Cusuco National Park, Honduras

Status, ecology and conservation of a cloud forest

2008 preliminary field report

Peter Long and Richard Field

OPERATION WALLACEA

The University of Nottingham

UNIVERSITY OF BATH

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Contents

Contact

Dr Peter Long[1] & Dr Richard Field[2]

[1] Department of Biology and Biochemistry, University of Bath, Claverton Down, Bath BA2 7AY, UK
+44 (0)1225 385437
p.r.long@bath.ac.uk

[2] Department of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, UK
+44 (0)115 84 66146
richard.field@nottingham.ac.uk

Operation Wallacea Ltd.
Hope House, Old Bolingbroke, Spilsby, Lincolnshire, PE23 4EX, UK
+44 (0)1790 763194
info@opwall.com
www.opwall.com

Introduction

Operation Wallacea is an international conservation research organisation specialising in tropical forest and coral reef ecology and conservation. The University of Nottingham and the University of Bath are leading research-intensive universities in the UK. These organisations work together to manage a programme of research in the Parque Nacional Cusuco (PNC) in Honduras. The overall aim of this research programme is to inform the effective conservation management of this important tropical montane forest and cloud forest.

Research each year is concentrated into a two-month period in July and August each year. Science staff are contracted to lead scientific projects in Cusuco National Park and social science research in the communities within the park. Our science staff are drawn largely from Universities in the UK, Ireland, USA and Canada, but also from other countries. School students and undergraduates from the UK, Ireland, Canada and the USA pay to join expeditions and participate in the research projects whilst gaining experience of working in a tropical environment and an understanding of various survey techniques and forest ecology. Some students collect data to be used in their undergraduate dissertations. Students provide the funding that supports scientific work and the necessary logistics support needed to safely work in the forest.

Scientific research is co-ordinated by the senior science team: Dr Richard Field from the University of Nottingham, Dr Peter Long from the University of Bath, Joe Nunez-Miño from the University of Oxford. And Dr Jonathan Winn, University of Sheffield. Alex Tozer of Operation Wallacea has overall responsibility for the entire programme in Honduras.

The aims of the expedition in 2008 were:

- Documenting the diversity, abundance and distribution of animals and plants in Cusuco.
- Studying the ecology of a range of important organisms
- Monitoring habitats status, dung-beetles, reptiles and amphibians, birds, small mammals, bats and large mammals.
- Investigating the social and economic structure of the villages Buenos Aires and Santo Tomas to inform sustainable development in PNC, particularly the implementation of a cooperative producing shade-grown coffee, a wildlife conservation product (WCP).

This season our scientists also pursued a number of additional projects on the community ecology of invertebrates in streams, spatial patterns of genetic diversity in several taxonomic groups and behavioural ecology of mantled howler monkeys at Rancho Manacal, just outside the park.

In delivering our scientific aims we also intend to give the students on which the entire programme depends the best possible learning experience. Fortunately the diversity of science teams investigating all major taxonomic groups, plus a genetics team, GIS facilities and a canopy access team together with a programme of evening seminars and the enthusiasm of all staff ensured that the students felt that their contributions were valued and learned useful skills whilst experiencing living and working in a tropical forest.

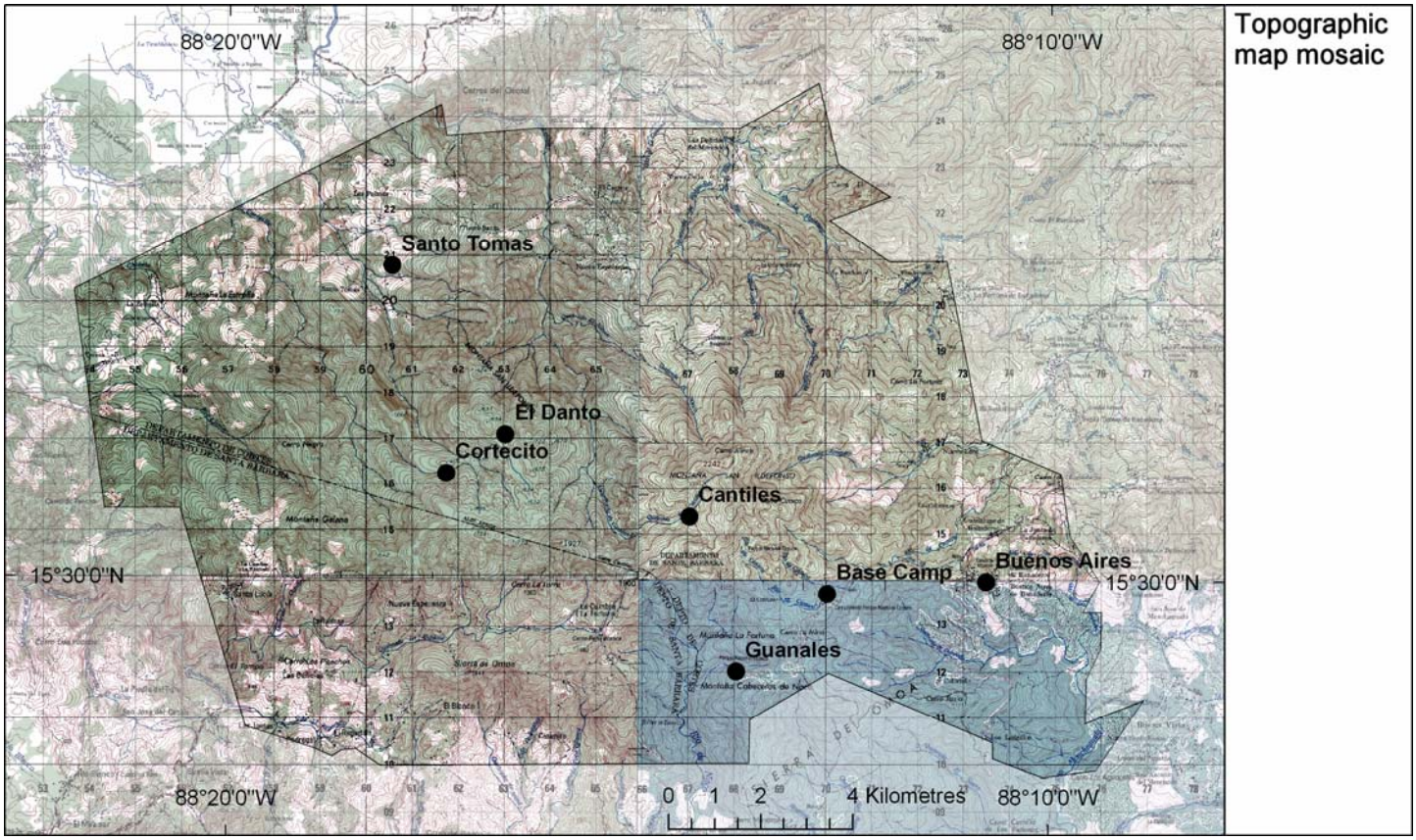
This report outlines the physical and human geography of the park, the spatial sampling framework for studying biodiversity, the methods used to study each group and how data, including spatial data, were managed. We present summary results from each team, and species lists are presented in the appendixes. We also interpret the results to understand the state of Cusuco and identify some research and management priorities for the future.

Further information about research in previous years, publications arising from the research programmes in PNC and student dissertations are archived on the Operation Wallacea website www.opwall.com.

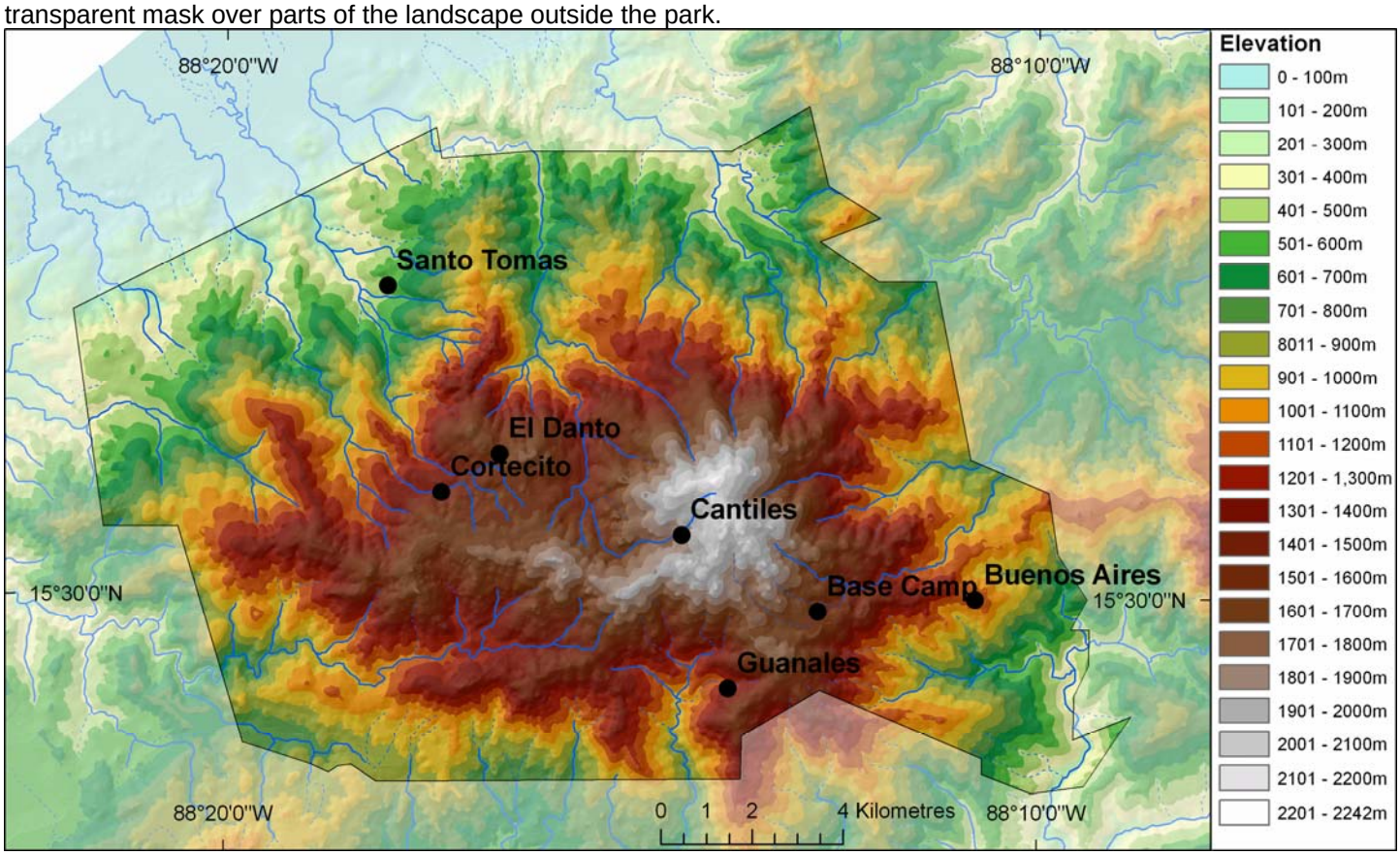
The students and scientists learnt a lot from working in PNC this summer. We have collected much valuable data. We are particularly grateful for the hospitality of the people of Buenos Aires and Santo Tomas for their generous hospitality. We look forward to returning in 2009.

