"Project Tambopata 1"

Tourism Development and the Status of Neotropical Lowland Wildlife in Tambopata, South-eastern Peru: Recommendations for Tourism and Conservation.

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TReeS-RAMOS
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I. Glossary of Abbreviations

BSNP	Bahuaja Sonene National Park
CAPH	Cusco Amazónico Pueblo Hotel
DFA	Discriminant Function Analysis
ECO	EcoAmazonía Lodge
EI	Explorers' Inn
EIA	Environmental Impact Assessment
INRENA	National Institute of Natural Resources
MITINCI	Ministry of Tourism, Commerce and Industry
MBR	Manu Biosphere Reserve
PCA	Principle Component Analysis
RAMOS	Research & Monitoring Studies Unit
SACHA	Sachavacayoc Centre and Sachavaca Inn
TCCI	Trail-use Carrying Capacity Indicators
TCRZ	Tambopata Candamo Reserved Zone
TPL	Tambopata Jungle Lodge
TRC	Tambopata Research Center
TReeS	Tambopata Reserve Society
TRZ	Tambopata Reserve Zone
VCP	Variable Circular Plot
VDLT	Variable Distance Line Transect
VES	Visual Encounter Survey

II. Acknowledgements

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1.0 General Introduction

Wildlife and exotic landscapes are important tourist attractions throughout the world, and particularly so in developing countries which still contain large tracts of relatively undisturbed wilderness. In 1990 developing countries attracted 50 million tourists who left revenues of 55 billion US dollars in the process (WTO 1991). Furthermore, there is a growing tendency towards visiting protected areas in these countries (Ceballos-Lascurain 1996). Tourism has the potential to provide much needed economic benefit to a region, however this industry can also pose a serious threat to the cultural and natural environment affecting the lives of local people (Conservation International 1999) and the very wildlife, habitats and protected areas that are the basis of the attraction (Pigram 1980, Boyle & Samson 1985, Boo 1990, Groom 1990, Wallace 1993, Staib & Schenck 1994, Hidinger 1996, Yoon 1997). The environmental consequences of badly planned tourism are many, and vary from erosion, water, air and soil pollution, introduction of alien species and diseases, disruption and destruction of feeding and breeding habitats, redistribution of wild populations, and so forth. Environmental problems such as these can lead to long-term impacts on local habitats and wildlife and can put the very future of local tourist industries at stake by reducing the attractiveness of a destination (Mieczkowski 1995, Mihalic 2000).

Amazonian rainforests have seen a greater than average growth in tourist numbers over the last 15 years. There exists a significant degree of uncertainty regarding the magnitude of tourism related impacts on Amazonian wildlife, due in part to the relatively recent attraction of this environment and the scarcity of thorough long-term investigations. Rainforest tourism in the Peruvian Amazon, and particularly in the Department of Madre de Dios, is characterised to a great extent by large static lodge-based operations or tented camps with their associated clearings, infrastructure, trail networks, guides, motorised river boats, etc. Such operations are currently a growing phenomenon.

There is little or no information related to the effects of lodges on rainforest wildlife and an urgent need exists 1) to investigate the local impacts of this type of operation on wildlife, 2) to identify adequate management practices in order to prevent or alleviate impacts when they are found, and 3) to divulge this information to lodge administrators, tourists, global operators, and local people as well as the government authorities responsible for tourism and natural resource management.

Visitors to Madre de Dios are drawn, on the whole, to two protected areas, the Tambopata Candamo Reserved Zone (TCRZ, Figure 2.1) and the Manu Biosphere Reserve (MBR). In 1998 these areas attracted approximately 14,000 and 2,500 tourists, respectively. The average annual growth rate in tourists to Madre de Dios over the last 5 years has been approximately 22% with the vast majority of this growth occurring in the TCRZ (Figure 2.2).

In this report we present the findings of “Project Tambopata”, a tourism impact study undertaken from January 1997 to November 1998 at five lodges associated with the TCRZ. These were: Cusco Amazónico Pueblo Hotel (CAPH), Explorers’ Inn (EI), EcoAmazonía Lodge (ECO), Sachavacayoc Centre (and Sachavaca Inn) (SACHA) and the Tambopata Research Center (TRC). We investigated four faunal groups: mammals, reptiles, amphibians and birds. Many species within these groups are frequently considered important natural tourist attractions in their own right and so the information herein is of direct interest to lodge administrators and tour companies servicing the area.

The project was co-ordinated by the Research and Monitoring Studies Unit (RAMOS) of the Tambopata Reserve Society (TReeS). TReeS is an Non-governmental Organisation and UK Charity (No. 298054) that has been active in Tambopata since 1986 (see Appendix 3 for correspondence details).

The classic experimental procedure for environmental impact assessments (EIA) involving wild populations requires the measurement and analysis of abundance before and after a supposed impact variable commences, both in the area of influence of the variable (treatment) and well away from it (control), although always in comparable habitats. However, in this instance we were unable to examine the wildlife communities in question before the impact variable (tourism) began, as all lodges were already built and operational several years before. In order to overcome this we designed the study such that we could investigate the residual or ongoing effects of tourist lodges that have been operating for varying numbers of years and have hosted varying numbers of tourists as a consequence.

The central variables under investigation were the presence of tourist trails in the habitat and the intensity of trail-use. Other observable variables relating to tour-group management, guides, waste disposal, pets, and so forth are also discussed, although no quantitative data was collected on them. We feel these other issues required discussion in order to adequately illustrate the reality of tourism in Tambopata and the range of issues that can affect the local wildlife.

The stakeholders in the area, that is to say the lodge administrators and staff, protected area managers in the form of the National Institute of Natural Resources (INRENA), local government authorities such as the Ministry of Tourism, Industry and Commerce (MITINCI), as well as local communities are aware that tourism and lodge operations may be damaging the local environment. Many have expressed a need to investigate the issue in more detail and have expressed much interest in receiving information and recommendations to mitigate impacts where identified. This report addresses that need.

The conservation status of the TCRZ since it was created in 1990 has been temporary. Only after biological and social land-use studies have been undertaken will land-use zoning and categorisation of forested and agricultural lands be defined. The final stages of this planning process, which includes tourism as a land-use, were underway as this report was being prepared (1999). We therefore call the attention of the TCRZ Land-use Planning Committee to the findings of this report in their search for information and guidance in developing an appropriate tourism management plan for the area.

We also consider this report and the journal publications that will follow, as important baseline references for future investigations of the same wildlife communities and lodges that were studied, and we hope that future inquisitive scientists will continue where we have left off, improving our understanding of the mechanisms underlying tourism impacts and highlighting the importance of long-term wildlife monitoring of these impacts.

2.0 Study Area

The Tambopata Candamo Reserved Zone (TCRZ)

The Tambopata Candamo Reserved Zone, with which all the lodges studied are associated, is situated in the Departments of Madre de Dios and Puno, in south-eastern Peru (9º 57’ - 13º 20’ S, 68º 39’ - 72º 31’ W). It is also within Amazon’s south-western ecological region. This protected area was originally gazetted in 1990, although in 1996 part of it was declared the Bahuaja Sonene National Park (BSNP). Together they cover 14,000 km^2 (Figure 2.1). Biological inventories undertaken within the TCRZ since 1976 revealed that the area is exceptionally rich in terms of habitat types, numbers of species and endemics. Its biodiversity is arguably unequalled anywhere else in Amazonia. It is home to approximately 7% of the world’s bird species (~600), and up to 4% of the world’s mammal species (~160). Furthermore, thirteen local vertebrates are listed in the IUCN Red Data Book and considered highly endangered in the rest of their range: Giant anteater (*Myrmecophaga tridactyla*), Giant armadillo (*Priodontes maximus*), Bush dog (*Speothus venaticus*), Small-eared dog (*Atelocynus microtis*), Giant river otter (*Pteronura brasiliensis*), Jaguarundi (*Herpailurus yaguarundi*), Ocelot (*Leopardus pardalis*), Jaguar (*Panthera onca*), Crested eagle (*Morphous guianensis*), Harpy eagle (*Harpia harpyja*), Black caiman (*Melanosuchus niger*), Spectacled caiman (*Caiman crocodilus*), and Yellow-spotted side-necked turtle (*Podocnemis unifilis*).

It is situated within the transitional zone between humid tropical and subtropical rainforest (ONERN 1972) and receives an average annual precipitation of 2,400 mm. From north to south there exists an altitudinal gradient of more than 3,000 m, which in conjunction with the putative role of the area as a Pleistocene “refugium”, and the presence of drier tropical savannah ecosystems to the east (Pampas del Heath), contribute to the exceptional levels of species diversity encountered.

Tourism

Tambopata has been a tourism destination since 1975 (Groom et al. 1991, Gunther pers. com.). However, only since the re-emergence of Peru in the mid 1990s after a number of years of political instability, has the area seen a significant growth in the tourism sector (Figure 2.2). For example, in 1990 there were 3 lodges operational in and around the TCRZ hosting a total of approximately 3,000 tourists per year. Just eight years later, in 1998, the number had jumped to 14 lodges and 5 rural guest houses, and a total of 14,000 tourists, an average yearly rise of nearly 22% in visitor numbers over this period. Indications are that visitor numbers will increase substantially for the foreseeable future, although at a lower rate than in the 1990’s.

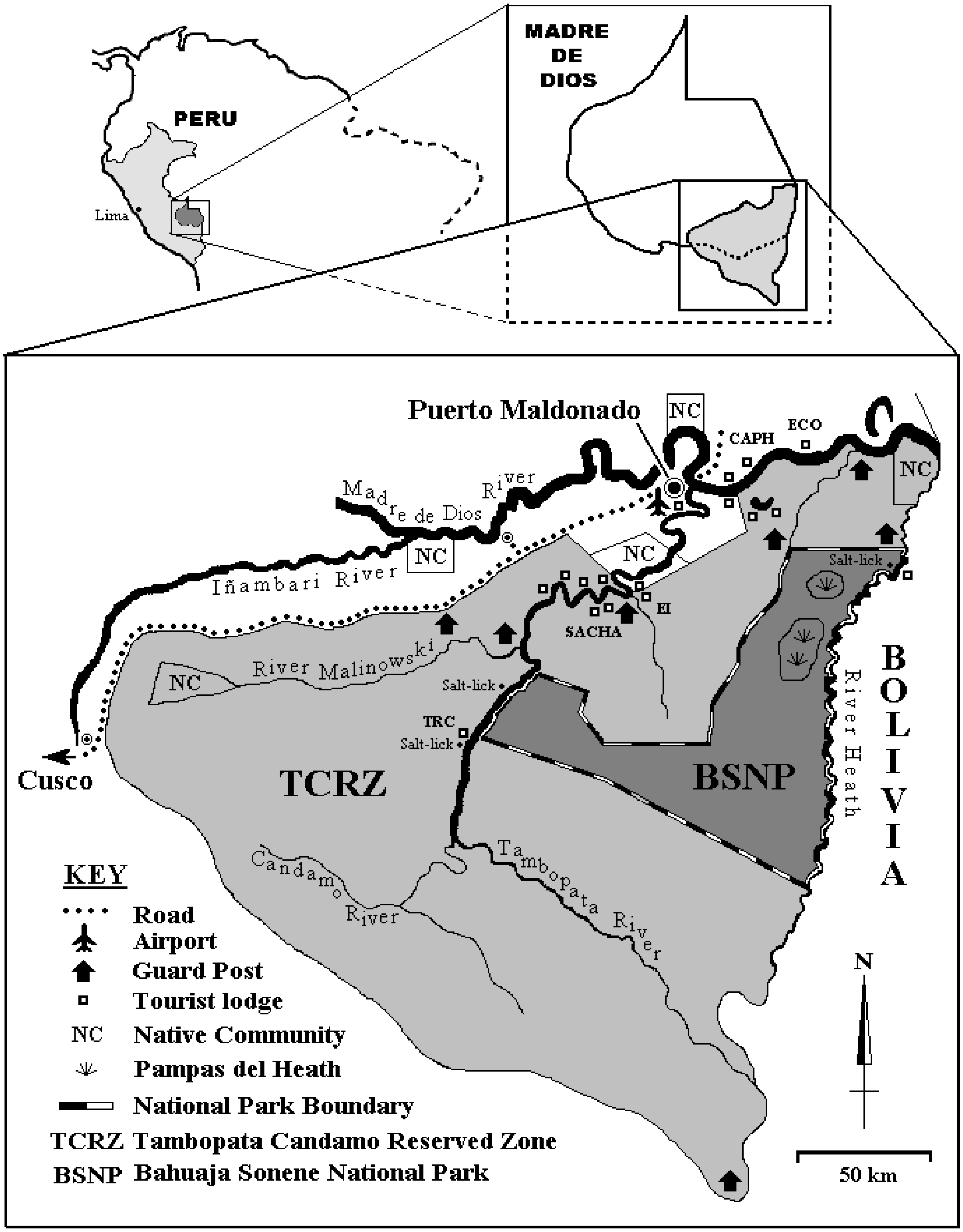

Figure 2.1. Study Area.

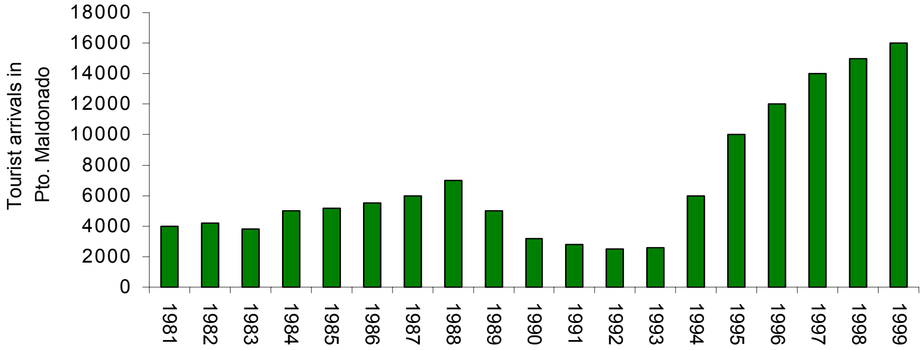

Figure 2.2. Foreign tourist arrivals in Puerto Maldonado from 1981-1999 (MITINCI).

Explorers' Inn (EI)

This lodge is located on the southern bank of the Tambopata river (12º50´15´´S, 69º17´30´´W), at the confluence with the La Torre river, and 30 km SSW from Puerto Maldonado (Figure 2.1). The company Peruvian Safaris built the lodge in 1975 and it began to receive tourists in 1976. It was the first tourism venture to operate along the Tambopata river and it may be said that it was one of the first to introduce the concept of tourism and conservation to the area (Gunther pers. com.). Soon after the lodge was built (1977) the Peruvian government granted Protected Area status to 5.5 km^2 of forest around the lodge which became known as the Tambopata Reserve Zone (Stewart 1988). Through its Resident Naturalist Program, which offered free room and board to graduate biologists in exchange for informing and guiding guests, the EI was successful in combining tourism with research. Investigations undertaken in the late 1970s and early 1980s found that this area is relatively unique and harbours the highest known levels of biodiversity on Earth. The 5.5 km^2 of lowland rainforest around the lodge holds numerous world records for species density: Birds 596 (Parker et al. 1994); Butterflies 1,234 (Lamas 1985, 1994); Dragonflies and Damselflies 151 (Paulson 1985); Horseflies 73 (Wilkerson & Fairchild 1985) and Tiger beetles 29 (Pearson 1985). The creation of the TCRZ and BSNP would likely not have been possible without the original investigative studies undertaken around this lodge.

Currently the lodge receives general interest and specialist visitors (birdwatchers), who remain there on average for 3 days. The total length of the trail system habitually used by tourists from the lodge is 35 km and is the oldest and most extensive in the area. Erwin (1984) was the first to classify the forest types around the lodge, basing his system largely on hydrological and soil characteristics. Later, Nicholson & Phillips (unpublished) and Phillips (1993) further developed the classification by presenting full forest type descriptions with new information on floristic characters. Further floristic descriptions of the area were undertaken by Conservation International (1994). A total of nine distinct forest types can be recognised:

- **Type A: Permanently Waterlogged Swamp Forest**, dominated by the palm *Mauritia flexuosa* and more rarely by *Lueheopsis hoehnei*. This forest type is frequently associated with the poorly drained areas around oxbow lakes and is considered one of the successional phases in the slow process of forest recolonisation of these lakes.

- **Type B: Seasonally Flooded Swamp Forest**, is characterised by an abundance of tall palms such as *Scheelea butyracea*, *Euterpe precatoria, Oenocarpus bataua* and *Socratea exorrhiza*. The canopy is normally low (<20 m) and broken, with a dense understory of shrubs and small palms, especially *Geonoma sp.* and *Bactris sp*. Vines and scandent herbs are moderately abundant but large lianas are rare. Ground vegetation is restricted to areas of drier ground atop low hummocks, where the fern *Adiantum latifolium* is usually common.
- **Type C: Lower Floodplain Forest**, an open early successional forest, situated on the banks of rivers, dominated by the cane *Gynerium sagittatum* and successional light demanding trees such as *Tessaria integrifolia*, *Salix humboldtiana*, *Cecropia sp.* and *Ochroma sp.* with frequent *Ficus insipida*, *Croton sp.* and *Sapium ixamasense*. This forest type is frequently disturbed by rising river waters after severe storms, particularly during the rainy season (Nov. – Apr.). Few trees reach more than 20-25 m in height. Small lianas, such as *Paullinia alata,* are common and can form locally dense tangles. Ground cover is sparse, mainly consisting of dense clonal patches of *Calathea sp.* and *Heliconia sp*.
- **Type D: Middle Floodplain Forest**, a tall closed canopy of frequent *Iriartea deltoidea*, *Astrocaryum gratum*, *Socratea exhorrhiza*, *Calycophyllum sp.* and *Spondias mombim*.
- **Type E: Upper Floodplain Forest**, palms such as *Iriartea*, *Astrocaryum*, *Socratea* remain frequent, although also present are large broad-leaved trees such as *Chorisia sp.*, *Ceiba pentandra* and *Pseudolmedia laevis*.
- **Type F : Old Floodplain Forest**, this forest type is a mature version of Type E except with a greater predominance of palms (30%), particularly *Iriartea*, and large broad-leaved emergents, including: *Dipteryx alata*, *Spondias*, strangling *Ficus*, *Ceiba* and in some cases *Caryocar magdiliformis*. The forest canopy is tall (>30 m) and is more continuous than other types. The dense shade caused by this closed canopy inhibits dense understory growth, with the result that the understory is relatively open. The fern *Adiantum latifolium* however remains dominant at ground level.
- **Type G: Terra Firme Clay Forest; Type H: Terra Firme Sandy Clay Forest and Type I: Terra Firme Ultrasand Forest**, characteristic broad-leaved trees in these types are *Bertholletia excelsa*, *Dipteryx, Cedrelinga cateniformis*, *Capirona sp.*, *Parkia sp.*, *Hevea brasiliensis* and *Coussapoa sp*. These forest types are located on freely draining soils and are not subject to flooding.
- **Bamboo**. Within the more poorly drained and/or disturbed areas of some of the aforementioned forest types can be found stands of bamboo (*Guadua weberbaueri* and *G. sarcocarpa*) which further adds to the habitat diversity of the area.

The lodge was originally built on a small area of agricultural land belonging to the mestizo community of La Torre. As a consequence a small area of forest near the lodge is regenerated secondary forest. La Torre, is a small permanent settlement with a population of approximately 70 people located on the opposite banks of the Tambopata and La Torre rivers. The rivers afford the lodge relative isolation. East of the lodge is the native Ese´eja community of Infierno, established in 1976 and currently with 400 inhabitants. The forest surrounding an oxbow lake (Laguna Cococococha) that is used by the lodge is claimed by Infierno. Members of the community also collect brazil-nuts for 3 months of the year in areas to the south and east of the lodge´s trail system.

Cusco Amazónico Pueblo Hotel (CAPH)

This lodge is located on the northern bank of the Madre de Dios river (12º32´30´´S, 69º03´20´´W), 15 km ENE from Puerto Maldonado (Figure 2.1). The company Palma Real built and began operating the lodge in 1976. It was the first tourist installation to be implemented along the Madre de Dios river. From its initial stages it has developed its own form of tourism based on the biological, cultural and historical attractions of the area. In 1977 the government approved the formation of a private ecological reserve around the lodge totalling 10 km^2. The status of the reserve prohibited the extraction or conversion of natural resources by the local inhabitants, although there is evidence that some resources, for instance the palm *Euterpe precatoria,* have been extracted over a large area. There is also evidence that the lodge itself is responsible for the majority of this.

In 1987 the government failed to renew the "ecological reserve" status of the majority of the land and subsequently previously forested lands close to the lodge were colonised and are now farmed. Furthermore, hunting pressure has grown significantly in the area as a consequence. Scientific collecting of mammals, birds, herpetofauna and vegetation was also undertaken periodically (Duellman 1987, Davis et al. 1991, Duellman & Salas 1991, Woodman et. al. 1991). Such research, complementary to that undertaken at the EI, further affirmed the importance of the Tambopata area in terms of biodiversity.

The lodge receives general interest tourists who remain on average for 3 days. The trail system that is habitually used by tourists staying at the lodge is one of the oldest, although at 5 km it is the least extensive in the area. The forest types found along the length of the trail network, following the above classification, include: Types A, B, E, and F. No bamboo is present. South of the lodge is a 45 ha island dominated by type C forest and currently used as a make-shift zoo. On both sides of the lodge, at a minimum distance of 0.5 km, are situated two farms belonging to families of the Lorin and Gamitana communities. These families have been known to use the trails for communication purposes as well as for hunting.

EcoAmazonía Lodge (ECO)

This lodge is located on the northern bank of the Madre de Dios river (12º31´45´´S, 68º56´10´´W), 28 km ENE from Puerto Maldonado (Figure 2.1). It was constructed in 1993 by the Toledo family (Cusco). No research has previously been undertaken at the lodge. The lodge receives general interest tourists who remain on average for 3 days. The trail system habitually used by tourists is 15 km long. The forest types associated with the trail system and the immediate area around the lodge include types A, B, D, E, and F. No bamboo is present. To the north of the trail system are numerous palm swamps (Type A) where aquatic plants such as *Apalanthe granatensis* and *Lemna aequinoctialis* are sometimes present in the standing water. At a distance of 6.1 km from the lodge are two canopy platforms. These are juxtapositioned between three distinct habitat types: A, B and an unknown type of riverine scrub. Located opposite the lodge is a 30 ha island, "Isla de Mono", which is used as a make-shift zoo. The island is dominated by type C forest. The lodge is built in an area not associated with any established community, the nearest being approximately 5 km distant, although it is known that fishermen from the native Ese'eja community of Palma Real use the eastern-most trails to access other areas.

Sachavacayoc Centre and Sachavaca Inn (SACHA)

These two neighbouring lodges, separated by only 200 m, are located on the southern bank of the Tambopata river (12º51´15´´S, 69º22´00´´W), 35 km SSW from Puerto Maldonado (Figure 2.1). The Sachavacayoc Centre was constructed in 1994 by Newton College, an independent international school in Lima, as a centre for conservation and education. The Centre caters mainly for student groups, who stay for 7 days. The Sachavaca Inn is a relatively recent construction, finished in 1997, and caters for tourists, who stay 3 days on average. A small amount of research has been carried out in the forest shared by both lodges although to date no comprehensive inventories have been completed. The lodges have a common trail system consisting of a total of 18 km. The trail system is also used relatively often by tour groups from the Tambopata Jungle Lodge, situated 5 km upstream. The forest types which the trail system crosses include types A, B, E, F and small patches of G, although the majority of the forest under study was type F. All, except type A, have significant stands of bamboo associated with them.

The land on which these two lodges are built use to be small agricultural plots belonging to members of the Sachavacayoc community. Consequently a small portion of the forest surrounding each lodge is regenerating secondary forest. Some families of the Sachavacayoc community continue to live alongside both lodges. Small-scale selective logging has occurred within the area studied, with species such as *Cedrela odorata* and *Cedrelinga cateniformis* consequently being relatively rare. The local inhabitants also use the forest for the collection of *Geonoma* palm leaves (Palmiche), which they use for thatching. Local hunters also access the area along the trail system, and two families are known to hunt relatively frequently in the area.

Tambopata Research Center (TRC)

This lodge is located on the western bank of the Tambopata river (13º08´10´´S, 69º36´40´´W), 75 km SSW from Puerto Maldonado (Figure 2.1) in an isolated area of the TCRZ adjacent to the BSNP, and within 200 m of a macaw claylick, or ccollpa. It was constructed in stages, beginning in 1989 when it was purely a research centre dedicated primarily to the study of macaws (Nycander et al. 1995), and was modified and completed in 1994 as the principle activity switched to tourism. A significant amount of research has been undertaken at this site over the last 10 years and comprehensive inventories of some taxa are available (Emmons & Romo 1994, Rodriguez & Emmons 1994, Ascorra 1995, Salas 1995). The TRC caters for both its own tourists, who stay for approximately 4 days, and also those from the Tambopata Jungle Lodge who stay for an average of 2 days. The trail system used by all visitors extends for a total of 12 km. The forest types associated with the trail system and the immediate area around the lodge include types: A, B, C, D, E, F and G. Most have significant stands of bamboo. There is also a large number of pure stands of bamboo where natural disturbance has been severe, thus defining a unique forest type. The habitats at the TRC have been described in more depth by numerous authors (Foster et al. 1994; Kratter, 1995a, b, 1997). No permanent settlements exist within 40 km of this lodge and hunting is negligible.

3.0 The Impact of Trail-use by Tourists on the Mammal Fauna of Tambopata, South-eastern Peru.

Authors:

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Introduction

The populations of many Neotropical rainforest mammals are regularly and directly impacted upon by humans, either by subsistence or commercial hunting, for their meat and/or skins (Peres 1990, 1996, 1999b, Robinson & Redford 1991, Fragoso 1991, Mittermeier 1993, Ascorra 1997, Bodmer et al. 1997, Kirkby & Padilla 1998, Maglianesi 1998, Noss 1998, Smith 1999), through persecution because of their "pest" status (Rabinowitz & Nottingham 1986), and by capture and trade to satisfy national and international demands for exotic pets. Indirect impacts, in the form of selective logging (Johns et al. 1987, Wallace et al. 1996) and the alteration or destruction of habitats through conversion of forest habitats to agricultural land (Barnes et al. 1991) are also important anthropogenic variables currently altering mammal populations and affecting the long-term stability and viability of rainforests throughout the world.

The effects of certain human land-uses which aren't necessarily destructive and don't directly alter large areas of habitat have been little studied. Tourism is a case in point. For a long time it was regarded to be environmentally benign. However, increasing evidence suggests that it can generate negative impacts. Impacts can range from the contamination and erosion of soils and the pollution of water-bodies through improper management of waste, inappropriate construction techniques, noise pollution from people and machinery, drainage of land, in forested habitats selective logging for construction purposes, the destruction of sensitive wildlife breeding habitats, and so forth. The main emphasis in this investigation, however, concentrates on a little studied issue - that relating to the impact of permanent forest trails and their use by up to 80 tourists a day. Previous studies have already identified this variable as having a negative impact on certain rainforest species around the world (Griffiths & Schaik 1993, Hidinger 1996, Yoon 1997). These authors documented that trail-use can result in either an increase or a decrease in local abundance of wildlife and/or a shift from diurnal to nocturnal habits amongst some species.

In the case of the TCRZ, where detailed information is required on the effects of current land-uses, such as tourism, before long-term management strategies can be implemented, this phenomenon requires further investigation, particularly the relationship between the intensity of trail-use (here-on referred to as "traffic") and the magnitude of any impact. In this chapter we report on the findings of a 23-month investigation into the relationship between trail traffic and the population abundance and community structure of 26 species of medium and large mammal. We illustrate, that traffic indeed can have significant impacts on some of the species, above and beyond other impacts such as hunting, and that the magnitude of traffic is a variable that should be considered when managing tourism in the area in the future. The long-term repercussions for the ecology of the forest and the tourism industry itself, as well as

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[1] Correspondence: Appendix 3

recommendations to reduce the impact where this is evident, and the use of trail-use carrying capacity as a tourism management tool, are discussed.

Objectives

- To determine and compare the diversity, abundance and community structure of mammals in forest traversed by tourist trails (Treatment) and in undisturbed areas (Control).
- To determine and compare the abundance of thirteen plant genera in the study areas (11 of which are important fruit resources).
- To measure the trail-use intensity (traffic) along the tourist trails under investigation.
- To estimate the relative hunting pressure around each lodge.
- To use the most traffic sensitive species as indicators for calculating trail-use carrying capacities.
- To outline appropriate recommendations for reducing the impact of tourists on the mammal fauna where evident.

Methods

As mentioned in the general introduction the experimental design behind the investigation, that of a post-impact assessment, involved setting up a sampling protocol within tourist and control areas at lodges of varying ages and with varying trail traffic histories. Rainforest mammals are difficult to observe, due to the thick vegetation and the inherently restricted visibility levels imposed by it. To investigate the diversity and abundance of mammals in such a way as to allow comparisons to be made between lodges a variety of direct and indirect sampling techniques were used; these included: transect censuses, quadrat sampling of mammal sign such as forage scrapings, and surveys of their tracks.

Transects

Transect sampling is a common technique for studying mammal populations, and received greatest effort in this study due to its ability to generate reliable comparative estimates of abundance. It can also provide a means of measuring differential visibility levels between different locations, and provides opportunities to collect ecological and behavioural data. Standard texts exist to help guide the investigator and provide informed critiques of the method (Buckland et al. 1993, Burnham et al. 1980, Brockelman et al. 1987, Peres 1999a). Furthermore, the data generated by transect censuses can now be rapidly and effectively analysed and compared to other studies using relatively new and powerful statistical and computational resources (Laake et al. 1994, Krebs 1999).

At each of the five lodges, parts of the trail system used for tourist excursions were identified and marked for use as transects, here-on referred to as tourist transects or T. A series of complementary transects were cut, here-on referred to as control transects or C, allowing us to sample forest well away from the tourist trails. Care was taken to site all transects within floodplain forest (mainly types B, D, E and F). C transects were traversed by humans very infrequently in comparison to T transects, which received almost daily visits of between 1 and 80 people throughout the period of the study. Variation in traffic intensity is related mainly to the season and the characteristics of the tour programs at each lodge.

Lodges were visited on 5 or 6 occasions for 18 days at a time between January 1997 and November 1998. The initial set of C transect censuses were conducted 48 hours after they were originally opened. During repeated visits over the entire study period very limited clearing of vegetation was required to maintain the C transects. The action of initially opening these transects had no apparent effect on mammal encounters.

At each of the 5 lodges, 2-3 T transects and 3-5 C transects were identified and marked at 25 m intervals, for a total of 11 and 17 transects respectively. The total combined lengths were 18.7 km (T) and 20.7 km (C), respectively (Table 3.1). Peres (1999a) identified 4 km per transect as a standard practice for investigating Neotropical primate species. However, in this study the average transect length was only 1.4 km. Smaller transect lengths were required because in most cases it was difficult to site long tourist transect within the floodplain forest types available.

Table 3.1. Number and total length of tourist and control transects at each lodge.

Lodge	**Tourist**		**Control**	
	No. of Transects	**Combined length (km)**	**No. of Transects**	**Combined length (km)**
CAPH	2	3.589	3	4.325
EI	3	3.000	3	3.000
ECO	2	4.700	5	5.725
SACHA	2	3.600	3	3.950
TRC	2	3.850	3	3.700
Total	11	18.739	17	20.700

The line-transect method (Burnham et al 1980, Brockelman et al. 1987) with slight alterations pertinent to rainforest environments [identified by Janzen & Terborgh (1980), Terborgh (1983), Whitesides et al. (1988), Buckland et al. (1993) and Peres (1999)], was implemented. The method involved two observers (although occasionally only one) who walked slowly and quietly along the centre-line of a transect at a rate of approximately 1 km/hr, stopping periodically to listen for the presence of mammals. On observing an individual, whether solitary or part of a group, up to 10 minutes was spent *in situ* recording data, such as: species; principal detection method (visual or auditory); time of day; height of the individual observed above the forest floor (m), in the case of arboreal species; distance along transect (m); straight-line observer-animal distance (m), to first animal sighted; sighting angle (degrees); number of individuals in group; group width (m); duration of visual contact (minutes); behaviour; presence or absence of young juveniles; and general comments. Some of these variables are illustrated in Figure 3.1.

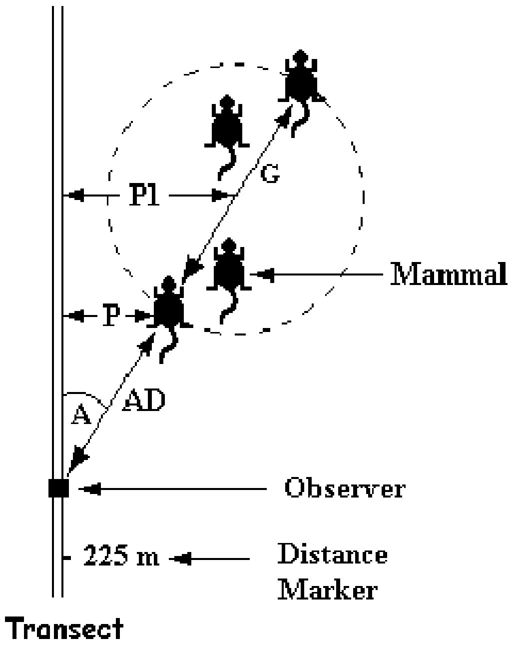


Figure 3.1. Schematic diagram of an encounter with a hypothetical mammal group of four individuals, depicting key data types: AD = Straight-line observer-animal distance to first animal sighted; A = Angle between transect and nearest mammal; G = Group Spread (m); P = Perpendicular detection distance from transect to nearest mammal, P1 = Perpendicular detection distance from transect to centre of mammal group, determined through trigonometry (Equation 3.1).

An individual was considered solitary if no other conspecifics were detected by sight during the 10 minute period it took to collect data. Distances were measured accurately to the nearest metre using a 50 m tape measure, although later in the study, as experience increased, distance estimation by eye was just as reliable for animals detected within 15 m of the observer. Surveys were initiated between 0500 - 0800 hrs and ended between 0700 – 1100 hrs, depending on the location and length of the transect. A survey was abandoned if rain fell continuously for more than 30 minutes, although data collected on distance travelled and mammals encountered before the rain was included in the dataset. During short interruptions for rain (<30 minutes) the observers remained stationary and completed the census after the rain had stopped. Consecutive censuses along any one transect were initiated at least 24 hours apart and direction of travel was reversed where possible.

During opportunistic encounters along the transects, which occurred whilst travelling to the starting point of a census or returning to the lodge afterwards, some of the aforementioned data was also collected, including: species; principal detection method (visual or auditory); distance along transect (m); straight-line observer-animal distance (m) to first animal sighted; sighting angle (degrees); number of individuals in group; and group width (m). This data was only used to analyse habitat visibility levels, species' group spreads, and species' group size (see Results).

Habitat and Fruit Resources

In any investigation of animal populations there is a need to study variations in the habitat in order to help account for variations in abundance. We chose to study the abundance of thirteen plant genera so as to get a better idea of the food and refuge resources available. Ten of the genera were of fruiting trees, of which four (*) are considered "keystones" providing important dry-season food resources for many mammals (Terborgh, 1983, 1986). These are: *Iriartea** (Palmae), *Scheelea** (Palmae), *Astrocaryum** (Palmae), *Ficus** (Moraceae), *Pseudolmedia* (Moraceae), *Brosimum* (Moraceae), *Dipteryx* (Fabaceae), *Caryocar* (Caryocaraceae), *Jacaratia* (Caricaceae), and *Spondias* (Anacardiaceae). The remaining three genera were observed to be important resources to many mammals under investigation either as an alternative food resource or as refuge. These included: *Salacia* (Hippocrateaceae), a fruiting liana; *Phyllocarpus* (Fabaceae), a red-flowering tree rich in nectar; and *Guadua* a genus of giant bamboo which in some areas can form tight impenetrable stands.

The absolute density of the genera selected was calculated by censusing trees in 25 x 50 m quadrats placed end-to-end along the transects. Only trees that had reached at least mid-canopy level were recorded. The sampling regime was adjusted for two genera: for *Phyllocarpus* the quadrat size was reduced to 25 x 25 m as the tree was difficult to identify visually from other genera at distances of more than 12.5 m; for *Guadua*, which has multiple stems per plant we only recorded the presence or absence of stems within the quadrats of 25 x 50 m.

Forage Scrapings

Along the length of the T and C transects a number of randomly placed rectangular shaped quadrats, each 100 m long and 4 m wide (area = 400 m^2), were identified, marked, and monitored for forage scrapings. In total, 110 quadrats were distributed between all available transects. A forage scraping, was characterised by a small earth digging, a result of mammals foraging for below-ground resources such as roots, buried fruit and invertebrates. If less than 1 m separated a group of scrapings they was counted together. Each quadrat was searched independently by eye by walking slowly down the middle of the quadrat. The types of mammals that were most commonly responsible for these scrapings (from direct observation or track data) were: peccaries (*Tayassu tajacu* and *T. pecari*), south american coati (*Nasua nasua*), armadillos (*Dasypus sp.*), paca (*Agouti paca*), and brown agouti (*Dasyprocta variegata*).

Track Census

The nocturnal and elusive behaviour of many terrestrial mammal species made it necessary to study indirect signs of their presence by monitoring their tracks. Firstly, a selection of near-permanently muddy points along the length of the transects were identified, as these areas guaranteed adequate conditions for track surveying throughout most of the year. These we term track traps. In total, 102 track traps, distributed between all available transects, were identified and monitored for the duration of the study. Fallen leaves and debris were cleared from track traps on a regular basis to ensure that the ground conditions were optimal. Every time an observer passed one of these track traps during the course of a transect survey up to a minute was spent recording data on the tracks present, including: the species, the number of individuals (where possible), and whether the tracks were directed along or across the axis of the transect. After having collected the data all tracks were erased.

Tourists and Trail Traffic

Data on tourist visits per month to each lodge (except for ECO), and the characteristics of the tour programs available, for the period 1994-1998 were kindly provided by the administrative staff. Data from official registers kept by the local offices of INRENA and MITINCI regarding declared tourist visits to each lodge was also collected. Furthermore, at four lodges (CAPH, ECO, EI and TRC) a system of formal trail-use monitoring, consisting of daily records of excursions and trails used, was already in place or else developed to obtain more precision regarding tourist related traffic. Such data along with knowledge of trail-use patterns associated with each type of tour program was used to determine in detail the underlying traffic intensity along the tourist transects under investigation at each lodge.

Permanent Settlements and Hunting Pressure

The four lodges closest to Puerto Maldonado (CAPH, ECO, EI, SACHA) are located within an area of the TCRZ influenced by human colonisation and are relatively close to permanent settlements. Such colonisation of riparian habitats for agricultural purposes began about 25 years ago although the majority of the local farmers have settled the banks only in the last 10 years or so. A major implication associated with this process of colonisation, and which cannot be ignored in this investigation, is pressure from hunting. The TRC on the other hand is relatively isolated, has no permanent human settlements within 40 km, and is assumed not be affected by hunting. The impacts of hunting on Neotropical mammals have been widely documented (Peres 1990, 1996, 1999b, Ayres et al. 1991, Fragoso 1991, Mittermeier 1993, Bodmer et al. 1994, 1997, Hill et al. 1997, Maglianesi 1998, Noss 1998) and there is little doubt that it is one of the most significant impacts reducing local abundance of several species.

To determine the importance of tourist traffic as an impact variable, it was necessary first to establish which lodges and which species were most heavily affected by hunting. To measure relative hunting pressure, data was collected on the number of spent cartridges found near the transects and the number of encounters with local inhabitants armed with firearms, normally shotguns, along or near the transects during the course of the investigation. Such data were used to produce a hunting pressure index for each lodge. These indices would be compared against data gathered by Ascorra (1997) and against abundance data of the Spix's Guan (*Penelope jacquacu*), a large cracid species reputedly very sensitive to hunting pressure (Peres 1990, Robinson et al. 1991, Silva & Strahl 1991). Data on this bird was collected in a similar fashion to that undertaken for mammals.

Analysis

Traffic

Calculating average traffic at each lodge, for the five year period concerned, was no easy task. Firstly, the monthly totals provided for CAPH, EI, SACHA and TRC were compared to the official MITINCI and INRENA registers. In percentage terms there was not much difference between these sets of data (+/- 7%), although the data provided by the lodges was marginally greater on the whole. For this reason lodge data formed the basis for calculating traffic at these 4 lodges. Secondly, the number of guides that accompanied the tourists was calculated by dividing the monthly tourist visitor totals by the average group size during excursions, a figure obtained after questioning guiding staff and analysing trail-use registers. This figure was subsequently added to the number of tourists to give yearly totals of potential traffic, i.e. the maximum number of tourists that were available to ventured along the trails.

The information gained from the trail registers showed that, for any given period, more tourists were present at a lodge than actually used the tourist transects under investigation. This is due to the fact that the probability of a tourist venturing out along a T transect is a variable of the tour program itinerary, guide preference, tourist preference, and weather conditions. The potential traffic levels per year (above) were therefore adjusted accordingly to provide a better estimate of actual traffic along only the T transects. Finally, the yearly totals for the period 1994-1998, inclusive, were averaged. This figure was that used to analyse impact, and was measured in terms of the average number of people who ventured out along the T transects per year (i.e. people per year)

In the case of ECO which did not provide detailed data on monthly tourist arrivals, the data collected from the trail registers was used to extrapolate up the data provided by MITINCI for the years 1996-98. For the period 1994-95, when MITINCI was provided with inadequate data for this lodge, we had to estimate tourist arrivals using the percentage trends observed at the other 4 lodges for this period.

Habitat and Fruit Resource

T-tests were used to compare the abundance between T and C at all lodges for each of the 5 most common plant genera under investigation i.e. those that made up between 70-90% of the sample in most cases (*Iriartea, Scheelea, Astrocaryum, Pseudolmedia,* and *Ficus*). To determine if there were any differences in abundance of each of these genera between lodges as a whole, all the available data for each lodge was first combined and subsequently analysed using t-tests. The program SYSTAT was also used to undertake a series of multivariate hierarchical cluster analyses, based on simple Euclidean distances, using data from all 13 genera simultaneously, in order to gauge the level of similarity between lodges.

Hunting Pressure

To determine if the hunting index of a lodge had any effect on mammal abundance a simple Spearman rank correlation coefficient was calculated using combined abundance data for several species known to be commonly sought by hunters in Madre de Dios (collared peccary, brazilian tapir, red howler, brown capuchin, red brocket deer. The relative abundance data collected on the Spix's Guan (*P. jacquacu*) was also regressed against hunting pressure and proved a useful indicator.

Transect Sampling Effort

Transect sampling effort was recorded as the distance (km) censused along T and C transects at each lodge within the permitted time period and weather conditions. The time it took to complete all censuses was also calculated and converted into an average velocity (km/hr).

Mammal Abundance

Encounters with each mammal species during the transects were converted into sighting frequencies, or relative indices of abundance. Initially these were measured in terms of the number of groups sighted per km walked (grps/km). Data collected on average group size for each species was then analysed using t-tests to determine if there were any significant differences in group size between T and C and between lodges as a whole. [Some data was also provided for this test from opportunistic encounters along the T and C transects although outside the census period, particularly where data was scarce.] Subsequently the data for grps/km was converted into individuals per km (ind/km). This index was used in the analysis of impact. For species where sufficient data were available, absolute density estimates (individuals/km^2) were computed using the program Distance developed by Laake et al. (1991), although these results were not used to analyse impacts and are included in this report for reference purposes only.

Forage Scrapings

Paired t-tests (1-tailed) were utilised to determine if there was a marked difference in forage scraping density between T and C from one lodge to another. Furthermore, a Pearson correlation coefficient was calculated to investigate whether there was a link between scraping density and the magnitude of traffic along T.

Tracks

Paired t-tests (1-tailed) were used to determine if there was a significant difference in the abundance of tracks between T and C. Pearson correlation coefficients were calculated to compare T track abundance and traffic, to determine whether any species was significantly affected by varying traffic intensity.

Visibility Levels

To determine if visibility levels were significantly different between T and C and between lodges as a whole the average straight-line observer-animal distances (AD) for the most abundant terrestrial species, the brown agouti, and the most abundant whole arboreal species, the saddleback tamarin, were compared using t-tests. By using these two species we could gauge the visibility through the shrub layer as well as the lower canopy.

Traffic Effects

For each of 13 species, paired t-tests (1-tailed) were used to test for overall significant differences in abundance between T and C. This test was undertaken after the data for these species had first been standardised using percentage abundance, in order to reduce the effects of major differences in abundance between lodges brought about by variables other than traffic. The Pearson correlation coefficient was calculated to investigate the relationship between the abundance of a species and the intensity of traffic along T. Hierarchical cluster analyses were used to determine if there were any similarities between T and C across all lodges for the species that showed the greatest indication of being affected by traffic. The same analysis were used to determine similarities between lodges as a whole based on average abundance per lodge of the 13 species.

Community Effects

The structure of four taxonomic groups: primates (6 species), ungulates (4 species), carnivores (4 species) and rodents (4 species), was determined using relative indices of biomass, i.e. kg observed per km walked, as insufficient data was available to determine absolute density with any degree of accuracy for all the species concerned. Weights for each species were obtained from the literature (Clutton-Brock et al. 1977, Emmons 1984, Robinson et al. 1986, Ayres et al. 1991, Mittermeier 1991, Peres 1993) and multiplied against the relative abundance of each species. Each community was compared between T and C and between lodges as a whole using paired t-tests (1-tailed) after having first converted biomass indices into percentage biomass indices. Finally, hierarchical cluster analyses were used to investigate the similarities between lodges in terms of each community.

Results

Traffic (Trail-use Intensity)

The data revealed that CAPH and the TRC had the highest and lowest traffic levels, respectively (Figure 3.2). The two lodges with the highest values were also those that have been established the longest.

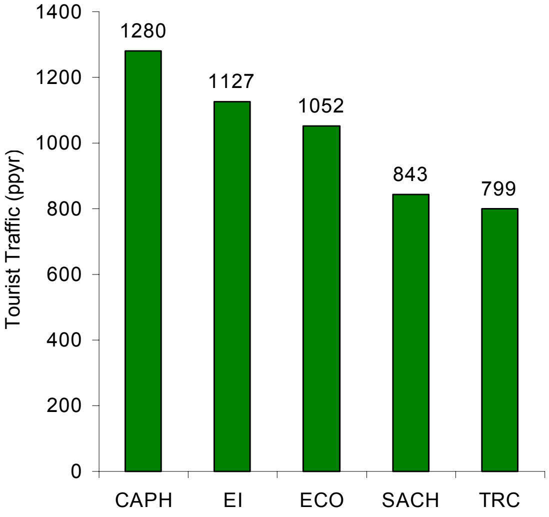


Figure 3.2. Tourist traffic (trail-use intensity) measured in terms of average number of people per year (ppyr) who used the tourist transects over a 5 year period (1994-1998 inclusive). [This data is not equal to total annual tourist arrivals at each lodge.]

Habitat and Fruit Resources

Five genera of fruiting tree dominated the plants under investigation, and accounted for between 70-90% of the samples (in decreasing order of abundance): *Iriartea**, *Astrocaryum**, *Pseudolmedia*, *Scheelea**, and *Ficus** (Figures 3.4-3.8), 4 of which (*) also provide keystone fruit resources for many mammals. The overall density of fruiting trees was highest at the TRC (86 trees/ha) and lowest at CAPH (39 trees/ha)(Figure 3.3).

Iriartea

This palm was by far the most consistently abundant genera at each lodge, making up between 41-82% of the trees under investigation. T-tests revealed that only at the EI was there a significant difference in the density of this palm between T and C (T = 28 trees/ha; C = 21 trees/ha; t = 2.16, $p < 0.05$) (Figure 3.4). The lodges with the highest and lowest average density were TRC (69 trees/ha) and CAPH (14 trees/ha), respectively. Further t-tests revealed that the abundance of this palm was significantly greater at the TRC than at any other lodge.

