction enabled loggers to enter remote pristine forests and work as far as fifteen days upstream, resulting in transportation times to the local market of 30 days. It therefore does not surprise that Peru's mahogany export had increased by more than 400% between 1997 and 2001. However, the mahogany populations are not likely to sustain such high harvest levels and will be exhausted in the near future. In 1996, Bolivia was one of the major exporters of mahogany but the populations were depleted with such severity that the export in 2000 represented hardly 8% of the former trade[49]. Peru's timber industry will face the same fate, unless immediate action is taken.

Wildlife

The strong impact of subsistence hunting by native communities on wildlife has been widely documented[50]. It has been shown that the selective extraction of large mammals causes local extinction of their populations and an inversion of mammalian biomass. Although the investigated mammal communities had faced severe hunting for prolonged periods, none of these dramatic consequences could be observed in this study. Two reasons were likely to be responsible for this result. First, failure of the experimental design to capture the impact and second the impact caused by loggers was sufficiently different from native communities that the above development did not occur.

Experimental design

The highest uncertainty included in the treatment allocation was caused by the lack of exact knowledge about the land-use history, i.e. period and scale of impact. No information was available about the presence of illegal loggers along the river from official sides, such as INRENA. All information had to be obtained directly from loggers and relied on their ability to remember events that happened several years ago and which they did not consider as important at that time. In addition, hunting was only one of the factors influencing mammal communities. Habitat alteration due to logging has been shown to have a pronounced impact on mammal communities[51]. Stevenson (2001) found that fruit production was positively related to primate biomass and since not all transects were censused simultaneously, we cannot rule out the possibility of real changes in mammal communities due to environmental variables and not the human impact. A higher number of replicated sites would certainly have resulted in stronger results and due to the high degree of within treatment variation, might even have led to different conclusions.

Difference in hunting behaviour

The observed bushmeat harvest per person per day was comparable with native communities in Peru and Brazil[52], however the actual number of hunted mammal species was lower. Apart from *A. belzebuth* all primates were of low food preference. Although, *C. apella* was commonly one of the most hunted mammals in native communities[53], it was of minor importance in the harvest of loggers. Even more obvious were the different preferences for *H. hydrochaeris*, which was commonly harvested by natives but very rarely by loggers who basically did not like the meat. Most authors have described the harvest of *T. terrestris* as unsustainable[54] but few loggers had hunted the species frequently, due to the species nocturnal activity. Six mammal species showed a strong decline at the active sites, of which four (*A. belzebuth*, *A. seniculus* and both *Mazama* species) suffered under high hunting pressure, *C. brunneus* was only slightly hunted and *P. aequatoriales* appears to have a patchy distribution[55] and was absent from many sites.

The results support the statement that loggers have a pronounced impact on bird species. *C. mitu* was the most intensively hunted bird and the low number of animals recorded at the active sites, suggested that the species was overharvested. Interesting, *A. pipile* did not show any difference in population abundances between the two treatments although the species was highly sought after by the loggers as well. The results stay in sharp contrast to results presented by *e.g.* Begazo and Bodmer (1998). They recorded an increase in

[49] Robbins 2000
[50] *e.g.* Bodmer 1997, Peres 2000 & Robinson 2000
[51] Chapman 2000
[52] Alvard *et al.* 1996 & Souza-Mazurek 2000
[53] Peres 2000
[54] *e.g.* Cullen 2001 & Peres 2000
[55] Emmons *et al.* 1999

the density of cracids from the protected areas to the moderately hunted areas and a tenfold decrease from protected sites to heavily hunted sites.