Physical geography of Cusuco

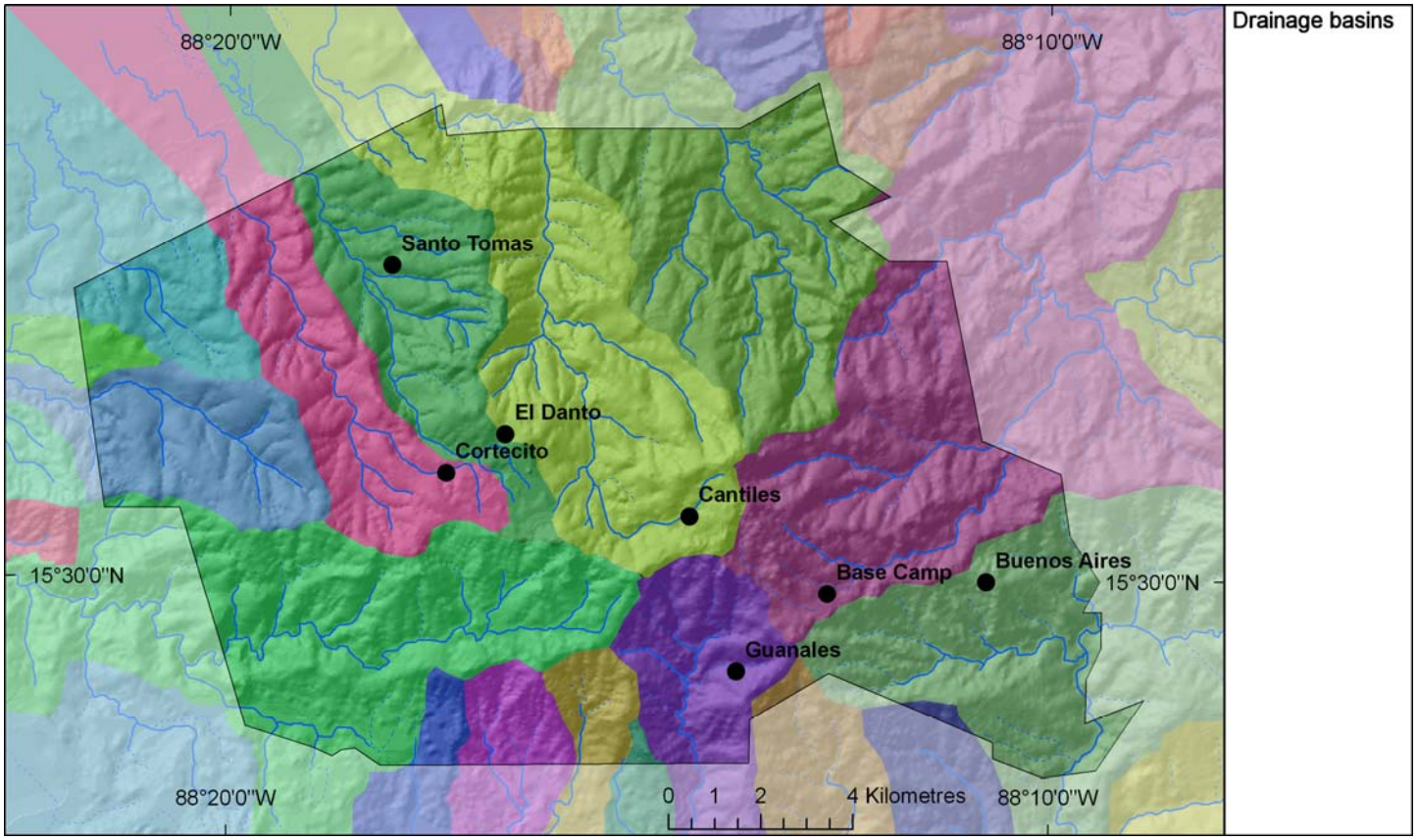
Cusuco National Park is a 23,400ha protected area in the Merendon mountains of northwest Honduras. The park ranges from just above sea level in the west to 2425m in the centre. Cusuco encompasses several major habit types including semi-arid pine forest, moist pine forest, moist broadleaf forest and dwarf forest (bosque enaño) at elevations above 2000m.



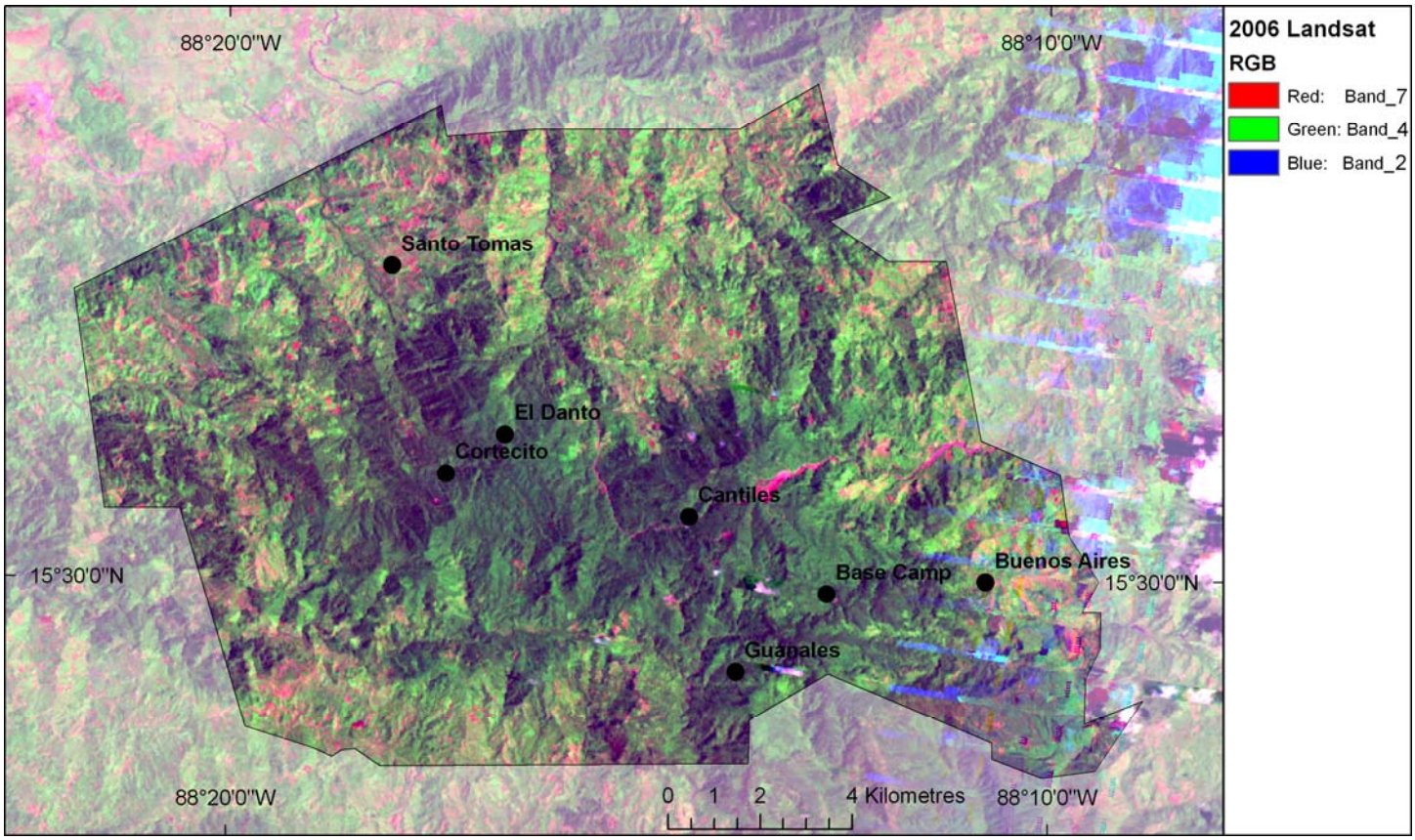
For further details please see appendix 5. In the maps throughout this report we use the convention of a partially transparent mask over parts of the landscape outside the park.



Elevations in the park range from almost sea level to 2242m



The dissected landscape of the park gives rise to several drainage basins. Streams from most basins in the park flow into the Rio Chamelecon which provides San Pedro Sula with drinking water.