Scheelea

T-tests revealed that at the EI, ECO and TRC there was a significant difference in the density of this palm between T and C, however there was no consistent trend either way to suggest that tourism was in any way responsible for the difference (Figure 3.5). The lodges with the highest and lowest average density were ECO (9 trees/ha) and TRC (0.5 trees/ha), respectively. The TRC had a significantly lower density of this palm than any other lodge, although the average density was not significantly different between the other four lodges.

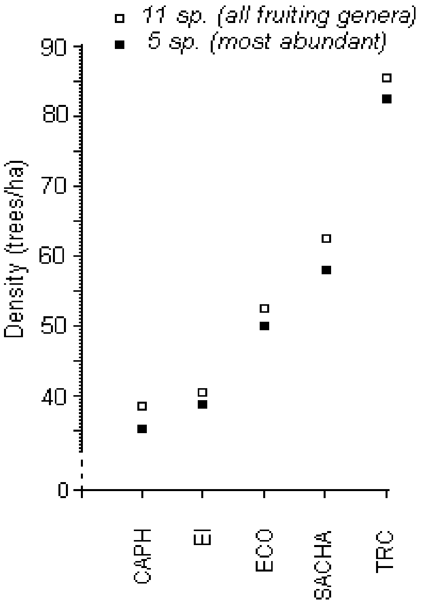


Figure 3.3. Average cumulative density of all 11 fruiting genera (white squares) and the 5 most abundant genera (black squares) at 5 lodges.

Astrocaryum

T-tests revealed that at CAPH, ECO, SACHA and TRC there was a significant difference in density between T and C, however there was no indication that tourism had any role in this (Figure 3.6). The lodges with the highest and lowest average density were ECO (13 trees/ha) and EI (2 trees/ha), respectively. The EI had a significantly lower density than any other lodge. The average density was not significantly different between the other 4 lodges.

Pseudolmedia

T-tests revealed that at CAPH, SACHA and TRC there was a significant difference in density between T and C, however there was no indication that tourism had any role in this (Figure 3.7). The lodges with the highest and lowest average density were ECO (8 trees/ha) and TRC (4 trees/ha), respectively. The density between ECO and SACHA was not significantly different although they both had significantly higher densities that the other three lodges.

Ficus

T-tests revealed that only at ECO was there a significant difference in density between T and C (T = 3.4 trees/ha; C = 2.2 trees/ha; t = 2.19, $p < 0.03$)(Figure 3.8). The lodges with the highest and lowest average density were ECO (2.8 trees/ha) and EI (1.8 trees/ha), respectively, although as a whole there were no significant differences in density between lodges.

Guadua

Bamboo was completely absent from the two lodges located along the Madre de Dios River (CAPH and ECO). It was most common along the Tambopata River at SACHA where it was more abundant along C than along T (Figure 3.9). At EI the average relative density was lower than at the other two lodges located along the Tambopata River, which in turn were found to be not significantly different from one another.

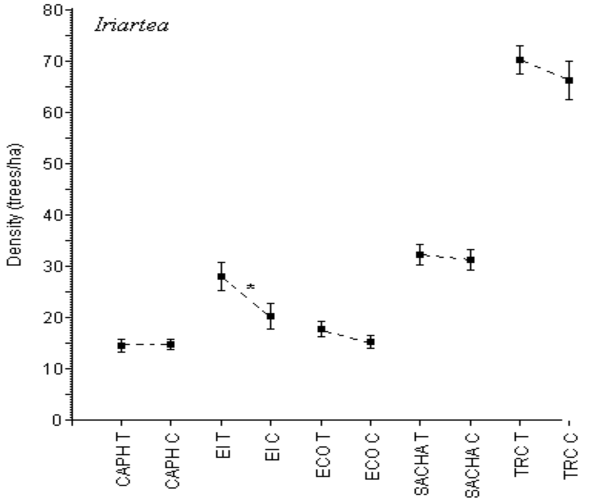


Figure 3.4. Density of the pona palm (*Iriartea*); * significant difference between T and C.

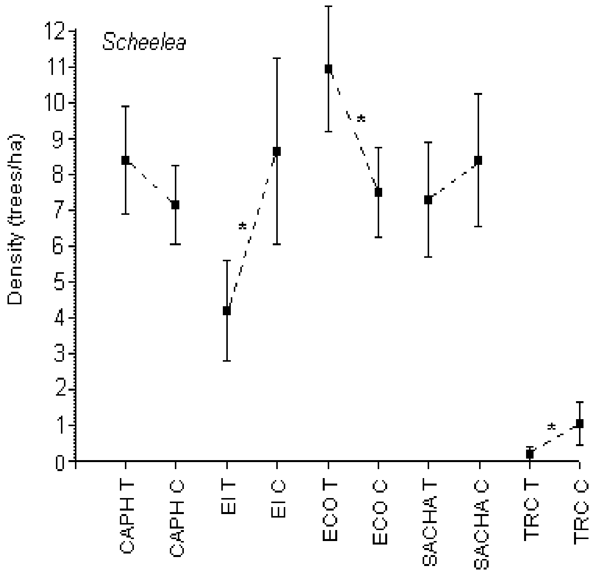


Figure 3.5. Density of the shebon palm (*Scheelea*); * significant difference between T and C.

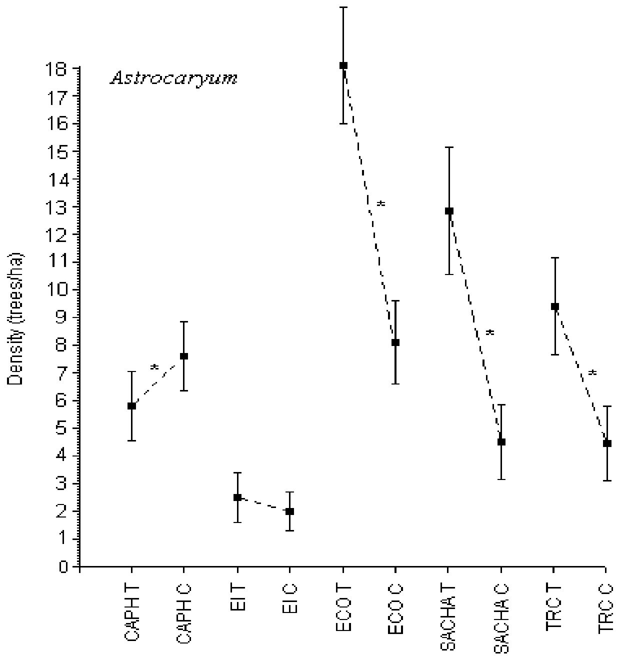


Figure 3.6. Density of the huicunguo palm (*Astrocaryum*); * significant difference between T and C.

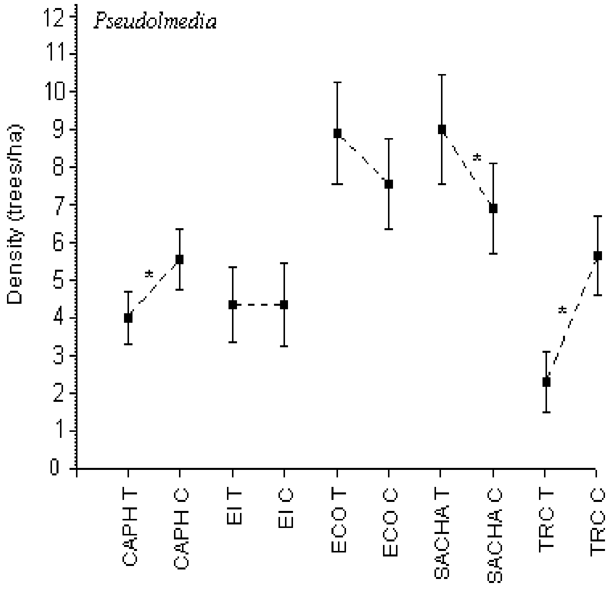


Figure 3.7. Density of the chimicua tree (*Pseudolmedia*); * significant difference between T and C.

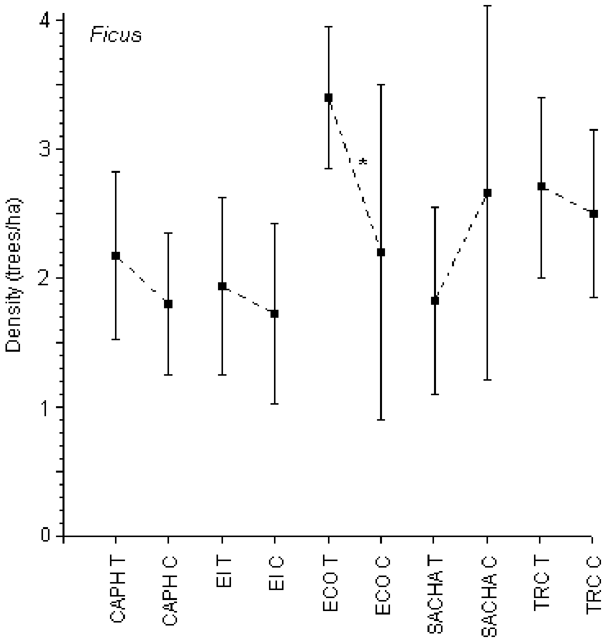


Figure 3.8. Density of the fig tree (*Ficus*); * significant difference between T and C.

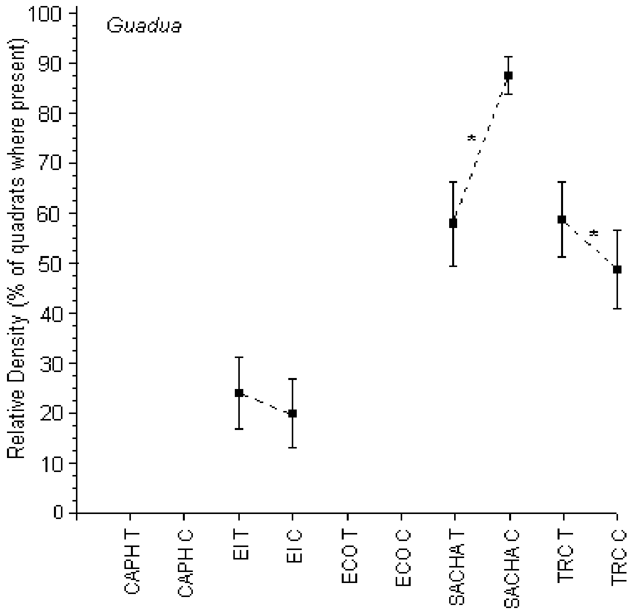


Figure 3.9. Relative density of Bamboo (*Guadua*); * significant difference between T and C.

A multivariate hierarchical cluster analysis revealed that lodges which are geographically close to one another are more similar in terms of the 13 genera studied (Figure 3.10) than those far apart, although in the majority of cases more than 50% of the variation is due to the dominance of one genera of palm (*Iriartea*). The major indicator genera which can explain the majority of the cluster pattern are: *Iriartea, Pseudolmedia,* and *Guadua*. The grouping together of the 4 lodges most closely associated with human colonisation and the large discrepancy between these and the TRC may well be likely to historical anthropogenic pressures on these genera, particularly the palms which are frequently used by the native and non-native peoples of the area. *Iriartea* for instance, which is responsible for the majority of the similarity between the 4 lodges is a common construction material and is also felled frequently to provide breeding grounds for beetle larvae, a local delicacy. Climate may also be playing a role in the observed abundance patterns, as it is known that the TRC receives more annual precipitation than the other lodges.

```
ECO    ---+
          +-----+
CAPH   ---+     +
                +------------------------------------------+
EI     -----+   +                                          +
            +---+                                          +
SACHA  -----+                                              +-------
                                                           +
TRC    ----------------------------------------------------+
```

Figure 3.10. Hierarchical cluster analysis of lodges based on the abundance of 13 plant genera.

Hunting Pressure

Data on spent shotgun cartridges found and encounters with local people carrying shotguns, showed that hunters are active at 3 lodges (SACHA, CAPH and ECO), however those with the highest hunting indices by far were SACHA and CAPH (Table 3.2). A Spearman correlation coefficient was calculated to analyse the relationship between hunting index and the relative abundance of five species frequently sought by hunters in Madre de Dios. The result was significantly negative (Spearman = -0.87, $p < 0.05$) (Table 3.3). One might have expected that EI be heavily affected from this activity due to its location near the native Ese'eja community of Infierno and the community of La Torre, however it appears that over the last 20 years or so these communities have largely respected the "reserve" status of the land used for tourism and do not now hunt within it. Data collected on the abundance of the Spix´s guan (*P. jacquacu*) also strongly suggests that hunting is very prevalent at CAPH and SACHA (Figure 3.11). Furthermore, the conclusions of Ascorra (1997) serve to reinforce these results.

Table 3.2. Hunting pressure variables at each lodge.

Lodge	No. of people encountered with rifles	Cartridges found along trails (1=Yes, 0=No)	Hunting Index	Distance travelled (km)
SACHA	5	1	6	296
CAPH	4	1	5	315
ECO	1	1	2	310
EI	0	0	0	172
TRC	0	0	0	181

Table 3.3. Spearman Rank Correlation Coefficient between a lodge's hunting index and the relative abundance of 5 species frequently sought by hunters in Madre de Dios (Collared Peccary, Brazilian Tapir, Red Howler, Brown Capuchin, Red Brocket Deer). Relative abundance was transformed using the following formula Sqrt(abundance+1).

Lodge	Hunting Index	Mammal Abundance Score	Spearman
SACHA	6	5.160	- 0.87 *
CAPH	5	5.102	
ECO	2	5.357	
EI	0	5.378	
TRC	0	5.725	

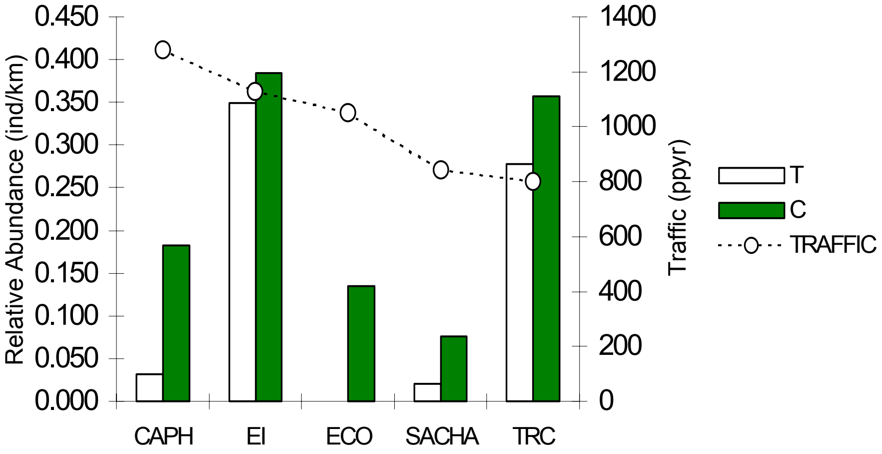


Figure 3.11. Relative abundance (individuals/km walked) of the Spix´s Guan (*Penelope jacquacu*).

Transect Sample Effort

Sampling effort, measured in terms of diurnal kilometres walked, along T and C transects at any lodge was very similar (Table 3.4). However, there were substantial differences in overall effort between lodges, the greatest extreme being 172 km (EI) versus 315 km (CAPH), a difference of 45%. This was due to a combination of factors; varying total transect lengths between lodges (EI had the lowest total) and the fact that TRC was only visited on five occasions and not the planned six. Overall, the total sample effort for the study was 1,274 km which is far more than any other study of its kind. The average speed of travel during transect censusing was 1.11 km/hr, which is close to the desired speed of 1 km/hr.

Table 3.4. Total number of kilometres sampled at each lodge.

Lodge	Tourist Transects (km)	Control Transects (km)	Total (km)
CAPH	156	159	315
EI	86	86	172
ECO	155	155	310
SACHA	151	145	296
TRC	97	84	181
Total	645	629	1,274

Species Richness (No. of Species)

During transect censuses and at opportunistic encounters at other times, between 21 - 27 species of mammal were recorded (visually and by track data) at each lodge for a total of 31 species (Figure 3.12). There was no statistical difference in species richness between T and C transects at any lodge. However, richness was found to be significantly negatively correlated with hunting pressure (Spearman = –0.90, $p < 0.05$). Both of these results suggest that tourist traffic on its own has little effect on species richness.

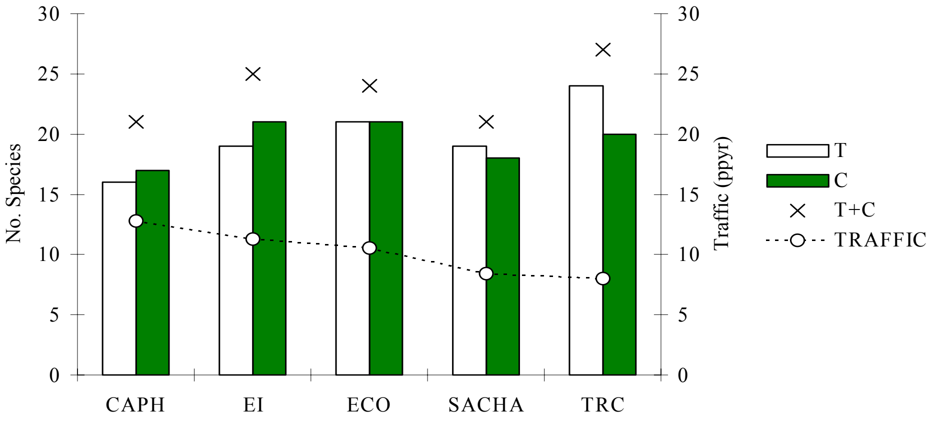


Figure 3.12. Species richness at each lodge, determined from visual observations and track data collected during transect surveys and opportunistic encounters.

Group Size

On many occasions it was impossible to accurately count groups because they were spread so sparsely over a relatively large area, however when a group was located feeding in a tree or travelling rapidly in linear formation over a transect it was possible to count them with more accuracy. Estimates of average group size per species were calculated from data on complete counts of groups when encountered during strict transect surveys and during opportunistic encounters along the transects at other times.

The species with the largest group size was the squirrel monkey (*Saimiri boliviensis*) which on one occasion reached 85 individuals (at SACHA). T-tests revealed that there was no significant variation in group size for any species between T and C transects at any lodge. However, further tests using pooled data from each lodge revealed that group sizes for the saddleback tamarin (*Saguinus fuscicollis*) (Figure 3.13; Table 3.5) and brown capuchins (*Cebus apella*) (Figure 3.14; Table 3.6) varied significantly between some lodges. Pearson rank correlation coefficients revealed that tamarin group size was significantly positively correlated with traffic (Pearson = +0.92, $p < 0.05$), whilst that of the capuchin was significantly negatively correlated with hunting pressure (Pearson = -0.88, $p < 0.05$). Overall, average group sizes calculated for a number of species are very similar to those found in other studies in Madre de Dios (Janzen et al. 1980, Freese et al. 1982, Kiltie 1983, Terborgh 1983, Ascorra 1997) (Table 3.7).

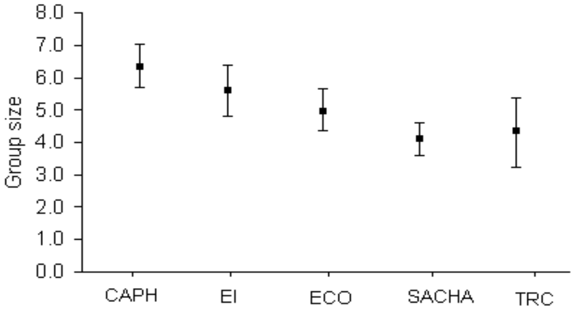


Figure 3.13. Group size variation between lodges for the Saddleback tamarin (*S. fuscicollis*).

Table 3.5. Probability values derived from t-tests of tamarin group sizes. * $p < 0.05$, ** $p < 0.01$.

	CAPH	EI	ECO	SACHA
EI	0.06			
ECO	0.00**	0.15		
SACHA	0.00**	0.00**	0.02*	
TRC	0.00**	0.04*	0.15	0.36

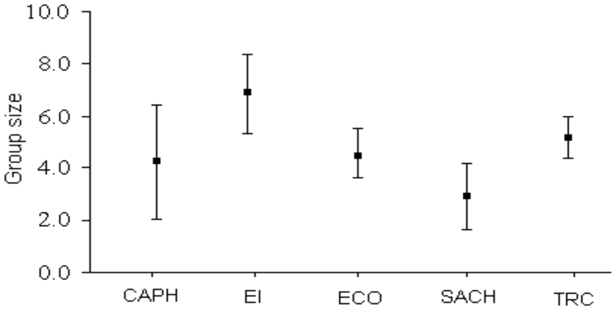


Figure 3.14. Group size variation between lodges for the Brown capuchin (*C. apella*).

Table 3.6. Probability values derived from t-tests of Brown capuchin group sizes. * $p < 0.05$, ** $p < 0.01$.

	CAPH	EI	ECO	SACHA
EI	0.05*			
ECO	0.41	0.01*		
SACHA	0.16	0.00**	0.02*	
TRC	0.25	0.03*	0.18	0.00*

Table 3.7. Summary of group size estimation using data from complete counts of identifiable conspecific and mixed species groups at all lodges. Other Studies: [1] Freese et al. (1982), [2] Kiltie et al. (1983), [3] Warner (1999).

Species		**Group Size**					
		N	**Min.**	**Max.**	**Ave.**	**95% CI**	**Other studies**
Southern Tamandua	*T. tetradactyla*	15	1	2	1.10	+/- 0.10	
Saddleback Tamarin	*S. fuscicollis*	288	1	16	5.40	+/- 2.20	6, 7 (1, 3)
Squirrel Monkey	*S. boliviensis*	57	1	85	28.60	+/- 5.32	40, 18 (1, 3)
Dusky titi Monkey	*C. brunneus*	44	1	6	2.70	+/- 1.90	3, 3 (1, 3)
Red Howler	*A. seniculus*	54	1	10	4.00	+/- 0.60	5 (1)
White-fronted Capuchin	*C. albifrons*	8	1	32	12.5	+/- 8.30	
Brown capuchin	*C. apella*	109	1	12	4.70	+/- 1.10	10, 6 (1, 3)
Black Spider Monkey	*A. belzebuth*	34	1	16	5.20	+/- 1.30	7 (1)
South American Coati	*N. nasua*	25	1	15	5.40	+/- 1.80	
Collared Peccary	*T. tajacu*	75	1	9	2.00	+/- 0.30	2 (2)
Bolivian Squirrel	*S. ignitus*	118	1	6	1.14	+/- 0.10	
Southern Amazon Red Squirrel	*S. spadiceus*	672	1	5	1.15	+/- 0.04	
Brown Agouti	*D. variegata*	364	1	3	1.10	+/- 0.03	

Mammal Abundance

After 23 months of censuses along T and C transects the team visually observed a total of 26 species and took data on 1,328 mammal groups, which on analysis equated to 4,568 individual animals. Encounter rates for each species, in terms of groups and individuals encountered per km walked are summarised in Tables 3.8-3.10. The three most often encountered species were the Southern amazon red squirrel (*Sciurus spadiceus*) with 516 encounters, Saddleback tamarin (*S. fuscicollis*) with 176 encounters, and the Brown agouti, with 169 encounters. Five species were observed on only once occasion while 15 species were observed on 10 occasions or more.

Table 3.8. Number of visual encounters with 26 species along tourist (T) and control (C) transect type at five lodges.

Lodge	**CAPH**		**EI**		**ECO**		**SACHA**		**TRC**		**Total**
Transect type	**T**	**C**	**T**	**C**	**T**	**C**	**T**	**C**	**T**	**C**	
Sample Effort (km)	156	159	86	86	155	155	151	145	97	84	1274
Xenarthra											
Myrmecophaga tridactyla		1	-	-	-	-	-	-	-	-	1
Tamandua tetradactyla	-	-	1	-	4	4	4	-	1	-	14
Bradypus variegata	-	-	-	1	-	-	-	-	2	-	3
Dasypus sp.	-	-	-	1	-	-	-	-	-	-	1
Primates											
Saguinus fuscicollis	47	25	10	7	31	22	10	12	4	8	176
Saimiri boliviensis	1	6	-	1	11	5	8	9	13	3	57
Aotus sp.	-	-	-	1	-	1	-	13	1	-	16
Callicebus brunneus	3	-	4	2	-	-	1	-	1	10	21
Alouatta seniculus	1	-	6	1	4	10	3	1	8	2	36
Cebus albifrons	-	-	-	-	1	4	-	-	-	-	5
Cebus apella	-	5	4	10	11	14	1	6	16	11	78
Ateles belzebuth	-	-	-	-	-	-	-	-	6	13	19
Carnivora											
Atelocynus microtis	-	-	-	-	-	-	-	-	1	-	1
Nasua nasua	1	-	-	1	2	3	-	4	1	-	12
Eira barbara	3	1	2	2	2	3	1	8	4	2	28
Gallictis vitata	-	-	-	-	1	-	-	-	-	-	1
Lontra longicauda	-	-	-	-	-	-	-	-	-	1	1
Leopardus pardalis	1	-	-	-	-	-	2	-	1	-	4
Perissodactyla											
Tapirus terrestris	-	-	-	-	-	2	-	-	1	2	5
Artiodactyla											
Tayassu pecari	-	-	-	-	-	-	-	1	1	-	2
Tayassu tajacu	3	7	8	7	-	4	4	9	4	1	47
Mazama americana	-	3	-	3	-	5	2	5	1	1	20
Rodentia											
Sciurus ignitus	14	17	6	3	4	2	13	9	16	8	92
Sciurus spadiceus	110	87	35	18	79	58	36	44	19	30	516
Dasyprocta variegata	43	20	8	12	6	20	27	26	4	3	169
Myoprocta pratti	-	1	-	1	1	-	-	-	-	-	3
Total	**227**	**173**	**84**	**71**	**157**	**157**	**112**	**147**	**105**	**95**	
T+C	**400**		**155**		**314**		**259**		**200**		**1328**

Table 3.9. No. of groups sighted per km walked for 26 species.

Lodge	**CAPH**		**EI**		**ECO**		**SACHA**		**TRC**		**Ave. $(x10^2)$**
Transect Type	**T**	**C**	**T**	**C**	**T**	**C**	**T**	**C**	**T**	**C**	
Sample Effort (km)	156	159	86	86	155	155	151	145	97	84	
Xenarthra											
Myrmecophaga tridactyla	-	0.012	-	-	-	-	-	-	-	-	0.10
Tamandua tetradactyla	-	-	0.012	-	0.026	0.026	0.026	-	0.010	-	1.00
Bradypus variegata	-	-	-	0.012	-	-	-	-	0.021	-	0.03
Dasypus sp.	-	-	-	0.012	-	-	-	-	-	-	0.10
Primates											
Saguinus fuscicollis	0.301	0.157	0.116	0.081	0.200	0.142	0.066	0.083	0.041	0.095	12.82
Saimiri boliviensis	0.006	0.038	-	0.012	0.071	0.032	0.053	0.062	0.134	0.036	4.44
Aotus sp.	-	-	-	0.012	-	0.006	-	0.090	0.010	-	1.18
Callicebus brunneus	0.019	-	0.047	0.023	-	-	0.007	-	0.010	0.119	2.25
Alouatta seniculus	0.006	-	0.070	0.010	0.026	0.065	0.020	0.007	0.082	0.024	3.10
Cebus albifrons	-	-	-	-	0.006	0.026	-	-	-	-	0.32
Cebus apella	-	0.031	0.047	0.116	0.071	0.090	0.007	0.041	0.165	0.131	6.99
Ateles belzebuth	-	-	-	-	-	-	-	-	0.062	0.155	2.17
Carnivora											
Atelocynus microtis	-	-	-	-	-	-	-	-	0.010	-	0.10
Nasua nasua	0.006	-	-	0.012	0.013	0.019	-	0.028	0.010	-	0.88
Eira barbara	0.019	0.006	0.023	0.023	0.013	0.019	0.007	0.055	0.041	0.024	2.30
Gallictis vitata	-	-	-	-	0.012	-	-	-	-	-	0.12
Lutra longicauda	-	-	-	-	-	-	-	-	-	0.012	0.12
Leopardus pardalis	0.006	-	-	-	-	-	0.013	-	0.010	-	0.29
Perissodactyla											
Tapirus terrestris	-	-	-	-	-	0.013	-	-	0.010	0.024	0.47
Artiodactyla											
Tayassu pecari	-	-	-	-	-	-	-	0.007	0.010	-	0.17
Tayassu tajacu	0.019	0.044	0.093	0.081	-	0.026	0.026	0.062	0.041	0.012	4.04
Mazama americana	-	0.019	-	0.035	-	0.032	0.013	0.034	0.010	0.012	1.55
Rodentia											
Sciurus ignitus	0.090	0.107	0.070	0.035	0.026	0.013	0.086	0.062	0.165	0.095	7.63
Sciurus spadiceus	0.705	0.547	0.407	0.209	0.510	0.374	0.238	0.303	0.196	0.357	38.46
Dasyprocta variegata	0.276	0.126	0.093	0.140	0.039	0.129	0.179	0.179	0.041	0.036	12.38
Myoprocta pratti	-	0.006	-	0.012	0.006	-	-	-	-	-	0.24
Total	**1.462**	**1.107**	**1.000**	**0.814**	**0.994**	**0.987**	**0.742**	**1.014**	**1.082**	**1.131**	
Average	**1.285**		**0.907**		**0.991**		**0.878**		**1.107**		**1.033**

Table 3.10. No. of individuals sighted per km walked for 26 species.

Lodge	**CAPH**		**EI**		**ECO**		**SACHA**		**TRC**		**Ave. ($x10^{-2}$)**
Transect Type	**T**	**C**	**T**	**C**	**T**	**C**	**T**	**C**	**T**	**C**	
Sample Effort (km)	156	159	86	86	155	155	151	145	97	84	
Xenarthra											
Myrmecophaga tridactyla	-	0.012	-	-	-	-	-	-	-	-	0.12
Tamandua tetradactyla	-	-	0.013	-	0.028	0.028	0.029	-	0.011	-	1.09
Bradypus variegata	-	-	-	0.012	-	-	-	-	0.021	-	0.33
Dasypus sp.	-	-	-	0.012	-	-	-	-	-	-	0.12
Primates											
Saguinus fuscicollis	1.838	0.959	0.663	0.464	0.960	0.681	0.285	0.356	0.190	0.438	68.34
Saimiri boliviensis	0.213	1.257	-	0.430	1.476	0.671	1.648	1.930	3.659	0.975	122.59
Aotus sp.	-	-	-	0.023	-	0.026	-	0.161	0.041	-	2.51
Callicebus brunneus	0.044	-	0.140	0.070	-	-	0.023	-	0.025	0.286	5.88
Alouatta seniculus	0.026	-	0.342	0.080	0.106	0.265	0.036	0.012	0.305	0.088	12.6
Cebus albifrons	-	-	-	-	0.081	0.323	-	-	-	-	4.04
Cebus apella	-	0.110	0.377	0.942	0.305	0.388	0.023	0.141	0.940	0.746	39.72
Ateles belzebuth	-	-	-	-	-	-	-	-	0.322	0.805	11.27
Carnivora											
Atelocynus microtis	-	-	-	-	-	-	-	-	0.010	-	0.1
Nasua nasua	0.013	-	-	0.012	0.090	0.135	-	0.221	0.134	-	6.05
Eira barbara	0.019	0.006	0.030	0.030	0.015	0.023	0.008	0.066	0.082	0.048	3.27
Gallictis vitata	-	-	-	-	0.012	-	-	-	-	-	0.12
Lutra longicauda	-	-	-	-	-	-	-	-	-	0.012	0.12
Leopardus pardalis	0.006	-	-	-	-	-	0.013	-	0.010	-	0.29
Perissodactyla											
Tapirus terrestris	-	-	-	-	-	0.013	-	-	0.010	0.024	0.47
Artiodactyla											
Tayassu pecari	-	-	-	-	-	-	-	0.207	0.515	-	7.22
Tayassu tajacu	0.035	0.079	0.158	0.138	-	0.077	0.061	0.143	0.078	0.023	7.92
Mazama americana	-	0.019	-	0.035	-	0.032	0.013	0.034	0.010	0.012	1.55
Rodentia											
Sciurus ignitus	0.099	0.118	0.077	0.038	0.028	0.014	0.095	0.068	0.181	0.105	8.23
Sciurus spadiceus	0.846	0.657	0.488	0.251	0.612	0.449	0.286	0.364	0.235	0.429	46.17
Dasyprocta variegata	0.303	0.138	0.102	0.153	0.043	0.142	0.197	0.197	0.045	0.039	13.59
Myoprocta pratti	-	0.006	-	0.012	0.006	-	-	-	-	-	0.24
Total	**3.442**	**3.361**	**2.401**	**2.610**	**3.757**	**3.268**	**2.716**	**3.901**	**6.827**	**4.029**	
Average	**3.402**		**2.506**		**3.513**		**3.309**		**5.428**		**3.631**

Mammal Density

To estimate the absolute density of a species it was first necessary to determine the effective area of forest sampled. This area is a factor of the distance walked (km) and the perpendicular detection distance of a species (Psp). This variable in turn was derived from a complicated analysis of all the perpendicular detection distances for a species using the program Distance (Laake et al. 1991). Each perpendicular distance estimate for each encounter was determined using Equation 3.1, where; P1 = Perpendicular detection distance (km); AD = Straight-line detection distance (km); G = Group spread (km); and A = Sighting angle (radians)(see Figure 3.1). For solitary species G is zero. A more detailed explanation of the parameters involved can be found in Buckland et al. (1993). Here we present a summary of the results pertaining to; group spread for the 10 most common species, encountered in groups of two or more; perpendicular detection distances of 14 species; and finally density estimations of 12 species for which sufficient data exists to calculate confidence limits.

Equation 3.1: $P1 = (AD+0.5G) \times \mathrm{Sin}(A);$

Group Spread (G)

Group spread was measured as the straight-line distance (m) between the first individual sighted and the individual furthest away at the moment a group was encountered (see Figure 3.1). Sufficient data on group spread was collected for ten species (Table 3.11). The Squirrel monkey (*S. boliviensis*) consistently formed the largest groups with group spreads averaging 31 m. By contrast the Brown agouti, which is normally solitary although occasionally found in pairs, had group spreads averaging 4 m. Group spread is very much a species specific variable and in turn is affected by variables such as group size, species weight, behaviour, etc.

Table 3.11. Average group spreads for 10 species, * ½ Group Spread, calculated by including data on encounters with solitary animals (i.e. where G = 0) and is the value used in Equation 3.1.

Species	**Group spread (m) (2+ ind/grp.)**		**½ Group Spread (m)* [Adjusted for Solitaries]**
	N	**Ave.**	
S. fuscicollis	146	13	6.1
S. boliviensis	11	31	14.6
C. brunneus	13	11	4.7
A. seniculus	24	8	3.6
C. apella	38	18	7.9
A. belzebuth	11	30	13.8
N. nasua	5	10	3.9
T. tajacu	11	5	1.1
S. spadiceus	28	6	0.2
D. variegata	14	4	0.1

Species-Specific Detection Distances (Psp)

Every species differs in its detectability to a human observer, particularly in rainforest habitats where visibility is naturally impeded. The important variables that are at play include: degree of social or solitary behaviour, social species as a rule are easier to detect; group size, the larger the group size the easier it is to detect; species weight, the heavier a species the more noise it tends to make whilst in motion and hence the greater its detectability; anti-predator behaviour, some species flee on observing a potential predator (human) whilst others freeze; and calling behaviour, the more noise a species makes during intra- or inter-group communication the greater its detectability. The innumerable permutations of these variables in the field endow every species with its own distinctive detection distance.

The perpendicular detection distances for the species in Table 3.11 were calculated using the computer program Distance (Laake et al. 1993). This program can determine an appropriate detection function or distance decay model, for a species, using the frequency distribution of P1 data and isolates the perpendicular distance beyond which the number of groups observed equals the number of groups likely to have been overlooked (Figure 3.15).

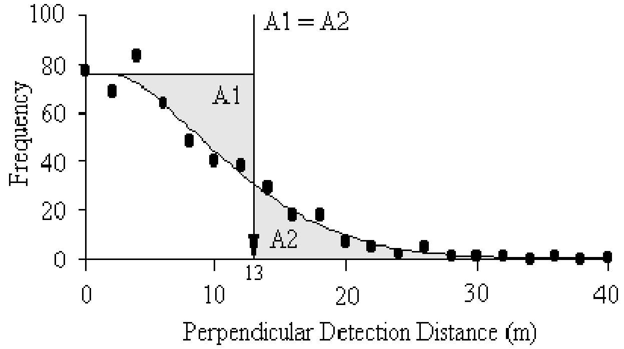


Figure 3.15. Frequency distribution of perpendicular detection distances for the Southern amazon red squirrel (*S. spadiceus*). Program Distance computes the appropriate detection function, and then calculates the distance where the area of A1 equals that of A2; in this case 13 m.

Table 3.12. Perpendicular detection distance (Psp), 95% CI, and appropriate distance decay model for 12 species for which sufficient data was collected. Distance decay models: HNC = Half-Normal/Cosine; UC = Uniform/Cosine; HC = Hazard/Cosine.

Species	Psp (m)	95% CI	“Distance” Model	Species	Psp (m)	95% CI	“Distance” Model
T. tetradactyla	22	12 – 38	UC	*N. nasua*	27	20 – 36	UC
S. fuscicollis	32	28 – 35	HC	*T. tajacu*	15	13 – 18	UC
S. boliviensis	50	40 –62	UC	*M. americana*	15	11 – 21	UC
C. brunneus	26	18 – 39	HC	*S. ignitus*	10	9 – 12	UC
A. seniculus	30	24 – 39	HNC	*S. spadiceus*	13	12 – 14	HNC
C. apella	39	33 – 47	UC	*D. variegata*	13	11 – 15	HC

Table 3.13. Perpendicular detection distance (Psp), for 14 species for which insufficient data was collected to determine 95% CI.

Species	Psp (m)	Species	Psp (m)
M. tridactyla	15	*E. barbara*	18
B. variegata	1	*G. vitata*	10
Dasypus sp.	5	*L. longicauda*	24
Aotus sp.	13	*L. pardalis*	46
C. albifrons	77	*T. terrestris*	50
A. belzebuth	63	*T. pecari*	50
A. microtis	18	*M. pratti*	13

Table 3.14. Density estimates for 12 mammal species (individulas/km^2).

Species	CAPH		EI		ECO		SACHA		TRC	
	T	C	T	C	T	C	T	C	T	C
T. tetradactyla	0.0	0.0	0.5	0.0	1.1	1.1	1.2	0.0	0.5	0.0
S. fuscicollis	29.1	15.2	10.5	7.4	15.2	10.8	4.5	5.6	3.0	6.9
S. boliviensis	2.1	12.6	0.0	4.3	14.8	6.7	16.5	19.3	36.6	9.8
C. brunneus	0.8	0.0	2.6	1.3	0.0	0.0	0.4	0.0	0.5	5.4
A. seniculus	0.4	0.0	5.6	0.0	1.7	4.3	0.6	0.2	5.0	1.5
C. apella	0.0	1.4	4.8	12.0	3.9	4.9	0.3	1.8	11.9	9.5
N. nasua	0.2	0.0	0.0	0.2	1.7	2.5	0.0	4.1	2.5	0.0
T. tajacu	1.1	2.6	5.2	4.5	0.0	2.5	2.0	4.7	2.6	0.7
M. americana	0.0	0.6	0.0	1.2	0.0	1.1	0.4	1.1	0.3	0.4
S. ignitus	4.8	5.8	3.8	1.9	1.4	0.7	4.7	3.4	8.9	5.1
S. spadiceus	31.9	24.7	18.4	9.5	23.0	16.9	10.8	13.7	8.9	16.2
D. variegata	11.8	5.4	4.0	6.0	1.7	5.5	7.6	7.7	1.8	1.5

Forage Scrapings

A total of 342 individual quadrat searches were made over the period of the study, for an average of 3.1 searches per quadrat and a total search area of 13.7 hectares (Table 3.15). This search effort encountered a total of 751 forage scrapings, the overall distribution of which was found to be significantly clumped and characterised by a negative binomial distribution (Figure 3.16), as shown by the values of Index of Dispersion (Observed variance/Observed mean) which are generally larger than 1. A paired t-test revealed that the average density of scrapes along T transects was found to be significantly lower than along C transects ($t = -3.37$, $p < 0.03$), a trend that is evident from figure 3.17. Furthermore, a Pearson correlation coefficient revealed a significant negative correlation between traffic and scrape density near T (Pearson = –0.92, $p < 0.05$).

Table 3.15. Summary of scrapings data, each quadrat = 0.04 ha.

Lodge		No. of quadrats sited	No. of searches	Area searched (ha)	No. scrapes found	Ave. Density (scr/quad)	VAR	Index of Dispersal
CAPH	T	16	49	1.96	43	0.88	1.77	2.02
	C	13	35	1.40	73	2.09	4.54	2.18
EI	T	7	23	0.92	24	1.04	2.50	2.40
	C	7	24	0.96	156	6.50	40.58	6.24
ECO	T	11	40	1.60	36	0.90	2.86	3.18
	C	13	52	2.08	119	2.29	3.03	1.32
SACHA	T	9	26	1.04	36	1.38	4.67	3.37
	C	9	24	0.96	146	6.08	19.54	3.21
TRC	T	13	35	1.40	50	1.43	1.54	1.08
	C	12	34	1.36	68	2.00	1.82	0.91
Total		110	342	13.68	751	2.20	9.73	2.59

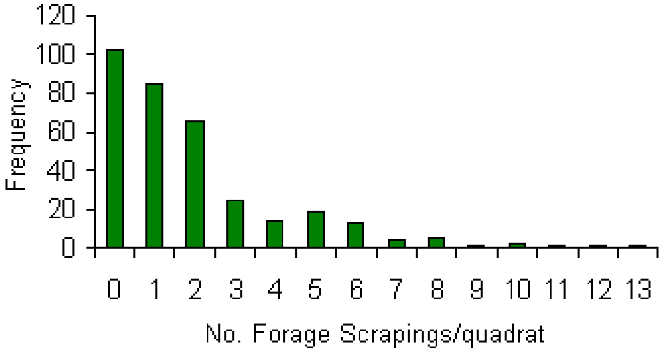


Figure 3.16. Frequency distribution of number of forage scrapings per quadrat.

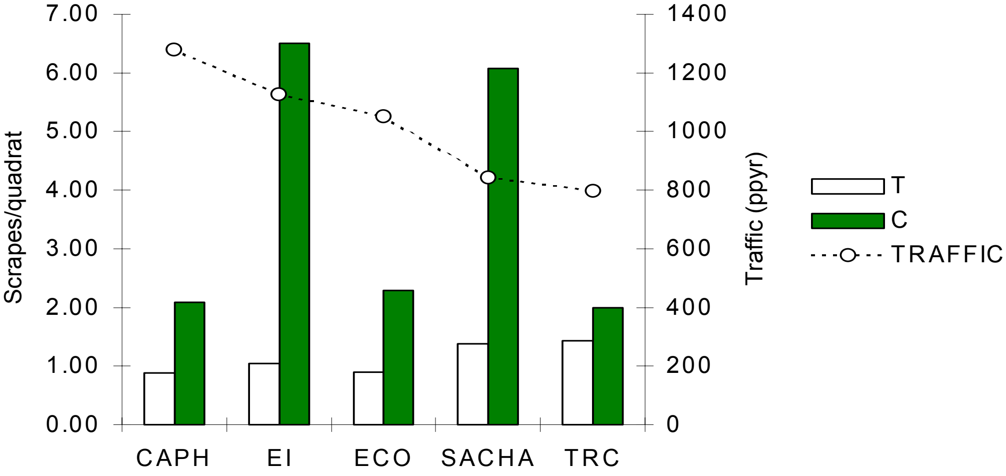


Figure 3.17. Scrape density along T and C at each lodge.

Track Census

Tracks were recorded for a total of 15 species although there was only sufficient data available to adequately graph 7 of them; 2 cats (*L. pardalis, P. onca*), 3 ungulates (*T. tajacu, M. americana, T. terrestris*), and 2 rodents (*D. variegata, A. paca*). These species yielded 330 separate track encounters in designated track traps. Paired t-tests revealed that the abundance of jaguar (*P. onca*) tracks were greater along T transects than C transects. The results for this species (Figure 3.18) give the impression that it is restricted almost entirely to tourist trails! This however is not the case, the results are probably an artefact of the methodology and the behaviour of this species. It was noted that jaguars did walk along C but much less frequently and for shorter distances than along T, thus significantly reducing the chances of them being recorded. Furthermore, it has been known for some time that this and other cat species show a significant propensity to walk along man-made tails for long distances (Emmons 1984, 1990). The methodology is therefore significantly biased towards over-recording of species which prefer to walk along open clear trails for long distances. The trend in track abundance between T and C for 3 species were significantly correlated: *T. tajacu,*(Spearman = +0.87), *L. pardalis* (Spearman = +1.00) and *A. paca* (Spearman = +1.00). Further Spearman correlation analyses (Table 3.16) showed that all species except *T. tajacu* were negatively correlated with traffic along tourist transects, however only *M. americana*, *T. terrestris* and *L. pardalis* were significantly affected it appears. No correlation was evident between track abundance and relative abundance, as calculated from observational data, for any species.

Table 3.16. Results from a Spearman correlation analysis between traffic and track abundance along T. * p < 0.05

Species	***D. variegata***	***A. Paca***	***M. americana***	***T. terrestris***	***T. tajacu***	***P. onca***	***L. pardalis***
Spearman	-0.67	-0.50	-0.90 *	-0.87 *	+0.1	-0.56	-0.80 *

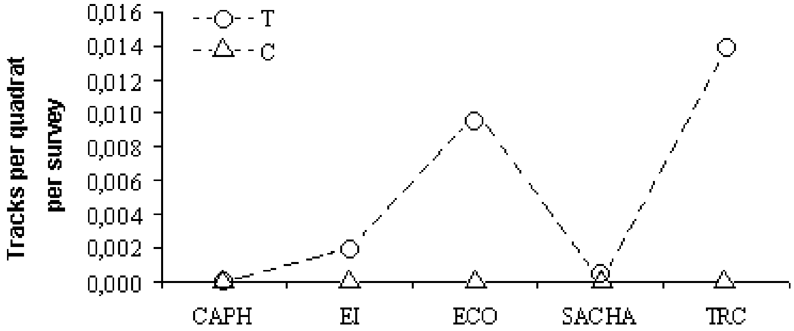


Figure 3.18. Relative abundance of Jaguar (*P. onca*) tracks.

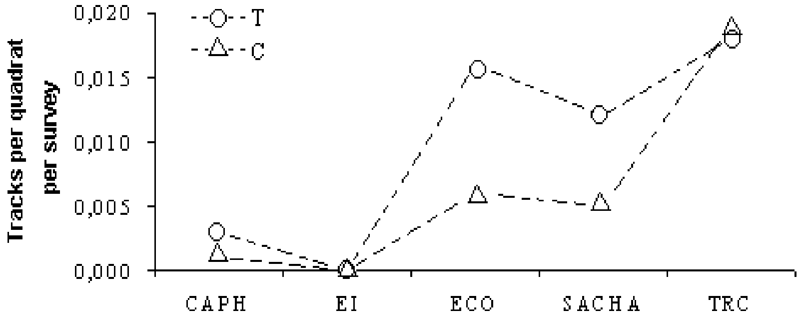


Figure 3.19. Relative abundance of Ocelot (*L. pardalis*) tracks.

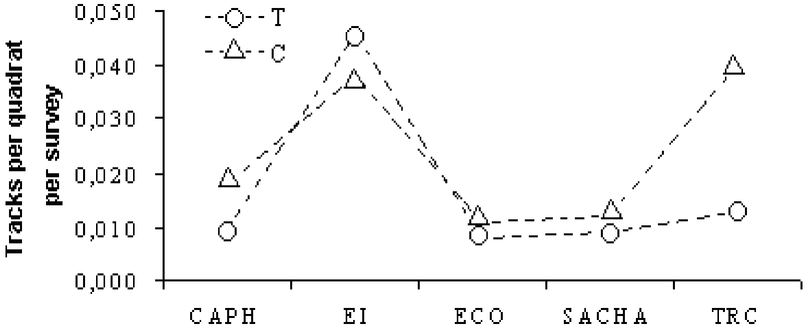


Figure 3.20. Relative abundance of Collared Peccary (*T. tajacu*) tracks.

