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Appendix 1.3: Snake Bite Prevention Protocol
Executive summary

2005 proved to be a highly productive season for the Operation Wallacea research teams. Much new evidence was gathered through the varied survey techniques to demonstrate the richness and diversity of the flora and fauna of PNC, and many new species were added to existing park records along the way. During the 2005 field season for example twelve species of herpetofauna, 31 new birds, two previously unrecorded carnivores, three unidentified rodents and five new bat species were all recorded within PNC. The invertebrate studies added many more species to existing park inventories. Among these additions are several species not previously recorded in Honduras and some that are undescribed and therefore new to science.

The Operation Wallacea social science team reiterated the findings of 2004 that there is a deeply held respect for the park amongst those living in the buffer zone villages, and whilst a great deal of confusion regarding park regulations still exists among many villagers, this situation is improving through Operation Wallacea working closely with these communities. Local people are in the main very willing to get involved with potential projects designed to provide an income for them whilst ensuring that PNC is protected from logging, land clearance, hunting and other illegal activities. Potential projects include the setting up of cooperatives, ecotourism, and the production of environmentally friendly fair-trade coffee and other sustainable agriculture.

In addition to all the positive results highlighted by the research teams however there were a number of concerns raised regarding threats posed to the park, such as the continued hunting of many of the larger mammal species for meat and trade, and significant land clearance within the park’s boundaries post-1990. Both topics need to be addressed further as the focus of the survey shifts in subsequent years to a monitoring role, and represent a priority challenge for the seasons to come.

Finally, we would like to thank all those who have offered us hospitality, help or expertise during our time spent in Honduras. We have all expanded our scientific knowledge considerably, both in terms of other aspects of biology and geography, and in terms of knowledge about a different part of the world. It has also been a great cultural experience and many people have enjoyed getting to know the people of Buenos Aires. We look forward to our return!
Operation Wallacea & University of Nottingham in Honduran forests

The University of Nottingham (www.nottingham.ac.uk) is one of the leading universities in the UK. It is research intensive and global in its outlook. Operation Wallacea (www.opwall.com) is a conservation research organisation specialising in tropical forest and coral reef science and conservation. The two organisations have joined forces in the Parque Nacional Cusuco (PNC), Honduras, in an effort to study and help protect the tropical montane rainforest of the park. In order to do this, staff with expertise in a range of scientific areas (especially biology and social science) have been contracted to lead scientific projects based in Cusuco. Most scientific staff are from universities in the UK, USA and Canada, with others from Honduras, Cuba, Austria, Ireland and elsewhere. Paying volunteers are invited to join these projects and to undertake small-scale projects of their own (usually for dissertations for university degrees). This provides the funding for the costs of the scientific work. Most of the fieldwork for the studies in the 2005 season was carried out in July and August 2005. The projects are listed in subsequent sections of this report.

The main aims of the 2005 work have been to continue the work of:

1. building an inventory of the flora and fauna of PNC (diversity and abundance);
2. studying the ecology of a range of important organisms, to achieve a better understanding of them and produce scientific dissertations and papers;
3. investigating the social and economic structure of the villages of Buenos Aires (primarily), Guadalupe and La Laguna; and the attitudes of the people in these villages to PNC, in order to inform plans for development of PNC as a conservation, fair trade and ecotourism centre.
**List of the projects undertaken in 2004, with scientists’ names**

**Forest structure and composition**
Cordula Lenkkh (University of Glamorgan, Wales)

**Herpetofaunal diversity, abundance and ecology**
Josiah Townsend (University of Florida, USA)
Dr. Larry Wilson (Miami Dade College)
T. Lynette Plenderleith
Douglas Fraser (Edinburgh University)
Brook Talley (University of Florida)
James Nifong

**Bird diversity, abundance and ecology**
Dr. Robin Brace (Nottingham University, UK)
Robin Cosgrove (Operation Wallacea, UK)
Ernesto Reyes (EIIM, Cuba)
Roberto Downing (COHDEFOR, Honduras)

**Terrestrial mammal diversity, abundance and ecology**
Dr. Rachel Freer (Operation Wallacea)
Dr. Ruth Cox (University of Liverpool, UK)
Dr. Kimberly Williams-Guillén (New York University, USA)
Sharon Hodge (Edinburgh University, UK)
Mandy Apps (University of Wales, Bangor)

**Bat diversity and abundance**
Tamir Caras (Inter University Institute)
Ruari Allan (Aberdeen University, UK)
Gerald Carter (University of Western Ontario, Canada)

**Primate behaviour**
Kymberley Anne Snarr (University of Toronto, Canada)
Kate Edwards (University of Liverpool, UK)

**Invertebrate diversity, abundance and ecology**
Jose Nunez-Mino (Oxford University, UK)
Dr. Jacqualine Grant (Colorado State University, USA)
Robin LeCraw (University of Guelph, Canada)
Andrew Smith (Oxford University, UK)
Greg Chamberlain (Glamorgan University, UK)

**The social and economic structure of the village communities in Cusuco’s buffer zone**
Dr. Richard Phillips (University of Liverpool)
List of papers, reports and dissertations to be written from this work, with proposed dates of submission

Bat diversity, activity and ecology

Bird diversity, abundance and ecology
- Kershaw, F. The co-evolution of hummingbird bill morphology and floral structures with regard to both native and non-native species. BSc Dissertation, University of Leeds, UK. Submission date July 2006.
- Collis, M. The co-evolution of hummingbird bill morphology and floral structures with regard to both native and non-native species. BSc Dissertation, Keele University, UK. Submission date July 2006.

Herpetofaunal diversity, abundance and ecology
- Woodhead, C. A comparison of the variation in herpetofaunal diversity and abundance in different microhabitats of the Paraíso valley. BSc Dissertation, University of, UK. Submission date July 2006.

Invertebrate diversity, abundance and ecology
- Simcock, J.C. Do edge effects exist in bromeliad fauna at natural and anthropogenic boundaries of cloud montane forest in Cusuco National Park, and if so are they significantly different in nature? BSc Dissertation, University of Nottingham. Submission date July 2006.
Terrestrial mammal diversity, abundance and ecology


The social and economic structure of the village communities in Cusuco’s buffer zone

- Murray, A. Agriculture within the villages surrounding Cusuco National Park. BSc Dissertation, Queens University, Belfast. Submission date July 2006.
**Summary of findings prior to 2005 season**

Operation Wallacea led a pilot expedition to PNC in 2003, during which some data were collected. This was followed in 2004 by the first full Operation Wallacea/University of Nottingham scientific expedition to the area. In 2003-4 we found that PNC is biologically very rich, with far greater diversity of all organisms studied than was known from previously existing records. In addition to numerous new records for PNC, we discovered many species new to Honduras and some new to science. Among the species in the park’s inventory are many cloud forest specialists and other species that are of considerable conservation importance in the global context (e.g. Baird’s tapir, resplendent quetzal, highland guan). The 2004 work was only very preliminary in terms of understanding the ecology of the organisms living in PNC. However, we found the primary forest of the core zone to be approximately as rich as the forests of the buffer zone for a range of organisms, despite its higher altitude. More importantly, there was typically little overlap in species composition between the primary forest and the secondary forest/plantations in the buffer zone. The species in the core zone of the park tend to be cloud forest specialists and other globally important species, while a higher proportion of buffer zone species tends to be common and relatively wide-ranging species. However, there are valuable species in the buffer zone and it is recommended that considerable attention be paid to conserving this area as well as the core zone. Of the non-forest land uses in PNC, our findings suggested that shade-grown coffee plantations support the most diverse and valuable set of species – much more so than other types of plantation and agriculture.

Our social-scientific research in 2004 suggested that the people living in Buenos Aires and surrounding buffer-zone villages, while being poor, have developed a healthy respect for the forest of PNC. The role of DIMA, COHDEFOR and other organisations in providing education programmes for the people seemed to be largely responsible for this. The people are very willing to get involved with potential projects designed to provide an income for them whilst ensuring that PNC is protected from logging, land clearance, hunting and other illegal activities. Such projects are likely to be focused on ecotourism and on the production of environmentally friendly fair-trade coffee.

The scientists and volunteers taking part in the scientific programme in 2004 benefited greatly from the experience of coming to PNC. Scientifically, it was both fascinating and valuable. We accumulated data that confirmed our initial impression that Cusuco is an area of high conservation value.

**The 2005 field season**

The rest of this report details the findings and preliminary conclusions from the 2005 field season (late June to early September 2005), as of 23rd August 2005. The main focus of the work during this period has been to continue to build baseline data for PNC and for the Paraiso valley. Most of the projects were designed to sample a wide range of species and, to a lesser extent, to gain population density and habitat data. Social science work continued the previous year’s aim of building understanding of the social and economic conditions and opportunities of a selection of buffer-zone villages, and of the attitudes to the national park and awareness of its regulations.

The following (main) section of this report consists of the individual reports from scientists and university dissertation students about the various projects run in 2005. In terms of the main focus of increasing our baseline knowledge of PNC and the Paraiso valley, it is notable that the species lists continue to grow rapidly in all taxonomic groups sampled. In particular, the accumulation of known herpetofauna in the park shows no sign of slowing, with more species added to the park list in 2005 than was the case in 2004 – despite the fact that this taxonomic group was the best studied and best known of all the park’s fauna and flora before the Operation Wallacea/University of Nottingham work started. In addition, the number of definitely and potentially undescribed species (new to science) found in 2005 is greater than was the case in 2004, and includes a lot of vertebrate species. On the social science side, despite the rapid clearance of forest our findings about the attitudes of the people living in the southern part of the buffer zone are encouraging. The forest seems to be respected at a number of levels (possibly including a religious level, though this should be the focus of further study). However, knowledge of the park’s extent and regulations is extremely limited and this probably explains the scale of the clearance of and damage to the forest.
Threat of deforestation in the North-West of Cusuco National Park, Honduras

Cordula A. M. Lennkh, University of Glamorgan, Wales, August 2005

Abstract
Deforestation in the northwestern part of the Cusuco National Park threatens a so far unstudied part of the Park. An analysis of remote sensed data shows an increase of deforested areas. Operation Wallacea scientists witnessed ongoing logging within the core zone in a recent visit.

Introduction
Tropical deforestation poses a major global threat to ecological sustainability and socio-economic development. High rates of population growth and poverty in Honduras have accelerated deforestation due to forest clearance for crop cultivation and urban expansion, resulting in extensive areas of National Parks being converted to agricultural use. This GIS based study analyses the level of deforestation in the Cusuco National Park, located in the North of Honduras close to the border to Guatemala.

Figure 1 Major settlements in the buffer zone of Cusuco National Park (Landsat, 2000)

There are a number of existing settlements (Figure 1) in the buffer zone of the National Park, causing threat of illegal logging within the Parks’ core zone.

Land Use change 1990-2000
The change of land cover over the decade 1990-2000 was assessed by comparing the 1990 image (false colour bands, 7,4,2) with a false colour composite image created from the 2000 data (Landsat bands 7,4,2). The assessment detected deforestation in a section of the North-Eastern part of the core zone of Cusuco National Park (Figure 2).

The 1990 image shows some cleared areas with a sparse spread of settlements. Comparing the two images, 2000 shows distinctly more settlements, cleared land and non-forest vegetation (plantations and agricultural land), represented in red colour in the image. As population is increasing, it would be expected that deforestation will expand in areas with existing settlements, putting more pressure to the primary forest in the core zone of the National Park.

Changes in reflection were detected by subtracting the two Landsat images from each other, helping to make assumptions about changes in land use (Figure 3). The different changes were divided into five different reflectance classes.
Figure 2 Comparison of land use in the North-East of Cusuco National Pak using Landsat imagery (Jenkins, 2004)

Figure 3 Highlighted changes, Landsat image – 1990-2000 (Jenkins, 2004)
The image subtraction showed an increase of reflectance for the core zone of the Cusuco National Park. The East and Northwest of the National Park, the heavily cultivated areas, showed a decrease in reflectance. However, it is difficult to discern whether this is due to changes in land cover or simply because the images are from different Landsat sensors (the 1990 data was collected by the Landsat 5 TM sensor and the 2000 by the Landsat 7, ETM+ sensor).

Extents of deforestation
An analysis of IKONOS data acquired on 18th November 2003 showed the extent of deforestation in the Northwest and East of the Cusuco National Park (Figure 4).

Figure 4 IKONOS true colour and near infrared image with vector polygons of major features

The deforestation of the North-western part reaches deep into the Parks’ core zone, with several cleared areas in the vicinity (Figure 7). A recent visit to the area showed that logging is still continuing. For more details more recent IKONOS data needs to be acquired in order to see the extent of ongoing logging in the past years.

Recent deforestation
The area of Aqua Manca (UTM 364817/1716588) was visited in the time 09th to 16th August 2005 by a team of Operation Wallacea Honduras scientists. The group witnessed ongoing logging of large areas in the middle of the core zone stated by the management plan of 1995 (Fundacion Ecologista Hector Rodrigo Pastor Fasquelle, 1995). Large areas are cleared of and converted into grazing areas (Figure 5).
Forest quadrats (20x20) metres were carried out in the vicinity of Aqua Manca Opwall camp (UTM 364817/1716588) to assess the level of disturbance as well as the difference in structure of disturbed forests/areas and primary broad leaf forest (Figure 6). The quadrats were done in six areas of different level of disturbance (Table 1).

Table 1 Forest quadrats in areas of different levels of disturbance.

<table>
<thead>
<tr>
<th>Quadrat</th>
<th>Description</th>
<th>UTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-14</td>
<td>Understorey and part of the trees cleared for cattle grazing, not in use for 2-3 years.</td>
<td>364876</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1716605</td>
</tr>
<tr>
<td>2005-15</td>
<td>Understorey and part of the trees cleared out for cattle grazing about 10 years ago</td>
<td>365468</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1717199</td>
</tr>
<tr>
<td>2005-16</td>
<td>Revegataion of cleared area, main tree species Cecropia peltata</td>
<td></td>
</tr>
<tr>
<td>2005-17</td>
<td>Primary broad leaf forest. No evidence of human disturbance</td>
<td>364483</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1716576</td>
</tr>
<tr>
<td>2005-18</td>
<td>Primary broad leaf forest. Mature Guano palms cleared for food</td>
<td>364396</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1716543</td>
</tr>
<tr>
<td>2005-19</td>
<td>Primary broad leaf forest. No evidence of human disturbance.</td>
<td>364358</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1716398</td>
</tr>
</tbody>
</table>

The pictures of the understorey show very dense vegetation for the disturbed areas (Figure 6).
Figure 6 Understorey in forests with different levels of disturbance

Fast areas were logged in the area of Aqua Manca (UTM 364817/1716588) in direction of the local village Nueva Esperanza (UTM 366553/1719080). Additional to illegal logging for cattle grazing, inhabitants of the settlements use other forest products on a regular base. Oocote (*Pinus oocarpa*) is collected for firewood and in several areas (e.g. Quadrat 2005-18) mature Guano palms for food.

Figure 7 Picture of deforestation in the area between Aqua Manca and Nuevo Esperanza
Conclusion
The Western part of the core zone of the Cusuco National Park is relatively unknown. No scientific study has been carried out in this part of the park. Immediate action needs to be taken to prevent further clearing and loss of habitat. The visit in August 2005 showed that the western part of the Park contains a very different forest habitats which are not found in the Eastern part of the core zone.

Bibliography

Preliminary reports from the individual projects, 2005

Forest structure within Cusuco National Park, Honduras
Cordula Lennkh, University of Glamorgan U.K., end of season report October 2005

Introduction
The field work in forest structure is part of a PhD at the University of Glamorgan on “Spatial and temporal changes in rain forest structure and composition in Honduras, Central America”. This project is investigating the relationships between forest structures (physiogamy and species associations) and remotely sensed data for the development of a remote survey system that can be used in the management of the Cusuco National Park in Honduras.

Methodology

Ground truthing
The measurement of rainforest structure at different locations for comparison with remotely sensed data: It is not possible to sample rainforest at random locations so a transect method was adopted along which random plots were selected for study. Quadrats 400m² were taken every 1000m along trails across the National Park. Trails, (existing and new) passed over hills and valleys through forests of differing species composition and structure. Each quadrat was selected to the right of the transect line approximately 20 metres into the forest.

At each site Global Position System (GPS) coordinates, a description of the location, angle and direction of the slope, Forest Type, number of forest layers, percentage of pines, gap area and the number and local names of trees were recorded. The physiognomic measurements included: diameter at breast height (DBH), height of first major living branch and total height of tree. The percentage cover of non-woody herbs, low-woody shrubs, saplings of understory, bare soil and exposed rock were estimated.

Forest classification and remote sensing
The data collected in the 2004 and 2005 field season will be used to classify different forest types within the Cusuco National Park. The classification information will be used supervised classification of Landsat, IKONOS, Aster and Modis data with ERDAS IMAGINE 8.6.

Results
The Forest structure work was finished in the East Side of Cusuco National Park during this year’s field season.
A total of 19 forest quadrats (400m²) were recorded during the season along two trails. The transect lines were used to cover large areas of the East Side of the Cusuco National Park. Additional quadrats were taken in the Area of Aqua Manca to identify different stages of forest succession after clearing.

Transect-line 1 (T1): Base Camp (UTM 370102/1713673) to Camp Cantiles (UTM) with a total length of 6 km.
Transect-line 2 (T2): Base Camp (UTM 370102/1713673) going eastwards up to a big landslide (UTM 369498/1716560) via Camp Laenes (UTM) with a total length of 3km. Forest structure classification

Three forest types were identified according to data gathered in the 2004 and, with information from semi-structured interviews with guides and rangers, a preliminary map of the distribution of the three forest types was made (Figure 1).
Data gathered in the 2004 field season (June-September 2004) was used for a preliminary classification of the three forest types using supervised classification in ERDAS IMAGINE 8.6 (Figure 2).

Botanical identification

Initial classification of Honduran forests according to species composition proved difficult as local names varied and scientific names were not available. This is an aspect that is being pursued so that local and scientific names can be matched.

Samples of the most common tree species were collected. A database of digital photos to help identification was compiled. For each tree species photos of colour of timber, bark and trunk, branch, leaf and leaf arrangement, top and bottom of the leaf, fruits and flowers were taken (Figure 3).
Project stage and future research
The first phase of the project, the development of a set of measures of tropical forest structures that identify different forests within the National Park is finished. Extensive ground truthing has been carried out in the 2004 and 2005 field seasons in the East Side of the Cusuco National Park.

The second phase of the project aims to develop an analysis of remote sensed information in connection with the data collected during ground truthing. Supervised classification using ERDAS IMAGINE 8.6 will be carried out on a set of satellite images (IKONOS, Landsat, Aster, and MODIS) with input information from structures classified on physiognomy and species associations.

To date there is no published classification scheme based on physiogamy has been located. Initial statistical analysis (using SPSS and physiognomic measurements from 2004) were not sufficient to pick out significant differences in physiogamy. Further work needs to be done to develop a system of classification of forest structures according to physiogamy including aspects of canopy composition and more powerful multivariate statistics.

A continuous problem is the lack of tree identification, which needs to be addressed urgently in the coming field season. Continuing the work carried out by Dr. Daniel Kelly, Trinity College Dublin in 2004. It is highly recommended to have a separate Forest Botany team working in the Cusuco National Park to address this problem.

Finally predictions of forest types from satellite data will be compared with actual vegetation on the ground and the system refined.
Herpetofaunal diversity, abundance and ecology

1. Herpetofaunal research summary: Parque Nacional El Cusuco

Report by senior herpetologist, Dr Larry D. Wilson, and assistant herpetologist, Ms. Brooke L. Talley, on the work of the herpetology team to 18th August 2005

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Ms B.L. Talley, Department of Environmental Engineering Sciences, Howard T. Odum Center for Wetlands, University of Florida, Gainesville, Florida 32611, USA

Figure 1. Brooke L. Talley, assistant herpetologist, and Dr. Larry D. Wilson, senior herpetologist, authors of this report, in an informal moment in front of the botanic garden at Base Camp (Centro de Visitantes) in Parque Nacional Cusuco (photo taken 7 August 2005).

Rationale
The rationales for the herpetological research work during the 2005 field season are as follows:


- To assess the effectiveness of the use of leaf litterbags as attractants for tropical stream anuran larvae, already demonstrated to be of use with larvae of Eurycea bislineata and Pseudotriton ruber in the southeastern United States (Talley, 2005)

- To determine the extent of malformations of the mouthparts of the larvae of the stream-breeding anurans known to occur in Cusuco National Park (McCranie and Wilson, 2002; Wilson and McCranie, 2004a and b).

- To gather information for use in writing a bilingual field guide to the amphibians and reptiles of Cusuco National Park, intended to increase awareness among visitors to the park, OpWall participants, and English and Spanish-speaking people in general of the conservation significance of these organisms.

- To provide information for the grant proposal to the World Bank for support of conservation initiatives to secure a sustainable future for Cusuco National Park.
Methods
The methods we used in our herpetological work were: (1) opportunistic collecting, in connection with
the general survey of the herpetofauna; (2) drift fence arrays or traplines, also used to conduct a
general survey of the herpetofauna; and (3) leaf litterbags, used for the study of their effectiveness as
attractants for tropical anuran larvae. Our collection, data recording, and specimen preservation
protocols are included in this report as Appendix 1.1

We employed opportunistic collecting, the classic herpetological technique, which consists of scrounging
the forest for whatever can be found. This technique involves turning over and breaking up logs (and
returning them to as close to their original condition as possible to minimize the damage done to the
creatures’ habitat), raking leaf litter, searching through the vegetation, turning over rocks, and
searching along the watercourses, especially for anuran adults and their larvae.

The drift fence arrays or traplines were constructed of plastic buckets buried in the ground flush with
the top. These buckets were connected by a fence constructed of aluminum window screening
supported by pieces of tree branches to keep it upright. The bottom of the screening was buried in the
ground. Three such traplines were positioned along the beginning of the Las Minas trail, one at 1560 m,
another at 1570 m, and a third at 1580 m. Two were set up along the El Danto trail, one at 1555 m and
the other at 1585 m. These five traplines were checked daily and their contents removed.

The third and final technique we employed involved the placement of so-called leaf litterbags in side
pools in the Rio Cusuco, in order to determine their effectiveness in attracting anuran larvae so as to
assess species composition, population numbers, and degree of damage to their mouthparts by
environmental agents, the latter having been demonstrated to occur within the park in earlier years
(Wilson and McCranie, 2004a). This technique has proven useful in assessing populations of
plethodontid salamander larvae found in first-order streams of southern Georgia, USA (Talley, 2005).
Five transects of six litterbag sites were established along the river. The usual procedure was to survey
three transects during one day and the other two on the subsequent day. Then two days were skipped
and the procedure repeated.

Results
The work of the herpetology team operating within the nuclear zone of Cusuco National Park (at base
camp, Guanales camp, and Cantiles camp) was very successful. A total of 42 species of the 52 known
from the park was observed during the current field season. For the full accounting of the species of
Cusuco herpetofauna now known by camp, see Table 1. Based on the data in this table, it is evident
that 37 species are now recorded for the base camp area, 20 for the Guanales camp, 13 for the La
Fortuna camp, four for the Cantiles camp, and seven for the Buenos Aires area. Thus, only ten species
(19.2%) escaped the notice of the team, including one species thought extinct (Eleutherodactylus milesi;
Wilson and McCranie, 2004a) and another thought to be extirpated from the park (Rana maculata). The
other eight are Bufo valliceps, Sceloporus variabilis, Sphenomorphus cherriei, Drymarchon melanurus,
Ninia espinali, Omoadiphas aurula, Scaphiodontophis annulatus, and Stenorrhina degenhardtii. Four
of these nine species were collected during the 2004 field season.

A collection of 95 voucher specimens was made, under collecting permits issued by COHDEFOR to
Josiah H. Townsend and Larry D. Wilson. The size of this collection is very small, compared to
collections made in other field seasons elsewhere in Honduras for about the same investment of time. It
is important to emphasize this fact, due to the rumors that circulated indicating that the herp team
members were overcollecting and the somewhat contentious meeting that occurred on 10 August 2005,
during which our collection protocols were subjected to an interesting examination by professional
scientists and laypeople alike. For example, a typical trip of 6 weeks in the Mosquitia of Honduras has
netted about 500 specimens of about 80 species. In fact, during the current field season, we collected
only the specimens absolutely necessary for our work save for a couple of specimens of venomous snakes
that were sacrificed with a view to the safety of the staff, students, and teachers using the park facilities.
Additional material of a newly described snake (Geophis sp.; Townsend and Wilson, 2005) was collected, principally from the drift fence arrays, that demonstrates that a single, pattern-variable species of Geophis occurs in the park, instead of the two species initially thought to exist here. In addition, material of a supposed new anole (Norops sp.) was amassed, adding to the material secured during the 2004 season. We now hope that sufficient material exists to determine if it does represent, in fact, a new species of lizard. Additionally, a single specimen of an unidentified Plectrohyla, a hylid frog, was found at the Cantiles camp. As of this writing, this specimen does not fit the description of any of the members of the genus known to occupy Honduras (McCranie and Wilson, 2002). Its mix of features points to it either being representative of a new species or a species not recorded for Honduras, perhaps one that occurs in neighboring Guatemala. Also, a single specimen of an Oedipina was also collected at the Cantiles camp. This specimen cannot be identified using the information in McCranie and Wilson (2002). Its combination of characteristics points to it being representative of a species recorded elsewhere or of a species new to science. Determination of its status will have to await a return to the United States for examination of the pertinent literature and comparative museum material. Additionally, a single specimen of an unidentified species of Hyla was secured from a bromeliad in a tree in dwarf forest. Determination of the status of this animal also will have to await study in the United States. Finally, a single specimen of a salamander of the genus Nototriton was collected from a bromeliad in the bosque enano. This salamander specimen represents at a minimal consideration, a new species for Honduras and may, in fact, represent a species new to science.

A large number of photographs of amphibians and reptiles and of park habitats were taken by the second author of this report that are intended to be used in the preparation of a field guide to the herpetofauna of the park (Townsend and Wilson, in preparation). The writing of this guide will begin in earnest with the beginning of the new academic year. The second author is on board to serve as photo editor. The English text will be translated into Spanish by Luz María Espona, a student of the first author of this report.

The study of the effectiveness of leaf litterbags as a means of attracting tropical anuran larvae resulted in the collection of sufficient data to produce a paper on this collecting technique, which will be written by both authors of this report. The protocol for this study is included in this report as Appendix 1.2. This paper will complement the paper the second author wrote on the use of this technique with U.S. salamander larvae (Talley, 2005).

The use of the above-described technique resulted in the amassing of a number of useful data on the prevalence of malformed mouthparts in the tadpoles occurring in Rio Cusuco. The results will be discussed in another paper to be authored by the second author of this report.

Finally, we wrote a series of three protocol documents, two of which are referred to earlier in this report. The first document deals with the protocols concerning the scientific use of voucher specimens (see Appendix 1.1). The second is a set of protocols for conducting the leaf litterbag study (see Appendix 1.2). Finally, we wrote a set of protocols for snakebite prevention in the field (see Appendix 1.3).
Table 1. Distribution by OpWall Camp of the Amphibians and Reptiles of Parque Nacional Cusuco

<table>
<thead>
<tr>
<th>Species</th>
<th>Base Camp</th>
<th>Guanales</th>
<th>La Fortuna</th>
<th>Cantiles</th>
<th>Buenos Aires</th>
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<tbody>
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<tr>
<td>Bolitoglossa dunni</td>
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<tr>
<td>Cryptotriton nasalis</td>
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<tr>
<td>*Nototriton sp.</td>
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<tr>
<td>*Oedipina sp.</td>
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<tr>
<td>Bufo valliceps</td>
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<tr>
<td>Duellmanohyla soralia</td>
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<tr>
<td>Hyla bromelacia</td>
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<td>*Hyla sp.</td>
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<tr>
<td>Plectrohyla dasypus</td>
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<td>Plectrohyla exquisita</td>
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<td>Ptychohyla hypomykter</td>
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<td>Smilisca baudini</td>
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<td>Eleutherodactylus milesi</td>
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<td>Mesaspis moreletti</td>
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<tr>
<td>Sceloporus variabilis</td>
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<tr>
<td>Norops amplisquamosus</td>
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<td>Norops capito</td>
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<td>Norops Cusuco</td>
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<td>Norops johnmeyeri</td>
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<td>Norops ocelloscapularis</td>
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<tr>
<td>Norops petersii</td>
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<tr>
<td>*Norops sp.</td>
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<tr>
<td>Sphenomorphus cherriei</td>
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<td>Sphenomorphus incertus</td>
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<tr>
<td>Adelphicos quadrirvirgatum</td>
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<tr>
<td>Dryadophis dorsalis</td>
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<td>Drymarchon melanurus</td>
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<td>Drymobius chloroticus</td>
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<tr>
<td>*Geophis sp.</td>
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<td>Imantodes cenchao</td>
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<td>Lampropeltis triangulum</td>
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<td>Leptophis ahaetulla</td>
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<td>Ninia espinali</td>
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<td>Pseudes poecilonotus</td>
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<td>Rhadinoga montecristi</td>
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<td>Scaphiodontophis annulatus</td>
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<td>Stenorrhina degenhartii</td>
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<td>Tantilla cf. schistose</td>
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<td>Micrurus diastema</td>
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<td>Atropoides mexicanus</td>
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<tr>
<td>Bothriechis marchi</td>
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<tr>
<td>Bothrops asper</td>
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<td>Cerrophidion godmani</td>
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</tbody>
</table>

**Total (52 species)**: 37 20 13 4 7
In all, twelve species were added to the known park herpetofauna as a result of the combined efforts of the authors of this report, Joe Townsend, Lynette Plenderleith, and Doug Fraser. These species are as follows: *Nototriton* sp. (possible new species), *Oedipina* sp. (possible new species), *Hyla* sp. (possible new species), *Plectrohyla* sp. (possible new species), *Smilisca baudinii* (based on a call record), *Norops capito*, *Norops petersii*, *Lampropeltis triangulum*, *Pseustes poecilonotus*, *Rhadinaca montecristi*, *Atropoides mexicanus*, and *Bothrops asper*. This number of species, when added to those discovered new for the park during the 2004 field season, has added 22 species to the number (30) reported by Wilson and McCranie (2004a).

Figure 2. *Geophis sp.* Townsend and Wilson, 2005. Patternless specimen, exhibiting one end of the range of color variation in this newly-described species endemic to Cusuco National Park.

![Image](image1.png)

Figure 3. *Geophis sp.* Townsend and Wilson, 2005. Patterned specimen exhibiting the other end of the range of color pattern variation in this species.

![Image](image2.png)
Discussion

The herpetofauna of Cusuco National Park has a considerable degree of biodiversity significance (Wilson and McCranie, 2004a, b, and c), as does the entire herpetofauna of Honduras (Wilson and McCranie, 2004b). Thus, in our opinion, a case for the perpetual protection of the habitats of this park can be made on the basis of the herpetofauna alone.

The work of Wilson and McCranie (2004a) demonstrated the presence of a herpetofauna for the park of 30 species, including four salamanders, nine anurans, six lizards, and 11 snakes. As of this writing, the park herpetofauna is known to consist of 52 species, including six salamanders, 13 anurans, 13 lizards, and 20 snakes. The total number represents a 63.3% increase over the figure reported by Wilson and McCranie (2004a). The species involved are indicated in Table 1.

McCranie and Wilson (2002) and Wilson and McCranie (2004 a and b) used a set of categories of broad patterns of distribution. There are 13 such categories, only eight of which apply to the herpetofauna of Cusuco National Park. These eight categories and the species contained are as follows:

A. Northern terminus of the range in the United States (or Canada) and southern terminus in South America—Drymarchon melanurus, Lampropeltis triangulum.

B. Northern terminus of the range in the United States and the southern terminus in Central America south of the Nicaraguan Depression—Smilisca baudinii, Sceloporus variabilis.

C. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in South America—Imantodes cenchoa, Leptophis ahaetulla, Pseudotus poecilonotus, Scaphiodontophis annulatus, Stenorrhina degennarditi, Bothrops asper.

D. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in Central America south of the Nicaraguan Depression—Bufo valliceps, Sphenomorphus cherriei, Tantilla cf. schistosa.

E. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in Central America south of the Nicaraguan Depression—Norops capito, Sceloporus malachiticus, Atropoides mexicanus, Cerrophidion godmani.

F. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in Nuclear Middle America—Norops petersi, Adelphicos quadririgratum, Drymobius chloroticus, Micrurus diastema.

G. Northern terminus of the range in Nuclear Middle America and southern terminus in Central America south of the Nicaraguan Depression—Norops capito, Sceloporus malachiticus, Atropoides mexicanus, Cerrophidion godmani.

I. Restricted to Nuclear Middle America (exclusive of Honduran endemics)—Bolitoglossa conanti, B. dunni, Duellmanohyla soralia, Hyla bromeliacia, Pychohyla hypomykter, Eleutherodactylus charadra, E. rostralis, Rana maculata, Celestus montanus, Mesaspis moreletii, Sphenomorphus incertus, Dryadophis dorsalis, Ninia espinai, Rhadinaea montecritisi.


This analysis makes it clear that the distributional categories containing the largest number of species of amphibians and reptiles are I and J. There are 31 such species of the total number of 52 or 59.6%. Twenty-one species or 40.4% occupy the other six distributional categories. The species in categories I and J have the narrowest distributional ranges of any of the other groupings. Therefore, their occurrence in Cusuco National Park is an excellent argument for the continued protection of this park for perpetuity, inasmuch as these 31 species are endemic (or thought to be endemic, in the case of the four taxa postulated to be new to science) to Nuclear Middle America, Honduras, the Sierra de Omoa, or the nuclear zone of Cusuco National Park, depending on the extent of their ranges.

The seventeen endemic (to Honduras) species in the park constitute 19.3% of the 88 species of amphibians and reptiles endemic to Honduras. Thus, almost a fifth of the Honduran endemics occur in Cusuco National Park. This is another important reason for the protection of the area. Unfortunately, the maintenance of the integrity of the forest alone will not assure the continuing survival of all members of the endemic herpetofauna, inasmuch as Eleutherodactylus misesi appears to have already
disappeared from its entire range and may have been gone since 1987 (Wilson and McCranie, 2004a),
ironically the same year the park was established. In addition, *Rana maculata*, an anuran amphibian
indicated to have its park populations in decline (Wilson and McCranie, 2004a) was not seen during
the work of the 2005 field season. Several other species were indicated to have declining park
populations by Wilson and McCranie (2004a), including *Duellmanohyla soralia* (endemic to Nuclear
Middle America), *Eleutherodactylus rostralis* (endemic to Nuclear Middle America), *Rana maculata*
(endemic to Nuclear Middle America and now thought to be extirpated from the park), *Drymobius
chloroticus*, and *Bothriechis marchi* (endemic to Honduras).

In terms of future research, it is clear that there is a need to continue to survey the park for additions to
the herpetofauna. This is the case for two principal reasons. One, new sites within the nuclear zone of
the park have been opened recently and more are intended to be opened in the near future. We have
shown through this field season’s work that the majority of the additions to the known park
herpetofauna have come from the so-called satellite camps of Guanales and Cantiles (Townsend et al.,
in preparation; paper on addition to the herpetofauna of Parque Nacional Cusuco). Most of the past
work on the herpetofauna reported in Wilson and McCranie (2004) was based on collections made in
the vicinity of the base camp (Centro de Visitantes). The Guanales camp is at a lower elevation (1300 m)
than the base camp (1550 m) and is demonstrating what we would expect, viz., that amphibians and
reptiles known from moderate elevations in Honduras are being found within the nuclear zone of
the park. The Cantiles camp is a deep-forest camp and is demonstrating the value of accessing and
surveying higher elevation areas in the park. The second principal reason for continuing survey work
is that several new taxa or presumed new taxa have been found in the last two field seasons. One of
these new taxa, *Geophis sp.*, was discovered last year and has now been described (Townsend and
Wilson, 2005). Work both last year and this year has also demonstrated that this species is highly
variable in color pattern, which condition will be reported in a subsequent paper. Another taxon
discovered last year and again this year is a presumed new species of the highly speciose anole genus
*Norops*. This year, amazingly enough, inasmuch as the herpetofauna has been the subject of
continuing studies carried out primarily by Wilson and McCranie (2004), which began in 1979, four
presumed new taxa, including two salamanders and two anurans were discovered. The salamanders
belong to the genera *Nototriton* and *Oedipina*. One of the anurans belongs to the hylid genus
*Plectrohyla* and the other to the genus *Hyla*, which has recently been subjected to a highly significant
systematic revision, which restricted the use of the name *Hyla* to a group of Holarctic treefrogs,
leaving the need for the resurrection and or erection of a number of new genera for the remaining
members of the genus, including all those former members occurring in Mesoamerica (Faivovich et al.,
2005). Each of the four presumed new taxa discovered this year is known from but a single
specimen, which will make it challenging to describe them as new to science without additional
material, because of the demands of scientific publication.

In light of these exigencies, we hope that we have made a case for the need for the continued
collection of select material of the herpetofauna of Cusuco National Park and have suitably addressed
the concerns of those members of the OpWall staff who have questioned our collecting protocols (see
Appendix 1 below).

Beyond the survey work, it will be necessary to conduct longer-term population studies to ascertain
the conservation status of the members of the park herpetofauna. Without this information, it will not
be possible to make the best case for the need to conserve the members of this herpetofauna. It is
hoped that the OpWall program will be able to provide support for such a conservation initiative.

**Final Report Details**
The papers that have and will result from the work of the 2004 and 2005 field seasons are listed
among the references (see section below).

**Acknowledgments**
We wish to sincerely extend our gratitude for the efforts of Josiah H. Townsend, senior herpetologist,
and Douglas C. Fraser and T. Lynette Plenderleith, assistant herpetologists respectively stationed at
the Guanales and Cantiles camps, in securing material of the members of the park herpetofauna, which
materially added to the value of our survey work this field season. In addition, we would like to thank the other members of the OpWall staff who made our time here interesting and challenging.

Figure 4. This is a Find the Snake in the Picture picture. A specimen of the Honduran endemic Emerald Tree Viper, *Bothriechis marchi*, is in this picture. The snake was photographed *in situ* alongside the Rio Cusuco at the point it is crossed by the Quetzal Trail.
References


Figure 5. Three recent publications of pertinence to the study of the herpetofauna of Parque Nacional Cusuco
Figure 6. *Norops petersii*. Giant anole recorded for Parque Nacional Cusuco for the first time this field season.

Figure 7. *Celestus montanus*. Honduran endemic anguid lizard. Specimen pictured is fifth known to science. Rediscovered in park in 2004 (Townsend *et al.*, 2005).
2. Abundance and diversity of herpetofauna in and around Cantiles Camp

By T. Lynette Plenderleith

Rationale
Cantiles sits at an elevation of 1782 metres in the core of Parque Nacional El Cusuco in broadleaf forest. As a site both at higher elevation and in true primary forest; Cantiles ‘satellite camp’ provides a base line of data from very different habitats to the other sites. The herpetofauna at the site had not previously been studied and the herpetological work carried out was to continue to collect data on the range and population of herpetofaunal species in Parque Nacional El Cusuco and to provide a base line of data for the species to be found in and around the Cantiles camp. Amphibians and reptiles were sampled from an area around the camp up to and including the nearby bosque enano (elfin forest) on Cerro Jilinco and to the landslide to the south of the camp. The research methods employed (pit traps and opportunistic surveys) were also assessed during the study period, to determine their value for future monitoring programmes.

A study was carried out to determine the feasibility of future study of lizard territoriality. Norops sp. and Sceloporus malachiticus were used as some of the most abundant lizards and the most easily marked. As well as a potential dissertation topic for future students, there may be implications in the disturbance of parts of the forest that contain territorial lizards.

Methods
Pitfall traps were located at various points along the trail to the west of Cantiles camp. Eight traps were dug where physically possible, with elevations ranging from 1780 to point 142 (ask Cordula). Traps were constructed from 10 gallon sized plastic buckets implanted just below the ground surface to act as a pitfall with a wire mesh ‘drift fence’ placed over the top of the buckets, running between the middle of each end bucket and over the top of any middle buckets. This fence was buried a little under the surface of the ground in order to prevent animals from running underneath and was supported by sticks pushed into the ground on either side and tied to the mesh to prevent movement by large animals or heavy rain etc. Sites for traps were restricted by slope and presence of roots. Traps varied in design from one bucket to three and straight fences to one with a right angle at the midway point, the buckets were 3 to 10 metres apart, depending on the terrain. The pit traps were checked at least once a day, every day that the camp was open for five weeks and any herpetofauna in the traps were identified, measured and released about 5 metres away from the trap (in order to prevent immediate recapture).

Opportunistic searches to the landslide and bosque enano consisted of a walk along previously cut trails once a week. Any animals encountered were identified, measured and released, as and where found.

Nighttime opportunistic searches were carried out between 19:30 and 21:00 most nights. Walks alternated between the trails to the east and the west of camp. The group walked along very slowly, examining every branch, leaf and area of the ground. Herpetofauna encountered were identified, measured and marked (if a Sceloporus or Norops spp.) and replaced in the manner in which they were found. The animals were mapped to show where they were found.

Once a week a trip to the landslide included opportunistic searches travelling there and back. Whilst at the landslide, a search was carried out by all members of the group. Any animal encountered was brought to the attention of the herpetologist(s) present and were then caught by the staff member, identified, marked (if appropriate), mapped (Sceloporus malachiticus only) and released exactly where and how they were found.

In all areas of study, Sceloporus and Norops spp. were numbered on the ventral surface with a ‘Sharpie’ permanent marker.
Results
Species recorded in and around Cantiles:

Amphibians
- Plectrohyla dasypus
- Plectrohyla sp.
- Bolitoglossa diaphora
- Bolitoglossa conanti
- Oedipina sp.

Reptiles
- Bothriechis marchi
- Cerrophidion godmani
- Geophis sp.
- Rhadinacea montecristi
- Celestus montanus
- Mesaspis moreletii
- Norops amplisquamosus
- Norops johnmeyeri
- Sceloporus malachiticus

This list includes 2 species of amphibian (Plectrohyla sp. And Oedipina sp.) that are at least new country records and possibly represent species new to science. Rhadinacea montecristi is a new record for the park and a considerable range extension, having previously only been recorded in the south-east of Honduras.

The Geophis sp. is thought to be either Geophis omoae or G. nephodrymas. Reference to the literature (that is not available at time of writing) will provide a more accurate answer as soon as possible.

Bothriechis marchi is a species previously only recorded at lower elevations (see Kohler, 2003, literature not available at time of writing).

Not listed above is Norops cusuco, which was found on the trail leading to the camp, but on the southern side of the Rio Cantiles.

Opportunistic searches proved far more productive than pit trap captures (see Table 1).

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In the lizard territory study, Norops johnmeyeri were found to be highly abundant and suitable to the study. Several recaptures confirmed the hypothesis of territories. However, despite recaptures of Sceloporus malachiticus, territories were not apparent. The method of marking the lizards was found to be effective, for estimated periods of up to a month.

For more data, please refer to the Excel file entitled ‘Cantiles herps data 2005’
Discussion
One of the major conclusions drawn from the season at Cantiles was the relatively poor results from pit traps. Opportunistic searches were considerably more productive than the traps. However, time spent checking the pit traps was also used as opportunistic search time (although not recorded as such in the data) and therefore the time spent checking the traps was not wasted. The traps were well designed and constantly in good condition, they trapped many small mammals and large invertebrates, demonstrating their effectiveness and so it has been concluded that the species inhabiting the trapping area were merely not susceptible to the traps. However, pitfall traps are a method much liked by herpetologists throughout the world and are normally productive, it is to be assumed that they may still be useful in the future as a method of sampling herpetofauna in Cusuco National Park. In an ideal situation, the traps would also have been kept open for the whole season. However, because the satellite camp was closed nearly all weekends and it was necessary for staff to leave, many data were not collected due to time constraints. The season could have been much more successful had more time been made available for work. The traps are designed to catch animals that would not be found on opportunistic searches and therefore should be used in the future. It is recommended that they be employed over a wider area (as would have occurred this year had the materials been available) and in a more stratified manner in order to provide a better data set. Pit traps can be used to assess differences over a gradient of (for example) altitude or disturbance. This is highly relevant to future projects in the park, but to be employed, better standardization is required. The addition of cover boards (or refugia) may also provide a higher yield of animals for data collection.

The opportunistic searches were considerably more effective than the pit traps. However, for a longer term monitoring programme, they need to be standardized. Reference to literature for suggestions is required and recommendations for such can be sent to Operation Wallacea at request from tplenderleith@hotmail.com.

Man hours (i.e. number of people on searches etc) would normally have been included in data analysis. However, due to the unreliable assistants with huge differences in ability and enthusiasm, this could not be taken into account.

The feasibility study of lizard territories proved the possibility of using the project as a dissertation topic for future volunteers. Again, the lack of time the camp was open restricted the study. The study of Norops johnmeyeri is definitely possible, however further study is required to assess the suitability of Sceloporus malachiticus at the landslide before it is considered a possibility for a study. More accurate maps are also required to properly record the territories of the lizards. This was not achieved this year due to time restrictions.

For details of publications see the main Cusuco herps report.

Reference
Introduction

The amphibians and reptiles of Honduras comprise one of the most thoroughly studied herpetofaunas in Central America (Wilson and Meyer, 1985; McCranie and Wilson, 2002; Wilson and McCranie, 2002; McCranie et al., In press). The first herpetofaunal species described based on Honduran type material were Eleutherodactylus laevisimus and E. rostralis (Werner, 1896), and in the subsequent 110 years at least 50 additional species have been described based on Honduran material (Wilson and Townsend, In prep). The majority of herpetological study to date in Honduras has been systematic in nature, however in recent years there has been a growing emphasis on conservation and to a lesser extent ecological study (Wilson and Townsend, In prep).

In 2003 Operation Wallacea began working in the vicinity of the Sierra de Omoa, an isolated mountain range in northwestern Honduras whose highest peaks are protected as part of Parque Nacional El Cusuco. In addition to the pine-oak and cloud forests of P.N. El Cusuco, Operation Wallacea has been working at the privately owned El Paraiso Valley Ecological Reserve (EPV), a lowland forest site on the northern Caribbean slope of the Sierra de Omoa. Herpetological research at the El Paraiso site was very limited during the 2003 and 2004 seasons, making it necessary to undertake a baseline survey and inventory project during the 2005 season in order to develop future projects involving long term ecological research and monitoring of indicator species.