A stunning result was the development of the two *Tayassu* species, which both declined after cessation of the human impact, despite the fact that they belonged to the most severely hunted species. Due to the high food preference of *T. pecari* and the ease with which the species could be hunted in large numbers, the species has been reported to decline under high hunting pressure and has frequently been recorded as locally extinct at sites with high hunting pressure[56]. The difference between the active and not active sites observed in this study was supposedly not due to the actual human impact but to natural changes, i.e. migration. Unlikely alternative explanations are a high impact of hunters at the sites during temporary visits after cessation of logging activity and the long lasting alteration of forest structure and food availability due to logging (see Chapman, 2000). Taking into account that *T. pecari* was severely hunted but recorded at all sites in large numbers, the data suggests that the populations had not suffered for a long time period under today's high hunting pressure. In fact, Las Piedras had hardly experienced any loggers or hunters before 1990 and the majority of people entered the river approximately three years ago. Despite the low reproductive potential of large mammals, the populations of prime game species strongly increased after cessation of hunting, suggesting immigration of animals from source areas. Primates are considered good dispersers and able to cover large distances[57]. Unfortunately, it was not possible to compare our results with sighting data from pristine sites in Madre de Dios, in order to assess the recovery status of the mammal populations, since forest ecology and therefore mammal communities at different rivers was likely to be substantially different.

Our results suggest that logging and associated subsistence hunting had a strong impact on large mammals and birds. However, few species could not recover after cessation of the human impact, *i.e. C. mitu*. It appeared that source populations had remained relatively healthy and that highly selective manual logging activity had not led to fragmentation of the forest.

8.2. Future

Timber concessions and maintenance of selective logging activity are not a realistic option in Neotropical rainforests with their naturally low density of high value timber species[58]. The example of mahogany has shown that the most valuable tree species are quickly driven to extinction and the timber harvest has to be expanded to several other species of lower value in order to become economically viable. Less selective logging however, relies on the use of heavy machinery, *i.e.* tractors, and results in large scale destruction of the forest[59]. Subsistence hunting in combination with logging, *i.e.* habitat fragmentation, potentially poses a greater threat to mammal populations than hunting alone[60]. The impact of hunting is emphasised in fragmented areas, due to the disruption of metapopulation dynamics. Destruction of forests crucial to the persistence of migration routes from source to sink areas prevent the refreshing of depleted populations[61]. We showed that small scale logging has a large impact on the mammal communities but also that recovery of the mammal populations is possible if the overall impact on the forest ecosystem is low and relatively short in duration.

Although, the allocation of timber concessions in Madre de Dios represented a major step towards the managed use of the forest, it does not necessarily imply its sustainable use. In fact, the impact of human land-use is likely to increase substantially in the future. We observed that the amount of wood harvested and the distance from the river at which trees were felled, were limited by the transportation time of the wood. Tractors accelerate this working step and enable the processing of more wood, which in turn requires more personnel and therewith increases the demand for bushmeat. The typical hunting pattern of opportunity encounters[62] will not provide sufficient harvest for a large number of people working in a small area, hence professional hunters will be employed, searching the forest continuously for bushmeat. The width of logging trails was not greater than 2m, however, we observed tractor trails of up to 10m, significantly increasing the impacted area of the forest. The greater habitat disturbance resulting from less selective timber extraction,

[56] Peres 1996 & Cullen 2001
[57] Novaro *et al.* 2000
[58] Pearce *et al.* 2003
[59] Jackson *et al.* 2002 & Uhl *et al.* 1989
[60] Robinson *et al.* 1999
[61] Novaro *et al.* 2000 & Peres 2001
[62] see hunting study for more details

leads to alteration of the distribution of fruiting trees and, indirectly, the biomass of mammals that the forest can support[63].

Management plans are a prerequisite for maintaining the high biodiversity of the area. Management plans are in preparation but they have, to our knowledge, not yet acknowledged the impact of timber extraction on the fauna. Due to the widely reported devastating impact of subsistence hunting and the reinforcing effect of habitat fragmentation, we conclude by highlighting the urgent need for a monitoring scheme into the impact of timber concessions on wildlife, which a) acknowledges the seasonal and inter-annual natural variation of mammal communities in tropical forests, b) includes control sites c) includes intense interviews with timber personnel concerning their hunting behaviour, d) is conducted in cooperation with concessionaires and is implemented directly into wildlife policy.