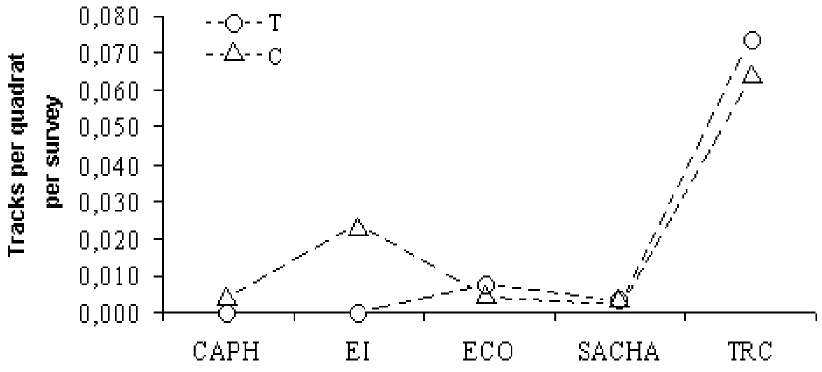
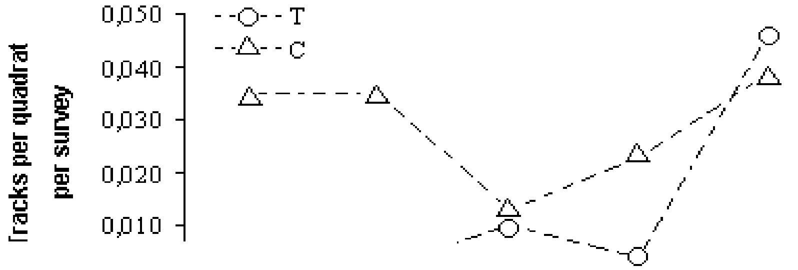


Figure 3.21. Relative abundance of Brazilian Tapir (*T. terrestris*) tracks.

Figure 3.22. Relative abundance of Red Brocket Deer (*M. americana*) tracks.



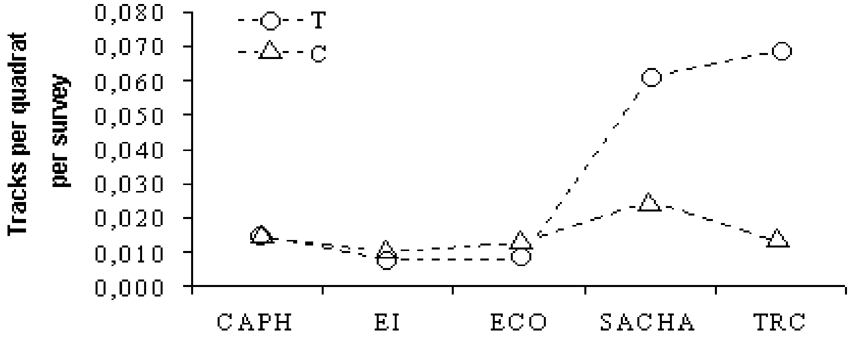


Figure 3.23. Relative abundance of Brown Agouti (*D. variegata*) tracks.

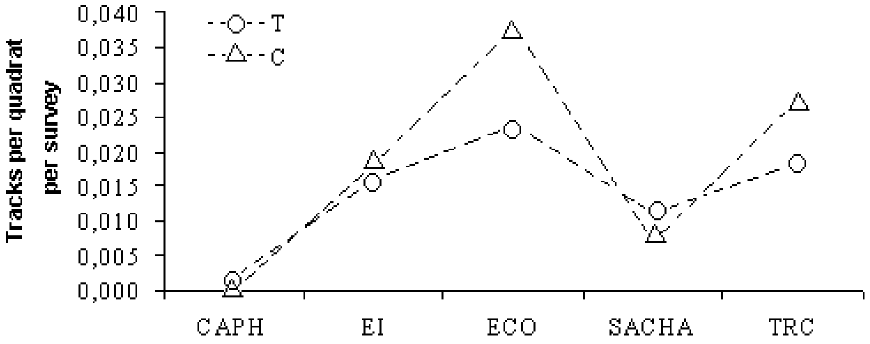


Figure 3.24. Relative abundance of Paca (*A. paca*) tracks.

Visibility Levels

There is the potential for the abundance of a species, when determined with distance sampling methodology, to vary from place to place simply due to variations in visibility levels brought about by variations in vegetation characteristics. To investigate this we chose to analyse visibility in terms of the average straight-line observer-animal distance (AD) for the saddleback tamarin (*S. fuscicollis)* and the brown agouti (*D. variegata)*, two commonly observed mammals. Each is either entirely arboreal or terrestrial thus allowing for an analysis visibility at the level of the low to mid canopy as well as the undergrowth. The results (Tables 3.17 and 3.18) and t-tests showed that only in the case of the brown agouti at EI was there a difference in visibility between T and C. When data was grouped no significant differences between lodges as a whole was evident.

Table 3.17. Straight-line observer-animal distance (m) for *S. fuscicollis*.

	CAPH T	CAPH C	EI T	EI C	ECO T	ECO C	SACHA T	SACHA C	TRC T	TRC C
N	71	36	15	15	43	23	19	18	11	9
Min.	5	0	5	0	0	5	5	5	11	12
Max.	70	45	50	30	55	60	65	60	26	60
Mean	20.5	19.5	17.5	16.1	19.1	22.0	20.8	20.7	19.0	21.6
+/-	3.0	3.0	6.1	5.0	3.5	5.7	6.4	6.0	3.3	11.4

Table 3.18. Straight-line observer-animal distance (m) for *D. variegata*. * $p < 0.01$.

	CAPH T	CAPH C	EI T	EI C	ECO T	ECO C	SACHA T	SACHA C	TRC T	TRC C
N	43	19	8	12	6	20	27	26	4	3
Min.	4	1	4	6	5	2	2	1	7	6
Max.	33	25	20	23	31	36	22	17	25	20
Mean	14.3	12.5	9.5*	15.6*	16.3	16.7	11.1	10.4	13.3	11.3
+/-	2.2	2.2	4.4	3.7	11.1	3.4	1.9	1.6	13.1	18.9

Discussion

Habitat and Fruit Resources

It was evident that at some lodges there was significant variation between T and C in terms of the abundance of the five most common fruiting tree genera (*Iriartea, Scheelea, Astrocaryum, Pseudolmedia* and *Ficus*), however there was no evidence to suggest that tourists or the presence of trails was a factor in this and is likely a consequence of natural variation. Significant differences in the abundance of fruit tree genera and other genera between lodges as a whole was most apparent with *Iriartea*, a likely consequence of past utilisation of this palm by people, and *Guadua*, which was completely absent from the two lodges along the Madre de Dios river, perhaps due to a lack of source propagules for the northern bank of the river. *Guadua* was relatively common however along the length of the Tambopata river.

There was no evidence to suggest that the total abundance of fruiting trees (11 genera) at a lodge had any effect on the abundance of individual mammal species, although the underlying greater availability of fruit at the TRC may help to explain the greater mammal diversity and the abundance of certain communities such as primates and ungulates.

Mammal Species with Insufficient Data

13 species were encountered too infrequently or only at one lodge for it to be possible to determine with any degree of confidence which variable (habitat, hunting, or traffic) may be responsible for the variation in their abundance. These included: *M. tridactyla*, *B. variegata*, *Dasypus sp.*, *Aotus sp.*, *C. albifrons*, *A. belzebuth**, *A. microtis*, *G. vitata*, *L. longicauda*, *L. pardalis*, *T. terrestris**, *T. pecari**, and *M. pratti*. However, some of these species (*) show some affinity to having been impacted by historical hunting levels at those lodges situated close to settlements.

Species Affected by Hunting

It is a known fact that local inhabitants in Amazonia frequently hunt wild animals for subsistence purposes and for the bush-meat trade, and studies have shown that this can seriously deplete local population abundance of certain species (Ayres et al. 1991, Bodmer et al. 1994, 1997, Fragoso 1991, Hill et al. 1997, Maglianesi 1998, Mittermeier 1993, Noss 1998, Peres 1990, 1996, 1999). Hunting where present has to be regarded as a stronger impact variable than tourism because it actively extracts individuals from the population. Tourism disturbance in Tambopata doesn't actively or knowingly kill mammals on a regular basis. As it is evident that hunting is very prevalent near two of the lodges studied (SACHA and CAPH) and historically present around two others (ECO and EI) it is necessary therefore to determine which species are being impacted primarily by hunting above and beyond the effects of tourism.

In this part of Amazonia nine of the species encountered in this study are commonly sought by hunters. These include black spider monkey, white-fronted capuchin monkey, red howler monkey, brown capuchin monkey, south american coati, brazilian tapir, white-lipped peccary, collared peccary, red brocket deer, brown agouti (Freese et al. 1982, Ascorra 1997). Furthermore, cats such as the jaguar and ocelot are also killed if they are encountered as they are considered a menace to livestock and there is still a local market for their skins (though small).

On simple visual inspection of the abundance profiles of these species it was evident that the abundance of the red howler and brown capuchin monkeys were strongly influenced by the hunting pressure index at a lodge. Insufficient data was available to test the black spider monkey, white-fronted capuchin monkey, brazilian tapir, and white-lipped peccary. The collared peccary, red brocket deer, brown agouti and south american coati appear unaffected by current hunting pressure. These species are discussed in more detail below.

The track abundance patterns for the cats indicate that the jaguar and the ocelot are affected by current hunting pressure, although the ocelot appears to be more resistant.

Black Spider Monkey (*Ateles belzebuth*)

The black spider monkey is evidently locally extinct around the four lodges closest to civilisation, a likely result of historical hunting pressures before the onset of tourism development in the area (Figure 3.25). Some good news is that there were three unconfirmed reports during 1997-98 of sightings at EI, SACHA and even within the native community of Infierno. So it is possible that this species could recolonise certain locations if hunting is controlled. At the TRC, this species still survives in relative abundance, however the results hint at a possible negative impact of traffic, although further investigation would be required to test this. In Manu where the species is also common, Yoon (1997) found that this species was not affected by tourist traffic, however traffic levels along the tourist trails that he studied were on the whole lower than those at the TRC.

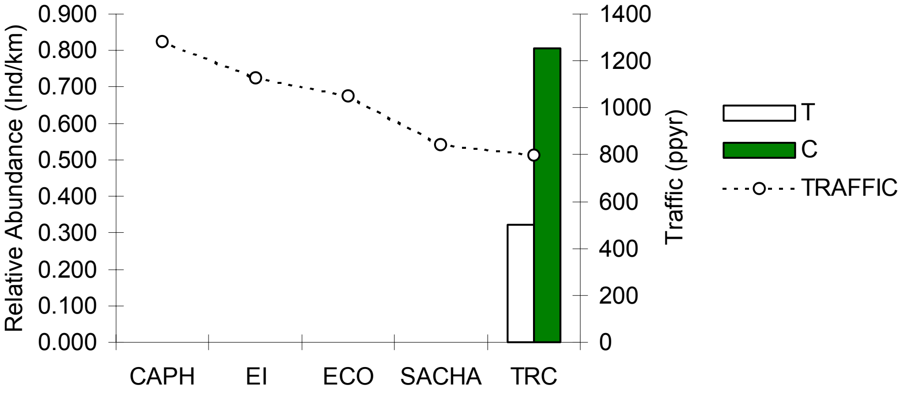


Figure 3.25. Relative abundance of the black spider monkey (*Ateles belzebuth*).

Brazilian Tapir (*Tapirus terrestris*)

In the case of the brazilian tapir insufficient visual encounter data was available to undertake any meaningful analysis. However, track data revealed that although the species was present at all the lodges it was most abundant at the TRC and EI (Figure 3.21), the two lodges where hunting pressure was found to be lowest. A Pearson correlation coefficient revealed that track abundance was negatively correlated with hunting pressure (Pearson = -0.75), although it was not significant. There was no evidence from the track survey to suggest that this species is affected in any way by tourist traffic.

White-lipped peccary (*Tayassu pecari*)

The white-lipped peccary was also observed too infrequently to assess the significance of any impact variable directly, however our data mirror the opinion of local people who suggest that this species is generally rarer around permanent settlements where hunting pressures are highest and more abundant in isolated areas such as the TRC, an opinion also backed up by other studies of this species (Fragoso 1991, Kirkby et al. 1998, Kirkby 1999).

No evidence was found to suggest that tourism affects this species. The fact that the home range of this species is one of the largest for any Neotropical mammal makes it very unlikely that a group of white-lipped peccaries would be able to adequately perceive areas of high tourist traffic and actively avoid them, as their visits to the trail systems of lodges tend to be extremely infrequent and usually last no longer than a few hours. Never-the-less, the experience of one of the authors (CK) with this species suggest that the groups encountered at the TRC were unusually shy and tended to flee a lot earlier and for greater distances than in areas of Madre de Dios where the presence of humans is negligible. This may be due to underlying human odours in the forest around the TRC which may make the species more wary and prone to fleeing.

It is known that this species is susceptible to disease and it is believed the regional abundance of this species may fluctuate wildly over a period of decades. Introduced diseases carried by domestic animals have also been implicated in this phenomenon and may also help to explain the absence of this species from most of the lodges which are situated near human settlements. Once eliminated from an area by hunting or disease it may take many years for them to naturally recolonise.

It is the opinion of the authors that as a tourism resource this species has a lot to offer, due to its tendency to create large noisy groups, and efforts should be made to protect it from over-hunting near tourist lodges.

Other species: Testing for the effects of traffic

For 13 species paired t-tests (1-tail) were used to investigate whether there was any consistent difference in abundance between T and C transects (Table 3.19). This revealed that two species (brown capuchin monkey and red brocket deer) are consistently more abundant along C and two others (southern tamandua and bolivian squirrel) are consistently more abundant along T. These species are discussed in more detail below.

Table 3.19. Results of paired t-tests (1-tailed) comparing the abundance of each of 13 species between tourist and control transects at 5 lodges (h = species shown to be primarily affected by hunting), * $p < 0.05$, ** $p < 0.01$, + almost significant ($p < 0.07$).

Species	Ave. T	Ave. C	p
Southern Tamandua	0.016	0.006	0.03 *T
Saddleback Tamarin	0.787	0.580	0.41
Squirrel Monkey	1.399	1.053	0.30
Dusky titi Monkey	0.046	0.071	0.23
Red Howler Monkey (h)	0.163	0.073	0.06 +T
Brown capuchin Monkey (h)	0.329	0.465	0.05 *C
South American Coati	0.047	0.074	0.47
Tayra	0.031	0.035	0.43
Collared Peccary	0.066	0.092	0.20
Red Brocket Deer	0.005	0.026	0.01 *C
Bolivian Squirrel	0.096	0.069	0.03 *T
S. Amazon Red Squirrel	0.493	0.430	0.38
Brown Agouti	0.138	0.134	0.36

Southern Tamandua (*Tamandua tetradactyla*)

The above analysis indicates that the species is positively affected by traffic, even though the overall number of encounters is insufficient to have any real confidence in this result. Interestingly, it was not observed at the CAPH (Figure 3.26), although other members of the research team encountered it on a couple of occasions so it can't be considered as locally extinct at this lodge. At all other lodges abundance was restricted mainly to the tourist transects. A Pearson correlation analysis between traffic and abundance along T did not reveal any underlying trend. In truth there were insufficient encounters with this species at most lodges to be very confident that this species is affected unequivocally by traffic and we suggest that further study is undertaken.

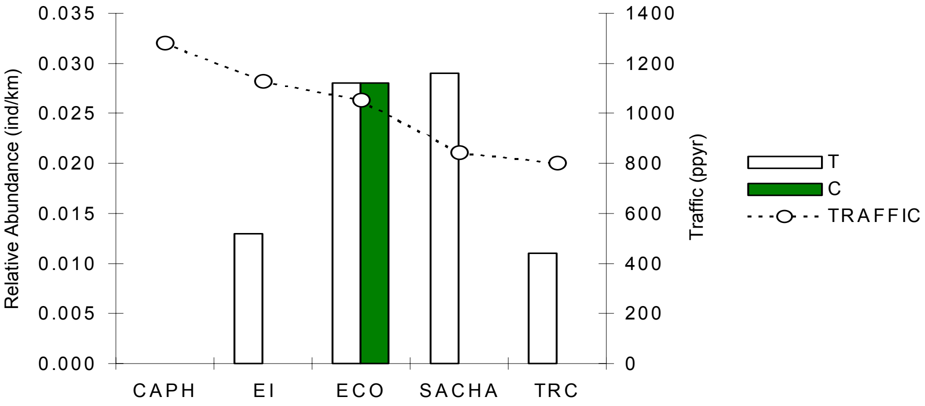


Figure 3.26. Relative abundance of the southern tamandua.

Brown Capuchin (*Cebus apella*)

The pattern of abundance of this medium sized primate (member of the insectivore-frugivore guild) at CAPH and SACHA is consistent with the claim that the species is negatively affected by hunting (Figure 3.27). However, there was also a relatively consistent trend of higher abundance along C transects (Table 3.19), more especially at the four lodges located near permanent settlements where hunting is currently or has historically been prevalent. So, although primarily affected by hunting, there are significant signs that the species is also being susceptible to the presence of tourists within their habitat.

This difference between T and C could very well be the result of an innate fear of people, particularly amongst those local populations near settlements which could have developed this fear after occasional contact with hunters. Indeed it is possible to speculate that this species is unable to tell the difference between tourists and hunters. A Pearson correlation analysis between traffic and abundance along T transects at the 3 lodges unaffected by hunting revealed a strong negative correlation, although it was not significant (Pearson = -0.95, $p < 0.10$).

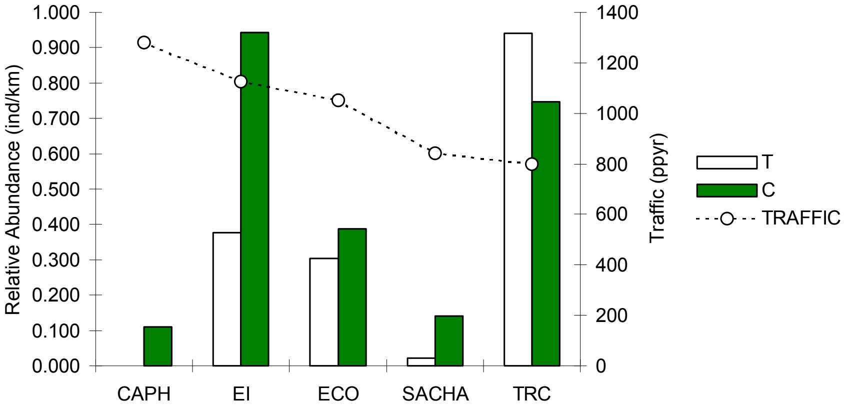


Figure 3.27. Relative abundance of the brown capuchin monkey.

Red Howler Monkey (*Alouatta seniculus*)

The pattern of abundance of this large folivorous/frugivorous primate clearly demonstrates that the species is strongly and negatively influenced by hunting pressure (Figure 3.28). Interestingly however, it was consistently more abundant along T transects, particularly at EI and TRC, indicating that the species is likely affected in a positive fashion by the presence of tourists, even if under the pressure of hunting. A Pearson correlation analysis revealed that there was no evidence to suggest that the species is affected in any way by the magnitude of traffic. We can only speculate at this stage with regards to the underlying reasons behind this pattern. It could be a reduction in predation pressure near the trails, although there is little data on the abundance of large eagles such as the Harpy Eagle (*Hapia harpyja*) to test this, and/or a reduction in inter-specific competition. It is also plausible to conclude that the species may have attained a degree of habituation to tourists, which would make these otherwise secretive species less likely to flee from the areas close to the tourist trails and could even have contributed to an improved detection profile for the observers, although no evidence in terms of average straight-line detection distance was apparent.

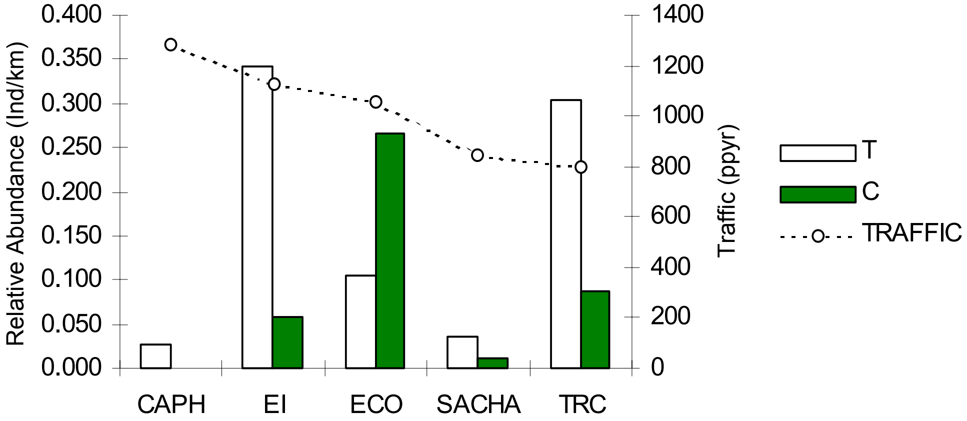


Figure 3.28. Relative abundance of the red howler monkey (Alouatta seniculus).

Red Brocket Deer (*Mazama americana*)

The analyses revealed that this species is the most consistently and most strongly influenced by traffic. At all lodges the abundance along control transects was greater than along tourist transects (Figure 3.29), although the strength of the relationship was less evident at the TRC. A Pearson correlation between traffic and T abundance revealed a strong negative correlation (Pearson = –0.88, $p < 0.05$). The overall pattern, using pooled data per lodge, is consistent with a claim that the species is negatively affected at a very localised level by tourists. That is to say they appear to be scared away from areas close to the tourist trails, although it appears that these displaced animals can survive greater densities in the control areas, particularly around the lodges near permanent human settlements where there is evidence to suggest that cats such as the Jaguar, which are potential predators of this species (Terborgh & Emmons unpubl.) are much less common.

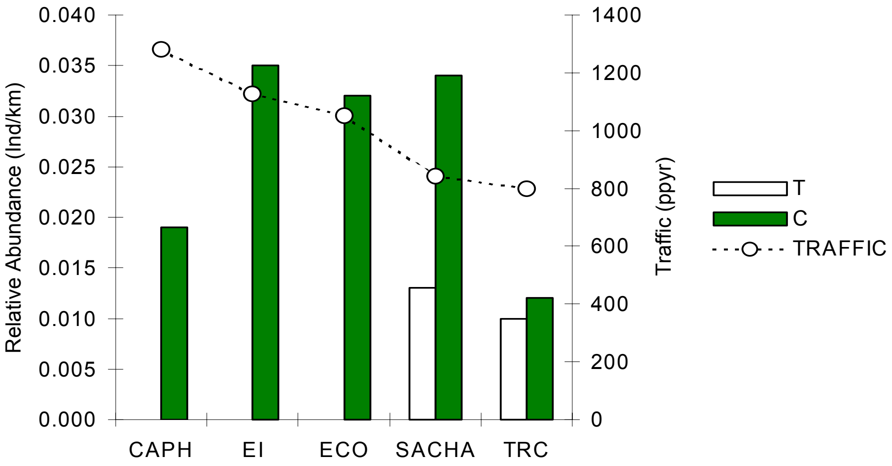


Figure 3.29. Relative abundance of the red brocket deer.

Bolivian Squirrel (*Sciurus ignitus*)

At four lodges the abundance of this species along T was greater than along C (Figure 3.30), which implies that the species is likely positively affected by the presence of tourists. It appears that the species is sensitive to very small levels of tourist traffic, even below that of the TRC. However, a Pearson correlation analysis between traffic and abundance along T transects revealed that it is not sensitive to the different traffic intensities we tested. The variability in abundance along T was found to be greater than along C (SD; T = 0.06, C = 0.04) indicating that abundance is more stable away from tourist trails.

At ECO the species was evidently uncommon, likely the result of some unknown habitat or predation variable, although it could also be loosely coupled to the abundance of its principal competitor, i.e. the Southern Amazon Red squirrel, which is significantly larger and more aggressive and was observed chasing the bolivian squirrel on numerous occasions. However, no significant correlation was evident between these two species.

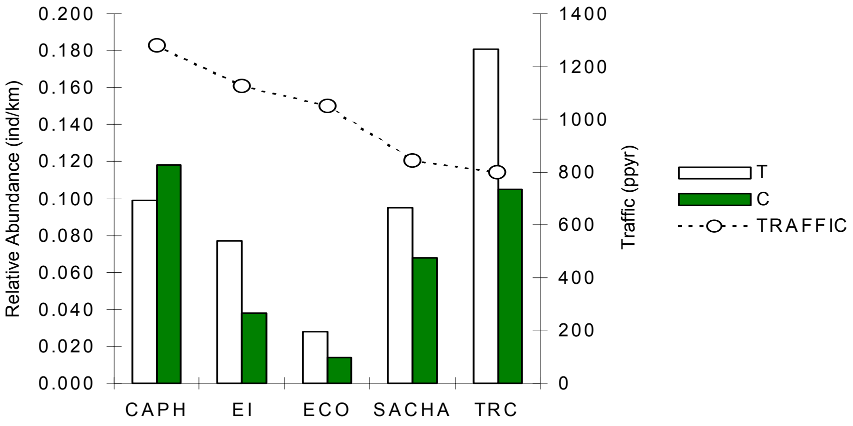


Figure 3.30. Relative abundance of the bolivian squirrel.

Species Sensitive to Traffic Intensity

Pearson correlation analyses between T abundance and traffic, on the same 13 species described in Table 3.19, revealed 3 significant results (Table 3.20). Two species were significantly positively correlated (saddleback tamarin and southern amazon red squirrel) and one was negatively correlated (red brocket deer - a species which was also singled out in the above paired t-tests). The difference in the standard deviation values between T and C for these three species was also large, and in the case of the tamarin and the red squirrel, abundance along C was more stable than along T, as might be expected if traffic were playing a significant role in affecting these species.

Table 3.20. Pearson correlation, T abundance vs. traffic, and the % difference between T and C in terms of standard deviation (SD) from the mean. * $p < 0.05$, (T) = SD of T > SD of C.

Species	Pearson		%Difference SD (T vs. C)
Southern Tamandua	- 0.539		
Saddleback Tamarin	+ 0.916	*	272 % (T)
Squirrel Monkey	- 0.854		251 % (T)
Dusky titi Monkey	+ 0.384		
Red Howler Monkey (h)	- 0.226		
Brown capuchin Monkey (h)	- 0.532		
South American Coati	- 0.477		
Tayra	- 0.460		
Collared Peccary	- 0.044		
Red Brocket Deer	- 0.883	*	
Bolivian Squirrel	- 0.498		
S. Amazon Red Squirrel	+ 0.946	*	167% (T)
Brown Agouti	+ 0.517		191% (T)

Saddleback Tamarin (*Saguinus fuscicollis*)

The pattern of abundance of this tamarin [a small primate and member of the frugivore/insectivore guild] is very similar to that observed for the southern amazon red squirrel, a mammal of similar size (Figure 3.31). A correlation analysis between traffic and abundance along T transects revealed a positive and above all a significant relationship (Table 3.20). The same analysis along C transects also revealed a positive relationship, although it was not significant. The abundance pattern and these results suggest that once the effects of traffic begin to be felt they appear to reach into the forest beyond the immediate vicinity of the tourist trails. The variability in abundance along T was also found to be greater than along C (SD; T = 0.66, C = 0.24), which adds further fuel to this argument.

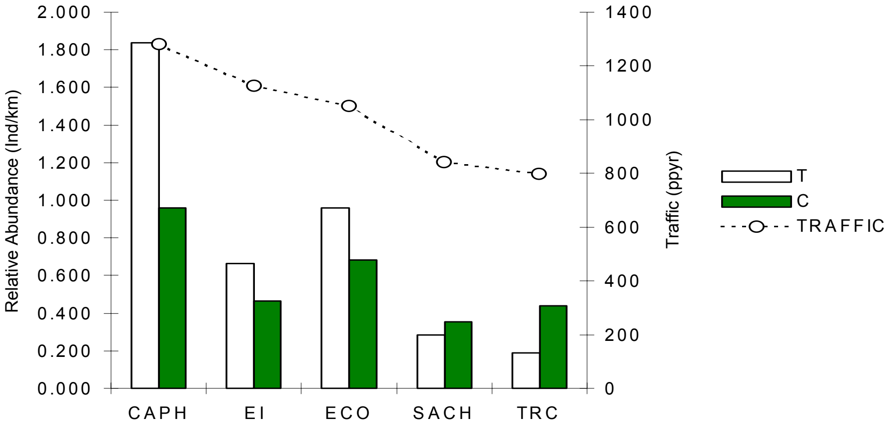


Figure 3.31. Relative abundance of the saddleback tamarin.

Southern Amazon Red Squirrel (*Sciurus spadiceus*)

The abundance pattern of this species (Figure 3.33) as indicated is remarkably similar to that of the saddleback tamarin (above). A Pearson correlation coefficient was calculated between traffic and T abundance which revealed a significant positive relationship (table 3.20). This indicates that the species is sensitive to the magnitude of traffic. Furthermore, the variability in abundance along T (SD = 0.25) was found to be greater than along C (SD = 0.15), which leads us to reach similar conclusions regarding the positive impact of traffic on this species.

Although the abundance of this species and that of the saddleback tamarin were found to be extremely similar (Regression, Z = 66.517, p = 0.000), there was no evidence from behavioural data of extensive inter-specific associations between these species in the field, although on a few occasions they were observed foraging near one-another although not more so than would be predicted by chance. There is very little if any dietary overlap between these two species, although we provide some evidence to suggest that they are more abundant in forests where underlying fruit tree density is low. It is also plausible to speculate that these species are being affected by a common set of predators, for instance hawks, falcons, ocelots, which would be consistent with their size, foraging habits and preference for foraging in the lower canopy, although insufficient data on these predators was available to test this hypothesis.

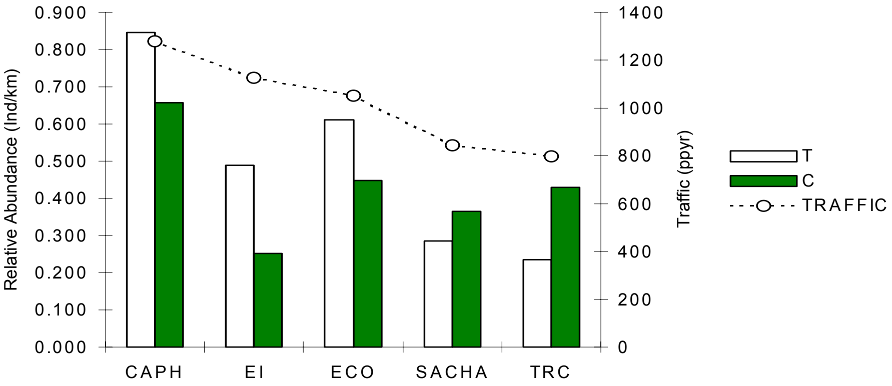


Figure 3.33. Relative abundance of the south american red squirrel.

Squirrel Monkey (*Saimiri boliviensis*)

The abundance pattern of this small primate (Figure 3.32) shows a considerable amount of variability between T and C from lodge to lodge. Overall the variability in T was found to be greater than along C (SD; T = 1.46, C = 0.58). A Pearson correlation analysis between traffic and T abundance revealed a significant negative relationship (Table 3.20), indicating that an association may exist and that the magnitude of trail-use intensity may be affecting abundance. The large home range size of this species may also have affected the results. A large home range makes it more difficult to identify a difference between T and C, if it exists, because the average separation distance between these two types of sample area are on the whole well within the distance that typical groups of this species may cover in a season. This means that the resident group(s) at the lodges may be forced, through ecological necessity to traverse and use areas near T and C in their search for food, shelter and for moving across their home range.

After combining the abundance data for T and C a Pearson correlation analysis with traffic revealed an even more significant negative correlation than before (Pearson = -0.87, $p < 0.05$). However, there is exists a stronger correlation between abundance of this species and the overall abundance of fruiting trees (Pearson = +0.93, $p < 0.03$). Furthermore, the forests around SACHA and TRC were found to be relatively more mature and canopy cover less disturbed (Lloyd and Palomino, this publication), which is likely to benefit insect populations. Insects are an important variable in the diet of this species. Therefore at this stage we are still unable to determine whether traffic or fruit availability are most important factors affecting abundance of this species.

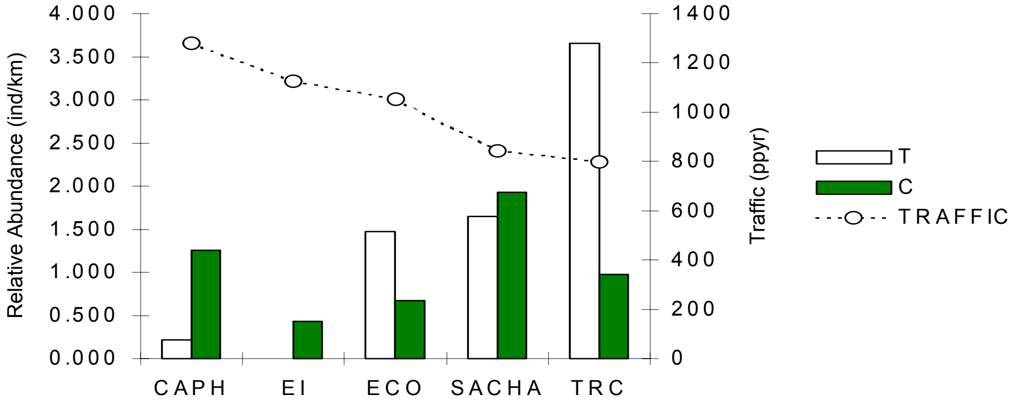


Figure 3.32. Relative abundance of the squirrel monkey.

South American Coati (*Nasua nasua*)

The high abundance of this species at SACHA does not suggest that this species is feeling any serious effects from hunting (Figure 3.36). The species was present at all lodges, although no consistent pattern between T and C abundance is evident. Average abundance within lodges and subsequent analysis revealed that there was no significant correlation between abundance and traffic (Pearson = -0.67). However, the two lodges with the lowest average abundance were CAPH and EI, which are also the oldest lodges in the area, and a very strong significant correlation was found when average abundance was regressed against the number of years the lodge had been in operation ($p = 0.02$)

(Figure 3.37). So, on the macro scale this species appears to be sensitive to long periods of human presence, although it is unclear whether current traffic is affecting this species at the younger lodges. The large home range size of this species would have made it difficult to identify a consistent difference between T and C, if it exists, as any particular social group at a lodge would have a greater tendency to roam over both types of transects. It is also plausible to speculate that the species is naturally rare at CAPH and EI due to some unknown habitat variable.

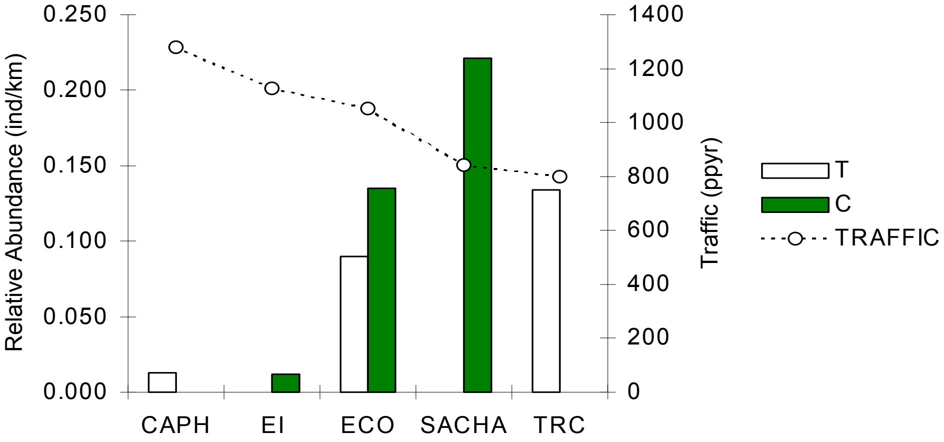


Figure 3.36. Relative abundance of the South American coati (*Nasua nasua)*.

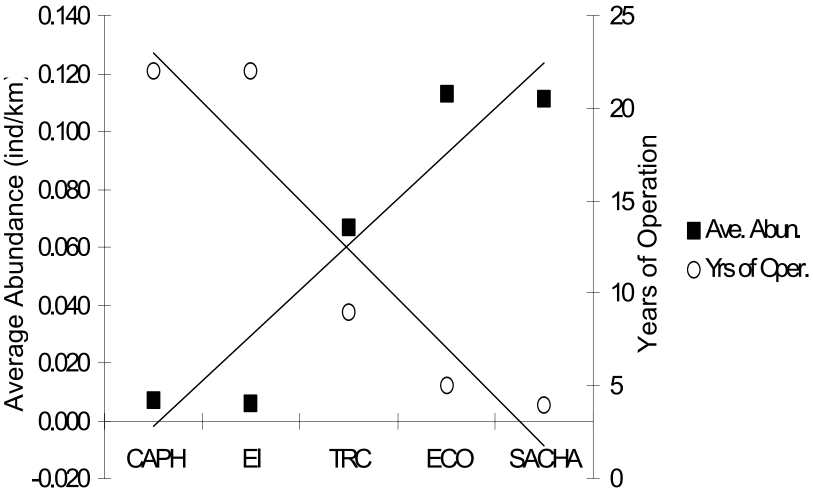


Figure 3.37. Relationship between average abundance of *N. nasua* at each lodge and years since the lodges began operating.

Similarity Between Lodges

The previous analyses have identified five species which are closely influenced by tourist traffic (brown capuchin, red brocket deer, bolivian squirrel, southern amazon red squirrel, and saddleback Tamarin). A hierarchical cluster analysis was used to combine the data from all of these species in order to determine if the trends between T and C are consistent across all lodges. To accomplish this the data for each species was first standardised, in order to reduce the importance of any one species, by calculating percentage abundance, i.e. T% and C%. The resulting cluster (Figure 3.34) did indeed show a complete separation between T and C indicating that as a group these species are consistently affected by traffic across all lodges and would be candidates as tourism impact indicator species. A similar analysis but with the aim of isolating the similarities between lodges showed that the two lodges with the highest traffic were the most similar to each other (Figure 3.35).

```
EIC       ------------------+
CAPHC     ------------------+----+
                                 +--+
SACHAC    ---------------------+-+  +
ECOC      ---------------------+    +--+
TRCC      --------------------------+  +
                                       +----------
EIT       ------------------+          +
CAPHT     ------------------+----+     +
                                 +--+  +
SACHAT    ---------------------+-+  +  +
ECOT      ---------------------+    +--+
TRCT      --------------------------+
```

Figure 3.34. Dendrogram showing the relationship between T and C across all lodges based on % abundance of five species.

```
EI        ---------------+
CAPH      ---------------+---+
                             +--+
SACHA     -----------------+-+  +
ECO       -----------------+    +---------
TRC       ----------------------+
```

Figure 3.35. Dendrogram showing the relationship between lodges as a whole, based on the pooled abundance (T + C - not converted to %) of the same five species.

Mammal Community Structure

Primates

The TRC had a full complement of primates for its locality, due to its relative isolation (Figure 3.43). The white-fronted capuchin although not observed during the census periods was registered during opportunistic encounters at this lodge. In general, the other four lodges situated near settlements, had significantly lower primate biomass than those at the TRC (Figure 3.38), this was particularly evident at SACHA and CAPH where both brown capuchin and red howler monkeys were scarce due to hunting. These results add further evidence to the argument laid down by Freese et al. (1982), that human disturbance and particularly hunting is the single most influential factor affecting monkey biomass in Amazonia.

The primate community structure of the two lodges where hunting is prevalent (SACHA and CAPH) is quite similar, although they differ from other lodges in that they are dominated by the smaller more reproductively efficient species, namely the saddleback tamarin and the squirrel monkey. These two species can cope well with the lower fruit availability at CAPH due to their diverse diets. Where hunting is low, or absent, the community is dominated by larger species, particularly the red howler monkey, brown capuchin monkey and black spider monkey (at TRC only). Interestingly EI is most similar to the TRC in terms of community structure, which suggests that the lack of hunting immediately around this lodge has been beneficial.

The Dusky-titi monkey is a very minor constituent of the community and it appears to favour areas of more disturbed vegetation or where bamboo is common, a finding that is consistent with other studies of habitat preference of this species in Tambopata (Warner 1999).

Although structurally the lodges appear to differ from one another a Paired t-test revealed that at none of them was there a significant difference between T and C in terms of biomass (Table 3.22). Interestingly fruit tree availability at each lodge is not strongly correlated with primate biomass, which further underlines the impact that hunting is having on the larger frugivorous species of the community.

Table 3.21. Reference data of species weights (kg); the ¾ average adult body weight was calculated for social species where juveniles were commonly noted in the dataset; * the weight used to calculate relative biomass of each species; [1] Clutton-Brock et al. 1977, [2] Emmons 1984, [3] Robinson et al. 1986, [4] Ayres et al. 1991, [5] Mittermeier 1991, [6] Peres 1993.

Species	Adult body weight (kg)	Average (kg)	¾ of Average (kg)
Primates			
Saddleback tamarin	0.40[2], 0.36[3], 0.39[6],	0.38	0.29*
Squirrel monkey	0.67[1], 1.00[2], 0.80[3], 0.90[6],	0.84	0.63*
Dusky titi monkey	0.68[1], 0.80[2], 1.17[3], 0.70[4],	0.84	0.63*
Red howler monkey	7.00[2], 6.19[3], 6.50[6], 7.00[5],	6.67	5.00*
Brown capuchin	2.50[1], 3.00[2], 3.45[3], 3.70[5], 2.20[6]	2.97	2.23*
Black spider monkey	7.8[3], 8.50[6], 8.10[7]	8.13	6.10*
Ungulates			
Brazilian tapir	110[3], 177[5]	143.65*	
White-lipped peccary	18.00[3], 28.56[5]	23.28	17.46*
Collared peccary	17.52[3], 12.00[5]	14.76	11.07*
Red brocket deer	26.10[3], 23.5[4], 15.00[5]	21.53*	
Carnivores			
Tayra	3.98[3]	3.98*	
Coati	3.40[5], 3.00[4], 3.88[3]	3.43	2.57*
Short-eared dog	7.00[2]	7.00*	
Ocelot	10.46[2]	10.46*	
Rodents			
Bolivian squirrel	0.20[2], 0.38[3]	0.29	0.22*
S. A. red squirrel	0.60[2]	0.60	0.45*
Green acouchi	1.5[3]	1.5*	
Brown agouti	3.60[3], 4.20[5]	3.90	2.93*

Ungulates

Again, the TRC was the only lodge to have a full complement of ungulates for its location (Figure 3.42), which included the white-lipped peccary. At the other extreme, the two lodges with the greatest traffic (CAPH and EI) the collared Peccary and the red brocket deer were the only ungulates observed, and these made up similar percentages of the community at these lodges. Total ungulate biomass was greatest at the TRC (Figure 3.39). A paired t-test revealed that there was a significant difference between T and C in terms of ungulate biomass (Table 3.22) although the majority of the pattern was dominated by the red brocket deer.

Rodents

Rodent biomass was dominated at every lodge by the brown agouti (Figure 3.44). It was also evident that the green acouchi favoured the lodges with most traffic and was for all intents and purposes absent or very rare at the TRC and SACHA. Rodent biomass reached a maximum at CAPH (Figure 3.40). Overall the data revealed that biomass was greatest at the two lodges most affected by hunting, i.e. SACHA and CAPH suggesting that the rodent community has benefited from reduced predation pressure or reduced inter-specific competition brought on by higher hunting pressures. A paired t-test revealed that there was no significant difference between T and C in terms of rodent biomass at any lodge (Table 3.22).

Carnivores

The TRC had the greatest diversity of carnivore species, which included the relatively rare small-eared dog (*A. microtis*). The most common species at all lodges was either the coati or the tayra (Figure 3.45), species known for their more omnivorous even predominantly frugivorous diet. Carnivore biomass was greatest at SACHA (Figure 3.41), although the lodge with the greatest proportion of feline biomass was the TRC. When biomass data along T and C transects are combined both the TRC and SACHA stand out markedly above the rest. These two lodges are relatively new and have the lowest traffic associated with them. A Pearson correlation coefficient revealed that indeed carnivore biomass is strongly negatively correlated with traffic (Pearson = -0.9). A similar pattern was also evident with respect to the track abundance of the ocelot (Figure 3.19). These two lodges however are also the most mature in terms of fruit production, so the large coati and/or tayra populations at these lodges may be due to this variable. A paired t-test revealed that there was no significant difference between T and C in terms of carnivore biomass from
one lodge to another (Table 3.22).

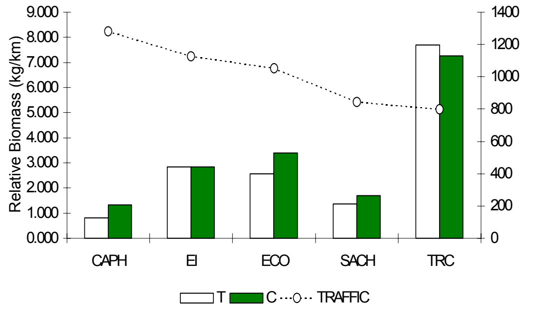


Figure 3.38. Relative primate biomass.

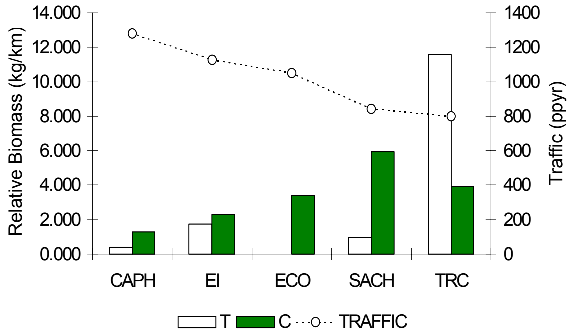


Figure 3.39. Relative ungulate biomass

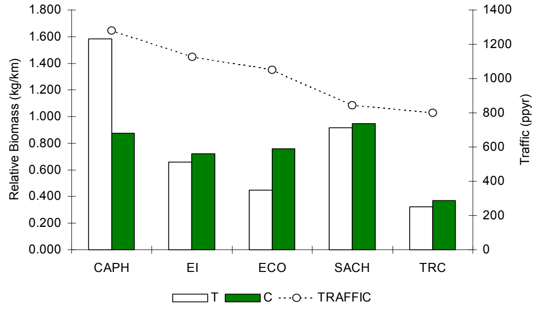


Figure 3.40. Relative rodent biomass.

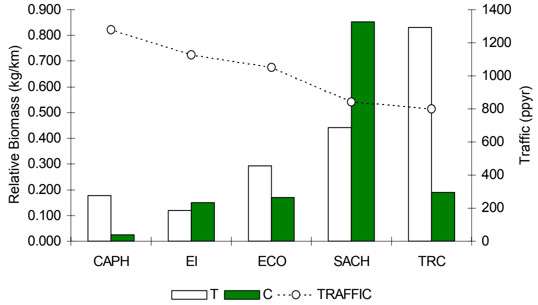


Figure 3.41. Relative carnivore biomass

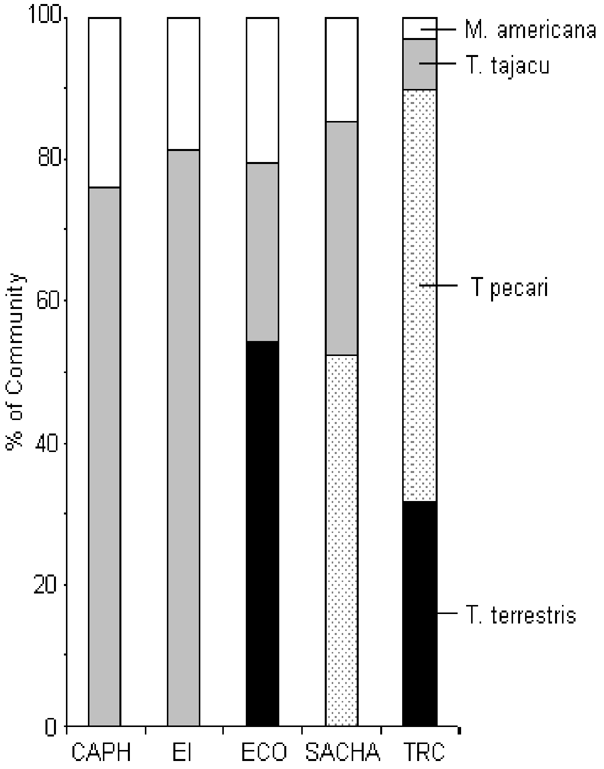


Figure 3.42. Ungulates.