Landsat 7 image of Cusuco National Park

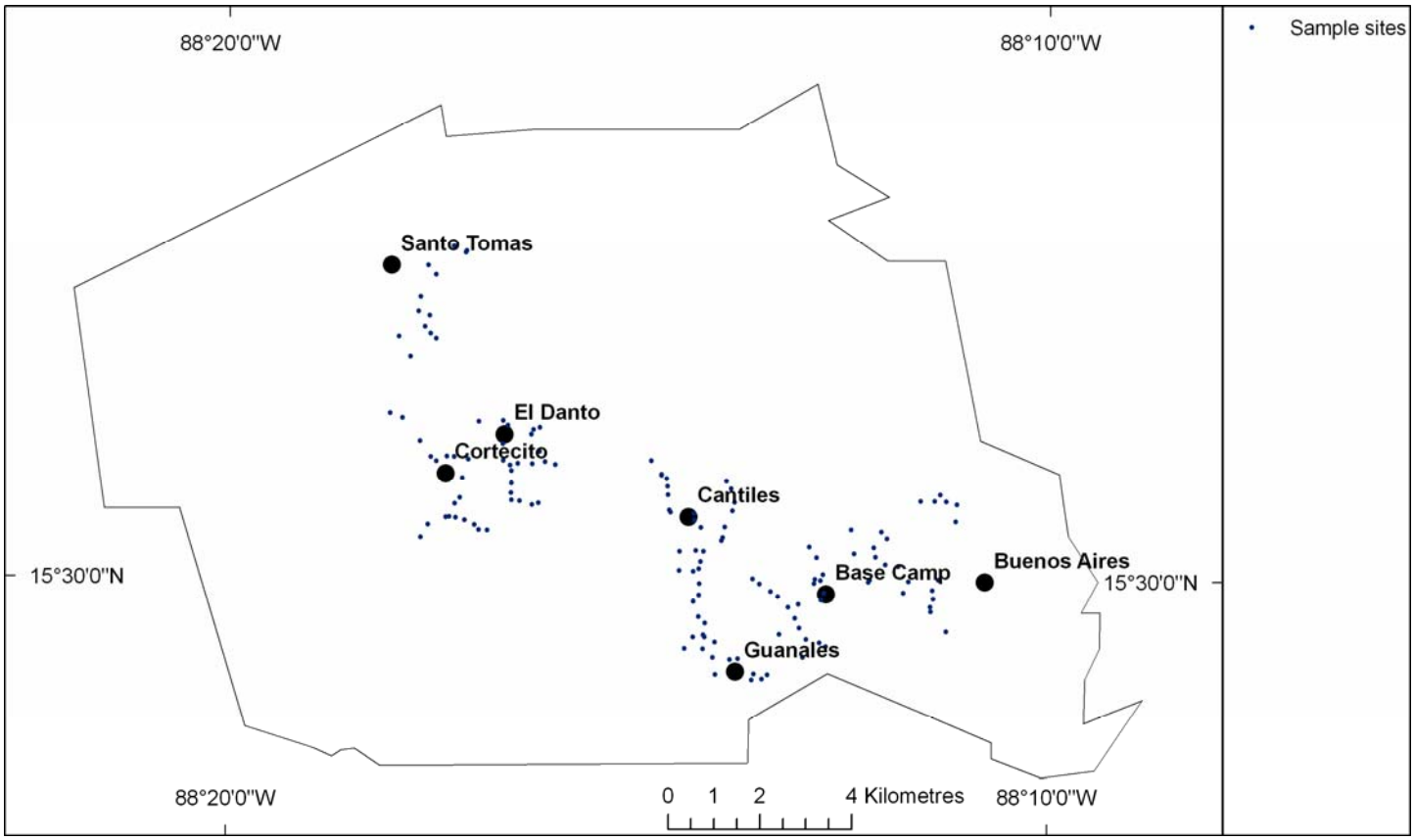
Spatial sampling framework

Seven camps were used in Cusuco in 2008: Buenos Aires (BA), Base Camp (BC), Cantiles (CA), Cortecito (CO), Danto (DA), Guanales (GU) and Santo Tomas (ST) At each camp, four sampling routes have been laid and sample sites have been marked at intervals of at least 200m along the transect. Sample routes were designed to access a stratified random set of sample sites with respect to elevation and different habitat types and for an approximately equal number of sites to be located in the core and buffer zones of the park. However, sample routes and sample site locations were constrained by topography and safety considerations.

One sample site on each sample route was selected as representative of the surrounding forest and designated the main site. The other sites on the sample route are then known as subsidiary sites.

At sample sites habitat structure data was collected, plant specimens collected, dung beetles, trapped, bird point counts took place, pitfall trapping and opportunistic searches for reptiles and amphibians were conducted.

Bird mist netting and bat mist netting took place in areas adjacent to transects, but not usually in sample sites. Small mammal traps were set along sample routes, as sample sites were too disturbed. The main sampling unit for herptiles was the sample route. Large mammal monitoring was independent of the sample sites.



Distribution of sample sites

Field methods

Habitat survey team

Forest structure data were collected at all sample sites by teams of general surveyors led by a member of the habitat survey team. At each site, the teams mark a 20m*20m plot and lay two perpendicular tapes across the plot in a cross shape bisecting each edge and creating four 10m*10m plots. The team then divides into four groups. First, a position and disturbance group record position of the site with a GPS receiver, measure the slope and aspect of the plot and classify the plot by level of disturbance using the categories on the data collection form. This group also counts cut stumps and measures fallen trees. Second, a tree survey group tags all tree with a circumference at breast height >30cm, measured the circumference of all trees >15cm circumference at breast height and estimates the height of the four tallest trees in the plot using a clinometer. Third, a profiles group draws a plan profile for the whole 20m*20m plot on graph paper, marking the positions of all trees >30cm circumference at breast height. Finally, a vegetation cover group estimates canopy openness, counts vegetation intercepting 0.5m segments of a 3m pole positioned every 1m along the two bisecting tapes, estimates percentage ground cover b y bare rock, bare soil, leaf litter and vegetation and finally counts the number of woody saplings in 4 quadrants of 2m*2m randomly positioned in the plot.

Habitat survey data are used to characterise forest structure across the park, monitor human disturbance, relate to patterns of biodiversity dat collected by other groups and ground-truth satellite images.

Invertebrate team

A total of seven camps were open in Cusuco National Park in 2008 (Buenos Aires, Base Camp, Guanales, Cantiles, El Danto, El Cortecito & Santo Tomas) which covered a diverse array of habitats at a range of altitudes. Each site has four sample routes with a main site (50x50m) and up to seven subsidiary sites (20x20m) where sampling of dun beetles

Dung baited traps were run at each main and subsidiary sites. Traps consisted of two 16oz plastic cups (one inside the other) dug into the ground with their lip flush with the ground surface. A small (approx. 20g) of fresh horse dung wrapped in cheese cloth was tied onto a stick and placed across the plastic cup. Traps were emptied every four days.

Herpetology team

A variety of techniques were employed in 2008 to maximize the frequency of herpetological encounters while also producing accurate data in a standardized fashion. The first and most effective method engaged this season was that of walking prescribed sample routes through a variety of habitats at a rate of 500 m/hr and recording all individuals sighted or captured during that time. Data was recorded for each individual, including factors such as identification, morphological observations and measurements, habitat notes, and the location along the transect where each individual was encountered.

The herpetology team also used opportunistic surveys. Searches were conducted both day and night in locations which appeared to be productive habitats for finding reptiles and amphibians. Examples include river walks, night walks in a variety of habitats, and any other productive-looking areas which might not have been visited whilst performing transect line surveys. Looking under rocks, breaking up dead logs, and raking through leaf litter are all effective practices. This technique proved very useful for two main reasons: (1) It proved to be the main source of data for species which are primarily nocturnal (of which Cusuco has many), (2) Many streams and rivers are crossed by the transect lines but are not followed; without searching these habitats, amphibian encounters would be much lower and the data less complete.

Lastly, the third technique used in an opportunistic fashion to encounter small, secretive fossorial species was pitfall trapping. An array of 4 plastic buckets were buried in the ground in a Y-shaped formation, with each of the three rays extending outwards at 120 degree angles. Plastic lining was used as fencing in 4m lengths, radiating outwards from the central bucket, the bottom of which was buried in substrate and supported vertically by sticks. One array was placed near each camp in a suitable habitat and checked daily.

Bird team

10 minute point counts were conducted 3 times at each sample site along the 28 sample routes across seven camps within the park. During a point count when a bird was sighted or heard the following data were recorded: species, number in group, method of observation, distance, habitat data. Additionally, cloud cover, rain and wind were each recorded on a five point scale.

The point count data was supplemented by mist-netting with 200ft of net from 0530-0830. When birds were removed from mist nets they were identified to species, aged, sexed, morphometric measurements taken, their moult condition was scored and all bird were ringed, except hummingbirds. A large number of informal opportunistic sightings at all camps were also made.

Small mammal team

In 2008, the small mammal team operated the following sample routes: BA1, BA2, BA4, BC1, BC3, BC4, CA1, CA2, CA4, CO1, CO3, CO4, DA0, DA1, DA2, GU1, GU2, GU4, ST1, ST2 and ST3.

A standardized trap-line was used in each transect and consisted of 54 aluminium "Freya" wire-cage traps (320 x 173 x 140mm). Traps were placed approximately 30m apart in an approximately straight line on levelled ground and marked from 1-54 consecutively. Plastic bags, plastic sheeting (a.k.a. GLADWRAP®) or leaves were used as shelter from the rain. Surrounding leaf litter was placed inside for bedding. Traps were baited with a mixture of peanut butter, granola or oats, flour, honey and vanilla essence. Traps were checked in the morning and rebaited and reset as required.

The traps were baited as close to dusk as achievable and were checked early the next morning – it is important that the mammals were not in the traps for longer than is absolutely necessary. As a rule of thumb, we aimed for all traps to be empty and closed by 9am. Traps were not re-baited immediately, but baited and set as close to dusk as possible. Bedding (dry brown leaves – to offer refuge and insulation) was placed in the traps when they are set. A plastic cover or large leaves was used to provide a roof for the traps, to ensure that the animals had shelter from rain and shade from the sun.

Captured animals were uniquely marked by ear clippings for long term identification of the animal. Unfortunately, individuals captured from previous years cannot be identified and long term ecological and biological data is unattainable. Other means of unique marking can be performed, but the equipment necessary for such procedures were not available. Animals were then weighed, sexed, reproductive status noted (adult and juveniles) and morphometric data collected. Morphometric data included nose-anus, anus-tail (not noted if part of tail missing) and hind-foot. The trap number, date of capture and recapture, and fate (released or taken) of the animal (and comments if necessary) was recorded. The ear clipping was stored in 95% ethanol to preserve DNA for any future identification and/or population studies. Hair samples were collected to develop a reference hair library for future studies.