[63] Johns 1988 & Stevenson 2001

9. Acknowledgements

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We are grateful to INRENA for their assistance in attaining the research permission and FENAMAD for the permission to enter the native community Montesalvado.

We want to thank the following people for supporting us, without whom, this project could not have been carried out: Ann-Charlotte Bergman, Giovanna Espino Delgado and Renan C. Valega Rosas (Amazon Conservation Association), Gustavo Suarez de Freitas and Jessica Espinoza (INRENA), John Forrest (TReeS-UK & Anglo Peruvian Society), Alfredo Manuel Garcia Altamirano (TReeS-Peru), Prof. John Grace (University of Edinburgh), Laurel Hannah (Picaflor Research Center), Emma Hume and Juan Julio Durand (Tambopata Expeditions), Chris Kirkby (TReeS), Colin Legg (University of Edinburgh), Lewis (the internet man), Wilsons Miranda (FEPEFMAD), Helen Newing (University of Kent & TReeS), Ernesto Raez-Luna, Juan Loja and Cesar Ascorra (Conservation International Peru), Favio Rios (ProNaturaleza), Philip Wadge and Pepe Moscosso (Jungle Odyssey), Graham Russel (University of Edinburgh), Salvation Army in Jönköping and in Lima and especially Gerd Dahlin-Öberg, Ulla Dahlquist and Joakim Storck, Holger Thiel (webmaster), Claudia Torres and family, Victor Velasquez (UNAMAD), Sandra Vera, Dr Wolfgang Weber (University Hospital Bielefeld), Katrin Wünsch (German Embassy, Lima) and last but definitely not least our friends and families for encouragement and patience.

10. The Research Team

Björn Schulte-Herbrüggen (Project Co-ordinator), 27 years, German
Björn has a BSc (Hons) in Ecology from the University of Edinburgh. Prior to the field study Björn spent four months in Madre de Dios organising the project logistics and cementing contacts with NGOs and loggers. He previously gained extensive experience in mammal censusing techniques during field work in Europe and is experienced in experimental design.

Marcos Manuel Maguiña Paredes, 26 years, Peruvian
Marcos recently graduated with a BSc course in Biology from the University Peruana Cayetano Heredia in Lima (Peru) and is currently enrolled in Veterinary Medicine at the same university. He will participate in Forest Future 2003.

Helfrid Rossiter (Medical Officer), 23 years, British-Swedish
Helfrid is a 3rd year undergraduate student of environmental chemistry at the University of Edinburgh. She participated the Royal Geographical Society (RGS) course in "Wilderness Medicine" prior to this study and prepared herself intensively for her task as medical officer with the help of Wolfgang Kaymer (University Hospital Bielefeld). Her experience regarding group dynamics gained while leading youth camps for the Salvation Army proved to be invaluable during the course of the field period.

Guillermo Martin Montoya Mordes, 26 years, Peruvian
Guillermo graduated from his 4th year of Biology at the Universidad Peruana Cayetano Heredia in Lima (Peru). He has participated in many research projects in a variety of fields throughout Peru. He is specialized in marine fish ecology and fishery management and is looking forward to undertaking a Master degree in marine biology.

Jake Charles Dunn, 22 years, British
Jake is currently enrolled as a 4th year student of Zoology at the University of Edinburgh. He has volunteered for many years at the "Monkey House" of the Twycross Zoo and is familiar with Neotropical mammals.

Patricia Teresa Salizar Vasquez, 28 years, Peruvian
Patricia is currently finishing her BSc course in Biology at the National University Mayor de San Marcos, in Lima (Peru). She has worked as a research assistant at the marine biology station in Paracass National Reserve, Peru, where she gained extensive experience in scientific data collection, including line-transect methodology. She is looking forward to undertaking a Master degree in Marine Biology.

Tina Mills, 26 years, British-German
Tina is a 4th year undergraduate student of Wildlife Management at the University of Edinburgh. She has previously worked as a tourist guide in Venezuela and through this gained valuable experience of working with the local communities.