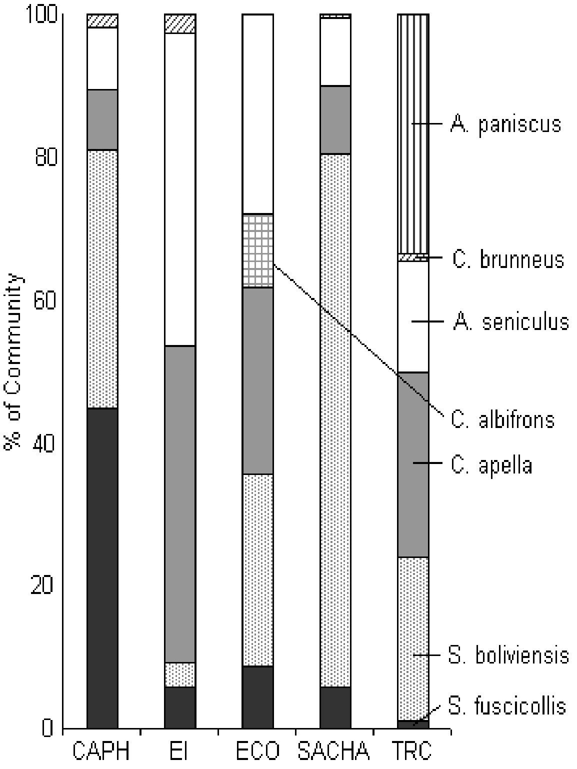


Figure 3.43. Primates.

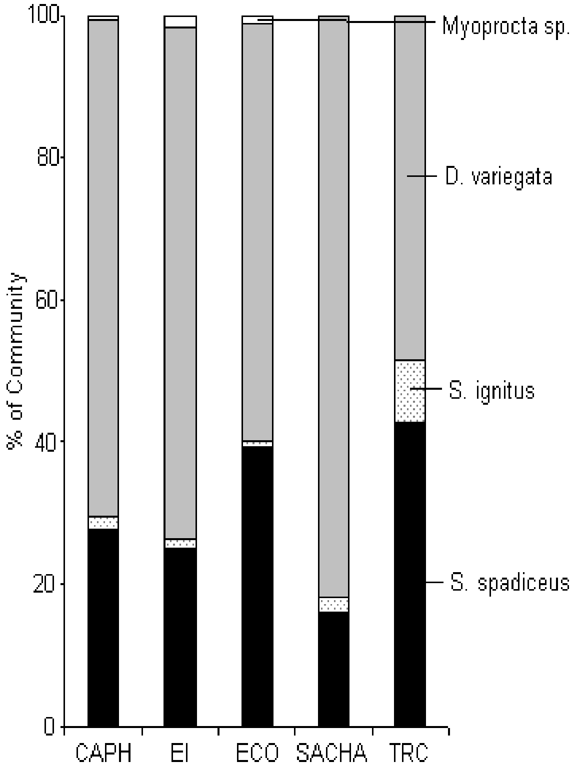


Figure 3.44. Rodents.

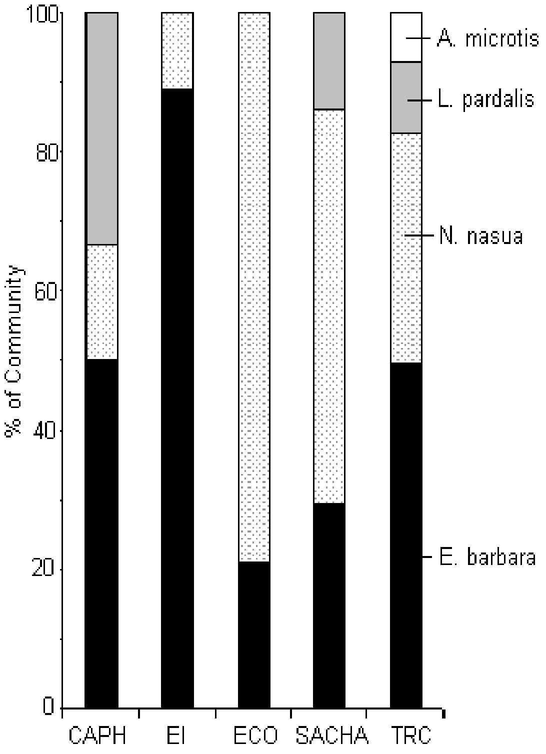


Figure 3.45. Carnivores.

All Four Communities

Underlying mammal biomass at each lodge, i.e. a combination of the above four communities, reveal than the TRC has a healthy community of mammals (Figure 3.46). All other lodges have depressed mammal biomass in comparison, although the principal cause we conclude is due to historical hunting pressures associated with human settlements. No significant difference was found between T and C in terms of the overall biomass of mammals. The pattern is more closely associated with fruit availability and hunting pressure.

Table 3.22. Results of paired t-tests (1 tail) showing differences between T and C in terms of community biomass, * $p < 0.05$, + almost significant.

Lodge	**Primates**	**Ungulates**	**Carnivores**	**Rodents**	**All**
No. of Species	6	4	4	4	18
Probability	0.07 +C	0.05*C	0.46	0.40	0.16

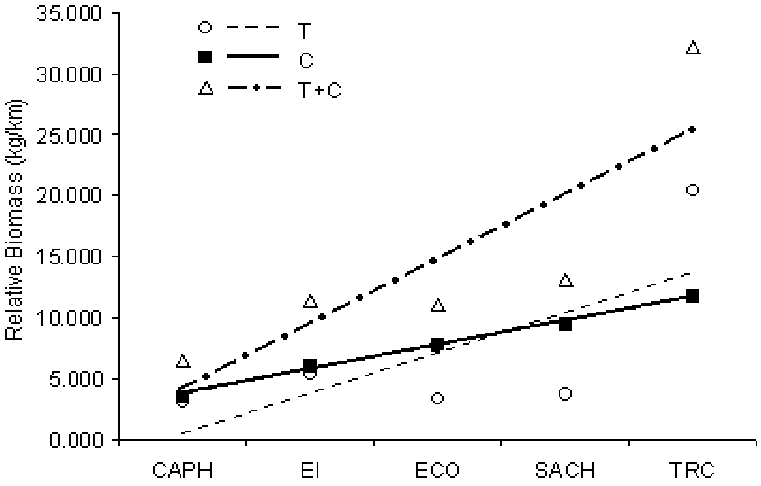


Figure 3.46. Trends in overall mammal biomass.

Trail-use Carrying Capacity

The concept of carrying capacity is an old one and dates from the time of Malthus in the 18th Century, when it was used to describe the issues relating to the capacity of the World's resources to sustain an ever growing human population. For the purposes of this investigation we define the term Trail-use Carrying Capacity as "the capacity of wildlife communities, resident in a localised area of rainforest, to withstand tourists using trails within this area." In this sense we aim to determine the trail-use intensity, above which wildlife appears unable to cope and beyond which abundance and community structure is likely to change.

To do this we only concentrated on those species that showed the most definite signs of being affected by traffic, i.e. species which have shown significant consistent differences in abundance between T and C transects (Brown capuchin, Red Brocket Deer, Bolivian Squirrel) and significant strong correlations between trail-use and abundance along T, where the abundance along C is on average lower and more stable than along T (Saddleback Tamarin, Southern Amazon Red Squirrel). These species we term here Trail-use Carrying Capacity Indicators (TCCI). Our main assumption in choosing these species is that they all show significant signs that as traffic increases there is an increasing tendency for divergence between tourist and control transects.

To determine the trail-use carrying capacity for a species, trend lines were introduced to the abundance data and where the two lines cross is the point at which abundance along T = C. In the case of the Capuchin monkey, we omitted the data from CAPH and SACHA due to the obvious effects of hunting and converted the data into % abundance. In the case of the Bolivian Squirrel, we believe that the effects of traffic begin to be felt well below the minimum traffic value we tested (799 ppyr, TRC), and that at traffic values around that for CAPH the trend breaks down. Consequently we re-graphed this species omitting data for CAPH and converted to % abundance. The species' profiles are re-graphed with their respective trend lines in Figures 3.47-51.

The average convergence point for these TCCI species was found to be 696 ppyr +/- 314 (Table 3.23). This result should form the starting point in the process of identifying appropriate tourism management strategies concerning trail-use both for the lodges that were studied and for others in the area. Final acceptance of some form of trail-use carrying capacity will likely be affected to varying degrees by social, economic and political pressures associated with planning these strategies on a regional and a lodge to lodge basis. However, we strongly recommend that the effort is made to negotiate a suitable means of implementing some form of trail-use management, certainly, if lodges are serious in their claims or attempts to help reduce impacts on the local environment to a minimum and to some degree improve the wildlife spectacle offered to their visitors in the long term. The information provided here should be of help to this end. One possible management strategy is detailed in the recommendations section at the end of this report.

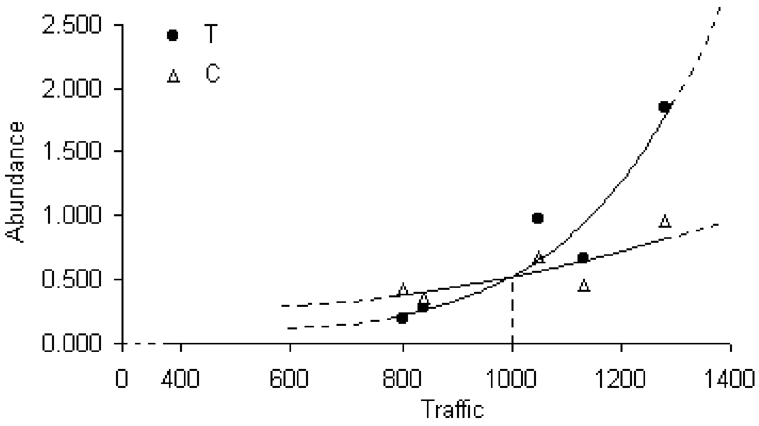


Figure 3.47. The trends in Saddleback tamarin abundance (T vs. C), illustrating the convergence point where T = C.

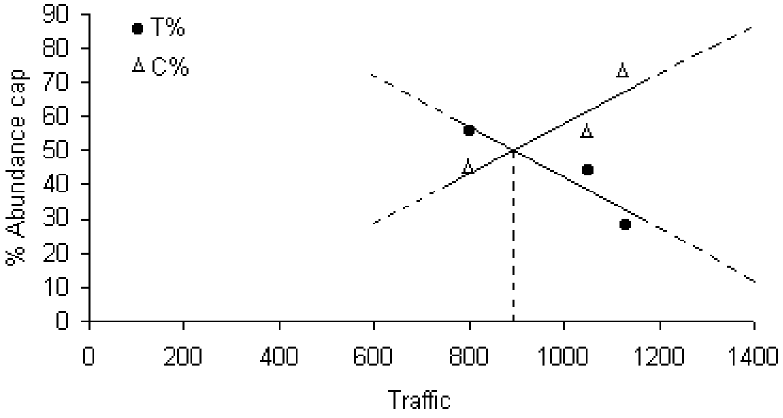


Figure 3.48. The trends in Brown capuchin abundance at lodges where hunting is negligible, (T% vs. C%) illustrating the convergence point where T% = C%.

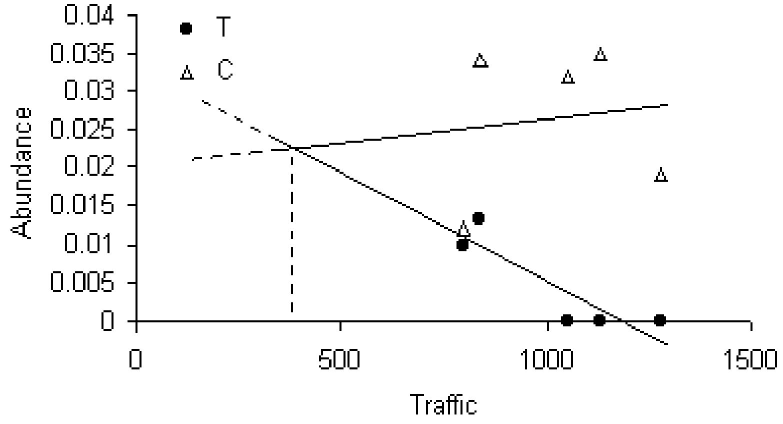


Figure 3.49. The trends in Red brocket deer abundance (T vs. C) illustrating the convergence point, where T = C.

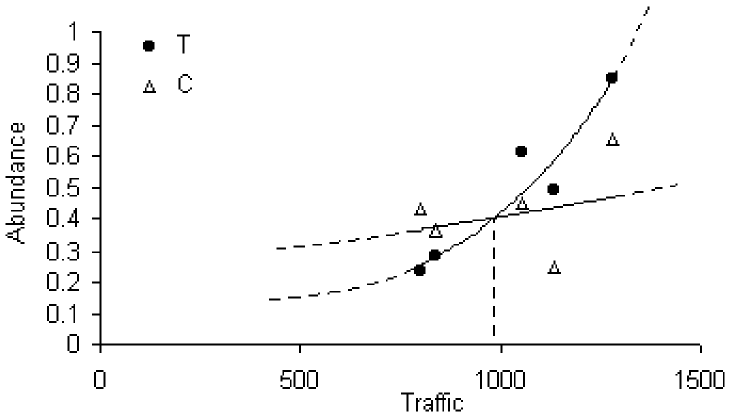


Figure 3.50. The trends in Southern amazon red squirrel abundance (T vs. C), illustrating the convergence point, where T = C.

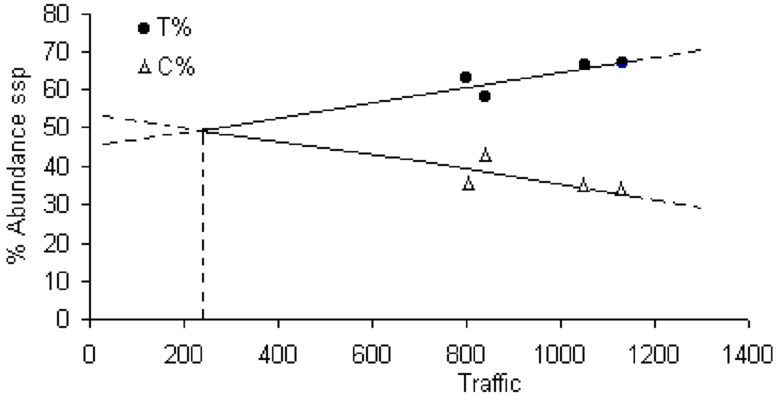


Figure 3.51. The trends in Bolivian squirrel abundance (T% vs. C%) illustrating the convergence point where T% = C% [Data from ECO has been ignored due to insufficient number of encounters].

Table 3.23. Results of convergence points.

Species/Community	Convergence Point (ppyr)
Bolivian Squirrel	240
Red Brocket Deer	380
Brown capuchin	880
Southern Amazon Red Squirrel	980
Saddleback Tamarin	1000
Average	**696**
95% CI (+/-)	314

Conclusions

The results of this study clearly shown that hunting has seriously depleted the population of some mammal species around SACHA and CAPH, particularly the large primates such as the red howler and brown capuchin and the large ungulates such as the tapir and white-lipped peccary. Total primate biomass was also affected in a similar way. Hunting pressure was high in the areas of forest used for tourism at SACHA and CAPH largely due to the ease of accessibility from nearby settlements and the lack of agreements between the lodges and local hunters regarding rights of access to the forest and trail system and related land-use issues concerning natural resource utilisation. As a consequence of hunting, species richness has declined around lodges located near settlements.

Although hunting is an important impact variable for some species there is still persuasive evidence to suggest that two persecuted species are impacted upon negatively (brown capuchin) and positively (red howler) by tourist traffic. However, further studies of these species would be required in order to determine if they would still show signs of tourist impact in the absence of hunting.

Lodges situated close to settlements would do well entering into discussions with local hunters, as well as other forest users, regarding land-use zoning and the provision of incentives to reduce or eliminate hunting pressure in forest areas visited by tourists. Some species may also benefit from a reduction in trail–use intensity where hunting is or has been prevalent.

The track study provided more information on the relative abundance of predators than the transect surveys. This was especially the case for the more nocturnal and cryptic forest cats such as the ocelot and jaguar. Track data provided plausible evidence to conclude that these cat species are negatively affected by hunting at SACHA and CAPH, however there is also evidence to suggest that relatively high trail-use intensities are also detrimental especially where hunting is or has been prevalent. The lodge with the highest predator species richness and abundance was the TRC, where hunting is absent and traffic levels are at their lowest. Whether or not increasing traffic at the TRC will affect the carnivore community in the future, either directly or indirectly, is still not certain although precautionary measures should be taken to monitor all major predator and prey species and adapt trail-use accordingly in the future.

The community of keystone fruiting trees was dominated by the *Iriartea* palm, which in some lodges accounted for up to 90% of the trees studied. There are indications to suggest that this palm, due to its usefulness as a construction material, has been depleted in areas close to human settlements. The abundance of the squirrel monkey appeared to be closely associated with the abundance of fruit trees from lodge to lodge, as was the biomass of the ungulate community.

The study of forage scrapings revealed that many terrestrial mammals forage significantly less often near tourist trails, in some cases by as much as 80%. The reasons governing this reduction are not related to fruit tree availability and are likely a consequence of 1) higher predation levels near trails, cats for instance have been shown to be attracted to man-made trails along which they frequently walk, 2) timidness when confronted by tourists moving along the trails and their associated lingering human odours, and 3) insufficient ground cover near trails for animals to hide from predators and tourists.

With regards to the impact of trail-use by tourists on other species the study revealed that the red brocket deer (*M. americana*) consistently vacated the area near tourist trails, although the scale of the impact we consider to be very localised and is probably restricted to areas up to 200m away from the trails. This species was generally less abundant at the TRC than at other lodges although this is likely due to the higher predation levels at the TRC as a consequence of the greater abundance of jaguars, the main predator of deer.

Other species that were shown to be significantly influenced by trail-use and/or were very sensitive to changes in the magnitude of trail-use were generally small in stature, for instance rodents such as the bolivian squirrel (*S. ignitus*) and southern amazon red squirrel (*S. spadiceus*), and primates such as the saddleback tamarin (*S. fuscicollis*) and there is also a case for the squirrel monkey (*S. boliviensis*), although as mentioned above there are indications that this latter species is most strongly influenced by fruit tree abundance. The red squirrel and the tamarin were observed to double or even triple their normal abundance levels at those lodges which have been established the longest and which have consequently exposed the forests bordering the trails to a high degree of traffic over a long period of time. The mechanisms behind this increase are associated theoretically with reduced predation levels, lower inter-specific competition for resources with larger mammal species, high reproductive rates relative to other species and a greater propensity of habituation to tourists.

For those lodges interested in reducing the effects of current or future traffic induced impacts we have identified five indicator species 1) red brocket deer, 2) bolivian squirrel, 3) southern amazon red squirrel, 4) saddleback tamarin, and 5) brown capuchin. An analysis of the difference in their abundance between T and C or their trend in abundance with increasing trail-use intensity suggests that optimal levels of tourist traffic should not exceed 696 people per year for any stretch of trail. In Chapter 7.0 we describe a simple model of trail-use management, based on experimental alteration of tourist traffic in conjunction with continued monitoring of these indicator species. Those lodges or institutions which require further guidance on monitoring their wildlife and implementing this trail-use management system should contact the authors (see Appendix 3 for correspondence details).

4.0 The Impact of Tourism on the Herpetofauna of Tambopata, South-eastern Peru

Authors:

Tiffany M. Doan[1] & **Wilfredo Arizábal Arriaga**[1]

Introduction

Unlike the large amount of attention that the mammal and avian fauna of South America have received, the reptiles and amphibians of the Amazon rainforest are largely unstudied (Vitt 1996). The first comprehensive study of a South American herpetofaunal community was an appended species list of Santa Cecilia, Ecuador (Duellman 1978). Subsequently, the herpetofaunal communities of Iquitos, Peru (Dixon & Soini 1986, Duellman & Mendelson 1995) and Manu National Park, Peru (Rodríguez & Cadle 1990, Morales & McDiarmid 1996) were studied, as well as the commencement of the Minimum Critical Size of Ecosystems Project near Manaus, Brazil (Zimmerman & Rodrigues 1990). In the Tambopata region of south-eastern Peru preliminary species lists of four sites were written (McDiarmid & Cocroft, unpubl., Duellman & Salas 1991, Sehgelmeble 1997, Salas 1995). All of the above studies were merely lists of species; Duellman (1990, see also Duellman & Koechlin 1991) summarised the knowledge of Neotropical rainforest herpetofaunal communities, finding that much more research into the ecology of the species needed to be conducted.

The herpetofaunal component of TReeS-RAMOS Project Tambopata is the first study to analyse potential anthropogenic impacts on rainforest herpetofaunal communities. While studies have shown that some mammal and bird communities are altered by tourism (Griffiths & van Schaik 1993, Hidinger 1996, Yoon 1997), effects on herpetofauna are completely unknown. Reptiles and amphibians, many of which are nocturnal, arboreal, fossorial, or cryptozoic, come into contact with tourists less often than the larger, more visible mammal and bird species. Nevertheless, the presence of tourists and their trails may, indeed, impact the local herpetofauna.

For the herpetofaunal study, parcel locations were carefully chosen in order to match forest types (see Phillips 1993) and history of trail usage. As each lodge has a different complement of available forest types, one type was chosen per site in which to census. The older and higher forest types [Old Floodplain Forest (Type F) and Terra Firme Forest (Types G and H)] were preferred for the study to facilitate sampling. Due to the careful selection of forest types, many species known to be present at the lodge sites were not sampled. For example, many amphibians may only be found near lakes or rivers, but none of our surveys included these microhabitats. This study did not attempt to sample populations of all species; a smaller number of species is sufficient to demonstrate trends in tourist versus non-tourist areas.

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[1] Correspondence: Appendix 3.

The forest types used for herpetofaunal surveying at each lodge were:

Cusco Amazónico (CAPH)	Seasonally Flooded Swamp Forest/ Old Floodplain Forest transition (Type B/F).
Explorers' Inn (EI)	Terra Firme Sandy-Clay Forest (Type H).
EcoAmazonía (ECO)	Seasonally Flooded Swamp Forest (Type B).
Sachavacayoc (SACHA)	Old Floodplain Forest/ Terra Firme Clay Forest transition (Type F/G) with bamboo.
Tambopata Research Center (TRC)	Old Floodplain Forest/ Terra Firme Clay Forest transition (Type F/G) with bamboo

Methods

Each of the five sites was visited five times during the two-year study with the same amount of sampling days at each site during each visit. In order to assess the population levels of reptiles and amphibians in areas of current tourism and control areas free of tourism, two principle sampling methods were utilised: Quadrats and Visual Encounter Surveys (VES).

Quadrats

The quadrat method has been shown to be one of the most effective herpetofaunal sampling techniques (Jaeger & Inger 1994). Four observers intensively searched each quadrat, which measured 8 by 8 meters. Observers began at one of the four corners of each quadrat and moved at the same velocity in a clockwise direction. Each observer searched for one metre in width and moved one metre inward at each corner, until all four observers met in the centre of the quadrat. This synchronised movement prevented most of the individual reptiles and amphibians from exiting the quadrat before capture. The four observers consisted of two experienced co-ordinators (the authors) and two assistants. With four observers, quadrats were completed in an average of 11.33 minutes each during the daytime and 14.88 minutes each at night.

Observers searched for reptiles and amphibians through the leaf litter and on branches, trunks, and leaves up to 2 m in height. Each individual encountered was captured by hand, measured to the nearest 0.1 mm with callipers, weighed on a Pesola spring scale to the nearest 0.25 grams, marked, and immediately released at the point of capture. Also recorded were substrate and height at which individuals were encountered. Frogs and lizards were individually marked by toe clipping using the Twitty scheme (Twitty 1966, Donnelly et al. 1994). Snakes and caecilians were not marked because the likelihood of encountering them again is very small.

For each 8 by 8 m quadrat, environmental variables were also recorded. Air temperature was noted at the start of sampling. The percentage of cloud cover at the start of each quadrat was estimated. The diameter of all trees greater than 10 cm in diameter at breast height (dbh) was measured. Additionally, leaf litter depth was measured by penetrating the leaf litter with a metal wire and counting the number of leaves that the wire penetrated. This was done at four points on each side of the quadrat, for a total of 16 depth estimates. These environmental variables were recorded to account for variation among individual quadrats.

Quadrats were arranged in parcels measuring 80 by 70 metres. Each of the 56 quadrats per parcel was centred in a 10 by 10 m square with 2 m separating adjacent quadrats and 1 m between all quadrats and the borders of the plot. At each site two treatment quadrat plots were traversed by tourist trails. Also at each site, two control plots were located at least 200 m away from all tourist trails and treatment plots. A distance of two hundred metres was chosen after it was determined that the vast majority of the reptiles and amphibians captured during this study do not move more than 100 m in a lifetime.

Out of the 56 quadrats within each parcel, one half was sampled per site visit. The quadrats to be sampled were chosen randomly, using a random number table. During the two first visits of a site 14 of the 28 randomly chosen quadrats were surveyed during the morning and 14 at night. Beginning with the third site visit 22 quadrats were sampled at night and the remaining 6 during the morning. The reason for this change was that the capture rate for almost all species was much higher at night, therefore the change greatly increased the capture rate. In total, 112 quadrats were sampled per lodge visit.

Visual Encounter Survey (VES)

Two plots measuring one hectare each were demarcated, one for use as a treatment (tourist trail) parcel and one as a control parcel. Within each square plot, 24 straight-line transects of 100 m were marked with 4 metres separating adjacent transects. A small path was cut along each transect to facilitate walking and searching, and to prevent observers from straying into neighbouring transects while navigating with compasses at night. Each transect was walked twice per site visit, once during the morning and once at night. At least three days were allowed following parcel installation and maintenance before surveying began and at least two days between subsequent sampling of the same transect.

Transects were walked at an average pace of 25.71 minutes per 100 m transect during daylight and 39.63 minutes per transect at night. This slow pace enabled thorough examination of the vegetation by each observer. Relative to quadrats, effort expended while sampling was light, being confined to visual searching without disturbing the vegetation. Each team consisted of one co-ordinator, a second observer, and another assistant who processed all of the individuals caught. As with quadrats, all reptiles and amphibians were captured and processed as above, the only difference being that the transect where the individual was caught, the distance along that transect, and time of each individual capture were also recorded and tree diameter was not measured in the transect parcels.

Both quadrats and visual encounter surveys were used in this study because each targets different species. Faster moving lizards, most snakes, and arboreal frogs are more likely to be caught during VES, while frogs and small lizards that inhabit the leaf litter are more likely to be captured with quadrats (Crump and Scott 1994).

Analysis

Each lodge was sampled five times during the two-year study. Total person hours were calculated by summing the total number of quadrats and transects conducted during the two-year period (3,336 quadrats; 2,832 transects) and multiplying those numbers by the average length of the method (diurnal and nocturnal surveys separately) and the number of investigators present.

Four main categories of analysis were conducted. The first three types are analyses that were performed for each site separately. The last type also includes analyses among all the sites of Tambopata. The first analysis type compared the three treatment parcels (two quadrat, one transect) versus the control parcels to determine if there exist any direct effects on the abundance, species richness, or diversity of the herpetofaunal communities. The second tests effects on individual species. The third examined the effects of the tourist trails themselves on the herpetofaunal community. The fourth type of analysis examined the herpetofaunal community as a whole, considering abiotic factors. Each type of analysis will be examined in turn.

Treatment versus Control

Herpetofaunal diversity was calculated using the Shannon-Wiener Index (H') by lumping the three treatment parcels versus the three control parcels. Community similarity was broadly examined by using the Morisita and Percent Similarity indices. Two indices were used because they produce slightly different results; Krebs (1999) recommends Percent Similarity while Wolda (1981) recommends the Morisita Index as the best index available. The lumped treatment versus control abundances, by anuran and lizard species, were tested using the Wilcoxon Matched Pairs Sign Rank test. Snake abundances were not sufficiently high to perform this analysis.

Individual Species Parcel Abundance

Species abundances were tested by considering the six parcels individually, treatment versus control. All species present in Tambopata were not tested because many of the species do not have a sufficiently high abundance per parcel to produce valid results. Therefore, the eight most abundant anuran species of the region were chosen for analysis. Some species do not occur (or only marginally occur) at all sites; thus they were not analysed. In addition, the anuran species abundances per site were ranked and all the species within the top ten of each site (that were not included in the original eight) were also tested. One lizard species, *Anolis fuscoauratus*, was also tested at all sites; three other lizard species: *Gonatodes humeralis, Pseudogonatodes guianensis*, and *Prionodactylus eigenmanni*, were analysed at the two Río Madre de Dios sites (ECO and CAPH) where they were abundant. All species in this analysis were compared using the Mann-Whitney U Test. Snakes were not analysed.

Trail Effects

To determine if the tourist trail itself effects the abundance, species richness, or diversity of reptiles and amphibians, the quadrats that were in actual contact with the tourist trail (trail quadrats) were tested against a randomly chosen equal number of quadrats that did not touch the trail. Mann-Whitney U tests compared the species richness, diversity, and abundance of common species. The Percent Similarity and Morisita indices of similarity were also used to compare the trail and off-trail anuran and lizard communities. Snakes were omitted from all trail analyses because of their low occurrence.

To acquire an even finer view of potential trail effects, quadrats within each treatment parcel were grouped into units based on the distance from the trail to the quadrat. Five groupings were established as follows: trail quadrats, quadrats beginning no closer than five meters from the trail and no farther than ten meters from the trail, quadrat beginning 11-15 m from the trail, quadrats beginning 16-20 m from the trail, and quadrats more than 20 m from the trail. The quadrats that began less than five meters from the trail were excluded from the analysis. The number of quadrats in each grouping was determined by the number of quadrats available in every grouping, depending on the trail layout and parcel orientation. Some parcels did not have sufficient numbers of quadrats per grouping (e. g. parcels in which a circuitous trail filled most of the parcel) and were excluded from the analysis. The diversity of each trail grouping was regressed on the distance in meters from the trail to determine if distance from the trail directly causes differing levels of anuran diversity. Additionally, the anuran diversity and species abundance for the common species by trail grouping per site were tested using the Kruskal-Wallis Test.

Overall Effects of Tourism in Tambopata

The final analysis type examines potential trends throughout all the lodges sampled. Firstly, all of the quadrats in each trail grouping (see Trail Effects above) per site were combined and the diversity of the entire grouping per site was determined using the Shannon-Wiener Index of Diversity. Using the five sites as replicates, a Kruskal-Wallis test determined whether distance from the tourist trail affected anuran diversity as an overall trend throughout Tambopata.

Secondly, the treatment diversity (two quadrat parcels plus one transect parcel) of each site (see Table 4.2) was regressed on the average annual number of tourist visitors to each lodge (the log of tourist numbers was used to control heteroscedasticity). This regression was used to determine if the quantity of tourists (who walk upon the tourist trails of this study daily) affects the diversity of anurans and/or lizards of Tambopata.

Results

The intensive two-year herpetofaunal sampling of Project Tambopata yielded 6,012.92 person-hours, divided between diurnal and nocturnal surveys and transect and quadrat methodologies. The number of individuals caught for the entire study was 19,957, with 18,146 amphibians and 1,811 reptiles in total. When referring to species richness, 88 amphibian species and 55 reptile species were captured during sampling. More specifically, there were 87 anuran species registered, one caecilian, one turtle species, 23 lizard species, and 32 snake species. Many additional species were recorded during non-sampling hours but those results will not be presented here. Figure 4.1 is a graphical depiction of the number of new species registered every month of the study. Figure 4.2 represents a graph of the accumulation of those species per month. It can be seen from this that the amphibian curve begins to flatten after the seventeenth month, signifying that a large percentage of all species were registered by the study; the portion of species that were not registered by that time represents an insignificant proportion of the total species actually occurring in Tambopata. The reptile curve, which begins to flatten at the fourteenth month, signifies that most species catchable with transect and quadrat methodologies had been caught by that time. Previous studies by other authors (e. g. McDiarmid and Cocroft, unpubl., Duellman and Salas 1991) registered many more species in Tambopata by sampling a wider diversity of forest types than was used in this study. The majority of reptiles not encountered were snakes, mostly arboreal and aquatic species.

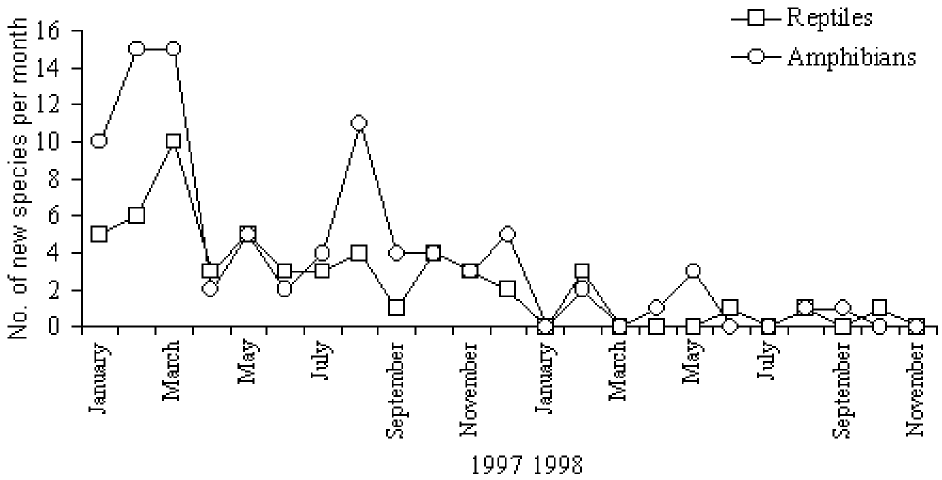

Figure 4.1. Number of new species encountered per month.

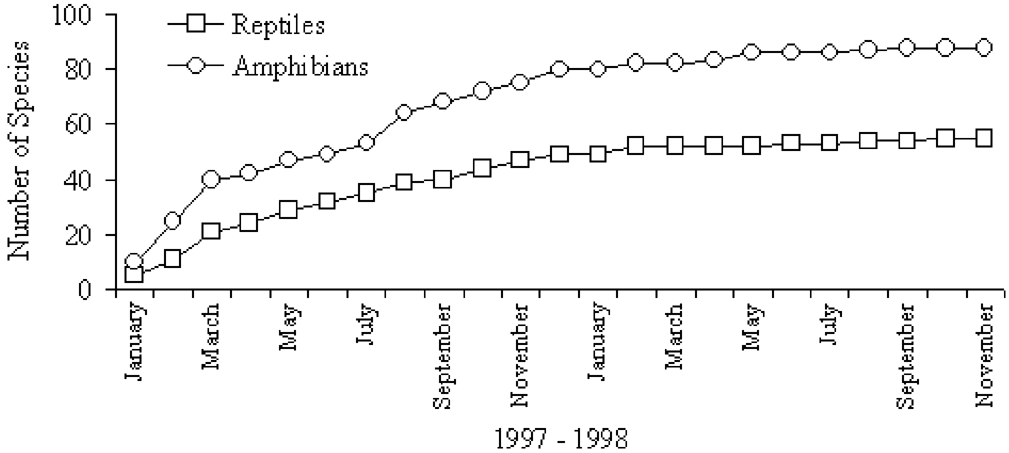

Figure 4.2. Species accumulation curves.

Treatment versus Control

The species richness of the treatment and control areas at each site is presented in Table 4.1. The Shannon-Wiener Index of Diversity for each site is shown in Table 4.2. The TRC has the highest overall amphibian diversity; EI has the lowest. While there is no test of significance for the Shannon-Wiener Diversity Index, it appears obvious that CAPH has strikingly higher amphibian diversity in its control areas while EI has much higher diversity in its treatment areas, and the other three sites have roughly the same diversity in both treatment and control. For reptiles, CAPH has the highest diversity while SACHA has the lowest. Both EI and SACHA have much higher diversity in the treatment areas than the control areas but the other three sites show similar diversities in both areas.

Table 4.1. Species richness sampled at 5 lodges.

Lodge	Treatment			Control		
	Frogs	Lizards	Snakes	Frogs	Lizards	Snakes
Cusco Amazónico	32	12	11	36	12	12
Explorers' Inn	39	4	11	27	5	6
EcoAmazonía	42	14	14	41	14	12
Sachavacayoc	38	10	15	36	7	9
Tambopata Research Center	43	10	9	44	8	13

Table 4.2. Diversity of amphibians and reptiles in Tambopata, Shannon-Wiener Index, Treatment vs. Control.

Lodge	Treatment		Control	
	Amphibians	Reptiles	Amphibians	Reptiles
Cusco Amazónico	0.833	1.001	1.076	1.005
Explorers' Inn	0.943	0.934	0.794	0.777
EcoAmazonía	1.062	0.896	1.004	0.934
Sachavacayoc	0.980	0.863	0.960	0.564
Tambopata Research Center	1.104	0.986	1.156	0.911

As a broad look at the overall results of the herpetofaunal study, community similarity indices were used. The results of the Percent Similarity and Morisita indices are shown in Table 4.3. According to each of the indices, the TRC appears to have the largest difference of anurans between treatment and control areas (i.e. tourism has affected the herpetofaunal community the most), while SACHA is the least affected. For reptiles the results were quite different; ECO is least affected while EI is most affected.

Table 4.3. Herpetofuana community similarity indices; Treatment vs. Control.

Lodge	Percent Similarity		Morisita	
	Amphibians	Reptiles	Amphibians	Reptiles
Cusco Amazónico	72.883	75.060	0.867	0.958
Explorers' Inn	74.236	62.973	0.921	0.951
EcoAmazonía	80.545	84.680	0.919	0.982
Sachavacayoc	86.616	73.622	0.971	0.967
Tambopata Research Center	62.793	68.109	0.742	0.983

When relative abundances of all species present per site were compared in treatment versus control, the Wilcoxon Test showed that only EI ($Z = -4.133$, $p = 0.000$) had significantly different anuran abundances over all species (see Table 4.4) with higher abundances in the treatment area. SACHA had significantly higher relative reptile abundances in the treatment areas but contrastingly, CAPH had higher reptile abundances in the control areas.

Table 4.4. Relative abundance, Wilcoxon probabilities, * $p < 0.05$, ** $P < 0.01$, *** $p < 0.001$, T = Treatment, C = Control.

Lodge	Anurans	Reptiles
Cusco Amazónico	0.896	0.030 *C
Explorers' Inn	0.000 ***T	0.138
EcoAmazonía	0.899	0.334
Sachavacayoc	0.153	0.001 ***T
Tambopata Research Center	0.628	0.861

Individual Species Parcel Abundance

The results of the Mann-Whitney U tests for parcel abundance by individual species are presented in Table 4.5. The numbers in the table are the calculated probability levels (p). None of the four lizard species tested produced significant results; some anuran species, however, had significantly higher abundances in either treatment or control areas.

Neither of the two Río Madre de Dios sites, ECO and CAPH, had any significant differences while each of the Río Tambopata sites had at least two significant results. EI had significantly higher abundance of the dendrobatid *Colostethus marchesianus,* the bufonid *Dendrophryniscus minutus,* and the leptodactylid *Physalaemus petersi* in the treatment parcels. SACHA had significantly higher abundance of the leptodactylid *Phyllonastes myrmecoides* and the microhylid *Ctenophryne geayi* in the treatment parcels. TRC had significantly higher abundance of the bufonid *Bufo cf. typhonius,* the microhylid *Chiasmocleis bassleri*, and *Physalaemus petersi* in the treatment parcels, while the dendrobatid *Epipedobates pictus* was significantly more abundant in the control area. For all of the other species tested, the null hypothesis of no relationship between tourism versus non-tourism parcels was accepted.

Trail Effects

When the potential effects of the actual tourist trail were considered no significant effect was found on the species richness of anurans at any site (Table 4.6). The diversity of anurans, however, was shown to differ significantly at SACHA ($U = 60.00$, $p = 0.029$) by having higher diversity in the trail quadrats, but at no other sites. On a species by species basis, only the microhylid, *Hamptophryne boliviana* was found significantly more often on the tourist trail than away from the trail (Table 4.7). In all cases of richness, diversity, and by species, lizard and snake abundances were too low to detect any trend. Similarity indices between the trail and off-trail groups for anurans showed high similarity with CAPH being the highest and TRC the lowest (Table 4.8). Reptile communities in the two treatments have low similarity, probably due to the large number of species with few individuals within each species. At finer scales, the linear regression of trail group diversity on quadrat distance from the tourist trail produced no significant results (Table 4.9). When actual distance from the tourist trail was considered, no patterns were detected in abundance of individual species (see Table 4.10).

Overall Effects in Tambopata

When trail groupings for all lodges were utilised to discover trends throughout the Tambopata area, no significant differences were detected (K-W = 1.935, p = 0.748). Regressions of treatment parcel diversity against annual tourist numbers also proved to be not significant, although the anuran regression suggests that a slight trend may be present (F = 6.981, p = 0.078), while lizard diversity showed no trend whatsoever (F = 0.344, p = 0.599).

Table 4.5. Results of the abundance per parcel, Mann-Whitney probabilities. IA = Insufficient Abundance to test; * p < 0.05, ** p < 0.01, *** p < 0.001, T = Treatment, C = Control.

		Lodges				
	The eight most abundant Anurans	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
1	*Adenomera andreae*	0.275	0.184	0.513	0.513	0.127
2	*Hamptophryne boliviana*	0.275	0.121	0.127	0.827	0.825
3	*Eleutherodactylus toftae*	0.376	IA	IA	0.827	0.275
4	*Chiasmocleis ventrimaculata*	0.827	IA	0.827	0.813	0.507
5	*Colostethus marchesianus*	0.513	0.050*T	0.513	IA	IA
6	*Eleutherodactylus peruvianus*	0.261	0.827	0.827	0.261	0.827
7	*Phyllonastes myrmecoides*	IA	0.121	IA	0.050*T	0.513
8	*Bufo cf. typhonius*	0.500	0.127	0.827	IA	0.050*T
	Other Abundant Anurans					
9	*Dendrophryniscus minutus*		0.050*T			
10	*Epipedobates pictus*			0.184		0.050*C
11	*Hyla fasciata*					0.827
12	*Osteocephalus taurinus*		0.077			
13	*Scarthyla ostinodactyla*			0.513		
14	*Scinax cruentomma*				0.827	
15	*Scinax garbei*			0.507		
16	*Scinax icterica*				0.513	
17	*Scinax pedromedinai*	0.268		0.513		
18	*Scinax rubra*				0.513	
19	*Eleutherodactylus skydmainos*					0.127
20	*Eleutherodactylus sp. 1*		0.077			
21	*Leptodactylus mystaceus*	0.127		0.827	0.268	
22	*Physalaemus petersi*		0.050*T			0.050*T
23	*Chiasmocleis bassleri*					0.046*T
24	*Ctenophryne geayi*	0.376			0.050*T	
25	*Elachistocleis bicolor*	0.127				
	Top Four Lizard Species					
1	*Anolis fuscoauratus*	0.268	0.658	0.376	0.268	0.513
2	*Prionodactylus eigenmanni*	0.827		0.827		
3	*Gonatodes humeralis*	0.127		0.827		
4	*Pseudogonatodes guianensis*	0.513		0.658		

Table 4.6. Results of trail vs. non-trail for Anurans per lodge, Mann-Whitney probabilities; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, T = Treatment, C = Control.

Lodge	Species Richness	Species Diversity
Cusco Amazónico	0.563	0.659
Explorers' Inn	0.920	0.582
EcoAmazonía	0.126	0.286
Sachavacayoc	0.183	0.029*T
Tambopata Research Center	0.196	0.157

Table 4.7. Results per species for trail vs. non-trail per lodge, Kruskall-Wallis probabilities; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, T = Treatment, C = Control.

Species	CAPH	EI	ECO	SACHA	TRC
Adenomera andreae	0.600	0.885		0.786	
Eleutherodactylus toftae				0.562	0.919
Physalaemus petersi		0.796			
Chiasmocleis ventrimaculata	0.697			0.376	
Hamptophryne boliviana	0.713		0.006**T	0.727	

Table 4.8. Results of trail vs. non-trail indices of community similarity, IA = Insufficient Abundance to test.

Lodge	Percent Similarity		Morisita	
	Amphibians	Reptiles	Amphibians	Reptiles
Cusco Amazónico	87.668	70.370	1.008	1.074
Explorers' Inn	81.715	75.000	0.991	1.875
EcoAmazonía	75.655	66.194	0.973	0.946
Sachavacayoc	80.967	40.000	0.953	0.908
Tambopata Research Center	69.423	IA	0.911	IA

Table 4.9. Regression results per lodge based on trail groups, F-test probabilities; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, T = Treatment, C = Control.

Lodge	Probability
Cusco Amazónico	0.324
Explorers' Inn	0.986
EcoAmazonía	0.545
Sachavacayoc	0.512
Tambopata Research Center	0.199

Table 4.10. Results of trail groups by species, Kruskall-Wallis probabilities, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Species	CAPH	EI	ECO	SACHA	TRC
Dendrophryniscus minutus		0.204			
Scinax spp.				0.970	
Adenomera andreae	0.746	0.850		0.168	
Eleutherodactylus peruvianus		0.134			
Eleutherodactylus toftae				0.146	0.975
Leptodactylus mystaceus				0.970	
Phyllonastes myrmecoides				0.234	
Physalaemus petersi		0.417			
Chiasmocleis ventrimaculata	0.826			0.223	
Ctenophryne geayi				0.975	
Hamptophryne boliviana	0.646		0.212		

Discussion

The herpetofaunal research team of TReeS-RAMOS Project Tambopata sampled an amazing array of species of reptiles and amphibians. Never before has a herpetofaunal study of this length and scale been performed in a rainforest habitat. Accordingly, with nearly 20,000 individuals censused, this study is uniquely able to discern trends of tourism impact on the local herpetofauna in Tambopata if such trends exist. The treatment versus control tests provide a wide variety of approaches that produce an equally large array of differing results. There are some important overall trends that may be gleaned from these results. EI has both higher diversity and relative abundance of anurans in the treatment areas. For reptiles, both EI and SACHA are more diverse in the treatment areas. Contrastingly, CAPH has higher diversity and relative abundance of both amphibians and reptiles in the control areas. No other sites have clear relationships of tourism and herpetofaunal diversity or relative abundance.

Anurans, indeed, are affected by the presence of tourism. This result is most obvious in CAPH where the diversity and relative abundance of amphibians is higher in the control areas after nearly twenty-five years of daily tourist pressure. When the trail vegetation becomes trampled and dies, it is likely that the absence of plant cover forces arthropods, the primary prey of anurans, to move away from the trails. Thus, the anurans have lost their local food source and must vacate the trail area to find their arthropod prey. In time, the anurans discover new food sources away from the trail area.

The effects at EI also support the alternative hypothesis that tourism affects the herpetological community, but in a different sense. Like CAPH, EI has been receiving tourists for nearly twenty-five years. But unlike CAPH, which has low, seasonally inundated forest, the Type H forest of the EI parcels never floods. The highly eroded trails at EI become flooded gullies during the rainy season which attract many species of frogs to the limited water source. The authors have observed oviposition by several anuran species in these trail pools (within the treatment parcels) at EI on various occasions. The temporary pools seemingly serve as suitable oviposition sites; however, when as many as forty tourists trample the area the next day, the survival rate of eggs and tadpoles is probably minimal. At EI anurans do not have the luxury of migrating to areas free of tourists because oviposition sites are limited in the non-flooding "high forests". They instead remain near these man-made bodies of water.