Bat team

Bat surveys were conducted in all camps within the buffer zone and the core zone of the park with similar sampling efforts between sites. Bats were captured in the forest understorey with regular mist nets of different lengths (6, 9 and 12m X 2.5m). Netting was restricted to two transects per survey camp and around the 100m^2 main sampling sites but always intending to intersect flight paths to maximize capture success. Full moon and rainy nights were avoided. Captured bats were sexed, weighted and measured following standardized protocols (Jones 1996). Adults were distinguished from juveniles or sub-adults by the ossification of the epiphysis in the phalange. Field identification was based on Mammals of Central America (Read 1997), A Field Guide to the Bats of Costa Rica (Tim and LaVal 1998) and the key of the bats of México (Medellin et al. 1997).

Monkey team

Study Site

The study was conducted at Rancho Manacal, a privately owned cattle ranch and sugar cane plantation located outside Cofradia, off the main highway to San Pedro Sula. The ranch is managed by Continental Ltd, which enforce a strict policy to ensure the protection of the primates within the property. There are five different troops of howler monkeys within the forest fragment at Rancho Manacal of varied sizes and compositions. Outside Rancho Manacal on the opposite side of the road is a small water purification plant run by a cooperative of local villagers called Gracias a Dios. The water purification plant is located within a long thin strip of forest that also houses a large number of howler monkeys in two separate groups.

Behavioural Data Collection

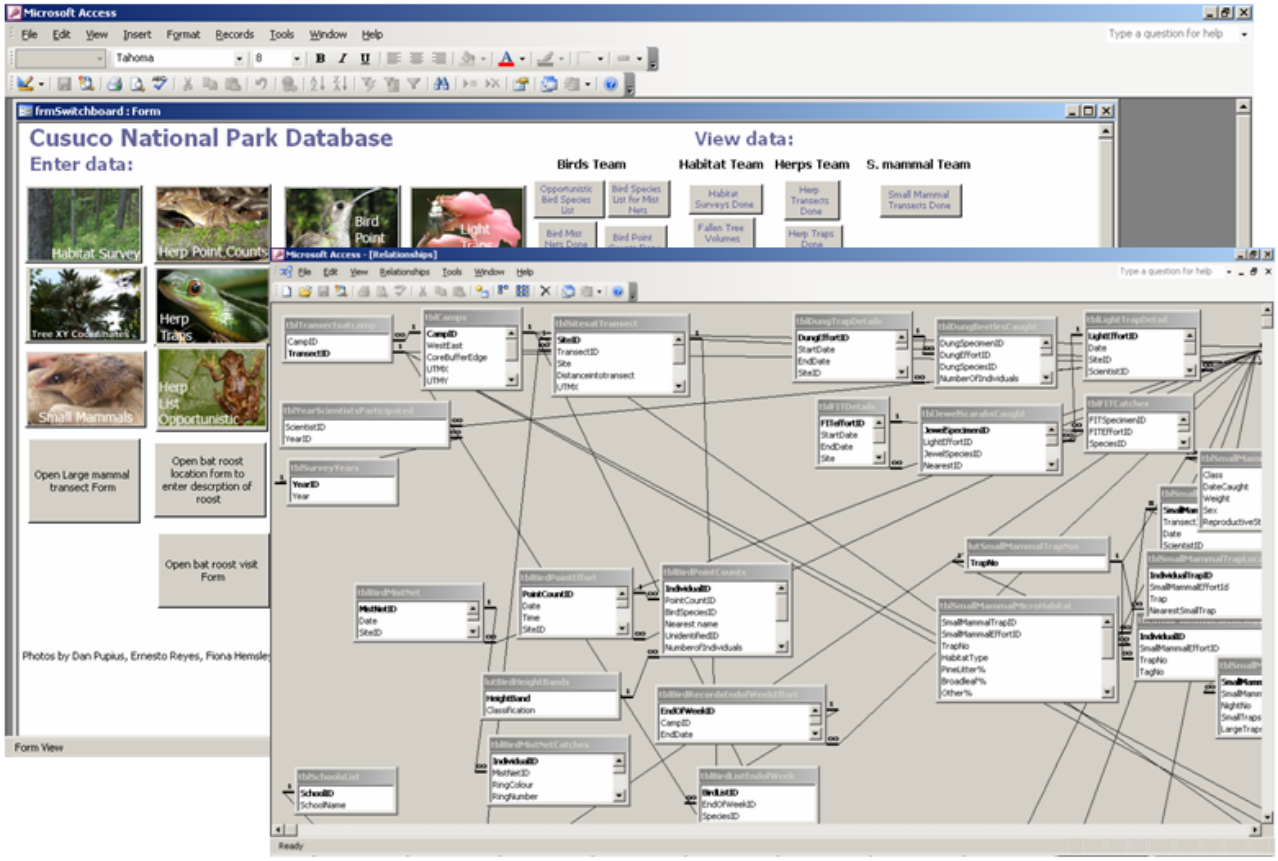
At Manacal, groups were habituated and therefore easily located within minutes of arriving at the field site. Behavioural data collection at Manacal was centred on group one as each member of this group could be individually identified. Group one were observed daily for 6 hour periods either from 05.30 until 11.30 or from 11.30 until 17.30 and an equal number of morning and afternoon observations were conducted. The GPS location of the group was recorded throughout the day in order to assess home and day range.

Age-sex classification was based on Carpenter's (1934) criteria with some modifications from Glander (1980): Infants (<18 months), juvenile (18-48 months), adult female (>48 months), and adult male (>60 months). Adult males were defined by the presence of a white scrotum, large size relative to females with associated longer hair, the presence of beard giving the appearance of square shape to head. Males were also be identified by their loud vocalizations. Adult females were smaller than males, but larger than other age classes and were distinguished from males by the presence of nipples, the lacking of testicles and the potential presence of infants. Infants were defined as small sized with pelage of grey/brown/black, did not feed independently of their mothers and were carried by the mother when travelling between trees. When the group was stationary however, infants were observed to move freely with increasing tendency to play. Juveniles travelled independently from their mothers and were defined as slightly larger in size than infants, possibly with the beginnings of a distinguishable mantle.

Behavioural data was collected using instantaneous scan samples, at 10-minute intervals, noting the age/sex class of each individual in view, their corresponding behaviour and the plant/tree species being utilised. Each behavioural category was predefined in a behavioural ethogram). When feeding, the type of food (mature leaves, young leaves, fruit and flowers) and corresponding plant species was recorded or samples taken for later identification if the plant species was unfamiliar. All occurrences of aggression, vocalisations and social events were recorded, noting the individuals IDs or age/sex class of the individuals involved and the context in which the event occurred. Habitat survey data were collected at 15 randomly located sites within Rancho Manacal and Gracias a Dios water station, recording the DBH of all tree with circumference over 30cm, canopy cover using canopy scopes, the height of the five tallest trees and the slope of the terrain using a clinometers, the number of cut stumps and fallen trees within the plot, the number of small trees <30cm in circumference, and the GPS location of the plot. For each tree over 30cm in circumference, the state of the tree (alive or dead), the presence or absence of bromeliads, and the presence or absence of fruit flowers and new growth were recorded. Similar habitat surveys were conducted at each of the sample sites along the transects at Guanales by the habitat assessment team.

<u>Data management</u>

All field data were entered into a custom Access database to maintain the integrity of the dat and to allow sophisticated queries to be performed.



Preliminary results

Ornithological Report - *Report compiled by Nick Bayly*
Nick Bayly, Camila Gomez, Andrew Bodey, Ugo Mellone, Wilf Simcox

This year's ornithological team consisted of five members, who brought with them an excellent level of experience of Central American birds which greatly aided the survey effort. Both Nick Bayly and Camila Gomez had spent the previous year in Belize and thus were very familiar with the lowland species occurring in the park whilst Andrew Bodey came with prior experience gained in Nicaragua. Completing the team was Ugo Mellone from Italy and Wilf Simcox, the primary mist-netter, who made his third but unfortunately delayed appearance in Cusuco due to a back injury. During the ten weeks the team trekked all over the park recording over 5000 individuals during 424 point counts, whilst mist netting resulted in the capture of over 350 individuals. In total, 197 species were recorded, 10 of which had been new park records in 2007 and four of which were new additions for the park.

Point counts were the primary method adopted by the bird team to describe the bird community of the park and to continue the standardized population monitoring that began in 2006. Each count was carried out at predetermined sites in the park and consisted of recording all birds heard and seen during a ten minute period. Well over 90% of birds registered during counts were identified by call which was made possible by an intensive two week training period in base camp and constant referral to MP3 recordings. In total, 5279 individuals (compared to 3553 individuals in 2007) of 132 species were recorded during point counts and highlights included a glittering Wine-throated Hummingbird, two near-threatened Great Curassow and 110 near-threatened Highland Guan, suggesting that this species still maintains healthy populations in the park. An important improvement in 2008 was the reduction in the percentage of unidentified species from 13% in 2007 to 6.5. The commonest species five species recorded during point counts were identical to 2007, whilst the top 20 changed markedly with eight new entries, notably these included: 185 records of Yellowish Flycatcher, rendering it in sixth place in terms of commonness, vs. six in 2007; 101 Green-throated Mountain Gems, a Central American endemic hummingbird, vs. 9 in 2007; 94 Spotted Woodcreeper vs. 6 in 2007. These dramatic increases in numbers and in overall abundance in 2008 are unlikely to reflect population increases but are more likely a consequence of improved detection, highlighting the importance of ensuring that observers are well trained before commencing point counts.

The 2008 point count data probably represents the best description of Cusuco's avifauna to date, largely due to an improvement in the description of the lowland bird communities. Consequently, a number of detailed analyses of the data are planned. Firstly, Amy Miles is set to describe how the bird community changes with altitude for her dissertation whilst Andrew Bodey will tease apart how the park's highly varied topography affects bird communities for his dissertation. With many forests throughout the tropics being felled so that only the highest, steepest and most inaccessible forests remain, it is important to understand the conservation value of these forests and conservation measures that may be required to maximize the protection of unique montane bird communities. In addition, the bird team also intends to examine the distribution of birds in the park in relation to rainfall and temperature and, through the resulting models, predict how the bird community might be affected under different climate change scenarios.