Margarita Medina Müller, 25 years, Peruvian
Margarita has finished her 4th year in Biology at the University Agraria La Molina, in Lima (Peru). Her interest in amphibians has led her to conduct fieldwork with her university and INRENA (Department of Environment, Peru) in the Peruvian rainforest.

Victor Berris, 23 years, Peruvian
Victor Berris is a 3rd year forestry student at the University Nacional San Antonio Abad del Cuzco in Puerto Maldonado. He has volunteered in several field projects managed by Conservation International in Madre de Dios and has proved his capacity by independently undertaking the interviews for the market study.

Nek Yuri Monroy Huarcaya, 23 years, Peruvian
Nek is a 3rd year forestry student at the University Nacional San Antonio Abad del Cuzco in Puerto Maldonado. He shared responsibility for the market study with Victor.

Julio Canaciri, 45 years, Peruvian
Julio has worked for many years in logging industry in Madre de Dios but decided to start a university degree in forestry. He finished at the University of Puerto Maldonado in 2002 and is looking forward to gaining further field experience in scientific data collection. Project Las Piedras was a good start.

Local guides
Andres Vera, 43 years, Peruvian
Andres has worked for more than 20 years in logging and gold mining camps in Peru and Bolivia. He has gained experience in scientific data collection whilst participating in ecological projects in Madre de Dios, *e.g.* Project Tambopata (Kirkby *et al.* 2000). His experience, enthusiasm and friendship with many of the loggers encountered was invaluable during the data collection.

Orlando Javier Pacaya Alvarez, 34 years, Peruvian
Javier is a native of the San Jacinto community, situated close to Puerto Maldonado. He is primary school teacher without employment, since he did not have enough money to finish his degree. At the moment he works as a part-time artisan, fisherman and logger. We could not have done without his expert eyes when it came to spotting animals during transect walking.

Manuel R. Yumbato, 40 years, Peruvian
Manuel has worked all his life in mining and logging camps in Madre de Dios. However, during the last few years he has become involved in guiding visiting biologists and specialist groups, *e.g.* photographers of the National Geographic, and conservation work. He has participated in a variety of field projects for organisations such as the Amazon Conservation Association and TReeS.

Victor Yumbato, 52 years, Peruvian
Victor is Manuel's brother and shares a similar career history with him. He is often employed as a boat driver for tourist lodges and works as a logger when no other job can be found.

Trail cutters
Rudolfo Rolin, Lewis Rolin and Fernando Belinda have been loggers for many years. Currently, they work in the port of Puerto Maldonado and on their farms. They are in general always available for new jobs.

Medical advisor
Wolfgang Kaymer: Mr Kaymer is consultant at the University Hospital of Bielefeld (Germany) and lecturer at the University of Bielefeld. He has conducted expeditions to Africa and Europe and gained invaluable experience in wilderness medical skills, which we discussed in full detail with him prior to our departure.

11. Glossary

- Aquatero: assistant in timber camp who is responsible carrying water used for cooling the disk
- Asseradero: circular saw used by loggers to cut tree trunks into boards
- Balseros: people specialised in transporting balsas from logging camps to the local market
- Carapero: assistant in the logging camp, who carries away the waste wood and helps the aquatero.
- Cargadores: assistants in timber camps employed for carrying boards from logged sites to the river
- Castanero: person who collects brazil-nuts in the forest
- Chacra: an area of agricultural cultivation that can vary greatly in size from a small allotment to a large field, and which can be used for subsistence and/or commercial purposes.
- Concessions: the legal right to, and the physical land owned under the New Forestry Law.
- Cortador: timber personnel operating a castillo or circular saw
- Disk: see asseradero
- Estibadores: people working at the port in Puerto Maldonado. Their tasks involve piling up timber boards that arrived at the port and present them to potential customers.
- INRENA: the Institute of Natural Resources in Peru. (www.inrena.gob.pe)
- Madereros: camp owner and people who employ obreros
- New Forestry Law - No 27308: the new contractual system of forest management implemented in the year 2000.
- NGO: Non-Governmental Organisation.
- Obreros: general 'workers'.
- Pequenos madereros: refers to loggers working on a small scale without any large machinery
- Peke-peke: boat motor with 16HP, most common method of transport in the Peruvian Amazon. Its advantages are the relatively low price (US$ 1,000), it can be used in shallow water and extreme durability. The name refers to the noise of the motor.
- Board foot: A measurement of commercial timber measuring a foot by a foot by an inch. There are 423.8 board feet in one cubic metre of wood.
- Quebrada: a small river tributary by which logs are transported.
- Rumbiador: men who are sent out to scout for commercially valuable trees esp. mahogany.
- TReeS: Tambopta Reserve Society. Local NGO aiming to promote conservation in the Tambopata region. www.geocities.com/treesweb
- WWF: The World Wildlife Fund (North American Conservation NGO). www.wwfperu.org.pe