Accordingly, the reptile abundance at CAPH, and both the abundance and diversity at EI follow the anuran results. Where there are more amphibians, their snake and lizard predators are also more abundant and diverse. This pattern is easily explained by prey availability. The only site that cannot be explained thus far is SACHA. The reptile diversity and relative abundance of the treatment parcels are significantly higher than the control parcels, but without the concomitant amphibian pattern. The SACHA trends will be examined with the other analyses.

Besides the larger scale community results, some individual species are affected by tourism as well. For the most part the species that are affected by tourism have higher abundance in the treatment areas. Only *Epipedobates pictus* at the TRC was more abundant in the control areas. The EI species follow the previous treatment versus control results. Indeed, breeding congregations of *Physalaemus petersi* were seen calling and ovipositing in "Main Trail" at EI for several nights at the start of the rainy season. In other areas of EI trails, adult male *Colostethus marchesianus* deposit their tadpoles directly in the trail. Recently metamorphosed juveniles are occasionally seen emerging from the small pools on the trail, indicating that some tadpoles in the man-made pools do indeed survive past the tadpole stage, despite probable overall depressed developmental success.

At SACHA and TRC the microhylids *Ctenophryne geayi* and *Chiasmocleis bassleri* were significantly more abundant in the treatment areas. Additionally, *Dendrophryniscus minutus* and *Phyllonastes myrmecoides* were more abundant in treatment areas at EI and SACHA, respectively. A likely reason for their significant presence in the treatment areas is that all four of these species are ant specialists (Rodríguez and Duellman 1994) that prefer to live near tourist trails where ants of many species (e. g. *Atta* and *Ecyton*) commonly utilise human-made trails (pers. obs.). Similarly, many bufonids prefer trails for their locomotion because of large body size; the *Bufo* cf. *typhonius* results agree with this notion.

The Tambopata species of the dendrobatid genus *Epipedobates* (*E. femoralis, pictus,* and *trivittatus*) all prefer the specific microhabitat of tree fall gaps (Duellman 1978, pers. obs.). When tourist trails are created tree fall gaps are usually avoided because the lodge owners and guides prefer to show the tourists what they consider "pristine" and uncluttered forest. By omitting the gap microhabitat, they are inadvertently avoiding areas where poison dart frogs are abundant, as shown at TRC where *Epipedobates pictus* is most abundant.

The trail analyses utilise a very different approach than the former analyses by examining tourism only using the treatment parcels and by searching for effects on the smaller scale of the parcel itself. No significant effects on anuran species richness were found, supporting Ludwig and Reynolds's (1988) statement that species richness is not an adequate measure of a community. SACHA was the only site to differ significantly in biodiversity between trail and off-trail quadrats. The similarity indices, however, result in a rather high similarity in the trail versus off-trail comparison at SACHA. Because similarity indices do not have statistical probability distributions associated with them (Krebs 1999) higher confidence should be placed in the Mann-Whitney U tests than the similarity indices. Therefore, the significant diversity difference at SACHA is an important result. No individual species, however, had significantly different abundances in the trail versus off-trail quadrats at this lodge.

The only species that had significantly different abundance between the trail quadrats and non-trail quadrats was the microhylid *Hamptophryne boliviana* at ECO. As the overall second most abundant frog species at ECO (behind *Adenomera andreae*) this is a very important result. As with the microhylid species mentioned above, it is likely that this ant specialist stays near open trails where many species of ants prefer to march.

The treatment versus control and trail versus off-trail similarity results may be directly compared to determine which tourism effect (i. e. large scale or small scale) is more important to the structuring of herpetofaunal communities in Tambopata (Tables 4.3 and 4.8). At three sites (CAPH, EI, and TRC) there is a larger treatment versus control effect while at ECO and SACHA effects are on the parcel scale of trail versus off-trail. Because of these dichotomous results no general statement of which effect is more important can be made at this time.

Neither the linear regressions on trail group distance nor the trail groups tests on individual species were statistically significant. This result may mean one of two possibilities: 1) the actual distance from the trail is not an important factor, or 2) the sampling was inadequate to determine such an effect. In the case of the trail groups analyses it is highly possible that the sampling was too thinly spread over the eligible parcels to contain enough individuals per species to amount to significant numbers for this type of analysis. As mentioned above, the trail systems of some sites meandered so much that they nearly filled the entire parcels, voiding them from the analysis. In other sites the habitat heterogeneity and trail system caused the parcel to contain too little of the trail to be used in the trail groups analysis. Because of the limited number of suitable parcels available no significant results were found. To attempt to counter the problem of sample size per trail grouping, all quadrats per trail grouping per site were combined into one data set. When sites were used as replicates, again, no significant result was found. Therefore, either the effects of distance from the trail are localised but not detected in these analyses or there is no effect of trail distance.

Annual tourist numbers may produce an effect on the diversity of the local herpetofauna. Although the regression was not significant ($p = 0.078$), a correlation of the same data shows a strong negative relationship (Pearson = -0.900) of annual tourists numbers and treatment diversity. As was concluded with the treatment versus control data, sites with long-standing high quantities of tourists (e. g. EI and CAPH) are most impacted by tourism pressure.

The fixed structure of current tourism programs at four of the lodges used in this study allows the tourist little opportunity to view reptiles and amphibians. Three lodges do offer a nocturnal boat trips to spot caimans, which occasionally gives the tourists views of one of the largest herpetofaunal species of the area. Sightings of frogs, lizards, and snakes are few and the general view of the lodge personnel and management is that tourists have little interest in seeing them. It must be mentioned, however, that one lodge, the TRC, does offer night-time hikes with the express purpose of searching for reptiles and amphibians. The herpetofauna questionnaire (see Chapter 6.0) provided some unexpected results that may be used to modify current tourism programs to include opportunities to view the more secretive herpetofauna. As can be seen from the results of this questionnaire, tourists do wish to see amphibians and reptiles and would participate in a night walk if it were offered. Additionally, a high percentage of tourists do not want the lodges to keep amphibians and reptiles as pets or capture caimans during the nocturnal boat trips. Both of these results acknowledge that most tourists are aware of conservation issues and understand that mistreating rainforest fauna is simply unacceptable. The questionnaire was also able to detect that tourists require more information about the wildlife they are likely to observe during their visit. A case in point is that four tourists claimed to have seen crocodiles during their stay although there are no crocodiles in Tambopata. Finally, seventy-three percent of the tourists sampled request more information about venomous snakes to be available at the lodge.

Conclusions

From the preceding Discussion it may be seen that tourism, in fact, does have an impact on the herpetofaunal communities of Tambopata, Perú. We may have great confidence in these conclusions because of the long length of the study, the rigorous methodologies, and extensive sampling. One important factor of tourism effects involves the intensity and length of tourism in an area. From TReeS-RAMOS Project Tambopata herpetological data we can see that, for amphibians, diversity decreases with time and high quantities of tourists. After a long period the amphibians either migrate to other areas that are not under tourism pressure or, in the case of the EI high forest, they remain in tourism areas but likely have very low reproductive fitness.

On the other hand, the presence of the actual tourist trail is not necessarily damaging to herpetofaunal communities. For many species the trail serves as a convenient area to hunt their prey, whether it be the ant prey of ant specialists or the amphibian prey of snakes and lizards. Additionally, trails facilitate movement of large species, including the bufonid toads and snakes.

In order to manage for high diversity of herpetofauna, the results of this study suggest several strategies that should be implemented by lodge owners and personnel. One possible strategy is to spread out the impact of tourists by having several different routes that different tourist groups can travel so that no one area of forest is impacted excessively. The current tourism programs at most of the tourist lodges in Tambopata utilise one route along which all tourists hike, thus concentrating the impact in one area. Providing more choices to the lodge guides may eliminate these "impact zones". A problem with this strategy is that, although it may benefit amphibians, numerous researchers (e. g. Mieczkowski 1995, Hunter and Green 1995) have shown that the most dramatic damage to vegetation occurs immediately after trail construction; creating many low-impact trails is more damaging to the forest than few high-impact trails. Another possibility, in lieu of cutting various trails, is to have one or two tourist routes with well-maintained raised platform trails. These trails may be wooden, metal, or any available material that may be made into a raised platform that may be easily walked by tourists. A raised platform does not cause erosion of the soil and the subsequent death of vegetation that may be the principle reason that amphibians flee areas of long-term tourist presence. The vegetation would not be altered and the herpetofaunal community would not be forced to emigrate to other areas.

5.0 The lowland rainforest bird communities of five ecotourism locations in Tambopata, Madre de Dios, South-eastern Peru

Authors:

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Introduction

South-eastern Peru and adjacent parts of Bolivia contain what is probably the largest and least disturbed area remaining of Upper Amazonian and Lower Andean ecosystems (Foster et al. 1994). The Department of Madre de Dios contains extraordinary levels of bird species richness. Over 570 bird species have been recorded at two single site locations; Cocha Cashu Biological Research Station, in Manu Biosphere Reserve (MBR), and at the Explorers' Inn (EI), in the Tambopata Candamo Reserved Zone (TCRZ)(see Foster et al. 1994 for a review of bird species located at the latter). Furthermore, over 440 species have been recorded at the Tambopata Research Centre, located in the Upper regions of the Tambopata River within the TCRZ.

It is evident that the number of lodges and tourist visitors has increased significantly over the last decade in the area under study (see General Introduction). The process of looking for tourism related impacts on bird populations is a very problematic exercise. Firstly one must chose a 'unit' of ecotourism to measure e.g. number of tourists walking the trails, the presence of the trail itself, etc. How does one quantify this unit of tourism? How can one relate this unit of ecotourism to the abundance of birds in the habitats surrounding the lodges? The hardest obstacle, however, is how to distinguish any apparent impact from other forms of disturbance as it is evident from many other studies that many bird species are habitat specialists and can be very susceptible to slight habitat changes brought about by natural and anthropomorphic phenomena not related to tourism.

The bird communities around the lodges in the TCRZ have been, as a rule, subjected to a number of different forms of disturbance over the years. Poor trail management and selective logging, which has been a practice at many lodges, are often characterised by changes in forest biomass and tree size parameters, different tree architectures and tree species compositions which are the important habitat parameters which can affect bird communities (Bibby et al. 1998). There has been exploitation over the years of the Brazil-nut tree and many lodges are situated relatively close to human settlements, and both variables tend to increase local hunting pressures. Some species may also be captured, noticeably members of the Psittacidae and Ramphastidae families, for the pet trade. The distance from the lodges to the nearest settlement may be correlated with the degree to which it has been disturbed or used by the local people for other purposes other than tourism. Furthermore, two of the main lodges have been operating for over twenty years (CAPH and EI). EI has been a major centre for bird-orientated tourism and research, the latter of which has exposed the bird communities to a relatively high level of "playback recordings", which can impact particularly territorial species. A severe form of natural disturbance in Tambopata which has been

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[1] Correspondence: Appendix 3.

little studied although potentially very significant is the mass seeding events of *Guadua* bamboo thickets.

Even if one could find a relationship between anyone of these forms of disturbance and the bird communities in the Tambopata region, one is still confronted by the problem that there is no quantified baseline population data prior to the lodges becoming established, to compare it with. The only quantitative research of an undisturbed lowland rainforest bird community in Peru comes from the Cocha Cashu Biological Station in the Manu Biosphere Reserve (Terborgh 1986, Terborgh et al. 1990, Robinson & Terborgh 1990). We are unable to make direct comparisons between the avifauna in Tambopata and Manu due to a lack of comparative habitat information between the two areas.

Previous research on bird species in the Tambopata province over the last twenty years has largely focused on simple observations (Parker, 1982), or on building species lists for five localities in the region (Davies et al. 1991, Foster et al. 1994). Three of these are ecotourist lodges we investigated here, however the other two sites are the Pampas del Heath (see Figure 2.1 - now incorporated into the Bahuaja-Sonene National Park) and the Cerros de Tavara, in the Andean foothill region (Foster et al. 1994). Kratter (1995b, 1997) was the first biologist to provide population data and habitat associations on a 'subset' of the lowland bird community in the Tambopata region, with his research on the habitat-restricted bamboo specialists at the TRC. Dyrcz (1990) and Lloyd (unpubl.) have also studied smaller 'subsets' of the whole bird community at the EI (understory bird species and terrestrial bird species, respectively).

Given the aforementioned problems with ecotourism impact studies on birds, we decided for this research, not to focus or examine a cause and effect relationship between tourism and the bird communities. Our aim was simple: to provide the first quantitative and descriptive population data on the lowland rainforest bird communities and to relate the findings to features of the lowland forest habitat at each site. Determination of avian habitat use is important for understanding both the ecology and conservation needs of a species or community (Rappole et al. 1998). The value of such an approach may come from predicting distribution and numbers in unsurveyed areas; providing an understanding of the nature of the relationship between a bird species and its habitat; predicting possible consequences of future changes of land use (Bibby et al. 1998); and in this case providing much needed background information on bird populations for the benefit of the participating tourism operations.

Objectives

- To examine the habitat structure of the predominant forest types at each lodge and to see whether this habitat structure differs significantly between lodges.

- To describe the bird community in each forest type and to investigate the status of each by examining the composition of indicator species, following the criteria of Stotz et al. (1996).

- To produce the first species lists for SACHA and ECO.

- To examine the abundance of indicator species and total number of species surveyed and their relationship with features of the habitat in each forest type.

- To calculate absolute population densities of indicator species per unit area of forest habitat, with the aim of estimating absolute densities for the whole Tambopata region for the more habitat-restricted species, and thus those species most at risk from habitat alteration. [Total population estimates and subsequent recommendations for the conservation status for these habitat-restricted species are addressed in the section 'Species Accounts']

- To examine the abundance of large frugivorous birds, mainly parrots and toucans, and relate this to the timing of the fruiting season in Tambopata. [Due to their colouration, behaviour and familiarity to tourists from the pet trade and television documentaries, these species are frequently the species that tourist most want to see in the rainforest (Munn, 1992).]

- To make recommendations to lodge administrators regarding the management of forest habitats with respect to birds.

Habitat Descriptions of Avifauna Study Sites

EcoAmazonía Lodge (ECO)

The primary habitat around the point count stations at ECO was Seasonally Flooded Swamp forest (Type B). Type B forest is characterised by an abundance of tree palms e.g. *Scheelea butyracea*, *Euterpe precatoria* and *Socratea exorrhiza*. Broad-leaved tree species include *Symphonia globulifera*. The canopy is normally low (<20 m) and broken, with a dense understory of shrubs and small palms, especially *Geonoma* and *Bactris* species. Vines and scandent herbs are moderately abundant but large lianas are rare. Ground vegetation is restricted to areas of drier ground atop low hummocks, dominated by the fern *Adiantum latifolium*.

Aguajals are numerous within an area of 10,000 ha. around the lodge. There are three small aguajals running from North to South, whilst a fourth larger aguajal is also present (see satellite image). Following the main tourist trail, at 5 km there is a fairly extensive stand of riverine scrub. At 6.1 km two canopy platforms are located at the juxtaposition of three distinct habitat types; the scrub, type B forest and a large stand of Permanently Flooded Swamp forest (type A forest). This latter forest occurs in former ox-bow lakes and other permanently flooded or waterlogged situations. It's characterised by a predominance of the palm *Mauritia flexuosa*. Due to the extended periods of flooding, ground and understory vegetation is scarce or absent. Aquatics such as *Apalanthe granatensis* and *Lemna aequinoctialis* are sometimes present in the standing water. A considerable amount of organic detritus is usually present, accumulating normally around the base of the trees so that these sometimes form small raised islets within the swamp and may be colonised by terrestrial trees and other vegetation. Water levels in the swamp forest may drop during the dry season by as much as one metre during the dry season.

Located in the river, opposite the lodge is Monkey Island (Isla de Monos), a 30 ha. island dominated by Type C Lower Floodplain forest. This consists of pioneer trees and herbaceous vegetation, and is found on low recently developed or developing floodplain beaches, but is more characteristic of river islands in both the Rio's Madre de Dios and Tambopata. *Cecropia membranacea*, *Ficus insipida* and *Sapium ixamasense* dominate this open successional forest. Few trees reach more than 20-25 m in height.

The cane *Gynerium sagitatum* is the dominant understory species. Small liana's such as *Paullinia alata* are common and form locally dense tangles. Ground cover is sparse, mainly consisting of dense clonal patches of *Calathea* and *Heliconia* species. *Tessaria integrifolia* and *Salix humboldtiana* are found growing on a narrow belt along the river edge, upon levee deposits.

Cusco Amazónico Pueblo Hotel (CAPH)

Predominant forest type at CAPH is a mosaic of type B forest with Old Floodplain Forest (type F). Extensive areas of pure type F forest are the second most common type within the 10,000 ha. of land surrounding the lodge. The forest canopy in areas is tall (>30 m) and is more continuous than type B forest. The palm species *Iriartea deltoidea* is particularly abundant. In total, palm species make up approximately 30% of the tree stems in this forest type. Large emergents such as *Dipteryx* species, *Ceiba pentandra* and strangling figs are common. The dense shade caused by the more closed canopy inhibits dense understory growth, with the result that the understory is relatively open. The ground fern *Adiantum latifolium* dominates the ground vegetation. In pure type F forest flooding no longer occurs but probably has happened in recent years. However, due to the presence of type B forest in this mosaic, this forest floods more frequently than normal.

North of the trail system there are larger areas of type B forest exist, whereas south-east of the lodge, is situated a 45 ha island, also named Isla del Mono. Larger in size than the island at ECO, it is also covered with type C forest.

Explorers' Inn (EI)

The vegetation types of the reserve have previously been described by Phillips (1993), Nicholson and Edwards (1994), and Nicholson and Phillips (unpubl.). Nine distinct forest types are recognised. Type A forest is found along the northern region of Laguna Cocococha, a large oxbow lake in the north-eastern part of the reserve. Areas of type C forest are found along the banks of the Rio La Torre to the south of the lodge clearing, while in the southern area of the reserve, there are extensive areas of type E and type F forest (Nicholson and Edwards, 1994). A mosaic of type B and type G forest covers an extensive area to the east of the lodge clearing, whilst type H forest occupies the large areas of higher ground, to the south and east of the Laguna Cocococha. The light texture and free draining nature of the soils distinguishes this forest type from type G forest. Floristically it is also quite distinct from type G forest; palms such as *Iriartea deltoidea* and *Socratea* are almost completely absent, while emergents such as *Bertholletia excelsa*, *Cedrelinga cateniformis*, and *Dipteryx* species are common. Subcanopy species include *Bixa arborea, Pourouma* species, and *Capirona* species amongst others. The canopy is tall (>30 m), and closed, while the understory is relatively open and composed of small palms such as *Geonoma deversa* plus a variety of broad-leaved shrubs.

Sachavacayoc (SACHA)

SACHA contains a similar variety of habitat types to that found at the nearby EI. We recorded around five different forest types in total. The initial 2.7 km along the main tourist trail is dominated by Old Floodplain forest (type F). Extensive areas of bamboo (*Guadua weberbaueri*) are common in the understory vegetation here. In one area located between the nearby stream on the west of the lodge and the lodge itself, there is a large thicket of dense bamboo.

Around 2.5km along the main tourist trail and approximately 400 m east of it, there exist smaller areas of type G Terra Firme Clay Forest. This latter forest type has a very tall canopy layer (>30 m) but is much more open than type F forest, thus resulting in a more dense understory and ground layer. This forest type is usually found on higher raised platforms than the corresponding floodplain forests. Prominent tree species include the palms *Iriartea deltoidea*, and *Euterpe precatoria*, and broad-leaves such as *Pourouma* and *Pseudolmedia* species. Large emergents present include *Dipteryx* sp., and *Parkia nitidia*. Characteristics of the understory are shrubs such as *Cephaelis tomentosa* and smaller palm species such as *Geonoma*. More extensive however are patches of type B, Seasonally Flooded Swamp forest, of which some encroach to within 250 m on the main tourist trail.

The area beyond the 2.7 km mark along the main trail and extending for a further 3 km consists of an extensive area of Terra Firme Sandy Clay forest (type H). This forest continues up to a 45 ha. oxbow lake, Lago Sachavacayoc. On the east and west ends of the lake exist smaller areas of type A, Permanently Flooded Swamp forest. The type H forest type continues on the south side beyond the lake for an unknown but vastly extensive area until it reaches the foothill region.

Selective logging has occurred within the forests at SACHA. In 1985 small scale extraction of *Cedrela odorata* (Tropical Cedar) and *Cedrelinga cateniformis* began, while south of the lake in the type H forest, *Sweitenia* sp. were removed. Currently there are incidents of hunting near the lodge, along with small scale harvesting of *Geonoma* palms (Palmiche).

Tambopata Research Centre (TRC)

The different habitats at the TRC have already been described by numerous authors (Foster et al. 1994; Kratter, 1995a, b, 1997) and will only be briefly mentioned here. The main area of forest encompassing the majority of tourist trails is a mosaic of type E/F, Upper Floodplain/Old Floodplain forest. The Upper Floodplain forest component of the mosaic has relatively open canopy cover and a mean canopy height of 25-30 m. Palm genera such as *Iriartea*, *Astrocaryum*, and *Socratea* are frequent, as are emergents broad-leaved trees such as *Ficus*, *Chorisia* and *Ceiba*. Large lianas are more prominent than in type F forest. The understory contains species such as *Geonoma* sp. and broad-leaved shrubs. The fern *Adiantum latifolium* is the dominant ground level species. This forest type is subjected to more frequent flooding than Old Floodplain forest, probably once per decade. In other areas there exist blocks of type B forest, and type F forest inundated with bamboo (see Kratter, 1995a, 1997). Bamboo also dominates the 2.5 km long and 50 m tall bluff which runs in a NW-SE direction and located just SW of the lodge, it also dominates the vegetation atop the macaw clay-lick situated on the western shore of the Tambopata River, 200 m from the lodge (see Foster et al. 1994; Kratter, 1995a).

Methods

Given the aims of the research, we focused our attentions on the 319 bird species that are associated with the interior or edge of lowland rainforest habitats (Terborgh et al. 1990). Twenty families of bird species associated with other habitat types, e.g. oxbow lakes, river edge habitats, swamps, arboreal dwellers, etc. were judged to be not associated with lowland rainforest habitat, and were thus excluded from the principle surveys in this study (e.g. *Ardeidae*, *Ciconiidae*, *Scolopacidae*, *Apodidae*, *Alcedinidae*, *Hirundinidae,* etc). These species were only recorded during general observations particularly if they were rare or new sightings, to complete the bird species lists for each lodge. These records are presented in the section 'Species Accounts', and in Appendix 2.

Bird Census Methods

A combination of different census methods must be used to achieve the best possible accuracy in counts of species that possess different social and territorial systems (Terborgh et al. 1990). In the few population surveys that have been conducted in lowland rainforest habitats in Madre de Dios, the principle method used (in conjunction with other methods) has been Spot-Mapping (Kendeigh, 1944; Terborgh et al. 1990; Kratter, 1995a, 1995b, 1997). These spot-mapping surveys have usually been conducted during the peak in the breeding season of the lowland forest bird species (based on the respective authors personal observations), and they produce a density of number of breeding pairs per unit area of habitat. However, our study is a continuous survey over a 21-month period, and is not restricted to this corresponding timing of the peak in the breeding season. In fact we make no assumptions as to whether there is a peak in the breeding season. We aim to calculate absolute densities of the number of individuals per unit area of habitat and not number of breeding adult pairs. Thus the spot-mapping method was not chosen for this study.

The methods that were implemented were based on Distance Sampling Methods (Buckland et al. 1993). Distance sampling incorporates estimates of distance between bird contacts and the observer at fixed point count stations in the forest to estimate densities of species (Lloyd et al. 1998). These density estimates take account of the fact that some birds are detectable over much greater distances than others, or that species are more easily detected in one habitat type than another (Lloyd et al. 1998). This distance data also allows us to make comparisons between species and between the same species in different habitats that are not possible with other relative density estimation methods (Lloyd et al. 1998). There are four basic assumptions of distance sampling that have to be adhered to, in order to obtain unbiased results: 1) points and transects are placed irrespective of prior conceptions of bird density; 2) objects (birds) directly over each point count station or on a transect line are always detected; 3) objects are detected at their initial location prior to natural movement or movement in response to the observers; 4) distances are measured accurately or at least estimated with small and random error (Lloyd et al. 1998).

Our principle distance sampling method we used to survey the local diurnal bird species of each lodge was the Variable Circular Plot method (VCP)(Reynolds et al. 1980), this is also based on point transect methodology (Buckland et al. 1993; Jones et al. 1995: Marsden et al. 1997; Marsden and Jones, 1997; Marsden *in press*; and Lloyd et al. 1998). At three of the sites, ECO (type B forest), SACHA (type F forest), and EI (type H forest), 39 census stations were located along transect routes. For the other two smaller areas, 26 census stations were established in type E/F forest at TRC while 24 stations were established in type B/F forest at the CAPH site. Each census station was located 200 m apart, while each transect was also located at a minimum distance of 200 m apart. At all sites transects were situated either perpendicular across existing trails, along existing trails, or they were established in areas were there were no trail systems. Transects located perpendicular across trails had a central census station placed directly on the trail, with the remainder of the transect continuing up to 400 m either side of the trail. The number of census stations and length of each transect was dependant on the amount of available habitat at each site.

During January and September of each year, VCP surveys began at 0530 hrs and were concluded by 0830 hrs after which time vocal activity decreases significantly. During the months of September to December, dawn arrives earlier. Thus VCP surveys had to begin at 0445 hrs in order to adequately census the bird species that normally only sing during the predawn chorus (see Terborgh et al. 1990). Two observers spent 10 minutes at each census station recording all bird contacts. These contacts were assigned to one of three categories; seen, heard or seen and heard. Observers noted the time of the contact, species, and the number of individuals. Each bird contact was also assigned to one of five height categories: 1 = ground level (< 1 metre); 2 = understory (1 – 5 m); 3 = mid-canopy (5 – 15 m); 4 = canopy; 5 = flying above the canopy.

Observers then accurately estimated horizontal distance from the centre of the census station to each individual contact. For species that habitually occur in monotypic flocks, such as the parrot species, estimations of distance were made from the point count to the centre of the flock. Similarly, for the canopy mixed species flocks, it proved impossible to identify flock members during the predawn hours, high up in the canopy. Distance estimations were made from the point count to the geometric centre of each flock. The number of species and individuals was later obtained by searching for the same flock during later hours of the day.

Two repeats of each transect were made per visit to each site, with the number of visits to each site governed by permission from the lodge owners (see Results). The direction of the surveys along each transect was rotated to counter the bias of bird activity and the time of day. Distance data was then analysed using the program Distance, version 3.5 (Buckland, 1998).

For nocturnal species, principally members of the families *Psophiidae* (not strictly nocturnal, but most vocally active during the night), *Strigidae*, *Nyctibiidae*, and *Caprimulgidae* along with certain species of the families *Tinamidae*, *Rallidae*, and *Cracidae*, a second distance sampling method was used. The Variable-Distance Line Transect method (VDLT) is similar to the VCP method except that this method is based on line transect methodology (Buckland et al. 1993). This method is more suited to these larger, mobile species which are assumed to occur at lower densities (Jones, 1998).

Nocturnal surveys were only conducted at three of the five sites, due to time and resources available. Between September 1997 and September 1998 each census began at 0700 hrs and concluded at 1030 hrs, with brief observations also made during the hours of 0330 hrs and 0530 hrs. Two transects were surveyed at ECO (transect length = 3,700 m and 1,115m respectively), while three were established at SACHA (transect length 2,400m, 1,775m and 2,275m respectively), and two at the TRC (transect length = 2,850m and 1,600m respectively). Each transect was marked at 25 m intervals and were located either along existing trails at the lodges, or were situated in forest away from the trail system.

Transects were walked at a slow but steady pace. The observer recorded the time of each contact, the species, number of individuals, the distance of the nearest transect marker, and an estimation of distance from the bird contact perpendicular to the transect. For *Psophia leucoptera*, distance estimations were made to the geometric centre of each group, perpendicular to the transect. One to three repeats of each transect were made per visit, depending on suitable weather conditions. As for the VCP data, the data obtained during VDLT surveys was also analysed using program Distance version 3.5 (Buckland, 1998).

For the more furtive, cryptic understory species that do not vocalise frequently, and are usually under-represented in song-based census methods, Mist-netting was employed. This technique has been the subject of debate by numerous authors (e.g. Karr, 1976, 1979; Parker and Remsen, 1987; Terborgh and Weske, 1975; Lovejoy et al. 1986). On every morning at each of the five sites, nine mist nets were located at three census stations, with three nets erected at each station in a straight line. Each net was 2 m high and 12 m long, consisting of four or five trammels, and were placed at ground level. Each station was only sampled once per visit, at stations that were not being sampled during VCP surveys that same morning. Nets were opened at 0600 hrs and closed at 1100 hrs, at which time they were moved to the next three census stations, erected and left furled in preparation for the next day's survey.

For each individual bird captured, the following variables were recorded: date, time, census station, net number, species, sex, age (adult or juvenile) wing length, tail length, culmen length, tarsus length, and weight. Recaptures were re-measured and compared to when and where they were first captured. During September 1997 and September 1998, we also recorded whether or not each individual was moulting.

Direct counts were reserved for several species of diurnal raptors associated with forest habitat. These species are notoriously difficult to census accurately (Thiollay, 1989; Robinson, 1994). Observers are confronted by the lack of standardised methodology, species low population densities, high diversity, large territory sizes, and inconspicuous behaviour (Robinson, 1994). Forest dwelling raptors rarely vocalise apart from during the predawn chorus whereby some species of the *Falconidae* family are most regularly heard (Terborgh et al. 1990; Lloyd, per obs). During VCP surveys whenever a raptor was encountered at any of the census stations, the species and number of individuals was noted. The abundance of these species was then referred to as either present or absent (see Results).

Direct counts of territorial pairs were also conducted on two species of bamboo specialists; *Celeus spectabilis* and *Cecromacra manu*. During May and July 1998 one observer spent many hours of general observations, searching for the territories of these two species, following no standardised methodology. These two species were located on the periphery of the study site, and represent an important component of the bamboo bird community (see Noteworthy Records for the conservation status of both species).

The criteria for classifying indicator bird species follow that of Stotz et al. (1996). Broadly defined they: (1) occur in one or a very few habitats; (2) they are relatively common; (3) they can be detected easily; (4) they show high sensitivity to habitat disturbance (i.e. they become rare or disappear, in habitats that are altered, over-hunted or fragmented). The complete lists of indicator species that are applicable to the forest habitats of the Tambopata region are shown in Appendix 1.

Habitat Surveys

Habitat surveys were conducted at 30 of the census stations located at ECO, SACHA and TRC, and conducted at all of the census stations at the two remaining sites. We estimated the vegetation cover at each census station using a sighting tube (Bibby et al. 1993). Four height categories were used; ground level (<1m), understory level (1-5m), mid-canopy level (5-15m) and canopy level. At each census station, and within a 30m radius, the ten nearest trees with a dbh at breast height of > 0.2 m were selected and labelled with aluminium tags. For each tree the following variables were recorded: estimation of height, dbh (using a dbh tape measure), distance to the centre of the station, presence or absence of viny tangles and liana's, whether the tree was a species of palm tree or non-palm species.

Features of tree architecture were also recorded following the methods described by Torquebiau (1986); Jones et al. (1995) and summarised by Bibby et al. (1998). Each of the ten trees were allocated to one of the following groups; crown of the tree branches above half its height (trees which have developed under the closed canopy of primary forest tend to have the first major branching of the crown well above half their height); branching below half their height (trees which have developed in more open canopies usually have the major branching of the crown below half their height); and presence or absence of scars (trees which have major scars from dropped branches tend to be characteristic signs of regeneration).

From September 1997 through until September 1998, for each of the ten trees selected, observers recorded the presence or absence of fruit and/or flowers. For each subsequent visit the same trees were re-examined for the presence of fruit or flowers. This would help us determine the timing of fruiting and flowering for the larger trees over the year. The number of subsequent visits was unfortunately dependent on permission of the lodge owners, and some sites were visited more than others (see Results). Tree density at each site was calculated using the equation 5.1, where; D = tree density per hectare, Π = pi, dmax = distance to the furthest of the 10 trees (m).

Equation 5.1: $D = 100\ 000/ \Pi. (dmax)\ 2$

At SACHA further habitat details were recorded in order to determine habitat relationships of the bamboo specialists located there. Within the 30 m radius of each of the 30 census stations, an 8m x 8m quadrat was randomly located. A team of four observers then walked through each quadrat, recording the following variables: total number of bamboo stems; the number of live and dead bamboo stems; the total number of non-bamboo stems > 0.02m in dbh; the number of live and dead non-bamboo stems; and the dbh of all bamboo stems (live and dead).

Results

Habitat Data

A total of 1,386 trees were recorded and measured during the habitat surveys. Table 5.1 shows the mean values for all the habitat variables recorded in each forest type. All habitat variables differed significantly between the five sites (one-way ANOVA, * $p < 0.05$. Sample sizes unequal, harmonic mean values used). Density of trees was greatest in type F forest and type E/F forest (177 trees per hectare for both SACHA and TRC) while type B forest (ECO) had the lowest tree density. Larger and taller trees were recorded in type B forest, while the shorter trees with smaller dbh were recorded from type H forest. Type H forest also had the more open canopy vegetation cover and most dense mid-canopy vegetation cover. Canopy cover was more closed in type E/F forest (TRC), which also had a more open ground cover.

The E/F forest site at TRC had the highest overall percentage of palm trees recorded (31.9%), consistent with the findings in the mammal chapter, while type H forest contained the least number of palm trees (10.2%). Fewer trees, 28.8% of the total number recorded at TRC, supported dense tangles of vines or woody lianas, whilst 51.9 % or trees in type B forest did so.

Type F forest at SACHA showed the most dense ground and understory vegetation cover. The dense understory vegetation is probably due to the presence of *Guadua weberbaueri* bamboo stems. Table 5.2 summarises the bamboo understory habitat at SACHA. This habitat covers approximately an area of 1.63 sq. km at this site. With a mean of 5.4 stems per 8 m x 8 m quadrat, bamboo stems account for 6.3 % of all plant stems > 0.02 m in dbh in each quadrat. This suggests that the bamboo is less dense here than at floodplain forest bamboo habitats at the EI and TRC (Kratter, pers. com.). The mean dbh of bamboo stems at SACHA was 0.03 m, also suggesting that the bamboo here is younger than the bamboo of E/F floodplain forest at the TRC (see Kratter, 1995b). This does not mean that it's less structurally mature than the bamboo at TRC, given the full complement of bamboo indicator species recorded here (see Table 5.16) and at TRC but which are not recorded in the bamboo habitats of the EI.

Table 5.3 shows the results of the tree architecture classification. Type B forest at ECO shows the highest level of disturbance. Trees with scars from previous branch fall were more abundant in this forest type, as were the number (and overall percentage) of regenerating trees. Type H forest at the EI shows the second highest level of trees growing under more open canopy cover and loss of major branches, while the B/F forest at CAPH shows the third highest level. The forest types at SACHA and the TRC are structurally more indicative of primary forest habitats following the classification system. Fewer trees at both sites branch below half their height and fewer trees also have major scarring on their trunks.

Further evidence supporting the notion that type B forest experiences the highest level of disturbance can also be seen in table 5.4. On each of the repeat visits to the type B forest site during the last 12 months of the project, a few marked and monitored trees had died since the previous visit. Although an increase in the number of dead trees was recorded in four of the five forest types during the latter 12 months (Tables 5.5 to 5.7), in type B forest were new dead trees recorded at every return visit. The highest number of dead trees was recorded in type H forest (Table 5.8), which, along with the type B forest, showed the highest overall percentage of dead trees (5% for both sites). Only two repeat visits were allowed to the study site at EI, which were five months apart. In this time no trees were found to have died in this forest type (Table 5.8), whereas in type B forest, there was an increase in tree mortality (with the overall percentage of dead trees increasing from 3% to 4%).

Subsequent visits to CAPH were over a longer time period. Over a six month period between January and June 1998 there was a large increase in the number of new dead trees, and thus the overall percentage of dead trees in the study plot (Table 5.7). Its not known if this increase in the number of dead trees would have been recorded in an earlier visit to the site. This emphasises the one point of caution from drawing conclusions based on the small number of return visits to these plots and the time between each visit (see Discussion).

Table 5.1. Results of habitat variables associated with the point count stations within each type of forest; [1] Tree density is expressed in terms of large woody trees per

hectare; * $p < 0.05$ (one-way ANOVA).

Variable		CAPH	EI	ECO	SACHA	TRC
Predominant forest type		B/F	H	B	F	E/F
Total number of trees sampled	*	240	300	289	297	260
Tree density [1]	*	160	177	119	128	177
Number of palm trees	*	52	32	44	85	83
Trees with vines (%)	*	41.7	43.0	51.9	35.4	28.8
Distance from p. c. station (m)	*	8.7	10.1	10.0	8.5	8.2
Dbh (m)	*	0.48	0.40	0.56	0.55	0.43
Height (m)	*	19.1	18.5	23.4	19.4	20.6
Ground cover (%)	*	29.8	19.5	20.3	35.0	17.1
Low cover (%)	*	39.2	41.5	37.2	50.3	29.4
Mid-canopy cover (%)	*	48.1	62.5	55.5	58.2	28.8
Canopy cover (%)	*	67.1	56.0	57.5	58.8	68.6

Table 5.2. Mean values of habitat variables per 8m x 8m quadrat, recorded in bamboo understory of type F forest at SACHA.

Variable		Variable	
Number of quadrats	30	Number of non-bamboo stems	80.7
Total area surveyed (m^2)	1,926	Live non-bamboo stems	76.0
Number of bamboo stems	5.4	Dead non-bamboo stems	2.4
Live bamboo stems	4.0	Dbh of bamboo stems	0.03
Dead bamboo stems	1.4		

Table 5.3. Results of tree architecture classification for each site.

Variable	CAPH	EI	ECO	SACHA	TRC
Forest type	B/F	H	B	F	E/F
Total no. of trees measured (N)	240	300	289	297	260
No. of trees with branches above half height	215	249	235	276	234
% of trees with branches above half height	90	83	81	93	90
Above and with scars. No. (%)	2 (1)	11 (4)	17 (6)	2 (1)	1 (1)
Above and without scars. No. (%)	213 (89)	238 (79)	218 (75)	274 (92)	233 (90)
No. of trees with branches below half height	24	36	46	11	16
% of trees with branches below half height	10	12	16	4	6
Below with scars. No. (%)	3 (1)	3 (1)	38 (13)	0 (0)	2 (1)
Below without scars. No. (%)	21(9)	33 (11)	8 (3)	11 (4)	14 (5)

Table 5.4. Summary of fruiting data and number of dead trees recorded from census stations in type B forest, during September 1997 to September 1998, at ECO.

	Oct. 97	Mar. 98	Jun. 98	Sep. 98
Total number of fruiting trees (incl. palms)	10	12	20	21
Total number of flowering trees	10	4	10	12
Total number of fruiting palm trees	4	8	8	4
Number of dead trees	8	11 (+3)	13 (+2)	14 (+1)

Table 5.5. Summary of fruiting data and number of dead trees recorded from census stations in type F forest, during November 1997 to July 1998, at SACHA.

	Nov. 97	May 98	Jul. 98
Total number of fruiting trees (incl. palms)	24	42	35
Total number of flowering trees	15	14	36
Total number of fruiting palm trees	19	22	22
Number of dead trees	10	10 (+0)	13 (+3)

Table 5.6. Summary of fruiting data and number of dead trees recorded from census stations in type E/F forest, during December 1997 to August 1998, at the Tambopata Research Centre.

	Dec. 97	Feb. 98	Aug. 98
Total number of fruiting trees (incl. palms)	38	44	36
Total number of flowering trees	11	11	28
Total number of fruiting palm trees	32	35	18
Number of dead trees	7	11 (+4)	11 (+0)

Table 5.7. Summary of fruiting data and number of dead trees recorded from census stations in type B/F forest, during only two visits to CAPH during 1998.

	Jan. 98	Jun. 98
Total number of fruiting trees (incl. Palms)	1	13
Total number of flowering trees	2	5
Total number of fruiting palm trees	1	2
Number of dead trees.	1	5 (+4)

Table 5.8. Summary of fruiting data and number of dead trees recorded from census stations in type H forest, during only two visits to EI, between October 1997 and April 1998.

	Oct. 97	Apr. 98
Total number of fruiting trees (incl. palms)	12	29
Total number of flowering trees	10	8
Total number of fruiting palm trees	5	19
Number of dead trees.	15	15 (+0)

Tables 5.4, 5.5 and 5.6 show the data regarding the number of trees in fruit and flower during 3 or more visits to ECO, SACHA and TRC sites, respectively. As already mentioned, only two visits were made to the other two sites. Although the data is displayed in tables 5.7 and 5.8, the number of visits was judged to be unsatisfactory to

build up a basic picture of the timing of fruiting in trees, in these forest types, during the last 12 months of the study.

In type B forest, at ECO, the number of fruiting trees was greatest during September 1998, which also corresponded to the greatest number of trees in flower (Table 5.4). 19% of all the trees recorded fruiting were palm trees. The number of fruiting trees recorded between each of the visits to the plot were almost significantly different (one-way ANOVA, F = 2.232, p = 0.08), while there was no significant difference in the number of trees recorded flowering (F = 1.493, p = 0.215). In type F forest at SACHA, the greatest number of fruiting trees was recorded in May 1998, while most trees seem to be in flower in July. Of the fruiting trees, 52% of them were palm trees. The number of fruiting trees recorded between each visit again was almost significantly different between each visit (F = 2.480, p = 0.08), while there was a significant difference in the number of trees flowering, between each visit (F = 6.698, $p < 0.05$). A significant difference in the number of flowering trees between each visit to the study plot in E/F forest at the TRC was also found (F = 5.777, $p < 0.05$), while there was no significant difference in the number of fruiting trees (F = 0.368, p = 0.692). The number of fruiting trees was highest in the second visit, in February 1998, 80% of these trees were palms. The highest number of trees in flower was recorded in August 1998.

Similarity between Forest Types

Figure 5.1 shows the results of a Discriminant Function Analysis on the measured habitat variables from each of the five forest types, as shown in table 5.1. DFA was used since all five forest types were predefined based on Phillips (1993). In order to test the similarity of the forest types based on the habitat variables mentioned, all variables were analysed for significant differences (one-way ANOVA, $p < 0.05$ see Table 5.1). Principle Component Analysis (PCA) was then used to compress the set of variables into a smaller set of derived components (Fielding, 1997). The result of the PCA analysis was the reduction of the data set to five components, explaining up to 65.4% of the variability. DFA was then conducted on these five components to give a final indication of the associations between each forest type.

The DFA produced four discriminant functions. The first two scores, DFA1 and DFA2 accounted for 60.0% and 26.4% of the variance respectively. DFA1 had high positive scores for the PCA components dominated by tree height (very tall trees), estimated % canopy cover (dense, closed canopy cover), estimated % understory cover (dense understory) and number of palm trees (high number of palm trees), while having a high score also for the height of the tree crown (point of bifurcation). DFA2 had high positive scores for tree height (very tall trees), and high negative scores for tree crown height (high number of trees developed under open canopy), estimated % canopy and understory cover (open canopy cover and open understory vegetation cover), and number of palms (small number of palm trees).

The PCA components were finally plotted against these two functions to produce Figure 5.1. By examining the clusters and the group centroids, it shows that the three floodplain forest types, type B/F at CAPH; type F forest at SACHA, and type E/F forest at the TRC, are the most similar, based upon the habitat variables mentioned. The two most distinct forest types are the Terra Firme Sandy Clay Forest (type H) of EI, and the Seasonally Flooded Swamp forest (type B) at ECO.

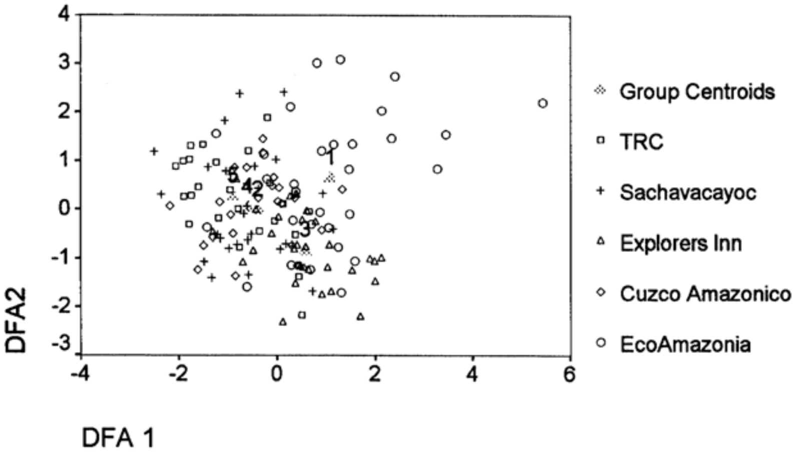

Figure 5.1. Habitat profiles, DFA 1 vs. DFA 2.

Bird Census

A total of 259 species were recorded over approximately 336 days of VCP and VDLT surveys, mist-netting and visual counts within the study plots and habitats under study at the five lodges. Of this total, 233 species were recorded during VCP surveys, corresponding to 18,107 contacts of 21,453 individual birds. Of these contacts, 94.4% were vocal contacts; visual contacts totalled just 1.1%, while birds that were seen and heard made up 4.5% of all contacts. 29.8% of contacts were birds recorded at mid-canopy level, 23.0% were birds located in the canopy, 21.7% were understory contacts, while terrestrial bird contacts constituted 18.1%. The remaining 7.5% of birds were recorded flying above the canopy. [Species lists for the five lodges which include ad hoc observations of birds throughout the lodge are given in Appendix 2]. At the TRC, 180 bird species were recorded during VCP sampling, while 179, 177, 172 and 144 bird species were recorded at SACHA, EI, ECO, and CAPH, respectively. Figure 5.2 shows the species accumulation curves for VCP surveys over the number of repeated visits to each site. The number of new species recorded increases at each visit to each site, with the curve just failing to reach a significant plateau for any of the forest types.

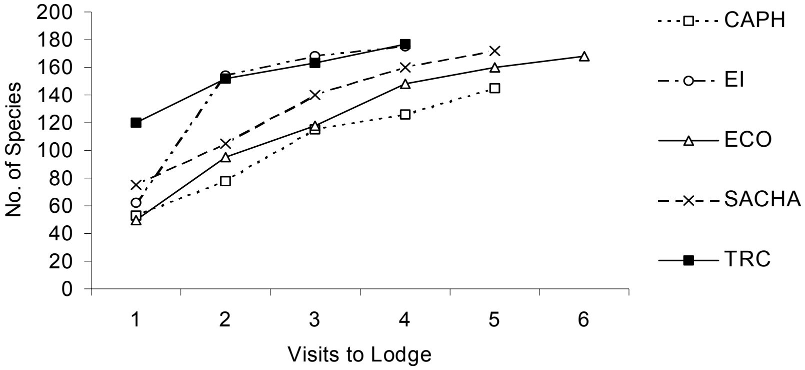

Figure 5.2. Species accumulation curves using VCP data only.

Table 5.9 shows the number of individuals recorded at the different times of the 21-month survey period. The greatest number of individual birds was recorded during the month of May 1997 and 1998, in the type B and F forests of ECO and SACHA. The greatest number of individual birds were recorded in April 1997, in type B/F forest of

CAPH, in February 1998 in type E/F forest (TRC) and in October 1997, in type H forest, EI Reserve.

Table 5.9. Total number of individual birds recorded during VCP surveys, during each visit, for each of the five lodges.