Methodologies

Animal collection and preservation protocol

Animals captured using methods elucidated below are either identified in the field and released or taken back to the research station for further investigation. Data recorded at the time of the specimen’s capture included: time of day, temperature, elevation, position, activity, substrate, measurement of surface, and height from ground. To ensure minimal stress to the animals, amphibians were placed in plastic bags filled with damp leaf litter and reptiles were placed in cloth sacks filled with damp leaf litter or damp soil. All specimens collected stayed captive for as little time as possible, so not to stress the animals. Upon return to the field station, photographs were taken in natural poses for life color descriptions and documentation. After identification, it is determined whether the specimen should to be preserved as a voucher, and if so the specimen was euthanized. Amphibians were placed in a bottle of strong chlorotone solution (hydrous chlorobutanol crystals dissolved in 95% ethyl alcohol) and died within a few minutes of being removed from the solution. Reptiles cannot absorb chlorotone through the skin and required an injection of chlorotone into the heart. Once the specimen died and became relaxed, tissue samples were taken. Surgical scissors, tweezers, and scalpels used for tissue samples remained in alcohol before and after usage, once removed from alcohol utensils were heated by flame, further sanitizing the tools. Samples were taken ideally from the liver or thick muscle tissue; depending on the size of the animal a tail tip would also be taken normally with small species of salamander. All tissues were immediately deposited in sterile tissue tubes filled with 95% ethyl alcohol and labeled with the same field number as the specimens.
Once an amphibian or reptile was dead and relaxed, it was fixed in a plastic refrigerator tray (30x40x15cm) with a tightly fitting lid and lined with brown paper towels soaked in 10% formalin solution. All specimens were given field tags prior to fixation so not loss track of any specimen data. Each specimen was then positioned in a way that will facilitate measurement and examination of key features and that will provide most effective storage of specimens. Most frogs and toads were positioned so that the limbs are drawn next to the body and flexed; fingers and toes are straightened and interdigital webbing extended. Most salamanders laid flat with feet extended and palmer surface down and toes spread; the tail is straight. Caecilians are preserved with the body in a straight loop and mouths held open by a small piece of wood for examination of teeth. Lizards were laid on ventral side up and legs extended with toes spread, then injected starting at the tail inverting hemipenes if possible, then injected in each limb and body cavity. Snakes were curled in a circular form and injected starting at the tail and continuing up the body cavity until the desired shape and fullness was achieved. Allowing at least 24 hours for fixation in the tray, all specimens were placed in 95% ethyl alcohol for storage.

**Drift fence arrays** - Seven drift fence arrays were placed in three different forest formations two in secondary growth, two in riparian forest (within 10 meters of the river), and three in heterogeneous old plantation growth dominated by banana or cocoa. Each drift fence array comprised of three or four 5 gallon buckets placed flush in the ground not more than 5 meters apart transected midway by metal mesh screening 45 cm wide; buried 4cm under the soil and extending 0.5 meter past each of the last buckets. The screen was vertical supported by two branches; one on each side of the screen tied above the screening by zip ties and placed every 2 m down the line. To avoid flooding in the buckets, numerous small holes had been punched in the bottom of each bucket and approximately 10 cm of small rocks under each bucket to allow for drainage. Each array was checked daily, when excess water and trapped animals were removed by hand. All drift fence arrays stayed open for at least four weeks and closed in the order that they were opened to ensure the same trapping effort for each site.

**Artificial refugia sampling** - As a trial method, 20 PVC pipe traps measuring 8 cm in diameter were placed randomly throughout the forest not less than 20 m apart to serve as artificial refugia for breeding Hylid tree frogs. Each pipe measured 1m in length and cut at a 45-degree angle on one end. The angled end place .1m in the ground and the flat end opened vertically above. Since this type of trap allows for voluntary escape by the animals each pipe needed only to be checked twice a week. Animals found in the traps were removed and identified, then released or taken back for proper identification in plastic bags containing damp leaf litter.

**Opportunistic searches** - To best assess the species richness in EPV, opportunistic searches were performed daily. Each search consisted of field personnel walking through an area or habitat for a prescribed amount of time systematically searching for animals. All searches lasted for at least two hours and no more than four hours; slowly walking along trails flipping logs, raking dead foliage, checking crevices or tree holes, turning movable rocks, and checking the undersides of leaves. Since not all species present in an area are diurnal, additional searches were performed at night with flashlights and head lamps. Much of the time spent searching was done in the vicinity of the river or tributary streams, and stream walks consisted of entering the stream at any random point, continuing walking in and along the stream for a set amount of time traveling no more than 10m from either side of the waters edge. When decaying logs, piles of rubbish, movable rocks, and over-hanging trees were encountered they were thoroughly searched. Due to safety constraints during night surveys in and along the stream, much less area is searched per unit time.

**Quadrat sampling** - Three main areas of EPV were identified as study sites, each site contained three microhabitats: riparian, abandoned crop plantation and secondary forest; these microhabitats were within a reasonable proximity to minimize sampling bias due to systematic biological variation. Three quadrats (10 x 5 m) were placed in each microhabitat type and this was replicated in all three study sites for a total of 27. Quadrats were only placed in areas of homogeneous microhabitat, to avoid sampling bias due to ‘edge effects’. The quadrat positions were randomized by dividing the core region of each microhabitat in each site into plots of 10 x 5 m and assigning each plot a number, which was written down and put into an opaque container. Three numbers were then blindly selected to
randomize selection where to place the quadrants. Quadrats were systematically searched both in the
day and at night for 20 minutes; the sites were searched on a three-day rotation. Searches involved
walking in parallel lines across and along the plot, raking leaf litter, uncovering movable rocks, raking
decaying logs, looking at foliage, branches and any other surface for herpetofauna. Any individuals
found were identified in situ if possible, or returned to the camp for identification. The species name,
its position, substrate and activity were recorded along with the temperature, time and elevation. Each
time a site was returned to three new quadrats were randomly selected and searched. A total of 189
quadrats (63 per microhabitat type) were searched, producing a sizable dataset for statistical analysis.

Results
Data collection went on for eight weeks, from the 30th of June thru the 20th of August; during this
period we recorded 55 species of amphibians and reptiles: one species of Gymnophiona, three species
of Caudata, 12 species of Anura, two species of Testudines, and a total of 37 Squamates (19 species of
Sauria and 18 species of Serpentes). One snake was a new country record (Townsend et al.,
Submitted), and one salamander was the first verified record from Honduras (Townsend et al., In
press).

Many species were abundant and encountered regularly using a variety of methods in most or all
forest formations, including human habitation. These species include Bufo valliceps, Smilisca
baudinii, Ameiva undulata, Cnemidophorus lemniscatus, Norops uniformis, Sphenomorphus cherriei,
Bothrops asper, Drymobius margaritiferus, Dryadophis melanomorus, and Imantodes cenchoa.
Species, which existed for the most part strictly in scrub forest or in close proximity to forest edge
formations, included Bufo marinus, Leptodactylus melanotus, Rana maculata, Rana berlandieri,
Basiliscus vittatus, Cnemidophorus lemniscatus, Kinosternon leucostomum, and Ninia sebae.
Individuals that were restricted to secondary forest formations including old crop plantations, but were
recorded with great frequency, include: Bolitoglossa rufescens, Eleutherodactylus spp,
Hyalinobatrachium fleischmanni, Ameiva festiva, Corytophanes cristatus, Norops spp,
Sphaerodactylus spp, Dryadophis melanomorus, and Leptophis ahaetulla. Species that were
encountered in infrequently these include: Dermophis mexicanus, Oedipina elongata,
Gymnophthalmsus speciosus, Laemancus longipes, Lepidophyrmia flavinaculatum, Norops capito,
Atropoides mexicanus, Clelia clelia, Lampropeltis triangulum, Tantilla schistosa, Tantillita lintoni,
and Tropidodipsas sartori.

The quadrat surveys were the most successful method in terms of diversity, with 22 out of 55 total
species recorded using this method. The drift-fall arrays provided many important specimens which
would other wise go unnoticed or very unlikely to be found due to their activity patterns; providing a
total of 14 species collected, three of which were solely found in the drift-fence arrays. The artificial
refugia provided no specimens. In the future different measures may be taken to utilize these artificial
refugia at higher levels in the canopy to attract species in the areas where competition for shelter and
calling sites are high.

Noteworthy results

Bolitoglossa rufescens complex: A large number of tissue samples for this complex of salamanders
was secured to facilitate future investigation of the molecular relationships of this poorly known
salamander group.

Dermophis mexicanus: A local farmer found a single specimen of a rarely encountered caecilian in El
Paraiso. This legless fossorial amphibian is usually found along streams hidden within rotten logs or
loss moist soil in Lowland Dry Forest and Lowland Moist Forest formations (McCranie and Wilson,
2002), yet this specimen was collected in the middle of a town beneath dry sandy soil.
Eleutherodactylus frogs: At least two species of Eleutherodactylus are present in the El Paraiso Valley
that could not be identified in the field. Further study of specimens and tissue samples of these frogs
may result in their identification as additions to the Honduran herpetofauna.

Hyalinobatrachium fleischmanni: An abundant population of this glass frog is present along the Río
Piedra de Muclé in the El Paraiso valley. Classified as an indicator species for biodiversity monitoring,
the glass frog could serve as a key species for further studies in the valley.
Laemanctus longipes: A single gravid adult female of this highly arboreal (living only in trees) and seldom collected species of lizard was collected along one of the main trails. This casquehead iguanid is only known to leave its’ life in the trees only retreating to ground level while looking for an area to lay eggs (Köhler, 2003), making it a truly valued find.

Oedipina elongata: A single specimen of this worm salamander was found near the fly camp in the Paraiso Valley. This is the first record of this species with confirmed locality data from Honduras (Townsend et al., In press).

Rhadinæa anachoreta: A single specimen of this delicate snake was collected in a drift fence array. This is a new country record for Honduras (Townsend et al., submitted).

Sphaerodactylus sp.: Two specimens of small forest gecko were collected during the season, which could not be identified in the field. After further investigations these specimens may represent a new addition to the herpetofauna of the El Paraiso valley and Honduras.

Tantilla schistosa: A single, apparently adult, male specimen of this poorly known species was found in a drift fence array. This specimen closely matches the typical form of T. schistosa, making it extremely valuable for morphological and molecular comparison to a series of specimens from Cusuco National Park that are tentatively assigned to T. schistosa but thought to represent an undescribed taxa.

Tantillita lintoni: Two individuals of this very small snake were collected. Both specimens were found moving along the trail in wet foliage startled by the collectors.

Tropidodipsas sartorii: Two adults of this rare nocturnal terrestrial snake were found during night searches along the trails of the El Paraiso valley.

Literature Cited
Species of amphibians and reptiles recorded during the 2005 Operation Wallacea field season in the El Paraíso Valley. Abbreviations utilized are as follows: OS = opportunistic search; DF = collected in a drift fence array; QS = observed during quadrat sampling; C = common species encountered frequently using multiple survey methods; I = infrequently encountered species observed less than 10 times during the season; R = rarely encountered species observed less than three times during the season.

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4. A survey of the herpetofaunal species diversity of the Paraiso Valley and a comparison of the diversity between different microhabitats

Charlotte Woodhead, 2005

Background
Honduras is the second biggest Central American country, encompassing 112,088 km squared (McCranie and Wilson, 2002a). Paraiso valley is situated in the northwest corner of Honduras in the Department of Cortes. It lies along the Caribbean Central plain and has a lowland moist forest climate-defined as having a mean annual rainfall of greater than 2000 mm and temperature of above 24 C (Wilson, L.D., and Townsend, J.H., in press). The Rio piedra nucle runs through the valley, which rises from sea level to around 950m. Previous studies of the Herpetofauna in Honduras date back as far as the ‘Biologia Centrali-Americani’ by Albert C.L.G. Gunther, from 1885-1902 (Kohler, G.,2003). Today much active research is still being conducted into this area that promises to contain a diverse array of hepetofauna due to the variation in vegetation, being in the tropics, known to contain the most biodiversity in the world (Miller, 2001; Raven and Berg, 2001 cited in Wilson, L.D., and McCranie J.R., 2003a) as well as lying between, and containing a mixture of, both North and South American species (Kohler, G., 2003; McCranie, J.R. and Wilson, L.D., 2002a). Recent studies have been carried out in Honduran rainforests include, ‘The herpetofauna of the cloud forests of Honduras’ (Wilson, L.D. and J.R., McCranie, 2003b) which addresses the composition of, the distribution, relative abundance and conservation status of the species found in the cloud forests. Further research that includes other forest formations and their constituent species is currently in press (Wilson, J.D., and Townsend, J.H.).

This study is designed to look in more detail into the species composition of the Paraiso valley, in particular because this was made a protected reserve 13 years ago having been extensively cleared for agricultural use as plantations such as oil palm, cocoa and banana. This is especially important considering the need to assess the effectiveness of the system of biotic reserves and protected areas outlined by at least 2 publications (Wilson, L.D., and McCranie, J.R., 2002a, 2003a).

Aims
The main aim of this study was to build on the pilot study of herpetofaunal biodiversity carried out in 2003 by conducting a more extensive survey of the Paraiso valley using a combination of methods. Furthermore, the diversity of herpetofauna species in three different microhabitat types were to be compared, as described in terms of species richness, the total number of species and evenness, the distribution of individuals among species (Heyer et al., 1993). I originally wanted to compare three microhabitats that had been exposed to different levels of human disturbance, using primary forest, secondary forest and recently abandoned crop plantation areas. I would have expected the greatest species diversity in primary areas due to the greater structural complexity of the mature rainforest. McCranie and Wilson, 2002a explained that this effect was due to the provision of numerous niches in a more complex forest type, for example the accumulation of decomposing vegetation between tree buttresses and deep leaf litter cover. However, the latter aim had to be amended upon arrival at Paraiso because the only areas of primary vegetation were too far from the camp to be accessed often enough for repeated sampling. Furthermore these areas were at a significantly higher elevation than the other microhabitats to be surveyed so that any conclusions drawn may have been biased due to the difficulty in controlling for systematic biological variation between study sites. I therefore compared secondary, recently abandoned crop plantation and riparian forest to see whether there was a difference in the species composition, number and distribution within the valley. By surveying these areas, a more representative view of the herpetofaunal diversity should be obtained, for example if riparian forest was not surveyed, those species that prefer to stay close to water may not have been seen and thus not included in the species list.

It was predicted that secondary forest regions would contain the greatest species richness, as they had had longer to rejuvenate and to build up a greater structural complexity than the crop plantations abandoned more recently. It was predicted that the diversity in riparian forest would be less than the other two microhabitat types due to the relative harshness of the environment in terms of exposure, lack of hiding places and vegetation structure; it was expected to contain certain species that would not have been found in other areas, for example those using the stream as breeding sites.
Methods and materials

Quadrat Sampling

Three main areas of the Paraiso Valley between 30 and 160 m elevation were identified as study sites, all contained each of the three microhabitats that were under investigation; riparian forest, abandoned crop plantation (including oil palm, cocoa and banana) and secondary forest. These were within reasonable proximity so as to minimise systematic biological variation between microhabitats within each site. The first site was furthest up the valley, the third site was closest to the reserve entrance and the second site between those. Three quadrats (10 x 5m) were randomly placed in each microhabitat in every site, 27 in total, these were placed well into the microhabitats to avoid bias from sampling the edges. The quadrat positions were randomised by dividing the core region of each microhabitat into plots of 10 x 5 m, assigning each a number and putting them into an opaque container. Three pieces were then selected blindly, randomly indicating in which place the quadrats should be put.

The quadrats were searched on a three day rotation. A different site was covered everyday and each quadrat of each microhabitat in a particular site was searched on the same day to minimise any bias in sampling due to daily variation (for example rainfall), searches were carried out at night and during the day to include nocturnal species. The quadrats were searched for 20 minutes by walking in parallel lines a metre apart both across and lengthways. We used a high intensity search in that leaf litter was raked, rocks were overturned and decaying logs were broken up in order to uncover species that would not otherwise be visible on the surface. Where possible any moved objects were returned to their original position to minimise disturbance. Any species found were identified in situ using an identification key, or placed into a bag with some water for moisture and a handful of leaf litter so that they could be taken to a more experienced herpetologist to be identified. Any species taken were returned to the position they were found having been identified. When an individual was spotted it was recorded in a logbook including its position, substrate, activity and microhabitat type. The temperature and elevation was also recorded as well as any other notes of relevance (for example any unusual weather conditions etc). Each time a site was returned to, 3 new numbers were picked out of a hat per microhabitat and 3 new quadrats measured out. These were searched in the same way as above to sample a more representative area of the microhabitats and to remove any bias in data due to returning to quadrats that had already been disturbed.

Drift fences/ Pitfall Traps

Three traps consisting of 3-4 buckets of 40 litre capacity each were placed in all three sites, one pitfall per microhabitat per site, nine in total. The buckets were dug in 2-5m apart, deep enough so the opening was at ground level. Drainage holes (2-3mm diameter) were pierced through the underside of each bucket to avoid them filling up with rainwater, possibly drowning any organisms caught and a thin layer of leaf litter was placed inside to provide a warm, moist environment. A drift fence approximately 40cm tall was run along the length and through the middle of each of the series of buckets with a 1m overhang at each end to increase the area of the trap. The bottom of each fence was buried into the ground slightly so as to be continuous with it and the fences were anchored at 1.5m intervals with stakes. This method was used to trap individuals so that they encounter the fence at any point as they are locomoting and are guided by the fence into the bucket. The pitfalls/drift fences were checked every morning between 9 am and 12 pm. This is suitable for determining species richness and for trapping rare individual species (Heyer et al. 1993). Pitfall traps were used to trap terrestrial and fossorial individuals and has been shown to be effective at trapping amphibians (Szaro et al. 1988). Those species which are arboreal /prefer decaying logs/ tree holes/ are strong climbers or jumpers etc however are less likely to be caught.

Transect Sampling

10 transects each 100m long were measured out for each microhabitat. This was repeated in all three sites. The transects were sampled by walking along the transect line and searching the area 2m on both sides so that the total area searched per transect was 400 m squared. The sampling time for each transect was restricted to 45 minutes as a measure of standardisation and the search level was of high intensity as for the quadrats above. All the individuals spotted were identified; their position, activity and substrate were recorded as well as the temperature, time and altitude.
Stream walks
In order to build up a more complete account of the biodiversity of herpetofauna in the Paraiso Valley stream walks were conducted - mainly at night - to avoid those trails that were frequently disturbed thus may have been unrepresentative as many herps may have left these areas. Stream walks involved walking for two hours upstream and two hours downstream through the water and searching the surrounding vegetation and protruding rocks. The stream ran through each of the three main sites and also ran through or very close to each of the different microhabitat types. The vegetation on either side of the stream was classified as riparian, secondary or abandoned crop plantation and searched by area (metres squared) covered so that the total area searched of each microhabitat type was the same. Any individuals were identified and recorded along with the microhabitat in which it was seen.

Opportunistic searches
These involved walking around each microhabitat type for a prescribed time period (60 minutes) both along and off the trails and recording any individuals that we came across opportunistically. The same time was dedicated to each site and to each microhabitat type, and walks were taken both during the day and at night.

Measuring forest structure
3 quadrats (5 x 5 m) per microhabitat in each site were chosen at random and marked out in order to measure any differences in forest structure between them. Tree circumference was measured with a tape measure, as was the distance between trees. Estimations of ground coverage for % rock cover, % low growing/midstory/understory/upperstorey vegetation cover, % leaf litter cover, light intensity % were also made and recorded into a data sheet.

Materials
Flagging tape
Tape measure (20m and 50m)
Data paper
Pencil
Plastic bags
Thermometer
Altimeter
Plastic buckets (30)
Wire mesh
String
Results
A table to show the species found and the microhabitat/s in which they were found. The methods by which each species were found are also shown; Q=quadrat sampling, T=transect sampling, O=opportunistic sampling and P=pitfall trap.

<table>
<thead>
<tr>
<th>Species</th>
<th>Microhabitat type</th>
<th>Secondary</th>
<th>Crop plantation</th>
<th>Riparian</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolitoglossa rufescens</td>
<td>Q,T,O</td>
<td>9</td>
<td>Q,T,O</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Bolitoglossa Spp.</td>
<td>T</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Bufo valliceps</td>
<td>T,O,P</td>
<td>6</td>
<td>Q,O,P</td>
<td>5,Q,T,O</td>
<td>19</td>
</tr>
<tr>
<td>Corytophanes cristatus</td>
<td>Q,T,P</td>
<td>3</td>
<td>Q</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Sphenomorphus cherriei</td>
<td>P</td>
<td>1</td>
<td>Q,T,O</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Norops lemurinus</td>
<td>T,O</td>
<td>4</td>
<td>Q,T</td>
<td>4,T,O</td>
<td>12</td>
</tr>
<tr>
<td>Norops sericeus</td>
<td>T,O</td>
<td>3</td>
<td>Q,T</td>
<td>4</td>
<td>7</td>
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<tr>
<td>Norops uniformis</td>
<td>Q,T,O,P</td>
<td>14</td>
<td>Q,T,P</td>
<td>22,Q,T,O</td>
<td>47</td>
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<td>Eleutherodactylus Spp.B</td>
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<td>2</td>
<td>T,O</td>
<td>4,Q,T,O</td>
<td>10</td>
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<tr>
<td>Eleutherodactylus Spp.C</td>
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<td>5</td>
<td>Q,T,O</td>
<td>8</td>
<td>13</td>
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<tr>
<td>Eleutherodactylus charada</td>
<td>O</td>
<td>2</td>
<td>O</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Hyalinobatrachium fleischmanni</td>
<td>0</td>
<td>Q,T</td>
<td>3</td>
<td>3</td>
<td></td>
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<tr>
<td>Scaphiodontophis annulatus</td>
<td>O</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Norops rodriquezii</td>
<td>Q</td>
<td>1</td>
<td>Q,T</td>
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<td>7</td>
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<tr>
<td>Ameiva undulata</td>
<td>T</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<td>Imantodes cenchoa</td>
<td>T</td>
<td>1</td>
<td>T,O</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Gymnophthalmalus speciosus</td>
<td>0</td>
<td>T</td>
<td>1</td>
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<tr>
<td>Norops capito</td>
<td>0</td>
<td>0</td>
<td>T,P</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Dryadophis melanolomus</td>
<td>Q,T</td>
<td>2</td>
<td>T</td>
<td>1</td>
<td>3</td>
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<tr>
<td>Basiliiscus vittatus</td>
<td>0</td>
<td>T</td>
<td>P</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Lepidophyma flavimaculatum</td>
<td>Q</td>
<td>1</td>
<td>Q,P</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Drymobius margaritiferus</td>
<td>P</td>
<td>1</td>
<td>Q</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tallia schistoso</td>
<td>P</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Tallia taeniata</td>
<td>Q,P</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Tropidodipsas sartorii</td>
<td>Q</td>
<td>1</td>
<td>O</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Drymarchon corais unicolor</td>
<td>0</td>
<td>0</td>
<td>Q</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Laemacrus longipes</td>
<td>O</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Bothrops asper</td>
<td>T,O</td>
<td>2</td>
<td>O</td>
<td>1,Q</td>
<td>4</td>
</tr>
<tr>
<td>Adelphicos quadririgatus</td>
<td>P</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Atropoides nummifer</td>
<td>O</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sphaerodactylus Spp.</td>
<td>O</td>
<td>1</td>
<td>O</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Tantilla lintoni</td>
<td>0</td>
<td>O</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Clelia clelia</td>
<td>T,O</td>
<td>2</td>
<td>0</td>
<td>T</td>
<td>3</td>
</tr>
<tr>
<td>Smilisca baudinii</td>
<td>0</td>
<td>O</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Eleutherodactylus Spp.A</td>
<td>Q,T,O</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Leptophis ahaetulla</td>
<td>0</td>
<td>O</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total no. individuals</td>
<td>79</td>
<td>79</td>
<td>66</td>
<td>224</td>
<td></td>
</tr>
<tr>
<td>Total no. species</td>
<td>27</td>
<td>24</td>
<td>18</td>
<td>37</td>
<td></td>
</tr>
</tbody>
</table>
The results show that 73% of the total number of species found were in Secondary forest, 65% in abandoned crop plantation and 49% in riparian forest. The most common species was *Norops uniformis*, constituting 21% of the total individuals found. The species found only in secondary forest were *Adelphicos quadrivirgatus, Atropoides nummifer, Eleutherodactylus Spp.A, Laemanctus longipes, Tantilla taeniata, Tantilla schistosus* and *Bolitoglossa Spp.* Four of these were snakes, two lizards and one amphibian. The species found only in abandoned crop plantation were *Leptophis ahaetulla, Tantillita lintoni* and *Gymnothalamus speciosus*, these included two snakes and a lizard. The species found only in riparian forest were *Hyalinobatrachium fleischmanni, Norops capito and Drymarchon corais unicolor*, these included one amphibian, one lizard and one snake.

Most of the species found were snakes (38%), however this constituted only 26 of the 224 individuals found, the majority of which were lizards (98 individuals). The secondary forest appeared to support the greatest diversity of snake species, both in terms of numbers of different species (10 altogether), and of abundance (14 individuals). The diversity of lizards and amphibians was more evenly distributed between the three microhabitats, the percentage of the total number of lizard species found in secondary, crop plantation and riparian forest was 77%, 77%, and 62% respectively, whereas the proportion of the total number of amphibian species was 70%, 60% and 70% respectively. 22 of the species were found opportunistically, 19 by quadrat sampling, 21 with transects and 11 with pitfall traps although the greatest number of individuals were found along transects (98/224).

**Discussion**

The results do appear to confirm at least in part the predictions outlined in the aims section, secondary forest areas did support the most number of herpetofaunal species, however there was little difference between secondary and abandoned crop plantation in terms of numbers of species and the number of individuals caught was the same in both microhabitats. This suggests that the negative effects of human disturbance on species diversity either is less than predicted or that these effects take longer than appreciated to recover. If the latter is the case, those areas abandoned up to 50 years ago are no better off in terms of species diversity than those areas abandoned less than 15 years ago. Another possibility is that the species composition of these two microhabitats may be significantly different despite the diversity being the same, this would suggest that different species have adapted to specific niches within the different forest types. Different microhabitats may provide a greater diversity of structure and vegetation type within the forest as a whole, providing a greater range of different niches able to be exploited by a greater array of species.

The riparian areas did seem to contain the least species diversity and as predicted, it did contain several species that were not to be found in the other microhabitats, however this was also true for the other two types. The smaller number of species and individuals may indeed reflect the harsher environment such as the degree of exposure due to lack of mid and upper canopy cover, ground vegetation and hiding places such as deep leaf litter, tree buttresses etc.

The most effective method for spotting species were the transects and opportunistic searches. The quadrat searches were not so successful; this is because the method did not turn out to be suitable for herps. The area covered was only a small fraction of the forest as a whole and these species are highly motile and not abundant enough to have a high chance of falling into the confines of a small quadrat area. This method is perhaps more suited to monitor the diversity of more abundant organisms such as insects or certain plants.

The pitfall traps did not trap many individuals, however did trap some species that would otherwise not have been found, at least in that microhabitat type, such as the snake *Adelphicos quadrivirgatus*, and I would recommend that this method be used again with a greater number of traps.

<table>
<thead>
<tr>
<th>Microhabitat</th>
<th>No. Planted trees</th>
<th>No. Non-planted trees</th>
<th>Ave. Tree circumference (cm)</th>
<th>Ave. Distance between trees</th>
<th>% rock cover</th>
<th>% leaf litter cover</th>
<th>% low vegetation cover</th>
<th>% mid-storey vegetation</th>
<th>% upper storey vegetation</th>
<th>% light intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average R</td>
<td>0.2</td>
<td>3.9</td>
<td>46.9</td>
<td>235.8</td>
<td>82.8</td>
<td>45</td>
<td>25.6</td>
<td>49.4</td>
<td>33.2</td>
<td>55</td>
</tr>
<tr>
<td>Average CP</td>
<td>6.2</td>
<td>3.3</td>
<td>40</td>
<td>331.3</td>
<td>19.4</td>
<td>71.1</td>
<td>56.4</td>
<td>84.2</td>
<td>45</td>
<td>8.7</td>
</tr>
<tr>
<td>Average S</td>
<td>1.1</td>
<td>4</td>
<td>133.9</td>
<td>382.9</td>
<td>9.6</td>
<td>72</td>
<td>30.1</td>
<td>48</td>
<td>79.8</td>
<td>10.6</td>
</tr>
</tbody>
</table>
Further research is needed to monitor the longer term situation in the Paraiso valley in order to effectively measure both how well the reserve is being protected and on the conservation status of those species present. It is also necessary to sample those primary forest areas deeper into the valley to determine the species diversity status of this forest type.

The completed paper will be handed in to Opwall by December 2005, titled ‘A comparison of the variation in herpetofaunal diversity and abundance in different microhabitats of the Paraiso valley’

References
5. Measuring the diversity and relative abundance of herpetofauna in the Paraíso valley, Honduras Comparing differences between 3 different microhabitats – riparian forest, abandoned plantations and secondary forest

Philip Lewis, Liverpool John Moores University

Methods
Diversity and relative abundance of the herpetofauna in the Paraíso valley was measured using several techniques. Firstly, 3 study sites were selected in the forest, and within each study site there were 3 microhabitats, riparian forest, abandoned plantations and secondary forest. An equal amount of quadrats were measured for each microhabitat within each study site, this gave us 9 replicates of each microhabitat being checked daily on a rotational basis. New quadrats were measured up each time we entered the study sites as using the same quadrats would yield little or no data. Pit fall traps and drift fences were also set up and checked daily, with an even amount in each study site. Opportunistic transects were also undertaken for each of the 3 microhabitats and biases were eliminated by measuring the distance covered, which for each transect was 400m².

Results/Discussion
The pooled quadrat data from the 3 study sites gave the following results:

Riparian forest = total 7 individuals divided amongst 7 different species.
Abandoned plantations = total 19 individuals divided amongst 12 different species.

Secondary forest = total 23 individuals divided amongst 10 different species.

The pooled transect data from the 3 study sites gave the following results:

Riparian forest = total 36 individuals divided amongst 13 species.
Abandoned plantations = total 37 individuals divided amongst 13 different species.

Secondary forest = total 27 individuals divided amongst 13 species.

The quadrat data obtained, shows that the abandoned plantations had a slightly higher diversity than did the secondary forest, and the secondary forest had a higher number of individuals. This was not expected, it was expected that the secondary forest would have the greater species richness and that the abandoned plantations would have the higher number of individuals. As expected from doing the field work the quadrat data yielded only a small number of species and individuals in riparian forest.

The transect data obtained showed that riparian, abandoned plantations and secondary all had an even amount of species diversity, which certainly was not expected, especially when looking at the quadrat data for riparian forest. The amount of individuals for abandoned plantations was 37 compared with only 27 for secondary. This however, was no surprise as when the field study was conducted, the emerging pattern seemed to be that there were less individuals in secondary forest, with more individuals being found in the abandoned plantations, what was a surprise was the equal number of diversification across them two particular microhabitats as it was expected that secondary would have the greater diversity.

The above results suggest that it may have been the sampling methods used, which have caused such unexpected results between the 3 forest microhabitats, making the opportunistic transect method the most reliable in obtaining relative abundance and diversity data as opposed to sampling with quadrats.
Bird survey work, Cusuco 2005

1. Bird research summary: Parque Nacional El Cusuco

Report by senior ornithologist Dr Robin Brace

Ornithology Team
Dr Robin Brace (Senior Ornithologist) (University of Nottingham) (Units 3 to 8)
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Ernesto Reyes (Assistant Ornithologist) (Estacion de Investigaciones Integrales de la Montana, Pinares de Mayari, Cuba) (Units 1 to 10)
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Dissertation students
Mary-Anne Collis (Units 3 to 8) (Keele University) (Hummingbird bill morphology and floral structures)
Francine Kershaw (Units 3 to 8) (University of Leeds) (Hummingbird bill morphology and floral structures)

General volunteers
Chloe Loo (Units 1 to 4)
Louise Fletcher (Unit 5)
Stephanie Winnard (Unit 4)

Rationale

(a) Introduction and 2004 Research Backcloth:
Honduras has a rich Neotropical avifauna comprising over 730 species. A good proportion of this fauna (both residents and migrants) can be found in west Honduras, where Cusuco Park is located, with the park being rich in both Caribbean Slope and highland species. Obviously, obtaining a comprehensive picture of the park’s avifaunal diversity is crucial in underpinning conservation initiatives. To that end our principal objective in 2004 (first study year) was to produce reasonably comprehensive species lists for all major locations studied, in particular from park core sites. As a result of our endeavours, the avifaunal inventory for the park was raised by 80 species, from 105 (Brough 1992) to 185 species, with 94 species being recorded from the core (Base Camp, Guanales and the elfin forest above Base Camp) and 103 from the buffer zone (Buenos Aires), yielding a total species count of 155 species (Brace et al. 2005).

Visual observations were supplemented by mist-netting that can help greatly in detecting cryptic species and also in the identification of hummingbirds that are difficult to view well in rapid flight: forty-seven species were trapped in both the park core and buffer zone, giving a total of 75 species handled. All birds trapped – the exception of hummingbirds (that have short legs making ring fitting difficult) – were ringed, in order to study residency. No less than 14 species of hummingbird were recorded from the park core (including two range-restricted species), together with seven woodcreepers. Only 30 species listed by Brough (loc. cit.) were not recorded in 2004, of which 10 were Nearctic migrants that are unlikely to have been present during the majority of our stay in Cusuco.

Additionally, we wished to gather comparative quantitative data from the core and buffer zones in order to assess the impact of habitat modification in the latter. That aim was successfully fulfilled through 1 km long transect surveys undertaken at Base Camp (along the Danto and Quetzal trails) and Buenos Aires (adjacent to the “Toucan” and above the village [both the latter transects included shade coffee plantations]).
The principal findings and conclusions of our 2004 work were as follows:

- There are dramatic qualitative and quantitative differences between the avifauna of the park core and that of the buffer zone.
- Consequently, any habitat modification in the core zone will result in the loss of an extensive set of specialist species not found in the buffer zone.
- Thus it has been demonstrated unequivocally that conservation of the core zone is imperative to maintaining the integrity of the highland/cloud forest bird community in the region. This is an important finding that strongly underpins Opwall’s GEF application for strategic “Conservation and Sustainable Management in the Cusuco National Park Forests”.
- Although the greater range of habitats found at Buenos Aires in comparison to the core zone should provide for a much greater range of niches, the expected, substantially enhanced species complement was not realised (103 species versus 94), a finding that provides evidence, albeit indirect, indicating that altitude (c. 1100m) is a limiting factor in avian occupancy at Buenos Aires.

(b) Principle Aims and Objectives of the 2005 Programme:

The over-riding theme this year has been one of consolidating species lists in order to pave the way for future monitoring work. In this context, it was deemed especially important to augment substantially our appraisal of birds utilizing the park core, (though obviously a knowledge gap remains with respect to Nearctic migrants [e.g. warblers] [see above]). This has been achieved by further observational work and by netting/trapping in the Base Camp area, in the vicinity of the new Cantiles satellite camp and at Guanales, a ‘fly’ camp used/visited in 2004 also. Short visits were paid to the higher reaches of the park (elfin forest) in order to attempt to supplement the limited data gathered from that habitat already.

Work at Buenos Aires has augmented substantially the tally of species there, especially since a much wider range of locations was explored than was the case last year (e.g. mist-netting in a grassland location adjacent to the Eco-lodge, and in gallery adjacent to the Rio Cusuco below the village); consequently a much wider spectrum of habitats (encompassing somewhat lower altitudes). Nevertheless, our expectations are modest in terms of documenting fully the avifauna of the buffer zone, since our work has been focused effectively on a very limited sector of what is a very extensive and climatically variable swath of terrain.

This year there has been a highly selective research focus on hummingbirds that have closely co-evolved with those plants for which they act as pollinator agents. Such co-evolution may – for some species – involve sexual dimorphism in bill design so as to facilitate utilization of different food plants, thereby reducing inter-sexual competition for resources (e.g. Purple-throated Carib found in St. Lucia) (Temeles & Kress 2003). In common with many birds, sexual dimorphism in plumage is evident in many hummingbirds, especially those that lek. Significantly, these two types of dimorphism are not independent of one another: the degree of bill differentiation (with males having typically shorter bills than females) correlates well with the brightness of male plumage (with males of species that lek being typically, especially brightly coloured) (Bleileweiss 1999). Consequently, it is apparent that selection for both bill construct and plumage characters is strongly influenced by the degree of territoriality associated with differing sexual strategies. It is these fascinating evolutionary interactions that are the subject of study by the two dissertation students. Luckily for them, a large number of hummingbirds have been trapped and processed, both in the park core and buffer zone, thereby supplying much relevant morphometric data (i.e. bill length and curvature).

Methods

Bird sightings (and auditory-based identifications) in various localities/along a variety of routes are being logged on a daily basis so as to both build up species lists and to provide some idea of relative abundances/encounter rates.

Mist netting has been undertaken at a small number of locations in the Base Camp Area, and also at Buenos Aires (i.e. adjacent to the Eco-Lodge). Birds trapped by Robin Cosgrove are being fitted with numbered, split plastic rings that are red in colour this year (blue last year). Mist-netting has been undertaken also by Ernesto Reyes (at both Cantiles and Buenos Aires), though birds trapped, not fitted
with rings, though marked by removing a small wedge of the inner shaft of an outer tail feather. All birds not ringed (hummingbirds), were marked as noted above so as to avoid duplication of morphometric data collection.

With regard to the hummingbird research, morphometric measurements were taken (i.e. weight, overall and wing lengths, and bill length and curvature) of all trapped birds. Observations on feeding behaviour were made at sites with flowers found to attract one or more species on a regular basis. Resource patch foraging data gathered, included various visitation statistics (arrival time, length of visit, number of flowers visited and times spent at individual flowers). Plant species utilized have been/will be identified, and flower size and shape measured so as to assess correlations in and adaptive breath of bill/flower structures.

**Results**

(a) **Ornithological team coverage across park areas:**
Coverage by the various ornithological team members of the areas (camps) visited throughout the expedition period is depicted in Table 1. Note that the designated Base Camp and Cantiles areas extend to (respective sides of) the landslide brought about by Hurricane “Mitch”. An elfin forest category is not included since visits were short and relevant records (species seen) highly limited indeed.

<table>
<thead>
<tr>
<th>Area</th>
<th>Units 1 &amp; 2</th>
<th>Units 3 &amp; 4</th>
<th>Units 5 &amp; 6</th>
<th>Units 7 &amp; 8</th>
<th>Units 9 &amp; 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park Core</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Camp</td>
<td>X(m-1,M-2)</td>
<td>X(M-3)</td>
<td>X(M-5/6)</td>
<td>X(8)</td>
<td></td>
</tr>
<tr>
<td>Cantiles</td>
<td>X(m-4) *</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guanales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X(m-8) *</td>
</tr>
<tr>
<td>Buffer Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buenos Aires</td>
<td>X(m-3,M-4)</td>
<td>X(m-5/6)</td>
<td>X(M-7/8)</td>
<td>X(m-9)!</td>
<td></td>
</tr>
</tbody>
</table>

Table notes: X – signifies ornithological presence; M – mist-netting with ringing capability; m – mist-netting without ringing capability; * – mist-netting curtailed by poor weather.

(b) **Synopsis of species seen:**
One hundred and sixty three species have been recorded (through field sightings and mist-netting) this field season, with 82, 43 and 29 noted from the Base Camp, Cantiles and Guanales areas respectively in the park core (with a total of 107 species across these core localities), and 113 from Buenos Aires in the buffer zone. Moreover, 79 species have been trapped (c. 640 individuals), with c. 315 being ringed. No (new) species exclusive to the elfin forest have been detected. La Fortuna records (no ornithological presence) span 24 species.

(c) **Inter-year re-traps:**
Significantly, 17 re-traps of ringed individuals handled initially in 2004, have been secured; these inter-year re-traps (across 11 species) are listed (in systematic order) in Table 2 below.
Table 2: Species re-trapped on inter-year basis, with locations.

<table>
<thead>
<tr>
<th>Species</th>
<th>Core Zone (area)</th>
<th>Buffer Zone (area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaly-throated Foliage-gleaner (2)</td>
<td>Base Camp</td>
<td></td>
</tr>
<tr>
<td>Tawny-throated Leaftosser (1)</td>
<td>Base Camp</td>
<td></td>
</tr>
<tr>
<td>Ruddy Foliage-gleaner (1)</td>
<td>Base Camp</td>
<td></td>
</tr>
<tr>
<td>Olivaceous Woodcreeper (1)</td>
<td>Base Camp</td>
<td></td>
</tr>
<tr>
<td>Spot-breasted Wren (1)</td>
<td></td>
<td>Buenos Aires</td>
</tr>
<tr>
<td>Plain Wren (1)</td>
<td></td>
<td>Buenos Aires</td>
</tr>
<tr>
<td>Slate-colored Solitaire (2)</td>
<td>Base Camp</td>
<td></td>
</tr>
<tr>
<td>Black-headed Nightingale-Thrush (1)</td>
<td>Base Camp</td>
<td></td>
</tr>
<tr>
<td>Clay-coloured Robin (2)</td>
<td>Base Camp</td>
<td>Buenos Aires</td>
</tr>
<tr>
<td>Common Bush-Tanager (4)</td>
<td>Base Camp</td>
<td></td>
</tr>
<tr>
<td>Yellow-faced Grassquit (1)</td>
<td></td>
<td>Buenos Aires</td>
</tr>
</tbody>
</table>

Table note: numbers in parentheses signify the numbers of individuals involved.

Species additions to the Cusuco park list:

A range of new species for both the park core and buffer zone have been added. These additions are listed in Table 3 that depicts too those records that are new for Cusuco per se.
Table 3: Species additions in systematic order (re: Clements 2000).

<table>
<thead>
<tr>
<th>Species new to core zone</th>
<th>Species new to buffer zone</th>
<th>New to Cusuco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey-headed Kite (BA)</td>
<td>Grey-headed Kite (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Hook-billed Kite (BC)</td>
<td>Hook-billed Kite (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Common Black-Hawk (BA)</td>
<td>Common Black-Hawk (BA)</td>
<td>√</td>
</tr>
<tr>
<td>White-tailed Hawk (BA)</td>
<td>White-tailed Hawk (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Ornate Hawk-Eagle (BC)</td>
<td>Ornate Hawk-Eagle (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Peregrine Falcon (BA)</td>
<td>Peregrine Falcon (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Guatemalan Screech-Owl (h) (BC)</td>
<td>Guatemalan Screech-Owl (h) (BC)</td>
<td></td>
</tr>
<tr>
<td>Buffy-crowned Wood-Partridge (BC)</td>
<td>Buffy-crowned Wood-Partridge (BC)</td>
<td></td>
</tr>
<tr>
<td>Crested Bobwhite (BA)</td>
<td>Crested Bobwhite (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Sunbittern (T) (BC)</td>
<td>Sunbittern (T) (BC)</td>
<td></td>
</tr>
<tr>
<td>Barred Parakeet (CN)</td>
<td>Barred Parakeet (CN)</td>
<td></td>
</tr>
<tr>
<td>Pheasant Cuckoo (BC)</td>
<td>Pheasant Cuckoo (BC)</td>
<td></td>
</tr>
<tr>
<td>Crested Owl (h) (BC)</td>
<td>Crested Owl (h) (BC)</td>
<td></td>
</tr>
<tr>
<td>Lesser Nighthawk (h) (BC)</td>
<td>Lesser Nighthawk (h) (BC)</td>
<td></td>
</tr>
<tr>
<td>Chestnut-collared Swift (BC)</td>
<td>Chestnut-collared Swift (BC)</td>
<td></td>
</tr>
<tr>
<td>White-necked Jacobin (T) (BA)</td>
<td>White-necked Jacobin (T) (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Canivet’s Emerald (T) (BA)</td>
<td>Canivet’s Emerald (T) (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Blue-throated Goldentail (T) (BA)</td>
<td>Blue-throated Goldentail (T) (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Cinnamon Hummingbird (T) (BA)</td>
<td>Cinnamon Hummingbird (T) (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Beryline Hummingbird (T) (BA)</td>
<td>Beryline Hummingbird (T) (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Acorn Woodpecker (BC, CN)</td>
<td>Acorn Woodpecker (BC, CN)</td>
<td></td>
</tr>
<tr>
<td>Yellow-bellied Sapsucker (BC)</td>
<td>Yellow-bellied Sapsucker (BC)</td>
<td></td>
</tr>
<tr>
<td>Chestnut-colored Woodpecker (BA)</td>
<td>Chestnut-colored Woodpecker (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Buff-throated Foliage-gleaner (BA)</td>
<td>Buff-throated Foliage-gleaner (BA)</td>
<td>√</td>
</tr>
<tr>
<td>Barred Antshrike (T) (BA)</td>
<td>Barred Antshrike (T) (BA)</td>
<td></td>
</tr>
<tr>
<td>Acorn Woodpecker (BC, CN)</td>
<td>Acorn Woodpecker (BC, CN)</td>
<td></td>
</tr>
<tr>
<td>Black Phoebe (CN)</td>
<td>Black Phoebe (CN)</td>
<td></td>
</tr>
<tr>
<td>American Dipper (CN)</td>
<td>American Dipper (CN)</td>
<td></td>
</tr>
<tr>
<td>Plain Wren (LF)</td>
<td>Plain Wren (LF)</td>
<td></td>
</tr>
<tr>
<td>Rufous-collared Robin (RR1) (CN)</td>
<td>Rufous-collared Robin (RR1) (CN)</td>
<td>√</td>
</tr>
<tr>
<td>Brown Jay (LF) *</td>
<td>Brown Jay (LF) *</td>
<td></td>
</tr>
<tr>
<td>Plumbeous Vireo (GU)</td>
<td>Plumbeous Vireo (GU)</td>
<td></td>
</tr>
<tr>
<td>Yellow-throated Warbler (BC)</td>
<td>Yellow-throated Warbler (BC)</td>
<td></td>
</tr>
<tr>
<td>Gray-crowned Yellowthroat (BA)</td>
<td>Gray-crowned Yellowthroat (BA)</td>
<td></td>
</tr>
<tr>
<td>Bananaquit (T) (BC)</td>
<td>Bananaquit (T) (BC)</td>
<td></td>
</tr>
<tr>
<td>Crimson-collared Tanager (LF)</td>
<td>Crimson-collared Tanager (LF)</td>
<td></td>
</tr>
<tr>
<td>Yellow-winged Tanager (LF)</td>
<td>Yellow-winged Tanager (LF)</td>
<td></td>
</tr>
<tr>
<td>White-collared Seedeater (LF)</td>
<td>White-collared Seedeater (LF)</td>
<td></td>
</tr>
<tr>
<td>Black-headed Saltator (LF) *</td>
<td>Black-headed Saltator (LF) *</td>
<td></td>
</tr>
<tr>
<td>Yellow-backed Oriole (LF) *</td>
<td>Yellow-backed Oriole (LF) *</td>
<td></td>
</tr>
<tr>
<td>Chestnut-headed Oropendola (LF)</td>
<td>Chestnut-headed Oropendola (LF)</td>
<td></td>
</tr>
<tr>
<td>TOTALS 27</td>
<td>16</td>
<td>31</td>
</tr>
</tbody>
</table>

Table notes: h – heard only; RR1 – Range-restricted (North Central American Highlands Endemic Bird Area); T – trapped; * Listed by Brough (1992) as being in either Zone 2 or 3 (i.e. habitats that span the park core and buffer zone). ** – caught in net, but escaped (i.e. not handled). BA – Buenos Aires area; BC – Base Camp area; CN – Cantiles area; GU – Guanales area; LF – La Fortuna (re: observations made by Andy Stronach during Unit 1).
Sunbittern

Canivet’s Emerald (♂)  Cinnamon Hummingbird

Blue-throated Goldentail (♂)  American Dipper
Although not new for the park (re: Brough 1992), a Northern Bentbill (a flycatcher) recorded from Buenos Aires this year was the first Opwall-based record for this species.

(c) Retrospective species addition to the Cusuco National Park list:
We have been informed that a male Great Curassow was seen (and photographed) by Joe Townsend (Opwall staff herpetologist) near Base Camp in 2004.

(f) Updated Cusuco avifaunal complements:
New species statistics for Cusuco Park are provided in Table 4 that shows that the park total has easily surpassed the 200 mark.