12. Species list

Scientific name	Common name (English)	Common name (Spanish)
MAMMALS		
Agouti paca	paca	Picuro
Alouatta seniculus	howler monkey	Coto
Ateles belzebuth	long haired spider monkey	Maquisapa
Atelocynus microtis	short-eared dog	
Bradypus variegatus	Brown-throated three-toed sloth	
Callicebus moloch	dusky tit monkey	Tocon
Cebus albifrons	white capuchin monkey	Mono blanco
Cebus apella	brown capuchin monkey	Mono negro
Dasypus novemcinctus	nine-banded long-nosed armadillo	Carachupa
Dasyprocta variegata	brown agouti	Anuje
Eira barbara	tayra	Perro de monte
Hydrochaeris hydrochaeris	capybara	Ronsoco
Leopardus pardalis	ocelot	Tigrillo
Mazama americana	red brocket deer	Venado colorado
Mazama gouazoubira	grey brocket deer	Venado
Myoprocta pratti	green acouchy	Punchana
Nasua nasua	south american coati	Achuni
Panthera onca	jaguar	Jaguar/tigre
Pithecia aequatorialis	equatorial saki monkey	Huapo negro
Pteronura brasiliensis	giant river otter	Lobo del rio
Puma concolor	puma	
Saguinus fuscicollis	saddleback tamarin	Pichico
Saimiri boliviensis	squirrel monkey	Frailecito
Sciurus ignitus	bolivian squirrel	Ardilla gris
Sciurus pyrrhinus	junin red squirrel	Ardilla rojy
Speothos venaticus	bush dog	
Tamandua tetradactyla	southern tamandua	Tamandua
Tapirus terrestris	brazilian tapir	Sacha vaca
Tayassu pecari	white lipped peccary	Huangana
Tayassu tajacu	collared peccary	Sajino
BIRDS		
Aburria pipile	piping guan	Pava campania
Ara spp.	macaw	
Crax mitu (*Mitu tuberosa*)	razor billed curassow	Paujil
Penelope jacquacu	spix's guan	Pava pucacunga
Tinamus major	tinamou	Perdiz
Cairina moschata	muscovy duck	Pato de monte
Psophia leucoptera	pale-winged trumpeter	trompetero
Crypturellus undulatus	undulated tinamou	panguana
Geochelone spp.	tortoise	Motello
Ortalis [motmot] guttata	speckled chachalaca	Manacaraco
PLANTS		
Swietenia macrophylla	bigleaf mahogany	Caoba
Cedrela odorata	spanish cedar	Cedro
Cedrelinga catenaeformis		Tornillo

13. Raw data - mammal census

Table 13-1 Observations along the six transects: First row shows the total number of group encounters. the second row shows the number of group encounters per 10 walked kilometres and the third row shows the number of animal sightings per 10 walked kilometres