Lodge	Month	Year	Visit	Number of Individuals
ECO	Jan.	1997	1	562
	May	1997	2	1389
	Oct.	1997	3	758
	Mar.	1998	4	1275
	Jun.	1998	5	777
	Sep.	1998	6	1144
CAPH	Feb.	1997	1	525
	Apr.	1997	2	970
	Aug.	1997	3	779
	Feb.	1998	4	315
	Jun.	1998	5	605
EI	Mar.	1997	1	537
	Jul.	1997	2	697
	Oct.	1997	3	1125
	Apr.	1998	4	939
SACHA	Mar.	1997	1	782
	Jun.	1997	2	1128
	Nov.	1997	3	1233
	May	1998	4	1306
	Jul.	1998	5	512
TRC	Aug.	1997	1	629
	Dec.	1997	2	1018
	Feb.	1998	3	1186
	Aug.	1998	4	684

Population Densities

Tables 5.10-17 show the absolute population densities of the indicator bird species for each of the forest types surveyed. Of the indicator species representative of seasonally flooded forest habitats, all 13 species were recorded at ECO although only 11 were actually observed in type B forest during the legal census periods the site, of these only 5 species had sufficient data to determine their density (Table 5.10). In the type B/F forest at CAPH, a total of 8 species were observed although only 7 species were recorded during legal censusing. Five species were not recorded at all in this forest type, during the five visits. Again, densities were calculable only for 5 species, the same four species found at ECO (Table 5.11). Of these four species, only *C. cinereus* is more abundant in type F/B forest.

Of the 35 lowland forest indicator bird species, more species were recorded during surveying in the more mature forests of SACHA and the TRC (31 and 30 respectively; 33 species in total for the two sites) than the other two sites, although the difference is small (Tables 5.12-15). The greatest number of measurable population densities were calculated from type H forest at EI (21 species, Table 5.13), with the lowest figure calculated from B/F forest at CAPH (Table 5.12). The lower population densities of bird species at CAPH is probably due to the smaller area of available habitat and the presence of the type B forest component in the habitat mosaic.

By examining the tables of population densities and from what we know of each of the forest habitats as described above, we can draw some raw conclusions regarding the abundance of the individual lowland forest indicator species, which are summarised below (other information is given in the section 'Species Accounts').

A number of indicator species clearly have a preference for Terra Firme Sandy-Clay forest (type H). These are *T. guttatus*, *C. variegatus, S. rutilans, T. aethiops, P. rubrocapilla*, while other species, *M. menetriesii, M. myotherinus*, although found in all the four forest types, are far more abundant in type H forest. Two other species, *C. nobilis* and *M. campanisoma*, have high estimated population densities in the more mature forests of SACHA and TRC. These species prefer floodplain forest types and are far more abundant in mature primary floodplain forests than disturbed forests. *C. torquata*, although abundant in all forest types, also has a higher population density in the two primary forest sites. However, *O. stellatus* was much more abundant in the other two more disturbed forest sites. *D. cincta* occurs at a naturally low population density in all forest types, and is naturally 'rare' Other species show a preference for floodplain forest types (*D. certhia, S. caudacutus, F. colma, P. coronatus, H. rubrica*) while some avoid forest mosaics with type B flooded forest (*D. fuliginosa, X. spixii, M. marginatus*).

A total of 14 and 13 bamboo indicator species were recorded during VCP surveys in *Guadua* bamboo habitats at SACHA and TRC, respectively (overall number of species totalled 17 and 19, respectively, Table 5.16 and 5.17). One species was not recorded at either site, *Sporophila schistacea*, due to the fact that the ecology of this rare seedeater is closely tied to the seeding ecology of *Guadua* bamboo thickets. Population densities were calculable for 12 bamboo indicator species at SACHA, while it was only possible to calculate densities for half that number at TRC. The simple reason for this was that only 5 census stations were located in E/F forest bamboo habitat at TRC, whereas over half the number of census stations at SACHA contained bamboo stems. This resulted in fewer contacts for bamboo indicator species at TRC. Of the six comparable densities, *C. sanctaemariae* and *S. ucayalae* were found to be denser in the E/F forest bamboo habitat, than in type F forest bamboo.

Table 5.10. Population densities of Flooded Tropical Evergreen Forest indicator species, in type B forest, ECO. Densities are expressed as number of individuals per km^2; + recorded during VCP surveys, but insufficient number of contacts to produce density estimate; - not recorded during VCP sampling, but recorded elsewhere at the lodge, during general observations; X recorded during mist-net captures only; NR not recorded at this site. Census Method: VCP Variable Circular Plot Method; VDLT Variable Distance Line Transect Method; MN Mist-netting; DC Direct Counts; GO General Observations.

Indicator Species for Flooded Tropical Evergreen forest at ECO – Type B forest	Population Density	Census Method
Crypturellus bartletti	25.9	VDLT
C. cinereus	0.6	VCP
Agami agami	-	GO
Leucopternis schistacea	+	DC
Aramides cajaena	+	VDLT
Eurypyga helias	-	GO
Phaethornis hispidus	6.7	MN
Hypocnemoides maculicauda	+	VCP
Sclateria naevia	+	VCP
Hylophylax punctulata	X	MN
Schiffornis major	+	VCP
Pipra fasiicauda	35.2	VCP, MN
Turdus hauxwelli	30.7	VCP

Table 5.11. Population densities of Flooded Tropical Evergreen Forest indicator species, in type B/F forest, CAPH lodge

Indicator Species for Flooded Tropical Evergreen forest at CAPH – Type B/F forest	Population Density	Census Method
Crypturellus bartletti	19.9	VCP
C. cinereus	0.6	VCP
Agami agami	NR	GO
Leucopternis schistacea	+	DC
Aramides cajaena	-	GO
Eurypyga helias	NR	GO
Phaethornis hispidus	4.6	MN
Hypocnemoides maculicauda	NR	VCP
Sclateria naevia	+	VCP
Hylophylax punctulata	NR	MN, GO
Schiffornis major	NR	VCP
Pipra fasiicauda	9.8	VCP, MN
Turdus hauxwelli	9.4	VCP

Table 5.12. Population densities of Lowland Forest indicator species, in type B/F forest habitat, at CAPH lodge.

Indicator Species for Lowland forest at CAPH – Type B/F forest	**Population Density**	**Census Method**
Tinamus guttatus	-	GO
Crypturellus strigulosus	NR	VCP, GO
C. variegatus	+	VCP
Micrastur gilvicollis	+	DC
Mitu tuberosa	NR	VCP
Odontophorus stellatus	11.0	VCP
Psophia leucoptera	-	GO
Phaethornis phillipii	x	MN
Malacoptila semicincta	1.3	MN
Dendrocincla fuliginosa	1.3	VCP, MN
D. merula	15.8	MN
Dendrocolaptes certhia	1.5	VCP
Xiphorhynchus spixii	+	VCP, MN
Synallaxis rutilans	+	VCP
Automolus infuscatus	1.3	VCP
Sclerurus caudacutus	2.0	VCP
Thamnophilius aethiops	NR	VCP, GO
Thamnomanes ardesiacus	31.4	VCP
Myrmotherula haematonata	4.6	MN
M. hauxwelli	7.0	VCP
M. leucophthalma	4.1	VCP, MN
M. longipennis	4.6	VCP
M. menetriesii	14.7	VCP
Dichrozona cincta	+	VCP, MN
Myrmoborus myotherinus	10.5	VCP
Gymnopithys salvini	12.5	MN
Formicarius colma	NR	VCP, GO
Chamaeza nobilis	-	GO
Myrmothera campanisoma	+	VCP
Conopophaga peruviana	5.3	MN
Corythopis torquata	14.7	VCP
Platyrinchus coronatus	10.5	VCP
Pipra rubrocapilla	NR	VCP, GO
Microcerculus marginatus	0.5	VCP
Habia rubrica	5.3	VCP

Table 5.13. Population densities of Lowland Forest indicator species, in type H forest habitat, at EI.

Indicator Species for Lowland Forest at EI – Type H forest	Population Density	Census Method
Tinamus guttatus	13.3	VCP
Crypturellus strigulosus	NR	GO
C. variegatus	1.8	VCP
Micrastur gilvicollis	+	DC
Mitu tuberosa	-	GO
Odontophorus stellatus	40.8	VCP
Psophia leucoptera	-	GO
Phaethornis phillipii	X	MN
Malacoptila semicincta	+	MN
Dendrocincla fuliginosa	2.7	VCP, MN
D. merula	10.5	MN
Dendrocolaptes certhia	0.6	VCP
Xiphorhynchus spixii	1.9	VCP
Synallaxis rutilans	7.4	VCP
Automolus infuscatus	2.5	VCP
Sclerurus caudacutus	3.0	MN
Thamnophilius aethiops	8.0	VCP
Thamnomanes ardesiacus	15.8	VCP
Myrmotherula haematonata	NR	VCP, MN, GO
M. hauxwelli	8.9	VCP
M. leucophthalma	3.5	MN
M. longipennis	10.9	VCP
M. menetriesii	11.1	VCP
Dichrozona cincta	+	VCP
Myrmoborus myotherinus	48.0	VCP
Gymnopithys salvini	16.0	VCP, MN
Formicarius colma	3.7	VCP
Chamaeza nobilis	NR	VCP, GO
Myrmothera campanisoma	2.5	VCP
Conopophaga peruviana	+	MN
Corythopis torquata	12.9	VCP
Platyrinchus coronatus	+	VCP, MN
Pipra rubrocapilla	5.7	VCP
Microcerculus marginatus	12.3	VCP
Habia rubrica	2.2	VCP

Table 5.14. Population densities of Lowland Forest indicator species, in type F forest habitat, at SACHA.

Indicator Species for Lowland Forest at SACHA – Type F forest	Population Density	Census Method
Tinamus guttatus	+	VCP
Crypturellus strigulosus	NR	GO
C. variegatus	+	VCP
Micrastur gilvicollis	+	DC
Mitu tuberosa	-	GO
Odontophorus stellatus	+	VCP
Psophia leucoptera	+	VDLT, VCP
Phaethornis phillipii	-	GO
Malacoptila semicincta	+	VCP, MN
Dendrocincla fuliginosa	1.2	VCP, MN
D. merula	4.0	MN
Dendrocolaptes certhia	1.0	VCP
Xiphorhynchus spixii	1.3	VCP
Synallaxis rutilans	+	VCP
Automolus infuscatus	+	VCP
Sclerurus caudacutus	1.4	VCP, MN
Thamnophilius aethiops	+	VCP
Thamnomanes ardesiacus	16.2	VCP
Myrmotherula haematonata	NR	VCP, MN
M. hauxwelli	7.4	VCP
M. leucophthalma	2.3	MN
M. longipennis	13.0	VCP
M. menetriesii	33.6	VCP
Dichrozona cincta	+	VCP
Myrmoborus myotherinus	11.8	VCP
Gymnopithys salvini	3.3	MN
Formicarius colma	15.8	VCP
Chamaeza nobilis	1.4	VCP
Myrmothera campanisoma	6.0	VCP
Conopophaga peruviana	4.5	MN
Corythopis torquata	28.6	VCP
Platyrinchus coronatus	3.9	VCP
Pipra rubrocapilla	+	VCP
Microcerculus marginatus	10.7	VCP
Habia rubrica	4.2	VCP

Table 5.15. Population densities of Lowland Forest indicator species, in type E/F forest habitat, at Tambopata Research Centre.

Indicator Species for Lowland Forest at TRC– Type E/F forest	Population Density	Census Method
Tinamus guttatus	1.6	VCP
Crypturellus strigulosus	NR	GO
C. variegatus	NR	VCP
Micrastur gilvicollis	+	DC
Mitu tuberosa	8.2	VDLT
Odontophorus stellatus	+	VDLT, VCP
Psophia leucoptera	+	VDLT, VCP
Phaethornis phillipii	-	GO
Malacoptila semicincta	+	VCP, MN
Dendrocincla fuliginosa	1.4	VCP, MN
D. merula	1.8	MN
Dendrocolaptes certhia	0.6	VCP
Xiphorhynchus spixii	5.8	VCP
Synallaxis rutilans	+	VCP
Automolus infuscatus	3.0	VCP
Sclerurus caudacutus	1.8	MN
Thamnophilius aethiops	+	VCP
Thamnomanes ardesiacus	11.4	VCP
Myrmotherula haematonata	+	MN
M. hauxwelli	11.1	VCP
M. leucophthalma	1.8	MN
M. longipennis	14.8	VCP
M. menetriesii	20.1	VCP
Dichrozona cincta	0.3	VCP
Myrmoborus myotherinus	26.2	VCP
Gymnopithys salvini	10.1	VCP, MN
Formicarius colma	5.4	VCP
Chamaeza nobilis	1.6	VCP
Myrmothera campanisoma	5.1	VCP
Conopophaga peruviana	1.8	MN
Corythopis torquata	30.1	VCP
Platyrinchus coronatus	+	VCP
Pipra rubrocapilla	-	GO
Microcerculus marginatus	11.4	VCP
Habia rubrica	6.7	VCP

Table 5.16. Population densities of Bamboo indicator species, located in type F forest bamboo habitat, at SACHA (* = number of pairs)

Indicator Species for Bamboo at SACHA–Type F forest	Population Density	Census Method
Dromococcyx pavoninus	-	GO
Nonnula ruficapilla	-	GO
Monasa flavirostris	-	GO
Campylorhamphus trochilirostris	+	VCP, MN
Simoxenops ucayalae	4.7	VCP
Anabazenops dorsalis	+	VCP
Automolus melanpezus	12.4	VCP
Cymbiliaimus sanctaemariae	6.2	VCP
Myrmotherula iheringi	3.8	VCP
Myrmotherula ornata	2.6	VCP
Microrhopias quixensis	-	GO
Drymophila devillei	42.3	VCP
Cecromacra manu *	3.7	DC
Percnostola lophotes	48.3	VCP
Myrmeciza goeldii	31.1	VCP
Poecilotriccus albifacies	4.4	VCP
Hemitriccus flammulatus	-	GO
Ramphotrigon fuscicauda	4.3	VCP
R. megacephala	13.1	VCP
Sporophila schistacea	NR	GO

Table 5.17. Population densities of Bamboo indicator species, located in type E/F forest bamboo habitat, at the Tambopata Research Centre (TRC) (* = number of pairs)

Indicator Species for Bamboo at TRC–Type E/F forest	Population Density	Census Method
Dromococcyx pavoninus	-	GO
Nonnula ruficapilla	NR	GO
Monasa flavirostris	-	GO
Campylorhamphus trochilirostris	1.4	MN
Simoxenops ucayalae	7.7	VCP
Anabazenops dorsalis	+	VCP
Automolus melanpezus	+	VCP
Cymbiliaimus sanctaemariae	8.1	VCP
Myrmotherula iheringi	+	VCP
Myrmotherula ornata	+	VCP
Microrhopias quixensis	-	VCP, GO
Drymophila devillei	6.7	GO
Cecromacra manu *	-	DC
Percnostola lophotes	14.8	VCP
Myrmeciza goeldii	21.5	VCP
Poecilotriccus albifacies	+	VCP
Hemitriccus flammulatus	-	GO
Ramphotrigon fusiicauda	+	VCP
R. megacephala	6.0	VCP
Sporophila schistacea	NR	GO

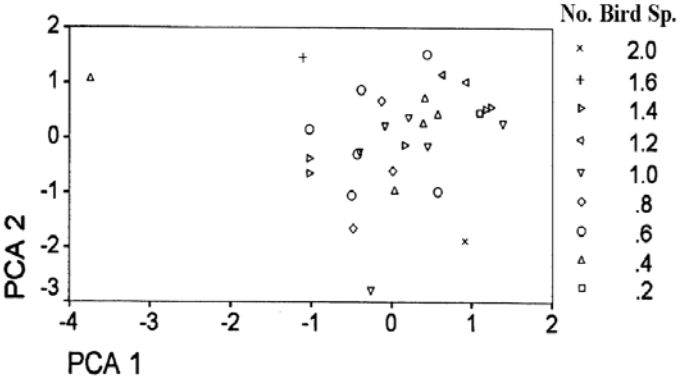

Figure 5.3. PCA profile for Flooded Forest indicator species at ECO.

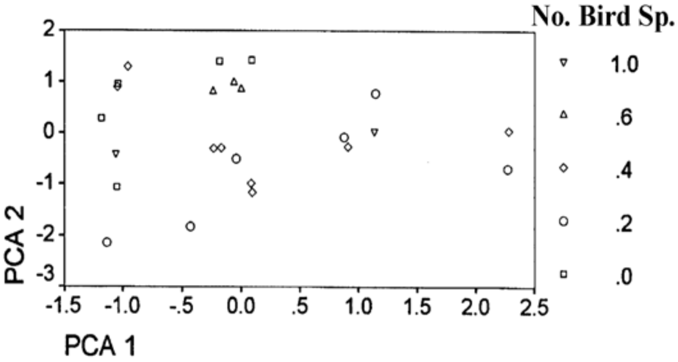

Figure 5.4. PCA profile for Flooded Forest indicator species at CAPH.

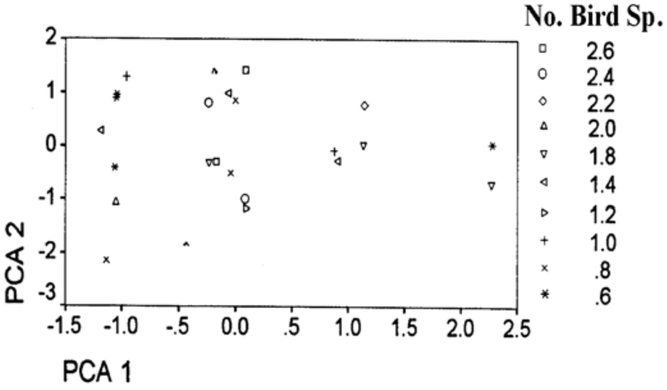

Figure 5.5. PCA profile for Lowland Forest indicator species at CAPH.

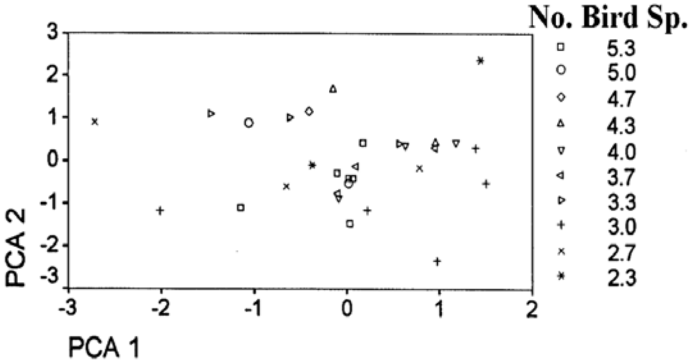

Figure 5.6. PCA profile for Lowland Forest indicator species at EI.

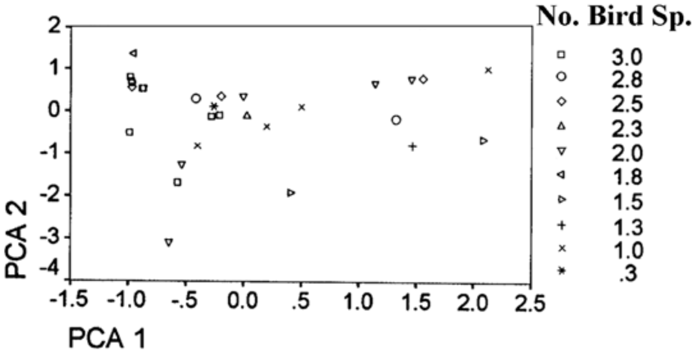

Figure 5.7. PCA profile for Lowland Forest indicator species at SACHA.

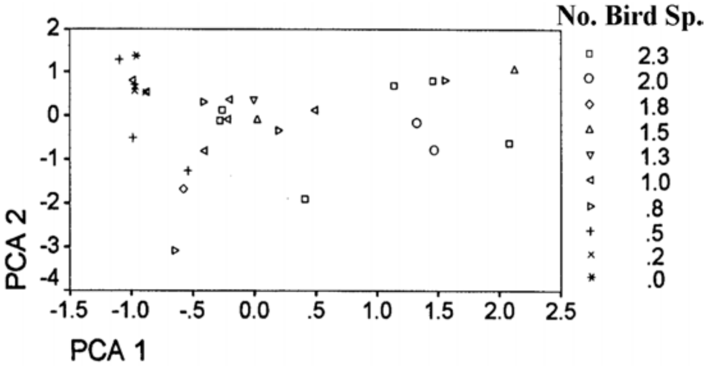

Figure 5.8. PCA profile for Bamboo Forest indicator species at SACHA.

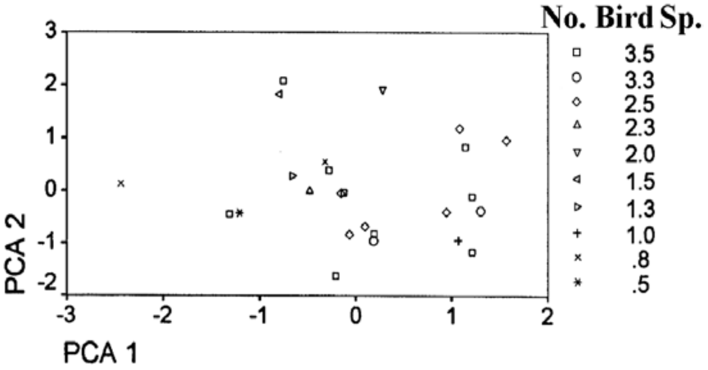

Figure 5.9. PCA profile for Lowland Forest indicator species at TRC.

Habitat Associations of Species

PCA profiles of the five different forest types were constructed following one-way ANOVA analysis of habitat variability in each forest type. The number of variable features of the habitat differed between the forest types as did the number of habitat components produced by the PCA. The first two PCA components in each forest type (PCA1 and PCA2) accounted for the highest percentage of habitat variability (see later). PCA1 and PCA2 for each forest type were then plotted on an X-Y axis to produce the PCA habitat profile for that site. The mean number of indicator bird species recorded at each census station were then plotted on both axes (Figures 5.3 – 5.9). Habitat associations for the bamboo indicator species at TRC were not conducted since this has already been the subject of highly detailed research by Kratter (1995b, 1997)

For the type B forest at ECO, PCA1 and PCA2 accounted for 49.2% of habitat variability. Figure 5.3 shows the habitat profile for type B forest. PCA1 axis represents the height of the canopy, while PCA2 represents estimated percentage canopy cover. Figure 5.3 shows that the greater mean number of flooded forest indicator bird species were recorded in areas where the canopy is of a medium to tall height, and where the canopy cover is more open (less dense).

In type B/F forest at CAPH, PCA1 and PCA2 accounted for 48.6% of the variation, and represented canopy height and estimated percentage canopy cover respectively. Figure 4 shows the results of the mean number of flooded forest indicator species recorded at each census station, plotted on the PCA1 and PCA2 axis. A higher mean number of indicator species were recorded in areas where the canopy height was fairly tall. Similarly to type B forest, most indicator species were recorded where the canopy cover was fairly open (less dense).

For the lowland forest indicator species, the higher mean number of species were recorded in areas of medium canopy height, with fewer species being recorded in areas where the canopy height was very low (Figure 5.5). Lowland indicator species also appear to be tolerant of varying canopy density, with high mean numbers recorded in fairly open and fairly dense canopy cover.

PCA1 and PCA2 accounted for 58.4% of the habitat variability in type H forest, at EI, with PCA1 representing the number (density) of palm trees, and PCA2 representing estimated percentage mid-canopy cover. Figure 5.6 shows that the greater mean number of indicator species in type H forest are recorded where there are fewer palm trees (low density of palm trees) but that these species are tolerant of a fairly open and fairly dense estimated percentage mid-canopy cover.

At SACHA, PCA1 and PCA2 corresponded to 56.6% of the overall habitat variation. PCA1 represented by the number of live bamboo stems, while PCA2 represented the height of the canopy. Figure 5.7 shows that the highest mean number of lowland forest indicator species were recorded in areas where the canopy height was high and bamboo density was low. The reverse is true for the bamboo indicator species. These are some of the most habitat restricted of all lowland bird species in Tambopata, and the highest mean number of these specialists were recorded where the density of live bamboo stems was high, and the low forest canopy height was very low (Figure 5.8). This indicates that these specialists are less dependant on forest cover, and more dependant on the density and structural features of the bamboo habitat (see also Kratter, 1995b).

For the final site at TRC, PCA1 and PCA2 were responsible for 56.3% of the overall variation. The first component once again represented canopy height, whilst PCA2 reflected the density of vegetation at the ground level. Figure 5.9 shows the mean number of lowland forest indicator species plotted against these two components. The higher mean number if indicator species are recorded in E/F forest where the canopy height is very tall and where the estimated percentage ground cover is very sparse (less dense).

Canopy Frugivores

Two families of canopy-dwelling frugivorous bird species, *Psittacidae* and *Ramphastidae*, are those most sought after by tourists visiting lowland forest in Madre de Dios (Munn, 1992; see Tourist Questionnaire results). A total of 1,632 contacts with parrot species, representing 9% of all bird contacts, were made during 21 months of VCP sampling. 1,251 of these were ‘flying’ contacts, above the canopy. Parrots thus made up 92.7% of all flying contacts during VCP surveys. A total of 347 contacts (21.3% of all parrot contacts) were for the three largest macaw species; *Ara ararauna,* *A. macao* and *A. chloroptera*. Table 5.18 shows the total number of contacts for all parrot species and those for the three largest species of macaws. The important note is that the number of visits to each site was not equal (see earlier section). This was solely due to the lack of permission from each lodge. Despite this there are some interesting results.

The highest number of contacts to parrot species over the 21 months was made in type B forest, at ECO. However, the number of large macaw contacts is quite low, a reflection of the abundance of species which prefer wetter forest types, swamps, aguajals and that feed and roost in palm trees. The most contacts were made in the two primary forest sites, SACHA and TRC, both sites recorded the highest number of contacts to the large macaw species also. The figures that give high cause for concern, are those from the two most disturbed forest areas, EI and CAPH. While fewer contacts of all parrot species were made from EI, CAPH shows an alarming lack of registrations for the large macaw species.

During the 12 month period of September 1997 to September 1998, the total number of parrot species recorded at all five sites was significantly and positively correlated with the total number of fruiting trees (Pearson's correlation $r = 0.587$, $p < 0 .05$). The number of flying parrots was also higher and positively correlated with the number of fruiting trees ($r = 0.575$, $p < 0.05$), indicating that more parrots were visiting the region actively searching for fruiting trees. The same pattern can be seen when one examines just the three larger species of macaws. The number of macaws is positively correlated to the number of fruiting trees ($r = 0.787$, $p < 0.05$) as is the number of flying birds ($r = 0.759$, $p < 0.05$). More macaws are recorded and activity is greatest when the number of fruiting trees are more abundant. This has important consequences for surveying parrot populations in Tambopata, and also has important consequences for tourism (see Discussion).

No clear patterns emerge when one examines the number of toucans recorded during VCP surveys (Table 5.18). Number of toucan species was highest at EI, while the least number of species were recorded in both B/F forest (CAPH) and E/F forest (TRC). The highest number of individuals was recorded from type B forest, at ECO. During the same 12 month period whereby presence of absence of fruit was recorded at each site, the number of toucans recorded during VCP surveys was not significantly correlated with the number of fruiting trees ($r = -0.179$, $p = 0.539$).

Table 5.18 showing the number of large canopy-dwelling frugivores recorded during VCP sampling at all five forest sites. The number of 'large macaw species' refers to the three largest macaw species *Ara ararauna, A. macao* and *A. chloroptera*.

Lodge	**No. Visits**	**No. parrot contacts**	**No. contacts for large macaw species**	**No. of toucan species**	**No. of individual toucans**
EcoAmazonía	6	665	45	6	226
Cusco Amazónico	5	216	6	4	86
Explorers' Inn	5	175	26	7	182
Sachavacayoc	4	491	109	6	141
TRC	4	519	161	4	79

Mist Net Surveys

Sampling effort ranged from 1,620 net/hours at the TRC to 2,700 net/hours at ECO (Table 5.19) for a total of 10,530 net/hours. This resulted in a total of 1,808 captures representing 126 species (Table 5.20). The three most commonly captured species were *Pipra fascicauda* (249), *Myrmotherula hauxwelli* (157) and *Gymnopithys salvini* (107) while 26 species were represented only by a single capture. *P. fascicauda* was the most frequently caught species at ECO, CAPH and the Tambopata Research Centre, *G. salvini* was the most frequently caught in terra firme sandy-clay forest at the EI, and *Myrmotherula hauxwelli* was the most frequently captured species in the old floodplain forest at SACHA. Population densities determined from capture data for some species are shown in Tables 5.10-17.

Table 5.19. Mist-net sampling effort.

Lodge	CAPH	EI	ECO	SACHA	TRC
Net/hours	2,160	1,800	2,700	2,250	1,620

Table 5.20. Number of captures for each of 126 species at each lodge.

FAMILY	No.	SPECIES	CAPH	EI	ECO	SACH	TRC	Total
Tinamidae	1	*Crypturellus bartletti*			1			1
	2	*C. soui*	1					1
Accipitridae	3	*Leucopternis schistacea*			2			2
Falconidae	4	*Micrastur gilbicollis*			1			1
	5	*M. ruficollis*	1					1
Phasianidae	6	*Odontophorus stellatus*	2					2
Columbidae	7	*Geotrygon montana*	2	1	3	1	1	8
Trochilidae	8	*Florisuga mellivora*			1			1
	9	*Glaucis hirsuta*			14		3	17
	10	*Phaethornis ruber*	1		1			2
	11	*P. hispidus*	7	1	14	3	7	32
	12	*Thalurania furcata*		1	2		1	4
	13	*Threnetes leucurus*	3		1	1	3	8
Alcedinidae	14	*Chloroceryle aenea*	1		5			6
Momotidae	15	*Electron platyrhynchun*					1	1
	16	*Momotus momota*		2	3			5
Bucconidae	17	*Bucco macrodactylus*			1			1
	18	*Malacoptila semicincta*	2		3		1	6
	19	*Monasa nigrifrons*	3	1	2	1		7
	20	*Nystalus striolatus*		1				1
Ramphastidae	21	*Aulaconrhynchus prasinus*					2	2
	22	*Ramphastos culminatus*		1				1
	23	*Selenidera reinwardtii*		2			2	4
Picidae	24	*Picumnus rufiventris*					2	2
	25	*Veniliornis affinis*			1			1
Dendrocolaptidae	26	*Campylorhamphus trochilirostris*					3	3
	27	*Deconychura longicauda*	4	4	5	2	8	23
	28	*Dendrocincla fuliginosa*	2	2	6	2	3	15
	29	*D. merula*	24	21	22	7	4	78
	30	*D. certhia*			2			2
	31	*D. picumnus*			2			2
	32	*Glyphorynchus spirurus*	3	33		2	5	43
FAMILY	**No.**	**SPECIES**	**CAPH**	**EI**	**ECO**	**SACH**	**TRC**	**Total**
	33	*Sittasomus griseicapillus*	1					1
	34	*Xyphorhynchus guttatus*	2	1	7		12	22
	35	*X. ocellatus*	8	3	9		4	24
	36	*X. spixii*	5	5	12	4	9	35
Furnariidae	37	*Ancistrops strigilatus*		2				2

	38	*Automolus dorsalis*		1			1	2
	39	*A. infuscatus*	2	9			8	19
	40	*A. melanopezus*				1	3	4
	41	*A. ochralaemus*	4	10		2	5	21
	42	*A. rubiginosus*			1			1
	43	*A. rufipileatus*				1	1	2
	44	*Hyloctistes subulatus*					4	4
	45	*Philydor pirrhodes*	3		7	2	1	13
	46	*Sclerurus caudacutus*	7	6	3	2	4	22
	47	*Simoxenops ucayale*		1		1	1	3
	48	*Synallaxis rutilans*		3				3
	49	*Xenops minutus*	3	4	6	3	4	20
Formicariidae	50	*Cercomacra manu*		2				2
	51	*Chamaeza nobilis*					1	1
	52	*Conopophaga peruviana*	8		9	8	4	29
	53	*Dichrozoma cincta*	3		1		1	5
	54	*Formicarius analis*	11	2	6	6	8	33
	55	*F. colma*		2		3	2	7
	56	*Gymnopithys salvini*	19	32	28	6	22	107
	57	*Hylophylax naevia*					13	13
	58	*H. punctulata*			2			2
	59	*H. poecilonota*	1	16				17
	60	*Hypocnemis cantator*			2	1		3
	61	*Hypocnemoides maculicauda*				1		1
	62	*Microrhopias quixensis*					1	1
	63	*Myrmeciza atrothorax*			1			1
	64	*M. goeldii*				4	1	5
	65	*M. hemimelaena*		5		9	9	23
	66	*M. hyperythra*	4		6	3	2	15
	67	*Myrmoborus leucophys*	1	1		5	6	13
	68	*M. myotherinus*	8	11	3	10	6	38
	69	*Myrmotherula axillaris*	2	7	2	5		16
	70	*M. haematonata*	7		10		1	18
	71	*M. hauxwelli*	44	15	36	31	31	157
	72	*M. iheringi*	1				1	2
	73	*M. lecophthalma*	3	7	1	4	4	19
	74	*M. longipennis*	12	3	4	1	4	24
	75	*M. menetriesii*			2	1	1	4
	76	*M. ornata*		1				1
	77	*Schirtocichla leucostigma*	2					2
	78	*Percnostola lophotes*				2	1	3
	79	*Phlegopsis nigromaculata*	10		9	14	13	46
	80	*Pygiptila stellaris*				1	1	2
	81	*Sclateria naevia*					1	1
	82	*Thamnomanes ardesiacus*	10	4	11	3	9	37
	83	*T. schistogynus*	2	1	3	4	8	18
	84	*Thamnophilus aethiops*		8			2	10
	85	*T. schistaceus*	3	2	1	1	2	9
Cotingidae	86	*Lipaugus vociferans*	1		1			2
FAMILY	**No.**	**SPECIES**	**CAPH**	**EI**	**ECO**	**SACH**	**TRC**	**Total**
Pipridae	87	*Pipra chloromeros*	13	6	7	1	5	29
	88	*P. coronata*		1			8	9
	89	*P. fascicauda*	69	9	85	22	64	249
	90	*P. rubrocapilla*		1		2	1	7
	91	*Machaeropterus pyrocephalus*					1	1
	92	*Schiffornis turdinus*		9				9

Tyrannidae	93	*Attila bolivianus*		1				1
	94	*A. spadiceus*		2				2
	95	*Corythopis torquata*		7	8	5	11	31
	96	*Hemitriccus flamulatus*		3				3
	97	*H. zosterops*		2	1			3
	98	*Laniocera hypopyrrha*	2		1	1		4
	99	*Leptopogon amaurocephalus*	1					1
	100	*Mionectes macconnelli*				1	1	2
	101	*M. oleagineus*	3	4	1	2	1	11
	102	*Mionectes olivaceus*	1	2			4	7
	103	*Onychorhynchus coronatus*	1	2		1	8	12
	104	*Platyrinchus coronatus*	26		17	9	3	55
	105	*P. platyrhynchos*	3	1	1		1	6
	106	*Ramphotrigon megacephala*					2	2
	107	*Rhynchocyclus olivaceus*					1	1
	108	*Rhytipterna simplex*	1	2		1		4
	109	*Terenotricus erythrurus*	3	3	4	5	3	18
Troglodytidae	110	*Cyphorhinus aradus*	9	4	10	11	3	37
	111	*Microcerculus marginatus*		4	1	3	2	10
Muscicapidae	112	*Catharus ustulatus*				1	1	2
	113	*Turdus albicollis*	6	1	1	3	6	17
	114	*T. amaurochalinus*			1			1
	115	*T. hauxwelli*	4		10		3	17
	116	*T. lawrencii*				1		1
Vireonidae	117	*Hylophilus ochraceiceps*	2		1			3
Icteridae	118	*Psarocolius oseryi*					1	1
Parulidae	119	*Basileuterus fulvicauda*					2	2
Emberizidae	120	*Habia rubica*	7	15	9	6	2	39
	121	*Lanio versicolor*	2		2		4	8
	122	*Tangara schrankii*	2		1		3	6
	123	*Arremon taciturnus*	5	2	8		3	18
	124	*Oryzoborus angolensis*	1					1
	125	*Saltator maximus*			2			2
	126	*Cyanocompsa cyanoides*		2	1		4	7
Total Captures			**404**	**318**	**447**	**233**	**406**	**1808**
Total No. Species			**63**	**62**	**69**	**55**	**82**	**126**

Species Accounts

The following section details the data on the near-threatened and vulnerable bird species found within the Tambopata region, following Collar et al. (1992) and Parker et al. (1996), with information regarding their population densities and future conservation status recommendations. Also included are data regarding those species restricted to the south-western Amazonia endemic bird area and other rare and new bird records for the Tambopata region, made during the 21-months of surveying.

Small-billed Tinamou (*Crypturellus parvirostris*)

This species was not recorded during VCP Sampling. However this was recorded in scrubby grassland secondary habitat near the Tambopata River at SACHA and on numerous farms located along the Tambopata River. The frequency of daily encounters of this species from neighbouring farms is indicative of the amount of suitable secondary habitat for this species, created by human settlement. Also heard and seen regularly around Puerto Tambopata in Puerto Maldonado.

Variegated Tinamou (*C. variegatus*)

This species was found to be more abundant than what previous records suggest, with densities of 1.8 pairs per sq. km of type H forest. This species was only located in the dryer older floodplain forests (type F) and Terra Firme forests (G and H). Described as being rare at EI by Parker et al. (1994) and Donahue (1994), this species was recorded on a daily basis in type H forest at the reserve. In the past it has undoubtedly been under-recorded. There are many reasons for this. Type H forest is usually situated further inland than other forest types and takes a lot of effort during the early hours of the morning to reach, since this species is only heard during predawn chorus 0045 hrs to 0530 hrs. Also in the past, many birders have confined their observations to the trail systems, whereby this species was often found off trails in type H forest (EI); in type F/B (CAPH) and F/G forest (SACHA). Like most other tinamous (except for *Tinamus major* and *C. bartletti*) this species is very rarely heard during night surveys.

Brazilian Tinamou (*C. strigulosus*)

This species was recorded on five occasions in type B forest at ECO, only 30 m from the main trail, within the principal 2.4 km of the main tourist trail. Recorded during dusk hours of 1745 hrs and 1845 hrs. However without further tape recordings and the lack of a specimen, these records still remain in doubt. If confirmed in future observations, this represents a major new location for this species. Despite having a massive distribution, populations are local and patchy, and nothing is known of its ecology. It is possible that the race in south-eastern Peru represents a distinct sub-species.

Jabiru (*Jabiru mycteria*)

This species was recorded from all four locations. All but a few sightings were made on the exposed sand bars and shallows on the islands opposite the two lodges, ECO and CAPH, or from the sandbars and beaches opposite and adjacent to the main clay lick at the TRC. The largest flock of Jabiru ever recorded in and around the Tambopata province was recorded at the CAPH lodge, in April 1997. A flock of 204 individuals were seen flying low, from the south, heading in a northerly direction. At SACHA, individuals were observed on sandbars exposed at the bends of the Tambopata River. A flock of 39 birds was seen to land and forage at this sight at SACHA in November 1997. A week later another flock of four birds were seen at the same area.

Roseate Spoonbill (*Platalea ajaja*)

Recorded from the Cerros del Tavara by Parker et al. (1994), there have been sporadic sightings of single birds or pairs of this species at various points along the Tambopata River since 1995 (Lloyd, pers obs.). This species was recorded on four occasions feeding in the shallows off the exposed sandbars of Monkey Island, ECO. In June 1998, a pair was seen foraging in the same area on four consecutive days. In

September of the same year, groups of one to five birds were seen intermittently over an eight-day period in the same area. Recorded by Parker et al. (1994) as being 'rare' at the EI, there are sporadic records of this species along the Tambopata River (Lloyd, pers obs). Recorded on the Madre de Dios River, Bolivia by Davies et al. (1994).

Crested Eagle (*Morphnus guianensis*)

Status: Near threatened.

We made only one sighting of this species during two years of observations in Madre de Dios. One juvenile was seen flying through the subcanopy of the forest edge at the EI clearing, on the 10th March 1997. Too few records to make any definitive conclusions regarding its conservation status, but this does appear to be the rarest member of the Accipitridae family in the Tambopata region.

Harpy Eagle (*Harpia harpyja*)

Status: Near-threatened

Numerous reports of nest sites being located in Madre de Dios. One nest was found at the SACHA in 1997. This pair did not nest in 1998. Presumed parents seen at nearby oxbow lake, Lago SACHA, some 7 km from the river. Another pair was also seen and recorded on video at the Tambopata Research Centre in type E/F forest in August 1998. There are too few records to make any form of conclusions regarding the conservation of this species.

Blue-throated Piping Guan (*Aburria cumanensis*)

Recorded as 'uncommon' by Parker et al. (1994). This species appears to be in serious threat in the lower region of the Tambopata River, from the mouth of the River Malinowski, to Puerto Maldonado (see Figure 2.1). Only one bird was recorded in this stretch of habitat during the two years of Proyecto Tambopata. The massive habitat destruction caused by human settlement along the river banks has nearly obliterated this species from this stretch of river edge habitat. The population of this species in the lower region of the Tambopata River faces imminent local extinction due to clearance of river-edge habitat for human settlement, including the creation of tourist lodges, and hunting. Substantial populations exist in the Upper Tambopata region extending beyond the River Malinowski to the Tavara foothills, where there is no human settlement. In this region (i.e. at the TRC) this species was observed on a daily basis foraging on exposed rocky beaches and in tall trees along the river's edge.

Razor-billed Currasow (*Mitu tuberosa*)

This cracid faces a similar situation to that of *A cumanensis*. Records for this species at the other four sites are cause for concern. During VCP and Nocturnal VDLT surveys, only one record of a single bird calling in type F forest in SACHA, a single bird was observed walking along the main trail in type G forest at EI, adjacent to a small swamp. The species was absent from CAPH but again recorded on one occasion from ECO, from type B forest, near a large aguajal, some 5km from the lodge, during the predawn chorus. As with *A. cumanensis* the lower Tambopata River and Madre de

Dios population of *M. tuberosa* faces elimination despite the presence of the lodges. The fact remains that the lodges cannot protect these large cracids from local extirpation.

The species was recorded daily on the sides of the upper Tambopata River at the TRC, along rocky beaches, and calling from river edge forest. During VCP and VDLT surveys at TRC it was recorded from type E/F forest. Population densities calculated for this species in E/F forest is 8.2 individuals per sq. km. In the foothills, this species is also encountered daily (Parker et al. 1994; Lloyd pers. obs.) mirroring the situation for *A. cumanensis*. The likelihood of there being a substantial population of this species in the upper Tambopata region and foothills is under threat given the fact that oil exploration is underway in the foothills.

Pale-winged Trumpeter (*Psophia leucoptera*)

Recorded at three sites during VCP and VDLT Sampling, whilst also recorded at EI and CAPH during general observations. Absolute densities calculated for this species in type B forest are 3.0 breeding groups (10.8 individuals per group) per sq. km. Classified as 'vulnerable by Parker et al (1996) this species seems to be of no immediate threat at either of the lodges except CAPH, where like all large terrestrial birds, it has probably been decimated by the high levels of hunting over the years. Its capture for the local pet trade does not appear to be a current cause for concern, with only four birds reported to be domesticated in and around the Puerto Maldonado area (Velasquez, pers. com).

Blue-headed Macaw (*Propyrrhura colouni*)

This species was recorded on five occasions at SACHA. Four sightings were of single birds calling and flying over the type F forest. On one occasion in June 1997, a pair was observed flying over the lodge clearing. At TRC single birds were recorded on several occasions, primarily during the hours of 0700 hrs to 0900 hrs. Mostly recorded flying over the area of the main clay lick, associated bamboo forest and the lodge clearing. Other pairs or individual birds were recorded flying over and perching momentarily in Type E/F forest some 4km from the lodge (records from December 1997, February and August 1998). More recently, groups of up to 8 individuals have been observed at close quarters, perched high in emergent *Ficus* trees only 400 m from the lodge (Valdez, pers. com.). Noted as 'fairly common' at this site by Parker et al. (1994), this site probably does have the largest known population of this species in Tambopata. At CAPH a pair of Blue-headed macaws were first recorded perching in a tall tree in the lodge clearing, in February 1997. Other individuals and pairs were seen flying over he nearby aguajal, in the east of the 'reserve'. Last recorded at CA on two consecutive days in January 1998. In total we made 28 separate sightings of this species during VCP surveys and general observations and calculated mean group size of 1.8 individuals.

Nothing is known about its ecology or it's breeding behaviour, yet this species is listed as being not globally threatened (CITES Appendix II) and one of the least known parrot species in South America. Its movements in lowland habitats in south-eastern Peru are described as 'erratic' (del Hoyo et al. 1997). Estimations on its population in Madre de Dios by local ornithologists may be as low as 350 pairs (Valdez, pers. com.). Possibly breeding between January and April. Unlike recent suggestions from observations in the Manu region and from the Beni region in Bolivia (del Hoyo et al.

1997), this species is not numerous in foothill regions. To date, it has yet to be recorded in the Tavara-Candamo foothills in the south of the TCRZ. Some authors (e.g. Parker et al. 1996; del Hoyo et al. 1997) suggest that its populations may increase due to patchwork clearances of forest. We can find no evidence for this other than observations of birds made from occupied areas. This species deserves the formal conservation status of Data Deficient/Near-threatened as its current status is not to our satisfaction given the lack of quantitative data it is based upon.

Red-shouldered Macaw (*Diopsittaca nobilis*)

Previously recorded from the Pampas del Heath in the BSNP (Parker et al. 1994). The other known location for this species in the region is from Lago Sandoval (12°37'S, 69°5'W) situated south of the Madre de Dios river, some 45 minutes from Puerto Maldonado (Walker, pers com). In March 1998, this species was observed flying high over the lodge clearing at ECO, heading north, from a south-easterly direction, on four occasions, in raucous flocks of between 14 to 18 individuals, between 1600hrs and 1715hrs. This species was recorded only once during VCP sampling, a single flock was observed flying high over the type B forest canopy in June 1998. In September of the same year, three birds were flushed from the crown of an *Iriartea deltoidea* palm tree in type B forest during mist net sampling.

Scarlet-shouldered Parrotlet (*Touit huetii*)

Few records exist for this *Touit* parrotlet. Lack of detection maybe due to the species being temporarily patchy reflecting nomadism (Parker et al. 1996). This species was recorded on one occasion at TRC in February 1998, flying high over the type E/F forest canopy. There are two records for ECO, during VCP survey; a flock of unknown size was heard flying high overhead census stations. On September 1998, a flock of three birds were seen from the canopy platforms, flying from type B forest, circling noisily and then returning to the same direction. At SACHA large flocks of unknown size were heard on two occasions (May and July 1998) flying high above the type F forest canopy.

Amazonian Parrotlet (*Nannopsittaca dachilleae*)

Status: Near-threatened.

Only located at two sites during the two years during general observations, and not during VCP Sampling. Recorded at river edge bamboo habitat, near the lodge clearing at the SACHA. Also recorded in bamboo and river edge habitat adjacent and above the clay lick at TRC. We interviewed one local parrot trapper whilst examining captured wild Tui Parakeets (*Brotogeris sanctithomae*) in the INRENA headquarters in Puerto Maldonado, Madre de Dios. He described a species similar to *N. dachilleae*, and he has seen many on river islands, but he also said that he is aware of no one (including himself) trapping the species. Recorded from EI by Parker et al. 1994, but not by us, because our surveys were mainly concerned with forest-interior species in type H forest. With few records, we are unable to calculate population densities for this species. Locally threatened in Tambopata, due to the threats to floodplain forests and more specifically because of almost total deforestation of river edge habitat by human settlement. Another reason for the paucity of records could be due to the possible nomadic ecology of this species.

Great Horned Owl (*Bubo virginianus*)

A pair or Great Horned Owls were seen and tape-recorded in the E/F forest edge at the lodge clearing of the TRC. This pair was seen during two visits to the TRC, in December 1997 and February 1998. These owls have been resident here for a few years and have also been observed copulating (Valdez, pers com).