Table 4: Avifaunal statistics for Cusuco National Park:

<table>
<thead>
<tr>
<th></th>
<th>Park Core</th>
<th>Buffer Zone</th>
<th>Core + Buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004 inventory</td>
<td>94</td>
<td>103</td>
<td>185</td>
</tr>
<tr>
<td>2005 species additions</td>
<td>28 (27 + 1)</td>
<td>16</td>
<td>32 (31 + 1)</td>
</tr>
<tr>
<td>Updated inventory</td>
<td>122</td>
<td>119</td>
<td>217</td>
</tr>
</tbody>
</table>

Although the number of additions for the park core is quite substantial, approximately one third of these derive from observations made at La Fortuna, where clearance has permitted a range of open/mixed habitat species to colonize (e.g. White-collared Seedeeater). A further three species new to the core, had been recorded in the buffer in 2004. The remaining new species that have been recorded only from well forested core terrain, (and not from the buffer zone as yet), are as follows: Buffycrowned Wood-Partridge, Sunbittern, Pheasant Cuckoo, Crested Owl, Lesser Nighthawk, Chestnut-collared Swift, Yellow-bellied Sapsucker, Black Phoebe, American Dipper, Rufous-collared Robin, Yellow-throated Warbler, Plumbeous Vireo and Bananaquit. Of these, two – Sunbittern and Bananaquit – are surprise finds, since they are very much lowland forms (the altitude limit for both species is given by Howell & Webb [1995] as up to 1000m). However, the remaining species listed are all within their proscribed altitudinal ranges. With the exception of Rufous-collared Robin, all ‘finds’ are – with respect to their occurrence in Cusuco – well within their described distributional (migratory in the case of the sapsucker and warbler) ranges (Howell & Webb loc. cit.), and thus are not unexpected finds. Rufous-collared Robin is a North Central American Highlands endemic (re: Endemic Bird Area [EBA] 018) (Stattersfield et al. 1998), whose distribution is limited to the Chiapas-Guatemalan highlands, with breeding outposts in western El Salvador. Its occurrence in Honduras is unclear according to Howell & Webb (1995), and is given as “vagrant?”. Thus it is possible that the Cantiles sighting might represent the first definitive Honduran sighting! Homework to ascertain this awaits the team’s return to the UK.

There are no surprises amongst the 16 additions to the buffer zone inventory. Persistence in scanning for long periods from the balcony of the Ecolodge resulted in the addition of six raptor species (two of which have been added to the core list too), and mist-netting across a wider range of habitats yielded five additional hummingbird species.

(g) Hummingbird research – re: dissertation remits:
Morphological data on hummingbird data has been gathered now from 19 species (c. 270 birds), with most data pertaining to Violet Sabrewing, White-bellied Emerald, Azure-crowned Hummingbird, Green-throated Mountain-gem (a range restricted species [EBA018] [see above]) and Green Violetear. Around Base Camp, Green-throated Mountain-Gem was particularly prevalent, whilst at Buenos Aires White-bellied Emerald and Azure-crowned Hummingbird were the two most frequently encountered species.

Behavioural observations on hummingbird feeding adjacent to Base Camp took place at six sites (e.g. (i) opposite side of river from camp, (ii) Macrin’s clearing, (iii) along the Quetzal Trail) having concentrations of flowers (e.g. Heliconia, Hibiscus), with much data on Magnificent Hummingbird being gathered in addition to that on those species commented on in the previous paragraph. At
Buenos Aires, observations were made again across six sites (e.g. (i) within the confines of the village itself, (ii) adjacent to the Ecolodge (iii) start of the Waterfall Trail where trees with purple flowers (identification to be ascertained) were found to attract not only White-bellied emeralds and Azure-crowned hummingbirds, but also – on occasion – two Black-crested coquettes).

Overall, it appears that each of the species studied thus far are fairly catholic in their choice of flowers, and visit a range of species, both native and non-native. To some extent this finding mitigates against the hope that some species at least would be highly selective, with some – hopefully – some displaying sex-related preference differences. Nevertheless, this behavioural data when combined with the morphometrics has yielded a greatly enhanced picture of how the more prevalent ‘hummers’ are using resources in both the core and buffer zones of Cusuco. Of necessity, of course, most hummingbirds have no option but to use a variety of resources since flowers ‘come-and-go’, though it should be noted that many supplement their diet with insects.

White-bellied Emerald  Azure-crowned Hummingbird

Full details of the hummingbird work can be gleaned from the Operation Wallacea (combined) dissertation report that discusses fully both morphological and behavioural findings. Such discussions are not included in the Discussion below.

Discussion

The 32 additions made to the Cusuco National Park list in 2005 –bringing the inventory to 217 species – represent a 17% increase in the known avifaunal complement.

There are undoubtedly many more species to be documented for the very extensive buffer zone, that – as the enhanced 2005 complement for Buenos Aires (and even La Fortuna within the core zone) indicates – will be found to contain a plethora of lowland species (both forest-based and open habitat dwelling). Obviously the birds detected at Buenos Aires represent just a ‘snapshot’ of those that inhabit the entire buffer zone, and it is to be expected that with exploration of additional localities many more species will be added – perhaps as many as a 100 or more?

But with respect to the core zone it is felt now that we are aware of the great majority of forest-dwelling species (see below), though as noted earlier with regard to sightings at La Fortuna, widespread clearance at lower elevations in the park core (i.e. western sector) will only serve to enhance invasion by ‘buffer zone species’. In the higher eastern sector of the core, with which we are familiar, altitude itself serves to limit such invasion by many species. Nevertheless, there still remains one deficiency in our coverage. The elfin (dwarf) forest is very difficult ‘to bird’, and it seems likely that a full synthesis of the avifauna of that forest zone will only come about after a prolonged visit or visits.

As noted in our 2004 report, the core contains a distinct set of highland specialists, and even the abundant and ubiquitous Common Bush-Tanager has yet to be recorded at Buenos Aires just c. 400m lower than Base Camp. One such addition to the park list this year has been Barred Parakeet, with a sizeable flock being noted at Cantiles.
In this context, it is worth appraising the possible occurrence of additional EBA018 species within Cusuco. Table 5 shows all those relevant endemic species that have either been recorded to date or might conceivably be recorded in the future.

Table 5: Recorded and putative occurrence of North Central American Highlands EBA species in Cusuco.

<table>
<thead>
<tr>
<th>Species</th>
<th>Occurrence</th>
<th>Altitudinal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horned Guan</td>
<td>√</td>
<td>2000-3000m</td>
</tr>
<tr>
<td>Ocellated Quail</td>
<td>√</td>
<td>to 1000m</td>
</tr>
<tr>
<td>Fulvous Owl</td>
<td>√</td>
<td>1200-3000m</td>
</tr>
<tr>
<td>Green-throated Mountain-Gem</td>
<td>√</td>
<td>900-2700m</td>
</tr>
<tr>
<td>Wine-throated Hummingbird</td>
<td>√</td>
<td>1500-3500m</td>
</tr>
<tr>
<td>Blue-throated Motmot</td>
<td>√</td>
<td>1500-3000m</td>
</tr>
<tr>
<td>Rufous-browed Wren</td>
<td>√</td>
<td>1750-3500m</td>
</tr>
<tr>
<td>Rufous-collared Robin</td>
<td>√</td>
<td>1500-3500m</td>
</tr>
<tr>
<td>Bushy-crested Jay</td>
<td>√</td>
<td>600-2400m</td>
</tr>
</tbody>
</table>

TOTALS 9 3 7

Table note: Altitudinal ranges are taken from Stattersfield et al. (1998).

Appendix 1 shows those species appearing on the Brough (1992) list, but that have yet to be recorded by Opwall. It can be seen that of the 25 species tabulated, no less than 10 are Nearctic migrants that are either only just returning to (or passing through) Cusuco in late August as this report is being written, or have yet to reach Honduras. Turning to the other 15, the majority are species that have predominantly low altitude distributions. The five exceptions are Collared Forest-Falcon, Northern Flicker, Pale-billed Woodpecker, Sulphur-bellied Flycatcher (very similar to Streaked Flycatcher that has been seen and heard routinely) and Spotted Nightingale-Thrush, all of which have been actively looked for, but to no avail.

Significantly, the total number of species of hummingbird recorded from Cusuco is now 22 (>50% of those on the Honduran list!). Surprisingly, prior to Opwall’s involvement, only seven species of hummingbird were known to occur in the park!

As might be anticipated (see above), returning Nearctic migrants were relatively thin on the ground during the early weeks of the expedition, but during August no less than four species – Blackburnian Warbler, Yellow-throated Warbler (new for the park), Black-and-white Warbler and Louisiana Waterthrush – were met with.

In conclusion, this year’s fieldwork serves only to reinforce the major finding from 2004 that the core area of Cusuco National Park represents an important oasis/refuge for a range of highland/cloud forest specialists, including – as we know now – three EBA018 endemics, with Rufous-collared Robin possibly representing an addition to the Honduran avifauna. Although the buffer zone houses an equivalent number of species, many of these are wide-ranging lowland forms. In terms of conservation prioritisation, therefore, it is clear that Opwall’s current application for GEF funding is entirely appropriate, and, in the light of increasing encroachment on to the core in the north and west (e.g. evidence gathered by Opwall at Agua Mansa), undoubtedly timely.

Postscript
Ernesto Reyes will remain in Cusuco (Buenos Aires) for at least one further week beyond Unit 8, and thus further species may well be added to this year’s tallies. Therefore the summary statistics provided above should be regarded as provisional.
References


Ornithology Team

22/08/’05

Blue-crowned Chlorophonia (♂)
### Appendix 1: Bird species listed by Brough (1992), but yet to be recorded by Opwall.

<table>
<thead>
<tr>
<th>Species</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Resident/ Summer Visitor *</td>
</tr>
<tr>
<td></td>
<td>Nearctic Migrant</td>
</tr>
<tr>
<td>Collared Forest-Falcon</td>
<td>✓</td>
</tr>
<tr>
<td>Yellow-billed Cuckoo</td>
<td>✓</td>
</tr>
<tr>
<td>Lesser Roadrunner</td>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Northern Flicker</td>
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</tr>
<tr>
<td>Pale-billed Woodpecker</td>
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</tr>
<tr>
<td>Sulphur-bellied Flycatcher</td>
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</tr>
<tr>
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</tr>
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<td>Yellow-rumped Warbler</td>
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<tr>
<td>Hooded Warbler</td>
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<td>Passerini’s Tanager</td>
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<td>Olive-backed Euphonia</td>
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<td>Golden-hooded Tanager</td>
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<td>Red-legged Honeycreeper</td>
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<td>Rose-breasted Grosbeak</td>
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<tr>
<td>Indigo Bunting</td>
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<tr>
<td><strong>TOTALS</strong></td>
<td><strong>25</strong> <strong>15</strong> <strong>10</strong></td>
</tr>
</tbody>
</table>
2. The co-evolution of hummingbird bill morphology and floral structures with regard to both native and non-native species.

Francine Kershaw* and Mary-Anne Collis**

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Expected date of project submission: March 2006

Introduction
The Cusuco national park was founded in 1987 in the Merendon mountain range of NW Honduras. The 7 690 Ha core zone consists of a combination of secondary pine forest and mixed broadleaf forest with some dwarf forest at high altitudes. Surrounding this is a 15 750 Ha buffer zone containing semi urban areas and agricultural land. This striking habitat contrast allows for much needed research on the effects of disturbance in areas of cloud forest indicating the necessity of protected areas.

The park is rich in bird diversity, in particular hummingbird species as half the total species of Honduras can be found within the park. Hummingbirds show remarkable variation in bill morphology and overall body size, both of which are apparent in this study area. Darwin (1876, as cited in Temeles 1996) declared that, “[the] beaks of hummingbirds are specifically adapted to the various kinds of flowers they visit”. There has been research both in support of and against this theory; however, little research has been conducted on the utilization of introduced species where co-evolution could not have occurred.

Aim 1: To find a correlation between hummingbird bill morphology and floral structures.
Aim 2: To find if the correlations are conserved across both native and non-native flowering plants.

Methodology
Mist Netting
Bird morphology data was collected using three mist net sites covering different habitat types.
Site 1-Base Camp: Closed canopy, broad leaved forest occupied by a static and characteristic hummingbird population. Although previously an area of logging in the 1930’s and 40’s, in recent years it has remained relatively undisturbed and now serves as a quiet visitor’s centre for tourists.
Site 2-Las Minas: Semi-open canopy, coniferous forest with a dynamic, slightly distorted population as it is a low ridge between two valleys and is used as a corridor for movement.
Site 3-Buenos Aires: Semi-urban area containing a high concentration of non-native flower species grown for ornamental purposes and surrounded by agricultural plantations. A disturbed bird population is therefore in existence.

Bird Morphology Data
The following measurements were taken for each individual hummingbird:
Wing length: Millimetre ruler used to measure wing chord (cannot use data if longest primary feather undergoing moult).
Total length: Millimetre ruler used to measure the distance from tip of bill to end of tail feathers (cannot use data if the tail is undergoing moult).
Weight: Taken to the nearest 0.1g using digital scale in combination with a cone to hold the bird. The data cannot be analysed due to temporal weight changes.
Bill length: Distance from bill to feathering recorded to the nearest 0.1 mm using dial callipers.
Bill curvature: The bill was placed on 2 mm graph paper so that the straight part of the bill nearest the head was in line with the first 6 mm. The deflection of the tip of the bill from the line was then measured to the nearest 0.5 mm.
The birds were also aged and sexed using the British Trust for Ornithology (BTO) official standards involving the stages of moult, bleaching of feathers, wear and tear of feathers and presence of a brood patch. Many species could not be identified with respect to sex due to monomorphic plumage. A small notch was made in the outer tail feather to ensure a previously caught bird was not processed twice.
**Site Observations**

Spot observations were undertaken at twelve sites, six surrounding Base Camp and six within the village of Buenos Aires. Sites for spot observations were chosen randomly in patches of high flower concentration. Each of these sites were tested for two hours, if this proved successful a further ten hours at Base Camp were conducted. Due to repeated data this was reduced to a total of six hours in Buenos Aires.

At each site the following data was recorded:
- Species of bird
- Sex of bird
- Time of arrival
- Species of flower
- Height of flower in canopy
- Weather – including temperature, cloud cover, wind speed and precipitation.

Originally the number of flowers visited and average length of time at each flower was recorded. However, this was deemed unnecessary and in some cases unreliable.

**Site Descriptions**

Preliminary habitat analysis was performed using the Domin Scale (Kent and Coker, 1992) to estimate the percentage cover occupied by the flowering plants utilized. The area of each site was estimated along with the canopy cover and the number of other flowering species present but not utilized by the birds. Panoramic site photographs were taken and labelled according to compass direction.

**Flower Morphology**

At least 10 flowers of each species were collected and the following measurements taken for each individual flower using dial callipers to the nearest 0.01 mm:
- Width of aperture leading to nectaries
- Height of aperture leading to nectaries
- Length from aperture to nectaries

The flower was then measured by placing it on a scale background and photographs were taken with the view to calculate curvature in concordance with hummingbird bill curvature (see Bird Morphology Data).

The identification of the flower species has proved difficult within the field and will require further research back in the UK.

**Results**

Initially, the composition of hummingbird species between the three mist net sites was compared. The most abundant species was given the value 100 and the data was transformed for the remaining species so that it represents a proportion of this value. An example can be seen in Table 1.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of individuals</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTMG</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>VSW</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>GVE</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Mag</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Stripe T</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32</strong></td>
<td></td>
</tr>
</tbody>
</table>
For each site a histogram of the data was constructed to show a graphical species comparison (see Graphs 1, 2 and 3).

Graph 1: Species composition at Base Camp mist net site

Graph 2: Species composition at Las Minas mist net site
A second comparison was then investigated using data from the spot observations. The number of flower species visited by each hummingbird species was calculated and then a histogram produced (see graph 4).

In relation to this, the number of hummingbird species utilising each flower species was also compared using a histogram (see graph 5).
Discussion
From the preliminary findings shown in graphs 1, 2 and 3 it is apparent that Base Camp (graph 1) and Las Minas (graph 2) are very similar in terms of composition. Although the 4 main species (Green-throated Mountain-gem, Violet sabrewing, Green violet ear and Magnificent) are identical Las Minas is much richer in diversity with twelve species as apposed to the five found at Base Camp. This may be due to different habitat vegetation in each of the valleys in Las Minas and so increasing the number of species of hummingbirds moving across the ridge.

The data from Buenos Aires (graph 3) portrays a completely different composition of species than that of Base Camp and Las Minas. Here, the White-bellied emerald and Azure crowned are the primary species with the Green-throated Mountain-gem contributing very little to the proportion of the data. The number of species found in Buenos Aires (14 species) is comparable to that of Las Minas (with 12) although there is not a complete species overlap.

It is interesting to find such diversity in a disturbed area however due to the high concentration and diversity of flowers grown there, there exists many niches for a variety of species to occupy. General observations of the plantations have given the impression that competition for food is much higher with a greater interaction of different hummingbird species over the same food source (generally established, flowering trees that have preserved within the plantation).

The Green-throated Mountain-gem is an endemic species to the area, which may account for its change in distribution between Las Minas and Buenos Aires. This could be a result of a closer evolutionary relationship between itself and the endemic plant species in the area leaving it more sensitive to disturbance.

Graph 4 shows how some hummingbird species are more generalist by feeding on a wider range of plant species and how some seem to be more specialized to one or two species. This may correspond to the curvature of the bill as theory suggests a straighter bill will allow for utilization of a greater number of species whereas a significantly curved bill may limit the bird’s feeding options.

Surprisingly from graph 5, showing the number of hummingbird species utilizing each flower species, one can conclude that introduced species are fed on by many more hummingbird species than the native flower species. For example, the introduced Big red hibiscus was seen to be visited by 6 different species of hummingbird as opposed to the native Bromeliad which was only utilized by one. Possibly the structure of the non-native flowers allow for a greater variety of bill dimensions than those that have evolved closely with the hummingbirds.
Future Plans
To calculate bill and flower curvature with regards to previous research.
To compare bill morphology and flower morphology via the use of correlations, regressions and t-tests (or other non-parametric equivalents).
Using the data from this we can determine possible co-evolution between native floral species and hummingbird species.
To find if the hummingbird species are specializing or generalizing in the buffer zone with respect to their bill morphology.

References


Introduction
The rainforest regions of Honduras support a diverse mammalian assemblage, including both Central American endemics and taxa with predominantly South American or North American distributions. More than 180 terrestrial mammal species have been recorded from Honduras to date (Reid, 1997). However despite the biogeographical significance of the Central American land bridge, relatively few surveys have as yet been undertaken within Honduras. Voss and Emmons (1996) described the country as 'a crucial sampling gap’ within the Neotropics and highlighted Honduras as priority area for future surveys of mammalian diversity.

There is a clear need for further study in order that conservation concerns relating to both individual species and Cusuco National Park as a whole may be addressed in an informed manner. Status assessments for selected taxa aid the prioritisation of areas for conservation, and support arguments for extra protection or attention from local governing bodies and international conservation organisations. Such information therefore enables resources to be targeted where they can be most useful and/or are most needed. Small mammal species are a particularly good subject for study as they are relatively easy to trap, give a good indication of the overall ecosystem productivity and fulfil key roles as predators of invertebrates, pollinators for flowering plants and dispersers of seeds, as well as forming a large part of the diet of carnivorous mammals, birds and snakes (e.g. see Reid, 1997 and Emmons & Feer, 1997). Primary highlands such as Cusuco are of particular interest and may contain endemic species or restricted range small mammal species of conservation value in their own right.

The Cantiles Study Area
The Cantiles study area was established at the beginning of the 2005 study season. The site is two to three hours walk from Base Camp (approximately 5 km), within primary broadleaf forest well inside the core zone of Cusuco National Park. In addition to being the most pristine of the Operation Wallacea field sites, it is also the highest, at approximately 1800m.

Figure 1. Sketch map of Cantiles study area
Methods
Survey work conducted within the Cantiles study area between units 2 and 8.

40 small mammal traps plus eight larger cage design traps for carnivores were available for this study. These traps were spaced at minimal intervals of 20m apart within different areas of the site. Due to the considerable rainfall experienced in the core zone it was necessary that the traps were provided with a waterproof shelter; these were constructed using hardboard roofs and wooden sticks. The larger traps were baited with either fresh chicken or tinned tuna; the small mammal traps were baited using a mixture of granola cereal and peanut butter. Occasionally this was supplemented with fresh plantain, when supplies allowed. Traps were checked in the early morning and then closed for the day. They were reopened again in the evening when they were also re-baited. In order to maximise the range of localities surveyed traps were set for periods of no more than eight days before they were moved to a new location within the study site.

Morphological Data Collection
Captured animals were gently shaken into a transparent plastic bag to ensure they did not escape whilst being removed from the trap. This also minimized handling and allowed for identification, examination for markings etc. If the individual had not been encountered before, it was removed from the bag for closer examination and for measurements to be taken. Gloves were worn to reduce the risk of bites. Each individual captured was identified to species, measured, weighed, and given a unique hair clip (Figure 2) for use in recapture analyses before release at their site of capture. In addition, the date, site, trap location, and weather conditions the previous night were also recorded.

Active opportunistic censuses were conducted when time and manpower allowed. These searches comprised of small groups of people walking quietly along forest trails, noting any mammals or sign observed.

Figure 2: Hair-clip pattern used to identify recaptured animals
## Results

Table 1. Mammal species positively identified within Cantiles study area.

<table>
<thead>
<tr>
<th>Order</th>
<th>Family / Subfamily</th>
<th>Species</th>
<th>English</th>
<th>Method of Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didelphimorphia</td>
<td>Didelphidae</td>
<td><em>Didelphis marsupialis</em></td>
<td>Common opossum</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Dudelphis virginiana</em></td>
<td>Virginia opossum</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Marmosa robinsoni</em></td>
<td>Robinson’s mouse opossum</td>
<td>C</td>
</tr>
<tr>
<td>Primates</td>
<td>Cebidae</td>
<td><em>Alouatta palliata</em></td>
<td>Mantled howler monkey</td>
<td>V</td>
</tr>
<tr>
<td>Rodentia</td>
<td>Sciuridae</td>
<td><em>Sciurus variegatoides</em></td>
<td>Variegated squirrel</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>Heteromydae</td>
<td><em>Heteromys desmarestianus</em></td>
<td>Forest spiny pocket mouse</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Peromyscus mexicanus</em></td>
<td>Mexican deer mouse</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>?</td>
<td>Grey deer mouse</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Scotinomys teguina</em></td>
<td>Alston’s singing mouse</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Erethizontidae</td>
<td><em>Coendou mexicanus</em></td>
<td>Mexican porcupine</td>
<td>S</td>
</tr>
<tr>
<td>Carnivora</td>
<td>Procyonidae</td>
<td><em>Potos flavus</em></td>
<td>Kinkajou</td>
<td>O</td>
</tr>
<tr>
<td>Perissodactyla</td>
<td>Tapiridae</td>
<td><em>Tapirus bairdii</em></td>
<td>Baird’s tapir</td>
<td>S</td>
</tr>
<tr>
<td>Artiodactyla</td>
<td>Tayassuidae</td>
<td><em>Tayassu tajacu</em></td>
<td>Collared peccary</td>
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<tr>
<td>Cervidae</td>
<td></td>
<td><em>Odocoileus virginianus</em></td>
<td>White-tailed deer</td>
<td>S</td>
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</table>

Additional mammals noted in Cusuco National Park, but not recorded in other site reports.

<table>
<thead>
<tr>
<th>Order</th>
<th>Family / Subfamily</th>
<th>Species</th>
<th>English</th>
<th>Site</th>
<th>Method of Identification</th>
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</thead>
<tbody>
<tr>
<td>Rodentia</td>
<td>Heteromydae</td>
<td><em>Reithrodontomys fulvescens</em></td>
<td>Fulvous harvest mouse</td>
<td>Base Camp</td>
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<tr>
<td>Carnivora</td>
<td>Mustelidae</td>
<td><em>Mustela frenata</em></td>
<td>Long-tailed weasel</td>
<td>Near Base Camp</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Spilogale putorius</em></td>
<td>Spotted skunk</td>
<td>Near Buenos Aires</td>
<td>O</td>
</tr>
</tbody>
</table>

Method of Identification / Type of contact
C  Captured
O  Observed
S  Spoor
V  Vocalisation
Table 2. Small mammal captures from 605 trap nights (621 – 16 closures)

<table>
<thead>
<tr>
<th>Trail</th>
<th>No. capture(s)</th>
<th>H. desmarestianus</th>
<th>P. mexicanus</th>
<th>M. robinsoni</th>
<th>‘Grey’ Deer mouse</th>
<th>S. teguina</th>
<th>Total</th>
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</thead>
<tbody>
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<td>144</td>
<td>17</td>
<td>12</td>
<td>3</td>
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<td></td>
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<tr>
<td>Rosita</td>
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<td>54</td>
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</tbody>
</table>

The forest spiny pocket mouse *H. desmarestianus* was the most frequently encountered species at each location surveyed within the Cantiles area. *P. mexicanus* was also trapped regularly, but interestingly never at the Baño trail site, the most modified and ‘busy’ of the trails. Two female *M. robinsoni* were captured during the first week of trapping, this species was not encountered again throughout the remainder of the season. *S. teguina*, a species associated with conifer forest (Apps, 2004) was captured most frequently on the Rosita trail, specifically on a ridge dominated by pine trees.

In addition to the small mammals species trapped, a number of larger species were observed during the season. These included common and Virginia opossums, both widespread throughout the park, and spoor of Baird’s tapir, collared peccary and white-tailed deer. Tapir spoor was encountered particularly frequently. Four previously unrecorded (at least by opwall teams) larger mammals were noted by this study (Freer, 2003), the Mexican porcupine and kinkajou were both encountered within the Cantiles study area, and the long-tailed weasel and spotted skunk were seen close to the Base Camp and Buenos Aires sites respectively. Each of these species are highly charismatic, and the kinkajou in particular may potentially fulfil the role of ‘flagship species’, i.e. be used to generate favourable public attention (Meffe and Carroll, 1997; Simberloff, 1998).

As a final note, a number of nine-banded armadillos *Dasypus novemcinctus* were noted in the Buenos Aires village, where they were being kept before being sold on for meat. As has been noted in the 2005 primate report (Snarr, 2005), the hunting of wildlife within the park, particularly mammals, represents a very real threat to many species and needs to be addressed by any future management plans.

References

Apps, M. 2004. comparison of small mammal populations from broadleaf and conifer forest types within the Cusuco core zone. Unpublished BSc dissertation, Bangor University.


Kinkajou *Potos flavus*  Photo credit Dedy Muldiana

Spotted skunk *Spilogale putorius*  Photo credit Joe Nuñez

Nine-banded armadillo *Dasypus novemcinctus*  Photo credit Joe Nuñez
2. Small Mammal Report, Base Camp Surveys

Dr. Kimberly Williams-Guillén, New York University, USA
2005 Field Season, Units 4 – 8.

Background
Beginning in 2003, scientists affiliated with Operation Wallacea began studies of mammalian diversity and abundance in Parque Nacional El Cusuco. These surveys play an important role in the biodiversity surveys underlying grant proposals and management schemes for the area. Forested areas near Base Camp were sampled for mammals in 2004 as part of dissertation projects. This report details small mammal sampling conducted in and around Base Camp in Units 4 – 8, under the supervision of Kim Williams-Guillén and Mandy Apps.

Aims and Objectives, 2005 Season
In light of the extensive sampling that occurred in the vicinity of base camp in 2004, our primary aim in 2005 was to increase the species list for the core zone area surrounding base camp, rather than to generate a species list from scratch, or determine population sizes.

Study Sites and Methods
Unless otherwise noted, methods are as described in the general small mammals report. We began using granola as bait, but after about a week began mixing in peanut butter, as it made it more difficult for ants to carry off the bait. (Also, it was much tastier that way.)

Study Site 1: Pine forest approximately 10 minutes walk from the camp, after the disused shower block and near a campsite (a.k.a. “Old Bathroom Forest”). We placed traps along two perpendicular transects in this area, separated by approximately 5 meters, and also in a 16-trap grid array. The primary purpose of this sampling was to train the dissertation students in methods before they began data collection. We also placed a few larger traps nearby, baited with old chicken bones, cheese, or “Spam.”

Study Site 2: A matched pair of shade coffee plantation and a secondary pine/broadleaf forest. The coffee plantation is known as Finca Los Dragos and is a 45 min walk from Base Camp over rough terrain. We ran two 49-trap grids simultaneously at the two sites for a 5-night period, as part of sampling for the two dissertation students’ research contrasting mammals in shade coffee and secondary forest fragments. Because of the distance from Base Camp and the steepness of the terrain in the forest site, we minimized trips into the area by checking traps and rebaiting them at the same time. Traps were checked the in early afternoon, and rebaited immediately. Following Reid (1997), we also placed a large piece of carrot or potato in each trap, as a water source for any animal in the trap. Having traps open during the day could result in captures of birds; however, there was only one bird trapped during the 5-day run. In spite of the potential risk of dehydration, we had no mortalities and several recaptures, indicating that the animals did not suffer unduly in spite of their longer periods of captivity (although a couple of larger individuals were lethargic upon release).

Study Site 3: We placed two 30-trap transects along the already existing trails of Las Minas and Quetzal. Traps were separated by 10 m, and placed on the ground or, when possible, in trees. Ground traps were baited with peanut butter and granola, tree traps with the same or with ripe fruit. We also placed some larger traps opportunistically at the ends of the transects and baited these with egg or plantain. The goal of this sampling procedure was to record species not normally recorded by the regular grid sampling procedure.

Study Site 4: Macrin’s garden and a nearby broadleaf forest site. We placed a 25-trap grid at each location. Macrin’s was the capture site last year of an unidentified rat, and as they grow a small amount of coffee, sampling there is complimentary to the work undertaken by the two dissertation students. No morphometric data taken due to lack of equipment (in Buenos Aires for dissertation students). Sampling here was sporadic and depended on the presence of interested schools students to assist in trap placement and baiting.
Results
Species Captured (see Appendix I for dates, details, morphometrics)

- Virginia opossum, *Didelphis virginiana*
- Mexican mouse opossum, *Marmosa mexicana*
- Forest spiny pocket mouse, *Heteromys desmarestianus*
- Unidentified long-tailed shrew, *Sorex* sp. (from pit traps)
- Merriam’s small-eared shrew, *Cryptotis merriami* (from pit traps)
- Alston’s singing mouse, *Scotinomys teguina*
- Slender harvest mouse, *Reithrodontomys gracilis*
- Mexican deer mouse, *Peromyscus mexicanus*
- “Grey” deer mouse, *Peromyscus* sp.
- Gray fox, *Urocyon cinereoargenteus*

Species Observed

- Common opossum, *Didelphis marsupialis*
- Variegated squirrel, *Sciurus variegatoides* (observed brown with grey tail morph)
- Deppe’s squirrel, *Sciurus deppei*

Species Sign Observed (scat, tracks, dens, etc.)

- Nine-banded armadillo, *Dasypus novemcinctus*
- Northern raccoon, *Procyon lotor*
- White-tailed deer, *Odocoileus virginianus*

Discussion

Regular trapping with the small wire traps and larger medium-sized mammal traps did not reveal the presence of any species new to the park, although the existence of an undescribed “grey” deer mouse was confirmed. Two dead shrews recovered from the herpetology pit traps were of the genus *Sorex* and most probably represent a new species. (As *Sorex* species are differentiated based on skeletal and dental characteristics, it is difficult to determine based on field investigation of external characteristics.)

In my opinion, future research on mammalian biodiversity in the core zone around Base Camp could take a lower priority to similar research at satellite camp sites, as this area has been well-surveyed at this point. However, a number of measures could be taken to increase the confirmed species list for the area surrounding Base Camp. If any new species are to be detected, new methods must be adopted – baiting ground traps with granola has brought in everything that it’s going to bring! Increased use of the larger traps, with either bait more appropriate for capturing carnivores (e.g., *fresh meat*) or with varied bait aimed at larger frugivores (agoutis, pacas, etc.) should confirm the existence of several expected species. Although traps placed in trees have not yet been successful they should be continued as there is a higher chance of capturing unrecorded species – particularly if the baits used are varied beyond grains. Placement of sand traps and camera traps in key areas would also increase recorded species; these latter activities could potentially be of interest to and incorporate larger numbers of school students.

References

## Appendix 1

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*Guanales*: Sharon's mystery mouse
3. Small Mammal Report, Guanales Survey
Sharon Hodge, Edinburgh University

Introduction
Guanales is a flycamp situated on the edge of the core zone of Cusuco National Park, Honduras and is at an altitude of 1350m. The forest in the area varies from secondary palm to undisturbed primary forest and there is also some disturbed primary forest. In the 2005 season small mammal trapping was carried out in a number of areas around the Guanales Camp using small and medium sized mammal traps. Grid sites were used which contained 49 traps, to determine population density, for five of the eight weeks of the season. Opportunistic traps were set in various areas around camp to study the arboreal species.

Method
Small mammal traps were utilised, baited with either granola cereal or crushed peanuts, to trap the mice. The trap sites used were the same as used the previous year; the marking tape was renewed before trapping began, Figure 1. The traps were placed in a 7x7 49-trap grid system with traps placed 7m from one another. Traps and trap sites were labelled with a number and a letter (A-G and 1-7) to allow ease of processing. In addition, each trap was placed under a shelter constructed from a piece of hardboard held above the trap by sticks and string to reduce the volume of rainwater entering the trap.

Traps were baited between 3 pm and 5 pm each day, and then checked between 6 am and 7.30 am the next morning. The number of traps closed without a mouse trapped inside was counted and any traps remaining open were closed to prevent mice entering during the day.

Any small mammals caught were taken to a designated processing area and the cages covered with an assortment of leaves to reduce stress levels. One by one, the mice were processed by shaking them into a plastic bag (for ease of handling), weighed and then picked up by the scruff of the neck for the other measurements to be taken (sex, status, body length, tail length, hind leg length, forearm length and ear length). Gloves were used throughout to reduce the risk of being bitten by the mouse; only the small mammal staff member handled the mice caught.

The trap number was recorded for each mouse caught for use in recapture analyses. A hair-clip method was used to identify recaptured animals.
The data were analysed using the Jolly-Seber test for open population density estimations and included all species trapped:

\[ N_i = \frac{(n_i + 1)m_i}{m_i + 1} \]

where: \( N_i \) = population size at period \( i \), \( n_i \) = total number of animals (marked and unmarked) caught in period \( i \) and \( m_i \) = number of marked animals caught in the sampling period \( i \).

There are several assumptions to this model which are made and can be justified in this study. The assumptions are that every animal present in the population at sample period \( i \) has the same probability of capture, that every marked animal has present in the population has the same probability of survival as the unmarked animals, marks are neither lost nor overlooked and all sample are instantaneous and release immediately follows sampling. The morphometric data taken can be stored for later comparisons with future year’s data or for size comparisons with other populations of the same species.

Some traps were tied onto fallen trees with string and baited with granola and peanut butter mix, a change in bait was required to remove the possibility of dry granola being lost from the trap whilst it was being set up. The traps were not placed more than head-height above the ground (2m) since there was the possibility that an animal caught may chew through the string and the trap could potentially fall to the ground and injure the trapped animal. It was assumed that the farther the trap could fall the more damage the trapped animal could suffer. Also, setting traps any higher may endanger the person setting the trap. These traps were waterproofed using half a ziplock bag to cover the top (with holes cut out for the trap mechanism) and tied to the cage with string. Medium sized mammal traps were set opportunistically and baited with a variety of foodstuffs, from chicken bones and tuna to fruit and granola.

Species List
Spiny Pocket Mouse (Heteromys desmarestianus)
Mexican Deer Mouse (Peromyscus stirtoni)
Alston’s Singing Mouse (Scotinomys teguina)
Vesper Rat (Nyctomys sumichrasti)
Mexican Mouse Opossum (Marmosa mexicana)
Merriam’s small-eared shrew (Cryptotis merriami)
Alfaro’s Rice Rat (Oryzomys alfaroi group)
Variegated Squirrel (Sciurus variegatoides)
Nine-banded Armadillo (Dasypus novemcinctus)
Central American Agouti (Dasyprocta punctata)
Collared Peccary (Tayassu tajacu)
Unidentified Arboreal mouse (Specimen taken in unit 5, also see Figure 2)

Figure 2: Photographs of the unidentified species of mouse
Grid Results
Site 1 (Timbo Hill: Primary broadleaf with 60% canopy cover and 40% vegetation cover)
14 animals in total:
7 Spiny Pocket Mice
5 Mexican Deer Mice
1 Alston’s Singing Mouse
1 Unidentified Species
Average of 9 traps closed by means other than a mouse per night, success rate of 82%
Population Density estimate of 13 mice per grid area (42m²)

Site 2 (Pre-Timbo/Timbito junction: Primary broadleaf with 80% canopy cover & 50% vegetation cover)
16 animals in total
8 Spiny Pocket Mice
7 Mexican Deer Mice
1 Alston’s Singing Mouse
Average of 5 traps closed by means other than a mouse per night, success rate of 90%
Population Density estimate of 14 mice per grid area (42m²)

Site 3 (Venado: Primary broadleaf with 80% canopy cover and 60% vegetation cover)
14 animals in total
8 Spiny Pocket Mice
3 Mexican Deer Mice
2 Alston’s Singing Mice
1 Mexican Mouse Opossum
Average of 9 traps closed by means other than a mouse per night, success rate of 82%. One night saw 24 closures, success rate of 52%
Population Density estimate of 12 mice per grid area (42m²)

Site 4 (Post-Timbo/Timbito: Primary broadleaf with 70% canopy cover and 55% vegetation cover)
9 animals in total
7 Spiny Pocket Mice
1 Mexican Deer Mouse
1 Alston’s Singing Mouse
Average of 8 traps closed by means other than a mouse per night, success rate of 84%
Population Density estimate of 8 mice per grid area (42m²)

Site 5 (Base Camp Trail: secondary broadleaf palm forest with 65% canopy cover and 25% vegetation cover, with some grassy areas)
8 animals in total
7 Spiny Pocket Mice
1 Alston’s Singing Mouse
Average of 3 traps closed by means other than a mouse per night, success rate of 95%. One night saw 21 closures, success rate of 58%
Population Density estimate of 6 mice per grid area (42m²)

Conclusions
The forest area around Guanales is host to a variety of small mammal species, both terrestrial and arboreal. The population densities vary with habitat type and vegetation cover in the way that fewer mice are found in areas with less vegetation. Trap success (i.e. how many traps could in theory trap a mouse) varied from 50% up to 95%, however the majority of nights saw success rates of greater than 80% which is an acceptable level. There are larger mammals about including peccary, agouti, armadillo and according to our guides Guanales was also the subject of attention by a variety of larger carnivores.
**Further Study**
The small mammal grids should be run in the same areas next year to monitor population levels and species diversity. In addition, more arboreal traps should be set possibly using wire to tie to the trees so there is no chance of the animal chewing through the ties.
4. Final report: Mammals in Buenos Aires

Mandy Apps, 2005

The main aim of the terrestrial mammal work in BA during the OpWall 2005 season was to increase the species list for the region. Minimal terrestrial mammal trapping/observations were undertaken previously. 4 small mammal trapping grids run in 2004, resulting in 9 individuals of 3 species being caught: *Liomys salvini* (Salvin’s Spiny Pocket Mouse), *Rattus rattus* (Roof Rat) and *Didelphis marsupialis* (Common Opossum). Grids were placed in a range of agricultural and secondary forest sites around the village in an attempt to survey as many different habitats as possible. Additional work with two dissertation students (Sophie Fidoe and Tom Roberts) compared the value of shade coffee plantation for terrestrial mammals compared to remaining forest fragments. Work this season resulted in 11 species being caught in small traps, plus one additional species trapped with larger traps. One further unidentified taxon was caught; this is one of the unidentified taxa from the 2004 season, similar to *P. mexicanus* but smaller and with a greyish rather than brownish fur colour. Two additional species were observed but not trapped (*Nyctomys sumichrasti* and *Dasypus novemcinctus*). Investigations revealed a number of potential sites which it would be beneficial sample next year. These include regenerating conifer forest and broadleaf areas and coffee plantations of all ages.

**Methodology**

Areas with minimum size 56m x 56m containing a 7 x 7 trap station grid with 7m trap spacing surrounded by a 7m buffer zone were prepared. The sites were within 45 minutes trekking of Buenos Aires. Grid sites were selected to reflect the range of disturbed habitats around the village: shade and sun coffee plantations and secondary forest sites. At each site co-ordinates and altitude were obtained using Global Positioning System.

49 live traps were positioned in each grid; paths were trampled/cut with a machete along the lines of the grid to enable access to the traps and aid relocation; these quickly grow over in the warm, wet conditions. Each trap station was marked with flagging tape with the station reference (A1, A2 etc) to allow reference and relocation. Traps were placed in a suitable flat position within a 1m radius of the trap station. Each trap was protected from the rain by a ply board rectangular roof, resting upon the roof of the trap with holes drilled to enable correct positioning without interfering with the mechanism. ‘Freya’ traps were used; these are aluminium cage design mouse traps made in China (320mm x 173mm x 140mm) similar to the better-known Tomahawk traps. The trap shelter design has been modified since last year with assistance by Tim Pickman, Bootham School. This seems to be work well. The new design removes the need for the two sets of sticks used to support the roofs last year. After 1st August when the two dissertation students were working in BA different shelters was utilised. This works in the same way but thin plastic sheeting is used in place of the wooden board.

Traps were positioned, baited and set each evening just before dusk. Leaves were used to line the base inside the traps, particularly the treadle and wide metal strip at the front. Bait was placed on the treadle. During the first few weeks only salted peanuts and cornflakes were available. Use of salted peanuts was minimised due to the risk of dehydration. After the 1st August peanut butter and Granola, an oat-based cereal, were used in preference. Each morning the traps were checked; empty traps were closed for the day to reduce captures of non-target species, mainly birds and domestic animals. Captured mammals were gently shaken into a transparent plastic bag to ensure they did not escape while being removed from the trap. Thick leather gardening gloves were worn to reduce the risk of bites.
Data collected from each capture:

Date
Site
 Trap station reference
Weather conditions during the previous night (dry, a few hours of rain, or heavy prolonged rain)
Species identified using Reid (1997).
Body weight (g) measured using a portable spring weigh scale, maximum 100g.
Sex
Age
Reproductive status
Head/body length (cm)  measured using a 30 cm rule.
Tail length (cm)
Left rear foot length (cm)  measured using callipers.
Left front arm length (cm)
Left ear length (cm)
Identification hair clip given using safety scissors/observed (Figure 1). Allocated code letter(s) was also drawn on the underside of the body using red non-toxic marker pen (Merkens, 1998).
Photograph taken from first capture of each species.

Figure 1: Position of hair clips used to identify recaptured individuals.

Nine positions were used in three rows of three positions along the back of the animals’ body. A small amount of fur was cut close to the skin at position A for the first individual of each species. The second individual of this species was given a fur clip at B. Once all nine positions had been allocated a combination of two fur clips was used, for example AB, AC, AD. Each species was given fur clips beginning from single positions A to I.

In those individuals that had scars or other marks on their body resembling fur clips, this mark was made into a clear fur clip and used as part of the combination.

Marked animals were released within one meter of capture. Any food, faeces or ant nests were removed from the traps before they were repositioned, re-baited and reset each evening. Each grid was run for five continuous nights.
Additionally medium traps and small traps were placed opportunistically in places which have not been surveyed previously. Bait used in these includes fruit, chicken bones and peanut butter mixed with cornflakes or oats.

Sophie Fidoe and Tom Roberts have processed the data for those grids they were involved with. Kimberly Williams-Guiller ran the grids with Sophie and Tom for part of August and also undertook interviews with the owner/manager of each grid site.

**Results**
A species list for each site is present in appendix 1. The main species were *H. desmarestianus*, *P. mexicanus* and *S. teguina* in both coffee and forest sites.

Raw data is present in appendix 2. The average number of species caught in forest sites (3 surveyed) was 3 compared to 2 species on average in all of the various coffee sites (7 surveyed). The figure remains the same for the coffee sites if the two grids which were only run for two nights are excluded. The total number of species caught in all three of the forest sites was 7. 8 species were caught in the five coffee sites run for the full 5 nights, and 6 species considering only the three sites run consecutively with forest sites. The number of trap nights available in sites run for the full five nights was 535 for the forest and 904 for the coffee sites. The Shannon-Weaver Index for the five coffee plantations ranged from 0.000 to 1.168, total 1.744; values for the three forest grids vary from 0.859 to 0.950, total 1.688. The three coffee plantations paired with forest grids had an Index of 1.530.

The mean number of individuals caught over the five nights in forest grids was 15 compared to 7 individuals in the coffee sites (9 individuals excluding the two sites run for only two nights). The mean trap success in the forest grids was 13% compared with 6% in the coffee grids. Considering only those coffee sites which were paired with forest sites, 25 individuals were caught in the coffee sites compared to 45 in forest sites.

**Additional work**
4 medium traps were set at Base Camp on Saturday 2nd and Sunday 3rd July:
Two traps were baited with rotten egg and two with shrew mortalities from the herp traps. Rotten egg bait resulted in capture of a *Urocyon cinereoargenteus* (Gray Fox) on Saturday 2nd July. N 15°29.710’ HO 88°12.555’ Altitude 1653m, conifer forest in the same location where one was caught last year. There were no other captures.

Two night walks were conducted from Base Camp along the Las Minas and El Danto trails. Some eyeshine was observed and some animals were heard but success was minimal. Possibly the groups participating were too large.

**Discussion**
Sophie Fidoe and Tom Roberts have been comparing the species diversity between shade coffee and neighbouring secondary forest sites (please see the relevant final field reports). No significant difference was observed. This suggests that some shade coffee plantations and secondary forest sites are equally valuable for small terrestrial mammals.

Considering only the three forest and three coffee sites run consecutively the coffee plantations had a slightly lower biodiversity (Shannon-Weaver Index 1.688 and 1.530 respectively). The mean trap success was approximately double in the forest sites compared to the coffee sites indicating a greater abundance of terrestrial mammals in the forest areas. Dominant species were the same throughout the region irrespective of land use.

A possible explanation for the lack of small mammals caught in the second coffee grid surveyed and forest grid site 6 is the presence of small mammal predators (*Didelphis marsupialis* and *Philander opossum* respectively).

The full moon phase may explain the low capture rates in forest and coffee grid 6, especially given the light canopy cover.
Future work
Potential survey sites which it would be valuable to survey in the future were found during week 9. These include conifer and broadleaf forest which is regenerating and no longer used for agriculture and coffee plantations at all stages of the agricultural cycle. There is also land currently left fallow which will be farmed again in the next few years. These sites are all in a region between the Tucan waterfall and the boundary between the buffer and core zone of the park. The best access is currently along a track off the right hand side of the road from BA to Base Camp just before the core zone is entered. This leads to the path that circumnavigates the core zone. Alternative access points may be created from the Tucan waterfall. Olvin Santiago Alvarenga Gomez and his sons know the area best.

Notes
Work was limited initially by the lack of assistance setting up and working the grids, plus time constraints enforced by the Buenos Aires Camp during the early part of the season. These problems reduced during the season with the arrival of the dissertation students and more reliable availability of assistance from students/volunteers. The nature of the terrain is very steep and slippery especially after heavy rainfall; this was also more of a problem early during the season. These factors combined to make working very difficult at times, with the majority of school students unprepared to get involved.

There was minimal intentional interference from people excepting the removal of four small traps on separate occasions. Disturbance from domestic animals including horses, dogs, cats and chickens accounted for a significant number of trap closures. Ants continue to be a problem, removing the bait from traps. Additionally various non-target species were caught (grasshoppers, crickets, cane toads and crabs), making the traps unavailable to mammals.