Treatment	**Active**			**Not-active**					
Transect	**B**	**E**	**Average**	**A**	**C**	**D**	**F**	**Average**	**% Change from active to not-active**
Sample Effort (km)	166	232		194	161	130	220		
Xenarthra									
Tamandua tetradactyla	2.00	2.00	**2.00**	2.00	0.00	2.00	3.00	**1.75**	-12.50
	0.12	0.09	**0.11**	0.10	0.00	0.15	0.14	**0.10**	-7.14
	0.18	0.09	**0.14**	0.10	0.00	0.15	0.14	**0.10**	-27.78
Bradypus variegatus	1.00	0.00	**0.50**	0.00	0.00	0.00	0.00	**0.00**	-100.00
	0.06	0.00	**0.03**	0.00	0.00	0.00	0.00	**0.00**	-100.00
	0.06	0.00	**0.03**	0.00	0.00	0.00	0.00	**0.00**	-100.00
Dasypus novemcinctus	0.00	1.00	**0.50**	Track	0.00	0.00	0.00	**0.00**	-100.00
	0.00	0.04	**0.02**		0.00	0.00	0.00	**0.00**	-100.00
	0.00	0.04	**0.02**		0.00	0.00	0.00	**0.00**	-100.00
Primates									
Saguinus fuscicollis	18.00	12.00	**15.00**	30.00	13.00	12.00	6.00	**15.25**	1.67
	1.08	0.52	**0.80**	1.55	0.80	0.92	0.27	**0.89**	10.63
	4.49	2.37	**3.43**	6.36	3.22	5.22	1.36	**4.04**	17.78
Saimiri boliviensis	7.00	2.00	**4.50**	6.00	1.00	3.00	9.00	**4.75**	5.56
	0.42	0.09	**0.26**	0.31	0.06	0.23	0.41	**0.25**	-0.98
	6.29	0.43	**3.36**	2.79	1.98	3.53	6.41	**3.68**	9.45
Callicebus brunneus	5.00	5.00	**5.00**	10.00	10.00	0.00	9.00	**7.25**	45.00
	0.30	0.22	**0.26**	0.16	0.62	0.00	0.41	**0.30**	14.42
	0.54	0.47	**0.51**	1.24	1.55	0.00	1.00	**0.95**	87.62
Aotus spp.	0.00	0.00	**0.00**	0.00	4.00	2.00	0.00	**1.50**	100.00
	0.00	0.00	**0.00**	0.00	0.25	0.15	0.00	**0.10**	100.00
	0.00	0.00	**0.00**	0.00	0.56	0.15	0.00	**0.18**	100.00
Pithecia aequatorialis	0.00	0.00	**0.00**	3.00	0.00	2.00	2.00	**1.75**	100.00
	0.00	0.00	**0.00**	0.16	0.00	0.15	0.09	**0.10**	100.00
	0.00	0.00	**0.00**	0.36	0.00	0.38	0.23	**0.24**	100.00
Cebus albifrons	7.00	15.00	**11.00**	5.00	8.00	8.00	3.00	**6.00**	-45.45
	0.42	0.65	**0.54**	0.26	0.50	0.61	0.14	**0.38**	-29.44
	2.16	4.65	**3.41**	1.71	2.48	8.29	0.77	**3.31**	-2.72
Cebus apella	17.00	31.00	**24.00**	29.00	26.00	13.00	27.00	**23.75**	-1.04
	1.02	1.33	**1.18**	1.50	1.61	1.00	1.23	**1.34**	13.62
	4.31	7.36	**5.84**	5.06	7.74	6.52	6.73	**6.51**	11.61
Alouatta seniculus	6.00	14.00	**10.00**	15.00	19.00	18.00	12.00	**16.00**	60.00
	0.36	0.60	**0.48**	0.78	1.18	1.38	0.55	**0.97**	102.60
	1.38	1.94	**1.66**	3.93	4.58	7.44	2.73	**4.67**	181.33
Ateles belzebuth	6.00	26.00	**16.00**	13.00	25.00	17.00	15.00	**17.50**	9.38
	0.36	1.12	**0.74**	0.67	1.55	1.30	0.68	**1.05**	41.89
	1.26	5.08	**3.17**	2.48	9.66	6.75	2.36	**5.31**	67.59