With Wilf Simcox not making it to Cusuco till week eight, mist-netting activity was limited to educational displays at Santo Tomas prior to week eight. After this point, some intensive work was carried out at Base Camp and resulted in some interesting captures, including two Golden-cheeked Warblers, an endangered migrant that winters in pine-oak forest in Central America, a Blue-throated Goldentail and a rarely recorded Canivet's Emerald. In Santo Tomas the mist-netting produced some rarely seen forest flycatchers in the form of a Sepia-capped Flycatcher (recorded for the first time in 2007) and a Sulphur-rumped Flycatcher (new for the park in 2008). Like the mist-netting, opportunistic observations also revealed rarely recorded species including three new additions to the park list. These included a Scaled Antpitta, a shy ground dwelling montane specialist that further increases the park's importance to Central American montane species, a Piratic Flycatcher, a common summer migrant to lowland Central America and therefore an expected addition, and a Hermit Warbler, a migrant warbler that winters in highland pine-oak in Central America. Finally, five further Golden-cheeked Warblers were observed, including three in one group on the 18th August, highlighting the park's potential role as an important wintering site for this endangered migrant.

In addition to science work the bird team worked hard to involve both general surveyors and school groups in their work. Such educational activities included mist-netting demonstrations that also involved guides and cooks, visits to a Red-capped Manakin lek, undertaking raptor counts from view points specially selected by Ugo Mellone and finally walks to see Resplendant Quetzals around Base Camp.

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Table 1: New species recorded in Cusuco National Park in 2008. Observers: CG = Camila Gomez, NB = Nick Bayly

Common Name	Scientific Name	Camp	Observer & Type of observation
Scaled Antpitta	*Grallaria guatimalensis*	El Danto	CG, Prolonged views
Sulphur-rumped Flycatcher	*Myiobius sulphureipygius*	St. Tomas	CG, In hand
Piratic Flycatcher	*Legatus leucophaius*	St. Tomas	NB, Seen and heard
Hermit Warbler	*Dendroica occidentalis*	Base camp	NB & CG, seen well

Status of Cusuco National Park

In order to measure the status of Cusuco National Park from our monitoring data we have developed several indicators which will summarise our knowledge of the system at intervals in time. A set of complementary indicators can be used to communicate a picture of the state of the park and how is changing over time. The means of verification for each indicator are either a document, a database query, or a GIS analysis.

Pressure indicators – provisionally:

- Population size of each settlement (from census data) Action: Roberto Downing is working on this.
- Number of households (from high resolution satellite images)
- Hunting take in Buenos Aires - estimated numbers of each species (anonymous respondents) Action: Kathy Slater
- Number of hunting platforms – from large mammal team (at transects)
- Human disturbance of sample sites (at sample sites)
- Infrastructure development (histogram of cost-distances to landscape units in the park)
- Fertiliser consumption (from social science questionnaires)
- Prevalence and/or distribution of Chytrid in the park (at transect segments)
- Numbers/distribution of invasive plants (at sample sites)

State indicators

- Remote sensing

- Land cover – especially forest cover (disaggregated by village hinterlands)
- Forest fragmentation - geometric zonal statistics of forest patches (disaggregated by village hinterlands)

- Habitats

- Biomass estimate - f(basal area of all trees <30cm dbh + height of four tallest trees) (at sample sites)
- Number of dead trees – habitat trees, a scare resource (at sample sites)
- Volume of deadwood – a microhabitat proxy (at sample sites)
- Sapling density – a regeneration proxy (at sample sites)

- Water quality

- To be included from 2009 (at stream level). Action: Merlijn Jocque will develop this indicator

- Ecosystem services

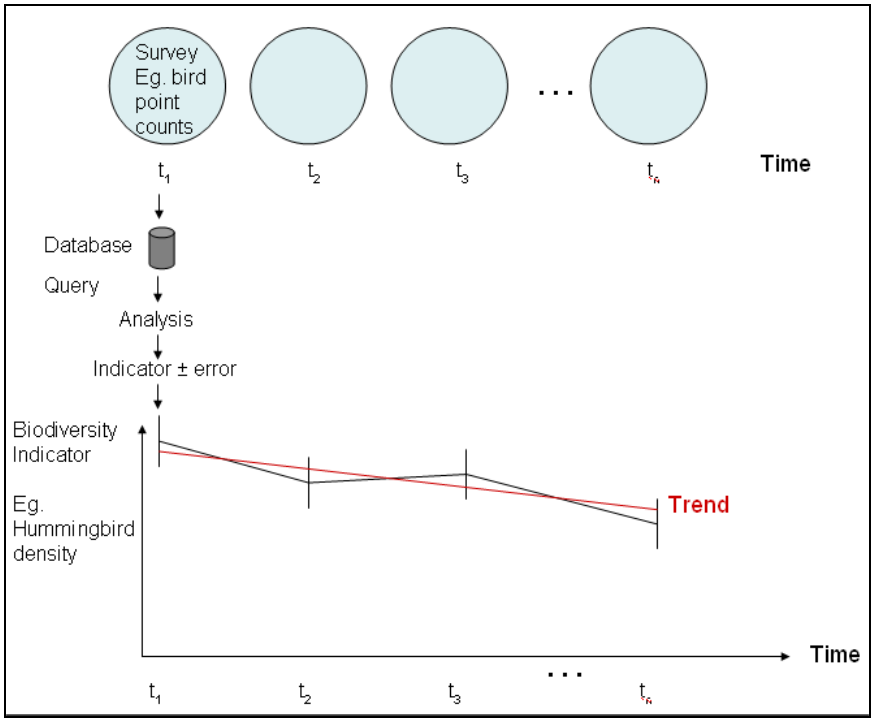
- Flow in streams (hydrological model)
- Erosion hazard (RUSLE model)

- Biodiversity

- Dung beetle community attributes (at sample sites)
- Encounter rate of reptile groups – lizards, terrestrial snakes, semi-arboreal snakes, fossorial snakes (at transects)
- Encounter rate of amphibian groups – salamanders, leaf-litter frogs, stream frogs, bromeliad frogs (at transects)
- Density of birds by group – montane, lowland, broad-elevation, disturbed habitat, large ground birds (at sample sites)
- Catch per unit effort of the three most common small mammal species (at transects)
- Catch per unit effort of two bat guilds – frugivores, insectivores (at nets)
- Encounter rate of six groups of large mammals and large mammal signs – large rodents, Baird's tapir, deer, peccary, carnivores, Howler monkeys (at transects)

Response indicators – provisionally:

- Park budget
- Number of Park staff
- Money spent by OpWall in Honduras
- Official area of PA (core and buffer) according to Honduran government
- Number of tourist visits to the park
- Number of TV, radio and newspaper reports about Cusuco
- Number of peer-reviewed publications
- Revenue per unit mass of coffee produced in the buffer zone (from social science questionnaires)



Schematic diagram of the linkages between biodiversity survey data and the indicators which allow trends to be detected.

Potential future research and management priorities

Water quality
The flow of clean freshwater is probably the most important single ecosystem service provided by the park. Although it's not very glamorous, resources need to be committed to this project to develop a robust biological index of water quality based on macro-invertebrates. Action: Merlijn Jocque will lead this.

Orchids
A flagship group for the park and of potential economic importance. Very possibly there are park-endemic undescribed species. Micro-propagated orchids could complement shade grown coffee as a high-return, sustainable wildlife conservation product for village co-operatives. To move the project forward we need some capital investment (from the horticulture industry) and some expert know-how (hopefully from Simon Pugh-Jones). Action: Dan Kerrins leading on this.

Conservation management
We need to consolidate the progress made in 2008 on baseline indicators of wealth/security in Buenos Aires. It would be very useful in future years if the effectiveness of the cooperative in increasing village income and spreading coffee revenues in a more equitable way were monitored, including people's perceptions of the effectiveness of the co-operative. It would be good to involve development economists in this aspect of the programme.

We need to know much more about hunting of large mammals in the park in order to model whether the current levels are sustainable for each species (and our level of uncertainty about this – as the precautionary principle should then be applied) and in order to effectively monitor the efficacy of the WCP village contracts. Numbers of hunting platforms are almost certainly not a good proxy for overall effort, and tell us nothing about actual exploitation of individual species. It would be much better to identify anonymous key informants to obtain estimates of hunting take of each species at village level. This is a delicate issue, but it should be possible for tactful and discreet OpWall or ESAC staff to collect this data.

We should eventually aim to extend sampling to collect basic information on livelihoods and coffee production in villages other than Buenos Aires, Banaderos and Santo Tomas. Quite soon we will need to know more about La Fortuna, La Ruidosa, Nuevo Eden and Santa Teresa.

Agricultural systems
Dan Kerrins suggested that it's very important to better understand patterns of agriculture in the wider landscape. Which crops are grown in which environmental conditions, with which yields? This would enable us to identify areas in the buffer zone which most important for agriculture and areas which are of very marginal value for agriculture, a key step in a) identifying villages which are most dependent on continued deforestation for their livelihoods; and b) informing plans to allocate conservation incentives and landscape management activities such as forest restoration in order to maximize conservation impact. Partnering with other NGOs such as CARITAS which hold data on agricultural practices in the buffer zone might enable us to eventually develop a better management plan for the park.

Ecosystem services
Incorporating ecosystem services into conservation planning is currently a hot-topic in global conservation science.
It should be possible to model the spatial distribution of provision of the following services in the park and surroundin area: water flow, protection from erosion hazard conferred by the forest, carbon sequestration. The park provides additional services which are harder to model, eg. pollination of crops, ecotourism potential – but which could be addressed by detailed studies in future.

Although GIS analyses are free, fast and can be done from outside Honduras, at some point it would be very worthwhile to collect data to properly parameterize such models of ecosystem services eg. soil erosion rates, AET. Fortunately the equipment needed to do these things is very cheap and the methods quick and simple, so it should be straightforward to build into the work of habitat survey teams in future years. Modelling spatial patterns of services is a useful first step, but for the models to be really useful they should be monetized – at this stage we may need input from economists. Action: Peter Long to develop preliminary models of distribution of ecosystem services.