It has been very noticeable that ticks are much more of a problem on the mice caught this year than last; other parasites such as mites are present at similar levels in 2004/5. No data has been recorded regarding parasites in 2004 or 2005. This may be useful and should be recorded in the future.

References
Appendix 1  Species list/locations. Identification according to Reid (1997).
Small mammals caught:

Grid site 1  1142m elevation  N 15°30.008’ HO 88°10.573’ 16th-20th July 2005
Coppice coffee, tomato and pepper plantation. No shading.
Bait used: salted peanuts.
 *Rattus rattus*  Roof Rat
 *Mus musculus*  House Mouse
 *Peromyscus mexicanus*  Mexican Deer Mouse – not certain of identity of this individual

Opportunist  1059m elevation  N 15°30.120’ HO 88°10.526’ 12th, 26th-27th July 2005
Opportunist trapping in secondary forest below EcoAlbergue in small streambed.
Bait used: peanut butter and cornflakes.
 *Peromyscus mexicanus*  Mexican Deer Mouse

Grid site 2  1050m elevation  N 15°30.108’ HO 88°10.575’ 23rd-27th July 2005
Heavily shaded coffee with some undergrowth.
Bait used: salted peanuts.
No small mammal captures.
 *Didelphis marsupialis*  Common Opossum

Grid site 3  1141m elevation  N 15°29.894’ HO 88°10.654’ 30th-31st July 2005
Heavily shaded coffee with very little undergrowth, close to houses.
Bait used: salted peanuts.
Run for only two nights.
 *Rattus rattus*  Roof Rat

Forest site 4  1091m elevation  N 15°30.402’ HO 88°11.282’ 1st-5th August 2005
Dissertation students’ Forest grid 2.
Secondary forest with dense undergrowth, overstorey and canopy; close to a second order river.
Bait used: granola and peanut butter mixture.
 *Peromyscus mexicanus*  Mexican Deer Mouse
 *Heteromys desmarestianus*  Forest Spiny Pocket Mouse
 *Scotinomys teguina*  Alston’s Singing Mouse
 *Marmosa mexicana*  Mexican Mouse Opossum
 *Reithrodontomys gracilis*  Slender Harvest Mouse
Also seen on sight but not caught (clear sighting resulting in confident identification):
 *Nyctomys sumichrasti*  Vesper Rat

Coffee site 4  1192m elevation  N 15°30.342’ HO 88°11.305’ 1st-5th August 2005
Dissertation students’ Coffee grid 2.
Lightly shaded coffee with undergrowth variable from sparse to dense, fairly close to a second order river.
Bait used: granola and peanut butter mixture.
 *Heteromys desmarestianus*  Forest Spiny Pocket Mouse
 *Scotinomys teguina*  Alston’s Singing Mouse
 *Marmosa mexicana*  Mexican Mouse Opossum
 *Reithrodontomys fulvescens*  Fulvous Harvest Mouse

Forest site 5  (?)908m elevation N 15°30.306’ HO 88°10.653’ 9th-13th August 2005
Dissertation students’ Forest grid 3.
Very steep site encompassing a second order river; semi-established canopy with substantial understorey and undergrowth.
Bait used: granola and peanut butter mixture.
 *Peromyscus mexicanus*  Mexican Deer Mouse
 *Peromyscus sp*  Mexican Deer Mouse like taxon which is smaller and greyish
Coffee site 5  1103m elevation  N 15°30.299'  HO 88°10.724'  9th-13th August 2005
Dissertation students’ Coffee grid 3.
Fairly heavily shaded coffee with substantial undergrowth, close to a second order river.
Bait used: granola and peanut butter mixture.

*Heteromys desmarestianus*  Forest Spiny Pocket Mouse
*Scotinomys teguina*  Alston’s Singing Mouse
*Peromyscus mexicanus*  Mexican Deer Mouse

Forest site 6  1267m elevation  N 15°30.152'  HO 88°11.377'  14th-18th August 2005
Dissertation students’ Forest grid 4.
Very steep site close to a second order river with semi-established canopy with dense understorey and undergrowth.
Bait used: granola and peanut butter mixture.

*Peromyscus mexicanus*  Mexican Deer Mouse
*Peromyscus*  sp  Mexican Deer Mouse like taxon which is smaller and greyish
*Philander opossum*  Grey Four-eyed Opossum

Coffee site 6  1312m elevation  N 15°30.077'  HO 88°11.430'  14th-18th August 2005
Lightly shaded coffee with relatively sparse undergrowth.
Bait used: granola and peanut butter mixture.

*Peromyscus mexicanus*  Mexican Deer Mouse

Opportunistic  19th August 2005
2 transects in a well maintained conifer shaded coffee plantation adjacent to forest site 6.
Bait used: granola and peanut butter mixture.
No captures.
Run for one night only.

Coffee site 7  1197m elevation  N 15°30.162'  HO 88°10.785'  23rd-24th August 2005
Fairly shaded redundant coffee plantation with dense undergrowth, close to houses.
Bait used: granola and peanut butter mixture.

*Mus musculus*  House Mouse
*Scotinomys teguina*  Alston’s Singing Mouse

Medium mammals:
Opportunistic  1059m elevation  N 15°30.120'  HO 88°10.526'  16th, 26th-27th July 2005
Secondary forest below EcoAlbergue in small stream bed.
Bait used: chicken bones.

*Didelphis virginiana*  Virginia Opossum
Additional trapping has resulted in no captures; the trap has been tampered with once.

Night watches/walks:
Opportunistic  1085m elevation  N 15°30.296’  HO 88°10.510’  30th July 2005
These targeted areas where tracks showed animals to be active, especially feeding areas or burrows.
Advice was taken from Leonardo Alvarenga Lopez who also guided for these activities. Success was low and work was interrupted by unrelated circumstances after baiting. The main focus was *Dasypus novemcinctus*. 
## Appendix 2

### Raw data for grids.

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<th>Rattus rattus</th>
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### Opportunistic trapping.

**Opportunistic captures - small traps**

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<td>Peromyscus mexicanus caught in one trap</td>
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**Opportunistic captures - medium trap**

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<td>16th July</td>
<td>Chicken</td>
<td>Woods below EcoHotel</td>
<td>5</td>
<td>Dendelphius virginianus</td>
<td>1059m</td>
<td>10530</td>
<td>120880</td>
</tr>
<tr>
<td>21st July</td>
<td>Chicken</td>
<td>EcoHotel roof</td>
<td>1</td>
<td>trap set</td>
<td>None</td>
<td>None</td>
<td>1059m</td>
</tr>
<tr>
<td>27th July</td>
<td>Chicken</td>
<td>Woods below EcoHotel</td>
<td>1</td>
<td>Dendelphius marsupialis</td>
<td>1059m</td>
<td>10530</td>
<td>120880</td>
</tr>
<tr>
<td>26th July</td>
<td>Chicken</td>
<td>Copse of trees in grassland below EcoHotel</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

### Opportunistic trapping.
Lisa Signorile

Introduction
The Rawacala Nature Reserve is a valley that runs along the Rio de Piedras close to the village of El Paraíso on the Northwestern coast of Honduras and covers an area of approximately 350 ha. The valley contains one of the few remaining examples of lowland forest in Honduras (Lennkh et al., 2004).

The forest has been widely used in the past for crop cultivation (bean, maize) and tree plantations (cocoa, oil seed palms, orange), especially in the lower parts, but about 20 years ago it was purchased and left fallow to allow regeneration. The highest parts of the valley, on the other hand, still contain some patchy stands of primary forest, mixed with abandoned plantations (e.g. of coffee).

In this regenerating environment a thorough study of the small mammal population is crucial as they are good indicators of the value of an area, since their lack of ability to migrate between separate habitats and their ability to act as seed dispersers and, in some cases, pollinators. They also have a key role in all the ecological niches for their diversity (almost 40% of all the mammals are rodents), and for their place in the food chain, since they are both prey for larger mammals, birds and reptiles and predators of invertebrates.

According to Reid (1997) the small mammals in the valley are represented by four families of rodents (Sciuridae, Heteromyidae, Geomyidae and Muridae), one of opossums (Didelphidae) and one poorly known family of insectivores (Soricidae).

The large size and diverse nature of the small mammals implies that the ecology of the species differs greatly in diet (they range from generalist omnivores to frugivores, insectivores, and seed eaters) and occupied niche (underground, ground and tree dwelling species).

One of the aims of the present study was to investigate differences in food preferences and niche-occupation by the small mammals of the valley in order to provide information towards future long term studies and assessments of biodiversity in the area. In addition, a library of hair samples of the animals of the valley was collected for further histological analyses. This library will allow hair collected from different techniques such as hair tubes, carnivore droppings, and owl pellets to be analyzed in the future.

Methods
Research was conducted between the 1st of July and the 16th of August 2005. The sites chosen to position the traps were ad hoc in order to obtain as much information as possible about the ecology and biodiversity of the animals (see Appendix I). Furthermore, stratified random sampling procedures could not be used since the steep sides of the valley did not offer large homogeneous sites for the grids, as they differed largely in aspect, slope and tree composition.

In each site traps were positioned at regular distances forming a grid or a linear transect. Aluminium cage live traps were used (170 x 130 x 310 mm) covered with a plastic sheet to protect the animals from the rain and to prevent the rain from triggering the closing mechanism. The traps were lined inside with leaves and litter and in some occasions camouflaged with leaves on top of the plastic sheet. In addition two bigger foldable “Tomahawk” traps (66 x 23 x 23 cm) were occasionally used to assess the presence of bigger mammals. When forming linear transects (weeks 2, 3 and 7) the traps were positioned 10m apart in two parallel rows on both the sides of the path (facing the river or the forest) (week 2 and 7) or in a single line (week 3) at a distance of 7m. When plots were set in, 49 traps were positioned in a regular grid measuring 42 m² spaced 7m apart in 7 rows (weeks 1,3,4,5,6). In week 4, 5, 6, 7 some traps were positioned on platforms nailed in trees at understory level (1.5m in average) (Figure 1).
In weeks 5, 6 and part of 7 a double grid of 49 traps each was set in the same site: in each of the 49 trapping station two traps were placed, one on the ground and one on the nearest tree (at a maximum distance of one metre from the trapping station), for a total of 98 traps. This grid was set in a regenerating former cocoa plantation at about 100m a.s.l.

In weeks 6 and 7, moreover, eight traps were relocated on the platforms of the zip line present in the forest as a tourist attraction and running on and over the canopy. Two out of five platforms are on trees at 25 m height, the others are in elevated points facing the upper level of the canopy. The traps were baited every night between 3.30 and 6 PM and checked and closed on the following morning between 5 and 8 AM.

Each animal caught in the trap was identified according to Reid (1997) and the following biometric parameters were taken: sex, class of age, reproductive status, head-body length, tail length, left ear length, left forearm length, left hind foot length. In addiction, climatic conditions for the night and moon phase were recorded.

The animals were then given a unique mark using red nail polish in standard positions. From the recaptures it was observed that the animals, soon after the release, groomed themselves to remove the stained hair living a bald patch corresponding to the position of the mark that lasted for at least three weeks (figs. 2 and 3).

Nine positions were used in three rows on the back of the animal to mark uniquely each mouse, labeled from A to I, as shown in Fig. 4. The first animal captured of each species in each site was labeled as A, the second B and so on. Once all the nine positions were allocated, a combination of two marks was used, e.g. AB, AC and so on.
Figure 2- Mexican deer mouse just given a mark in position F with nail polish

Figure 3- Mexican deer mouse showing a bold patch corresponding to a mark in position A

From the trap the mice were transferred to a transparent plastic bag that was cinched tightly shut to prevent escapes and the animal was then measured directly in the plastic bag to minimize the trauma of handling. They were taken out from the bag using thick gloves as shown in figs. 2 and 3, photographed, marked and a sample of hair from the back was taken using double-sided Sellotape.

Figure 4 – Position of the marks used to identify recaptured animals.
In each plot a minimum of two different types of bait were tested to assess animals’ preferences. The different bait types used were:

- Dogs dry food
- Peanuts
- Salted peanuts
- Peanuts butter on bread
- Nachos
- Guava
- Avocado
- Banana
- Extra-butter maize kernels for popcorn.

Habitat data were recorded from the site hosting the double grid. Four randomly chosen quadrats of 25m² (a square of 5m side) were assessed to describe habitat structure and species composition. In each quadrat the following parameters were recorded:

- Species at ground, understorey and canopy level
- Overall percentage vegetation density at ground and understorey level and canopy level (estimated visually)
- Number and species of saplings (DBH < 5 cm)
- Number, species and diameter of trees (DBH > 5cm)
- Percentage of coverage of litter on the ground (estimated visually)
- Percentage of bare ground (including rocks) (estimated visually).

Taxonomy of the arboreal species was checked comparing the local names of the trees with the ones listed by Lennkh et al (2004).

**Opportunistic surveys**

Opportunistic surveys were also performed when possible to assess the presence of those animals too big or too shy to enter the traps. The walks were conducted both during the day and at night.

**Pitfall traps**

A set of seven pitfall traps, each consisting of 3-5 40 L buckets embedded in the ground with an aluminium-screening drift fence passing over the centre of each bucket was placed by the herpetological team and checked daily for the duration of the live trapping surveys.

**Results and Discussion**

Overall a total of 19 species were observed or captured during the study; in addition one was detected through its call at night (*Potos flavus*), one captured in a pitfall trap (*Marmosa sp.*; it was not possible to identify the animal at species level because it had to be freed quickly to avoid it hypothermia) and one (*Nasua narica*) was seen captive in the El Paraíso village. *Nasua narica* was captured in the forest from the highest parts of the valley (within a walking distance of four hours from the village). A few new species can therefore be added to the list of those 13 observed or captured species of the previous year. That brings to 23 the overall number of species of mammals censused in the valley (the Cana rice rat has not been detected during this survey, but it was previously).

A total of 92 animals were captured in the mouse or big traps, of which 43.5% were Mexican deer mice, 10.9% big eared climbing rats and 10.9% an unidentified grey mouse. Sixty-one out of 123 captures were female, suggesting a 1:1 sex ratio in the probability of being captured. The lack of replicates, nevertheless, makes a proper statistical analysis of the quantitative data impossible, and this should indeed be verified in future surveys. In one case a pregnant female of *Ototylomys phyllotis* gave birth overnight in the trap to a litter of three pups.

A double grid of traps was set in for a total of 12 capturing nights to study simultaneously the presence and abundance of small mammals on the ground and in the trees. The resulting cumulative curve for the species captured is shown in Fig. 5. The maximum number of species trapped in the plot (7) is reached by night seven, indicating a quite high biodiversity in small mammal species in the study area:
in Guanales in 2004 a maximum of 4 species per plot was identified (Hodge, 2004), whereas in Cusuco there was a maximum of six species per plot (Freer, 2004). It must be pointed out, nevertheless, that in the two last cases the grids were set in for 4/5 nights only and the traps were placed only on the ground. Therefore, in assessing biodiversity, it would be advisable to have a slightly longer period of capturing nights per grid (at least 7 nights) and the option of capturing at understory level should also be considered.

Table 1 – list of the species detected in El Paraíso Valley during the present survey

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Detection system</th>
<th>Layer of capture</th>
<th>N.</th>
<th>Favourite bait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common opossum</td>
<td>Didelphis marsupialis</td>
<td>Captured</td>
<td>G/US</td>
<td>5</td>
<td>Meat/banana</td>
</tr>
<tr>
<td>Virginia opossum</td>
<td>Didelphis virginiana</td>
<td>Captured</td>
<td>G</td>
<td>2</td>
<td>Meat/banana</td>
</tr>
<tr>
<td>Gray four-eyed op.</td>
<td>Philander opossum</td>
<td>Captured</td>
<td>G</td>
<td>4</td>
<td>Meat</td>
</tr>
<tr>
<td>C.A.woolly opossum*</td>
<td>Caluromys derbianus</td>
<td>Captured</td>
<td>Canopy</td>
<td>1</td>
<td>Guava</td>
</tr>
<tr>
<td>Water Opossum*</td>
<td>Chironectes minimus</td>
<td>Observed</td>
<td>Ground</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mouse Opossum*</td>
<td>Marmosa sp.</td>
<td>Pitfall trap</td>
<td>Ground</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Forest spiny pocket mouse</td>
<td>Heteromys desmarestianus</td>
<td>Captured</td>
<td>G</td>
<td>4</td>
<td>Peanuts</td>
</tr>
<tr>
<td>Salvini’s spiny pocket mouse</td>
<td>Liomys salvini</td>
<td>Captured</td>
<td>G</td>
<td>2</td>
<td>Peanuts, corn</td>
</tr>
<tr>
<td>Mexican deer mouse</td>
<td>Peromyscus mexicanus</td>
<td>Captured</td>
<td>G</td>
<td>40</td>
<td>Everything</td>
</tr>
<tr>
<td>Unidentified grey mouse</td>
<td>?</td>
<td>Captured</td>
<td>G/US</td>
<td>10</td>
<td>Mainly fruit, but also seeds</td>
</tr>
<tr>
<td>Big eared climbing rat</td>
<td>Ototylomys phyllotis</td>
<td>Captured</td>
<td>US/G</td>
<td>10</td>
<td>Peanuts, fruit</td>
</tr>
<tr>
<td>Northern climbing rat*</td>
<td>Tylomys nudicaudatus</td>
<td>Captured</td>
<td>US</td>
<td>3</td>
<td>Guava, banana</td>
</tr>
<tr>
<td>Black rat</td>
<td>Rattus rattus</td>
<td>Captured</td>
<td>G</td>
<td>4</td>
<td>Everything</td>
</tr>
<tr>
<td>Hispid cotton rat*</td>
<td>Sigmodon hispidus</td>
<td>Captured</td>
<td>G</td>
<td>4</td>
<td>Peanuts, corn</td>
</tr>
<tr>
<td>Alfaro’s rice rat</td>
<td>Oryzomys alfaroi</td>
<td>Captured</td>
<td>G</td>
<td>2</td>
<td>Peanuts</td>
</tr>
<tr>
<td>Rusty rice rat</td>
<td>Oryzomys rostratus</td>
<td>Captured</td>
<td>G</td>
<td>1</td>
<td>Banana</td>
</tr>
<tr>
<td>Variegated squirrel</td>
<td>Sciurus variegatoides</td>
<td>Observed</td>
<td>Canopy</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Deppe’s squirrel</td>
<td>Sciurus deppei</td>
<td>Observed</td>
<td>US</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>C.A. Agouti *</td>
<td>Dasyprocta punctata</td>
<td>Observed</td>
<td>G</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Nine-banded Armadillo</td>
<td>Dasypus novemcinctus</td>
<td>Observed</td>
<td>G</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Kinkajou *</td>
<td>Potos flavus</td>
<td>Call listen</td>
<td>Canopy</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

* = species recorded in El Paraíso for the first time during the present survey
G = ground level, US = understory level

Figure 5: Cumulative curve of the species trapped in a single site (double grid)

The density of the animals in the double plot was calculated using the Jolly-Seber method, which is the method of choice for open populations (Sutherland, 1996). The following densities were therefore calculated for the three most abundant species in the plot:
- Mexican Deer Mice: 25/hectare
- Big Eared Climbing Rat: 6.8/hectare
- Unidentified grey mouse: 6.3/hectare

As regards the different uses of habitat, the species censused in El Paraíso valley can belong to one of the following categories:

- Exclusively terrestrial (P. mexicanus, H. Desmarestianus, L. Salvini, D. Virginiana) (100% captures on the ground)
- Exclusively arboreal, understorey level (T. nudicaudatus, S. deppei) (100% of captures and sights at understorey level)
- Exclusively arboreal, canopy level (Caluromys derbianus) (only one specimen captured at 25m above ground) (Figure 6), Sciurus variegatoides
- Mostly arboreal (O. phyllothit) (75% of the captures on trees)
- Both terrestrial and arboreal (unidentified grey mouse, D. marsupialis).

In this latter case the choice between ground or understorey level seems to be driven by the bait: both the unidentified grey mouse and D. marsupialis were found only in traps baited with fruit, and never in traps baited with peanuts.

Figure 6. Central American woolly opossum captured placing the traps on the upper layer of the canopy

As regards the different kinds of bait tested, the most appreciated seems to be fresh fruit (guava, banana or avocado), with a capture rate ranging between 5.1 and 13.9% per night, and six different species captured in the double plot. Peanuts attracted the animals in a lesser amount, with a capture rate ranging between 5.5 and 8.3% per night and only three species captured. Finally, only Mexican deer mice appreciate dry dog food, with a capture rate of 1.4%. Interesting results can be obtained using dried maize kernels, but it should be tested more thoroughly.

A problem that emerged during this study was the lack of logistic support for bait supplies, which was never enough to attempt properly a comparative study and had to be purchased day by day by the small mammal scientist.

**Threats**

By interviews to local people emerged two main threats to the local mammalian fauna: the first is poaching in the reserve the animals traditionally eaten, especially Pacas (Agouti paca), Agoutis (Dasyprocta punctata), Opossums and Armadillos (Dasypus novemcinctus).

The second is the habit of capturing from the wild some animals to keep them as pets in small enclosures (squirrels, agoutis, coatis). More contact between the mammal scientist and the local people, especially the schools, would be advisable to attempt to educate the youngsters to consider the forest as a resource and not as an hunting reserve.
References
Freer, R. 2004. An assessment of terrestrial small mammal population within the Parque Nacional Cusuco core zone and surrounding areas – Operation Wallacea final report

APPENDIX I – PLOT LOCATIONS

<table>
<thead>
<tr>
<th>Plot name</th>
<th>UTM location</th>
<th>altitude</th>
<th>vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot 1</td>
<td>UTM 1734390</td>
<td>53 m</td>
<td>Beans, banana yucca plantation.</td>
</tr>
<tr>
<td>transect 1</td>
<td>from 1734240 to 1734023</td>
<td>57-103</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Transect 2</td>
<td>From 1734023 to 1733885</td>
<td>121-165</td>
<td>Secondary forest in abandoned mix plan.</td>
</tr>
<tr>
<td>Plot 2</td>
<td>utm 1733979</td>
<td>121</td>
<td>Secondary forest in abandoned cocoa plant.</td>
</tr>
<tr>
<td>Plot 3</td>
<td>utm 1733867</td>
<td>167</td>
<td>Secondary forest in abandoned oil palm pl.</td>
</tr>
<tr>
<td>Double plot</td>
<td>No gps lecture, about 1734023</td>
<td>About 120</td>
<td>Secondary forest in abandoned cocoa plant.</td>
</tr>
<tr>
<td>Transect 3</td>
<td>From 1734248 to 1734390</td>
<td>57</td>
<td>Regenerating forest</td>
</tr>
<tr>
<td>Canopy</td>
<td>utm 1733717</td>
<td>196</td>
<td>Secondary forest</td>
</tr>
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### Appendix II – Vegetation Assessment

<table>
<thead>
<tr>
<th>Quadrat 1</th>
<th>Quadrat 2</th>
<th>Quadrat 3</th>
<th>Quadrat 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canopy coverage</td>
<td>90%</td>
<td>75%</td>
<td>80%</td>
</tr>
<tr>
<td>Understorey cover.</td>
<td>5%</td>
<td>50%</td>
<td>10%</td>
</tr>
<tr>
<td>Grass level cover.</td>
<td>10%</td>
<td>40%</td>
<td>0</td>
</tr>
<tr>
<td>Bare ground cover.</td>
<td>5%</td>
<td>0%</td>
<td>35%</td>
</tr>
<tr>
<td>Litter coverage</td>
<td>80%</td>
<td>60%</td>
<td>65%</td>
</tr>
<tr>
<td>Trees &gt;5 cm DBH</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Trees &lt;5 cm DBH</td>
<td>0</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td><strong>Species trees &lt;5cm</strong></td>
<td></td>
<td>tambor (4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pacalla (12 pp)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trees</strong></td>
<td>Theobroma cacao (10 cm)</td>
<td>Tambor (15 cm)</td>
<td>majao (27 cm)</td>
</tr>
<tr>
<td></td>
<td>Theobroma cacao (11 cm)</td>
<td>T. cacao (9 cm)</td>
<td>(Malvaviscus arboretum)</td>
</tr>
<tr>
<td></td>
<td>T. cacao (21 cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T. cacao (11+12 cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guama (Inga pauoniana) (33 cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Understorey</strong></td>
<td>pacalla (50%)</td>
<td>tambor saplings (4 pp)</td>
<td>unknown plant 1</td>
</tr>
<tr>
<td></td>
<td>chichicaste (20%)</td>
<td></td>
<td>(2%)</td>
</tr>
<tr>
<td></td>
<td>puerco (10%)</td>
<td></td>
<td>chaperno (6 pp)</td>
</tr>
<tr>
<td></td>
<td>junciapa (1 p)</td>
<td></td>
<td>manzano (1 p)</td>
</tr>
<tr>
<td></td>
<td>caña (2 pp)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>elecho (2 pp)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>coroso (1 p) (Attalea cohone)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>costilla de danto (1 p)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>hule (1 p) (Castilla elastica)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>elecio (1 p)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pacalla (12 pp)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>conte (8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cachito (2 plants)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>pacalla (3 plants)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Grass level</strong></td>
<td>conte (40%)</td>
<td>conte (45%)</td>
<td></td>
</tr>
</tbody>
</table>
6. A Comparison of the Diversity and Abundance between Small Mammal Populations in Shade Coffee and Secondary Forest within Cusuco National Park

Dissertation Report 2005, Sophie Fidoe, University College London

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20th July – 12th August 2005

Expected report submission: -
May 2006

Introduction

Cusuco National Park in North West Honduras was the location in which my research was undertaken. Areas within both the parks core and buffer zones, which are situated in the Merendon mountain ranges in Central America and which expand over approximately 23,440 ha, were sampled. Biodiversity studies in previously neglected areas such as Cusuco National Park are of great importance to ecosystems as they enable the prioritisation of conservation efforts and permitting the identification of endemic species in these areas. Small mammals are especially of great importance to ecosystems, allowing seed dispersal, feeding on invertebrates and are prey for numerous birds, reptiles and large mammal species.

Small mammal studies within the park have been carried out over the last 2 years, concentrating on the differences in small mammal diversity and abundance between pine and broadleaf forests which make up the park’s vegetative fauna. 4 small mammal species were regularly sighted last year by OpWall students, Alston’s singing mice, Mexican Deer mice, Slender Harvest mice and Forest Spiny pocket mice, with differences being seen in the abundance of each between the broadleaf and pine forests.

The park also contains a large number of shade coffee plantations interspersed between areas of secondary forest. These areas were previously primary and secondary forest, however are now farmed to provide the local community with a source of income. No previous studies have been carried out to compare the small mammal diversity in these coffee plantations with that of the surrounding forest. The present study was therefore carried out to investigate whether these shade coffee agro systems still maintain the biodiversity of small mammal species seen in the remaining natural vegetation, in this case, secondary forest.

Past research has shown that shade coffee, as opposed to sun coffee farming, is much more favourable in terms of maintaining biodiversity of the area, acting as areas of refuge for endemic species in deforestation fragments, thus preventing their extinction (Perfecto, 1996) and acting as corridors between areas of forest. These traditional methods have the additional advantage of providing the farmer with fruits from the canopy species, fuel wood and building materials. Sun coffee plantations produce a much higher yield of coffee so many countries in South and Central America such as Costa Rica are tending to convert to these more modern practices, however it also involves an increase in chemical input, increasing in pruning and coffee plant density. All of these factors lead to the increase in water and soil runoff (Perfecto, 1996) and therefore reducing the quality of the plantation long-term. With the price of coffee fluctuating yearly, farmers are failing to receive a consistent income so are converting to alternate crop growth such as Sugarcane (Gallina, 1996).

In Buenos Aires (located in the buffer zone of Cusuco) tomatoes are now becoming an alternative farming practice, which is more profitable yet more capital is needed initially for pesticides and
fertilizers which are needed to grow the crop to maximum yield. The Global Environmental Foundation (GEF) grant (part of the World Bank) which has been applied for by Operation Wallacea would enable local coffee farmers within Cusuco to receive a greater price for their shade coffee. There is a greater chance of this happening if shade coffee is seen to support a high biodiversity of species, making it a sustainable income for locals as well as being an environmentally more favourable practice.

Previous studies have been carried out involving looking at the diversity of Arthropod species, migratory and resident species within shade coffee however few studies have previously looked at the diversity of small mammals in shade coffee. Arthropod numbers have been found to be just as great, if not greater in shade coffee compared with forest and a great diversity of birds have also been found (Perfecto, 1996). 50% of the original snake fauna are also seen to be supported in mixed shade plantations (Seib, 1986).

This then leads to the research question: To what extent does the diversity and abundance of small mammal populations differ between shade coffee and secondary forest within Cusuco National Park?

**Aims**

1. To compare the species diversity within shade coffee and the surrounding dominant secondary forest  
2. To compare the population densities of each species found within shade coffee and the surrounding dominant secondary forest.

**Objectives**

1. Using live trap grids at paired sites in a coffee plantation and nearby forest site and assessing the species caught within these grids over a period of 5 days, simultaneously.  
2. Using the mark- recapture method for this closed population the densities can be found.

**Methodology**

Four paired sights were chosen in order to achieve a comparison between the species abundance and diversity in shade coffee and secondary forest. A 42m² grid comprised of 49 aluminium cage traps (320 mm x 173 mm x 140 mm), 7 rows of 7 traps in a square so as to reduce edge effects (Sutherland) was set up in a coffee plantation and a nearby secondary forest site.

The distance between each trap was chosen to be 7m as previous studies (Apps, 2004) have shown that greater intervals tend to lead to capture rates greater than 60%. This is a value that Sutherland (1996) suggests as being too great as it can lead to trap competition as the rodents’ territories begin to overlap.

The grids were run simultaneously in order to reduce the number of variables that had to be accounted for in the study. The pair of grids was run for 5 days and 4 different pairs were run over a period of 5 weeks. The sites were actively chosen with the first set of grids being situated a 45-minute walk from Base Camp, adjacent to the core zone, with the remaining 3 pairs being near to Buenos Aires in the buffer zone.

The rows of traps were marked from A1- A7 through to G1-G7, with the trap positions also marked with flagging tape to allow for accurate relocation. The traps were set within a 1m radius around the marker on a flat area. Each trap was set in the evening, after 14.30 pm, before dusk and contained a few of the surrounding leaves to make the trap seem less foreign to the mammal, they also had plastic roofs attached to the trap with string to keep any captured mammals dry without inhibiting the trapping mechanisms.

The trap was baited with granola cereal, mixed with peanut butter after our pilot studies showed a high number of ants removed granola alone. Half a teaspoon of bait was placed, on a leaf, on the treadle at the back of the trap and the trap finely set so that the smallest mammal could trigger the door mechanism. The area around the front of the trap was cleared of any vegetation in order to prevent lodging of the door which might have caused accidental release of the rodent. The traps were checked after dawn the following morning and all remaining open traps were shut for the day in order to prevent any diurnal
birds of mammals from being caught accidentally. The captured rodents were brought to an area in the 
grid for measuring, the weight was taken once the rodent had been released into a plastic bag using 
gloves at all times and the following data was recorded on being removed from the bag: -

<table>
<thead>
<tr>
<th>Date of Capture</th>
<th>Weather the previous night</th>
<th>Species found</th>
<th>Grid Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Adult, sub-adult, juvenile)</td>
<td>Sex (M/F)</td>
<td>Reproductive Status</td>
<td>Net Weight (g)</td>
</tr>
<tr>
<td>Clip given or found (if a recapture)</td>
<td>Head-body length (cm)</td>
<td>Head-body-tail length (cm)</td>
<td>Left Hind leg length (Ankle to tip of toe) (cm)</td>
</tr>
<tr>
<td>Left Fore arm length (cm)</td>
<td>Left Ear length (base to tip) (cm)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Elbow to finger tip)

A recognizable clip was given to the individual using scissors.

The number of traps that were closed and empty (e.g. due to rain) was also recorded as this reduced 
the number of available traps within the grid.

In order to make a good assessment of the vegetation within each grid and in order to compare each 
coffee and forest habitat pair, a 5m² quadrat was positioned at 4 random trap locations within each grid 
(trap positions drawn out of a bag). The following data was recorded from within each quadrat, with 
the trap being centrally located (Cameron, 1997): -

- Average of 5 Leaf litter depths (using a ruler)
- % Total Canopy Cover (above shoulder height); estimated visually
- % of each dominant tree species making up the canopy; estimated visually
- % of each dominant plant species in the undergrowth (between shoulder height and knee); 
estimated visually
- % of each dominant species at ground level (below the knee), including % bare ground; 
estimated visually
- % Dead wood (to be converted into a scale, possibly the DAFOR scale); estimated visually
- Number of trees > 10 cm in diameter and their estimated circumference (using string & ruler)
- Number of trees < 10 cm in diameter

GPS readings taken from trap A1 at each sampling site: -

<table>
<thead>
<tr>
<th>Date</th>
<th>Grid Name</th>
<th>GPS Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>26th July – 30th July</td>
<td>Coffee 1</td>
<td>N 15° 29.465’ HO 88° 12.448’, Elevation 1393m</td>
</tr>
<tr>
<td></td>
<td>Forest 1</td>
<td>N 15° 29.455’ HO 88° 12.362’, Elevation 1358m</td>
</tr>
<tr>
<td>2nd July – 6th July</td>
<td>Coffee 2</td>
<td>N 15° 30.342’ HO 88° 11.305’, Elevation 1092m</td>
</tr>
<tr>
<td></td>
<td>Forest 2</td>
<td>N 15° 30.402’ HO 88° 11.282’, Elevation 1091m</td>
</tr>
<tr>
<td>9th July – 13th July</td>
<td>Coffee 3</td>
<td>N 15° 30.299’ HO 88° 10.724’, Elevation 1103m</td>
</tr>
<tr>
<td></td>
<td>Forest 3</td>
<td>N 15° 30.306’ HO 88° 10.653’, Elevation 908m</td>
</tr>
</tbody>
</table>
14th July – 18th July
Coffee 4
N 15° 30.077’
HO 88° 11.430’
Elevation 1312m
Forest 4
N 15° 30.152’
HO 88° 11.377’
Elevation 1267m

Results
The Mean trap success rates were 11.1% in the forest sites compared to a much lower 7.3% in the coffee sites, figures which exclude the “unavailable” closed, empty traps. A total of 6 different species were caught in the coffee compared with 9 in the forest as graphs 3-5 show.

There were four species which were common to both coffee and the secondary forest - *S. teguina* (Alston's singing mouse), *M. mexicana* (Mexican mouse opossum), *P. mexicanus* (Mexican deer mouse) and *H. desmarestianus* (Forest spiny pocket mouse) with the remaining species being shown in tables 1 & 2 and graphs 1 & 2.

<table>
<thead>
<tr>
<th>Grid</th>
<th>Total Captures</th>
<th>Recaptures</th>
<th>Individuals Caught</th>
<th>No. of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee1</td>
<td>19</td>
<td>3</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Coffee 2</td>
<td>15</td>
<td>4</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>Coffee 3</td>
<td>21</td>
<td>8</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Coffee 4</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Coffee Total</td>
<td>56</td>
<td>15</td>
<td>41</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grid</th>
<th>Total Captures</th>
<th>Recaptures</th>
<th>Individuals Caught</th>
<th>No. of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest 1</td>
<td>17</td>
<td>5</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Forest 2</td>
<td>33</td>
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</tr>
<tr>
<td>Forest 3</td>
<td>21</td>
<td>13</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Forest 4</td>
<td>8</td>
<td>2</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Forest Total</td>
<td>84</td>
<td>27</td>
<td>57</td>
<td>9</td>
</tr>
</tbody>
</table>
Graph 1

**Coffee Total Captures**
Chart to show no. of species in coffee:

- M. mexicana (Mexican Mouse Opossum)
- R. fulvescens (Fulvous Harvest Mouse)
- Heteromyos spp. (Spiny Pocket Mouse)
- S. tequila (Nelson's Singing Mouse)
- P. mexicanus (Mexican Deer Mouse)
- H. desmarestianus (Forest Spiny Pocket Mouse)

Graph 2

**Forest Capture Totals**
Chart to show no. species in forest:

- H. desmarestianus (Forest Spiny Pocket Mouse)
- M. mexicana (Mexican Mouse Opossum)
- P. mexicanus (Mexican Deer Mouse)
- Heteromyos spp. (Spiny Pocket Mouse)
- P. opossum (Striped Opossum)
- O. albifrons (Albino Rock Rat)
- P. orchiensis (Small Harvest Mouse)
- S. tequila (Nelson's Singing Mouse)
Graph 3

Cumulative frequency graph for no. of species caught

Sampling nights

Cumulative frequency graph for no. of species caught

Sampling nights

Captures in Coffee
Captures in Forest

Graph 4

Chart to show no. of species at each site pair

Site number

Site 1 Site 2 Site 3 Site 4

Site number

Coffee Forest
A paired samples t-test was carried out between coffee and forest grid pairs species richness $t = -2.449$ (3df) $p = 0.092$ and the Wilcoxon non-parametric test was also performed as even though a test for homogeneity of variance has yet to be carried out it is expected that there wouldn’t be a normal distribution of species in the population, $z = -1.633$ (3df) $p = 0.102$. A Paired samples t-test for abundance in all forest and coffee grid pairs revealed $t = -0.926$ (3df) $p = 0.423$ and the Wilcoxon $z = -0.816$ (3df) $p = 0.414$. Measures of diversity of species in each grid were then calculated and the Wilcoxon test was then performed to test for significant differences between the diversity in shade coffee and secondary forest.

The Shannon-Wiener and Simpson’s diversity index’s were found for each grid site as these take into account the equitability in the population and a Wilcoxon test was then performed on these values to give a good idea of the difference between the diversity in the shade coffee and forest sites.

<table>
<thead>
<tr>
<th></th>
<th>Shannon – Wiener Diversity Index</th>
<th>Evenness (J)</th>
<th>Simpson’s Diversity Index (D)</th>
<th>Evenness</th>
</tr>
</thead>
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<tr>
<td>Coffee 1</td>
<td>1.25</td>
<td>0.902</td>
<td>0.258</td>
<td>0.968</td>
</tr>
<tr>
<td>Forest 1</td>
<td>1.31</td>
<td>0.82</td>
<td>0.272</td>
<td>0.733</td>
</tr>
<tr>
<td>Coffee 2</td>
<td>1.17</td>
<td>0.843</td>
<td>0.289</td>
<td>0.865</td>
</tr>
<tr>
<td>Forest 2</td>
<td>1.42</td>
<td>0.88</td>
<td>0.246</td>
<td>0.813</td>
</tr>
<tr>
<td>Coffee 3</td>
<td>0.79</td>
<td>0.719</td>
<td>0.5</td>
<td>0.667</td>
</tr>
<tr>
<td>Forest 3</td>
<td>0.86</td>
<td>0.782</td>
<td>0.436</td>
<td>0.765</td>
</tr>
<tr>
<td>Coffee 4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Forest 4</td>
<td>0.95</td>
<td>0.865</td>
<td>0.3</td>
<td>1.111</td>
</tr>
</tbody>
</table>

The Wilcoxon value for Shannon-Weiner, $z = -1.826$ $p = 0.068$ and when calculating the value of evenness, $z = -0.730$ $p = 0.465$.

For the Simpson’s index $z = 0$ $p = 1$ and for evenness $z = -0.365$ $p = 0.715$.

**Discussion**

When comparing Shade coffee grids and secondary forest grids simultaneously it can be seen that differences occur in both the abundance and diversity of small mammal species yet both Alston’s singing mice and Mexican deer mice were seen to be the most dominant species in both forest and coffee. 3 out of the 4 paired sites showed more captures in the forest with the remaining pair having the same number of captures. This indicates that the coffee is unable to support such a high abundance of species with the overall number of mammals in the forest being 57 compared with 41 in the coffee, yet this is not a significant difference.
The forest clearly supports a greater number of species, however the ‘capture’ computer program will be able to estimate the number of each species per hectare in order to allow a more accurate comparison between the two habitat types. Simpson’s diversity index showed that the difference in species richness between the two habitat types was approaching significance with the forest supporting a greater number of species, 5 of which aren’t even present in any of the coffee sites; this could be due to the vegetation differences which will be compared using Principle component analysis.

References

Apps. M 2004 comparison of small mammal populations from broadleaf and conifer forest types within the Cusuco core zone. Unpublished.


7. A comparison of the diversity and abundance of small mammal populations between shade coffee plantations and areas of secondary forest in Cusuco National Park, Honduras

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Expected date of project submission: May 2006

Sites of Study (taken from A1):

<table>
<thead>
<tr>
<th>Site</th>
<th>GPS coordinates</th>
<th>Altitude</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee</td>
<td>N15°+29.465’ H088°+12.448’</td>
<td>1393m</td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>N15°+29.455’ H088°+12.362’</td>
<td>1358m</td>
<td></td>
</tr>
<tr>
<td>Coffee 2</td>
<td>N15°+30.342’ H088°+11.305’</td>
<td>1092m</td>
<td>27m</td>
</tr>
<tr>
<td>Forest 2</td>
<td>N15°+30.402’ H088°+11.282’</td>
<td>1091m</td>
<td>14m</td>
</tr>
<tr>
<td>Coffee 3</td>
<td>N15°+30.299’ H088°+10.725’</td>
<td>1103m</td>
<td>12m</td>
</tr>
<tr>
<td>Forest 3</td>
<td>N15°+30.306’ H088°+10.653’</td>
<td>908m</td>
<td>8m</td>
</tr>
<tr>
<td>Coffee 4</td>
<td>N15°+30.077’ H088°+11.430’</td>
<td>1312m</td>
<td>6m</td>
</tr>
<tr>
<td>Forest 4</td>
<td>N15°+30.152 H088°+11.377’</td>
<td>1267m</td>
<td>11m</td>
</tr>
</tbody>
</table>

Introduction

Cusuco National Park lies in the Merendon mountain range, North Western Honduras. It encompasses approximately 23,440 hectares comprising of a core zone and a buffer zone. The core zone contains broadleaf and conifer forest and dwarf forest at higher altitudes. The buffer zone is more populated and contains many shade and sun coffee plantations.

Honduras, along with much of Central America has been described as a ‘critical sampling area’ (Voss and Emmons, 1996). There is need for further work in Cusuco as few studies have been carried out there. Further information about the small mammal populations can help prioritise conservation areas and strengthen arguments for extra protection.

Small mammals are a good study base as they are small and relatively easy to catch. They can also be studied to gain an understanding of the health of an ecosystem as a whole as the fulfil several key roles, as predators of invertebrates, pollinators of flowering plants, dispersers of seeds and prey for larger mammals, raptors and snakes.

Cusuco National Park was logged extensively in the 1940’s and subsequently all the areas of forest surrounding shade coffee plantations are secondary forest.
Shade coffee has become a much used and varied term but it generally means coffee that has been grown under the shade of indigenous species of trees, to prevent scorching of the leaves. A substantial amount of undergrowth is also allowed to remain; from above a proper shade coffee plantation will show little difference from secondary forest. And from inside it will look a lot like secondary forest with almost all the under story comprising of coffee bushes.

A rival method of growing coffee is known as sun coffee. Sun coffee is grown with no other plants around apart from coffee bushes. All undergrowth and larger plants are cleared away. This reduces the quality of the topsoil very rapidly so fertilisers are often added. In addition the lack of other flora means there are fewer predators to remove the farmer’s pests so pesticides are often added. Many coffee plantations are on significant slopes, often above 35%. This means the chemicals are quickly washed downhill. Sun coffee is a much more intense way of producing coffee; it provides higher yields of poorer quality coffee.

This investigation is into the diversity of small mammal populations in shade coffee plantations and secondary forest. These two habitats often occur side by side. An investigation into their respective mammal fauna will help understanding of the ability of shade coffee to support biodiversity.

This forms an important part of Operation Wallacea’s bid for funding from the World Bank/Global Environment Fund (GEF). Shade coffee is being promoted as better for wildlife and also as method of producing better quality coffee, this investigation will form part of the data the bid is based on. If the bid goes through successfully local coffee growers will get a better share of the profits for their coffee.

Research Question: Does the diversity and abundance of small mammal populations differ between shade coffee plantations and areas of secondary forest?

Aim 1: To compare the diversity of the small mammal populations in shade coffee and secondary forest.

Objective 1: To use live trapping methods in regular grids to describe the composition by species in each area

Aim 2: To estimate the population sizes of small mammal at each site.

Objective 2: To use a mark-recapture method to estimate population sizes and densities.

Methodology

Over a 5 week study period 4 grids were set up in shade coffee plantations and 4 in areas of secondary forest. The first week was devoted to pilot tests and practice of handling techniques.

49 traps were set up in a 7x7 grid, covering 42$m^2$. Square grids were used to reduce edge effects (Sutherland 1996). These proportions were chosen after a study of previous work in similar areas.

The traps used were cage traps, similar in design to the better known ‘Tomahawk’ traps. Plastic roofs were made and fitted to all traps to provide shelter to captured animals.

Each trap position was laid out by hand and marked with flagging tape labelled A1, A2 to G7. All traps were positioned on the nearest patch of flat ground to the marker tape, usually with a 1m radius.

Traps were baited each afternoon/evening with granola and checked at 5:30-7am the next morning. After the pilot grid the bait was changed to include peanut butter to improve consistency and prevent ants removing it. Tests were done to ensure no bias was introduced by this change of bait.

The traps were closed during the day as most small mammal species are nocturnal and to avoid capture of non-target species.
The following data was taken from each captured individual:

- Date
- Weight (g)
- Site
- Head + Body measurement (cm)
- Species
- Head, Body + Tail measurement (cm)
- Age
- Hind Foot (cm)
- Sex
- Fore Arm (cm)
- Reproductive status
- Ear Length (cm)
- Weather (night before)
- Trap location within grid

A unique hair clip was given to individual to allow recognition of recaptures.

Quantitative vegetation data was collected from each grid site. Four 5m² quadrats were positioned at random trap locations at each grid and the following details collected:

- Grid Position
- Average depth of leaf litter
- No. of trees less than 10cm in diameter
- Percentage deadwood
- No. of trees greater than 10cm in diameter
- Percentage canopy cover
- Percentage density and species composition of undergrowth, overgrowth and ground level.

Habitat assessment was based on Cameron’s work, 1997.

Results
The main small mammal species caught throughout the investigation were *Scotinomys teguina* (Alston's Singing Mouse) and *Peromyscus mexicanus* (Mexican Deer Mouse). Also *Heteromys desmarestianus* (Forest Spiny Pocket Mouse) was caught throughout the coffee grids but was only found in half the forest grids. Other species caught include *Reithrodontomys fulvescens* (Fulvous Harvest Mouse), *Marmosa mexicana* (Mexican Mouse Opossum), *Reithrodontomys gracilis* (Slender Harvest Mouse), *Oryzomys alfaroi* group (Alfaro's Rice Rat) and one *Philander opossum* (Grey Four-eyed Opossum).

Also trapped were two unidentified species, one was a grey Mexican Deer Mouse like species and the other was a different species of Spiny Pocket Mouse.

Nine different species were found in the forest grids, six in the coffee grids. Forest clearly holds more diversity. Trap success rates were 11.1% in the forest sites compared to a much lower 7.3% in the coffee sites.