Treatment	**Active**	**Not-active**	

Transect	B	E	Average	A	C	D	F	Average	
Sample Effort (km)	166	232		194	161	130	220		**% Change from active to not-active**
Carnivora									
Atelocynus microtis	0.00	1.00	**0.50**	0.00	0.00	0.00	0.00	**0.00**	-100.00
	0.00	0.04	**0.02**	0.00	0.00	0.00	0.00	**0.00**	-100.00
	0.00	0.04	**0.02**	0.00	0.00	0.00	0.00	**0.00**	-100.00
Eira barbara	2.00	0.00	**1.00**	2.00	0.00	1.00	1.00	**1.00**	0.00
	0.12	0.00	**0.06**	0.10	0.00	0.08	0.05	**0.06**	-4.17
	0.12	0.00	**0.06**	0.10	0.00	0.08	0.05	**0.06**	-4.17
Panthera onca	Track	0.00	**0.00**	1.00	0.00	0.00	Track	**0.33**	100.00
		0.00	**0.00**	0.10	0.00	0.00		**0.03**	100.00
		0.00	**0.00**	0.10	0.00	0.00		**0.03**	100.00
Puma concolor	Track	----	**0.00**	----	---	----	----	**0**	0.00
Leopardus pardalis	Track	1.00	**0.50**	1.00	0.00	0.00	Faeces	**0.33**	-33.33
		0.04	**0.02**	0.10	0.00	0.00		**0.03**	66.67
		0.04	**0.02**	0.10	0.00	0.00		**0.03**	66.67
Nasua nasua	2.00	0.00	**1.00**	3.00	0.00	1.00	0.00	**1.00**	0.00
	0.12	0.00	**0.06**	0.16	0.00	0.08	0.00	**0.06**	0.00
	0.54	0.00	**0.27**	0.31	0.00	0.08	0.00	**0.10**	-63.89
Perissodactyla									
Tapirus terrestris	Track	---	**0.00**	Track	---	Track	Track	**0**	0.00
Artiodactyla									
Mazama americana	4.00	0.00	**2.00**	10.00	4.00	7.00	0.00	**5.25**	162.50
	0.24	0.00	**0.12**	0.52	0.25	0.54	0.00	**0.33**	172.92
	0.24	0.00	**0.12**	0.52	0.25	0.61	0.00	**0.35**	187.50
Mazama gouazoubira	1.00	0.00	**0.50**	4.00	0.00	3.00	0.00	**1.75**	250.00
	0.06	0.00	**0.03**	0.21	0.00	0.23	0.00	**0.11**	266.67
	0.06	0.00	**0.03**	0.21	0.00	0.23	0.00	**0.11**	266.67
Mazama spp.	0.00	Track	**0.00**	3.00	0.00	1.00	Track	**1.33**	100.00
	0.00		**0.00**	0.16	0.00	0.08		**0.08**	100.00
	0.00		**0.00**	0.16	0.00	0.08		**0.08**	100.00
Tayassu pecari	3.00	3.00	**3.00**	3.00	1.00	4.00	Track	**2.67**	-11.11
	0.18	0.13	**0.16**	0.16	0.06	0.31		**0.18**	13.98
	5.69	8.95	**7.32**	7.39	4.95	16.12		**9.49**	29.60
Tayassu tajacu	3.00	8.00	**5.50**	3.00	1.00	5.00	1.00	**2.50**	-54.55
	0.18	0.34	**0.26**	0.16	0.06	0.38	0.05	**0.16**	-37.50
	0.72	0.60	**0.66**	0.26	0.31	0.46	0.10	**0.28**	-57.20
Rodentia									
Dasyprocta variegata	10.00	16.00	**13.00**	20.00	12.00	5.00	18.00	**13.75**	5.77
	0.60	0.69	**0.65**	1.03	0.74	0.38	0.82	**0.74**	15.12
	0.66	0.73	**0.70**	1.03	0.74	0.46	0.91	**0.79**	12.95
Myoprocta pratti	0.00	0.00	**0.00**	0.00	6.00	0.00	0.00	**1.50**	100.00
	0.00	0.00	**0.00**	0.00	0.37	0.00	0.00	**0.09**	100.00
	0.00	0.00	**0.00**	0.00	0.37	0.00	0.00	**0.09**	100.00