Synecology of frogs, bromeliads, crustaceans, snakes, birds and bats
Thus far our science programme has focused on the ecology of individual taxonomic groups. The bromeliad system offers an excellent opportunity to make linkages between these groups. Frog species are keystones in Cusuco because they are a zoocoupling between the canopy and the forest floor, they disperse crustaceans between bromeliads and are a prey base for snakes and bats specialized to feed on tree frogs. The reproductive ecology of bromeliads also remains unknown; birds may play a role, and water and wind dispersal are also possible. In the context of chytridiomycosis-induced declines in amphibian populations, it is important to characterize the ecological interactions of tree frogs in order to predict the likely impacts on the system of frog extinctions and to justify intensive management of frog species.
Action: Merlijn Jocque and John Kolby are writing grants to do this.

Ethnobotany
Local people have considerable traditional ecological knowledge (TEK) concerning the use of medicinal plants. Such plants are a key feature of the park due to their social importance. It would be very helpful to identify which plants are used (and put latin names to them) and for what purposes. This is rather a tall order for a dissertation student, but a Spanish-speaking medical elective, ethnobotanist/anthropologist visiting academic might be able to deliver on this.

Awareness activities/Outreach
Not really a research priority, but there was general agreement that we should be doing more outreach to schools about the biodiversity of the forest, why the park is important and the processes that are threatening it. Also we should continue talking about particular taxonomic groups such as bats and snakes in order to dispel some myths. The nice thing about this project is that UK school groups could easily be encouraged to take ownership of aspects of this programme, by doing a bit of research, preparing some resources and then going into the schools in BA and ST to work with the kids for a few hours.

Extend habitat surveys along transects
It would be helpful to extend our use of habitat surveys to a set of additional sample sites linear referenced, at say 50 or 100m intervals, along all transects to a) collect a very limited set of habitat parameters to line up with the herptile, small mammal and large mammal biodiversity data; and b) minimize trampling damage to the OpWall sample sites by spreading the impacts of general surveyors more thinly. Action: Joe Nunez-Mino is championing this idea.

Extend temporal scope of sampling
Currently Rohair and Chico survey for large mammals outside the summer OpWall season. Other science teams could also benefit greatly from this approach. Eg.

- Birds.
    - Conduct bird points in the dry season to find out about migrants using the park.
    - Train guides to identify the subset of 22 bird species selected as monitoring indicators. Conduct point counts for just these species in OpWall sample sites at additional times of year – this is the single action that would be best able to increase the power of the bird monitoring programme to detect trends in bird populations more quickly than the current protocol can. Action: Peter Long to do some power analysis to look at how well this could work.
- Botany. Collect flowers and fruits from tagged trees opportunistically outside the OpWall season. This would greatly help in the identification of problem species.
- Small mammals. Perhaps deploy hair tubes outside the main season
- Climate parameters. It would be great if we could set up automated weather stations at BC, ST and BA and appoint people to look after them outside the OpWall season. Expensive, but the data would be very useful for hydrological models and for models exploring the effects of future climate change on the biodiversity of the park.

If this approach works, it may then be possible in future to engage local people in participatory ecological monitoring to a) strengthen local support for conservation of the park, b) potentially increase the power of our monitoring programme to detect trends. Action: Joe Nunez-Mino is very keen to do this.

Extend entomology
Given the ecological importance of insects, it would be great to be able to study and monitor more invertebrate groups: eg. Arachnida, Odonata, Hymenoptera, Orthoptera, Curculionidae (weevils), Carabidae (ground beetles). We really need input from taxonomists before much progress can be made on this though.

Extend mammal sampling
We would like to try camera trapping for medium mammals, large mammals and large ground birds. Action: Charlotte Palmer to look into grants for camera traps.

Appendix 1 – People

Project management team		
Operations co-ordinator	Alex Tozer, *Operation Wallacea*	alex.tozer@opwall.com
Volunteer co-ordinator	Pippa Disney, *Operation Wallacea*	pippa@opwall.com
Ground operations		
	Roberto Downing, *Expediciones y Servicios Ambientales de Cusuco*	
	Alex Vallejo, *Expediciones y Servicios Ambientales de Cusuco*	
		cusucoexp@yahoo.com
Field logistics		
BC camp manager	Danielle Hines, *Operation Wallacea*	danielle.hines@opwall.com
ST camp manager	Anne Barr, *FORO Miraflor*	barr_anne@hotmail.com
BA camp manager	Carlos Baeza, *Operation Wallacea*	superca69@hotmail.com
GU camp manager	Ben Towl, *Duchy College*	ben.towl@googlemail.com
CA camp manager	Dan Kerrins, *Duchy College*	dafoldildan@hotmail.com
CO/DA camp manager	Katy Dyer, *Operation Wallacea*	katy.wilson@opwall.com
Canopy access		
Canopy instructor	Ollie Laker, *Canopy Access Ltd*	olaker@hotmail.com
Canopy instructor	Waldo Etheringhorn, *Canopy Access Ltd*	
Canopy instructor	Jim Fenn, *Canopy Access Ltd*	
Medical staff		
Medical officer	Dr Tracy Murgatroyd	
	Catherine Simmonds	
	Dr Suzanne Brady	
	Dr Kate Roberts-Lewis	
	Mark Watson	
	Liz Walisko	
	Sam Crimmin	
	Dr Andrew Lamb	
Science management team		
Senior scientist	Dr Richard Field, *University of Nottingham*	richard.field@nottingham.ac.uk
Senior scientist	Dr Peter Long, *University of Bath*	p.r.long@bath.ac.uk
Biodiversity survey co-ordinator	Jose Nunez-Mino, *University of Oxford*	jose.nunez-mino@zoo.ox.ac.uk
Database manager	Dr Jonathan Winn, *University of Sheffield*	winn_jonathan@hotmail.com
Habitat team		
Leader	Caroline Acton, *Operation Wallacea*	caroline.acton@opwall.com
	Hannah Thomas, *University of Southampton*	hannahthomas86@gmail.com
	Tim Wilkes, *Aberystwyth University*	timmywilkes@gmail.com
	Mizuki Murai, *University of Bristol*	mm6189@bristol.ac.uk
	Gareth Newton, *University of Plymouth*	gareth.newton@plymouth.ac.uk
	Elizabeth Dyer, *University of Cambridge*	e.e.dyer@cantab.net
	Nick Dyer, *Imperial College*	nick_dyer@hotmail.com
	Craig Barlow, *University of Hull*	c.a.barlow@2005.hull.ac.uk
	Danielle Fountain, *University of Oxford*	danielle.fountain@pnb.ox.ac.uk
	Nadia Ham Pong, *University of Western Ontario*	nhampong@uwo.ca
	Bryony Carter, *Operation Wallacea*	bryony_carter_is@hotmail.com
Botany team		
Leader	Dr Daniel Kelly, *Trintiy College Dublin*	dkelly@tcd.ie
	Kate Fagan, *University of Liverpool*	katecf@hotmail.com
Freshwater team		
Leader	Dr Merlijn Jocque, *University of Leuven*	merlijn.jocque@biokuleuven.be
	Helen Michels,	helenmichels@gmail.com
Invertebrate team		
Leader	Jose Nunez-Mino, *University of Oxford*	jose.nunez-mino@zoo.ox.ac.uk
	Rebecca Jefree, *Imperial College*	becca_jefree@yahoo.co.uk
	Alastair Hotchkiss, *National Botanic Garden of Wales*	

		ajhotchkiss@googlemail.com
	John Pemberton, *Napier University*	j_pemberton@hotmail.com
	Helen Scott, *University of Cambridge*	hes198@hotmail.com
	Susannah O'Riordan, *Leicestershire and Rutland Wildlife Trust*	billynanas@hotmail.com
Herpetology team		
Leader	Dr Jon Kolby, *US Fish & Wildlife service*	j_kolby@hotmail.com
	Michael Wall, *University of Sydney*	mwall2@gmail.com
	Jose Mario Solis Ramos, *Pasanate University*	jm9biol@yahoo.es
	Roberto Gardola, *Bangor University*	robertgardola747@hotmail.com
	Catriona Hendry, *Bangor University*	cathendry2@hotmail.com
Bird team		
Leader	Dr Nick Bayly, *Wetland Trust*	nick_bayly@hotmail.com
	Camilla Gomes Montes, *ProAves Colombia*	camilgomo@yahoo.co.uk
	Ugo Mellone, *University of Pavia*	ugomellone@libero.it
	Andrew Bodey, *Sparsholt College*	apbodey@btinternet.com
Small mammal team		
Leader	Dr C.B. Woods, *Providence College*	cbwood@providence.edu
	Charlotte Palmer, *University of Birmingham*	charlyppp@hotmail.com
	David Beaune, *University of Perpignan*	david.beaune@gmail.com
	Stephen MacKenzie, *University of Aberdeen*	u34sm5@aberdeen.ac.uk
Large mammal team		
	Ben Wallis, *University of Newcastle*	benjamin.wallis@newcastle.ac.uk
Bat team		
Leader	Melinda Hoffman, *University of California*	melinda.hofmann@umail.ucsb.edu
	Daniel Hargreaves, *University of Bristol*	daniel@oakfieldfood.co.uk
	Heidi Cooper-Berry, *University of Bristol*	heidi@wildlifeawareness.com
	Clare Rawcliffe, *Durham Wildlife Society*	c_rawliffe@hotmail.com
Primate team		
Leader	Dr Kathy Slater, *Operation Wallacea*	kathy.slater@opwall.com
	Katy Wilson, *Operation Wallacea*	katy.wilson@opwall.com
	Claudia Bustos, *University of Windsor*	bustos@windsor.ca
Social science team		
	Dr Kathy Slater, *Operation Wallacea*	kathy.slater@opwall.com
Genetics team		
Leader	Dr Kim Hunter, *Salisbury University*	kxhunter@salisbury.edu
	Dr Richard Hunter, *Salisbury University*	rbhunter@salisbury.edu
	Eve Hunter	
	Emily Burnett, *Salisbury University*	eb14253@students.salisbury.edu
Visiting academics		
	Dr Tom Horton, *SUNY ESF*	trhorton@esf.edu
	Dr Patricia Chow-Fraser, *McMaster University*	chowfras@mcmaster.ca
	Dr Humberto Mendes, *Univeristy of Bergen*	humberto.mendes@bm.uib.no
	Dr Mary Kelly-Quinn, *University College Dublin*	mary.kelly-quinn@ucd.ie
	Dr Bob Payne, *Lakehead University*	rjpayne@lakeheadu.ca
	Dr Elizabeth Capaldi-Evans, *Bushnell University*	elizabeth.capaldi@bushnell.edu