<table>
<thead>
<tr>
<th>Grid</th>
<th>Total Captures</th>
<th>Recaptures</th>
<th>Individuals Caught</th>
<th>No. of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee1</td>
<td>19</td>
<td>3</td>
<td>16</td>
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</tr>
<tr>
<td>Coffee2</td>
<td>15</td>
<td>4</td>
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<tr>
<td>Coffee3</td>
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<tr>
<td>Coffee4</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Coffee Total</td>
<td>56</td>
<td>15</td>
<td>41</td>
<td>6</td>
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<table>
<thead>
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<th>Individuals Caught</th>
<th>No. of species</th>
</tr>
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<tbody>
<tr>
<td>Forest1</td>
<td>17</td>
<td>5</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Forest2</td>
<td>33</td>
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<td>5</td>
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<td>Forest3</td>
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<tr>
<td>Forest4</td>
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<tr>
<td>Forest Total</td>
<td>84</td>
<td>27</td>
<td>57</td>
<td>9</td>
</tr>
</tbody>
</table>
Discussion
There are two dominant species in both vegetation types, *P. mexicanus* (Mexican Deer Mouse) and *S. teguina* (Alston's Singing Mouse). In both grids these two species represented roughly two thirds of all captures.

Nine species of small mammal were found in total in the forest sites and 6 in the coffee sites. This record of species richness and the results of the Shannon-Weiner / Simpson’s diversity indices show that the all the forest sites had greater levels of diversity than there coffee counterparts. But no significant results have been obtained yet from any of the stats tests so far performed.

While secondary forest has been shown to be a more diverse habitat for small mammals, the lack of significant results implies that shade coffee is almost as good, if not as good, at supporting small mammal populations.
Bat diversity and abundance

1. Bat Diversity and Abundance in the Cusuco National Park Core Zone, Honduras

Gerald Carter (batbum@gmail.com)

Abstract
Due to their diversity, abundance, and great ecological significance, bats (Chiroptera) are potential indicator species for evaluating disturbance and potential conservation value. The goal of this study was to assess bat diversity and abundance in the core zone of the park using understory mist nets. Understorey mist net surveys at 5 sites in the core zone resulted in 5 new species records for the Cusuco National Park, and 8 new species records for the core zone bringing the species list totals to 23 species for the park and 17 species for the core zone. For the core zone, the total number of bat captures per 6 m net hour was 0.037 bats / 6 m net hr.

Introduction
As the most abundant and diverse group of neotropical mammals, bats (Order Chiroptera) comprise an extremely important part of the fauna of Central and South America. Throughout the Neotropics, bat diversity may comprise 40-50% of the mammalian species richness (e.g. Medellin et al. 2000, Bernard 2001). Several studies (e.g. Medellin et al. 2000, Pineda et al. 2005) have also highlighted bat diversity and abundance as useful indicators of habitat disturbance, environmental change, and potential conservation value. Bats serve as excellent indicator species in tropical rainforests because they are speciose, trophically diverse, abundant, widespread, easy to sample, and often predictably responsive to habitat alterations (Medellin et al. 2000). Neotropical bats also fulfill a large variety of central ecological roles as pollinators, seed dispersers, and predators of insects, other arthropods, and small vertebrates. For example, Medellin and Gaona (1999) found that bats disperse more seeds than birds at every level of disturbance. Indeed, bats are a key component of neotropical biodiversity, and surveying bat communities is an important aspect of biodiversity monitoring.

Cusuco National Park in northwestern Honduras is a 23,440 ha mountainous forested area with a diversity of habitats and elevations ranging from ~300 m to 2242 m above sea level. The park has been divided into two potential management regimes- the core zone and the buffer zone. Previous studies on bats conducted by Griffiths and Hopkins in 2004 for Operation Wallacea recorded 18 bat species for the park and 9 species in the core zone, albeit only one site in the core zone (Base Camp at 1600m) was surveyed. The goal for 2005 was to increase the species list inventory for the core zone of Cusuco National Park. Data will hopefully be used in further biological monitoring and to further conservation aims in the park.

Objectives for 2005

To assess bat diversity and abundance in the Cusuco National Park core zone

Study Sites
I conducted mist netting at five sites in the tropical montane forests of the Cusuco National Park “core zone”: La Fortuna, Agua Mansa, Base Camp, Guanales and Cantiles. All sites are biological monitoring camps operated by Operation Wallacea. La Fortuna is a secondary broadleaf forest site at approximately 1300 m elevation; two nights of netting took place on a stream. Agua Mansa and Guanales, both located at approximately 1400 m elevation, are both primary broadleaf forest with patches anthropogenic disturbance. The sites differ however in their forest structures (Lennkh, pers. comm.) and Guanales is located on the edge of the core zone while Agua Mansa is located near the center. Base Camp is a secondary mixed forest site at 1600 m. Cantiles is primary forest site with net locations ranging from approximately 1800-1900 m. In addition, I netted at Buenos Aires, a village at approximately 1250 m elevation located in the buffer zone.
Methods
I place one to three mist nets (6 m, 9 m, and 12 m) across possible bat flyways such as streams. No net sites are used two nights in a row, and new sites are continuously assessed and created. Starting at dusk, I net at each site for an average of 5 hours depending on the weather. Captured bats are identified to species and the following data are collected: age, sex, reproductive status, length of forearm, mass, net in which bat was caught, position of all nets, and the times of opening and closing of nets. Number of bats per net hour is calculated by: the number of bats caught / (the number of hours netting x number of 6 m of net units). For each new species caught, photos of the head and other distinguishing characteristics are taken. For bats in the genus *Sturnira* measurements of the foot and tibia are also taken. In addition, I have collected some parasites and fecal samples from *Myotis keaysi* and *Sturnira ludovici* (hondurensis).

Results

**Site Data**

<table>
<thead>
<tr>
<th></th>
<th>La Fortuna</th>
<th>Base Camp</th>
<th>Cantiles</th>
<th>Buenos Aires</th>
<th>Guanales**</th>
<th>Agua Mansa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total 6 m net hours*</td>
<td>55</td>
<td>810</td>
<td>2688</td>
<td>63</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>No. of recorded species</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>5</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Number of bat captures</td>
<td>20</td>
<td>27</td>
<td>60</td>
<td>14</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Bat captures/ 6 m net hr</td>
<td>0.36</td>
<td>0.03</td>
<td>0.02</td>
<td>0.22</td>
<td>0.1</td>
<td>0.74</td>
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<tr>
<td>Elevation (m)</td>
<td>1300</td>
<td>1600</td>
<td>1800-1900</td>
<td>1250</td>
<td>1400</td>
<td>1400</td>
</tr>
<tr>
<td>Habitat</td>
<td>Secondary</td>
<td>Secondary</td>
<td>Primary</td>
<td>Agricultural</td>
<td>Primary</td>
<td>Primary</td>
</tr>
</tbody>
</table>

* 6m net hours= hours spent netting X 6 meter net units
**Guanales was only sampled on two brief nights with a bright moon (low bat activity).

**Bat Captures 2005**

<table>
<thead>
<tr>
<th>Species</th>
<th>LF</th>
<th>BC</th>
<th>CT</th>
<th>BA</th>
<th>AM</th>
<th>GL</th>
<th>New to park</th>
<th>New to core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centurio senex</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
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<tr>
<td>Sturnira ludovici</td>
<td>8</td>
<td>12</td>
<td>21</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Myotis keaysi</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>Eptesicus brasiliensis</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>Artibeus toltecus</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
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<tr>
<td>Artibeus jamaicensis</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sturnira lilium</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>Uroderma bilobatum</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Bauerus dubiaquercus</td>
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<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Carollia breviceuda</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>Pteronotus parnellii</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Enchisthenes hartii</td>
<td>1</td>
<td>0</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Anoura geoffrovi</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
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<td>Lasiusrus blossevillii</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Glossophaga soricina</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>X</td>
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</tr>
<tr>
<td>Desmodus rotundus</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Trachops cirrhosus</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

LF= number of bat captures caught at La Fortuna; BC= number of bat captures at Base Camp; CT= number of bat captures at Cantiles; BA= number of bat captures at Buenos Aires; GL= number of bat captures at Guanales; AM= number of bat captures at Agua Mansa; new to park= species is newly recorded in Cusuco National Park in 2005; new to core = species is newly recorded in the park core zone in 2005.
Summary of results
Understorey mist net surveys resulted in 5 new species records for the Cusuco National Park, and 8 new species records for the core zone not found last year bringing the species list totals to 23 species for the park and 17 species for the core zone. For all sites in the core zone combined (all sites minus Buenos Aires), the total number of bat captures per 6 m net hour was 0.037 bats/6 m net hr. Higher abundance was roughly correlated with decreasing elevation.

Total Recorded Bat Diversity of Cusuco National Park 2005

<table>
<thead>
<tr>
<th>Family</th>
<th>Subfamily</th>
<th>Species</th>
<th>Guild</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phyllostomidae</td>
<td>Phyllostominae</td>
<td>Micronycteris microtis</td>
<td>Gleaning insectivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trachops cirrhosus</td>
<td>Gleaning insectivore/carnivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phyllostomus hastatus</td>
<td>Omnivore</td>
</tr>
<tr>
<td>Glossophaginae</td>
<td></td>
<td>Glossophaga soricina</td>
<td>Nectivore/insectivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anoura geoffroyi</td>
<td>Nectivore/insectivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hylonycteris underwoodi</td>
<td>Nectivore/insectivore</td>
</tr>
<tr>
<td>Carolliinae</td>
<td></td>
<td>Carollia brevicauda</td>
<td>Small frugivore</td>
</tr>
<tr>
<td>Stenodermatinae</td>
<td></td>
<td>Sturnira lilium</td>
<td>Small frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sturnira ludovici</td>
<td>Small frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Artibeus intermedius</td>
<td>Large frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Artibeus jamaicensis</td>
<td>Large frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Artibeus toltecus</td>
<td>Small frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enchisthenes hartii</td>
<td>Small frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Uroderma bilobatum</td>
<td>Small frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chiroderma salvini</td>
<td>Large frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vampyrodes caraccioli</td>
<td>Small frugivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Centurio senex</td>
<td>Small frugivore</td>
</tr>
<tr>
<td>Desmodontinae</td>
<td></td>
<td>Desmodus rotundus</td>
<td>Sanguivore parasite</td>
</tr>
<tr>
<td>Vespertilionidae</td>
<td></td>
<td>Myotis keaysi</td>
<td>Aerial insectivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Eptesicus brasiensis</td>
<td>Aerial insectivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bauerus dubiaquercus</td>
<td>Gleaning insectivore?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lasiurus blossevillii</td>
<td>Aerial insectivore</td>
</tr>
<tr>
<td>Mormoopidae</td>
<td></td>
<td>Pteronotus parnellii</td>
<td>Aerial insectivore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 recorded families</td>
<td>23 recorded species</td>
</tr>
</tbody>
</table>

Natural History Notes
A large number of wrinkle-faced bats (Centurio senex) were captured on an open mountain ridge at 1900m in primary forest. These bats were previously thought to live in very small groups at elevations under 1400 m in dense vine tangles and secondary growth.

A frog-eating bat (Trachops cirrhosus) was captured at 1400m, which matches the current elevational record of 1400m at Monteverde, Costa Rica. At this site, Agua Mansa, locals described sighting bats that matched the subfamily Phyllostominae, a group of large bats (including Trachops) that are good indicator species for areas of high conservation value (Medellin et al. 2000).

The Central American population of highland yellow shouldered bats (Sturnira ludovici) may be distinct from that in South America (Reid 1997). The forearm measurements recorded in Honduras are consistently and significantly larger than the measurements given by Reid (1997). These data may be further validating the existence of two distinct species. The correct name of this bat would then be S. hondurensis (Reid 1997). For this species, I am also taking measurements of the tibia and foot. A literature review will be conducted after leaving the field.
**Considerations for future work**

I strongly suggest the following changes to methodology: Canopy nets and possibly harp traps should be utilized in addition to understorey mist nets. Understorey mist net surveys are biased towards frugivorous phyllostomids that fly below the canopy, and the majority of captures were of this group of bats. About half of neotropical bat species are caught predominantly or exclusively at the canopy level (Bernard 2001). Harp traps are generally more productive for insectivorous species.

Survey sites and times spent at various sites should follow a rational sampling regime, and not be designed around the school program. For example, the vast majority of sampling effort was concentrated at a high elevation site, Cantiles, while lower elevation sites with potential for more diversity were undersampled, because time was allocated to sites primarily based on the need posed by school groups.

Captured bats should be marked with labeled bands (rings). DNA samples of all species should be taken using wing punch biopsies.

To increase the species inventory, further sampling should occur at Guanales and Agua Mansa as these sites have high potential for diversity due to their relatively low elevations in primary forest. Future work might also include radiotracking to find day roosts of captured bats, especially for species for which this information is lacking (e.g. *Sturnira* spp.).

**Literature Cited**


2. Bat Report El Paraiso 2005

Tamir Caras

Aims and objectives
While the main aim (and title) was to investigate the relationship between wing morphology and echolocation calls of lowland/coastal forest, in addition we have conducted an experiment studying the flight behaviour in relation to flight corridors. Additional efforts were put into general biodiversity investigation, most notably canopy trials for next year’s projects.

Rational
In cluttered/densely forested environments bats are found to have shorter/wider wings for increased manoeuvrability with a lower intensity echolocation call. In contrast, species living in more open/sparsely forested areas have longer thinner wings and a higher frequency echolocation call. This has been found to be true for bats in many areas, including Indonesia, North America and Europe.

The secondary experiment was based on another well known behavioural ecology phenomena bats are famous for. Using cleared corridors within dense vegetation serves the bats with few benefits – safety, allowing for speed, energy savings and navigation simplicity. Although this behaviour is reported and thought of as given fact – it was never quantified. We aimed to fill in this gap.

Methods
While the general netting was supplying us with species for the main project, towards the end of the season we made more effort to complete the second. Essentially the processing of the bats was identical for both netting system.

We used the corridor net system to exploit the already existing corridors or paths throughout the forest. We chose paths we knew bats use.

Netting was done at 8 different sites in the forest. These were divided into two categories - man made paths and natural corridors, such as rivers. Density of vegetation and other related attributes were noted. The paths were sampled twice with a different end of the net closed each time.

A 6m and a 9m mist net were used to form an open ended rectangle, 6m by 3m, with a height of 2.5m. The nets were opened at 6pm, and closed between 9pm and 12pm, depending on weather conditions. Some nights we couldn’t net due to rain, because when it is raining the nets have droplets of the rain on them and it makes them easier to see for the bats. (Not monitoring the rain conditions more closely is my biggest regret.) Secondly, bats caught in wet nets would suffer severely from stress and cold. The nets were checked every 15 minutes, and the bats were removed and placed into cotton bags. Notes were made of which net side bats flew into.

All bats were processed on site, and released in the same area as captured - keeping to the following procedure:

Bats weighed in the bag (minus the bag weight) to the nearest gram.
Forearm and tibia measurements were taken with callipers.
Bats were sexed; reproductive status and age were determined.
The wing was digitally photographed on mm paper, ventral side down, with the right wing extended.
Effort was put into making sure the wing was properly stretched for later measurements.
Wing punches were taken for DNA samples. This is also identified recaptures.
Where possible, faecal pellets were taken from the bags. An attempt to culture the seeds present was made successfully.
Echolocation calls were recorded on release.
Analysing data
All data recorded at night was inputted into computer the next day in an access database. Photographic and audio data were evaluated and ranked for quality. In the analysis low ranks and juveniles were ignored. The wing images were analysed using ImageTool software. Around 32 measurements of each wing were taken. Wing loading, aspect ratios and a wide variety of established calculation were then constructed and formed comprehensive set of attributes for further analysis.

Statistic analysis has taken place using SPSS 11.5 but is yet incomplete.

After screening all 283 individuals, 42 individuals of 16 species were eventually completed and used for analysis.

Results
We have caught a total of 285 bats, 23 different species, the majority of which are fruit bats, of the family Phyllostomidae (nose leafed or spear nose bats).

Preliminary analysis of corridor use indicates that only one species (Artibeus phaeotis) is an obligate non corridor user. Most of the other 15 species were very close to the 50% mark thus obviously all corridor users.

Naturally, no correlation between wing attribute and corridor use can be indicated (to the great disappointment of the student involved…). It is estimated that the lack of clear cut choice is related to surrounding vegetation and the in situ precipitation. Ultimately, the sample size is too small to filter away the above considerations.

Preliminary results are shown in the figure below, representing the three sides of the nets.

A & D: excellent flyers - don’t use the trial, fly through the vegetation
  = ‘none users’

E & F: bolt through the trail
  = ‘bolters’

B & C: agile flyers trail users with good manoeuvrability
  = ‘tryers’

After filtering out adults, quality control and completed sets of measurements, 42 individual wings and 16 species wings are investigated below. These are preliminary results and hopefully further work will be done. Of the many wing-attribute calculations, area/circumference ratio shows the tightest fit within species and greatest difference between genera. This seems to be correlated closely to the feeding behaviour. It is missing few species which are all insectivores. See next figures:
General evaluation and notes
In general the project run quiet well. After a steep learning curve methods were established and data collection moved into higher gear.

Netting went very well. The nets suffered some wear and tear as expected from working in a very dense environment. Although they will possibly last another season – we should consider getting a few replacement nets, unless we can get them in country. Trials with canopy nets were successful although demanded infinitely more manpower and skill. They would be a very good expansion direction for continued research.

The photography and wing analysis went very well and is recommended as an integral part of further research. Working with ImageTool software has shown good accuracy levels except for angle measurements. It is recommended that more effort should be put into closely training individual in its use.

Experimenting with seeding and faeces analysis have shown very encouraging signs. Here the ‘trick’ is to start as early as possible in the season (generally, I feel that a slightly longer season could be useful).
The use of the bat detector was limited this season and should be expanded. Unfortunately, it is suffering of the void of knowledge existing in the call-spp ID matching - database of calls = species does not yet exist. The data collection towards this has been started during this season but is not yet fully functional. It would benefit from more vigorous use although it is harder to tailor a dissertation based on its use alone. The mini disk was proven useless and all recording were done using my mp3 player. I believe this is a very valuable lesson to be learned – something I will introduce to bat work in my local bat group.

Something else I would like to suggest for the next season is the use of night vision. This will provide a whole new dimension of work opportunity and will greatly increase interest. These are seldom too expensive and can be effectively used students to undertake behavioural work and by college students alike. I would strongly recommend using it in conjunction to the bat detector as it will instantly solve our biggest difficulty related to ID of call.

DNA work has not yet been taken for analysis but has excellent prospective. Further research concerning the collection of external parasites opens a very exciting potential. In the last few days I have put my attention to this opportunity more closely and found that interspecific as well as intraspecific parasites were collected. This works well in conjunction with every other netting related study.

College students were often seen as a hindrance. I take a different view. They often surprised me with their enthusiasm and responsibility. Although unpredictable (in terms of human quality), I believe given the opportunity, they can have some input to offer. Much more so – this observation applies to general volunteers.

Potential publication
So far I’m far too busy to take any of these data further. Maybe during Xmas break. I’ll be in Israel and hopefully in a position to work with local bat scientists on the call analysis. DNA is one potential and wing – call morphology is the other. None of which is ready for data analysis (call analysis is not done so far, wing measurements are incomplete).
3. Wing and tail morphology of the microchiroptera of Honduras.

Alan Haynes, Keele University

Supervisor Tamir Caras

Aims
Does the wing of a bat with a greatly reduced tail membrane compensate in some way for the lack of the tail membrane?
Is there a significant difference between the frequency and timings of calls emitted by the different bats?
Does the tail membrane of insectivorous bats play a greater role on lift and flight than the tail membrane of frugivores?
Do bats with different tail membranes use paths in different ways?

Methods
Bats captured using mist nets in 2 different configurations. We trapped in a number of sites within the forest and repeated each at least once. We used straight nets to increase the diversity of bats caught, and we created corridors along paths. This gives us 6 directions that the bats may be using. The thinking behind this is that larger, less agile bats would be using the paths more getting caught in the end of the net, whereas smaller, more agile bats would be using the paths less, therefore getting caught in the sides of the nets.

Bats caught were weighed, identified, sexed, aged (by looking at the knuckles), sexual status determined, forearm and tibia measured and photographs taken of the out stretched wing, tail membrane and face. In some cases pictures were also taken of the coloration of fur (to confirm species later, if any doubt remained). Bats were released from the hand and the echolocation calls recorded as the bats fly away, calls recorded onto an mp3 recorder. This method produced mixed results since the bats can fly in a variety of directions and there is no guarantee that they will fly towards the recorder. Dependant on lighting the bat may not even call at all.

Pictures were transferred to computer and a number of measurements taken, including finger lengths, areas, circumference, approximately 30 different measurements were taken.

Recording were analysed on the computer using power spectra and hanning windows. Measurements taken include peak frequency, start, end, highest and lowest frequencies, call duration and intervals, and the number of harmonics.

All data was inputted into an MS Access database.

Preliminary analysis of data shows some significant differences between wings of different species and different areas of wings as well as the ratios between some of the different areas.

Completion: May 2006
Aims
Our original main aim was to investigate the relationship between wing morphology and echolocation calls of the Honduran insectivorous bats.

In cluttered/densely forested environments bats are found to have shorter/wider wings for increased manoeuvrability with a lower intensity echolocation call, in contrast to those found living in more open/sparsely forested areas who would have longer thinner wings and a higher echolocation call. This has been found to be true for bats in many areas, including Indonesia, but has yet to be researched in Honduras. However, it is thought to be a phenomenon true all over the world.

Our original plan to investigate this theory involved placing mist nets in various locations throughout Paraiso, in order to catch the bats and determine a general diversity of bats in the area. Due to the lack of echolocation data, we were advised to re-evaluate our original aims and perhaps focus more on the wing morphology. Therefore, we re-designed our method and our distribution of mist nets around Paraiso.

Our new aims now are to investigate:
whether bats actually use corridors throughout the Paraiso forests,
any differences or similarities between spp and how they use the nets,
the wing loading, manoeuvrability/agility of bats of different spp

Methods
We used the corridor net system to exploit the already existing corridors or paths throughout the forest. We chose paths we thought bats would use.

We netted at 8 different sites in the forest, normally in man-made paths, although some were in natural corridors, such as the dry riverbed. Some had more dense foliage surrounding the path, and some less dense. The paths were sampled twice with a different end of the net closed each time.

A 6 m and a 9m mist net were used to form an open-ended rectangle, 6m by 3m by 6m, with a height of 2.5m. The nets were opened at 6 pm, and closed between 9 pm and 12 pm, depending on weather conditions. Some night we couldn’t net due to rain, because when it is raining the nets have droplets of the rain on them and it makes them easier to see for the bats. And if the bats did get caught in wet nets they would get very cold and wet. The nets were checked every 15 minutes, and the bats were removed and placed into cotton bags. We made note of which net the bats flew into, and which side of the net.

The bats were processed on site, and released in the same area captured. We weighed the bats in the bag to the nearest mm, then took the weight of the empty bag away to get the mass of the bat. Forearm and tibia measurements were taken with callipers. Bats were sexed, reproductive status and age were determined. Wing punches were taken for DNA samples. We made two little holes in their wings, which grow back within 1-2 weeks. This is also helpful as we can tell from the holes whether a bat is a new one, or one we have previously caught. The wing was photographed on mm paper, ventral side down, with the right wing extended. We made sure the wing was properly stretched for later measurements. Where possible, faecal pellets were taken from the bags so any seeds present could be cultured and what plant they came from determined. Echolocation calls were recorded on release.

Analysing data
All data recorded on night was put onto computer. The pictures of wings were analysed. We measured the length of fingers, wing area, wingspan, angles between fingers etc, and also area of tail. We took around 32 measurements from each wing.

We decided to calculate wing loading as one of our measurements. Wing loading is basically the mass of the bat, divided it’s total wing area (which includes the tail membrane area.) You can predict things from
wing loading, such as the manoeuvrability and flight speed of the bat. The wing morphology of the bats may affect if they use corridors, and we can also suggest from which net they get caught their agility.
So our findings so far...

We have caught a total of 285 bats, 23 different spp, the majority of which are fruit bats, varying in shape and size – biggest fruit bats we’ve caught are the *Artibeus lituratus*, as well as the mid-range sized *Carollia’s*, to the smaller *Glossophaga soricina*, with some insectivores e.g. *Saccopteryx bilineata*, and one spp of vampire bat: *Desmodus rotundus*.

So far, primary analysis of the data has shown that four of the spp we’ve found are definite corridor users, these are:
*Artibeus jamaicensis*
*Carollia perspicillata*
*Glossophaga soricina*
*Sturnira lilium*

We were a bit disappointed to discover that *Artibeus lituratus* are not corridor users, as they were caught equally both inside and outside of the net corridors.
We predicted that they would be net users, as they have one of the largest wingspans of the species we have caught; however this seems not to be the case. We are still looking into possible explanations for this result, and need to continue with further stats. Possibly, they are extremely agile, and have no need to use the corridors.

We have found that *Artibeus phaeotis* are definitely not net users.

We have discovered a small correlation between the wing loading and net use. See graph.

When wing loading is low, manoeuvrability is increased, which is supported by the graph we’ve produced, because bats with higher wing loading, therefore lower manoeuvrability, get caught in the inside nets more often.

We haven’t really had enough time in the field to complete proper analysis of our data, but we hope to have a draft of our projects completed to give to OpWall by November 2005. We both at the moment don’t know what our final project titles will be, and although we are planning to report on similar aspects of our data, we both plan to complete our projects individually.
Primate Ecology

1. Primate Abundance and Behaviour Cusuco National Park, Honduras 2005

Senior Primatologist: Kymberley Anne Snarr, University of Toronto, Canada
Assistant Primatologist: Kate Edwards, University of Liverpool, England

Introduction

While there have been extensive studies of primates in various countries in Central America, there have been few primate studies conducted in Honduras. To date, there have been three long-term studies, each covering the three species that range in Honduras, *Alouatta palliata* (Snarr 2005, Snarr in press), *Ateles geoffroyi* (Hines 2005), and *Cebus capucinus* (Buckley 1983). As primates are the largest arboreal mammals in Neotropical forests and are important to forest ecology, it is critical to understand their density, specific ecological needs and current knowledge, attitudes and practices of the main stakeholders to develop appropriate conservation strategies.

Operation Wallacea has been conducting research in multiple areas in Honduras. One area is Parque Nacional Cusuco, which is located in the Merendon Mountain range in North West Honduras. The park consists of 23,440 acres including a buffer zone (15,650 hectares) and a central core area (7,790 hectares). The park was created in 1987 and has been managed by Corporacion Hondurena de Desarollo Forestal (CODEFOR) in conjunction with other non-government organizations. There are three main forest types: broadleaf, pine and dwarf forests with zones of transition, agriculture, shade coffee plantations and recently logged areas. It is reported that the three Honduran species of monkeys continue to range in Cusuco National Park. The rapid ecological assessment of the Nature Conservancy (1996) demonstrates the presence of only one species of primates, *Alouatta palliata*. Previous primate work in the 2004 season detected the presence of *Alouatta palliata* (mantled howlers) (sightings and vocalizations) and *Cebus capucinus* (white faced monkeys) (sightings and vocalizations) with no sightings or vocalizations of *Ateles geoffroyi* (Central American spider monkey). While there has been discussion of *Alouatta pigra* (the black howler) ranging south into northern Honduras and the possibility of this species residing here (Hines 2004), to date there has been no confirmed sightings of howlers lacking a distinct mantle.

This investigation addresses the population density of the three species of monkeys in the three forest types. Population density was calculated for the three primate species by means of repeat walks on cut transects with descriptions of groups encountered. Distance sampling will be employed for data analysis. A secondary project examines the activity budget of the howlers ranging in the primary broadleaved forest and includes a subsidiary project which indexes common food sources of the primate species. The tertiary project employs ethnographic inquiry to investigate the knowledge, attitudes and practices of local stakeholders in regards to the monkeys and the forests they range in.

Methods

Primary Project - Primate Density

The primat population density was surveyed through employment of repeat transect survey. Two transects were cut, one in the core area seven kilometers in length, and the second in the buffer zone five kilometers in length. Each transect included representation of the two main forest types, broadleaf and pine and includes both primary and secondary broadleaf forest. These transects were walked at approximately 1.25 km/hr twice weekly with when heavy rains were not occurring. Each time a group of primates were encountered, the researchers stopped walking, and recorded the species type, group size and composition with further details on activity if possible.

Transect locations were selected randomly with consideration to the forest type locations. The transects were cut by three local guides. Due to the mountainous nature of the core area of PNC, these transects were not a straight but were a continuous line, no wider than a half meter. Transect location can be seen in Figure 1.
Data collection

When primate groups were encountered, the general location was noted and if possible, an exact location was taken with a handheld Garmin 72 GPS unit. Perpendicular distance to the centre spread of the group, number of individuals, composition of group, and when possible, feeding and behavioural data were recorded. The centre spread of the group was based upon the visible individuals. Upon noting the group, a decision was made upon where the ‘centre’ of the group was located and which tree would represent this location and distance. When hunting routinely occurs in a region, groups would often flee thus vocalizations were also included in the data analysis. For sightings, perpendicular distances were first estimated by the researchers followed with definitive measures taken using a tape measure or a range finder (Bushnell yardage pro). To reduce inaccuracy, prior to data collection, the observers were trained to spot and agree upon the centre spread of the group encountered and the tree that would represent this location. To obtain perpendicular distance, one of the two observers would note a reference point at the edge of the trail, closest to the location of the detected group, often a tree or mat of vines which was easily identifiable was utilized. With this reference point, the perpendicular distance was measured from this point to the centre of the spread of the group.

To reduce systematic observer biases, discussions on group counts and censusing techniques were part of training sessions with the local observers. Two weeks of pre-work training and pre-survey joint work on the water paths were conducted to help standardize data collection (Peres 1999). During the initial data collection, comparisons and adjustments were made between the various observers to minimize systematic observational errors.

During the minimal 15 minute contact periods on the line transects, scans were conducted using two observers (Altmann 1974; National Research Council 1981; Clutton–Brock 1977). A count of all the visible members of the group or single individual monkeys and their age and sex category was taken. Scanning from left to right, the assigned observer would count all the individual(s) seen, indicating the age and sex category of the individuals. The categories were: adults, adult males, adult females, adults unknown sex, number of juveniles, juvenile males, juvenile females, juveniles unknown, and
number of infants. Due to difficulty in visualizing the sex of the infants, the sex was not recorded. The specific age and class categories for the three species are detailed with each species description below. The research assistants were trained using visual aids to ensure standardization of age and sexing.

**Primate Species under Investigation**

[A] *Alouatta palliata*

English common name: mantled howler  
Spanish common name: olingo

Mantled howlers live in groups ranging from 5-28 with single individual howlers found living solitary during periods of immigration (Crockett and Eisenberg 1987). Recent results from a long-term study in lowland swamp forest in Honduras found a group size of 6 (Snarr in press). Howlers are found from lowlands up to 2500 m (Reid 1997) and are relatively flexible in their diet but are known for their high degree of leaf eating.

For mantled howlers, the four age and class categories utilized are: infant (<1 year), juvenile (1 to 4/5 years), adult female (> 4 years), and adult male (> 5 years) (Clarke and Glander 1984; Crockett and Pope, 1993; Glander 1980). As the testicles do not descend and the scrotum does not become pendulous until 2-3 years of age, the older juvenile males can be difficult to distinguish from the adult females (Carpenter 1934; Glander 1980). Thus, if there was uncertainty, this was indicated in the notes during observational times as adult unknowns, abbreviated as AU.

Utilizing Carpenter’s (1934) criteria, adult males were identified by the following characteristics: presence of white scrotum, large size relative to adult females, with associated longer hair, presence of beard giving appearance of square shape to head, and vocalization behaviours associated with male as seen in Figure 2. Further to this, adult females were identified through the following characteristics: full sized but smaller than males, presence of nipples, lacking testicles, and potential presence of infant.

Identification of infants and juveniles were based upon Carpenter (1934) with some modification from Glander (1980). The category of infants, aged approximately up to 13 to 16 months of age, was based upon their small size, dependency on the mother, being carried, and/or pelage of grayish-brown to brownish-black to black with increasing tendency to play. Whereas, juveniles, approximately 18 to 48 months, were identified by their increasing size, independence from mother, increasingly distinguishable mantle, and/or decreasing amount of play with an increase in time spent on other activities.

Figure 2: Adult Mantled howler  
photo credit: Kymberley A Snarr
**Cebus capucinus**

English common name: white-faced, white-throated capuchin  
Spanish common name: mono cara blanca  
White-faced capuchins live in groups of 5-30 with the larger groups spreading out to forage during the day (Reid 1997). Capuchins are omnivore, eating fruits and insects mainly; while they use the entire canopy they are often found in the middle canopy. White-faced capuchins can be found from the lowlands up to 2000m (Reid 1997). The pelage of the adult is mostly black with yellow-cream fur on the head, chest and shoulders with a pink face as seen in Figure 3 (Reid 1997). Dimorphism exists in the white-faced capuchin with males about 30 % larger than females (Kinzey 1997). Thus, adult males can be distinguished from adult females. Infants are born with a gray face and ears transitioning to the adult pelage colour of black with a white front and face by 3 months (Napier and Napier 1967). As discussed by Kinzey (1997) new infants will cling to the mother’s ventral side up until approximately 9 weeks when the infant will climb onto the back of the mother. After 10 weeks, the infant will spend 50% of activities independently away from its mother.

Figure 3: White-faced or white-fronted capuchin  
photo credit: Kymberley A Snarr

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**Ateles geoffroyi**

English common name: Central American spider monkey  
Spanish common name: mono arana  
Spider monkeys live in fluid groups formed by fission-fusion organization, breaking into subgroups for feedings (Kinzey 1997). Thus, only subgroups are likely to be encountered. Spiders are frugivores, eating mainly from large fruiting trees (Kinzey 1997). They are found from lowlands up to 2500m (Hershkovitz 1977) whereas Reid (1997) only reports them to 1800m. The pelage of the adult spider monkey is mainly black above with some brown or orange on the lower sides and rump, with cream-white underparts as seen in Figure 4 (Reid 1997). The spider monkey is difficult to distinguish between the males and the females as they are of similar size (Kinzey 1997). The female has a pendulous clitoris which aids in distinguishing it from the male who has a relatively small scrotal sac (Hines 2005). Infants are black with juveniles transitioning to the adult pelage (Reid 1997).
Figure 4: Adult Central American spider monkey. Photo credit: Justin Hines

Distinguishing between the three species in the field
Generally, it is relatively easy to distinguish the three species of monkeys. Howlers are relatively large bodied with adults ranging from about 6-7 kg. They are large and stocky with a black coat which has an orange-copper to dark brown longer hair running along the sides. Males are larger than females with the males possessing beards and long pendulous scrotums. Spiders may be confused with howlers as they are large as well but they are about double the size of howlers, weighing in at 11-15 kg (Kinzey 1997; Reid 1997). What does distinguish them easily from howlers are their long thin limbs and small head. They have a vestigial thumb and a long prehensile tail. They are mainly black on the back with some brown or orange on the lower sides and rump, cream-white under parts. Capuchins are easily distinguished from the other two species via their coat and the fact that they are relatively smaller. The black coat contrasts dramatically against the pale yellow head and are considered medium sized at 4-6 kg (Kinzey 1997; Reid 1997).

Secondary Project - Activity budget of *Alouatta palliata* ranging in primary and disturbed broadleaved forest
To understand the activity budget of the most commonly encountered primate species, scan sampling was employed. The methodology for scan sampling was described above in the primary project section. With each individual count, an activity was also described. A list of the assigned behaviours and their definitions can be found in Table 1. The activity categories were broad categories as this project is studying unhabituated groups of mantled howlers and viewing distances were often greater than 20 meters.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Feed (f)</td>
<td>the consuming of food items</td>
</tr>
<tr>
<td>Climb (c)</td>
<td>the changing of positions within a tree</td>
</tr>
<tr>
<td>Forage (fo)</td>
<td>visually seeking food sources</td>
</tr>
<tr>
<td>Rest (r)</td>
<td>inactivity in a sitting, standing or laying position</td>
</tr>
<tr>
<td>Move (m)</td>
<td>movement between trees</td>
</tr>
<tr>
<td>Groom (g)</td>
<td>receiving (+)/giving (-) physical contact in the form of grooming</td>
</tr>
<tr>
<td>Autogroom (ag)</td>
<td>self cleaning coat</td>
</tr>
<tr>
<td>Play</td>
<td>grappling with self or other individual</td>
</tr>
<tr>
<td>Vocalization</td>
<td>all forms of oral vocalization, including long calls and soft throat barks</td>
</tr>
<tr>
<td>Other</td>
<td>includes all subcategories not assigned</td>
</tr>
</tbody>
</table>
Activity budget work was carried out mainly in the trail system of the Guanales fly camp in primary and primary disturbed forest broadleaf forest. The trail system is shown in Figure 5. There was a small amount of contact time in other areas of the park where activity budget information was gathered.

Figure 5: Representative Map of Trail System in Guanales Fly Camp, Cusuco National Park

To compliment the behavioural ecology work, a subsidiary project to identify basic species of food sources of howlers was undertaken. Common names were obtained from key informants and in field observations, and builds upon the 2004 season of food sources. When the opportunity arose, a representative sample of leaf arrangement and if available, fruit, along with good quality digital field photographs of the bark, canopy, leaf arrangement and fruit were obtained. In the field or in the science room, good quality digital photos of the leaf and fruit samples were taken with contextualizing measures. These samples and their common names were used to aid in identifying the scientific name. When samples of sources were obtained from primate observations, species utilizing source, GPS/ general location and forest type were recorded.

Tertiary project - Stakeholder knowledge, attitudes and practices towards monkeys and the forest they range in

Further information on population density, the background of primate density and the main stakeholders knowledge, attitudes and practices, key informant and semi-structured interviews were carried out opportunistically. As defined by Schensul et al (1999b), semi-structured interviews consist of a set of predetermined questions related to domains of interest and is administered to a representative sample of respondents to confirm study categories, and identify factors, variables, and items or attributes of variables for analysis. In this research project, open-ended questions were employed. Thus, allowing built-in flexibility as the predetermined questions allow the collection of data in specific areas while the open-endedness of the questions allows the researcher to expand and probe into areas of interest and importance at their discretion based upon respondent’s answers. As discussed in Schensul et al (1999b), the predetermined questions flow temporally from earlier to more recent events, from simpler to more complex topics, and contains grouped questions which move from concrete to abstract issues, and move from the least sensitive or threatening to more sensitive or threatening.

There were three general areas to the interview. The first section of the interview contextualized the interviewee by investigating their longevity, position and association within the particular stakeholder. The secondary section moved to knowledge of mammals and specifically monkeys, with sub-
questions relating to their knowledge of PNC and the connections between themselves and this area (historically and presently). The interview finished with a small more abstract section on the forest and environment in general, allowing the interviewee to discuss changes in the environment and to express what they felt the future held for the forests and the monkeys.

In the initial stages of the interview, I informed the interviewee of the project and material being covered, obtained verbal consent to carry out the interview and for inclusion of data collected during interview for research purposes. Confidentially of the information collected was stressed and that there was no attachment of the name to the material. For each interviewee, I employed a coded number based upon the date and their stakeholder association. The questions were asked in a conversational manner and thus, the interviews flowed as a ‘guided’ conversation. Dependent upon the answers, there was expansion with further questions or exploration into areas that were not thought of prior to the setting of the interview questions. If the predetermined questions were answered prior to asking them and while in the flow of discussion, I would ensure not to ask any questions that had already been answered, thus avoiding repetition.

During the interview, handwritten notes were made in a small handheld notebook in as an unobtrusive manner as possible. I recorded only detailed observations and responses from the interviews. Any inferences, hunches, emotional response from me were recorded in a separate part of the notes. When recording, I utilized key words, attempting to note as many words as possible without losing the train of listening or engagement in the ‘conversation’. At a later time, usually within 24 hours, I fleshed out the interview notes into full text. I attempted this as soon as was possible as memory can fade or alter the experience, resulting in missing or altered details. Tape recording and transcription is favored by some due to completeness of notes (Emerson et al 1995; Schensul et al 1999b), whereas others argue that handwritten notes in some settings are more appropriate as they are less intrusive, allowing for a higher comfort level of the interviewee (Schensul et al 1999a). As this data collection took place in mainly rural and natural settings, it was less intrusive to use small notepads and produce handwritten notes rather than tape recording as many of the interviewees were not familiar with and may have been uncomfortable with these types of electronic devices.

**Results**

**Primary project – Population Density**

Over the eight week period, there were eight walks on each of the two transects. During these walks, only mantled howler groups were encountered and/or vocalizations heard. There was no direct evidence of the Central American spider monkey (*Ateles geoffroyi*) or of the white-faced capuchin (*Cebus capucinus*) and thus, only mantled howlers are included in the population density analysis.

In the core zone transect, there were three encounters with howler groups where behavioural ecology data was collected. A number of vocalizations were evident. While distance sampling has not been carried out at this stage, there is strong evidence of approximately four groups of howlers ranging within the 3.5 km² contained in the core transect.

In the buffer zone transect, there were no encounters and only vocalizations of the mantled howlers indicating a lower density of mantled howlers than what was found in the core. While distance sampling has not been carried out at this stage, there is strong evidence of one group of howlers ranging within the 2.5 km² contained within the buffer transect.

**Secondary project - Activity budget of *Alouatta palliata* ranging in primary and disturbed broadleaved forest**

Eight weeks of attempted contact with mantled howlers in the area of the Guanales fly camp resulted in 39 hours of contact time and data collection on their behavioural ecology. Preliminary analysis shows that their activity budget falls within the normal range of other mantled howlers with a high percentage of the day spent resting. Feeding indicates a high degree of fruit intake as clearly indicated from opportunistically collected fecal samples during contact time. The fecal samples contained approximately 80-90% ficus seeds with other larger seeds contained within.
Tree measures to understand canopy height and depth were taken but have not been analyzed at this stage. Preliminary results show that there are areas which house a number of key fruiting sources which are utilized by the mantled howlers. At this stage, only common names have been included until further access to botanical literature can be accessed. Species in these key fruiting areas include: strangler figs, fig species, hichoso, lima de montana, and guamo. Some of the key fruiting and food sources were mapped out from the Guanales trail system and can be found in Figure 6.

Figure 6: Key fruit and food sources found along the Guanales trail system

Vocalizations were also tracked daily within the area understand the number and movements of the groups in the Guanales area which lies on the line between the buffer and the core zone. Within the 9km² area surrounding the Guanales camp, there are three to four groups of mantled howlers ranging through the area and using food resources from the primary and primary disturbed broadleaf forest.

A preliminary index of the food sources are contained within Appendix I: Photo Index for Identifying Food Sources for the Non-Human Primates of Cusuco National Park, Honduras and is an electronic attachment.

Tertiary project - Stakeholder knowledge, attitudes and practices towards monkeys and the forest they range in.

There were 12 semi-structured in-depth interviews conducted with 7 located in Buenos Aires (buffer zone village located on main access road) and 5 in Aqua Mansa (west end core area). There was only one female interviewed with the remaining 11 interviewees being male. In the males over 45 years of age, a good level of knowledge about the forest and the monkeys was found. These members of the community had experience hunting and extraction of non-timber forest products (NTFPs) from the forest.

The descriptions for the three primate species revealed low recognition of spider monkeys and capuchins whereas howlers were described correctly about 50% of the time.

Following the descriptions, photos were presented. From the photos, recognition of the three monkey species was relatively low with great confusion between howlers and spider monkeys. A wide range of common names was found as indicated in Table 2.
Table 2: Common names of the three primate species of Cusuco National Park, Honduras

<table>
<thead>
<tr>
<th>Primate Species</th>
<th>Common Names used by local residents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mantled howler</td>
<td>olingos, mico negro</td>
</tr>
<tr>
<td>Central American spider monkey</td>
<td>mono arana, mono cara blanca, mico</td>
</tr>
<tr>
<td>White-faced capuchin</td>
<td>mono cara blanca, mico cara blanca, mico</td>
</tr>
</tbody>
</table>

During the interviews, the more knowledgeable interviewees revealed good clear evidence of common fruiting sources. As well, the main areas where they ranged in the park indicated a good knowledge level that the monkeys range in the broad leaf forest areas. Some of the interviewers indicated that the howlers and spider monkeys were hunted for meat whereas the capuchin was not desired as meat due to the hairless face and poor flavour of the meat due to their diet. Three of the interviewees indicated the use of the oil of the spider and howler monkeys in the treatment of asthma. The numbers of monkeys are thought to have stayed the same or increased over time due to conservation and various reforestation programs. Most of the interviewees revealed that the forest in the park had a good future due to the previous reforestation programs and re-growth post-logging in 1945-1951.

**Discussion**

During the 2005 season, there was clear evidence of the continued presence of the mantled howler in Cususo National Park. Earlier reports indicate the presence of howlers in the park (Freer 2003; Hines 2004; TNC 1996). This species has a low density to absence in the buffer zone which lies close to the core boundary and close to the main access road into Base Camp. There is a higher density within the core area as indicated by vocalizations. Key informants indicated during interviews that howlers ranged near base camp in a riverine broadleaf forest approximately 10 years ago but have since been hunted out.

There was no direct evidence of the Central American spider monkey nor the white-faced capuchin during the 2005 season. Earlier reports indicate the lack of concrete evidence of their presence (Freer 2003; Hines 2004; TNC 1996). Key informants and interviews discuss their continued presence in the area of Guanales but there has been no confirmed evidence of their presence although one interviewee indicated that during September and November when there were more fruiting sources, the spider monkeys were present. Due to the lack of contact with these two species, exploration walks were taken into the western portion of the park (GPS 64.5/17.5) to find direct evidence of their continued existence. This area is located deeper in the core area and is commonly known as Aqua Mansa. While neither visuals nor vocal evidence was found, interviews indicated the presence of the three species in Aqua Mansa and Cedralles. Behaviour of the howlers from this exploration found them easy to locate. Their high level of vocalization and behaviour indicates a low level of hunting.

Due to the high level of fruit eating in both the howler and spider monkeys, both are desired for meat during hunting. As they do consume a large amount of fruit, these primates are important in the forest ecology as key seed dispersers due to their large home ranges. During the food sourcing project, a wide variety of fruit were found to be eaten, often with key sources clustered together. Other mammals and birds were found to heavily utilize these areas as well. An understanding of how the feeding habits of the primates affects the food consumption of the terrestrial mammals is a future project as the monkeys may be releasing fruit from the tree to the ground for other species. Thus maintenance of these areas and any conservation policies in collection of fruit as NTFP needs to be incorporated into management plans.

Evidence of hunting has been indicated both by the presence of hunting platforms for pacas, hunting dogs passing through Guanales camp after wild pig and the sounds of guns during the 2005 season in the Guanales area. Interviews indicate continued evidence of hunting of the larger mammals including howlers and spiders from various areas in the park. The future of the monkey species in the park remains uncertain the face of hunting and continued encroachment in the area.
Summary

1. Presence of mantled howlers indicates continued reasonable population densities in the core area.

2. Lack of concrete evidence on the presence of both the Central American spider monkey and white-faced capuchin indicates their extirpation or low population numbers.

3. Due to the large consumption of fruit in the primate species of CNP, there is a need to manage the fruit sources they are relying upon. If these fruits are to used as non-timber forest products and managed for extraction, further work on their

4. Hunting pressures threaten the security of all three species of primates ranging in Cusuco National Park.

5. Future study needed to study and confirm the presence of the spider monkey and white-faced capuchin, population density, habitat range and food sources.