Treatment	**Active**	**Not-active**							
Transect	**B**	**E**	**Average**	**A**	**C**	**D**	**F**	**Average**	**% Change from active to not-active**

Sample Effort (km)	166	232		194	161	130	220		
Myoprocta spp.	5.00	2.00	**3.50**	2.00	0.00	0.00	4.00	**1.50**	-57.14
	0.30	0.09	**0.20**	0.10	0.00	0.00	0.18	**0.07**	-64.10
	0.30	0.09	**0.20**	0.10	0.00	0.00	0.18	**0.07**	-64.10
Sciurus ignitus	5.00	1.00	**3.00**	8.00	3.00	2.00	4.00	**4.25**	41.67
	0.30	0.04	**0.17**	0.41	0.19	0.15	0.18	**0.23**	36.76
	0.30	0.04	**0.17**	0.52	0.19	0.15	0.18	**0.26**	52.94
Sciurus pyrrhinus	16.00	8.00	**12.00**	20.00	15.00	11.00	14.00	**15.00**	25.00
	0.90	0.34	**0.62**	1.00	0.93	0.84	0.64	**0.85**	37.50
	1.20	0.34	**0.77**	1.09	0.93	0.84	0.68	**0.89**	14.94
Sciurus spp.	2.00	2.00	**2.00**	3.00	1.00	0.00	4.00	**2.00**	0.00
	0.12	0.09	**0.11**	0.16	0.06	0.00	0.18	**0.10**	-4.76
	0.12	0.13	**0.13**	0.16	0.06	0.00	0.23	**0.11**	-10.00
Number of recorded species	**23**		**18**	**23**	**15**	**18**	**21**		
Mean number of recorded species per treatment	**20.5**			**19.5**					

Table 13-2 Observations of birds along the six transects: First row shows the total number of group encounters, the second row shows the number of group encounters per 10 walked kilometres and the third row shows the number of animal sightings per 10 walked kilometres

Transect	**B**	**E**	**Average**	**A**	**C**	**D**	**F**	**Average**	**% Change from active to not-active**
Sample Effort (km)	166	232.3		194	161	130	220		
Crax mitu	2	1	**1.5**	3	13	2	0	**4.50**	200.00
	0.12	0.04	**0.08**	0.1	0.81	0.15	0	**0.27**	231.25
	0.24	0.04	**0.14**	0.21	1.18	0.23	0	**0.41**	189.29
Penelope jacquacu	30	23	**26.5**	38	40	42	11	**32.75**	23.58
	1.81	0.99	**1.4**	1.96	2.48	3.22	0.5	**2.04**	45.71
	2.7	1.55	**2.13**	3.26	3.91	5.99	0.95	**3.53**	65.61
Aburria pipile	3	6	**4.5**	1	5	6	1	**3.25**	-27.78
	0.18	0.26	**0.22**	0.05	0.31	0.46	0.05	**0.22**	-1.14
	0.24	0.26	**0.25**	0.05	0.31	0.69	0.05	**0.28**	10.00
Psophia leucoptera	10	6	**8**	10	9	14	0	**8.25**	3.13
	0.6	0.26	**0.43**	0.52	0.56	1.07	0	**0.54**	25.00
	1.81	0.99	**1.4**	1.19	3.91	2.99	0	**2.02**	44.46
Tinamus spp.	20	7	**13.5**	23	7	15	15	**15.00**	11.11
	1.2	0.3	**0.75**	1.19	0.43	1.15	0.68	**0.86**	15.00
	1.33	0.3	**0.82**	2.02	0.43	1.53	0.91	**1.22**	49.09

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