Long-tailed Potoo (*Nyctibius aethereus*)

This poorly known nocturnal canopy dweller was not recorded during nocturnal VDLT surveys, but it was recorded during general observations in the early hours of the morning at all sites except in the type B forest of ECO. Regularly encountered at SACHA, where one territory situated only 400 m from the lodge is regularly found active. Recorded less regularly at TRC. Its very difficult to census this species as its less vocal than the other two larger Potoo species. Only one territory was located at EI.

Nest of this species has recently been found in Manu Wildlife Centre (Walker, pers. com.). Seems to prefer the dryer floodplain forests (types E and F) and terra firme forests (G and H) rather than recently flooded forest types. We know now that this species is distributed more continuously along the Tambopata River. It is under no threat, and has been under-recorded. An intensive effort is needed to survey all the potoo species, with surveys continuing into the early hours and not just confined to the periods of dusk and dawn (Lloyd and Palomino, unpublished).

Little Nightjar (*Caprimulgus parvulus*)

A pair of *C. parvulus* were recorded during VCP sampling between the 2nd and 6th of August 1998 in Type E/F forest, only 350 m along one of the main tourist trails, from the TRC. The birds were seen and heard singing, only 3-4 m from the trail, sitting on the ground or a few m up on a nearby fallen tree, always during 0510–0525hrs. Parker et al. (1994) located an unknown species of *Caprimulgus* in 1994 at the TRC, but its not thought to be this species (possibly *C. rufus* or *C. sericocaudatus*, Kratter, pers. com.). This Nightjar has previously recorded from gallery forest in the Pampas del Heath, BSNP, and recorded on fewer than five occasions at the EI in ‘floodplain forest’ (Parker et al. 1994; Donahue, 1994).

Purus Jacamar (*Galbalcyrhynchus purusianus*)

Not recorded during VCP Sampling due to its lakeside and riverside habitat preferences. This species was seen on two occasions during general observations at ECO. A single bird was recorded fishing from a perch approximately 5 m above the water on a stream nearby to the lodge. In May 1998 a group of five birds were seen at an aguajal some 1.5km from the lodge. All five individuals were seen 'sallying' for winged termites above the observation platform at the aguajal (Samuels, pers.com). Recorded from the Department of Loreto (known as Chestnut Jacamar), and also along the Rio Yurua in western Brazil. There are very few other sightings in the lowlands of Peru.

Yellow-billed Nunbird (*Monasa flavirostris*)

This is one of the rarest bird species associated with bamboo. We did not record this species during VCP sampling at the two sites inundated with bamboo despite one of the authors (HL) being familiar with its vocalisations. We recorded this species only once, at SACHA, in a clearing surrounded with bamboo near the river bank. There it was seen daily foraging at mid levels in the bamboo edge. The bird was mist-netted, measured and photographed. We also recorded this species during general observations in the bluff-top bamboo habitat at the TRC. The lack of records is alarming, although it prefers to use bamboo and viney edge habitat. Thus given its association with patchy stands of bamboo, we consider this species to be vulnerable locally, given the fact that this habitat's medium sensitivity to human disturbance.

Scarlet-hooded Barbet (*Eubucco tucinkae*)

Status: Least Concern.

This species is rare in Madre de Dios. From the Tambopata province it was only seen on few occasions in 'lodge clearings' around type B/F forest edges (EI), type B forest edges (ECO), type F forest edges (CAPH) and secondary forest edge habitat, bordering type F forest (SACHA). This species has always been observed foraging with mixed species flocks. There are too few records for us to estimate absolute population densities. Population density for this species estimated by Terborgh et al. (1990) at Cocha Cashu Biological Station in Manu National Park = 0.5 pairs sq. km of 'early successional' habitat. This habitat is threatened in large areas in Tambopata and in the Manu Biosphere Reserve. We recommend that this species' conservation status be raised to Data Deficient.

Recorded by Denton (pers. com.) at the Wasai lodge along the Tambopata River, upriver from SACHA. Also recorded by Widdowson (1994) in the furthest regions of the Tambopata River, near the Tavara River, near the foothills, which he called the 'Plateau Region' (13°21' S, 69°33' W). It is not known which forest type it was recorded from, but several are described for this location in an unpublished TReeS report.

Rufous-headed Woodpecker (*Celeus spectabilis*)

This largely unknown species was not recorded during VCP sampling. However four territories were located at SACHA, whereby it was also found nesting (Lloyd, submitted). Another two territories were located in type B/G forest inundated with bamboo during general observations at the EI. Also recorded from forest bamboo habitat at the newly created Wasai Lodge (Denton, pers. com.). The main problem in detecting this species is that this woodpecker is largely silent, and rarely calls except when nesting (Lloyd, submitted). This creates problems for both Distance Sampling and Spot-mapping methods (Kratter, 1995a, 1997), which also fail to adequately calculate densities for the species. The woodpecker is sensitive to playback, this is how it is commonly located or by looking for drilled holes in bamboo stems. Often located, in mixed flocks of bamboo specialists, by listening for drumming sounds on bamboo stems.

Classified as 'vulnerable' by Parker et al. (1996), it formerly deserves Near Threatened status. This species has very low population densities. We estimate that this is approximately 1.9 pairs per sq. km of type F forest bamboo habitats. Kratter (1995) calculates a range of population estimates for this species in three different bamboo habitats. Habitat is rare, patchily distributed, and subject to mass seeding and natural death in a short space of time. It then takes a number of years for the bamboo to reach maturity to support a full complement of bamboo specialists.

Like most bamboo specialists, it probably relies on river-edge bamboo habitats for dispersal between other bamboo areas. Of the three bamboo habitat types discussed by Kratter, pure and extensive thickets of *Guadua* bamboo are very rare and localised, while the river-edge bamboo habitat under the greatest threat due to human settlement. Its nesting requirements are now known (Kratter, 1998; Lloyd, in press). Suitable nesting trees are rare, particularly at SACHA, where selective logging has taken place.

Bar-bellied Woodcreeper (*Hylexetastes stresemanni*)

This species was recorded only once during two-years of VCP Sampling. In February 1998, a single bird was observed foraging at an army ant swarm, in type B forest at ECO. The bird was then attacked by an individual *Dendrocolaptes picumnus* and *Dendrocincla fuliginosa* flying to low-levels (~5m) hitching along tree trunks, with the other two species in pursuit. There are too few records to calculate absolute population densities. This species certainly deserves data deficient/ near-threatened status as its so poorly known throughout its range and highly sensitive to human disturbance. Classified as 'vulnerable' by Parker et al. (1996). There are maybe only six or more confirmed records of this species in Madre de Dios (Walker, pers. com.). Previously recorded from EI by Donahue (1994), but not Parker et al. (1994). Recent sighting of this species at the new Wasai lodge in the TCRZ (Denton, pers. com.).

Dusky-cheeked Foliage-Gleaner (*Anabazenops dorsalis*)

Too few records were obtained during VCP Sampling to calculate an absolute population density for this bamboo specialist, at either TRC or the SACHA. This species has been under-recorded at both sites by us, due to the nature of its call. Kratter (1995b) calculates a range of population densities using a spot-mapping method. Based on that research, and the nature of bamboo ecology (see notes on *C. spectabilis*) the status of *A. dorsalis* is of medium concern for conservation biologists.

Peruvian Recurvebill (*Simoxenops ucayalae*)

Status: Near threatened.

This species was more abundant in E/F forest bamboo than F bamboo (population densities of 7.7 individuals per sq. km versus 4.7 individuals per sq. km, respectively). Both these estimations are lower than those calculated by Kratter (1995b) for floodplain forest bamboo habitat. We estimate that the total population level for the Recurvebill, in floodplain forest bamboo habitats in Tambopata ranges from 550 individuals to 8285 individuals. During VCP surveys this is one of the first bamboo specialists to begin vocalising during the dawn chorus along with *Ramphotrigon megacephala*, and it often remains largely silent for the rest of the day. This near obligate bamboo specialist is largely confined to the bamboo habitats of south-western Amazonia with other widely disjunct population's further east in Brazil (Ridgley and Tudor, 1994).

Brown-rumped Foliage-Gleaner (*Automolus melanopezus*)

Fairly common in type F bamboo habitats with population density of 12.4 individuals per sq. km. Kratter (1995b) calculates the densities for this species in floodplain forest bamboo habitat at TRC as 15 pairs per sq. km. We calculate that the overall population size in Tambopata ranges from 1,451 individuals to 13,342 individuals. This species was recorded more often than not foraging with mixed species flocks with other Furnariids, with mixed flocks of bamboo specialists, and also foraging at army ant swarms.

Bamboo Antshrike (*Cymbiliaimus sanctaemariae*)

This near-obligate bamboo specialist, described in 1983, is restricted to bamboo habitats of south-western Amazonia. Tables 5.16 and 5.17 show the absolute densities calculated for this species in the two forest bamboo habitats. It is fairly common in these habitats, but once again, as with all the bamboo specialists, this habitat is rare and patchily distributed. Thus this, like all bamboo specialists must be given high conservation priority in the region. This antshrike species was also recorded during general observations in edge habitat around the lodge clearings at CA and ECO. These birds were recorded regularly during 1997 but were absent in 1998. Also recorded in bamboo habitats in type B/G forest, in the EI. Populations here are assumed to be smaller than those of other bamboo habitats due to the bamboo seeding on mass and dying during the early part of the decade (Kratter, 1995b). We estimate that the total population of the bamboo antshrike in forest bamboo habitats in Tambopata ranges from 725 to 8716 individuals.

Undulated Antshrike (*Frederickena unduligera*)

Previously recorded from the EI by Parker et al. (1994) and from the Pampas del Heath (BSNP) also by Parker et al. (1994). We first recorded *F. unduligera* at the TRC on 10th August 1998. A male was seen calling during VCP Sampling and taped at 0550 am, in the understory of E/F/forest, near an old regenerating forest gap, immediately adjacent to a large stream. A second bird, again a male, was seen and heard calling in a scrubby area of habitat at the forest edge of the ECO clearing. The bird was observed calling from a low perch (one metre from the ground) near the waste dump at the lodge. This species has also recently been recorded from dense undergrowth near streams at the new Wasai lodge within the TCRZ (Denton, pers. com.). This species has only been recorded twice from Bolivia (see Parker and Bailey, 1991 and Davies et al. 1996).

Stipple throated Antwren (*Myrmotherula haematonata*)

This species was mist netted at three sites. The mist net captures from the TRC in type E/F forest representing the first record of the species from the TCRZ. Individuals were also mist-netted in type B forest at ECO, in April, and December of 1997, and in March, May and September of 1998. This species was also netted in Type B/F mosaic at CAPH. Davis et al. (1991) had previously only recorded this species in the region, from the CAPH reserve.

Manu Antbird (*Cecromacra manu*)

This habitat restricted bamboo specialist was not recorded during VCP sampling, but six territories were mapped out by HL during general observations during May-July 1998. Estimated number of pairs for this species in type F bamboo habitat are 3.7 per sq. km.. This bamboo specialist is more restricted to pure stands of *Guadua* bamboo, rather than forest bamboo habitat (Kratter, 1995b). The precise habitat requirements for this species are discussed by Kratter (1995b). Classified as 'vulnerable' by Parker et al. (1996) this species formerly deserves near-threatened status given the nature of the habitat it requires, the amount of suitable habitat in the region, and its known nesting and foraging behaviour (Kratter 1995b, 1998). Despite the species being 'common' in these habitats, the habitats themselves are rare and patchily distributed. Estimations for the total population for this species in the Tambopata province range from 3,961 pairs (Lloyd and Palomino, unpublished) to 8,514 pairs (Kratter, 1995b).

White-lined Antbird (*Percnostola lophotes*)

Another of the habitat restricted bamboo specialists. This species is the most abundant and least threatened of all the bamboo specialists in the *Guadua* bamboo habitats. Estimations range from 48.3 individuals per sq. km of type F forest bamboo, to 14.8 individuals per sq. km of E/F forest bamboo habitat (Tables 5.16 and 5.17). Despite this species being common in this habitat, the habitat itself is rare and patchily distributed (see notes on *C. spectabilis*). We also recorded this species in scrubby edge habitat, located on the periphery of the football pitch at ECO. Only two pairs were located here amongst a small number of very young stems of *Guadua* bamboo.

Spot-winged Antbird (*Schistocichla leucostigma*)

Only previously recorded in this region from CAPH by Davis et al. (1991). A juvenile female was netted in type F forest adjacent to a stream in April 1997. Another individual was found at the forest edge near the lodge clearing at the TRC. The female was in poor health and heavily infested with botfly larvae. This represents the first record of the species within the TCRZ.

Goeldi's Antbird (*Myrmeciza goeldii*)

This near-obligate bamboo specialist was found to be very common in both bamboo sites (see Tables 5.16 and 5.17). Not currently threatened as it was also encountered during VCP surveys at ECO, in aguajal edge habitat. Also heard in similar habitat at CAPH lodge, during ad hoc observations. However, density estimates for this antbird species in this latter habitat type are likely to be much lower than populations in bamboo habitats. Restricted to south-western Amazonia, we estimate a total population in Tambopata, in forest bamboo habitats, of between 2,516 to 33,464 individuals.

Dot-backed Antbird (*Hylophylax punctulata*)

One of the rarer *Hylophylax* species (Ridgley and Tudor 1994), a pair were mist netted in type B forest at ECO in October 1997. The only previous record for this species from the region comes from the EI, within the TCRZ (Parker et al. 1994).

Noble Antthrush (*Chamaeza nobilis*)

This rare antthrush was recorded during VCP surveys only at SACHA and the TRC, although it was also recorded during ad hoc observations at CAPH. It naturally occurs at low densities with large territory sizes between pairs (Terborgh et al. 1990). Estimated densities range very little from 1.4 individuals per sq. km in type F forest to 1.6 individuals per sq. km in E/F forest. Not recorded at EI during the last five years (Lloyd, pers. obs). At the nearby Tambopata Jungle Lodge this species was found to be breeding in January/February 1998. Although a nest was never located, a pair flushed from a thicket in type E forest, performed an elaborate 'injured wing feigning' distraction display whilst leading the observers from the presumed nest location.

Rufous-fronted Antthrush (*Formicarius rufifrons*)

Status: Vulnerable.

Rediscovered in 1982 by the late Ted Parker III, this species is only known from the type locality at the mouth of the Rio Colorado, from the mouth of the Rio Inambari, and from six localities in the TCRZ (but see Kratter, 1995a), along with five locations in the Manu Biosphere Reserve - Cocha Salvador, Cocha Cashu Biological Station, Cocha Juarez, Manu Wildlife Centre, and also near the Blanquillo clay lick (Kratter, 1995; Walker, pers. com.). Also recorded from the Extractive Reserve of the upper Rio Juruá, Acre, Brazil in 1995, and from Cobija, Pando, Bolivia in 1996. For a description of its ecology and habitat preferences see Kratter (1995a).

This species was recorded at three of the four locations – the first site being the TRC. Two territories were located, corresponding to two areas (1a and 1c) located by Kratter (1995a) at the same site. Birds were heard calling in December 1997, and February 1998 at location 1a but only heard calling at location 1c during December 1997 and February 1998. Two further territories were located at the CAPH lodge in February 1997, representing the first records of this species in the lower region of the Madre de Dios River from the TCRZ to the Bolivian border. The two territories were located in Type F forest edge scrubby habitat at the lodge clearing, some 30 m from the river. Birds were often heard calling from 0700 hrs to 1700 hrs from both areas. On the 26th April 1997, at one territory directly adjacent to the lodge's tourist bungalows, a female was caught, measured and weighed, photographed and released at the point of capture (weight = 55.0g, wing length = 8.2 cm, tail length = 6.5 cm, culmen = 1.5 cm, tarsus = 3.7 cm). These two territories were in occupation during three further 18 day visits to the site (April 1997, March 1998, July 1998) and were still present in September 1998 although extensive damage was being done to their habitat, caused by lodge reconstruction. To date these two territories of this globally threatened species (Collar et al. 1992) at this site are under immediate danger from the lodge's activities. New tourist accommodation is being constructed directly on top of the two territories, and urgent decisions on the part of the lodge administration are required to prevent local extinction of this species.

In June 1998 at ECO, a single territory was located near the canopy platforms, 6 km from the lodge. A seemingly unfamiliar habitat for the species as most of the understory has been cleared in the vicinity of the platforms for a tourist resting area, and the fact that it's at the juxtaposition of Type B forest, scrub, and the permanently flooded Swamp type A forest. On two occasions (June 1998 and September 1998), a single bird was observed singing around the base of the two trees supporting the platforms.

Purple-throated Cotinga (*Porphyrolaema porphyrolaema*)

Status: Least Concern

This species has only been recorded from the EI within the TCRZ, where there are fewer than three records in over 20 years of observations of the bird communities (Parker et al. 1994). On the 15th September 1998, a male was seen perched in the canopy at the type B forest edge at ECO clearing. The male was seen preening itself at 0730 hrs and was observed for a further nine minutes before it joined a mixed canopy flock and returned into the forest interior. Also an unconfirmed report of this species seen at the edge of an oxbow lake at the new Bahuaja Research Lodge, 5 km upriver from the EI, in 1997. Its habitat requirements and nesting behaviour are unknown.

This species is probably more common than records might suggest, due to its canopy dwelling nature, and unfamiliarity with its song. Readily observed from the Manu Wildlife Centre, Manu Biosphere Reserve (Walker, pers. com.). We concur with Whittaker (1996) that this species will probably be found also in north-eastern Bolivia. Population densities calculated for this species in 'floodplain forest' in Manu region, by Terborgh et al. (1990) = 2 individuals per sq. km.

Black-faced Cotinga (*Conioptilon mcilhennyi*)

Status: Near threatened.

Previously recorded by Davis et al. (1991) at CAPH and formerly only described from the Department of Madre de Dios (Ridgley and Tudor 1994). This species was regularly encountered during VCP Sampling and during general observations recorded in pairs or groups of 4 to six individuals, in Type B forest at ECO. Population densities for this species in this forest type are 0.9 individuals per sq. km. Sometimes the species was observed roosting in pairs in the subcanopy of tall canopy trees. More commonly recorded foraging with flocks of *Brotogeris* parakeets, always in the vicinity of streams. Pairs and groups of up to four individuals were also observed foraging with mixed canopy flocks (*Thraupinae*, Vireonidae, etc.) feeding on the fruits of *Pourouma* trees and other species situated immediately around the lodge clearing. This is only the second recorded location for this species in the lower region of the Madre de Dios River (Lloyd, in press)

At CAPH the species was recorded throughout the 1997-1998 period foraging in type F/ B forest. Population densities for this species are slightly higher in this forest, than in type B forest; 1.7 individuals per sq. km (Lloyd, in press).

C. mcilhennyi has recently been recorded outside Madre de Dios. It has been recorded at Balta, Department of Ucayali, and along the Rio Camisea (Alto Urubamba), in the Department of Cusco. In Manu this species has been recorded from the clay lick located above Cocha Cashu Biological Station, along the length of the Manu River. Its distribution continues along the Madre de Dios River as far as the Manu Wildlife Centre and the Blanquillo clay lick. However, this species seems to be absent from upriver of Boca Manu. Likewise, it has never been recorded south of the Madre de Dios River. This river is probably a significant barrier for this species, representing its southern most limit in its small distribution, thus explaining its absence from the TCRZ. Recently recorded on the upper Rio Tejo and Rio Juruá, near Taumaturgo, Acre, extreme western Brazil (Whittaker & Oren, in press).

Olive-striped Flycatcher (*Mionectes olivaceus*)

Primarily a foothill species (Ridgley and Tudor, 1994), *M. olivaceus* was first recorded by Parker et al. (1994) at the TRC in ‘upland’ and ‘floodplain’ forest, due to the relative proximity of this location to the Tavara foothills. We mist netted individuals at TRC on a number of occasions. All captures were made 10 m from one of the main tourist trails at two or our census stations in type E/F forest. At SACHA, two individuals were mist netted in type F forest, in 1998. It is now widely accepted that this species has a wider distribution outside the foothill region than what was previously thought. Previously recorded at a minimum elevational range of 500 m by Ridgley and Tudor (1994), we have now shown it to occur at an elevation of 217 m.

Other recent records of this species include individuals recorded from forest habitat immediately beneath the Tavara foothills, in the upper Tambopata River region (Widdowson, 1994, unpublished), and from the Bolivian side of the River Heath, in ‘riverine forest’ near the BSNP, by Helme (1996).

Dusky-tailed Flatbill (*Ramphotrigon fuscicauda*)

This near obligate bamboo specialist was often recorded during VCP surveys in mixed species flocks of bamboo specialists, foraging above and amongst live bamboo foliage at the SACHA. Population density for this species in type F forest bamboo habitat was estimated at 4.3 individuals per sq. km. Although recorded at census stations located in E/F forest bamboo at TRC, there were too few records to calculate an absolute population density for this species at this site. Kratter (1995b) estimates a higher population density for this species in floodplain forest bamboo habitat at TRC (7.5 pairs per sq. km). We estimate the total population in floodplain forest bamboo habitats in Tambopata, to range between 503 to 4,627 individuals.

White-cheeked Tody-Tyrant (*Poecilotriccus albifacies*)

Status: Near threatened.

Endemic to only two Departments in south and south-eastern Peru. This obligate bamboo specialist was found to be more common in type F forest bamboo of the SACHA (population density of 4.4 individuals per sq. km) than in type E/F forest at TRC (too few records for density estimation) . At SACHA it was recorded quite frequently during VCP surveys, sometimes only 200 m from the lodge clearing. This species is totally dependent on stands of *Guadua* bamboo habitat (see Kratter 1995b, which provides further details on its habitat requirements and foraging behaviour). We recorded this species foraging in pairs, in mixed flocks of bamboo specialists, at heights of 2-5 m, amongst live and dead bamboo foliage, and also seen breaking open dead-leaf curls. This species is now absent from B/F forest bamboo habitat at EI since the bamboo seeded and died in the early part of the decade. The current stands of bamboo there are thought to be not yet mature enough to hold a population of this tody-tyrant (see Kratter 1995b). We estimate that the total population size for this species in floodplain forest habitats, in Tambopata ranges from 515 to 4,734 individuals.

Long-billed Gnatwren (*Ramphocaemus melanurus*)

The only previous records for this species are from the TRC by Parker et al. (1994). This species was observed in three different locations at ECO, in June and September 1998. Pairs were always observed foraging in densely packed viney tangles, from mid to sub canopy level, in both type B forest, and in dense viney tangles located around the type B forest edge of the lodge clearing. This species was always observed accompanying understory and canopy mixed species flocks.

Grey-headed Tanager (*Eucometis penicillata*)

This rare tanager was not recorded during VCP surveys due to the fact that the census stations were not located in river edge habitat. The first record we have of this species was that of an individual seen and later mist netted, in type B forest edge, around the lodge clearing at ECO. We also recorded this species foraging in secondary river edge habitat at the EI. Only previously recorded from Tambopata at EI (Donahue, 1994).

Conclusions

EcoAmazonía Lodge

This lodge was found to contain a full complement of flooded forest indicator species (Table 5.10). Populations estimated for the four species appear comparable to those in floodplain forest habitat of Cocha Cashu Biological Station, in the Manu National Park (Terborgh et al. 1990). The reason that we were unable to calculate absolute densities for the other species was not because they were rare or endangered, rather that they were relatively difficult to sample using the methodologies implemented here. The forest around this lodge was found to be the most disturbed of the five lodges surveyed. However, this disturbance is a natural phenomenon and not linked to tourism.

Type B forest has a naturally high turnover of trees and a more open canopy than other forest types. This lodge has great potential as a "birdwatchers" destination and harbours rare and endangered species, and the aguajals and marsh habitats strongly warrant further investigation. Care should be taken however not to further disturb this forest through the felling of canopy trees, something that has been observed from time to time especially when the lodge and trail infrastructure is refurbished. The issue of pets is particularly worrying at this lodge and numerous bird deaths from mismanagement have occurred. There is reason to believe that this lodge is actively employed in fomenting the trade in wildlife as pets.

Cusco Amazónico Pueblo Hotel

This lodge will continue to experience problems in the amount of birdlife it can offer tourists. Due to its location, relatively close to Puerto Maldonado and nearby rural settlements, populations of large bird species are threatened from general disturbance and particularly hunting pressure. The lodge has the lowest complement of indicator species for both lowland and flooded forests (Tables 5.11 and 5.12). The species present appear to be those that tolerate a range of canopy cover vegetation density brought about by local disturbance. Any further forms of habitat disturbance (particularly the felling of large trees for lodge reconstruction) that causes a shift in the density of canopy vegetation cover or the height of the canopy cover would probably lead to the further demise of the forest bird community at this lodge, primarily the floodplain forest community. Population densities of most of the species at this lodge are low, a result of the disturbed nature of the forest, although it could also be a manifestation of the relatively small area of forest sampled. Exactly how much of the variance in abundance is attributable to such habitat disturbance has still to be investigated.

The lodge administration have also failed to take the necessary measures to protect the most endangered bird species in the lowlands of Madre de Dios, the globally threatened species *Formicarius rufifrons* (see Species Accounts). It would be in the interest of the lodge to conserve this species and perhaps increase their market share of tourists by advertising their conservation campaign. Other rare species that visit the lodge from time to time are *Propyrrhura couloni* and *C. mcilhennyi* (see Species Accounts), with population density of the Cotinga species higher than that calculated for type B forest.

In order to try and attract more tourists to the lodge, the administration have also taken up the example of ECO, in creating a zoo (although a relatively bad one) situated on a neighbouring island. Individuals of *Mitu tuberosa* were caged on the island during 1998. We refer the owners and managers of this lodge to read the results of the tourist questionnaire (Chapter 6.0) which clearly demonstrate that tourists are largely unhappy with this practice.

Explorers' Inn

Bird sightings have been documented here for at least the last twenty years. Although this has been an important site for research in the tropics during this time (Foster et al. 1994) most of the bird studies have not been scientifically based. Our study shows that the terra firme sandy-clay forest here is fairly disturbed. The absence of a few of the lowland forest indicator species is probably attributed to this. However, despite these absentees, there is a large proportion of indicator species present (Table 5.13) and the status of the bird community in this area appears to be good. The story is not so good for the resident parrot species as mature canopy fruiting tree species are rarer (see later). Although not part of this study, the bamboo bird community has suffered in recent times, but this has been due to the natural reproductive cycle of the *Guadua* bamboo thickets (see earlier) and not related to anthropomorphic variables in any way. The lodge appears keen on displaying pet birds, particularly macaws and some mammals, although many tourists when questioned feel that this is not called for.

Sachavacayoc

The results of the habitat survey show the forests at this site to be one of the least naturally disturbed of the five locations. This site also holds populations of almost all of the habitat restricted bamboo indicator species and the lowland forest indicator bird species, including globally threatened species (Tables 5.14 and 5.16). The bird communities here represent a complete ecological assemblage, emphasising the nature of the primary forest habitat that dominates the area. Large macaws frequently use these forests for roosting and feeding (see section on Canopy Frugivores) alongside many other parrot and toucan species. Furthermore, at Lago Sachavacayoc there is an important nesting colony of approximately 60-80 pairs of *Ara ararauna*. SACHA also harbours one of the known nesting sites for the near-threatened *Harpia harpyja* and careful consideration to protect these individuals from tourism development should be considered. Given the above information and the threats to floodplain forests throughout Amazonia, this site warrents the highest conservation priority.

Our biggest concern in the SACHA area is the possible rise in habitat alteration caused by the activity of numerous lodges using the area simultaneously, at present 4 lodges are known to use the trail system and the Sachavaca Inn and the Tambopata Jungle Lodge have implemented independent access trails to the main trail network. These trails are at places wider than would be recommended. Lodges that use the same area of forest should enter into detailed discussions regarding trail-management issues.

Tambopata Research Centre

Our research, along with that of Foster et al. (1994) and Kratter (1995b) shows that this site has a complete ecological assemblage of birds in primary forest and bamboo habitats, containing most of the globally threatened species of the region. Furthermore, it is located alongside of one of the largest clay licks in the world (Foster et al. 1994) used by parrots, macaws, and cracids on a daily basis. The lodge administration has a moral imperative to conserve this area and should enter into detailed discussions with INRENA and all other lodge users regarding how best to manage this important ecological resource of high tourism value. The forest habitat around the TRC and the clay lick should be given some form of special protected status other than that currently in place.

Canopy Frugivores

The few records of parrot species, particularly of the three large macaw species at both CAPH and EI are a cause for concern. These two lodges are currently not good places to observe these types of birds. These two lodges have been established for over 20 years and no doubt that access into the forest interior by other people, has been facilitated to varying degrees via the trail network, particularly in the case of the CAPH. Information provided by local residents, and the data collected during the mammal study, has revealed that the amount of hunting of certain bird species at CAPH has been ‘considerable’. Hunting in the forest around EI is also thought to have been present in the past, and indeed the lodge was originally a hunting destination for a short time after it was first built in the late 1970s, although at present hunting pressure on the wildlife is low and large cracids are relatively common as a consequence (see Chapter 3.0).

Munn (1992) has shown that large macaw species avoid areas of permanent human settlement and his study revealed that the closer one surveys to the town of Puerto Maldonado the fewer individuals were seen. We present no evidence of impact by human traffic, around the two oldest lodges over the past 20 years, on the records of parrot species during this time, because this data simply does not exist. However, given the high degree of human settlement and activity in and around these two lodges, and that large macaw species in particular avoid human settlements, the circumstantial evidence is very persuasive.

At SACHA there is also a relatively high level of permanent settlement nearby. The difference between this site and the EI, which is only 10 km to the east, is the presence of large areas of mature floodplain forest which has been little disturbed at SACHA. This appears to be an important factor, macaws appear not to be able to tolerate the more disturbed forests of EI and CAPH.

Forest Classification

The Discriminant Function Analysis results were used to classify the similarity of the forest types based on the variables recorded, and not to distinguish between the more primary and disturbed forests. Of all five locations, the forest types at SACHA, TRC and CAPH appear to be the most similar. Based on the largely structural habitat variables studied we were effectively surveying three types of forest. Each of these three lodges had a component of old floodplain forest (Type F), in the case of SACHA virtually the whole area studied was dominated by this forest type. However, when one examines the abundance of the five commonest fruiting tree genera, results show that all three floodplain forests are fairly dissimilar (Kirkby and Cornejo, Chapter 3.0). Floristically, TRC has the most distinct forest type, while the seasonally flooded swamp/old floodplain forest mosaic of CAPH being most similar to the pure seasonally flooded swamp forest of ECO, both situated on the banks of the Madre de Dios river. This relationship is possibly caused by the presence of more of the type E forest component at TRC, and type B in the forest mosaics at CAPH and ECO.

Identification of forest types should also be a factor of tree architecture. We have shown that it is a rapid and reasonably accurate method of assessing primary forest areas from disturbed forest types. It has also proved to be successful in *Dipterocarpaceae* forests in south-east Asia (Jones et al. 1995; Marsden and Jones, 1997).

6.0 Tourist Questionnaire

In addition to directly studying the effects of tourists on the local wildlife in Tambopata, we wished to investigate the tourist's own perceptions of the wildlife and the lodges relationship with this wildlife. Questionnaires were written (in English and Spanish) and distributed amongst tourists on their last day at a lodge to assess their opinions on various aspects of their trip and the wildlife experience.

General Information (N = 45)

- What type of tour did you purchase that brought you to the rainforest?

Package Tour = 78% Independent Tour = 20% NA = 2%

- In total, how many nights did you stay at the lodge? Average = 3

- What was your primary reason for coming to the rainforest?

A general interest in nature	54%
To observe birds	13%
To observe mammals	7%
To observe flora	7%
To film or photograph nature	7%
To rest	6%
To observe amphibians and reptiles	4%
Other.	2%

- Have you visited the rainforest before?

YES = 55% NO = 42% NA = 3%

- Have you visited Madre de Dios before?

YES = 15% NO = 71% NA = 14 %

- Would you consider the areas you visited to be well conserved?

YES = 56% NO = 33% NA = 11%

Mammals (N = 45)

- Which of the following mammal groups did you expect to see during your visit versus what you actually saw?

Mammal Group	Expected to see	Actually saw
Monkeys	41	40
Bats *	25	32
Large Rodents	24	13
Small Rodents	21	11
Otters	17	11
Sloths	13	3
Cats	12	3
Peccaries	12	11
Tapir	11	0
Armadillos	10	0
Marsupials	8	2
Deer	5	0
Coatis	4	4
Other	5	3

* Actually saw > Expected to see

- Are you satisfied with the mammals you were able to observe?

YES = 58% NO = 33% NA = 9%

- How many people, on average, were with you whilst on the trails?

Average = 8 Maximum = 17 Minimum = 2

- Would you have been prepared to walk further to increase your chances of observing more mammals?

YES = 80% NO = 20% NA = 0%

- Would you have been prepared to get up early (at or before dawn) to increase your chances of observing mammals?

YES = 86% NO = 11% NA = 3%

- Would you consider going on a night excursion to observe "nocturnal" mammals?

YES = 84% NO = 16% NA = 0%

- Would you consider using hides, blinds or platforms to view mammals from?

YES = 84% NO = 16% NA = 0%

- Was your guide influential in helping you to find and then observe mammals?

YES = 82%	NO = 18%	NA = 0%

- Would you consider that he/she performed in a responsible and ecologically sensible manner?

YES = 96%	NO = 4%	NA = 0%

- In general, was there sufficient information available regarding the area's wildlife (i.e. field guides, posters, slide shows, illustrated talks, etc.)?

YES = 56%	NO = 44%	NA = 0%

- Would you recommend this lodge to others based on the mammal resources alone?

YES = 60%	NO = 38%	NA = 2%

Herpetofauna (N = 116)

- Which of the following amphibian and reptile groups did you expect to see during your visit versus what you actually saw?

Amphibians & Reptiles	Expected to see	Actually saw
Caiman *	38	78
Boa Constrictors	24	0
Poison-arrow Frogs	9	9
Frogs *	6	40
Tortoises/Turtles *	6	62
Crocodiles	4	4
Lizards *	1	61
Vipers *	0	5
None of the above	2	0

* Actually saw > Expected to see

- Would you like to see more amphibians?

Of course	49	No	0
Yes	41	Never	0
Neutral	19		

- Would you like to see more reptiles?

Of course	48	No	4
Yes	41	Never	2
Neutral	15		

- Should the lodge keep captive reptiles and amphibians for viewing by the tourists?

Of course	4	No	33
Yes	4	Never	57
Neutral	12		

- Would you like to take a night walk in the forest to see night-active reptiles and amphibians if offered by the lodge?

Of course	42	No	4
Yes	40	Never	4
Neutral	40		

- Should the lodge capture caimans during the night-time caiman viewing session so that the tourists can see them better?

Of course	2	No	28
Yes	4	Never	69
Neutral	8		

- Do you think that there should be more information available at the lodge about venomous snakes in the area?

YES = 73%   NO = 27%

Birds (N = 116)

- Are you a keen birdwatcher?

YES = 26%   NO = 74%

- Which of the following bird species or families did you expect to see during your visit versus what you actually saw?

Birds	Expected to see	Actually saw
Toucans	75	44
Macaws & Parrots	69	69
Hummingbirds	60	43
Harpy Eagles	48	12
Manakins	22	2

- Should the lodges keep captive birds on site as pets for tourism, photographs, etc?

YES = 13%   NO = 87%

- Do you think the use of blinds/hides and canopy platforms are essential for viewing bird species?

  YES = 57% NO = 43%

- Would you use a canopy platform to view birds if available?

  YES = 93% NO = 7%

- Do you think it is essential to have an expert on birds (an ornithologist) as a guide at the lodge?

  YES = 69% NO = 31%

A total of 161 questionnaires were completed by tourists staying at ECO, CAPH, EI, and the Tambopata Jungle Lodge (a lodge that was not included in the main study). The vast majority of tourists arrived as members of package tours. Such tours rarely spend more than three days in the rainforest, hence the average length of stay was relatively low (3 days) although 2 days are generally spent getting to and leaving each lodge. Most tourists had a general interest in the area's nature and wildlife although between 13-22% of them were primarily interested in the birdlife and considered themselves as "birdwatchers".

When considering the preconceptions of what the tourists expect to see compared to the wildlife that they actually saw, the herpetofauna group fared the best. In general, tourists saw more reptiles and amphibians, in both species and abundance, than they expected to see. Nevertheless, the vast majority of tourists, who observed more herpetofauna than expected, would have liked to have observed even more! This highlights the tourists' interest in frogs, lizards, and snakes. Herpetofauna is likely to grow in importance as a tourist attraction, especially if more information is made available to the tourist. However, care will have to be taken in the future with regards to viewing these groups of animals, as it is evident that some species are negatively affected by the presence of people.

Amongst the mammals, monkeys were expected from many tourists and on the whole they were observable, due to the relatively high abundance of one or two species such as the saddleback tamarin and the squirrel monkey. On the whole only monkeys and bats lived up to expectations, all other mammal groups were observed too infrequently for the likings of tourists. This may be part of the reason for the low level of satisfaction with mammal sightings expressed by the tourists (only 58%), which may also explain why only 60% of tourists stated that they would recommend a lodge based on the observable mammals alone.

Between 80-86% of tourists questioned would consider either walking further, getting up earlier, walking at night and/or using hides or platforms to improve their chances of seeing more mammals. The importance of the trained tour guides, provided by the lodges, should not be underestimated in bringing tourists and wildlife together; 82% said their guides were influential in helping the tourists encounter and observe mammals. Guides and their tour groups should spend longer periods in the forest immediately around the lodge where wildlife is likely to be more habituated, in order to better understanding the home ranges and habits of local mammal groups, particularly monkeys and to improve the chances of encountering mammals that are less likely to flee, thus improving the satisfaction levels of the visitors which is generally the bottom line in any tourist operation.

With regards to the birds, both macaws/parrots and toucans were the most popular although only the former lived up to expectations. These two groups of colourful and noisy birds have also been found to be very popular tourist attractions in other areas (Munn 1992). Macaws and parrots, furthermore, were found to abound in small flocks in the forest canopy of Tambopata and are relatively easily observed by tourists at most of the lodges. However, birds such as manakins were little known and hardly seen at all, although they have beautiful plumage and exhibit interesting courtship behaviour in the form of dancing in an understory arena, or "lek". One unexpected result was that although 48% of tourists expected to see a Harpy Eagle, 12% said they actually did see one. This sighting figure is very high considering the sighting frequency the authors experienced. It is most likely that the majority of these are actually mistaken identities on behalf of the tourists or their tour guides. The majority of guides are unfamiliar with bird identification (Lloyd, pers. obs.) and more effort in such training should be given. Furthermore, nearly 70% of tourists consider it is essential to have an ornithologist employed as a guide, which would be particularly useful for specialist birdwatching groups, and who could help provide appropriate training in bird identification to other less specialised guides. Tourists also consider that tree platforms and hides are important for viewing birdlife. These results show that 53% of birds are observable in the mid-canopy to canopy levels in the forest, while another 8% of birds were recorded flying above the canopy.

All tourists expressed a need for more information about the wildlife groups in the area. If more information were provided, lesser known species could become more interesting to tourists which would likely improve overall visitor satisfaction levels. The most basic information that should be provided are illustrated field guides to the major wildlife groups, although more detailed information on a limited number of species at each lodge, would be advantageous and each lodge should endeavour to identify which species should be investigated.

One very important finding was the almost unanimous opinion against the lodges keeping wild animals as pets; consequently, lodges who undertake this practice should relinquish this false attraction. We documented numerous cases of wild animals being traded with lodges as pets, and numerous pet deaths as a consequence of poor or negligent husbandry. We are particularly concerned with the case of the islands in the Madre de Dios river which currently harbour the majority of the area's tourist pets. The conditions on the islands and the lack of professional veterinary care are inappropriate and such sites should be banned, both in the interest of the animals concerned and for the long-term benefit of the areas tourist industry. A common point made by the lodges, to attempt to explain the reason for having pets, was that they were to be eventually reintroduced to the forest (Lloyd, pers. obs.), but no official reintroduction plans or other evidence was given in support this. Furthermore, it is potentially very hazardous to reintroduce animals that have been in contact with humans and domestic pets, as the transmission of diseases to wild populations could be detrimental.

Numerous additional negative comments were made by tourists including: badly kept trails that were too muddy and unkept; trails that were too short in some cases and too long in others; and most tour group sizes were considered too large.

7.0 Recommendations

Tourism Impact and Trail-use Carrying Capacity

This report presents compelling evidence that certain species of mammals and amphibians are strongly influenced by the presence of tourists and trail infrastructure in their habitat. It is still to be seen whether certain bird species will also prove to be influenced in similar ways, although it is very likely that this will be the case. However, we are only able to speculate at this stage regarding the principal ecological mechanisms underlying the impact without more thorough investigations, although it is likely that a variety of factors are playing a role, such as: 1) timidness and a propensity to flee at the presence of humans, particularly for those species which have experienced hunting pressure; 2) habituation and intrinsic ecological resistance to disturbance; 3) variations in predation pressure; 4) inter-specific competition for resources; and 5) changes in the micro-structure of the habitat which either improves or diminishes the successful search for prey, for herpetofauna species.

Some of these impacted species, particularly mammals, are positively influenced by tourism, although it would be wrong to conclude that this is a good thing and should be encouraged. When ever the balance in the abundance within and between species begins to change from that which is normal the long-term repercussions for the habitat and the structure of the vegetation could be serious, as the reproductive fitness of many species of tree are tightly linked to animal pollinators and dispersers.

If the variations between tourist and control areas, in terms of the abundance of wildlife, are to be minimised then a prudent first step would be to reduce trail-use intensity in those lodges where there is a marked discrepancy between T and C. Chapter 3 discussed trail-use carrying capacity for mammals, and suggests a level around 696 people per year would be appropriate. We advice that trail-use intensity should be capped at this average figure at all lodges for the time being and that an Adaptive Traffic Management Strategy be implemented thereafter to adjust this figure up or down as appropriate. Adaptive management is thought by many as a suitable method for addressing even small scale issues such as tourism impact (Johnson 1999)(see below).

Adaptive Traffic Management Strategy

We envisage that such a strategy would entail a more or less continuous monitoring program of indicator species with a system of experimental negative feedback loops affecting traffic. The wildlife monitoring methodology would proceed in a similar, or though more simplified, fashion to that illustrated in the mammal chapter. The parameters under continuous study would be traffic and the abundance of the five mammal indicator species. The required field work could be undertaken by lodge staff, and/or park guards and/or third parties, in all cases having previously received the required training. Abundance results from 2-month sample periods would be analysed against previous periods in a comparative fashion, using data from this investigation where appropriate. After every such 2-month period, traffic would be maintained, reduced or increased in accordance with the desired trend, i.e. a reduction in the difference in abundance between T and C to insignificant levels. At lodges where controls are currently lacking, additional investigation would be required. In this fashion traffic will be more directly linked to the capacity of the wildlife to support the presence of tourists.

In many cases the recommended level of traffic that we state in this investigation (696 people) would require many lodges to alter their current trail-use patterns. A number of options are available to them and not necessarily mutually exclusive, including 1) alternating use between different trails on a temporal and/or even seasonal level; 2) expanding the trail network or implementing new trails in otherwise un-visited areas; 3) reducing noise by reducing group sizes and improving group management through improved guide training; 4) providing more extensive nocturnal trail excursions thus reducing diurnal excursions; and 5) options such as implementing canopy platforms/walkways and hides in the near vicinity of the lodges (i.e. within 200 m) thus providing alternative attractions to customary forest excursions. These points are discussed in more depth below.

Continued Wildlife Monitoring

We would like to take this opportunity to impress upon lodge administrations and INRENA the benefits of continuing a comprehensive process of wildlife monitoring at these and other lodges, at least for the more easily identifiable species and more especially those identified as impact indicators. Over an extended period of time such monitoring will be able to indicate the status and health of local wildlife populations and would additionally provide an insight into the habits of species on a temporal scale, and will highlight favoured areas for conservation and for viewing, around each lodge. All of which would shed light on the status of the wildlife around each lodge and would improve encounter predictability in time and space thus improving the number of times tourists can successfully observe wildlife. However, in any monitoring system it is imperative that the observer(s) be consistent in terms of the methodology used and ideally should receive adequate training in the collection of data and the maintenance of databases. Furthermore, the importance of negative data, where a sample reveals no wildlife encounters, is vitally important and should always be recorded.

New Trails

In the process of analysing the need for a new trail it is advisable to weigh up all the pros and cons in advance. It is particularly important to note that physical damage, to the herbaceous and shrub layers in particular, will be an important consideration (Mieczkowski 1995, Hunter and Green 1995), which could affect the regeneration capabilities of understory vegetation on a localised level. Furthermore, issues such as control of access and ease of management, which are in turn associated with the types of other forest users in the area and topography, etc. have to be considered. In areas near permanent settlements the issue of opening up new trails should be discussed with the local inhabitants first, in order to reach agreement on rights of way and compensation if required, as it is imperative that these new trails are not used indiscriminately for hunting or impede the development of local peoples.

When implementing a new trail extreme care should be taken first to fully reconnoitre all possible routes and secondly to pay close attention to topography and soil conditions. Wet, potentially boggy, areas should be avoided at all costs unless elevated walkways or bridges are to be built and maintained. Cutting the trail should clear only the absolute minimum of vegetation (maximum width 1m), tree saplings more than 2m in height should be left standing and only lower branches pruned. Where possible trails should be cut in straight-line sections, to avoid unnecessary clearance of vegetation and to increase the chances of observing terrestrial mammals and birds as they cross or follow the trail. However, where topography is steep trails should follow contours in order to reduce the effects of erosion.

Most lodges in Tambopata have 1 – 3 principal attractions, for example an ox-bow lake, canopy platform, or clay-lick, with one or two trails leading to and from them. When an expansion of the trail network is required we do not recommend that further trails are cut to these same attractions as the separation distance between these new trails and the older ones will be insignificant to reduce the effects of traffic. What is required are trails in new areas, at a distance of at least 2 km from existing ones, which lead either to newly identified end point attractions, where these are available and have been granted by the relevant authorities for recreational use, or be simple circular forest routes providing access to a greater variety of interesting habitats.

Trail Maintenance

Close attention to trail maintenance on a regular basis will reduce the chances of long-term problems. Clearing of trails should be undertaken after every major storm event, using manual equipment such as machetes, band saws and axes to reduce noise pollution. Chainsaws should not be used as the noise may scare away some species. This will prevent the formation of trail off-shoots which quickly form around fallen vegetation and will thus reduce the amount of vegetation destroyed. When clearing tree bowls which have fallen across the trail the true direction of the trail should be maintained which will provide for greater opportunities to observe species which congregate in such disturbed areas, such as poison dart frogs.

Where trail erosion is high and the formation of excessively muddy conditions is rapid, which is currently common during the rainy season in all lodges, one of several options are available. These include 1) ameliorating the existing surface with porous materials, 2) building some form of elevated walkway, or 3) refraining from using the trail until conditions improve. An effective and sensitive means of improving the surface is the application of gravel, if available in nearby rivers, as is currently the practice at the TRC, or in the absence of gravel thick wood chippings or similar materials such as Brazil-nut husks would suffice if reapplied on a yearly basis. On no account should berms be constructed which form ditches as this will affect natural drainage patterns and will affect the rooting systems of nearby vegetation. Standing ponds of water in trails attract breeding amphibians whose breeding success is severely altered by people constantly disturbing them. Such ponds should be filled in immediately, as a short term measure, and one or other of the above precautionary measures taken in the longer term. When planning a raised walkway care should be taken to identify sources of appropriate material, which should ideally not be derived from the area in question particularly if it entails the felling of mature fruit trees. It is important to take note that intentional felling of canopy trees for construction material will alter an areas canopy cover and fruit resources, which in turn will reduce mammal and bird populations over time and should be avoided at all costs.

Canopy Platforms and Hides

The majority of tourists who completed the questionnaires agree that canopy platforms and hides would provide a further attraction and a viable alternative mechanism for observing wildlife, and up to 84% of visitors would use one if available. Such static attractions, if sited relatively near to a lodge (within 200 m) could also help to reduce traffic by providing an alternative to a long walk in the forest, particularly for older people (50+) who are common visitors to Tambopata at present. The major preoccupation amongst administrators with canopy platforms is undoubtedly the issue of safety. However, there are numerous arquitecturally and ecologically safe designs and modern materials for constructing platforms, although an initial expense is inevitable as the expertise and materials are currently not commonly found in Peru.