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SNARR, K.A. in press. Seismic activity response as observed in mantled howlers (Alouatta palliata), Cuero y Salado Wildlife Refuge, Honduras  Primates

Invertebrate diversity, abundance and ecology

1. Buenos Aires Butterfly Report

Jose Nuñez-Mino, 2005

Methodology
To follow on from the work carried out in 2004, two quantitative sampling methods were used to assess the butterfly diversity and abundance at two sites in the area surrounding Buenos Aires. The methods used were: Fruit baited butterfly traps and transect walks (Modified Pollard Technique). Each site was sampled for three weeks.

The two sampling techniques assess the biodiversity and abundance of the butterfly population at the two sites. Baited traps and transect walks provide complimentary data on butterfly diversity and abundance (Sparrow et al., 1994). These two techniques sample different adult butterfly guilds.

I. Van Sommeren butterfly-Rydon bait traps.
Van Someren traps (see Figure 1) were used to sample the fruit-feeding butterfly populations of the forest interior and shade coffee. All traps were made locally by the Alvarenge family in Buenos Aires.

Figure 1 – Schematic of Van Sommeren Trap (based on Daily & Ehrlich, 1995)

A total of 20 traps were available. Traps consist of a cylinder of fine mesh netting, held open by two wire loops. The netting has a plastic top to protect the trap and butterflies within from rain, while at the bottom (open end) a platform hangs suspended 6cm from the netting, see Figure 1. Each trap was at a minimum distance of 5m from the nearest neighbour, some were set at canopy level but the majority were set under 5m from the ground (last year’s results suggested that there was no difference between ground and canopy traps).

The traps were baited with bananas (Musa sp.) that were locally obtained. The bait was prepared by cutting up ripe bananas into a bucket and allowing them to ferment for 48 hours. Traps were baited 24 hours before the first check took place. Every day a small amount of the original bait was added to the trap in order to make up for losses to forest insects (mainly ants) and to keep the bait fresh.

A new batch of bait was created after four days before moving the traps to a new sampling site. The data collected over a four day period was considered one sample in order to account for variation in daily catches caused by changing bait quality and variable weather conditions. Pooling data in this way reduces individual trap variance (DeVries & Walla, 2001).
Traps were checked once daily; every butterfly found in the traps was either identified at the site or sampled for later identification. Butterflies were only killed if identification was not possible in the field immediately. Once killed (squeeze of the thorax) they were placed in a labeled (date, trap number, site/location and investigators initials) glassine envelopes. All captured butterflies were marked with unique identifiers (Felt tip pen mark on wing) in order to assess recapture rates.

In contrast to last years work the focus in Buenos Aires was to compare diversity and abundance of butterfly species in the disturbed secondary forest with the shade coffee plantations. The two habitats sampled were very similar to each other in both sample sites: both were near watercourses and the shade coffee had a high density of shade trees along with dense undergrowth. There were however substantial differences in the way habitats were paired at each sample site. The sampling areas in the first site were separated by a distance of approximately 1.5 Km while the second site had sampling areas that were bordering on each other (block sampling design). In addition, the first sampling area was set in a mosaic of intensively farmed land with relatively small fragments of forest while the second sampling area was in an area that had been largely abandoned since 1998 (Hurricane Mitch). The coffee in this area was surrounded by the secondary forest that had regenerated since 1998.

The two sampling areas were:
1. “Cascada El Tucan” (El Tucan Waterfall; Elevation: 1128m; N 15°29.337' W 088°14.063') paired with a shade coffee area (Elevation: 1091m; N 15°30.402' W 088°11.282'). The area in the map (Appendix 1) marked as T1 indicates the shade coffee site where trap sampling is being carried out. The T10 site is where the secondary forest site. The areas were sampled for three weeks from 11 of July 2005 through to 29 July 2005
2. “Quebrada Hernandez” (Hernandez stream; Elevation: 1103m; N 15°30.299' H 088°10.724') sampled from 4 August through to 24th August 2005.

II. Pollard transect walks.
Pollard (1977) developed a standardised method for sampling British butterflies which has proved very useful. The Modified Pollard Transect as developed and tested by Caldas and Robbins (2003) apply the same principles but in tropical environments. This method appears to hold good potential for being used in tropical countries where butterfly diversity is much higher and mimicry reigns supreme (Caldas and Robbins, 2003).

Transects were walked when volunteers were available and on clear sunny days between the hours of 9am and 3pm based on a modified Pollard transecting technique. The basic principle of the technique is that a researcher should walk a predetermined transect line at a constant speed and identify every butterfly that can be seen (flying or stationary) in an imaginary box (5m long x 5 m wide x 2 m high) in front of them. A minimum of two people were needed for each transect walk, one person lead the transect while carrying a sweep net (a standard 16” butterfly net with 2’ handle was used) with the second person noting the species seen and controlling the stop watch. All butterflies observed were identified where possible to genus or species level. If the butterfly was an unknown or confirmation was required, then the stopwatch was stopped while the butterfly was caught using the sweep net (samples were labelled in the same way as for bait traps). On occasions where it was not possible to record the butterfly species (unable to identify on the wing or catch), a note was made of its distinguishing features to attempt later identification. If identification was not possible it was assigned to the most abundant similar species (standard practice as part of Pollard technique). All transects were started at random points (distance generated through random number generation) along two long (approximately 5 Km each) tracks running out of BA.

Although initially all butterflies were recorded it was decided to disregard three families: Lycaenidae, Hesperiidae and Riodinidae. The similarity between species in these families and their small size makes them difficult to identify in the field (Walpole & Sheldon, 1999). Furthermore although an identification guide is available for the Riodinidae (DeVries, 1997), there is no definitive field guide for either of the two tropical families (Robert Lehman', personal communication).

1 La Ceiba Butterfly and Insect Museum, La Ceiba, Honduras (www.hondurasbutterfly.com)
**Changes to the Original Plan**

The overall butterfly survey was hindered by two factors: A lack of long term volunteers/dissertation students and the fact that the butterfly scientist had logistical/management responsibilities that took up 60-70% of time. The main impacts of these were:

The intention was to move traps on a weekly basis in order to avoid pseudo replication, however the above limitations restricted movement of traps to once during the sampling period.

Only a limited number of transects (18) were carried out.

**Location**

Site details: Buenos Aires, Situated (15° 30.063’ N, 38° 10.961’ W) at an altitude of 1200m in the “Parque Nacional de Cusucu” buffer zone. It is dominated by agricultural land (mainly shade coffee plantations but also various bean and tomato plantations) with some remnant gallery forest (following stream/river courses that lead up to Cusucu National Park). These forest remnants were identified as secondary forest fragments by Daniel Kelly (Trinity College Dublin) (personal communication). These forests are dominated by the following tree species: *Liquidambar strigiflua*, *Carpinus sp.* (awaiting full identification), *Pinus oocarpa* and *P. maximinoi*. With *Cecropia peltata* abundant in the forest edges.

**Results**

**Fruit baited traps**

Raw data collected throughout the 2005 season is presented in Appendix 2 for fruit baited traps and in Appendix 3 for transects.

General observations: The older and less disturbed secondary forest at “El Tucan” Waterfall has a lower species diversity than the relatively younger forest at “Quebrada Hernandez”. It should be noted that certain species such as *Morpho polyphemus* (White morpho) only began to appear in mid to late July and this may be the reason it was not caught at “El Tucan” waterfall. Local guides confirmed that this species only emerged and became common during the latter part of the research season, i.e. when sampling had moved to “Quebrada Hernandez”. Visits to “El Tucan” waterfall later in the season confirmed that *M. polyphemus* was present in the area.

The higher diversity at “Quebrada Hernandez” could also be due to the fact that this area is larger and less isolated that the “El Tucan” where the forest is surrounded by agricultural land. This is also reflected in the catches in the shade coffee at “Quebrada Hernandez” where a species (e.g. *Caligo uranus*) that were common but restricted to the forest site at “El Tucan” were recorded in both forest and shade coffee. *Smyrna blomfildia*, on the other hand, was recorded in relatively high numbers at both forest and shade coffee sites at “El Tucan” while it was only recorded once in the forest at “Quebrada Hernandez”. Again, there should be caution in reading to much into this finding since *S. blomfildia* is known to experience local population explosions (DeVries, 1997). Having said this, the pattern found may reflect the nature of the more mature forest at “El Tucan”. The catches in the surrounding coffee may be caused by migration out of the forest.

Species belonging to the Cissia genus (Satyrinae) dominated catches in shade coffee at both sites although far more in the “Quebrada Hernandez” coffee. This again may reflect the nature of the habitat in “Quebrada Hernandez” which is dominated by large areas of disturbed secondary forest with patches of shaded coffee. *Cissia metaluca* was the most abundant species in both shade coffee areas. One surprising result, which reflects last years works, is the presence of glasswing butterflies (Ithominiae) in traps on a regular basis. Samples have been collected in order to identify these species accurately and then possibly suggest a reason for these findings.

**Transect data**

The total distance transected for coffee, scrub and forest was 3726m, 1417m and 1496m. The fact that coffee was sampled more than twice the distance of the other two habitats is a reflection of the dominance of coffee in the area surrounding Buenos Aires. Even when taking this fact into account the coffee habitat was dominated by butterfly species belonging to the Cissia genus. Cissia were also
common in the scrub habitat. In the forest habitat the dominant species appear to be *Agraulis vanillae* and members of the *Ithimnia* sp although closer examination reveals that *A. vanillae* was only detected in a large group during a single transect while the *Ithomia* sp. make a more regular appearance during forest transects (a reflection of their habitat preference).

The proportion of singletons (Species only seen once during a single transect) was lower in the coffee habitat than in either of the other two habitats. This may be because the generalist species utilising the coffee habitat exploit resources within it successfully.

All the data collected awaits full and further analysis in the near future.
Appendix 2

Secondary forest at “El Tucan” Waterfall

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Shade coffee paired with “El Tucan” waterfall site.

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Secondary forest at “Quebrada Hernandez”

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Shade coffee at “Quebrada Hernandez”

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## Appendix 3  RESULTS FOR COFFEE TRANSECTS

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## References


2. Invertebrate diversity, abundance and ecology in the El Paraíso valley.
Jacqueline Grant, Ph.D. Colorado State University

Introduction
Honduran lowland tropical and upland cloud forests support exceptionally high levels of invertebrate biodiversity. The country has approximately 2,500 described insect species and estimations run as high as 50,000 species total (SERNA, 2001). Honduras ratified the Convention on Biological Diversity (CBD) in 1995, and in its National Strategy and Plan of Action it acknowledges that insects are the most speciose and least known of all invertebrate taxa. Clearly, insects are an important component of Honduran biodiversity and, as such, merit deeper examination. Butterflies are a particularly useful taxon on which to focus survey efforts in Central America because of their close connection to the flora and, more practically, because field identification guides are available for four families (DeVries, 1987, 1997). The total butterfly diversity of Honduras remains unknown, but in 2004 Operation Wallacea began baseline studies in Parque Nacional Cusuco and the Rawacala Reserve of El Paraíso.

The FAO (2003) defines all Honduran forests as tropical, but this does not accurately reflect the wide range of forest types classified as the Central American Montane Forest (Holdridge, 1967). Honduras is a highly mountainous country with 75% of its land having a gradient greater than 20° (CEP, 1996). The terrain varies from sea level to over 2800 m in elevation. Honduras’ National Park system primarily protects land above 1800 m to effect preservation of the national water supply. With its focus on the higher elevations, the current system to a certain extent neglects lowland tropical forests and renders areas such as the privately owned Rawacala Reserve exceptionally valuable. This reserve contains the source of the Río Piedras Muclé, which is a river situated in lowland tropical forest at elevations of less than 800 m. It flows through the valley reserve to the sea near the village of El Paraíso, Departamento de Cortés, Honduras. Rawacala is owned by Don Enrique Morales, a prominent Honduran businessman. In this study we test the hypothesis that the butterfly fauna in disturbed and secondary forest habitats will differ from each other in both species composition and forewing size. We also quantitatively assess forest structure in both disturbed and secondary forest habitats.

Objectives
- To determine whether habitat type (disturbed or secondary forest) has an effect on butterfly richness and abundance in the El Paraíso valley.
- To identify forest structure variables that influence butterfly distribution.
- To assess the suitability of butterfly assemblages as indicators of habitat change.
- To describe larval stages of butterflies and moths of lowland tropical forests.

Methods
Study site
Fieldwork was performed in the Rawacala Reserve (ºN, ºW, datum) near the village of El Paraíso, Departamento de Cortés, Honduras. The site is situated northeast of Parque Nacional Cusuco (PANACU) and is a privately owned reserve located within the Merendón mountain range. The valley consists of recovering secondary forest, scrub, and fallow palm and cacao plantations surrounded by a patchwork of multi-use agricultural areas. Sections of the reserve have been protected from logging and agriculture for the last 8 - 25 years. Altitude ranges from 30 – 800 m a.s.l. and the total area of the reserve is approximately 350 ha. The study area has temperature (annual mean = ºC) and rainfall (annual mean = cm year⁻¹). Temperature is generally constant throughout the year and rainfall varies minimally. Sampling was performed during the onset of the early rainy season over an eighteen day period from 3 to 20 August 2005.

Butterfly sampling
The forest interior of the Rawacala reserve harbours a very diverse flora in addition to difficult, steep, and wet terrain. Therefore, we focused on species of butterflies that come to fruit-baited traps to avoid problems with identification problems and individual bias. Traps were produced locally by the Alvarenge
family in Buenos Aires, second form students, Operation Wallacea volunteers, or members of the 2005 El Paraiso butterfly team (Jacqueline Grant, Josie Dade, and Emily Whitfield). Research progress was unacceptably impaired by organizational inability to provide traps at the start of the season. This lack of administrative ability affected the work of all scientists involved in the project, the quality of the data collected by dissertation students, the experience of paying sixth form students, and the morale of dissertation students. Scientists working on this project in the future should take care to ensure that Operation Wallacea administrative staff has all traps and other equipment ready prior to the onset of the field season or, and minimally acceptable, before the first sixth form students arrive.

Two approximately 1 km long transects were established through each habitat. Traps were hung at a height of approximately 2 m every 50 m along each transect for a total of 20 traps in disturbed habitat and 24 in forested habitat. The forest transect ran through the center of the reserve and generally followed the course of the Río Piedras Mucle. The disturbed habitat transect ran through abandoned citrus grove on the property of Don Enrique Morales in the village of El Paraíso, Departamento de Cortés, Honduras. The two transects were separated from each other by 2 km. Each transect was checked daily between 6 am and 3 pm, and traps were moved when necessary to minimize interference from animals, ants, and passersby. Traps were baited with smashed mature bananas mixed with 1-3 cans of beer (Salva Vida). The traps were sampled over an eighteen-day period and extra bait was added daily or as needed. Bait was replaced every fourth day. Every trapped butterfly was identified to species, marked with a felt-tipped pen, and the forewing length was recorded before release. Recaptured individuals were excluded from analysis. If the butterfly could not be identified in the field it was killed with a sharp pinch to the thorax and placed in a glassine envelope for later identification. All identifications were carried out using field identification guides for the butterflies of Costa Rica (DeVries 1987; DeVries 1997). Traps were checked daily between 7 am and 2 pm.

**Vegetation data**
Structural composition of the vegetation in forest and disturbed habitat was assessed by dividing each trapping station into four quadrants centred on the trap. Within each quadrant the two trees closest to the trap within a 10 m radius of it were selected for measurement. The following variables were recorded for each tree: 1) height, 2) diameter at breast height, 3) point of inversion (whether the first major branch was above or below the midpoint of the tree), 4) distance from the trap, 5) identity of the tree (when possible). For each trap, the distance from river, distance from trail, and a single estimate of percentage canopy cover was taken directly above the trap. Percentage ground cover and low level cover (>2 m from ground height) were also estimated within each quadrant. Trees were identified by a locally employed guide (Antolín Guerrero). Distances and tree girths were measured to the nearest 1 cm with a tape-measure, tree height was estimated to the nearest 2 m, and ground cover and low level cover were estimated to the nearest 5%. Trap distance from river and stream were estimated to the nearest 1 m for a total of ten vegetation variables. These ten variables will be examined with the ordination technique of principal components analysis to create a set of uncorrelated variables with which to examine the effects of forest structure on butterfly diversity.

**Butterfly diversity**
Upon return to the home campus, three indices of butterfly diversity will be computed: Shannon-Weiner, Margalef, and Simpson. Species accumulation curves showing estimated species richness for both habitats will be calculated using rarefaction.

**Caterpillar life histories**
Caterpillars were obtained during opportunistic surveys performed at night with sixth form students and volunteers.

**Results**
**Effects of reforestation on vegetation structure**
Secondary forest was structurally very different from disturbed habitat. Disturbed habitat consisted mostly of dense ground cover (Graminaceae) and *Citrus* spp., while secondary forest was more variable in species composition.
**Butterfly diversity in secondary forest and disturbed habitats**

Thirty different species were found in forest interior and disturbed habitats at El Paraíso (Table 1). Fewer species were found in forest interior than in disturbed and species composition differed markedly between the two habitats.

Figure 1. Species composition of forest and disturbed habitats.

Figure 2. Species abundance relation to trap day.

**Table 1. Nymphalid butterflies trapped in El Paraíso, August 2005.**

<table>
<thead>
<tr>
<th>Subfamily</th>
<th>Species</th>
<th>Number captures/wingspan (mm)</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brassolinae</td>
<td><em>Caligo atreus dionysos</em></td>
<td>1/81.5</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Brassolinae</td>
<td><em>Caligo eurilochys sulanus</em></td>
<td>2/80.0/63.3</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Brassolinae</td>
<td><em>Unknown escaper</em></td>
<td>1/&gt;20</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Nymphalinae</td>
<td><em>Unknown escaper</em></td>
<td>1/&gt;20</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Brassolinae</td>
<td></td>
<td></td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Ithomiinae</td>
<td><em>Oleria paula</em></td>
<td>1/23.3</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Morphinae</td>
<td><em>Morpho peliades</em></td>
<td>1/&gt;60</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Charaxinae</td>
<td><em>Archeoprepona demophon gilina</em></td>
<td>2</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Nymphalinae</td>
<td><em>Colobura dirce</em></td>
<td>1/37.4</td>
<td>Secondary forest</td>
</tr>
<tr>
<td>Satyrinae</td>
<td></td>
<td></td>
<td>Secondary forest</td>
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<tr>
<td>Satyrinae</td>
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<td>Satyrinae</td>
<td></td>
<td></td>
<td>Secondary forest</td>
</tr>
</tbody>
</table>

**Table II: Incidental butterfly catch**

<table>
<thead>
<tr>
<th>Family: Subfamily: Species</th>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nymphalidae: Heliconiinae: <em>Dryas julia</em></td>
<td>7/23/05</td>
<td>Helipad</td>
</tr>
<tr>
<td>Nymphalidae: Nymphalinae: <em>Hamadryas feronia farinulenta</em></td>
<td>7/22/05</td>
<td>Entrance road, pupa</td>
</tr>
<tr>
<td>Nymphalidae: Nymphalinae: <em>Temenis laothae agatha</em></td>
<td>7/22/05</td>
<td>Entrance road, pupa</td>
</tr>
<tr>
<td>Nymphalidae: Ithomiinae: <em>Hypothyris lycaste callispila</em></td>
<td>7/23/05</td>
<td>Right mule train, 2 adults</td>
</tr>
<tr>
<td>Papilionidae: <em>Parides aeneas Bolivar</em></td>
<td>7/23/05</td>
<td>Right mule train</td>
</tr>
<tr>
<td>Nymphalidae: Nymphalinae: <em>Hamadryas februa ferentina</em></td>
<td>7/23/05</td>
<td>Helipad</td>
</tr>
<tr>
<td>Nymphalidae: Satyrinae: <em>Cissa libye</em></td>
<td>7/12/05</td>
<td>El Paraíso</td>
</tr>
<tr>
<td>Pieridae: <em>Phoebis argante</em></td>
<td>7/23/05</td>
<td>Helipad</td>
</tr>
<tr>
<td>Nymphalidae: Heliconiinae: <em>Heliconius charitonius</em></td>
<td>7/27/05</td>
<td>Left mule train</td>
</tr>
</tbody>
</table>

**Butterfly size in secondary forest and disturbed habitats**

Forest butterflies were larger than disturbed butterflies (mean forewing length ± SE forest = 50 mm, disturbed = 15 mm, t-test, p < 0.001).

**Trap rate in secondary forest and disturbed habitats**

At X butterflies day⁻¹ trap⁻¹, catch-rate per trap was higher in disturbed traps than in forest traps X butterflies day⁻¹ trap⁻¹ (t-test, p < 0.001).

**Species of note**

*Caligo uranus*
**Initial Results:**

A total of ninety-three species were recorded at the site. Initial observations suggest that habitat type may influence butterfly richness and abundance (figure 1). The habitats surveyed provide a succession of habitat re-growth, with changes in vegetation structure and diversity as the habitat matures. The butterfly distribution observed appears to be correlated with these changes.

Disturbed was the habitat with the highest abundance of butterflies. The secondary forest and ex-plantation had the lowest butterfly abundance. A comparison of the butterfly species found in the different habitats showed that some species were restricted to a certain habitat, while others were found across them all. This can be demonstrated by the genus *Cissia* which were commonly found in all habitats, whilst a number of butterflies, including the *Caligo* species, were only found in the secondary forest. This suggests that some species have the potential to make good indicator species for future monitoring programs.

The forest edge traps recorded higher butterfly species richness and abundance than the traps placed in the forest interior (figure 2). This may provide evidence for the ‘edge effect’ where changes in biotic and abiotic conditions can result in differences in species composition depending on the physiological tolerances of the butterfly (Murcia 1995).

**Discussion**

The original comparison was meant to be of butterfly diversity in the forest interior versus forest edge. Originally, traps were set up along a transect that followed the eastern mule train (Camino Reál) bordering the reserve and roughly parallel to the forest interior transect. This transect had to be relocated to the property of Don Enrique Morales because traps were vandalized by local villagers traveling along the mule train. One trap was taken in its entirety, one was slashed, and the bait support boards from ten others were removed. However, after the relocation no further problems were encountered. I reiterate that if this project is to be continued scientists must make sure that Operation Wallacea has all the necessary equipment at hand before the season starts. This includes traps, bait dishes, a bow and arrow, strong monofilament fishing line, paracord, and access to bait. Lack of traps and bait was a major impediment during the 2005 research season.

**Recommendations for Future Study:**

- The diversity of habitats at El Paraíso makes the site ideal for comparative studies. However, this may also act as a pitfall as the variety and complexity of habitats may render replicate sites hard to find. It is strongly recommended that sufficient sample sites are established before commencing survey work within the forest. Information on the composition of the forest may be available through the findings of the Forest Structure Team 2004.
- The Van Someren traps did not yield as much data as expected and at times were almost entirely ineffective. It is recommended that future studies should aim to use 40 traps (as opposed to 20) and minimise the number of comparative sites used in order to increase the usefulness of the data collected.
References


McGeogh, M.A. 1998. The selection, testing and application of terrestrial insects as bioindicators. Biological Review. 73:181-201


3. A comparison of frugivorous butterfly diversity and abundance between areas of secondary forest and cultivated land.

Emily Whitfield – Royal Holloway University of London

Field Supervisor – Jackie Grant, University Supervisor – Dr Peter Credland

Rational

El Paraiso Nature Reserve is a valley found on the North-western coast of Honduras that is approximately 350ha, and is privately owned. Some parts of the valley were previously cultivated to grow cocoa, maize beans, maize, bananas and oil palm, but most of these plantations were left to re-establish into secondary forest.

This type of research is needed because very little is known about the butterflies found in Honduras. Even though Arthropods make up the majority of all named animal species there is very rarely any conservation work done on this phylum. In some Neotropical subzones many rare or endemic species are found. Due to the relationship some butterflies have with their host plant, they may be suitable indicators of potential biogeographical areas worth conservational protection. Insects contribute to the overall diversity of an ecosystem but they are also an important part of the ecosystem function.

Aims

- To determine the diversity of frugivorous butterflies on the edge of the forest and within the forest. Is there any difference between the species diversity in the areas?
- To obtain data about the relative abundance of frugivorous butterfly species within each area. Do the dominant butterfly species vary in number between the two types of regions?
- To determine if there is a relationship between the forest structure and the diversity and abundance of the butterflies.

Method

Butterfly sampling

The sample period for butterfly collection was carried out between 3rd August and 20th August 2005. Meaning that the sampling was conducted for a total of eighteen days. The data was collected by Josie Dade (University College of London), Jackie Grant (Field Supervisor) and myself, Emily Whitfield.

The adult butterflies were collected using Van Someren butterfly-Rydon bait traps in both the citrus orchard and the forest interior. The traps were made by the three people working on the project. The traps consisted of a cylindrical mesh net of approximately 60cms in length and 25cms in diameter. The nets were closed at the top and covered with plastic to prevent the rain from entering the trap; the bottom of the cylinder was open and attached to a wooden board where the bait was placed. The board was suspended 5cm from the net to allow the butterflies to enter and feed.

There were a total of 44 traps hung; 20 in the citrus orchard, 24 in the forest, of these 7 were in ex-cocoa plantations, 13 in ex banana plantation and 4 within in the forest canopy. The non-canopy forest traps were all within 20m from the river and the first orchard trap was put up 300m from the forest edge. The butterfly traps were suspended at approximately 1.5m from the ground and were set approximately 50m from each other along a transect, depending on the availability of a suitable tree. The canopy traps were made accessible through the use of a zip line running through out the forest canopy. The bait used was a mixture of banana and beer and this was contained in the bottom of a cut 2L bottle. The traps were baited every day to ensure that there was a mixture of fresh and rotting fruit to attract a variety of butterfly species. The traps were baited 24 hours before the first collection and then were checked daily between 9am and 1pm. The butterflies that were caught were immediately identified or placed in a glass jar for further examination; they were identified using DeVries The Butterflies of Costa Rica and their Natural History. Their right forewing (FW) measured in millimetres and the dorsal surface of the right forewing was marked with permanent marker and then released. This was done so that any butterfly that was recaptured could be identified. The recaptured individuals were excluded from the data analysis.
Forest Structure:
At each trap a vegetation survey was carried out to establish the plants there and the percentage cover of growth. This was done by dividing the trap station into four quadrats that centred on the trap; the quadrats were at a 10m radius from the trap. The following information was recorded for the two trees nearest to the trap in each quadrat:
- Understory cover %
- Ground cover %
- Height/m
- Girth/cm at chest height (130cm)
- Point of inversion
  (Does the 1st major branch come above or below the mid-point of the tree)
- Distance from trap/cm
- Identity (local name and scientific name).
This was carried out with the help of a local guide and a species list that had been established last year with the local names and the relevant scientific names.

The percentage canopy cover was estimated for the quadrat as a whole and the distance from the trap to the river and the trail was also measured in meters. The tree height was measured using a clinometer and the heights estimated to the nearest 2m. The tree girths and the distances were measured to the nearest centimetre.

Results
From the 18 days of collection we trapped a total of 690 butterflies, all but two of these were from the family *Nymphalidae* and a total of 37 species was collected. 20 individuals were trapped in the forest interior and this accounted for 13 of the species. 670 butterflies were collected in the citrus orchard and this was made up of 24 species. The dominant species in the citrus orchard was *Cissia hermes* and a total of 488 individuals were found.

From preliminary data analysis it can be seen that the diversity and abundance is greater in the citrus orchard than in the forest. There were two species that were found in both the orchard and the forest; *Opsiphanes cassina fabricii* and *Cissia usitata*.

There was a new species found to Honduras, the *Tigridia acesta* which up until now has only been found as North as Costa Rica.
4. A comparison of fruit feeding butterfly diversity and abundance in secondary forest and disturbed orchard habitat.

Josie Dade

Name of supervisor: Dr. Jackie Grant  Home supervisor: Professor James Mallet

Rational
El Paraiso is a 350 ha privately owned reserve on the North West coast of Honduras (15° 40.814' N, 88° 06.206' W). The site ranges from sea level to 800m altitude and consists of ex banana, oil palm and cocoa plantations that have been left to regenerate over the last 26 years. There are some areas of primary forest at the higher elevations, but the majority is secondary. There is a village lying between the coast and the forest, with highly disturbed habitats such as gardens and citrus orchards.

If the reserve is to function successfully as an ecotourism attraction and in the preservation of its flora and fauna, it is necessary to establish monitoring and management programs to assess how the biodiversity and abundance of species is changing. Recording the total biodiversity of an area can often be impossible, therefore it can be useful to monitor a particular subset of species to use as environmental indicators. Butterflies have strong potential as indicators species, as they contribute to overall biodiversity and play an important role in the functioning of ecosystems. Previous studies have shown that they are important indicators of disturbance.

This study will add to previous data collected by the Operation Wallacea butterfly team in the 2004 season. It not only has important implications for the reserve at El Paraiso, but will also add to the general scientific knowledge about how disturbance affects biodiversity and help in the design of future monitoring programs.

Aims
1) To assess how the diversity and abundance of fruit feeding butterflies varies between secondary tropical rainforest habitats (ex- cocoa and banana plantations) and highly disturbed citrus orchard habitat.
2) To assess how the forest structure influences the diversity and abundance of fruit feeding butterfly species.

Methods
Butterfly sampling
Butterflies were sampled for 18 consecutive days, from the 3rd July to the 20th of August 2005. To sample the butterfly populations in the forest and citrus orchard, Van Someren butterfly-Rydon bait traps (diagram/photo - based on Daily and Ehrlich, 1995) were used to attract and trap fruit feeding butterflies (family Nymphalidae). These were hand made in the first two weeks on site. They are made up of a cylinder of fine mesh netting supported by two wire loops at each end (diameter of 25 cm, length 60 cm). The top is covered by the mesh and a layer of plastic to protect the butterflies and the bait from heavy rain. The fermented banana was placed in a cup made from the bottom of 2 litre plastic bottles, and placed on a wooden platform suspended 5-6 cm from the bottom loop. The butterflies fly upwards after feeding on the bait and become trapped. They can be retrieved through a slit in the mesh on one side. The traps were hung using cord tied to the trees or using a stone tied to the end of the cord which is hung over a branch.

This was the only sampling technique used, as previous studies have shown random sampling and transect walks to be an ineffective method for short-term sampling due to difficulties with identifying butterflies in flight and different levels of experience leading to very

A total of 44 traps were used, with 20 in the orchard, 20 in the forest understory and 4 in the canopy which could be reached by zip lines. The traps in the forest were hung next to or close to the river valley. In the orchard and forest understory, all the traps were hung from branches at about 1.5m (head height) from the ground, except for 3 traps (E5, E6 and E7) in the orchard which were hung from bars along the air strip that runs through a part of the orchard. The orchard is situated 300m from the edge
of the forest, and the traps were placed at 50m intervals up to the coast. The forest traps started at 50m into the forest, and were also spaced approximately 50m apart, following the river valley.

The traps were primarily baited with a mixture of fermented guava, banana and beer (due to lack of bananas), 24 hours before the first morning of sampling. After the 3rd day, only banana and beer was used. They were checked every morning between 9 and 12 pm for 18 consecutive days, and each day some freshly mixed banana and beer was added to keep it topped up and maintain a mixture of slightly fermented and well fermented banana.

Any butterflies found in the traps were taken out and either immediately identified or placed in a jar for further examination and identified using DeVries Butterflies of Costa Rica. Any that could not be identified in the field were killed by a pinch to the thorax and place in a labelled envelope. The forewings were measured using callipers, and then they were marked with a blue dot on the right ventral forewing and released. Any recaptures were noted but not included in the data. The number of moths in each trap was also recorded, along with any other observations, such as the presence of ants, or loss of bait etc.

Forest Structure Analysis
The area around each trap was divided into 4 quadrats extending 10m from the trap. The two trees closest to the trap in each quad where identified by a local guide and analysed. The measurements taken were girth, height (using a clinometer), distance from trap and point of inversion (whether the first major branch is above or below the midline). In the forest, the distance from the trail and the river was also recorded. The % ground cover and understory was estimated for each quad, and % canopy cover for all 4 quads (the area above the trap).

Results
Initial analysis of the data clearly shows a significant difference in the butterfly biodiversity and abundance between the two sites. During the 18 days of sampling, we caught a total of species of 36 fruit-feeding Nyphalidae butterfly and one species of Pieridae. 24 species were found in the citrus orchard and 670 individuals, while in the forest there were 13 species and 20 individuals. Two species were found in both the forest and citrus orchard. The citrus orchard was significantly more diverse than the forest interior.

_Cissia hermes_ is by far the most abundant species in the orchard, with a total of 488 individuals trapped. This suggests that this species is a strong indicator of disturbed habitats. Only 2 species were found in both habitats, indicating that there is a considerable difference in the habitats and the type/abundance of species they are able to support. During the collection period, we caught a total of species of 37 fruit-feeding Nyphalidae butterfly and one species of Pieridae.

There are few data on the efficiency of the fruit-baited traps in attracting and retaining the butterflies, but any differences that do occur are more likely to vary among species than between the different habitats, so it is unlikely the conclusion will change. If the sample period could be extended this would have reduced any problems associated with the differences in species capture and escape rate. The orchard is a homogeneous habitat, whereas the secondary forest is more heterogeneous.

Nyphalidae butterflies feed on rotting fruit that is more likely to be abundant on the forest floor. Species have different resources requirements, this may show different results and to investigate this, a variety of different baits could be used, for example citrus fruit, dung etc.

Spatial scale of study and placement of traps will largely pre-determine the findings. Butterflies like light gaps, these are often found near rivers where the canopy breaks.

Ideally, sampling would have continued until the species accumulation curve levelled off....
Aim
To contribute to the development of a biological water quality index for Cusuco National Park.

Introduction
Limnological research of tropical rivers and streams has mainly concentrated upon investigating the principle environmental factors of lowland rivers and their effects upon selected invertebrate distribution and abundance (Fittkau 1964, Illies 1964, Jacobsen 1998, Payne 1986, Miserendino 2001).

The geological history of Central America has proved a significant factor in determining its present day biota. This relatively narrow isthmian, has a topography that reflects the dominant tectonic processes which have formed one of the earth’s most active volcanic chains from Guatemala to Mexico (Horne et al 1989, Williams and McBirney 1969, Gose and Schwartz 1977, Coney 1982). Following the break up of Pangea into Laurasia and Gondwana in the late Jurassic period, North and South America were finally joined through a series of volcanic islands in the late Cretaceous period forming proto-Central America (Coney 1982, Dott and Batten 1987).

The effects of geographical changes upon taxon distribution are difficult to explain. Mammalogists consider Central America to be primarily neartic in derivation with little influence from South America (Marshall et al 1982). Conversely, the majority of plants and insect taxa are of South American origin (Gentry 1982). In the neotropical region, insect fauna is distinctive composed of a southern component from Afrotropical and Austral forms and recent intrusions from the north of Neartic elements.

The use of freshwater biota as indicators of water quality has been applied throughout many countries in different forms, but many share the common traits of being reliable indicators, having high relative abundance of each species or group and have known pollution ranges. Benthic invertebrates are often the favoured group in most surveillance and monitoring studies due to their role in the functioning of aquatic ecosystems (Rosenberg & Resh, 1993b, Wallace & Webster, 1996).

Survey Sites
Cusuco National Park
Cusuco National Park is located in the Merendón Mountain range in the northeast of Honduras and is classified as Central American Montane Forest (Plate 1). It was established as a National Park in 1987 as part of Presidential Decree 87(87) that designated all areas above 1800m in Honduras as National Parks. Initial management was undertaken by Corporacion Hondurena de Desarrollo Forestal (COHDEFOR), which was replaced in 1992 by the Non-Governmental Organisation Fasquelle Foundation due to resource shortages. In 1994 the Fasquelle Foundation and COHDEFOR produced a management plan that extended the core zone of the park to 7,690 ha and created a buffer zone of 23,440 ha (Figure 1). The management of the park is currently undertaken by COHDEFOR, following the recent withdrawal of the Fasquelle Foundation.

The park is situated close to the Guatamalan border within the governmental districts of Cortés and San Pedro Sula, approximately 40 km from city of San Pedro Sula (Informacion General del Parque Nacional Cusuco). A majority of the high elevation forest remains intact although fragmented and provides areas of high biodiversity and endemism (Powell et al., 2001). A temperate like climate predominates with high precipitation and temperatures ranging between 16 °C – 22 °C.
Three major and one minor forest structures exist in the park;

1. Semi-arid pine forest
The Semi-arid pine forest forms an area of 11,100 hectares over an altitude range 800-1600 meters, which is predominately south facing and situated close to the main Cusuco road between Cofradia and Buenos Aires. This forest type is dominated by three pine species forming the top canopy with occasional broadleaved trees forming a lower layer canopy.

2. Wet deciduous forest
The Wet deciduous forest is north facing and found at an altitude of 1700 meters. It comprises 1,600 hectares of a mainly closed canopy of deciduous and non-deciduous broadleaf trees, with occasional canopy gaps, and an understorey of broadleaf saplings and fern trees (Bourgh, 1992).

3. Broad-leaf cloud forest
The cloud forest is situated on the peaks and steep slopes of the Merendón Mountains at 2000 meters altitude and comprises 13,000 hectares, characterised by large, buttressed trees with many epiphytes (Bear, 1975).

4. Dwarf forest
Between 2,000 – 2,200 meters altitude, Bosque Enano (dwarf forest) forms a distinct, although small forest structure. At the lower altitudinal range, tall, large trees form a top canopy with a light understorey of low-woody shrubs, in a marked contrast to trees at upper altitudinal range which exhibit maximum heights of three metres.

Figure 1 Location of the Cusuco National Park within Honduras
(Fundación Hondureña para la Protección y Conservación de Cayos Cochinos)
Three main rivers were surveyed providing 57 samples (Figure 2):
1. Quebrada de Colorado.
2. Rio Cusuco.
3. Quebrada de Las Hernandez.

Plate 1 Quebrada de Colorado along road to Cofradia, Cusuco National Park

**Methods**
The freshwater ecosystem provides a diverse range of habitats and consequently methods for collection vary according to habitat type. Benthic invertebrates are generally associated with the bottom substrate, shoreline gravel, interstitial environments and aquatic macrophytes.

**Lotic and lentic habitats**
1. A fine meshed dip net (2.5mm) was placed in a suitable section along a riffle habitat of river.
2. Standing upstream, the substrate was dislodged and collected in net.
3. The sample was sieved through large sieves of 3.0mm and 0.3 mm mesh.
4. The material contained in the fine mesh was transferred to white trays and active benthic invertebrates were removed by eye using bulb pipette and tweezers.
5. Adult, nymphs and larvae were preserved in 10% formalin.
6. Each sample was labelled recording:
   a. Date
   b. River and country
   c. Sample reference
   d. Brief site and habitat description
   e. Global Position System
   f. Altitude
   g. Collector
7. At each site the following environmental parameters were recorded:
   a. pH
   b. Dissolved oxygen (mg/l)
   c. Conductivity (ppm)
   d. Mean air temperature (°C)
   e. Mean water temperature (°C)
   f. Mean channel width (m)
   g. Mean channel depth (m)
   h. Stream order (1,2,3,4,5)
   i. Substrate size Wentworth scale (%)
   j. Organic matter (%)
Additional information recorded included
  j. Diagram of site with sampling points
  k. Habitats sampled
  l. Notable aquatic macro-invertebrates
  m. Photographs
8. Identification of samples was carried out using literature which principally consists of taxonomic papers based mainly on adult morphology.
  (To be carried out at the Tropical Research Unit, Glamorgan University).

References
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G.H. Chamberlain 21.8.05
6. The Diversity of Invertebrate Communities in Epiphytic Bromeliads in Primary and Secondary Forest Types

Robin LeCraw and Eifion Jones

Introduction
Tropical forests are accepted to be extraordinarily diverse in terms of both flora and fauna and much study has been done on the diversity of arthropods in forest canopies as a surrogate for overall forest diversity (Stuntz et al. 2002). Epiphytes, being any vascular plant relying on another plant for structural support but not water or nutrients, are especially diverse in the neotropics and provide a vast array of microhabitats for invertebrates and even some herpetofauna (Stuntz et al. 2002).

Vascular epiphytes rely on nutrients from the water and decomposing material that accumulates in the central impounding “tank”, and as such moisture tends to be the most important factor determining epiphyte communities (Zotz and Hietz 2001). As epiphytes tend to rely mostly on the structural elements of their environment, Benavides et al. found that communities did not differ between landscape types and that quick dispersal would show less effect of disturbance in a recolonizing area. On a smaller scale, epiphytic bromeliad species have been shown by Wolf (2005) to have a distinct vertical zonation between canopy and understory, but Pittendrigh (1948) found this to be irrespective of host tree species. Wolf (2005) also found bromeliads to be most diverse in Pine-Oak forest at an altitude band of 500-2000m.

The unique habitats created by bromeliad tanks as well as the quality of communities being fairly independent of the surrounding biotic community makes them ideal units for sampling invertebrates. Because of the vast array of microhabitats, epiphytes in general have been shown to host an equal, if not higher, diversity of invertebrates than the surrounding canopy. For this reason much study has been done on arthropod diversity in forest canopies but significantly less work has been done on the understory communities and in disturbed environments. In geographical terms, the area of this study in Central America and specifically Honduras has had very little attention paid to the considerable diversity of the montane forests. Cusuco National Park is in such an area and is currently threatened with deforestation due to inadequate funding for law enforcement. To protect the park, it is necessary to gain an understanding of the diversity at the fundamental level of invertebrates, and to determine the effect of disturbance on those communities.

Large areas of the core zone of Cusuco have been used for logging until the 1960’s. The areas around the current visitors’ centre are now in an area of secondary forest that has been regenerating for the past 40 years or so. To establish the long term effects of such disturbance on the diversity and invertebrate communities of the forest, a comparison will be made between the invertebrates found in epiphytic bromeliads in the secondary forest around the visitors’ centre and in the primary, untouched forest in nearby areas of the park. Because there are a range of altitudes and forest types included in the study area, an effort will be made to gather data equally from each habitat and lesser analyses will be conducted to indicate the most important factor governing the diversity measures.

Methods
A total of 22 sites were sampled in the south-east corner of the core zone of the park. The total study area comprised altitudes between 1350m and 1930m and included pine, broadleaf, and mixed forest types. Eleven sites were sampled for each primary and secondary and at least two were taken from each habitat type and altitude range. Sites were selected along established paths around the visitors’ centre (Base Camp), the two satellite camps (Guanales and Cantiles) and in the nearby dwarf forest (Bosque Enano).

Sample Collection
Sites were selected from a distinct reference point (usually a camp, or path junction) and separated by 500m. At each sample site, 3 replicate bromeliads were harvested at least 10m apart. Replicates were chosen by species, size and position on the tree. Wherever possible, plants of the genus Vriesea were taken, or if none were available, of the genus Tillandsia which has a similar morphology and tank capacity. Plants were of medium size (between ~20g and ~350g) and where more than one were present, the plant closest to the sampling point and lowest on the tree was chosen.
For each plant habitat measurements were taken including: % canopy cover, % shrub cover, host tree DBH, sample height from ground and in situ bromeliad width and height. The plant was harvested by covering with a plastic bag and pulling the roots off the host tree, containing all tank water in the bag which was sealed to prevent escapees.

**Plant Processing**

Bromeliads were brought back to the lab for processing. Each was weighed beforehand, then leaves were stripped off and contents rinsed into trays were invertebrates were collected and preserved for identification. All parts of the bromeliad were then reweighed to obtain a mass of tank material.

Individuals collected were identified to family in the case of insects, and to order for all other invertebrates. Both abundance and taxon richness were recorded for each plant. Some samples were preserved in formalin for transport back to Canada for further identification and study.

**Analysis**

Preliminary analysis of the data was carried out before leaving Cusuco in most cases by charting average data. A relationship between plant mass and individuals/taxa was examined as well as comparisons between numbers of individuals and taxa in primary vs. secondary forest, and between habitat types (pine, mixed, broadleaf).

Further statistical analyses involving calculation of diversity indices will be conducted at home universities. Other recorded factors such as canopy cover, altitude, sample height and bromeliad size will be considered in statistical analysis.

**Results**

All results to this point are preliminary and can only be referred to as “apparent” while lacking statistical confirmation.

We collected a total of 66 bromeliads and identified a total of 2356 individuals in 67 different taxa. A list of families and orders indentified is shown in table 1. The plants ranged in mass from 16g to 350g after processing. To standardize the results across all masses, number of individuals and taxa were plotted against plant mass and are shown in figures 1.1 and 1.2 to have an apparently linear increasing trend. Assuming this is a truly linear relationship we have transformed the data for individuals and taxa to a number per 100g of mass to compare values across all plant sizes.

**Primary vs. Secondary**

When the average number of individuals and taxa are plotted for primary and secondary forest, there seems to be slightly larger values in secondary forest. Secondary forest shows an average of 39.5 individuals and 9.8 taxa per unit of mass versus primary forest with an average of 30.9 individuals and 8.3 taxa. This is shown graphically in figure 2.0.

**Habitat Type**

The same graphical analysis was done for individuals and taxa found in each of pine, mixed and broadleaf forest habitat types. Pine forest had the lowest number of each with an average 31.6 individuals and 7.6 taxa per unit mass. Mixed showed the highest with an average of 48.1 individuals and 12.9 taxa. This is a slight difference as shown in figure 3.0.

**Discussion**

As the main analysis is based on the assumption of a linear relationship between mass and number of individuals and taxa, it is important to establish this relationship before any further results can be considered as valid. This type of relationship has been demonstrated by Stuntz *et al.* (2002) when pooling data for 2 genera of bromeliad (*Vriesea* and *Tillandsia*) and one orchid. There was a significant correlation among all 3 taxa however, within species only the mass and abundance relationship was still significant. This would suggest that assuming a linear relationship for abundance may be valid, but there are other factors at play concerning the number of taxa.
The same analysis suggested that bromeliad species may influence the taxon richness which would jeopardize our data where it was necessary to use a different species. However, the differences were largely between the bromeliads and the orchids, which have largely differing morphology. Among the bromeliads, *Vriesea* and *Tillandsia* showed similar effects on microclimate and have similar tank impounding morphology. It may be possible to assume that plant morphology is a more important factor than species thereby including our entire data set.

After considering these basic assumptions, it is possible to speculate on the factors underlying the small differences found between diversity in each forest type. The increased diversity in secondary forest may be explained by a number of factors. The most evident aspect is the forest structure; younger trees may mean a lower, more open canopy affecting heat and moisture creating more and different microhabitats. Another possibility is the stage of succession of the forest. While the secondary forest looks mature, it may still be changing in terms of species composition and structure 40 years after the disturbance. Such changes mean several more species and individuals may be immigrating to the forest and several others may be dying out, creating a dynamic community and resulting in a higher instantaneous diversity.

The different habitat types may affect diversity in much the same way. Pine forest, which appears to have the lowest diversity, is very different in structure from the other forest types; the canopy is much more open allowing more light to reach the understory, and the pine trees can retain more water creating a warmer and drier environment. Fewer species may be able to tolerate these more extreme conditions resulting in lower abundance and richness. Mixed forest, with the highest apparent diversity, benefits from both deciduous and coniferous trees producing a wider range of canopy cover, light and aridity. The increased number of microhabitats available may be the factor determining the higher abundance and richness of invertebrates. All of these same factors could support different community assemblages as well, but further analysis is required to determine if species composition differs between forest and habitat type.