Dissertation students

Maeve Costigan, *Trinity College Dublin* costiganm@tcd.ie
Sean Feeney, *Trinity College Dublin*, feeneyse@tcd.ie
Robyn Kent
Amira Rezkalla
Nicola Parsonage
Thomas Plant
Stephanie Johnson
Sam Stubbs, *University of Southampton*, ss2006@soton.ac.uk
Amy Miles, *University of Nottingham*

Karen Bell
Stefan Wuestner
Jasmin Atkinson
Elisabeth Wuffield
Rosalind Munday-Thompson
Eleanor Shipley
Ed Davenport
Sara Legros
Dan Lihou, *University of Manchester*

Research assistants

Karen Black
Erik Donald
Kimberley Doucette
Lauren Dudas
Anna Erzberger
Vanessa Garland
Tegan Haslam
Caitlin Hevey
Katie Hill
Carly Hough
Gerald Jackman
Markus Jaskari
Emily Johnston
Winifred (Elin) Jones
John Kosciuw
Michelle Rong Lam
Sonia Lanteigne
Sophie Leaning
Adam LeClair
Sarah MacDonald
Katarzyna Mikolajczak
Joey Mistretta
Angie Sanchez
Parth S. Sheth
James Smith
Steven Bruce Smith
Audrey Steedman
Thomas Swanson
Helen Truong
Shuhei Watarai
James D. Whitledge
Angela Woodside
Kyle Alexander Matheson
Scott Thompson Boutilier
Rebecca Ann Critser
Lily Dimitrov
Leanne Dunne
Claire Horrocks
Ben Hurst
Karen Kelleher
Joanna Kershaw
Brendan Laing
Lawrence Anthony Lam
Cathy Maguire
Mark Taavo Merilo
Ewa Baranowska
Alison Murphy
Caitlin Parker
Megan Riddington
Jeanne Sampier
Lindsay Selmes
Gareth Thomas
Ellie Trezise
Regis Dudley
Alexandra Victoria Ficula
Katy Orford
Valerie Perini
Andrew Snyder
Tanya Stafford-Jones
Kristal Anne Brown
Ian Anthony Fleming Frazao
Hayley Geldhart
Laetitia Gunton
Terina Hancock
Alexandra Laking
Siobhan Marie-Curry
Helen Medley
Madison Sieloff
Neil Simpson

General surveyors' schools

St Julie's High School
Millfield School
Whitgift School
The Godolphin School
Lord Lawson of Beamish School
Painsley School
Bourne School
Woodbridge School
Jersey College for Girls
Hind Leys Community School
The Thomas Hardye School
Watford Grammar School
Beaumont College
South Bromsgrove High School
King Edward VI School
Northampton School for Girls
Cobourg DCI East School
Clarke Road S.S School
Forest Heights School

Appendix 2 – Dissertation projects

Botany
Maeve Costigan, *Trinity College Dublin*
The pollination ecology of two sympatric populations of Heliconia in a high elevation rainforest of Honduras

Sean Feeney, *Trinity College Dublin*
Species distribution modelling of tree ferns (Pteridophyta: Cyatheaceae) in Cusuco National Park, Honduras

Invertebrates
Robyn Kent, *Keele University*
Freshwater macroinvertebrates

Amira Rezkalla
Genetic diversity of *Dichotomius satanas* and *Copris nubilosus* populations in Cusuco National Park, Honduras

Nicola Parsonage
The impact of living fences on dung beetles

Thomas Plant

Herptiles
Stephanie Johnson
Auditory niche partitioning

Sam Stubbs
Identification of *Craugaster* frogs using morphological and genetic data

Birds
Amy Miles, *University of Nottingham*
How does bird species richness and composition vary in relation to altitude in Cusuco National Park?

Bats
Karen Bell
Does interspecies variation in wing morphology occur between *Artibeus jamaicensis* and *Artibeus toltecus* in terms of wing loading and aspect ratio values, and does habitat determine or significantly affect this aspect of bat morphology?

Stefan Wuestner
Differences in bat communities between altitudes in Cusuco National Park

Primates
Jasmin Atkinson
The Effects of Dietary Preferences on Social Behaviour and Activity Budgets of Mantled Howler Monkeys *(Alouatta palliata)* at Rancho Manacal, Honduras

Elisabeth Wuffield
Impact of forest fragmentation on the home range of mantled howler monkeys (*Alouatta palliata*)

Rosalind Munday-Thompson
A Re-examination of Folivory and Inactivity in mantled howler monkeys (*Alouatta palliata*)

Eleanor Shipley
Behavioural responses of Howler monkeys (*Alouatta paliatta*) to vocalisations: Adult males and females with and without infants

Social science
Ed Davenport
An investigation of the Buenos Aires village cooperative: Suitability for inclusion in the Operation Wallacea Trust Wildlife Conservation Product Scheme

Sara Legros
Does the Use of Shade-Grown Coffee or Tomato Crops Affect the Productivity of the Soil When Used Long-term?

Dan Lihou
How effective are ethical pricing schemes in promoting environmental conservation by improving rural livelihoods?

Appendix 3 – Species lists

Plants

Family	Species
A. Tree ferns	
Cyatheaceae	Alsophila erinacea (H. Karst.) D.S. Conant vel aff.
	Alsophila salvinii Hook.
	Cyathea bicrenata Liebm.
	Cyathea divergens Kunze var. tuerckheimii (Maxon) Tryon
	Cyathea valdecrenata Domin
	Sphaeropteris horrida (Liebm.) Tryon
B. Conifers	
Pinaceae	Pinus oocarpa Schiede ex Schtdl. var. oocarpa
	Pinus maximinoi H.E. Moore
Podocarpaceae	Podocarpus oleifolius J.D. Sm.
Araliaceae	
C. Angiosperms (Flowering Plants)	
Actinidiaceae	Saurauia conzattii Busc.
Annonaceae	Guatteria cf. chiriquensis R.E. Fr.
	Guatteria dolichopoda Donn. (?)
Apocynaceae	Tabernaemontana amygdalifolia Jacq.
Aquifoliaceae	Ilex gracilipes I. M. Johnst. ?
	Ilex guianensis (Aubl.) O. Kuntze
	Ilex lamprophylla Standl.
Araliaceae	Dendropanax arboreus (L.) Decne & Planch.
	Oreopanax geminatus Marchal
	Oreopanax nicaraguensis M.J. & J.F.M.Cannon
Arecaceae	Chamaedorea arenbergiana H. Wendl.
	Chamaedorea costaricana Oerst.
	Chamaedorea pinnatifrons (Jacq.) Oerst.
	Cryosophila williamsii Allen vel aff.
	Geonoma undata Klotzsch
	Synechanthus fibrosus (H. Wendl.) H. Wendl.
Asteraceae	Eupatorium hypomalacum var. wetmorei B.L. Robins
Betulaceae	Carpinus tropicalis (Donn. Sm.) Lundell
Bignoniaceae	Amphitecna molinae L.O. Wms
Brunelliaceae	Brunellia mexicana Standley
Caprifoliaceae	Viburnum hartwegii Benth.
Clethraceae	Clethra macrophylla Mart. & Gal.
	Clethra occidentalis (L.) O. Kuntze
Clusiaceae	Calophyllum brasiliense var. rekoi (Standl.) Standl.
	Chrysochlamys sp.
	Clusia salvinii Donn. Sm.
	Garcinia intermedia (Pittier) Hammel
	Vismia baccifera (L.) Triana & Planch.
Cunoniaceae	Weinmannia balbisiana Kunth
Elaeocarpaceae	Sloanea meianthera Donn. Sm.
Ericaceae	Gaultheria acuminata Schlecht. & Cham.
	Orthaea brachysiphon (Sleumer) Luteyn
	Vaccinium poasanum Donn. Sm.
	Vaccinium stenophyllum Steud.
Euphorbiaceae	Acalypha macrostachya Jacq.