EcoAmazonía currently manages two canopy platforms. However, we unfortunately find the design highly unsuitable in terms of ecology and safety, as there is direct evidence that the construction of the platforms is affecting the health of the host trees, due to the many hundreds of nails that have been driven into the trunks, and the maintenance and safety measures are of an inadequate standard. We recommend that MITINCI and INRENA undertake an independent evaluation of this site and provide the necessary guidelines to the lodge administration in order to remedy the situation.

Information relating to the construction of canopy platforms, tree houses, and specialist construction firms and individuals, is widely available on the internet.

http://www.canopyaccess.com
http://www.canopyproject.org
http://www.tou.com/host/jake/treehouse.html
http://www.smithsonianmag.si.edu/smithsonian/issues97/aug97/treehouses.html
http://www.geocities.com/Yosemite/Gorge/5980/index.html
http://www.btinternet.com/~fulton/damage.htm
http://www.btinternet.com/~fulton/building.htm
http://www.treehouses.com/
rtaini@pacbell.net (Mr. Reno Taini)

Increased Protection for Threatened Species and Communities

The forest immediately around some lodges harbour very rare and endangered species. Opportunities exists to conserve these on a local basis and provide alternative specialist limited attractions, although ignorance could lead to their local extermination!

The forests around EcoAmazonía were found to be particularly rich and complex in terms of avifauna, particularly the community associated with flooded forests. The area is also home to the near-threatened *Conioptilon mcilhennyi* which has been recorded in very few other locations. We recommend that the lodge administration and/or INRENA promotes an in-depth study of the status and breeding habits of this and other rare species at EcoAmazonía and that discussions are implemented by both sides in order to incorporate part, if not all, of the forest around the lodge into the national protected area network. After consultation with specialists in the conservation of threatened bird species, the lodge administration should set aside preferred habitats for these rare species, as areas off limits to tourism, although one or two well managed sites with appropriate viewing facilities could be implemented for those specialist tourists interested in observing rare bird species.

In the immediate vicinity of the Cusco Amazónico Pueblo Hotel there are at least two breeding pairs of a globally threatened species, *Formicarius rufifrons*. As an immediate measure to help protect this local breeding population an urgent study of the home range, feeding and breeding ecology of this species is required. There should be an immediate halt to disruptive activities, such as the cutting of large trees and undergrowth, in a radius of 200 m around the lodge until foraging and breeding areas are identified. The lodge should then take measures to protect these key areas from destruction and monitor the population at intervals. Other rare species such as *Propyrrhura couloni* and *C. mcilhennyi* are also infrequent visitors. As above, the lodge administration should also seek advice from specialists in the conservation of threatened bird species, and devise appropriate viewing facilities and a localised management plan in order to allow observation of these rare birds by specialist tourists, who as a rule would pay well to view them.

The floodplain forest around Sachavacayoc, which is primarily restricted to the area south of the Tambopata river (see Satellite Images), is regarded as physically and floristically mature, indeed most of it was classed as Old Floodplain Forest or Type F. The forest contains a high abundance of mature fruiting tree species as well as patchily distributed stands of bamboo both in the understory and in large canopy openings. The resulting avifauna diversity is high and the resident bird community consists of many of the large canopy frugivores such as parrots, macaws and toucans, which are threatened over most of their range. In addition it should be remembered that these bird groups are important tourist attractions. Mammal species diversity has been significantly affected by hunting in and around the Sachavacayoc area although those species little affected by this pressure are relatively common and have contributed to a high mammal biomass when compared to other lodges located near permanent settlements. The area is not significantly different from other lodges in terms of the diversity of herpetofauna.

The current conservation value of the floodplain forest in this area in terms of the avifauna community, and the potential value of the area for the *in situ* conservation of large mammals should be taken into account and stricter protection of parts of this forest should be seriously considered, and a special “zone of conservation interest” developed and worked towards with the input of all stakeholders; INRENA, lodge administrators, and the local inhabitants that use the natural resources in this area.

Lodges as Refuges for Wildlife

We have presented evidence that tourism has the potential, over an extended period of time and where agreements are reached with local inhabitants regarding access to the forest, to conserve local populations of large mammals and large birds such as cracids (Guans), which are frequently over-hunted in many riverine areas of Amazonia. In the case of the Explorers’ Inn a non-formal agreement between the lodge and neighbouring settlements, which has significantly restricted access of local people to the forest visited by tourists, has resulted in a more stable community structure and diversity, although overall mammal biomass is lower than would be found in more isolated locations, likely a result of over-hunting of those species with large home ranges such as spider monkeys, white-lipped peccaries, tapir, etc. which tend to wander outside the semi-protected status of the forest immediately around the lodge and trail system.

However, where no formal or informal agreements exist between lodges and neighbouring communities regarding access to the forest and use of resources then the effects of over-hunting can be severe. Furthermore, we have shown that some species equate tourists with hunters which exacerbates the situation and reduces the abundance of these species even further, especially in areas of forest visited frequently by tourists. When large mammals disappear from an area the smaller species, such as Tamarins, Squirrel Monkeys and rodents, tend to increase as predation and inter-specific competition for fruit and other resources declines. This is the scenario currently observed at Cusco Amazónico and will become more evident at Sachavacayoc as time wears on. Only when lodges take a more active role in discussing issues, pertaining to access and hunting rights with local inhabitants (in areas as far away as 10 km from a lodge), and agreements are reached which are mutually beneficial will hunted species begin to recover.

Quantity versus Quality of the Wildlife Attraction

A large number of small mammals at some lodges, a result of both over-hunting of larger competitor species, reduced abundance of predators, and the greater resilience of smaller species to disturbance, will increase the success rate of tourists sighting mammals during their stay, however the quality of these sightings on average will be low. The vast majority of mammals (approx. 65%) that tourists would observe if they visited a lodge in Tambopata would be restricted to only three species; southern amazon red squirrel, brown agouti and the saddleback tamarin. Only the latter species is of much interest to tourists, the other two are but glorified rats to a tourist, solitary, shy and generally difficult to see, whereas tamarins are a gregarious and inquisitive species to which most tourists can relate. This may explain why 33% of tourists questioned expressed their dissatisfaction with regards to the mammals they were able to observe.

Wildlife Specialisation at each Lodge

As mentioned earlier, each lodge varies in terms of the wildlife community they potentially offer to visiting tourists. At Cusco Amazónico for example the commonest primate, in terms of group encounters per km, is the saddleback tamarin (0.30 grps/km walked) and the most distinguished rare bird is the Rufous-fronted antthrush. At the Tambopata Research Center by contrast the brown capuchin (0.17 grps/km walked) is the commonest primate, as well as bamboo bird specialists and large parrots, frequently sought after by birdwatchers, are likely important tourist resources. The marketing of tourist lodges based on the wildlife resources of the area is not a new idea, however few lodges provide any detailed information to prospective tourists or travel agents regarding the status of their resident wildlife populations and potential encounter probabilities of species of specialist interest. Information from this report and from a program of continued monitoring could help provide this information.

Tour Guides

Guides, provided by the lodges, should be trained in the general ecology of the wildlife groups in the vicinity of the lodge. They should strive to know more intimately the home ranges of specific animals or groups nearest the lodges, those most likely to have become habituated to the presence of tourists, in order to better predict diurnal and seasonal behaviour to increase encounter frequency if tourists do not want to walk far. Although it is stressed that breeding individuals should be left well alone at all times.

The lodges should recognise the observation and identification abilities of local peoples and endeavour to employ those locals willing to work in the lodge, particularly during the high season. However, it is important that sufficient training is provided and that observation etiquette is maintained, namely that on encountering animals all efforts should be made to maintain silence and not to call-in individuals. The most appropriate people for this type of seasonal job would be hunters. If they can be convinced, through appropriate incentives, this too may reduce hunting pressure in the area and lead to a resurgence in some populations.

Feeding Wildlife and the role of Enrichment Planting

We strongly recommend that animals are not actively fed by the lodge as this will tend to lead to dependency and a degree of unsustainability. The case of organic waste is discussed below. If lodges want to attract birds and mammals to the forest immediately neighbouring the lodge then we recommend that a system of enrichment planting is undertaken, which includes the planting of native fruiting and flowering plants immediately surrounding the lodge. Non native plants should be avoided as their consumption would, over time, alter the ecology of the animal species and might upset the balance of plant species in the local forest habitat. Attention to this should be paid by the lodge administrators of Cusco Amazónico and Explorers' Inn in particular. A number of plants would be ideal and include the following genera: *Inga* (Pacay, Shimbillo), *Ficus* (Oje, Matapalo), *Salacia*, *Manilkara* (Sapote), *Pseudolmedia* (Chimicua), *Bactris* (Pihuayo), *Mauritia* (Aguaje) – for streamside areas, and *Heliconia*.

Waste management

As a general rule all types of waste are potentially damaging for wildlife and should be disposed of in well maintained, covered pits and cesspools or removed from the area to Puerto Maldonado. All existing pits should be constructed in such a way as to minimise the chances of wildlife gaining access, else those species that do, particularly rodents, will overpopulate the local area thus inadvertently affecting the local ecology of the area and the appearance of the lodge. Non of the lodges studied managed their waste in an optimal manner with regards to the safety of local wildlife. Organic edible kitchen waste should be ideally managed for the production of compost. There exist simple and efficient methods of converting such waste to compost and the lodges should seriously consider investing in this "green" alternative to fattening vultures and rats. For lodges interested in recycling human waste they should investigate the feasibility of implementing composting toilets [www.compostingtoilet.com]

The Upper Tambopata River

During our studies at the Tambopata Research Center and our journeys too and from this site it is clearly evident that the upper reaches of the Tambopata river, beyond the Malinowski river, is an ecologically important or "source" area for the majority of persecuted species and those sensitive to the presence of people. Strict tourism management policies should be initiated in this area and careful consideration is given to the siting of new lodges where authorisation has been granted. Although not a variable that was investigated on this occasion it is evident from other studies (Groom 1990, Groom et al. 1991, Yoon et al. 1994) that boat traffic also has serious negative implications on riverine wildlife in Madre de Dios and should also be an integral part of any tourism management strategy for the area.

Conservation Workshops and Species Monitoring: The Role of INRENA

In 1998 the co-ordinators of Proyecto Tambopata participated in a series of workshops regarding the ecology and conservation of regional lowland forest flora and fauna, organised by the office of fauna of INRENA. We feel strongly that this type of workshop and the organisational role provided by INRENA should continue and that workshops should be hosted in outlying communities as well as in the town of Puerto Maldonado. We have a few recommendations in this respect: that core funding for this sort of activity is sought from the local and international NGO network, and that more importance is given to discussing the conservation issues relating to those habitat restricted and globally threatened species that are present in Tambopata. For example: bamboo specialist bird species. These are the most habitat-restricted species in Tambopata, some are globally threatened, while others are endemic to south-western Amazonia, such as: the Rufous-headed Woodpecker, Bamboo Antshrike, Manu Antbird, White-cheeked Tody Tyrant and the Peruvian Recurvebill. All these species would appeal to local residents due to their colouration, a particular anatomical feature or a behavioural attribute. Further campaign would concern the most threatened forest species, which are also globally threatened and restricted to this region of Amazonia. Such species include Rufous-fronted Antthrush, Blue-headed Macaw, Harpy Eagle, Black-faced Cotinga, Scarlet-hooded Barbet, and it would also have to include the two most threatened species in the Tavara foothills; *Tinamus osgoodi* (the Black Tinamou) and *Pauxi unicornis* (Southern helmeted Currasow). The question of conserving large mammals should also be discussed.

Furthermore, we call on INRENA to begin or oversee a comprehensive wildlife monitoring program with yearly analysis and local publication of results, in order to gauge the health and status of wild populations. Their numerous park guard stations and personnel are ideally located to monitor both virgin areas of forest and areas under increasing pressure from human encroachment.

Tourist Questionnaires

Most tourists on leaving a lodge are presented with questionnaires to gauge opinion on lodge services, etc. It would be advantageous as a management tool for lodges to also keep a record of opinion concerning the local wildlife, perhaps using some of our own questions to base their own systems. This would go a long way towards attaining an integral approach to tourism management.

Appendix 1: Indicator Species for Forest Habitats in the Tambopata Region, south-east Peru.

(Adapted from Stotz, Fitzpatrick, Parker and Moskovits, 1996).

Bamboo (Applicable only to sites with Floodplain bamboo: e.g. Sachavacayoc and the Tambopata Research Centre)

Dromococcyx pavoninus
Nonnula ruficapilla
Monasa flavirostris
Campylorhamphus trochilirostris
Simoxenops ucayalae
Anabazenops dorsalis
Automolus melanopezus
Cymbilaimus sanctaemariae
Myrmotherula iheringi
M. ornata
Microrhopias quixensis
Drymophila devillei
Cecromacra manu
Percnostola lophotes
Myrmeciza goeldii
Poecilotriccus albifacies
Hemitriccus flammulatus
Ramphotrigon fuscicauda
R. megacephala
Sporophila schistacea

Terra Firme/ Floodplain Forests (Applicable to sites with Terra Firme Clay Forest, Terra Firme Sandy Clay Forest, Upper Floodplain Forest, Old Floodplain Forest (types E, F, G, H), e.g. Cusco Amazónico, Sachavacayoc, Explorers' Inn, and the Tambopata Research Centre

Tinamus guttatus
Crypturellus strigulosus
C. variegatus
Micrastur gilvicollis
Mitu tuberosa
Odontophorus stellatus
Psophia leucoptera
Phaethornis philipii
Malacoptila semicincta
Dendrocincla fuliginosa
D. merula
Dendrocolaptes certhia
Xiphorhynchus spixii
Synallaxis rutilans
Automolus infuscatus
Sclerurus caudacutus
Thamnophilus aethiops
Thamnomanes ardesiacus
Myrmotherula haematonata
M. hauxwelli
M. leucophthalma
M. menetriesii
Dichrozona cincta
Myrmoborus myotherinus
Gymnopithys salvini
Formicarius colma
Chamaeza nobilis
Myrmothera campanisoma
Conopophaga peruviana
Corythopis torquata
Platyrinchus coronata
Pipra rubrocapilla
Microcerculus marginatus
Habia rubica

Flooded Swamp Forest (Applicable to sites with Seasonally Flooded Swamp Forest (type B), e.g. EcoAmazonía Lodge, Cusco Amazónico Lodge).

Crypturellus bartletti
C. cinereus
Agami agami
Aramides cajanea
Eurypyga helias
Phaethornis hispidus
Xiphorhynchus obsoletus
Hypocnemoides maculicauda
Sclateria naevia
Hylophylax punctulata
Schiffornis major
Pipra fasiicauda
Turdus hauxwelli

Appendix 2: Avifauna Species Lists (1 = Present)

Scientific Name	English Name	CAPH	EI	ECO	SACHA	TRC
Tinamidae:						
Tinamus major	Great Tinamou	1	1	1	1	1
T. guttatus	White throated Tinamou	1	1	1	1	1
Crypturellus cinereus	cinereus Tinamou	1	1	1	1	1
C. soui	Little Tinamou	1	1	1	1	1
C undulatus	Undulated Tinamou	1	1	1	1	1
C. bartletti	Bartlett's Tinamou	1	1	1	1	1
C. strigulosus ?	Brazilian Tinamou ?			1		
C. atrocapilus	Black capped Tinamou					1
C. variegatus	Variegated Tinamou	1	1		1	
C. parvirostris	Small billed Tinamou				1	
Phalacrocoracidae:						
Phalacrocorax olivaceus	Neotropical Cormorant			1		1
Anhingidae:						
Anhinga anhinga	Anhinga			1	1	1
Ardeidae:						
Ardea cocoi	White necked Heron	1		1	1	1
Egretta alba	Great Egret	1	1	1	1	1
E. thula	Snowy Egret	1		1	1	1
Butorides striatus	Striated Heron	1	1	1	1	
Agami agami	Agami Heron			1	1	
Bubulcus ibis	Cattle Egret	1	1	1	1	1
Pilherodias pileatus	Capped Heron	1	1	1	1	1
Trigosoma lineatum	Rufescent Tiger Heron		1	1	1	1
Cochleariidae:						
Cochlearius cochlearius	Boat-billed Heron			1	1	1
Ciconiidae:						
Mycteria americana	American Wood Stork			1		1
Jabiru mycteria	Jabiru	1	1	1	1	1
Threskiornithidae:						
Mesembrinibis cayennesis	Green Ibis			1	1	
Platalea ajaja	Roseate Spoonbill			1		
Anhimidae:						
Anhima cornuta	Horned Screamer	1	1	1	1	1
Anatidae:						
Cairina moschata	Muscovy Duck	1	1	1	1	1
Cathartidae:						
Sarcoramphus papa	King Vulture	1	1	1	1	1
Coragyps atratus	Black Vulture	1	1	1	1	1
Cathartes aura	Collard Forest-Falcon		1			
C. melambrotus	Greater Yellow headed Vulture	1	1	1	1	1
Accipitridae:						
Harpagus bidentatus	Double-toothed Kite			1		
Ictina plumbea	Plumbeous Kite		1	1	1	
Leptodon cayanensis	Grey-headed Kite	1	1	1		
Elanoides forficatus	Swallow-tailed Kite	1	1	1	1	1
Buteo magnirostris	Roadside Hawk	1	1	1	1	1
Leucopternis schistacea	Slate-coloured Hawk	1	1	1	1	1
Busarellus nigricollis	Black-collard Hawk			1		
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
Buteogallus urubitinga	Great Black Hawk	1	1	1	1	1

Morphnus guianensis	Crested Eagle		1			
Harpya harpia	Harpy Eagle				1	1
Spizaetus ornatus	Ornate Hawk-Eagle	1	1	1	1	
S. tyrannus	Black Hawk-Eagle	1	1	1	1	1
Geranospiza caerulescens	Crane Hawk			1		
Pandionidae:						
Pandion haliatus	Osprey				1	1
Falconidae:						
Herpetotheres cachinnans	Laughing Falcon	1	1	1	1	1
Micrastur semitorquatus	Collard Forest-Falcon	1	1	1	1	1
M. mirandollei	Slaty-backed Forest-Falcon	1	1	1	1	1
M. ruficollis	Barred Forest-Falcon	1	1	1	1	1
M. gilvicollis	Lined Forest-Falcon		1	1	1	1
Daptius ater	Black Caracara	1	1	1	1	1
D. americanus	Red-throated Caracara	1	1	1	1	1
Falco rufigularis	Bat Falcon	1	1	1	1	1
Cracidae:						
Ortalis guttata	Speckled Chachalaca	1	1	1	1	1
Penelope jacquacu	Spix's Guan	1	1	1	1	1
Pipile cumanensis	Blue-throated Piping Guan		1	1	1	1
Mitu tuberosa	Razor-billed Currasow		1	1	1	1
Phasianidae:						
Odontophorus stellatus	Starred Wood-Quail	1	1	1	1	1
Psophiidae:						
Psophia leucoptera	Pale-winged Trumpeter	1	1	1	1	1
Rallidae:						
Aramides cajaena	Grey-necked Wood-Rail	1	1	1	1	1
Porphyrula flavirostris	Azure Gallinule	1				
Laterailus melanophaius	Rufour-sided Crake		1	1		
L. viridis	Russet-crowned Crake			1		
Heliornithidae:						
Heliornis fulica	Sungrebe		1	1	1	1
Eurypygidae:						
Eurypyga helias	Sunbittern		1	1	1	1
Charadriidae:						
Pluvialis dominica	Lesser Golden Plover			1		
Charadrius collaris	Collard Plover			1		
Hopoxypterus resplendens	Pied Lapwing			1		
Jacanidae:						
Jacana jacana	Wattled Jacana				1	
Scolopacidae:						
Tringa solitaria	Solitary Sandpiper	1	1	1	1	1
Actitus macularia	Spotted Sandpiper	1		1		1
Laridae:						
Phaetusa simplex	Large-billed Tern	1		1		1
Sterna superciliaris	Yellow-billed Tern	1		1	1	1
Rynchopidae:						
Rynchops niger	Black Skimmer	1		1		
Columbidae:						
Columba speciosa	Scaled Pigeon			1		
C. cayennensis	Pale-vented Pigeon	1	1	1	1	1
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
C. subvinacea	Ruddy Pigeon	1	1	1	1	1
C. plumbea	Plumbeous Pigeon	1	1	1	1	1

Columbina talpacoti	Ruddy Ground-Dove	1			1	
Claravis pretiosa	Blue Ground-Dove	1				
Leptotila rufaxilla	Grey-fronted Dove	1	1	1	1	1
Geotrygon montana	Ruddy Quail-Dove	1	1	1	1	1
Psittacidae:						
Ara ararauna	Blue and Yellow Macaw	1	1	1	1	1
A. macao	Scarlet Macaw	1	1	1	1	1
A. chloroptera	Red and Green Macaw	1	1	1	1	1
A. severa	Chesnut-fronted Macaw	1	1	1	1	1
Orthopsittaca manilata	Red-bellied Macaw	1	1	1	1	1
Diopsittaca nobilis	Noble macaw			1		
Propyrrhura couloni	Blue-headed Macaw	1	1		1	1
Aratinga weddellii	Dusky-headed Parakeet	1	1	1	1	1
A. leucophthalmus	White-eyed Parakeet	1	1	1	1	1
Pyrrhura rupicola	Rock Parakeet	1	1	1	1	1
Forpus sclateri	Dusky-billed Parrotlet		1	1	1	1
Touit huetii	Scarlet-shouldered Parrotlet		1	1	1	1
Brotogeris cyanoptera	Cobalt-winged Parakeet	1	1	1	1	1
Nannopsittaca dachilleae	Amazonian Parrotlet				1	1
Pionites leucogaster	White-bellied Parrot	1	1	1	1	1
Pionopsitta barrabandi	Orange-cheeked Parrot		1	1	1	1
Pionus menstruus	Blue-headed Parrot	1	1	1	1	1
Amazonia ochrocephala	Yellow-crowned Parrot	1	1	1	1	1
A.farinosa	Mealy Parrot	1	1	1	1	1
Cuculidae:						
Piaya cayana	Squirrel Cuckoo	1	1	1	1	1
P. minuta	Squirrel Cuckoo	1	1	1	1	
P. melanogaster	Black-billed Cuckoo		1			
Crotophaga ani	Smooth-billed Ani	1	1	1	1	1
C. major	Greater Ani	1	1	1	1	
Dromococcyx phasianellus	Pheasant Cuckoo				1	1
D. pavoninus	Pavonine Cuckoo	1		1		1
Opisthocomidae:						
Opisthocomus hoazin	Hoatzin	1	1	1	1	1
Strigidae:						
Otus watsonii	Tawny-bellied Screech-Owl	1	1	1	1	1
O. choliba	Tropical Screech-Owl	1	1	1	1	
Lophostrix crsitata	Crested Owl	1	1	1	1	1
Pulsatrix perspicillata	Spectacled Owl	1	1	1	1	1
P. melanota ?	Band-bellied Owl ?			1	1	
Glaucidium hardeyi	Amazonian Pygmy-Owl	1	1	1	1	1
G. brasilianum	Ferruginous Pygmy-Owl	1	1	1	1	1
Ciccaba virgata	Mottled Owl	1	1	1	1	1
C. huhula	Black-banded Owl		1			
Bubo virginianus	Great Horned Owl					1
Nyctibiidae:						
Nyctibius grandis	Great Potoo	1	1	1	1	1
N. griseus	Common Potoo	1	1	1	1	1
N. aethereus	Long-tailed Potoo	1	1		1	1
Caprimulgidae:						
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
Lurocalis semitorquatus	Semi-collard Nighthawk	1	1	1	1	
Chordeilis rupuestris	Sand-coloured Nighthawk			1	1	1
Nyctidromus albicollis	Pauraque	1	1	1	1	1

Nyctiphrynus ocellatus	Ocellated Poorwill	1	1	1	1	1
Hydropsalis climacocerca	Ladder-tailed Nightjar	1	1	1	1	1
Caprimulgus parvulus	Little Nightjar					1
Apodidae:						
Streptoprone zonaris	White-collard Swift	1	1		1	1
Chaetura brachyura	Short-tailed Swift	1		1	1	1
C. cinereiventris	Grey-rumped Swift			1		
Panyptila cayennensis	Lesser Swallow-tailed Swift			1		
Reinarda squamata	Fork-tailed Palm-Swift	1	1	1	1	1
Trochilidae:						
Glaucis hirsuta	Rufous-breasted Hermit	1	1	1	1	1
Threnetes leucurus	Pale-tailed Barbthroat	1	1	1	1	1
Phaethornis hispidus	White-bearded Hermit	1	1	1	1	1
P. ruber	Reddish Hermit	1	1	1	1	1
P. philipii	Needle-billed Hermit		1	1	1	1
Campylopterus largipennis	Grey-breasted Sabrewing				1	1
Florisuga mellivora	White-necked Jacobin	1	1	1	1	1
Anthracocthorax nigricollis	Black-throated Mango	1	1	1	1	1
Lophornis chalybea	Festive Coquette		1	1	1	
Thalurania furcata	Fork-tailed Woodnymph	1	1	1	1	1
Hylocharis cyanus	White-chinned Sapphire	1		1	1	
Heliomaster longirostris	Long-billed Starthroat		1		1	
Trogonidae:						
Pharomachrus pavoninus	Pavonine Quetzal		1		1	1
Trogon melanurus	Black-tailed Trogon	1	1	1	1	1
T. viridis	White-tailed Trogon	1	1	1	1	
T. collaris	Collard Trogon	1	1	1	1	1
T. curucui	Blue-crowned Trogon	1	1	1	1	1
T. violaceus	Violaceous Trogon	1	1	1	1	1
Alcedinidae:						
Ceryle torquata	Ringed Kingfisher	1	1	1	1	1
Chloroceryle amazona	Amazonian Kingfisher			1	1	1
C. inda	Green and Rufous Kingfisher			1	1	1
C. aenea	Pygmy Kingfisher	1		1	1	1
C. americana	Green Kingfisher		1	1	1	
Motmotidae:						
Electron platyrhynchum	Broad-billed Motmot	1	1	1	1	1
Barypthengus ruficapillus	Rufous Motmot	1	1	1	1	1
Momouts motmuta	Blue-crowned Motmot	1	1	1	1	1
Galbulidae:						
Galbalcyrhynchus purusianus	Purus Jacamar			1		
Galbula cyanescens	Bluish-fronted Jacamar	1	1	1	1	1
G. dea	Paradise Jacamar			1		1
Jacamerops aurea	Great Jacamar		1	1	1	1
Brachygalba albogularis	White-throated Jacamar		1			1
Bucconidae:						
Notharchus macrorhynchos	White-necked Puffbird			1		
Bucco macrodactylus	Chestnut-capped Puffbird	1	1	1	1	1
Nystalis striolatus	Striolated Puffbird	1	1	1	1	1
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
Malacoptila semicincta	Semicollared Puffbird	1	1	1	1	
Nonnula ruficapilla	Rufous-capped Nunlet				1	1
Monasa nigrifrons	Black-fronted Nunbird	1	1	1	1	1
M. morphoeus	White-fronted Nunbird	1	1	1	1	1

M. flavirostris	Yellow-billed Nunbird				1	1
Chelidoptera tenebrosa	Swallow-winged Puffbird	1	1	1	1	1
Capitonidae:						
Capito niger	Black-spotted Barbet	1	1	1	1	1
Eubucco richardsoni	Lemon-throated Barbet	1	1	1	1	1
E. tucinkae	Scarlet-hooded Barbet			1	1	1
Ramphastidae:						
Aulacorhynchus prasinus	Emerald Toucanet					1
Pteroglossus castanotis	Chestnut-eared Aracari	1	1	1	1	1
P. inscriptus	Lettered Aracari		1	1		
P. azara	Ivory-billed Aracari	1	1	1	1	1
P. beauharnaesii	Curl-crested Aracari		1	1	1	1
Selendera reinwardtii	Golden collared Toucanet		1	1	1	1
Ramphastos vitellinus	Channel-billed Toucan	1	1	1	1	1
R. tucanus	White-throated Toucan	1	1	1	1	1
Picidae:						
Piculus leucolaemus	White-throated Woodpecker			1		
P. rufiventris	Rufous-breasted Piculet					1
Picumnus aurifrons	Bar-breasted Piculet				1	
P. chrysochlorus	Golden-green Woodpecker	1	1	1	1	1
Chrysochptilus puntigula	Spot-breasted Woodpecker				1	
Celeus elegans	Chestnut Woodpecker	1		1		
C. grammicus	Scale-breasted Woodpecker	1	1	1	1	1
C. flavus	Cream-coloured Woodpecker	1	1	1	1	1
C. torquatus	Ringed Woodpecker	1	1	1	1	1
C. spectabilis	Rufous-headed Woodpecker		1		1	1
Dryocopus lineatus	Linneated Woodpecker	1	1	1	1	1
Melanerpes cruentatus	Yellow-tufted Woodpecker	1	1	1	1	1
Veniliornis passerinus	Little Woodpecker	1				
V. affinis	Red-stained Woodpecker	1		1	1	1
Campephilus melanoleucas	Crimson-crested Woodpecker		1	1	1	1
C. rubricollis	Red-necked Woodpecker	1	1	1	1	1
Dendrocolaptidae:						
Dendrocincla fuliginosa	Plain-brown Woodcreeper	1	1	1	1	1
D. merula	White-chinned Woodcreeper	1	1	1	1	1
Deconychura longicauda	Long-tailed Woodcreeper	1	1	1	1	1
Sittasomus griseicapillus	Olivaceous Woodcreeper	1	1	1	1	1
Glyphorhynchus spirurus	Wedge-billed Woodcreeper	1	1	1	1	1
Nascia longirostris	Long-billed Woodcreeper	1	1	1	1	1
Dendrexetastes rufigula	Cinnamon-throated Woodcreeper	1	1	1	1	1
Hylexetatstes stresemanni	Bar-bellied Woodcreeper			1		
Xiphocolaptes promeropirhynchus	Strong-billed Woodcreeper	1	1	1	1	1
Dendrolaptes certhia	Barred Woodcreeper	1	1	1	1	1
D. picumnus	Black-banded Woodcreeper	1	1	1	1	1
Xiphorhyncus picus	Straight-billed Woodcreeper	1	1	1	1	1
X. obsoletus	Striped Woodcreeper			1		
X. spixii	Spix's Woodcreeper	1	1	1	1	1
X. ocellatus	Ocellated Woodcreeper	1	1	1	1	1
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
X. guttatus	Buff-throated Woodcreeper	1	1	1	1	1
Lepidocolaptes albolineatus	Linneated Woodcreeper	1	1	1	1	1
Campylorhamphus trochilirostris	Red-billed Scythebill		1	1	1	1
Furnariidae:						
Furnarius leucopus	Pale-legged Hornero			1		1

Synallaxis gujanensis	Plain-crowned Spinetail	1	1	1	1	
S. rutilans	Ruddy Spinetail	1	1	1	1	1
Cranioleuca gutturata	Speckled Spinetail		1			
Berlepshia rikeri	Point-tailed Palmcreeper				1	
Thripophaga fusiceps	Plain Softtail	1	1	1		1
Berlepshia rikeri	Point-tailed Palmcreeper			1		
Hyloctistes subulatus	Striped Woodhaunter		1	1	1	1
Ancistrops strigilatus	Chestnut-winged Hookbill	1	1	1	1	1
Metopothrix aurantiacus	Orange-fronted Plushcrown	1				
Simoxenops ucayalae	Peruvian Recurvebill				1	1
Philydor erythrocercus	Rufous-rumped Foliage Gleaner	1	1	1	1	1
P. pyrrhodes	Cinnamon-rumped Foliage Gleaner	1	1	1	1	1
P. rufus	Buff-fronted Foliage Gleaner			1		
P. erthropterus	Chestnut-winged Foliage Gleaner	1		1	1	1
Anabazenops dorsalis	Dusky-cheeked Foliage Gleaner				1	1
Automolus infuscatus	Olive-backed Foliage Gleaner	1	1		1	1
A.ochrolaemus	Buff-throated Foliage Gleaner	1	1		1	1
A.rufipileatus	Chestnut-crowned Foliage Gleaner	1	1	1	1	1
A.rubigonosus	Ruddy Foliage Gleaner			1		
A.melanopezus	Brown-rumped Foliage Gleaner		1		1	1
A.rubigonosus	Ruddy Foliage Gleaner				1	
Xenops milleri	Rufous-tailed Xenops	1		1		
X. tenuirostris	Slender-billed Xenops			1		
X. minutus	Plain Xenops	1	1	1	1	1
Sclerurus caudacutus	Black-tailed Leaftosser	1	1	1	1	1
Thamnophiliidae:						
Cymbilaimus lineatus	Fasciated Antshrike	1	1	1	1	1
C. sanctaemariae	Bamboo Antshrike	1	1	1	1	1
Frederickena unduligera	Undulated Antshrike			1		1
Taraba major	Great Antshrike	1	1	1	1	1
Thamnophilus doliatus	Barred Antshrike	1	1	1	1	
T. aethiops	White-shouldered Antshrike		1		1	1
T. schistaceus	Plain-winged Antshrike	1	1	1	1	1
T. amazonicus	Amazonian Antshrike			1		
Pygiptila stellaris	Spot-winged Antshrike	1	1	1	1	1
Thamnomanes ardesiacus	Dusky-throated Antshrike	1	1	1	1	1
T. schistogynus	Bluish-slate Antshrike	1	1	1	1	1
Myrmotherula brachyura	Pygmy Antwren	1	1	1	1	1
M. sclateri	Sclater's Antwren		1	1	1	1
M. surinamensis	Streaked Antwren		1	1	1	1
M. hauxwelli	Plain-throated Antwren	1	1	1	1	1
M. leucophthalmus	White-eyed Antwren	1	1	1	1	1
M. ornata	Ornate Antwren	1	1	1	1	1
M. longipennis	Long-winged Antwren	1	1	1	1	1
M. iheringi	Iherng's Antwren		1	1	1	1
M. menestriesii	Grey Antwren	1	1	1	1	1
M. haematonata	Stipple-throated Antwren	1		1		1
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
Dichrozona cincta	Banded Antbird	1	1	1	1	1
Terenura humeralis	Chestnut-shouldered Antwren			1	1	1
Microrhopias quixensis	Dot-winged Antwren			1	1	1
Drymophila devillei	Striated Antbird		1		1	1
Cecromacra cinerascens	Grey Antbird	1	1	1	1	1
C. nigriscens	Blackish Antbird					1

C. serva	Black Antbird		1			1
C. manu	Manu Antbird				1	1
Myrmoborus leucophrys	White-browed Antbird	1	1	1	1	1
M. myotherinus	Black-faced Antbird	1	1	1	1	1
Hypocnemis cantator	Warbling Antbird	1	1	1	1	1
Hypocnemoides maculicauda	Band-tailed Antbird	1	1	1	1	1
Percnostola lophotes	White-lined Antbird		1	1	1	1
Hylophylax puntulata	Dot-backed Antbird			1		
H. poecilonota	Scale-backed Antbird		1	1		
H. naevia	Spot-backed Antbird		1	1		1
Schistocichla leucostigma	Spot-winged Antbird	1				1
Myrmeciza hemimelaena	Chestnut-tailed Antbird	1	1	1	1	1
M. hyperythra	Plumbeous Antbid	1	1	1	1	1
M. goeldi	Goeldi’s Antbird	1	1	1	1	1
M. atrothorax	Black-throated Antbird	1		1	1	1
Gymnopithys salvini	White-throated Antbird	1	1	1	1	1
Phlegopsis nigromaculata	Black-spotted Bare-eye	1	1	1	1	1
Formicariidae:						
Chamaeza nobilis	Noble Antthrush	1			1	1
Formicarius colma	Rufous-capped Antthrush	1	1		1	1
F. analis	Black-faced Antthrush	1	1	1	1	1
F. rufifrons	Rufous-fronted Antthrush	1		1		1
Myrmothera campanisoma	Thrush-like Antpitta	1	1		1	1
Hylopezus berlepschi	Amazonian Antpitta			1	1	1
Conopophaga peruviana	Ash-throated Gnateater	1	1	1	1	1
Cotingidae:						
Iodopleura isabellae	White-browed Purpletuft			1		
Lipaugus vociferans	Screaming Piha	1	1	1	1	1
Porphyrolaema porphyrolaema	Purple-throated Cotinga			1		
Cotinga maynana	Plum-throated Cotinga			1		
C. cayana	Spangled Cotinga		1	1		
Gymnoderus foetidus	Bare-necked Fruitcrow		1	1	1	
Querula purpurata	Purple-throated Fruitcrow	1	1	1	1	1
Conioptilon mcilhennyi	Black-faced Cotinga	1		1		
Pipridae:						
Schiffornis major	Varzea Mourner		1	1	1	
S. turdinus	Thrush-like Mourner		1	1	1	
Piprites chloris	Winged-barred Piprites	1	1	1	1	1
Tyranneutes stolzmanni	Dwarf-tyrant Manakin		1		1	1
Pipra coronata	Blue-crowned Manakin		1			1
P. fasiicauda	Band-tailed Manakin	1	1	1	1	1
P. chloromera	Round-tailed Manakin	1	1	1	1	1
P. rubrocapilla	Red-headed Manakin		1		1	1
Tyrannidae:						
Zimmerus gracilipes	Slender-footed Tyrannulet		1	1	1	1
Ornithion inerme	White-lored Tyrannulet	1	1	1	1	1
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
Campostoma obsoletum	Southern Beardless Tyrannulet	1		1	1	
Phaeomyias aurina	Mouse-coloured Tyrannulet			1	1	
Sublegatus obscurior	Amazonian Scrub Flycatcher				1	
Tyrannulus elatus	Yellow-crowned Flycatcher	1	1	1	1	1
Myiopagis gaimardii	Forest Elaenia	1	1	1	1	1
M. caniceps	Grey Elaenia	1				
Elaenia gigas	Mottled-backed Elaenia					1

Mionectes olivaceus	Olive-striped Flycatcher				1	1
M. oleaginea	Ochre-bellied Flycatcher	1	1	1	1	1
M. macconelli	McConnel's Flycatcher		1		1	1
Leptopogon amaurocephalus	Sepia-capped Flycatcher		1		1	1
Corythopsis torquata	Ringed Antpipit	1	1	1	1	1
Myiornis ecaudatus	Short-tailed Pygmy-Tyrant	1	1	1	1	1
Poecilotriccus albifacies	White-cheeked Tody-Tyrant				1	1
Hemitriccus flammulatus	Flammulated Bamboo-Tyrant		1		1	
H. zosterops	White-eyed Tody-Tyrant	1	1	1	1	1
H. johannis	Johannes' Tody-Tyrant			1	1	
H. striaticollis	Stripe-necked Tody-Tyrant			1		
Todirostrum latirostre	Rusty-fronted Tody-Tyrant				1	
T. maculatum	Spotted Tody-Flycatcher			1	1	1
T. chrystocrophatum	Common Tody-Flycatcher	1	1	1	1	
Ramphotrigon megacephala	Large-headed Flatbill		1		1	1
R. fuscicauda	Dusky-tailed Flatbill				1	1
R. ruficauda	Rufous-tailed Flatbill		1		1	1
Rynchoyclus olivaceus	Olivaceous Flatbill		1			1
Tolmomyias assimilis	Yellow-margined Flycatcher		1	1		
T. poliocephalus	Grey-crowned Flycatcher			1	1	1
T. flaviventris	Yellow-breasted Flycatcher			1	1	1
Platyrinchus coronatus	Golden-crowned Spadebill	1	1	1	1	1
P. platyrhynchos	White-crested Spadebill	1	1	1		1
Onychorhynchus coronatus	Royal Flycatcher	1	1			1
Terenotriccus erythrurus	Ruddy-tailed Flycatcher	1	1	1	1	1
Contopus virens	Eastern Wood-Pewee				1	1
Myiophobus fasciatus	Bran-coloured Flycatcher	1		1	1	
Lathiotriccus euleri	Euler's Flycatcher	1		1	1	1
Pyrocephalus rubinus	Vermillion Flycatcher	1		1	1	
Octhoeca littoralis	Drab Water Tyrant	1	1	1	1	
Muscisaxicola fluviatilis	Little Ground-Tyrant			1		
Xolmis cinerea	Grey Monjita			1		
Attila bolivianus	White-eyed Attila	1	1	1	1	1
A.spadiceus	Bright-rumped Attila	1	1	1	1	1
Rhytipterna simplex	Greyish Mourner	1	1	1	1	1
Laniocerca hypopyrra	Cinereous Mourner	1	1	1	1	1
Sirystes silbilator	Sirystes	1	1	1	1	1
Myiarchus swainsonii	Swainson's Flycatcher	1		1		
M. ferox	Short crested Flycatcher	1		1		
Megarhynchus pitangua	Boat-billed Flycatcher					1
M. tuberculifer	Dusky-capped Flycatcher	1		1	1	
Pitangus lictor	Lesser Kiskadee			1	1	
P. sulphuratus	Greater Kiskadee			1	1	
Megarhynchus pitangua	Boat-billed Flycatcher	1		1	1	
Myiozetetes similis	Social Flycatcher	1	1	1	1	1
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
M. granadensis	Grey-capped Flycatcher	1				
M. luteiventris	Dusky-chested Flycatcher		1		1	
Myiodynastes maculatus	Streaked Flycatcher		1	1	1	
M. luteiventris	Sulphur-bellied Flycatcher		1		1	
Empidonomus varius	Variegated Flycatcher			1		
Legatus leucophaius	Piratic Flycatcher	1	1	1	1	1
Tyrannopsis sulphurea	Sulphury Flycatcher		1	1	1	1
T. melancholicus	Tropical Kingbird	1	1	1	1	1

Tyrannus savana	Fork-tailed Flycatcher	1		1	1	1
T. tyrannus	Eastern Kingbird			1	1	1
Pachyramphus castaneus	Chestnut-crowned Becard			1		
Pachyramphus polychopterus	White-winged Becard	1	1	1	1	1
P. marginatus	Black-capped Becard	1	1	1	1	1
P. minor	Pink-throated Becard	1	1	1	1	1
Tityra cayana	Black-tailed Tityra		1	1	1	1
T. semifasciata	Masked Tityra		1	1	1	1
T. inquisitor	Black-crowned Tityra		1	1	1	1
Hirundinidae:						
Tachycineta albiventer	White-winged Swallow	1	1	1	1	1
Phaeprogne tapera	Brown-chested Martin	1		1	1	1
Atticora fasciata	White-banded Swallow	1		1	1	1
Stelgidopteryx ruficollis	Southern Rough-winged Swallow	1	1	1	1	1
Troglodytidae:						
Campylorhynchus turdinus	Thrush-like Wren	1	1	1	1	1
Thryothorus leucotis	Buff-breasted Wren	1	1	1	1	1
T. genibarbis	Moustached Wren	1	1	1	1	1
Troglodytes aedon	House Wren	1	1	1	1	1
Microcerculus marginatus	Southern Nightingale Wren	1	1	1	1	1
Cyphorhinus arada	Musician Wren	1	1	1	1	1
Donacobius atricapillus	Black-capped Donacobius	1	1	1	1	
Muscicapidae:						
[Turdinae:]						
Turdus amaurochalinus	Creamy-bellied Thrush			1		
T. ignobilis	Black-billed Thrush	1	1	1	1	1
T. lawrencii	Lawrence's Thrush	1	1	1	1	1
T. hauxwelli	Hauxwell's Thrush	1	1	1	1	1
T. albicollis	White-necked Thrush		1		1	1
Catharus ustulatus	Swainson's Thrush		1		1	1
[Polioptilinae:]						
Ramphocaenus melanurus	Long-billed Gnatwren			1		
Emberizidae:						
[Emberizinae:]						
Myospiza aurifrons	Yellow-browed Sparrow	1	1	1	1	1
Sporophila bouvronides	Lesson's Seedeater	1		1		1
S. castaneiventris	Chestnut-bellied Seedeater			1		
Arremon tactiturnus	Pectoral Sparrow	1	1	1		1
Paroaria gularis	Red-capped Cardinal	1	1	1	1	
[Cardinalinae:]						
Pitylus grossus	Slate-coloured Grosbeak	1	1	1	1	1
Saltator maximus	Buff-throated Saltator	1	1	1	1	1
S. coerulescens	Greyish Saltator		1	1	1	1
Cyanocompsa cyanoides	Blue-black Grosbeak	1	1	1	1	1

Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
[Thraupinae:]						
Chlorophanes spiza	Green Honeycreeper			1		1
Dacnis cayana	Blue Dacnis	1	1	1	1	1
D. lineata	Black-faced Dacnis	1	1	1	1	1
D. flaviventer	Yellow-bellied Dacnis			1	1	
Chlorophanes spiza	Purple Honeycreeper				1	
Cyanerpes caeruleus	Green Honeycreeper				1	
Chlorophonia cyanea	Blue-naped Chlorophonia		1			
Euphonia chlorotica	Purple-throated Euphonia		1			

E. xanthogaster	Orange-bellied Euphonia	1	1	1	1	1
E. minuta	White-vented Euphonia	1		1	1	1
E. laniirostris	Thick-billed Euphonia	1		1	1	1
E. rufiventris	Rufous-bellied Euphonia	1	1	1	1	1
E. chrysopasta	White-lored Euphonia			1	1	
Thraupis episcopus	Blue-Grey Tanager	1	1	1	1	1
T. chilensis	Paradise Tanager	1	1	1	1	1
T. callphrys	Opal-crowned Tanager	1		1	1	
T. schrankii	Green and Gold Tanager	1	1	1	1	1
T. nigrocincta	Masked Tanager	1	1	1		
T. mexicana	Turquoise Tanager			1	1	
T. palmerum	Palm Tanager	1	1	1	1	1
Ramphocelus carbo	Silver-beaked Tanager	1	1	1	1	1
R. nigrogularis	Masked Crimson Tanager		1	1		1
Habia rubica	Red-crowned Ant-Tanager	1	1	1	1	1
Lanio versicolor	White-winged Shrike-Tanager	1	1	1	1	1
Tachyphonus cristatus	Flame-crested Tanager		1		1	
T. luctuosus	White-shouldered Tanager	1	1	1	1	1
Hemithraupis guira	Guira Tanager			1	1	
Eucometis pencillata	Grey-headed Tanager		1	1		
Thylopsis sordicta	Orange-headed Tanager			1		
Lamprospiza melanoleuca	Red-billed Pied Tanager			1		
Cissopis leveriana	Magpie Tanager	1	1	1	1	
Tersina viridis	Swallow Tanager		1	1		
[Parulinae:]						
Geothlypis aequinoctialis	Masked Yellowthroat			1		1
Basileuterus fulvicauda	Buff-rumped Warbler		1	1	1	1
Vireonidae:						
Vireo olivaceus	Red-eyed Vireo	1	1	1	1	1
Hylophilus thoracius	Lemon-chested Greenlet			1	1	
H. hypoxanthus	Dusky-capped Greenlet	1	1	1	1	1
H. ochraceiceps	Tawny-crowned Greenlet	1		1		
Icteridae:						
Scaphidura oryzivora	Giant Cowbird		1	1	1	1
Psaracolius oseryi	Casqued Oropendola	1	1	1	1	1
P. decumnus	Crested Oropendola	1	1	1	1	1
P. angustifrons	Russet-backed Oropendola	1	1	1	1	1
P. yuracares	Olive Oropendola	1	1	1	1	1
Cacicus cela	Yellow-rumped Cacique	1	1	1	1	1
C. haemorrhous	Red-rumped Cacique		1			
C. solitarius	Solitary Cacique	1		1	1	
Icterus cayanensis	Epaulet Oriole	1	1	1	1	1
Icterus icterus	Troupial	1		1	1	1
Scientific Name	**English Name**	**CAPH**	**EI**	**ECO**	**SACHA**	**TRC**
Corvidae:						
Cyanocorax chrysops	Purplish Jay					1
C. violaceus	Violaceous Jay	1	1	1	1	1
Total		**283**	**312**	**378**	**359**	**333**

Appendix 3: Correspondence Details

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