While these tentative results show only minor differences in invertebrate diversity, the variation may prove significant showing that logging has had a long-term effect on the community. Alternatively, if they do not prove significant it may indicate that 40 years is sufficient time for this forest to regenerate and it is possible to reclaim the areas now being cleared and disturbed. Regardless, having begun to understand the invertebrate community in the forest is an important step towards conservation of the park. Future research can be carried on in this area by expanding the study both up into the canopy and down into the leaf litter. A better picture of how diversity is distributed in the park would benefit from both a vertical extension and a geographical expansion into the north and west areas of the park.
<table>
<thead>
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<th>Total</th>
<th>Taxon</th>
<th>Total</th>
</tr>
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</tr>
<tr>
<td>Staphylinidae</td>
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Figure 1.1. Relationship between mass and individuals

Figure 1.2. Relationship between mass and number of taxa
Figure 2.0 Individuals and Taxa per unit mass in Primary and Secondary Forest

![Bar chart showing the number of individuals and taxa per unit mass in primary and secondary forests.]

Figure 3.0 Individuals and Taxa per unit mass in Each of the Three Habitat Types

![Bar chart showing the number of individuals and taxa per unit mass in pine, mixed, and broadleaf forests.]

7. A comparison between the invertebrate communities in two different species of bromeliads: 
*Vriesea* and *Catopsis*

Ching Lam Oxford University

Field supervisor: Robin Lecraw (robinlecraw@hotmail.com)  
Home supervisor: Prof. Andrew Smith (andrew.smith@plants.ox.ac.uk)

**Introduction**

Vascular epiphytes have become the focal point of forest research because of its important role in nutrient cycling and providing a vast array of niches (Stuntz, 2000), in particular epiphytes that have a spiral rosette structure (tank). This is because such structures trap a lot of moisture and debris, resulting in an independent aquatic and debris environment within these epiphytes, which can be colonised by a vast variety of invertebrates. Not surprisingly, tank epiphytes are very good indicators of forest invertebrate diversity because most invertebrates spend at least one stage of their life cycles within or at least associated with it. Therefore the communities within tank epiphytes are good representatives of the forest invertebrate fauna.

The Cusuco national park is remarkable for its abundance in epiphytic growth, the dominant family of epiphytes being Bromeliaceae, members of which frequently form tanks. Therefore I have chosen epiphytes of this family for my study. My aim is to survey and record the abundances, number of taxon and families of invertebrates found in sampled bromeliads. My other aim is to compare the invertebrate community structure between two species of bromeliads: *Vriesea* and *Catopsis*. Similar works have been carried out in the past, comparing invertebrate communities between 3 different species, all of which belong to different families. Comparison between two members of the same family has never been carried out before. A difference in invertebrate community structure is expected between the two species of bromeliads because of their difference in structure (*Vriesea* has a much more opened structure) and habitat preference (*Vriesea* prefers more shaded environments).

**Methodology**

Samples were collected from three different areas:
- Boundary between the buffer zone and core zone down BA (Alt 1350m)
- Areas around Basecamp (Alt 1600m)
- Bosque Enano (Alt 2000m)

The difference in altitude in all three areas is assumed to ensure independence from each other. Transects are set up along trails, sampling sites are determined by measuring 500m intervals from various reference points, such as the gate in the driveway down BA, basecamp and the summit of Bosque Enano. 3 bromeliads are taken from each sampling site, 1 from the trail, and 2 from 10m either side of the trail.

Bromeliads are carried back to the basecamp using plastic bags for further dissection and analysis. The weights of bromeliad before and after processing are measured. The invertebrates found are identified to family level.

**Results**

I have collected a total of 69 bromeliads from 23 sites (8 from Bosque Enano, 14 from base camp and 2 from the boundary near BA). The results have to be standardized because of the possible effects of plant weight on the invertebrate abundance and number of taxon held. All the results are plotted against weight and comparisons between the graphs can be made.
Graph 1: Taxon (Cat) against weight (for sites around BC)

Graph 2: Taxon (Vrie) against weight

Graph 3: Number of individuals (Cat) against weight (around BC)
Also, one species appears to prefer Catopsis to Vriesea for egg laying ground, as shown by its larval occurrence:

Graph 5: Probability of occurrence of Caliphoridae

Discussion:
Assuming the 3 sampling areas are independent of each other, a consistent difference between the invertebrate communities of the two bromeliad species across all 3 areas will confirm my hypothesis: the invertebrate communities within Vriesea is significantly different from that in Catopsis.

All the graphs shown are not tested statistically so I can only make speculations by eyeballing the data. There appears to be no relationship between weight and taxon number contained, perhaps the number of taxon quickly reaches maximum at very small plant masses, this holds true for both bromeliad species, and is also consistent in all samples of the 3 different areas. The number of individuals, however, showed some trend of increase as the mass goes up, this happened in both bromeliad species, and is also consistent in all 3 areas. But note that the number of individuals found in Vriesea is higher
than that in *Catopsis* most of the time, the significance of this difference has yet to be tested but this is not surprising given the more open structure of *Vriesea* compared to *Catopsis*. I will follow up into this relationship by investigating the amount of debris held in the different species and correlate it with invertebrate abundance.

*Caliphoridae*, a family of dipterans, larvae are found exclusively in *Catopsis* plants, given the fact that I sampled *Catopsis* and *Vriesea* that are very close together it is very likely that *Caliphoridae* is actively preferring *Catopsis* as its egg laying ground. Further identification to the species level will allow an explanation of this phenomenon, if knowledge about the species’ ecology is available. This also shows that although the number of invertebrate taxon seems to be the same in the two difference species of bromeliads and relative abundance of individual taxa may differ, this awaits further analysis.
8. Invertebrate communities. Do edge effects exist in bromeliad fauna at natural and anthropogenic boundaries of cloud montane forest in Cusuco National Park, and if so are they significantly different in nature?

Jennifer Catherine Simcock, University of Nottingham.

Department: Geography.
Home Supervisor: Richard Field. Dates of Study: 13th July – 24th August
Field Supervisor: Robin LeCraw. Date of Submission: Feb 2006

Introduction
Edge effects have become a key area of research within the field of biogeography over the past decade. They describe the differences in species richness, abundance, occurrence etc, which occur as a result of different microhabitats experienced at ecological boundaries (Goosem, 2000; Gehlhausen et al, 2000). They arise as a result of interaction between adjacent ecosystems, changing conditions (Osborne, 2000). These edge effects can have both positive and negative effects on communities as different species thrive in different conditions. As a result of this, disturbance plays a key role in maintaining forest diversity (Osborne, 2000). Although there is a general consensus that human activities such as habitat destruction and disturbance serve to promote edge effects at ecological boundaries, it has been suggested that edge effects also occur at natural boundaries (Holway, 2005). This is of particular concern in Honduras, where many areas of the native forested land have been labelled National Parks in order to conserve and protect them, while encouraging sustainable development in the local population. In recent years the areas of rainforest within Honduras have been significantly reduced due to deforestation for illegal logging and to make way for plantations to support the local population, an example of which is shade coffee. In addition to this the country was severely affected by Hurricane Mitch in 1998. These changes to the forest all impact on the species richness and abundance of the adjacent habitat, which can be considered to be an ‘edge effect’.

Cusuco National Park is located in the Merendon Mountains of North-Western Honduras. The cloud forest found in this area is considered to be some of the best in Central America, and is unusually rich in bromeliad species. Bromeliads provide “unique niches” for invertebrates making them a neat unit for this study due to their discrete nature as well as ease to collect and analyse their contents (Llamas, 2003). There have been few studies to date that have looked at the effect of disturbance on epiphytes, but it is thought that the removal of trees causes a decrease in epiphyte biomass and richness (Wolf, 2005). Wolf (2005) stated “the response of epiphytes to anthropogenic disturbance is particularly needed to facilitate the incorporation of the epiphytic component in forest management” (p377). This is also important, as most studies have either focused on the form and distribution of the bromeliads as plants or their contents, while few have tried to look at the interactions between these two areas of study.

Aim
1. To ascertain whether the organisms found in the tanks of bromeliads are affected by clearings in the forest (edge effects).
2. To identify whether there is a significant difference between edge effects at natural and anthropogenic boundaries.
3. To attempt to determine the extent of the edge effects into the forest (in terms of distance).

Methodology
The methodology used to address the aims of this project focused on standardising all other variables apart from location. The variables that I aimed to control were:

- Species of bromeliad.
- Bromeliad Size.
- Height of bromeliad from the ground on its host tree.
- Forest type.
- Altitude of sites.
- Size of clearing.
I therefore only sampled bromeliads of the genus *Vriesea*, the species of which is yet to be identified. I also controlled the dimensions of the bromeliad as far as was possible, ensuring bromeliads of similar size were sampled as well as their height on the trees to which they attach to ensure that no microhabitat or altitudinal effects were introduced into my study. Finally I also aimed to standardise the size of clearings chosen, so that area effects did not interfere with my results. In general these were between 10 and 20 meters in width, which ensures a sizable gap in the canopy and vegetation type.

At each site I laid out 2 transects, within 10 meters of each other (chosen by using random number tables), and took 4 bromeliad samples from each at 0, 5, 10 and 20 meters from the edge of the clearing into the forest. For each of these samples I noted the percentage canopy cover, percentage ground cover, DBH (diameter breast height) of the tree, height of the bromeliad from the floor, bromeliad width and bromeliad height. I collected data from 16 sites in total, 8 of which were labelled natural boundaries and 8 anthropogenic. The natural sites studied included a variety of landslides, which were associated with Hurricane Mitch in 1998 and large clearings in the canopy over rivers. Anthropogenic sites varied from areas cleared for camping used by Operation Wallacea scientists and volunteers, and other clearings associated with bird watching, a small farm and a trail. The sites studied are listed below:

**Anthropogenic boundaries:**
- Base Camp (x2)
- Macrins Clearing (x2)
- Cusuco Camp
- La Ines Camp
- Birding Clearing nr Base Camp
- Trail

**Natural boundaries:**
- Landslide at Mark 80 on the trail to Cantilles
- Landslide at Mark 76 on the trail to Cantilles
- River Cusuco by Base Camp
- River running through La Ines Camp
- Landslide on the La Ines trail.
- 3 consecutive landslides off the La Ines trail.

To process and identify the insect fauna found in the tank of the bromeliads I washed the leaves of the bromeliad into a tray and extracted any living individuals, preserving them in a vial of formalin for later identification. Dead individuals were not included in my species count as they may not have been resident in the bromeliad, but have fallen into the bromeliad from higher up the tree. Keys were used to identify individuals to family level, the references for which I have listed at the end of this report. However, not all individuals could be identified to family level, so they were identified to order and are being taken home for further identification.

**Results**

A basic preliminary analysis was undertaken on the data, the results of which are shown in Table 1 below. However, there was little time for statistical comparisons to be made in the field, so these will be undertaken at a later date. These may include an ANOVA to ascertain whether there is a significant difference between edge effects at natural and anthropogenic boundaries and ANCOVA to factor out certain variables within the analysis, to see which variables have a significant impact on insect fauna in bromeliads. This may include looking at altitude data collected at the same time as my study.

**Table 1**

<table>
<thead>
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<th>Distance from the edge (m)</th>
<th>Anthropogenic Boundaries</th>
<th>Natural Boundaries</th>
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<tr>
<td></td>
<td>Mean no. of individuals</td>
<td>Mean no. of taxa</td>
</tr>
<tr>
<td></td>
<td>Mean ±1 standard error</td>
<td>Mean no. of taxa</td>
</tr>
<tr>
<td></td>
<td>Mean ±1 standard error</td>
<td>Mean ±1 standard error</td>
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<td>0</td>
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<td>10</td>
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</tr>
<tr>
<td>20</td>
<td>23.6 ±2.2</td>
<td>5.00 ±0.38</td>
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</tbody>
</table>

values are mean ±1 standard error
Figure 1 below illustrates the relationship between bromeliad size and the number of taxa present. This appears to show that there is a positive correlation between these two variables, but that the gradient of this relationship is slightly steeper at natural boundaries than anthropogenic ones.

**Figure 1**

![Comparison of Edge Effects at Natural and Anthropogenic Boundaries in Terms of Taxa](image)

**Discussion**

There appears to be an edge effect present in the insect fauna of bromeliads at both natural and anthropogenic boundaries. However the manifestation of this appears to differ between sites. Some interesting observations of my data so far include:

- At the more disturbed human boundaries it was often difficult to find bromeliads, especially at the edge of the clearing. This suggests that bromeliads may be less likely to grow in highly disturbed areas.
- Bromeliads tended to be much more sparsely distributed in dense woodland as only a limited amount of light penetrates the canopy to the forest floor in these conditions.
- The highest diversity of taxa often occurred at 10 meters from the edge of a clearing. This may be due to the dense nature of the forest beyond this point limiting the number of species able to colonise the bromeliads, and the more protected nature of this area in comparison to the edge.
- In general there tended to be a decrease in individuals away from the edge at anthropogenic sites, in conjunction with a decrease in the number of taxa present, though the statistical significance of this remains to be tested. At natural boundaries there appeared to be a similar trend in terms of individuals with more present at the edge than 5 meters into the forest, but numbers seemed to level out after that at an average of 24 individuals per bromeliad. However, the number of taxa present did not seem to be affected at natural boundaries, with an average of approximately 4 taxa per bromeliad at 0, 5, 10 and 20 meters from the edge of the clearings.

This relationship of more individuals at the edge of a clearing than towards the interior of the forest could be due to greater accessibility of those bromeliads at the edge, making them a viable niche for more species than in the densely packed woodland. Light intensity may also be an important factor. The fact that the number of taxa found at natural edges stayed roughly constant with distance from the edge may indicate that the level of disturbance at these boundaries is much lower, and so has a less significant impact on the insect fauna of bromeliads.

Other more general observations were that bloodworms were much more abundant at the edge of clearings. This is probably due to the increased exposure to sunlight in these areas, as bloodworms favour the warm stagnant water conditions present here. In addition, at the edge of clearings individuals were more likely to be found in the outer leaves of the bromeliad, whereas towards the forest interior most individuals were found near the centre.
References
Environment and Development in the Buffer Zone of Cusuco National Park, Honduras: Experiences, Problems and Prospects

Dr Richard Phillips (Senior Lecturer in Geography and International Development, University of Liverpool), James Bown, Nick Lee, Anna Murray and Nina Porter (translator).

July-September 2005

Introduction: Research Aims and Questions

This report outlines the research questions, methodologies and findings of a social science survey, conducted in July and August 2005 in the buffer zone of Cusuco National Park, Honduras. This survey aims to understand household economics and environmental understandings and practises within the buffer zone, with the long-term aim of encouraging sustainable development there.

The survey described in this report builds upon previous research, conducted by dissertation students in 2004, which conducted a household census of Buenos Aires and a number of specific studies of environmental understandings and practises within the buffer zone of the National Park.

The project began with four main questions:

- What are the sources of livelihood in this region?
- What role does agriculture and agricultural intensification play in this?
- How do residents perceive the buffer zone; what local environmental rules do they know and/or respect?
- How do people position themselves within wider international and developmental contexts?

These questions were asked with the broader aim of assessing the environmental consequences of development in the buffer zone, and of exploring the possibility of intervention by Operation Wallacea and/or other bodies, to promote more sustainable development.

Prospects for further investigation and intervention will be pursued through a GEF (Global Environment Facility) Proposal, which will be submitted in 2005-06 for funding by the World Bank.

Scope and Contents

This report consists of summaries with illustrative results, rather than final detailed analysis, since the students will not complete their dissertations until Feb-Apr 2006; the individual students will provide copies of dissertations in due course. Though in some respects preliminary, therefore, this report works towards some conclusions about: the environmental consequences of development in this region; prospects for intervention to promote more sustainable development; and suggestions for further research (including dissertations and doctoral research) to inform future interventions and economic and environmental management in the region.

Methodology

To address these themes, within the constraints of time and human resources (one supervisor, one translator and three students), three research phases were planned.

Three villages in the buffer zone were included in the survey. The three villages were chosen based on their distance to the park entrance and their contact with outsiders, particularly with tourists/students/researchers entering the area with Operation Wallacea:

- Buenos Aires: deeply affected by Operation Wallacea’s activity
- Guadalupe de Banaderos: less closely affected by Operation Wallacea
- La Laguna: outside the range of Operation Wallacea and other tourism

The positions of three villages are shown on Map 1; the layouts of three villages are shown on Maps 2, 3 and 4. The detailed village maps show households by number; these numbers are used to identify interviewees throughout this report.
**Semi-Structured Interviews**

To address the broad themes of the project, and gain a basis for more detailed qualitative and quantitative investigations (in the 2005 and subsequent research seasons), semi-structured interviews were conducted with a sample of residents of the park buffer zone. The questionnaire, on which these interviews were based (Appendix A), was piloted and revised before its application in the field.

Fifteen interviews were conducted in each of the three villages. Sampling within the three villages was designed, in keeping with the aims of the project, to represent households of different wealth/livelihood levels and degrees of access to land. Given the small numbers of households from which respondents were selected (less than 90 households in Buenos Aires, and less than 30 in each of the other villages), there were practical constraints on sampling. In the smaller villages, we simply interviewed all households in which a respondent was prepared to speak to us; in Buenos Aires we used the 2004 census to select households from a range of wealth rankings/status, and interviewed those who were prepared to talk to us. This was as scientific as it was possible to be under the circumstances.

Given the wide range of questions in this survey, it was appropriate to target a wide range of respondents, within the household level. It would not be appropriate, for instance, to always (or never) speak to male head of households. When men were present, however, they generally spoke for their families, who generally gathered to watch. To avoid this bias towards a limited range of respondents, interviews were conducted at different times of the day and week, including times when men would be likely to be out at work in the fields or elsewhere.

The households were identified according to numbers, corresponding to numbers shown on a map of Buenos Aires produced in 2004, and maps of the other villages to be produced this year.

**Depth Interviews: Professionals**

Depth interviews with relevant professionals in the locality and with organisations based externally, which manage and govern the environment and society of the locality, were conducted to investigate the attitudes and practices of key figures. These included representatives of:
- Water authority
- Forestry authority
- Local education
- Local health care
- Community leaders
- Agricultural collectives
- Agricultural professionals

**Depth Interviews and Focus Groups: Members of the Community**

Depth interviews with selected residents of the buffer zone were included follow up and investigate in more detail the responses generated in the first stage of research. This expanded upon the themes raised in each of the four main sections of the semi-structured interviews. Selections of interviewees were made on the basis of relevance, e.g. when surveying agricultural intensification, the sample was stratified between: farmers who had not adopted intensification strategies, and those who had. The number of interviews in each case was designed to maximise the quantity of information gathered, subject to constraints of time available to the student and translator. Whereas semi-structured interviews were conducted by all students and produced common information, shared by all, the depth interviews and focus groups were conducted on an individual basis, each by one (in some cases two) students working with the translator and respondent, and this enabled more detailed attention to specific themes.
Map 1: Regional Map
Map 2: Buenos Aires
Source: Map Drafted by Buenos Aires community, focus group involving local residents, facilitated by Operation Wallacea dissertation students, 2004
Map 3: Guadalupe de Banaderos
Source: Map Drafted by James Bown and Nick Lee, 2005
Map 4: La Laguna
Source: Map Drafted by James Bown and Nick Lee, 2005
Results
The following sections consist of detailed reports on livelihood, agriculture and environment, completed by the three social science students. They are preceded by a brief summary of findings, on this page, and followed by a summary of conclusions.

Livelihood
The typical household has access to a few manzanas (approximately, acres) of land, from which they meet some of their needs. To supplement this income, men tend to work locally in fields, as casual workers or as guides, and some work in Cofradía, San Pedro or perhaps the United States for a few years. Many people would like to reduce their dependency on the land, finding better paid work and more secure income with employers outside the area, and/or through tourism: working as a guide, vigilante, driver or cook; taking in washing; hosting visitors.

The survey asked detailed questions about peoples’ livelihood, its distribution throughout the year, and between members of the villages. It investigated peoples’ perceptions of their livelihoods, also asking about their aspirations and intentions, and their strategies for change, setting all this in the context of wider questions about how livelihood change might affect the community and environment.

Agriculture
Typical households use the land they own or (less commonly) rent for growing coffee for sale, and vegetables such as maize and beans for their own consumption. Coffee production is largely through the traditional shade method, which is generally ‘environmentally friendly’. Some farmers do grow ‘forced’ coffee, however, using fertilisers and pesticides. Chemicals are also widely used for commercial tomato production, mainly by a smaller number of larger farmers.

The survey on agricultural intensification paid particular attention to the growing use of chemicals, and considered how this might be reduced; detailed findings and conclusions follow.

Environment
Residents of the buffer zone rarely visit the core zone of the park for their own recreational purposes. Their relationship with the environment is more practical, their environmental knowledge learned and practiced through activities such as hunting (older guides learned the forest this way as children) and work as guides or vigilantes. Most respondents spoke positively about the park and its rules, which they claimed to respect and obey, but about which they lacked detailed knowledge.

The survey on environmental knowledge paid particular attention to the levels and sources of environmental knowledge, and to the role of Operation Wallacea in changing this.

Wider context
Additional questions were added to explore peoples’ attitudes towards the wider world, with particular reference to the political and economic forces affecting their livelihoods. This was important for understanding more about their attitudes towards outside organisations such as Operation Wallacea, with specific reference to how such organisations might already affect them, and how they might affect them for the better, for instance in development projects. Most generally, it was found that people in this area knew little about the wider world, and did not show much interest, and had very low expectations.

This section is not reported in detail in the following sections, which concentrate on livelihood, agriculture and environmental knowledge, though a fuller summary is included in the Summary of Conclusions, which follows.

The following sections consist of preliminary reports, submitted by the three social science students to Operation Wallacea, describing research methodology and conclusions in detail.
1. Sustainable livelihoods for buffer zone communities of the Cusuco National Park

Nick Lee, Newcastle University

**Rationale:** “A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining in the natural resource base.” (DFID, 2001)

The sustainable livelihoods framework is a tool to improve our understanding of livelihoods. The framework presents the main factors that effect peoples’ livelihoods and the relationships between them.

**Figure 1. Sustainable livelihoods framework**


In terms of the in field research my study will be concentrating on the vulnerability context, livelihood assets and the transforming structures and processes.

**Research Question:**
How sustainable are the livelihoods of the buffer zone communities in the Cusuco National Park?

**Aims**

**Vulnerability Context:**
The vulnerability context frames the external environment in which people exist. Livelihoods are fundamentally affected by critical trends, shocks and seasonality over which people have little control. Each of these factors have direct impact on peoples assert status and their capabilities of achieving beneficial livelihood outcomes. Therefore the aim is to; identify those trends, shocks and aspects of seasonality that are of particular importance to these communities. Effort can then be concentrated on understanding these factors and how impacts can be minimized.

**Livelihood Assets:**
The approach is founded on the belief that people require a range of assets to achieve livelihood outcomes. Therefore no single ass et alone is sufficient to yield the many and varied livelihood outcomes that people seek. The assets can be viewed in a pentagon illustrating their important interrelationships. (See Figure 1) The aim is to; gain an understanding of people’s strengths in each of these assets and how they endeavour to convert these into positive livelihood outcomes:
- **Human Capital**: Assess the skills, knowledge, ability to labour and good health which are all required to make use of any of the other assets.
- **Social Capital**: Assess the social resources upon which people draw in pursuit of their livelihood objectives, represented by the sharing of goods services and information within communities.
- **Natural Capital**: Assess the natural resource stocks from which resource flows and services useful for livelihoods are derived, which is particularly important where the majority of livelihood is from resource based activities.
- **Physical Capital**: Assess the basic infrastructure and producer goods needed to support livelihoods. Lack of particular infrastructure or producer goods is a key dimension of poverty.
- **Financial Capital**: Assess the saving holding and use of financial capital. Financial capital can be used for the direct achievement of livelihood outcomes and also be converted into other types of capital.

### Methods

I decided that I wanted to complete research in three villages in the buffer zone; talking to locals in Buenos Aires and cross referencing with previous study I decided that there were 4 possibilities: Buenos Aires, Guadalupe, La Junta and La Laguna. (all bar La Laguna in the buffer zone)

I took guides to each of these settlements and drew annotated sketch maps of the settlements to familiarise ourselves with the surroundings and locate services and households. This was also an opportunity to make our presence known and chat informally about the reasons for coming and what I hoped to achieve. La Junta was the hardest settlement to map due to its dispersed layout and the atmosphere here was not as welcoming so I decided to sample the other settlements on this basis.

A sample size of fifteen preliminary interviews in three settlements was decided upon on the basis of time limitations, size of settlement and to allow time for potential in depth follow ups. The sample size also allows for quantitative methods to be used with a total of 45 preliminary interviews.

With a lack of census data in two out of three settlements a quantitative sampling technique was hard to justify. Therefore the snowball technique was adopted whereby the sample is selected in each settlement based upon the social networks active in that community. Guides were selected that knew each of the villages well allowing for the snowball technique to begin. Under the circumstances of limited availability of households to interview and lack of input from each interviewee in terms of suggesting another interviewee, the role of the guides in selecting houses was increased.

Fifteen background questions were developed to form census data for quantitative analysis and to select sampling for the in depth follow-ups.

Using the aims developed from the sustainable livelihoods framework I developed ten questions; these questions were then translated, reviewed and piloted until they were considered to achieve the aims and suitable for the locality. At the end of each interview I asked if I could come back and perform a follow up in depth interview.

The background data was tabulated into a census format and used to select a sampling method for the in depth interviews. The area of land owned was decided upon as a variable that would be used for sampling the in depth interviews. This is not the indicator that represents wealth on its own however due to the time restrictions a simple indicator had to be chosen. This indicator of wealth was justified by informal discussions with a number of members of the Buenos Aires community who all identified tenure as a significant indicator of wealth.

Categories of tenure were drawn to represent the broad spectrum of households. Those who own no land, those who own up to five manzanas and those who owned over five manzanas. Reference to the background data justifies this as a suitable sampling technique.

The time frame of the research limited the sample to four interviews in each category. An even spread was also achieved between the three settlements ensuring that spatial comparisons can be made.
Analysis of the background data and cross referencing with the original aims and theory allowed for the aims to be reconsidered. The information achieved in the background interviews meant that a deep insight into all of the forms of capital and vulnerability was achieved. Therefore identifying areas that needed to be followed up with a more unstructured framework. Furthermore, any gaps in the research were identified allowing for concentration in the in depth interviews.

The in depth interview framework was based around the themes that were identified in the background research. Themes and questions to encourage open-ended discussion of these themes were formed and used as the basic structure for the follow up in depth interviews.

Results and Analysis:
The results for the background of the study are best represented through separation into each of the original categories.

Vulnerability
Figure 1

Figure 2

Seasonal vulnerability due to the reliance on coffee season for income shown clearly by Figures 1 and 2.
Price fluctuations in the international coffee markets increasing this vulnerability.

- Access to markets limited by necessity to use middlemen.
- Lack of access to markets because the scale of poorer farmers growth means it is not economical to pay for the transport to take their own products to market.
- Therefore a lack of control over the prices which farmers in particular small scale farmers receive for their products.
- Gender issues of the risk for women at the markets.

**Human Capital**

Figure 3

![A Chart to Show Whether Households Have Everything They Need.](chart1.png)

- There is a high level of satisfaction throughout where 22 people were satisfied that they had all they needed.
- Lack of food as a seasonal trend is an issue of significant importance.
- Importance of education, access to education in terms of cost of education and cost of labour.
- The limit to the growth a more diverse range of products for personal use is limited not only by finance but also by access to land to cultivate.

Figure 4

![A Chart to Show The Effect on Livelihoods of Ill Health.](chart2.png)

The health of all households in general is good despite the limited access to healthcare. 32 out of the sample of 45 have not had health problems in the last two years that have stopped them from working. However in general it is felt that the medical services provided are limited by cost of medicine and access if treatment for anything more than a minor ailment. Awareness of medicine sourced from plants has been shown in 5 of the follow up interviews.
Social Capital

Figure 5

- Wealthier households have access to financial services.
- Sharing, Trust and Reciprocity are very important especially among the poorer households who do not have access to these services as shown by figure 5.
- 24 out of the sample have received help from a friend or neighbour to improve their livelihood.
- The role and importance of the existence of this trust in the formation of a cooperative has been emphasised in the follow up interviews.
- The sharing of information has particular emphasis in the hand down and lateral knowledge of farming methods within all communities.
- The role of the Catholic Church in all communities as a social facility has been emphasised in terms of help in times of need.

Natural Capital

Figure 6

- There is evidence of great respect for the environment, and sustainability in the way that natural resources especially firewood are being used.
- Firewood is largely gathered from households own land and if they have no land then the wood is gathered from land belonging to other members of the community at no charge.
- This suggests that the sustainability of the firewood in terms of household use is sustainable; particularly as a result of the organisational information households have received about growing good firewood trees for shade.
- The land owned by the poor is the limit to their diversification into other resource-based activities. The poor are therefore generally limited to growing a less diverse range of products.
Physical Capital

Figure 7

- Primary research indicated that the majority of people travel to Cofradia and San Pedro Sula. The households with less land tend to go less frequently for essential reasons, either medical or to buy food and clothes.
- Those households with more land tend to go more often because they have better access to the transport and they have family to visit, work to do or crops to sell.
- Improved roads would mean that people would travel more, however the access to transport will be a major issue in the future even if the roads are improved.
- If affordable transport was accessible then access to the markets for the smaller scale farmers will be greatly improved.
- It has been made clear that there is a mutual respect for the environment in particular with relation to the land people cultivate. Therefore there appears to be no lack in information in this respect.
- The information that is lacking seems to be on the awareness of the opportunities of selling fair trade products. This is particularly evident among the smaller scale cultivators. If a fair trade or cooperative was to be successful all members of the community must be aware of the opportunities.

Figure 8

- People value their households very highly as assets.
- If people were to invest there is a large portion of the sample that would improve their houses by building cement floors, walls and tin roves.
- This will also affect the sustainability of the household and indirectly affect the sustainability of the natural resources as much natural resource sourced repair work has to be done on the mud houses.
- The household is also seen as an investment of capital and form of saving.
- The construction process is something that can be sourced locally through the networks of trust identified earlier.

**Financial Capital**

Figure 9

A Chart to Show What People Would do to Get More Money.

- More financial capital would be spent in general on improving the house (walls, floors, roof) and invested in better crops and land.
- People also value the investment in a longer education for their children.
- Limiting this however is not only the cost of an education at the college, which is relatively low compared to San Pedro Sula; but also the cost of the labour that is lost through children not being able to work the land if they are at college.
- Seventeen of the households would cope in periods when money is short by getting more work. Investigating this in the in depth showed that the most popular method of finding more work is to work for a lower wage for other larger scale farmers.
- Access to bank loans is only available to the wealthier groups and 14 of the sample would get a loan from a friend or family as shown in Figure 9.

**Conclusions**

Capabilities, assets and activities for a means of living are being achieved. In terms of recovering from seasonality and stresses the sustainability of the communities is weakened not by the undermining of the natural resource base but by the access to the assets that allow people to enhance their livelihood capabilities. These include access to fair and stable markets and access to land and a diversity of products to grow.

Access to these assets would give these communities opportunity to enhance other areas of capital that are equally as important to achieving sustainable livelihoods. These include household assets and education.

**Further study**

Census data for all the communities in the buffer zone has been one of the main limitations to the social scientists investigation. Something that is essential for any implementation of policy in an area.
References

Appendix 1

List of Follow up interviews:

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Village</th>
<th>Household</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santiago Alvarenga</td>
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<td>31/7</td>
</tr>
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<td>Alfonso Cruz</td>
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<td>1/8</td>
</tr>
<tr>
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<td>52</td>
<td>31/7</td>
</tr>
<tr>
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<td>Opp. 30</td>
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</tr>
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2. Agriculture within the villages surrounding Cusuco National Park

Anna Murray, Queens University, Belfast

Rationale
Agriculture is one of the most prominent industries within Honduras, accounting for nearly 35% of the country’s GDP, with approximately 60% of the labour force generating the majority of its income from agriculture alone. Agriculture can therefore be seen to play an important role within the social, economic and environmental structure of the country as a whole. But the problem is ‘Can agriculture continue to provide a viable income source for the population in the future or will agriculture in Honduras face an unwelcome decline as it has over the past century throughout much of the developed world?’ The aim of this study is to answer this question in the context of the villages surrounding Cusuco National Park investigating the research question: ‘Is agriculture the way forward for sustainable development within three villages surrounding Cusuco National Park.

The park itself is an area of high scientific and environmental importance. But like so many habitats across the world Cusuco has come under increasing pressure from human activities such as illegal logging and hunting which subsequently threatens the forest’s unique and diverse status. In an attempt to curb such activities and conserve the forest a new management programme for the park has been proposed which aims to protect the core zone of the forest whilst also ensuring the sustainable development of surrounding communities. In the past activities such as illegal hunting and logging can be seen to have formed the basis of a stable and secure income for many communities and therefore it is essential that alternative sources of income are explored if complete protection of the forest is to be achieved. The sustainable development of agriculture within these communities has been suggested as one such alternative to enhance their economic development but the potential impact of such development on the social, economic and environmental status of the surrounding communities remains uncertain. The study will explore how any future agricultural development may affect local communities and households, examining the possible advantages and disadvantages this may bring to the area with regards to environmental, economic and social sustainability. In answering the research question the study will investigate three main objectives:

- To investigate the importance of agriculture within the three sample villages of Cusuco National Park
- To determine how sustainable current agricultural practices within the area are for the future sustainable development of the three sample villages
- To suggest future sustainable development pathways for the three sample villages

NB: See previous chapters for research methodology

Results
The research has shown that, like Honduras as a whole, agriculture plays an important role within the lives of the buffer zone communities of Cusuco National Park, with 93% of the households interviewed in each of the three sample villages engaged in some form of agricultural production and over 75% stating agriculture as their main source of livelihood. Like throughout Honduras private household plots consist of small family run plantations, with the majority of households owning between one and three manzanas. The investigation has also shown that traditional methods of cultivation still remain prominent within the three sample villages despite the rapidly growing technical advancement of agricultural practices across the globe. The majority of the crops grown within this area are the traditional products of maize, beans and coffee with a small expansion into tomato and chilli plantations. (See Graph 1 for details)
These products are farmed in a very traditional way with all work being completed by hand without the use of machinery. Only 1% of the households interviewed farmed over 3 manzanas of land with many of these describing themselves as commercial farmers, employing locals to work on their farm. As a result of the size of land they own these ‘commercial farmers’ are able to grow a much larger range of crops than the majority of the population.

The threat of high maintenance plantations
Shade coffee is a traditional form of coffee production prominent throughout Latin and Central America. Coffee bushes are cultivated under a forest over storey therefore protecting the coffee plants from the sun and the rain. This method of production is highly sustainable as the tree cover helps to maintain soil quality, reducing the need for weeding and aiding in pest control, whilst also providing a rich habitat for a variety of animal species. The research has shown that over 85% of households interviewed grow shade coffee but the study has also revealed that prices received for this crop are highly variable and prone to extreme rises and falls from year to year. The main reasons for this are instabilities within the world market et al alongside climatic conditions that affect soil fertility levels, and the level of pests. These in turn greatly affect the crop quantity and quality and therefore the price received.

In recent years coffee prices across the world have reached all time lows, as the market has been open to free market economies, having a dramatic impact on the lives of those households within the buffer zone villages. Many have been forced to cut their ties with the coffee market resulting in the transformation of the social, economic and environmental landscape as coffee plantations are increasingly replaced by the growing of tomatoes and chillies. These crops are generally regarded as high maintenance, requiring increased use of pesticides and fertilizers to achieve high quality saleable crops. Those who have moved away from coffee production completely therefore tend to be those with a greater disposable income and over 3 manzanas of land. The poor are often unable to afford the high prices demanded for chemical use and are therefore forced to rely upon the unstable world coffee market.

A further transformation within the coffee market has also been the transformation from shade grown coffee to that of sun coffee. Loureiro and Lotade (2004) believe that the economic need of Central America to maximise coffee production in the 1970’s has made coffee producers switch to agricultural techniques that degrade the environment, a switch involving a change from shade coffee to that of open or sun coffee. Sun coffee results in a greater quantity of coffee produced than shade coffee but despite this the quality of individual beans are greatly compromised. The restructuring of households social, economic and environmental situation is also common as a result of this transformation. Social networks are put under strain, as sun coffee requires a higher level of man-hours resulting in stresses, which may result in stresses within the household. Greater economic input from the farmer is also
required as sun coffee plantations require increased chemical purchases and the overall quality of the environment and its productivity may decline due to increased chemical use and tree cover removal which in turn leads to a decline in soil fertility and an increase in erosion vulnerability. Despite the fact that the majority of those interviewed (95%) grow shade coffee, transformation to open coffee plantations poses a real threat for the future if coffee prices continue to decline as farmers may be forced into this transformation in an attempt to secure their livelihoods.

All those interviewed expressed the wish to grow a greater range and better quality crop in an attempt to improve their livelihood, but they are prevented from expanding their land and enhancing their products due to lack of land and financial capital to invest in such changes. Without the guarantee of land behind them many are unable to borrow money from banks and other organisations therefore further limiting their chances of further development and trapping them in a vicious cycle of poverty.

Graph 2 Selling of produce in all three sample villages

The research has shown that in the past coffee cooperatives have existed in many of these communities but the majority have since folded as a result of lack of investment, administration and experience in running such organisations produce. The majority of the households sampled therefore stated they worked alone to sell and grow their products and this alongside lack of direct access to markets as a result of the high costs of transportation has meant many households are forced to receive relatively low prices for their produce. In all three-sample villages larger commercial farmers act as middlemen within the community, buying locals products that they then sell on for a profit in the markets of San Pedro or Cofradia. It is often cheaper for small farmers to sell to those middlemen, who own vehicles, than to hire transport to sell their products personally at these markets. (See Graph 2 for details). All those interviewed believe that cooperatives are a valuable way for local farmers to achieve higher prices for their produce and to compete on a national and global market. Despite this a major concern is the lack of outside help within the area.

Potential for the future

The research has highlighted the visible lack of assistance given to farmers by outside organisations and in particular the Honduran government. Only 1% of those households interviewed within the three sample villages received any form of help from outside organisations or government sources. Those who did receive help corresponded to those who owned the most land. The poor were left to their own means, with many feeling ‘the government often promises a lot but always fails to deliver.’ If cooperatives are to be used in the future as a method of enhancing the prices received by small farmers for their products outside help is essential to assist with the technical assistance and education needed within the local communities to ensure any future cooperative projects are a success.

Fair trade pricing systems may also provide an option for the future sustainable agricultural development of the three sample villages. According to the Fair Trade Federation (2004) sales of fair trade commodities are rising at close to 40% per year in North America and the Pacific Rim. Despite

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the relatively low prices currently received for shade coffee within the sample communities fair trade coffee may provide households with the potential to greatly enhance their income with very little effort. This fact is highlighted by Loureiro and Lotade (2005) who state ‘farmers in developing countries benefit from fair trade practices since the buyers and sellers of the products directly without the middlemen… the label also emphasises the messages of care for the environment, social justice and quality standards of products’. Research has shown that consumers in the western world are willing to pay higher premiums for organic, shade and fair trade coffee, highlighting the existence of niche markets available to differentiated products carrying ethical and environmentally preferable messages (Loureiro & Lotade, 2005). This evidence provides a strong argument for the case of aiming to achieve certification of the locally grown coffee as fair trade and shade-grown but like the promotion of locally run cooperatives this will initially require input from external organisations if the scheme is the run successfully.

The diversification of work opportunities both in terms of diversifying the number of crops grown by individual farmers and in the enhancement of off farm opportunities are also potential areas of future development for the sample villages. Reliance upon a small number of crops makes farmers highly susceptible to climatic and market variability were as an increase in the variety of products grown throughout the year may help to provide financial stability and security throughout the year. To achieve this access to technical assistance in growing new crop varieties, cultivation methods and loans for poorer farmers must be increased, as without this knowledge such diversification may be doomed to failure from the start.

Increased access to off-farm employment may provide an alternative to the instability of agriculture within the sample communities with the advancement of global eco-tourism providing a strong basis for a possible rise in tourists to Cusuco National Park. Presently the park receives little revenue for eco-tourism outside the Operation Wallacea season and the evidence shows that of the three sample villages only one (Buenos Aires) presently receives any benefit from their presence. If eco-tourism is to benefit all the surrounding communities a plan must be formulated which bring together all communities and households together to assess the benefits each can bring to the modern eco-tourist and how this can be completed in an inclusive and coordinated fashion. Alongside this the priority must be to improve the access routes to the park, which are currently in a poor state and to enhance the promotion of the park not only on a national but international scale which many believe lies in the hands of both the local and national government who have promised to invest more time and money into the region. Only the future will tell if such promises are carried out and indeed if eco-tourism is the way forward or if agriculture is the way forward for the sustainable development of the villages surrounding Cusuco National Park.

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3. Paper parks: Environments of Hybrid Knowledge?

James Bown, Nottingham University

Introduction

Geographical research on the environment remains theoretically and empirically diverse. Traditionally, western scientific attitudes and top-down management strategies have been brought in and used to analyse environmental development problems and offer solutions based on this scientific top-down environmental knowledge (SEK). However, this ‘certainty’ in SEK has come under increasing scrutiny in the post-development era (Escobar, 2001; 1995) with post-colonial and anti-development theorists arguing that this SEK has been elevated above ‘other-local’ knowledge systems, subsequently marginalizing multiple voices (Radeliffe, 1999) and undermining the Local Environmental Knowledge (LEK) of the people (Chambers, 1983).

Arguably, the management of the environment in the twenty-first century involves “far more than simply understanding the science of the environment” (Jones, 2004: 6). The “knowledge’s and values of local communities are now being acknowledged as valuable for biodiversity conservation” (Pretty & Smith, 2004: 631). There is a need to understand how these ‘distinctive’ and ‘contested’ environmental knowledge’s interact with one another in the same environment, and how they both could be integrated into future community development strategies under the term ‘hybrid knowledge’. (Hybrid Knowledge: Uses the local knowledge as the starting point in development research and then uses western science as the means to extend management practices into other areas (Forsyth, 1996; Nygren, 1999).

Cusuco National Park (CNP)

In 1987 the Honduran government set-up a number of National Parks to protect the remaining high altitude, ‘cloud’ forests. However, many of these National Parks and their associated imposed spatial zones and top-down rules only exist on paper. Essentially they are parks on paper with paper rules (Powell et al., 2001). This study aimed initially to discover what SEK the buffer zone and surrounding communities in the park knew, in order to test whether the CNP was just another park on paper with paper rules. However, as research progressed a new type of knowledge was discovered and tapped into, consequently new objectives and methods were formed to investigate this LEK of the people as well.

Dissertation Question:

Present research attempts to investigate and compare the types and levels of knowledge within the buffer zone and surrounding communities of the CNP and their use in future management strategies of the park:

To what extent do the environmental and regulatory knowledge levels differ between the buffer zone and surrounding communities of Cusuco National Park?

Dissertation Objectives:

- To investigate and compare what the buffer zone and surrounding communities currently know about the two spatial zones of the Cusuco National Park and the top-down, managerial rules which govern them.
- To investigate and understand what the Local Environmental Knowledge (LEK) is of the buffer zone and surrounding communities.
- To investigate how the buffer zone and surrounding communities value the Cusuco National Park and position themselves within it using this local environmental knowledge.
- To investigate how the buffer zone and surrounding communities have acquired this ‘local environmental knowledge’ (LEK) and the mechanisms by which it is reproduced/passed on.

Methodology (see BK overview for baseline interviews – sample size 45)
Results for Objective 1
In order to investigate what the current level of SEK was within the sample communities, concerning the CNP, I obtained a copy of the CNP’s definitions for the two zones and the rules which applied to them, all summarised in Decree 87:87, the official legal document (see Appendix 1).

From the baseline interviews three key findings were drawn out relating to objective 1. These findings are summarised below:

Core and Buffer Zone Knowledge (see Figure 1): All communities had very little, if any, SEK understanding of the two spatial zones. However, there was a clear difference in knowledge levels between Buenos Aires (60%) and other sample communities (0%). Preliminary results suggest this form of SEK not communicated to communities’ very well if at all. (N.B Information obtained triangulated with the secondary Manger and Professional Interviews).

![SEK Core and Buffer Zone Knowledge](image)

Figure 1
Park Boundaries (see Figure 2): Baseline interviews found that no knowledge existed for the buffer zone boundary in any of the sample communities. However, there was a clear difference in knowledge levels of the core zone boundary with 47% of the Buenos Aires sample knowing where it officially was, compared to no knowledge of it in the other sample communities. N.B Although BA indicated a higher knowledge of the park boundaries it is clear that none of the communities sampled have a clear significant knowledge of the park boundaries, especially the buffer zone. (Triangulated with Manger and Professional Interviews).

![SEK Boundary Knowledge](image)

Figure 2
Park Managers (Figure 3): From the baseline interviews it was clear that none of the sample communities knew clearly who the current managers of the park were, or even who the past managers had been.

Figure 3:

Also, it was clear that the Buenos Aires sample had more SEK about the two spatial zones of the Cusuco National Park and the top-down, managerial rules that govern them compared to the other sample communities of Guadalupe and La Laguna. Therefore, I went back and analysed all the baseline interview questions in more depth and found a group of respondents, pre-dominantly in Buenos Aires, that significantly knew more SEK about the park, its zones and the rules that govern them. I called this group ‘The Professionals’ and it included guides, DIMA workers, the eco-lodge owner and the owner of the waterfall. In-depth secondary interviews (see appendix 2) were held with this group over the coming weeks and part of the interview looked at how they acquired their SEK of the park (see text box 1 below).

Text Box 1:

Carlos: “the influence of Operation Wallacea has woken the community up to the fact that the park is an important natural resource”
Santiago: “BA has benefited due to its proximity to the park entrance and by our contact with foreigners from operation Wallacea that help educate us about the parks and its resources”
Leonardo: “people from BA have learnt about the environment from foreigners that have come here”
Teacher: “work with Operation Wallacea directly and indirectly educates those involved about the environment and increases the awareness within the community as people talk about it”
Guide Focus Group: “being a guide means that you are working in the park or in the buffer zone, so you start to learn about the place you work in and its value”

The interviews indicated that their SEK had been acquired through three chief factors: their work in the park, increased contact with foreigners, mainly through Operation Wallacea and the proximity of Buenos Aires to the entrance of the core zone. These factors were then triangulated with one of the baseline questions which investigated the impacts of the CNP upon the communities, in terms of work opportunities, levels of foreign contact and knowledge of Operation Wallacea (See Figures 4, 5 & 6):
When this evidence was triangulated together it became clear that the reasons Buenos Aires had higher levels of SEK about the park were down to the proximity of the village to the core zone entrance and the impact of Operation Wallacea providing work in the park. As distance from the park entrance increased levels of work, foreign contact and knowledge of Operation Wallacea all declined significantly, correlating with lower SEK knowledge levels about the park moving away from Buenos Aires.

**Conclusion for Objective 1**

The sample communities of Guadalupe and La Laguna do not know the two spatial zones of the park or their boundaries according to formal definitions in Decree 87:87. Neither do they know who the managers of the park are.

The sample of Buenos Aires did have some understanding of the two imposed spatial zones but only a certain group of individuals, the professionals. For this group SEK is reproduced through their work in the park, mainly with Operation Wallacea. However, the rest of the sample community had little SEK of the two spatial zones, and no SEK of their boundaries or who the managers are. Therefore, my preliminary conclusion is that there is no significant difference between the buffer zone and surrounding communities in terms of SEK about the two spatial zones, their boundaries or who the managers are. The formal top-down, managerial rules that apply to the two zones are only on paper. The rules do not exist for the communities because the communities do not know about the two formal spatial zones of the park, their boundaries or who the managers are. There also seems to be a lack of communication of the managerial rules and spatial zones to the people, which were followed up in the manager interviews with COHDEFOR and the Fasquell Foundation (see text book summary below).

“All the communities have a general knowledge about the park, its rules etc, but yes… some do know more compared to others. I think BA knows more but it does not mean the people obey the rules”

“Meetings were held to educate the people when the park was first set-up but since then I don’t what or how the other managers have educated the people about the rules” (COHDEFOR Interview)
New Directions and New Objectives
From my baseline interviews and the findings from objective 1 it was clear to me that I had found out what the people in the buffer zone and surrounding communities did not know (SEK). However, I needed now to find out what they do know about the CNP, I needed to tap into their local environmental knowledge (LEK) and investigate what the park meant to them. I came up with objectives 2-4 (see Text Box 2) after I had triangulated my indirect and direct participant observations with further analysis of the baseline interviews (see Text Box 3):

Text Box 2
To investigate and understand what the local environmental knowledge (LEK) is of the buffer zone and surrounding communities.

To investigate how the buffer zone and surrounding communities value the Cusuco National Park and position themselves within it using this local environmental knowledge.

To investigate how the buffer zone and surrounding communities have acquired this ‘local environmental knowledge’ (LEK) and the mechanisms by which it is reproduced/pass on.

Text Box 3

Objective 2:
- Deep respect and desire to protect forest from baseline interviews – “rules are good because they protect the life of the forest” (int - 25-GB) / “god sent the animals down to earth and because they are innocent we should not kill them” (int-14-GB) / “work only what you need to and leave the rest of the land” (int2 – BA) / “people still have a connection to the forest but since the park this connection has changed… now more people respect the park and want to protect it like they protect their land” (Rojare guide)

Objective 3:
- Park to the people is the mountains (the formal core zone), not both spatial zones. “No one works up there (points to mountains) from here” (Int 19; LL) / “too far to visit” (Int 26; GB).

Objective 4:
- Numerous organisations were mentioned as sources of knowledge in all communities, including: BAHNCAFE, Escula para Todos, ENESCO, and Operation Wallacea.

New Methodologies to ‘tap’ into LEK:

In-Depth Interviews
Formulated three groups of themed questions (park, land & home) to investigate LEK based around objectives 2-4. Piloted questions beforehand in each of three villages to test if questions were appropriate and answering objectives 2-4. Due to time limitations, in order to get a representative cross-sample of the population in each village I stratified the sample population by one variable: wealth in terms of number of manzanas. Using baseline interviews, I categorised manzanas into 3 wealth groups and therefore, 3 in-depth interviews within each village. Wealth groups chosen so that number in each wealth group tried to have more than one potential in-depth interviewee, because due to the nature and context of this research people were often busy or out.

Place and Space through local eyes
In order to fully investigate objectives 2-4 and tap into the LEK of the people I wanted to understand the important environmental places and things in the people’s lives in the context of the CNP and their surrounding environment. I wanted an insight into how the people used their LEK to view their environment, how do they visual position themselves within it. Therefore, I decided to do a very small-scale study using one household in Buenos Aires. I gave this household seven disposable cameras and asked them simply to take photos (15 photos/camera) of the environmental spaces and things important to
them in their daily life? (How do they value environment using LEK). I gave the cameras to this particular family because I had built a very special rapport with all of them. Also many of the family had varied jobs, ages, genders and this variety will allow me to explore the different LEK’s within one household.

**Transect walks:**
During my time in the community I accompanied the local people within Buenos Aires to their work – this could have been with a field worker on the coffee plantations or to their farm, walking with guides who were working in the core zone of the park or helping a housewife wash the clothes and look after the children etc. I tried to do this as often as possible in my final two weeks and ensured I did transect walks with different genders and ages and would informal chat to them about their work and knowledge about it, keeping my objectives in mind.

**Field Diary**
This was kept for the duration of my stay recording indirect observations and informal conversations, images, experiences etc to help later on when im triangulating and cross-checking my results.

**Preliminary Results and Conclusions for Objectives 2-4:**
The in-depth interviews have indicated that within the buffer zone communities and surrounding communities sampled there exists a deep respect and knowledge about the CNP and the wider environment. The word environment means in a local sense, the trees, the land and the water. “It’s the air we breathe and the water we drink”.

Everybody values the environment and thinks it has an important role within their daily rhythms of life. “The environment enables life to live…if we contaminate or harm it, we will not survive” or “I work in the heart of the land, the environment provides me with the soil for my crops, the water to live and the trees to shade my coffee and body in the heat”. When the people describe their experience in the park their language is holistic and spiritual, emphasising this deep respect e.g. “it is a beautiful and peaceful place, where I can learn about nature”, “it is a beautiful attractive place that protects the colourful flowers and rare animals and birds”.

The park to the people is a distinctively separate place compared to their land or home. This is either in terms of a mental distance, different environments or how the people behave differently the park. “It’s a different place, there are animals and plants there, whilst here there are none”, “It’s in the centre of the mountains, separate from the communities that live in its shadow”. “The land is good for cultivating crops, whilst the park’s soil is good for growing trees and protecting its animals and plants”.

People describe the park’s location in terms of mental distance, “far away in the mountains” or “up there”, however, even for the large majority of people that have never visited the park mentally associate and know that it is above Buenos Aires. In terms of the park boundaries and how the people know when they are in it e.g. “you just know when you are in the park, it has its own distinctive environment, the air is cooler and there are more trees, animals, there are the sounds of nature and life”.

People talk about the park as a place where “you must always care and respect the environment wherever you go” and “cannot do anything that will destroy the environment”. People clearly have a local environmental knowledge about what is good and bad practice for the environment both in terms of the park and their land. “I use the land for my work, whilst I cannot cultivate the land in the park or cut wood for the house”. This exemplified by the techniques the communities use to conserve and use wisely their limited firewood resource.

Local Environmental Knowledge (LEK) about the park and the surrounding environment is produced and reproduced by a variety of networks. Knowledge about the land and park and the importance of the environment in life has been passed down through family generations and childhood experiences of working on the land and learning about what resources are important to protect. Fundamentally, the land is the livelihood of the people in these communities, emphasising why the people have a great and deep respect for the wider environment. In Buenos Aires people also value the park in terms of it as a potential wealth of resources for tourism.
General Conclusion: Environments of Hybrid Knowledge?
Preliminary research has indicated that the buffer zone and surrounding communities have little if any knowledge about the formal top-down managerial rules of the CNP set out in Decree 87:87. However, the proximity of Buenos Aires combined with the influence of Operation Wallacea in terms of providing work opportunities in the park, has meant that some SEK about the park is being reproduced within a small ‘professional group of people’. However, this study has also explored the people’s local environmental knowledge (LEK). The study has found that despite little SEK, the local people have a deep respect and depth of knowledge about the park and the surrounding environment in which they live. The park, although on paper, is an environment of hybrid knowledge where LEK interacts with SEK. Future management plans in terms of developing the communities must ensure and understand this LEK and listen to what the local people want (more work and education).

Overall Conclusions
Livelihood
The ability to maintain and enhance livelihood capabilities is limited not by the undermining of the natural resource base but by access to fair and stable markets and access to land and diversity of crops to grow. Achievement of these assets would give households the ability to enhance assets that are valued very highly by these households; improving the structure of the household and increasing levels and relative value of education.

Agriculture
Poor access to land has resulted in a focus on the growing of a few main crops by small farmers. The prices gained for these crops are highly variable and this alongside heavy reliance upon middlemen to sell their crops means small farmers have little opportunity to expand their current livelihood sources.

Environment
Preliminary research has indicated that the buffer zone and surrounding communities have little if any knowledge about the formal top-down managerial rules of the CNP set out in Decree 87:87. However, the proximity of Buenos Aires combined with the influence of Operation Wallacea in terms of providing work opportunities in the park, has meant that some SEK about the park is being reproduced within a small ‘professional group of people’. The study has found that despite little SEK, the local people have a deep respect and depth of knowledge about the park and the surrounding environment in which they live.

Wider context
People in this area knew little about the wider world, and did not show much interest, and had very low expectations. For instance, most had heard of September 11 but knew little of its repercussions, and few were aware of the cancellation of most of Honduras’s national debt, which resulted from the G8 Summit on July 7, freeing up the 15% of government spending that was until recently devoted to servicing the debt.

There is one main exception to this isolationist worldview: despite low pay (by western standards), foreign employers in San Pedro and Cofradia are generally well regarded. Second to employment in the USA itself, jobs with American manufacturing companies are particularly coveted; Korean employers were regarded with less enthusiasm.

People in this area have very low expectations of their national government or of external and international organisations such as charities and development organisations. They know little or nothing of previous interventions, and do not expect any help in the future. Despite very low standards of health care, very little in the way of public services, and widespread poverty, few people can even imagine what outside organisations could or should do to benefit them and their community. However, this does not mean that outside organisations should not continue to work to improve conditions in community and environment; quite the contrary.

General
People have a deep knowledge and long term respect for the land they use and/or own, and the surrounding natural environment. There is no environmental crisis in this area; rather, a positive
relationship with the land and nature. However, there are threats on the horizon, in terms of increased pressure on the land – people are increasingly relying on limited portions of land, in the face of population increases (high natural increase rates) and vulnerability to unstable agricultural market prices. To maintain sustainable development and protect against looming environmental threats, we propose a number of interventions for action, which are set out below.

Interventions by western governments and organisations in developing countries have a problematic history of advancing western interests/values and/or “knowing what’s best for them” without fully consulting or involving local people. Recently, however, these bodies, overseen by organisations such as the World Bank and United Nations, have developed new approaches to intervention, which should be considered by Operation Wallacea as it develops plans for activity in developing countries such as Honduras. Put simply, there is a consensus that development projects, initiated by western organisations operating in developing countries, should be participatory, and should empower communities to set and achieve goals for positive change, particularly through the transfer of skills and knowledge. This approach is illustrated, in this part of Honduras, in the work of Fundacion Banhcafe, which transfers production and marketing skills and removes some of the financial barriers to their activities. This model, advanced by Maia Green in an article in the *Critique of Anthropology* published in 2000, is ‘the development of a person by themselves’. This approach will ensure that change is acceptable to the people concerned, and promoted by them in the long term, and it will avoid some of the pitfalls of past interventions that have failed to take the people with them or achieve lasting benefits. It may be achieved by working with people to influence their goals (bringing environmental concerns up the agenda, for instance), and acting to remove some of the obstacles that might prevent these goals being achieved (mitigating the poverty that forces the use of chemicals or the collection of live firewood, for instance). From this perspective, the interests of the outside organisation may be pursued by promoting certain priorities among the people concerned, and working selectively against the obstacles to those goals being achieved.

This report suggests that there are no simple answers to the question of how to promote sustainable development in the buffer zone. This presents a contrast with Operation Wallacea’s experience in some other place, Indonesia for instance, where people could simply be encouraged and/or paid to hand in chainsaws. In this part of Honduras, I think, the forms of environmentally damaging practices are varied and a little more subtle. They include the collection of live firewood, possibly some illegal hunting, and – probably most important – agricultural intensification: clearing scrubland and using pesticides to farm it, often for tomatoes or coffee. Nevertheless, the findings of this report point have a number of implications for action, some more practical than others, which are set out below.

*Fair Trade*

It would be desirable to help establish a system of Fair Trade certification for shade grown coffee in this area; this would be enhanced by forming contracts with all members of the communities, and would result in both increased access to markets and seeds, leading to sustainable personal and commercial cultivation.

*Cooperatives*

There is a need for assistance in providing the education and technical assistance necessary for the setting up of cooperatives and small enterprises. Existing organisations such as FunBanhcafe cannot cope with demand and would welcome and assist in the establishment of new projects, particularly for the smaller farmers they do not serve.

*Investment in Sustainable Agriculture*

Since poorer households are currently excluded from financing and some marketing outlets, e.g. FunBanhcafe projects and bank loans, it would be desirable for an outside organisation to act as guarantors for small loans through which less wealthy farmers (generally those with less than two manzanas, who do not currently have access to loans) could diversify and invest in environmentally friendly practices.

*Tourism*

By further spreading the wealth from tourism to provide an alternative source of income for small farmers, it would be possible to reduce pressure on farmers to intensify land use to unsustainable
levels. This would therefore improve living conditions and have an environmentally positive effect. By increasing the geographical range of Wallacea employment (including guides, cooks, porters and all others), it should also be possible to further disseminate positive environmental knowledge and practices, since the study has found that employment in the park spreads such knowledge.

**Education**

Direct investment into education will result in increased access to education and greater value of the teaching. Investment in education should focus not upon textbook provision (books are already provided by schools according our research), but rather through improved staffing (teachers are in short supply in both the college and schools).

Finally, it is desirable to better communicate the work of Operation Wallacea, perhaps through a permanent public exhibition, not only as a matter of public relations, but also to further disseminate environmental knowledge. This exhibition might ideally be interactive rather than didactic.

**Suggested Topics for Further Research**

This social science survey conducted in the buffer zone around Buenos Aires has answered some of the immediate questions relevant to Operation Wallacea’s presence in and contribution to this region, and to its forthcoming proposal to the World Bank. It also establishes a context and basis for further research, which may be taken up by dissertation students in 2006 and/or doctoral students from 2006 through the GEF/World Bank funding period to 2010, and possibly through an ESRC case studentship submitted by Operation Wallacea in partnership with Richard Phillips/University of Liverpool.

As explained above, there are no easy answers to the question of how sustainable practises can be promoted in this area. This question can be addressed, however, though future research, which would:

- Map and quantify the extent of agricultural intensification, including the expansion of open coffee
- Study the relationship between soil fertility and agricultural potential and change in the area;
- Assess the environmental impact of agricultural change in the area;
- Track the impacts of this process upon households and their land over a period of several years (which investments bring returns, which do not; how long do the returns last before the land is exhausted, if that happens);
- Track the impacts upon the health of households, including people directly exposed to chemicals and others in the household and village (following up suggestions that respiratory conditions are increasingly common);
- Investigate the causes of intensification? E.g. is it because people simply need the money, or (counter intuitively) do they have money to invest?
- Investigate how could people be encouraged to invest in more sustainable forms of development
- With the same physical, social and cultural capital (the same people on the same land), what would these more sustainable practises be?
- What, precisely, are the likely impacts of these sustainable practices.
- Investigate the effects of credit organisations, transport and marketing of crops
- Comparison of different generations’ environmental knowledge
- Social structure of environmental knowledge: age, gender, class, etc.
- Compare SEK and LEK in other locations.
- Compare ecotourism in Cusuco and Pico Bonito parks: why is the latter more successful and could Cusuco follow its lead?
- Detailed census of the three villages and collation of existing material. This would extend the detailed census that was produced for Buenos Aires in 2004 to surrounding villages, and then tracking the households over a period of years, watching the specific changes they make, the reasons for them, and the effects they have on the people, their land and the wider environment.
- What complex of outside forces, such as the World Bank, IMF, Honduran Government (at different levels), European Union, national and regional overseas development agencies, charities (e.g. Spanish Red Cross) are already active in this area? What are their experiences of attempting to divert people towards sustainable development? Is there scope for inter-agency coordination and cooperation?
Appendix 1: Summary of Decree 87:87 (waiting to be translated at time of writing)

Appendix 2: List of Professional Interviews

<table>
<thead>
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<th>Interviewee</th>
<th>Village</th>
<th>Household</th>
<th>Date</th>
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<td>Focus Group Guides</td>
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<td>Miguel Guide</td>
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Appendix 3: List of In-Depth Interviews

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Appendix A: Social science team questionnaire

Introductions: supervisor; student; translator; guide/contact.

I am here with a group of English students researching communities in this area. We hope that this research will help these communities receive funding from the World Bank. Any information you give us will be confidential and anonymous.

Estamos aquí con un grupo de estudiantes ingleses, haciendo investigaciones en las comunidades de esta area. Esperamos que estas investigaciones ayudaran a las comunidades a recibir dinero del Banco Mundial. La informacion que usted nos da sera confidencial y anonima.

Background

1. How many years have you lived here?
   Por cuantos anos ha vivido aqui?

2. How many people normally live in your household?
   Cuantas personas viven en su casa normalmente?

3. How many males? And their ages?
   Cuantos varones? Y sus edades?

4. How many females? And their ages?
   Cuantas hembras? Y sus edades?

5. What is your main source of livelihood?
   Cual es la forma de que gana la mayor parte de la vida?

6. What proportion of your total household livelihood is this? (prompt: e.g. half, quarter, etc)
   Translate to Spanish
   Cual es la forma de que gana la mayor parte de la vida?

7. What are your other sources of livelihood? (prompt if necessary: e.g. work for pay, driver, informal trading, etc.)
   Cuales otras formas de ingresos tiene? (Dinero y otras?)

8. What proportion of your total household livelihood does each represent? (prompt: e.g. half, quarter, etc)
   Translate to Spanish
   Cual es la forma de que gana la mayor parte de la vida?

9. What is your total household annual income?
   Translate to Spanish
   Tiene su propia tierra? Si no, la alquila?

10. Do you own your own land? If not, do you rent etc?
    Cuanta tierra tiene/alquila/usa?

11. How much land do you own/rent/use?
    Cuanta tierra tiene/alquila/usa?

12. Do any of the children in the household go to school? (prompt: details)
    Cuantos ninos de su casa van a la escuela?

13. What level of schooling, if any, did the adults in the household receive? (details)
    Por cuantos anos fueron los adultos de la casa a la escuela, y hasta que edad?

14. Would you like the opportunity for children in your household to have a longer education?
    Translate to Spanish
15. What would make this possible?

Translate to Spanish

Livelihood
1. Does your household have different jobs throughout the year? (prompt: people that live in the house)
La gente que viven en su casa tienen trabajos diferentes en diferentes meses del año?

2. Do you have everything you need in the household? (prompt: everyone in house)
Tiene todo lo que necesita en la casa?

3. Has anyone in your house not been able to work in the last two years due to poor health?
En los últimos dos años, hay alguien en su casa que no ha podido trabajar por causa de enfermedad o accidente?

4. Has a friend or neighbour helped you improve your livelihood?
Le ha ayudado alguna vez un amigo/vecino a mejorar su vida?

5. What do you use your land for?
Para que usa su tierra?

6. How much do you travel from Buenos Aires?
Cuántas veces sale de Buenos Aires? Y a donde va?

7. If your house has access to electricity, what do you use it for? (prompt: full list)
Tiene electricidad en su casa? Para que la usa?

8. Can you think of a time when you might need something you cannot afford?
Puede pensar en algún momento en el que necesita algo pero no tiene dinero?

9. What would you do to get it?
Como haría este dinero?

10. If you had extra money now, what would you use it for?
Translate

Agriculture
1. What do you grow on your land?
Que cultiva en su tierra?

2. What do you do with what you grow?
Que hace con lo que cultiva?

3. If you sell it, who do you sell it to? (prompt: specific company etc)
Si lo vende, a quien lo vende?

4. Do you work together with any other growers to sell produce?
Trabaja con otros jornaleros para vender lo que cultiva?

5. If yes, what do you think are the advantages of this?
Si si, Que son las ventajas?

6. Does anyone outside the household work for you? How many?
Hay otras personas que no viven en su casa que trabajan para usted? Cuantas?
7. Do you know the current price you receive for your crops? Details? (prompt: price per unit but also total monetary value received for main crops over year)

Sabe cuanto dinero recibe para sus productos? (see prompt)

8. Do you use any chemicals on your crops?

Usa químicos/pesticides/fertilizantes?

9. Do you have access to (farm) machinery?

Y maquinas?

10. Where do you get your seeds from? (prompt: specific company etc)

De donde viene sus semillas?

11. Do you receive any help/assistance from outside organisations or the government to help you grow your crops?

Recibe ayuda de otras organizaciones o del gobierno para crecer lo que cultiva?

12. Why might it be difficult for you to grow more and/or better crops to sell?

Seria dificil para usted cultivar mas/mejores productos? Porque?

Park and Environment

1. What do you understand by the terms core zone / buffer zone?

Que entiende de las frases zona nucleo y zona de amortiguamiento?

2. Where do you think the park boundaries start? (prompt: e.g. along road or path)

Donde empiezan las fronteras del parque?

3. How often do you go to the park? (daily monthly etc)

Cuantas veces va usted al parque?

4. Do you know any rules that affect your use of the park? (prompt: anything you are not allowed to do?)

Sabe las reglas del parque?

5. Do you think these rules protect the park - its animals and plants etc - or could they be more effective?

En su opinion estas reglas protegen el parque - los animales y las plantas - o podrian ser mejor?

6. Do you know any rules that affect your use of the buffer zone? (prompt: anything you are not allowed to do?)

Sabe las reglas de la zona de amortiguamiento?

7. Do you think these rules protect the buffer zone - its animals and plants etc - or could they be more effective?

En su opinion estas reglas protegen la zona de amortiguamiento - los animales y las plantas - o podrian ser mejor?

8. What animals and plants are important to you in these areas and why? (e.g. quetzal, toucan, jewel scarab beetle, etc)

Que animales y plantas son importante para usted en estas areas y porque?

9. What impact do you think the park has had on your daily life concerning…

Que tipo de impacto ha hecho el parque en su vida diaria en…

   a. Work opportunities

Oportunidades para trabajar?
b. Access to natural resources
   Acceso a recursos naturales?

c. Knowledge about animals, plants
   Conocimiento de animales y plantas?

d. Contact with foreigners
   Contacto con extranjeros?

10. Do you know who the managers of the park are?
   Sabe quien dirige el parque?

11. If there was one thing that should be done to protect the park, which might benefit you, what
   would it be?
   Si hubiera una cosa que debe ser hecho para proteger el parque, y que puede beneficiar a usted, que seria?

Monkeys
1. Are there monkeys present in this area? (i.e. the area near your home)
   Hay monos en esta area? (circia su casa)

2. If so, how many, and what kind?
   Cuantos y que tipo?

3. What do you think about monkeys?
   Que piensa de los monos?

4. Are there more or fewer monkeys in this area now compared to 10 or 20 years ago? Why?
   Hay mas o menos monos aqui ahora que hace 10/20 anos? Porque?

Broader Context
Now we’d like to ask more general questions about the outside world, and how it might affect you and
people in this area, including here, Cofradia and San Pedro.

Ahora queremos hacer preguntas mas generales sobre el mundo exterior, y como puede afectarle a usted y otra gente en esta area, incluyendo aqui, Cofradia y San Pedro.

1. What do you know of the September 11 attacks on Washington and New York, and the
   aftermath, and how this might have affected you or people in this area (including here and as
   far away as Cofradia and San Pedro):
   Que sabe de los ataques del 11 de septiembre en Washington y Nueva York, y las secuelas, y
   como le ha afectado a usted y la gente en esta area, incluyendo Cofradia y San Pedro.

2. And what, if anything, do you know of American companies that make things in this area
   (prompt: including Cofradia and San Pedro), and how they might affect you or people in this
   area?
   Que sabe de companias Americanas que hacen y/o venden cosas en esta area (y Cofradia y
   San Pedro), y como pueden afectar a usted y la gente en esta area?

3. Overall, would you say your feelings about the USA are positive, mixed, or negative? Why?
   Sus sentimientos de los Estados Unidos son positivos, mesclados, o negativos? Porque?

4. What other foreign companies do you know of, that operate in this area? (prompt: including
   Cofradia and San Pedro)
5. How do they affect you or other people in this area? (Prompt: ditto) And what are your feelings towards them?

6. Are you aware of any other foreign organisations such as charities that operate in this area? Prompt: details; and feelings towards them?

7. Have you heard of the national debt? What effect do you think it had?

8. Did you know the national debt was cancelled? If so, do you know how, by whom?

9. What effect might this have on Honduras? And on this area including Cofradia and San Pedro?

10. Is there anything else that you think foreign organisations or governments could do to help people in Honduras? People in this area? You?

Finally, Would you be prepared to follow this interview up with a more detailed interview about some of issues we have raised today?

Thank you!
Gracias!

Appendix B: Census of Buenos Aires
Attached as Excel Document
Source: Operation Wallacea archives
Appendices

Appendix 1

Appendix 1.0: General Operation Wallacea protocols for collection of vertebrate specimens
This short document was written by R. Field after a staff meeting held in early August 2005, which was called to allay concerns that were being consistently voiced about the specimen-taking regime. In the few instances in which this document disagrees with the following protocol document (Appendix 1.1), this document takes precedence.

General policy
All teams to continue as they have been going, with the exception of the herpetology team. For small mammals this means only taking specimens if the animals cannot be keyed out in either of the reference texts (and are therefore potentially new species). For bats no animals are euthanized, though small samples of wing tissue may be taken for DNA analysis. For birds, specimens are only taken if the species (or subspecies) seems to be undescribed.

Herpetofauna
Satellite camps within Cusuco: one sample of each species (BA & CA), but not from BC or GU (this merely repeats Joe Townsend’s protocol, which also lists some species as exceptions – for which additional specimens are to be taken).

El Paraiso: up to 5 specimens of each species found are to be taken, as per Joe Townsend’s protocol, though in practice typically only two specimens of each species are taken.

Venomous snakes: only to be euthanized if collected as specimens under the normal protocol (see above), except for those found within camps (and not brought back to camps from the field). Venomous snakes found on trails will not be euthanized, unless taken as specimens under the normal protocol.

New species: herein is a slight modification to Joe Townsend’s protocol, which states that all individuals of new species will be taken as vouchers. The modification is that the animals will be kept alive while a recommendation is formulated by the herpetology team, which is then put to the head scientist (or his deputy) for clearance; only once this clearance is received may the animals be euthanized.

Other: no animal is to be refrigerated or harmed in order to facilitate photography.
Appendix 1.1: Protocols for collection, data recording, and preservation of scientific herpetological specimens

Dr. Larry David Wilson, Brooke L. Talley, T. Lynette Plenderleith and Douglas C. Fraser

Introduction
Research on the biology of reptiles and amphibians oftentimes requires the collection of specimens (their removal from the field), the recording of various types of scientific data concerning these specimens, and the preservation as scientific specimens of selected individuals that have to serve as voucher specimens (scientific specimens that are needed to document important records). Contrariwise, it has to be determined which specimens can be returned to the field. Thus, one of the duties of the herpetological staff participating in Operation Wallacea is to determine which specimens are needed, how they should be collected, and how and which specimens should be turned into voucher material. It is the purpose of this document to establish the protocols for such activities.

Collection of Specimens
Scientific collecting of amphibians and reptiles involves the use of a number of techniques, depending on the nature of the creatures, the places where they are found, and the times when they can be found. In general, when in the field, the herpetologist will be collecting both during the day and at night, because of the different activity periods of the creatures being sought. Typically, the previous day’s catch will be processed in the morning after breakfast. Day collecting begins shortly thereafter and generally involves late morning and afternoon work, lunch being replaced by a light snack, eaten in the field. Usually, the field workers will return to camp for dinner and to prepare for the night work. Night work will continue as long as necessary, after which the group returns to camp for rest in order to prepare for the next day, when this procedure will be repeated.

The most widely used collection technique is termed opportunistic collecting, which means simply searching about for amphibians and reptiles in their habitats. Another technique used is pitfall drift fencing trapping, which involves burying containers in the ground and stringing along them some type of fencing material to direct the organisms sought into the pitfall traps. Dipnetting in ponds and streams can also be done, especially for anuran and salamander larvae. Leaf litterbags can also be placed in streams and ponds to act to attract amphibian larvae, which can later be collected.

It is when animals are encountered in the field that the decision is made as to what needs to be done with them. Basically, the decision involves determining whether the animal(s) needs to be returned to camp for processing or left in the field. At camp, the decision has to be made about whether the specimen can be processed in some non-sacrificial way (e.g., photographed and released) or needs to be turned into a voucher specimen, which will entail sacrificing the animal’s life. These decisions are made on the basis of the scientific worth of the animal, and require the researcher to know the literature on the herpetofauna of the region well enough to make such a decision. The one exception to this general rule involves venomous snakes. Since they represent a significant danger to the safety of the people working in the area, they must be removed from the field and euthanized. In this instance, they are prepared as scientific specimens, in order to make the best use of them.

If the decision is to sacrifice the animal’s life (euthanize it), because of the need to have the specimen act as a voucher, then this is accomplished in the most humane fashion possible, which with amphibians and reptiles generally involves the injection of chlorotone into the body cavity of the animal. Chlorotone is an anesthetic and “puts the animal to sleep.” An amount is injected sufficient to “put down the animal” as quickly as possible. This is not a decision to be taken lightly, inasmuch as most herpetologists are also conservationists and have a strong ethical bias toward the well being of the creatures to which they devote their scientific careers. Nonetheless, the advancement of the aims of conservation biology depend upon the existence of a sound basis of understanding of the evolutionary relationships and ecology of the organisms under concern in order to be able to make the most intelligent decisions about how to maintain viable natural populations of them.
Data Recording

Once the animal has been euthanized, it is possible to take some data on measurements and morphological features, such as color and pattern in life, best done upon fresh specimens before they are preserved. It is also possible to secure tissues for various kinds of genetic studies. It is common to excise liver tissue for this purpose. Other types of tissues can be obtained at this time (e.g., blood) for scientific study. Other data can be secured once the specimens have been preserved (see section below). These data are used in the preparation of scientific research papers intended for publication in the primary scientific literature. These published works are distributed worldwide and form the body of research data upon which the science of herpetology rests. Without them, the science of herpetology would not be a science.

Preservation of Scientific Specimens

When necessary or desirable, select specimens may be preserved for eventual deposit in a permanent museum collection. This process involves four steps: (1) injection of a 10% formaldehyde solution into the body cavity of the specimen; (2) tying of a field number tag on the specimen; (3) positioning of the specimen in a preserving tray; and (4) transfer of the specimen to 70% alcohol for eventual permanent storage in a museum collection.

Formaldehyde is a preservative chemical. Full-strength formaldehyde is diluted to 10% strength with water to make formalin. It is injected into the animal with a syringe and needle so as to fill the body cavity. With male reptiles with reproductive organs of classificatory interest, it may be necessary to inflate those organs as part of the preservation process. With snakes and lizards, which possess copulatory organs called hemipenes, these structures can be everted and injected with formalin for their fixation.

A field number tag is then attached to the specimen so it will not slip off, because this number will be permanently associated with the specimen, even when it has been provided with a permanent number and catalogued in a museum collection.

The specimen is then positioned in a plastic, sealable tray in either a naturalistic pose or, in the case of elongate amphibians (caecilians) and reptiles (snakes and snakelike lizards), coiled into a compact shape for ease of transport and storage.

Finally, after the specimen is fixed (i.e., preserved, usually after at least 24 hours), it is soaked in water to remove the superficial formalin and then transferred to a 70% solution of ethyl alcohol (ethanol or EtOH) for storage during transport and, eventually, for permanent storage in a museum collection.

Purpose of Museum Collections of Preserved Animals

The procedure described above is followed to provide collections of preserved animals for permanent storage in museum collections around the world. Fundamentally, these collections provide the primary base for the science of herpetology. This is the case because all knowledge of the biology of the world’s reptiles and amphibians arises from understanding what species of these creatures exist in the world. The process of bringing their existence to the attention of the scientific world and the human world in general begins with the description of a given species as new to science. This is a complicated and arcane process that involves providing a permanent scientific name for the species, the designation of a holotype (a specimen to which the scientific name is permanently attached), a description of the available preserved material of the species, and a discussion of its proposed evolutionary relationships to other known species.

All other knowledge of the organism’s biology can then be attached to the scientific name. All information gathered about its phylogenetic relationships, behavior, ecology, genetics, anatomy, physiology, biogeography, and so forth is tied to its scientific name, which is recognizable worldwide, irrespective of the language spoken. This is the reason why permanent scientific museum collections are necessary.
Scientific Collecting Permits
All of the work described above is possible only when the appropriate scientific collecting permits have been secured by the governmental agency in question. In the case of our herpetological work in Honduras, the agency is COHDEFOR (Corporación Hondureña de Desarrollo Forestal). Our permits allow us to collect whatever specimens we deem necessary for our scientific work in whatever portion of the country we need to work. Without such permits, however, we could not do our work—we would be breaking Honduran law and could be fined and/or jailed. In addition, we need to deposit a portion of our collected material in a Honduran collection. Finally, we need to secure exportation permits that allow us to transport the collected material out of the country for deposition in a permanent museum collection in the United States or elsewhere. These steps constitute an absolute legal requirement for our work.

Summary
The salient points of the discussion above are as follows:

- As part of herpetological fieldwork, protocols for the collection, data recording, and preservation of specimens of amphibians and reptiles need to be developed.

- One of the major purposes of such protocols is to determine which specimens encountered in the field need to be collected and, beyond this, which specimens need to be euthanized and preserved.

- Field herpetologists work at collecting specimens day and night, because of differing activity periods of the creatures they study. It is when they are in the field that the decision is made whether to remove the animals encountered to camp or leave them where they were found.

- In camp, the decision whether to euthanize the animals or to photograph them and release them is made. This decision is based on the perceived scientific worth of the specimens in question and requires an intimate knowledge of the pertinent scientific literature and research in progress.

- The recording of data on certain features of the specimens is accomplished prior to fixation. In addition, fresh tissues for various kinds of genetic studies can be obtained at this time, if warranted.

- Preservation of scientific specimens involves injection of the specimens with formalin, tying a field tag on them, positioning them in a preserving tray, and, upon fixation, their transfer to a container of 70% ethyl alcohol.

- The purpose of permanent museum collections of scientific specimens is to be able to tie all biological information of the species they represent to a proper scientific name. All biological research work finds its basis in these collections.

- In order that this scientific work can be accomplished, scientific collecting permits must be gained from appropriate governmental agencies. In addition, exportation permits have to be secured so that the specimens can be transported out of the country.
Introduction
Larval amphibians are often surveyed to provide baseline data on species richness and relative abundance (Gascon 1991, Scott and Woodward 1994). Sampling larvae can be difficult because of their benthic habitat preferences, strong swimming ability, and lack of vocalization (Jung et al. 2000; Shaffer et al. 1994). Common sampling strategies for larvae include using time-constrained searches, visual counts, dipnet sweeps, seines, and collapsible netting. Each method may have a capture bias based on variation in successful captures, time of year, and size-class sampled. Identification of potential sampling biases and limitations helps researchers choose appropriate sampling techniques to address study goals (Dodd et al. 2005). Jung et al. (2000) compared four monitoring techniques (leaf litter refugia bags, quadrats, visual encounter transects, and electric shocking) for Eurycea bislineata in Shenandoah and Big Bend national parks in spring 1998. They found no statistical difference among methods for relative abundance, indicating similar sampling biases (Jung et al. 2000). Crossman and Cairnes (1974) determined that artificial substrate samplers may reduce inter-observer sampling biases.

Leaf litterbags are a relatively new technique for sampling larval salamanders (Dodd et al. 2005), but have long been used in benthic invertebrate artificial substrate sampling (Anderson and Mason 1968, Crossman and Cairnes 1974, Hilsenhoff 1969). Although several varieties of litterbags have been used to sample larval E. cirrigera (Chalmers and Droge 2002; Jung et al. 2000), Pauley and Little (1998) were the first to use “refugia bags” to sample larval E. bislineata. While salamander captures in litterbags may underestimate population size, they can be used effectively to determine larval presence (Pauley and Little 1998) and species composition (Chalmers and Droge 2002; Waldron et al. 2003). To date, the effectiveness of sampling tadpoles with leaf litterbag employment has not been documented.

The effectiveness of leaf litterbag placement for sampling tadpoles in cloud forest streams of Cusuco National Park will be tested. Species known to occur in streams include: Duellmanohyla soralia, Plectrohyla dasypus, Plectrohyla exquisita, Psychohyla hypomykter, and Rana maculata.
Methods
Leaf Litterbags were constructed of “chicken wire” cut into 1.5 X 1.5 ft squares. The corners were secured together with plastic ties, forming an “envelope” shape. Litterbag size was based on Waldron et al. (2003), who found medium and large litterbags to be most successful in small streams. The resultant bag interior was filled with litter debris from the stream edge and from the stream bottom. In each sample reach, six leaf litterbags were placed where debris naturally accumulates (e.g., channel bends, pools, incised banks). To secure leaf litterbags in place, heavy rocks were placed in the interior to weigh the bags down during strong stream flow events. Using twine, each leaf litterbag was tied to a nearby tree to ensure placement.

Leaf litterbags are checked every 3-5 days. Tadpoles are identified in the field, using mouthparts and other distinguishing characteristics (e.g., body, color). Upon retrieval, the bags are rapidly pulled from the stream and placed in separate containers to prevent escape of tadpoles through the mesh. Leaf litterbag contents are then displaced in a dipnet to facilitate observation of tadpoles. Tadpoles are then identified to species, according to McCranie and Wilson (2002), measured for morphological features, classified according to life stage (McDiarmid and Altig 1999), and collected if mouthpart malformations are detected. Tadpoles with mouthpart malformations will be used to determine extent of mouthpart characteristics.

A more in depth survey of tadpole mouthpart malformations will be conducted using collections from the leaf litterbag survey and with additional opportunistic sampling. Once the leaf litterbag survey is well underway, a single comprehensive sample will be preserved to determine the extent of mouthpart malformations. These individuals will be analyzed to determine morphological characteristics in the natural population, as well as provide percent incidence of mouthpart malformation occurrence. All species known to breed in the Rio Cusuco (Duellmanohyla soralia, Plectrohyla dasypus, Plectrohyla exquisita, Ptychohyla hypomykter, and Rana maculata) have been documented to have tadpoles during the sampling events.

Site characterization will include GPS locations of leaf litterbags, altitudinal occurrence, individual pool features (i.e., depth, width, length, pool bed makeup), dissolved oxygen, water temperature, and stream velocity. The Rio Cusuco will contain 5 transects (A, B, C, D, and E).

Summary:
Leaf litterbag sampling will provide information about the tadpole composition of the Rio Cusuco in Parque Nacional El Cusuco. Tadpole identification will include species, life stage, and degree of mouthpart malformation.

Literature Cited:


Appendix 1.3: Snake Bite Prevention Protocol

Dr. Larry D. Wilson, Brooke L. Talley and Douglas C. Fraser

Figure A1.2. Venom delivery apparatus of *Bothrops asper*, the famed *barba amarilla* (yellow beard), the most dangerous snake in Mesoamerica. Its presence in the nuclear zone of Parque Nacional Cusuco was demonstrated for the first time this year, due to the efforts of assistant herpetologist Douglas C. Fraser. Note the drop of venom on the fang.

**Before entering the field:**
1. Make sure you have gone through snake training session before entering the field with students.
2. Be able to recognize the venomous snake species of the area.
3. Be aware where nearest member of the herpetology team is located.
4. Be aware of time of day when snakes are most active.
5. Be able to recognize typical venomous snake habitat.

**While in the field:**
1. Always wear proper footwear (i.e., hiking boots).
2. Always be aware of your surroundings.
3. Know where the students in your group are located at all times.
4. Be aware of where you are placing your body parts (e.g., when you are stepping, leaning, sitting, or lying).
5. When a snake is encountered, back away from it slowly, being aware of what is behind you. If possible, contact a herpetology team member as soon as possible so that the snake, if dangerous, can be removed properly.
6. Do not touch any snake at any time.

**Upon returning from the field:**
1. If not previously done, notify a member of the herpetology team if any snakes are encountered, dangerous or otherwise.
Before Entering the Field

- Make sure you have gone through snake training session before entering the field with students. As of this writing, there are five (5) species of seriously venomous snakes recorded for Parque Nacional Cusuco (Wilson and McCranie, 2004; Townsend et al., in preparation). They are as follows:

  Micurus diastema—Venomous coral snake
  Atropoides mexicanus—Jumping viper
  Bothriechis marchi—Emerald palm viper
  Bothrops asper—Fer-de-lance
  Cerrophidion godmani—Godman’s viper

The coral snake is a member of the family Elapidae, all of which are venomous; the remainder of the species belongs to the family Viperidae, also a family of wholly venomous snakes. The species belonging to this latter family occurring in the Western Hemisphere are collectively referred to as pit vipers, given the presence of a thermosensitive structure located in a depression on the side of the head between the nostril and the eye.

- Be able to recognize the venomous snake species of the area. Of the 20 species of snakes recorded for the park to date, only five or 25% are seriously venomous (i.e., capable of potentially causing human death). The remainder of the snakes, all belonging to the family Colubridae, offer no serious threat and range from being totally inoffensive and not offering to bite (e.g., the small snakes Adelphicos quadrivirgatum, Geophis nephodrymus, and Tantilla cf. schistosa) to being somewhat irascible and prone to bite, at least when first caught (e.g., the racers Drymobius chloroticus and Dryadophis dorsalis).

The five venomous snakes of the park are fairly easy to identify to species by use of the following characterizations [photographs added by R. Field]:

Micurus diastema—This venomous coral snake is the only snake known from the park that has a pattern of red, black, and yellow rings the length of the body. The red rings are bounded by yellow rings and separated from a similar sequence of rings by black rings. The sequence, thus, is red—yellow—black—yellow—red. The only other snake vaguely resembling this coral snake is Scaphiodontophis annulatus, which is a snake with a coral snake-like pattern on a variable amount of the anterior portion of the body and a pattern of dark brown lines on a paler brown background on the posterior portion of the body. Some specimens may have the coral snake-like pattern extending the length of the body, although this is not likely in this portion of the snake’s range, but the red rings are bounded by black ones and separated by yellow rings. The sequence, thus, is red—black—yellow—black—red. Spanish vernacular name—coral (a generic term used to refer to almost any snake in Honduras with red color in its pattern)

Figure A1.3 Micurus diastema. Photograph by B.L. Talley
*Atropoides mexicanus*—This pitviper is commonly called the jumping viper. It is a stockily built ground viper with a pattern of diamond-shaped cinnamon brown to dark brown to black middorsal blotches on a paler ground color at the bottom of which is a smaller, circular blotch that may be connected or not to the larger middorsal blotch. A well-defined dark postocular stripe extends from the eye to the angle of the mouth. As is typical of many vipers, the head is well set off from the neck. Spanish vernacular name—timbo or timbo grande.

Figure A1.4 *Atropoides mexicanus*. Photograph by B.L. Talley

*Bothriechis marchi*—This is the emerald palm viper. It is a relatively small, arboreal, prehensile-tailed pitviper that is a brilliant green in ground color with a series of slightly distinct turquoise blue blotches along the dorsum of the body. The only other snake vaguely resembling this arboreal pit viper is the also bright green racer *Drymobius chloroticus*. This snake, however, is and elongate, large-eyed ground snake with a non-prehensile tail. Spanish vernacular name—*tamagas verde* (a generic name used to refer to almost any snake with some amount of green in its color pattern).

Figure A1.5 *Bothriechis marchi*. Photograph by D. Pupius
**Bothrops asper**—This is the snake usually referred to in English as the fer-de-lance, a name actually properly applied to a member of the same genus occurring in the West Indies. This a large, terrestrial pit viper with all or most of the subcaudal scales (the scales underlying the tail) in a paired series (as opposed to a single series characteristic of the other pitvipers of the area). The color pattern is of a series of H-shaped pale-outlined dark blotches on a brown ground color. Spanish vernacular name—*barba amarilla*.

Figure A1.6 *Bothrops asper*. Photograph by B.L. Talley

**Cerrophidion godmani**—This is Godman’s viper, a relatively small ground viper with a dorsal pattern of darker spots on a paler ground color. The dark middorsal spots are often fused into a zigzag line. A dark postorbital stripe is also present. Spanish vernacular name—*timbo* or *timbo pequeño*.

Figure A1.7 *Cerrophidion godmani*. Photograph by D. Pupius.

- **Be aware of where the nearest member of the herpetology team is located.** All other staff members should know where the closest member of the herpetology team is working on a day-to-day basis. These herpetologists are the only staff members authorized to handle and identify snakes, so they should be consulted as soon as possible when a suspicious snake is encountered. It is understood that, in some cases, this may not be possible, but the effort to know their whereabouts should be made.

- **Be aware of the time of day when snakes are most active.** Diel or daily activity patterns vary from snake species to snake species. Some snakes are diurnal, whereas others are more active at night. In general, the venomous snakes of the region are more likely to forage at night, but may also be encountered during the day, especially when they are at rest. Some species, such as *Bothrops asper* and *Bothriechis marchi* are primarily sit-and-wait predators, although they can also actively forage for food. The coral snake is most likely to be abroad at night, resting in some secluded spot during the day. Any of these snakes can be expected to seek sunlight to warm their bodies, so one should be especially vigilant around sunlit areas in the forest.
Be able to recognize typical venomous snake habitat. Four of the five venomous snakes in the area are primarily terrestrial and, so, will be encountered either above ground or under debris on the forest floor. The other snake species, *Bothriechis marchi* is arboreal and will be most likely encountered sitting in vegetation at or near upper body level.

While in the Field

- **Always wear proper footwear (i.e., hiking boots).** When walking in the forest, one should always wear proper footwear. Such footwear should consist of hiking boots (10 inch types preferably) or knee-length rubber boots. Under no circumstances should sandals or sneakers be worn. Wearing proper footwear is no guarantee that one will not be bitten by a venomous snake, but it will offer some protection.

- **Always be aware of your surroundings.** Tropical forests are complex habitats and offer a multiplicity of niches in which one can find snakes, including the venomous ones. It is paramount to work in the forest with consistent attention to one’s surroundings. It is possible for venomous snakes to be in the middle of a pathway, on the ground to the side of such pathways, in bushes and trees alongside such paths, and on overhanging vegetation.

- **Know where the students in your group are located at all times.** The students who participate in the scientific expeditions that are part of Operation Wallacea are under our care. When they are in the field with us, we are responsible for their well-being. Thus, we need to be fully aware of where they are at all times. This can be most easily accomplished by keeping them together as a group.

- **Be aware of where you are placing your body parts (e.g., when you are stepping, leaning, sitting, or lying).** Venomous snake bites can occur to any part of one’s body (arms, legs, face and neck, buttocks, etc.), so it is imperative to realize where one is placing one’s body parts when moving about in the forest. Thus, one should not step where one’s feet cannot be seen or place one’s hands where the view is not clear. In addition, one should not sit or lie down in the forest without examining where one’s body will be placed.

- **When a snake is encountered, back away from it slowly, being aware of what is behind you. If possible, contact a herpetology team member as soon as possible so that the snake, if dangerous, can be removed properly.** Snakes, including venomous ones, will generally attempt to move away from a human being, because we are large animals that can be perceived as a threat to their well-being. Generally speaking, venomous snakes do not attack humans. Some of them, however, will stand their ground, depending on their venom delivery apparatus for protection. Members of the herpetology team (senior and assistant herpetologists, but not herpetology volunteers) are the only individuals who are authorized to interact with snakes, so one or more of them should be notified when a snake is seen, if possible. This is especially important when the snake involved is thought to be venomous. The senior or assistant herpetologist will remove the snake to a safe location, if possible.

- **Do not touch any snake at any time.** As indicated above, the members of the herpetology team are the only people who are authorized and qualified to deal with snakes. They can identify all the snakes in the area to species and know which are venomous and which are not. No one else is allowed to touch a snake at any time. This is the single most important aspect of this protocol.

Upon Returning from the Field

- **If not previously done, notify a member of the herpetology team if any snakes are encountered, dangerous or otherwise.** The members of the herpetology team are engaged in scientific studies of the amphibians and reptiles resident in Cusuco National Park. They need to know what snakes have been found, especially when such snakes have been just sighted. This is especially important when the snake is thought to be venomous, for the sake of safety.