	Alchornea latifolia Sw
	Croton draco Cham. & Schtdl.
	Hieronyma oblonga (Tul.) Muell. Arg.
	Tetrorchidium brevifolium Standl. & Steyerm.
Fabaceae	Dussia cuscatlantica (Standl.) Standl. & Steyerm.
	Ormosia isthmensis Standl.
Fagaceae	Quercus cortesii Liebm.
Hamamelidaceae	Liquidambar styraciflua L.
Hippocastanaceae	Billia hippocastanum Peyr
Juglandaceae	Alfaroa costaricensis Standl.
Lauraceae	Cinnamomum triplinerve (Ruiz & Pavon) Klosterm.
	Ocotea helicterifolia (Meissn.) Hemsl.
	Persea vesticula Standl. & Steyerm.
Magnoliaceae	Magnolia guatemalensis subsp. hondurensis (A.R. Molina) A. Vazquez
	Talauma gloriensis Pittier
Malvaceae	Malvaviscus arboreus Cav.
Melastomataceae	Henriettea fascicularis (Sw.) Gomez
	Miconia trinervia (Sw.) D. Don ex Loud.
Meliaceae	Cedrela odorata L.
Mimosaceae	Inga laurina (Sw.) Willd.
	Inga punctata Willd.
	Inga vera Willd.
Monimiaceae	Mollinedia guatemalensis Perk.
	Siparuna grandiflora (H.B.K.) A.DC.
Moraceae	Castilla elastica Sesse in Cerv.
	Cecropia peltata L.
	Ficus sp.
	Perebea xanthochyma H. Karst. vel aff.
	Trophis mexicana (Liebm.) Bureau
Myricaceae	Morella cerifera (L.) Small
Myrsinaceae	Gentlea micranthera (Donn. Sm.) Lundell
	Myrsine coriacea (Sw.) R.Br. ex Roem. & Schult.
	Synardisia nervosa (Masters) Lundell
Myrtaceae	Eugenia sp.
	Myrcia splendens (Sw.) DC.
	Syzygium jambos (L.) Alston
Poaceae	Chusquea heydei Hitchc. ?
Proteaceae	Roupala montana Aubl.
Rosaceae	Prunus brachybotrya Zucc.
Rubiaceae	Elaeagia auriculata Hemsl.
	Faramea occidentalis (L.) A. Rich
	Genipa americana L.
	Psychotria luxurians Rusby
	Randia matudae Lorence & Dwyer?
Rutaceae	Zanthoxylum melanostictum Schtdl. & Cham.
Sapotaceae	Pouteria durlandii (Standl.) Baehni ?
	Pouteria reticulata (Engl.) Eyma
Saxifragaceae	Phyllonoma cacuminis Standl. & Steyerm. vel aff.
Simaroubaceae	Picramnia antidesma ssp. fessonia (DC.) W.W.Thomas
Staphyleaceae	Turpinia occidentalis (Sw.) G. Don
Symplocaceae	Symplocos vernicosa L.O. Wms.
Theaceae	Ternstroemia tepazapote Schtdl. & Cham.
Tiliaceae	Heliocarpus appendiculatus Turcz.
	Mortoniodendron cf. pilosum Meijer ined.
	Trichospermum galeottii (Turcz.) Klosterm. vel aff.
Ulmaceae	Trema micrantha (L.) Blume

Urticaceae	Myriocarpa heterospicata Donn. Sm.
	Myriocarpa longipes Liebm.
Verbenaceae	Citharexylum donnell-smithii Greenm.
	Cornutia pyramidata L.
Winteraceae	Drimys granadensis L.f.

Lepidoptera

Papiliondae
Papilio sp 1
Papilio cresphontes
Papilio iphidamas iphidamas
Papilio polyxenes (asterius?)
Papilio thoas
Papilio astyalus
Eurytides branchus
Eurytides phaon
Parides iphidamas iphidamas

Riodinidae
Calephelis sp
Mesosemia gaudiolum

Pieridae
Ascia monuste
Anteos clorinde
Phoebis argante
Enantia sp. 1
Eurema sp. 2
Eurema albula
Eurema daira
Eurema nise
Eurema proterpia
Leptophobia aripa
Lieinix nemesis

Dismorphinae
Dismorphia amphiona praxinoe

Nymphalidae

Ithomiinae
Dircena sp. 1
Melinaea sp. 1
Hypoleria sp.
Ithomia sp.
Mechanitis sp.
Mechanitis lysimnia doryssus
Mechanitis polymnia isthmia
Napeogenes sp.
Godyris zavaleta sorites
Hypothyris sp.
Pteronymia sp.

Satyrinae
Cissia gigas
Dioriste sp.
Dioriste tauropolis
Cissia gomezi
Cissia hermes
Cissia metaleuca
Cissia hesione
Cissia sp.
Cissia renata
Euptychia westwoodi

Nymphalinae
Diaethria anna
Vanessa virginiensis
Anartia fatima
Siproeta epaphus epaphus
Siproeta sp.
Smyrna blomfida datis
Hamadryas fornax fornacalia
Hamadryas guatemalena
Hypanartia godmani
Hypanartia lethe
Catonephele mexicana
Adelpha leuceria
Marpesia Marcella
Nessaea aglaura
Adelpha sp
Thessalia theona

Heliconiinae
Aeria eurimedea
Dione june
Dione meneta poeyii
Heliconius hecale zuleika
Heliconius erato petiverana
Heliconius cyndo sub sp. Ukn
Heliconius cydno galanthus
Heliconius clysominus
Eueides sp
Eueides isabella
Dryas iulia
Agraulis vanillae
Lycorea cleobaea atergatis
Heliconius charatonius
Tithorea tarricina pinthias

Morphinae
Morpho polyphemus
Morpho peleides limpida
Morpho amathonte

Danaine
Danaus plexippus

Melitaeninae
Chlosyne lacinia
Chlosyne sp.
Chlosyne sp. (2)

Brassolinae
Caligo uranus

Charaxinae
Archeoprepona meander amphimachus
Memphis glycerium
Prepona lygia
Prepona brooksiana

Lycaenidae
Thecla aetoli

Coleoptera

Dung beetles
Aphodius sp1
Ateuchus near solis sp
Canthidium near ardens sp
Canthidium near ardens (no bumps) sp
Canthidium near moroni sp
Canthidium near vespertinum sp
*Canthon vazquezae**
*Copris laeviceps**
*Copris nubilosus**
Cryptocanthon nov sp
Deltochilum near barbipes/pseudoparile sp
Deltochilum near mexicanum sp
*Dichotomius satanas**
*Eurysternus magnus **
Onthophagus near atrosericeus sp
*Onthophagus breviconus**
*Onthophagus cyanellus**
Onthophagus near gratahelenae sp
Onthophagus near chevlorati group sp
*Onthophagus subcancer**
*Phanaeus endymion**
Uroxys bidentis sp
Uroxys dybasi sp

Jewel scarab beetles

Chrysina spectabilis
Chrysina quetzalcoatli
Chrysina pastori
Chrysina karschi
Platycoelia humeralis
Chrysina sp 1

Reptiles and amphibians

Bromeliahyla sp.
Bufo marinus
Bufo valliceps
Duellmanohyla soralia
Eleutherodactylus chac
Eleutherodactylus charadra
Eleutherodactylus milesi
Eleutherodactylus rostralis
Eleutherodactylus sp.
Hyalinobatrachium fleischmanni
Bromeliahyla bromeliacia
Plectrohyla dasypus
Plectrohyla exquisita
Plectrohyla matudai
Plectrohyla sp.
Ptychohyla hypomykter
Rana maculata
Smilisca baudini
Bolitoglossa conanti
Bolitoglossa diaphora
Bolitoglossa dolfeini
Bolitoglossa dunni
Bolitoglossa rufescens
Cryptotriton nasalis
Nototriton sp.
Oedipina sp.
Oedipina sp.
Ameiva festiva
Basiliscus vittatus
Celestus montanus
Corytophanes cristatus
Corytophanes hernandezii
Laemanctus longipes
Lepidophyma flavimaculatum
Mesaspis morelettii
Norops amplisquamosis
Norops biporcatus
Norops capito
Norops cusuco
Norops johnmeyerii
Norops lemurinus
Norops ocelloscapularis
Norops petersii
Norops sericeus
Norops sp.
Norops tropidonotus
Norops uniformis
Sceloporus malachiticus
Sceloporus variabilis
Sphenomorphus cherriei
Sphenomorphus incertus
Adelphicos quadrivirgatus
Atropoides nummifer
Bothriechis marchi
Bothrops asper
Cerrophidion godmani
Coniophanes sp.
Dendrophidion nuchale
Dryadophis dorsalis
Dryadophis melanolomus
Drymarchon melanurus
Drymobius chloroticus
Drymobius margaritiferus
Geophis sp.
Imantodes cenchoa
Lampropeltis triangulum
Leptophis ahaetulla
Micrurus diastema
Micrurus nigrocinctus
Ninia diademata
Ninia espinali
Ninia pavimentata
Ninia sebae
Omoadiphas aurula
Pseustes poecilonotus
Rhadinaea montecristi
Rhadinaea sp.
Scaphiodontophis annulatus
Sibon nebulatus
Stenorrhina degenhardtii
Sphenomorphus sp
Colubridae sp.
Anura sp.

Bird Species List – Cusuco National Park, 2008

Common Name	**Scientific Name**
Great Tinamou	*Tinamus major*
Little Tinamou	*Crypturellus soui*
Slaty-breasted Tinamou	*Crypturellus boucardi*
Black Vulture	*Coragyps atratus*
Turkey Vulture	*Cathartes aura*
King Vulture	*Sarcoramphus papa*
Swallow-tailed Kite	*Elanoides forficatus*
White-breasted Hawk	*Accipiter striatus chionogaster*
Common Black-Hawk	*Buteogallus anthracinus*
Grey Hawk	*Asturina nitida*
Short-tailed Hawk	*Buteo brachyurus*
Zone-tailed Hawk	*Buteo albonotatus*
Red-tailed Hawk	*Buteo jamaicensis*
Black Hawk-Eagle	*Spizaetus tyrannus*
Barred Forest-Falcon	*Micrastur ruficollis*
Collared Forest-Falcon	*Micrastur semitorquatus*
Plain Chachalaca	*Ortalis vetula*
Crested Guan	*Penelope purpurascens*
Highland Guan	*Penelopina nigra*
Great Curassow	*Crax rubra*
Buffy-crowned Wood-Partridge	*Dendrortyx leucophrys*

Spotted Wood-Quail	*Odontophorus guttatus*
Red-billed Pigeon	*Patagioenas flavirostris*
Short-billed Pigeon	*Patagioenas nigrirostris*
White-winged Dove	*Zenaida asiatica*
Grey-headed Dove	*Leptotila plumbeiceps*
Grey-chested Dove	*Leptotila cassini*
White-faced Quail-Dove	*Geotrygon albifacies*
Ruddy Quail-Dove	*Geotrygon montana*
Olive-throated Parakeet	*Aratinga nana*
Barred Parakeet	*Bolborhynchus lineola*
White-crowned Parrot	*Pionus senilis*
Squirrel Cuckoo	*Piaya cayana*
Groove-billed Ani	*Crotophaga sulcirostris*
Pheasant Cuckoo	*Dromococcyx phasianellus*
Lesser Roadrunner	*Geococcyx velox*
Mottled Owl	*Ciccaba virgata*
Crested Owl	*Lophostrix cristata*
Ferruginous Pygmy-Owl	*Glaucidium brasilianum*
Chestnut-collared Swift	*Streptoprocne rutila*
White-collared Swift	*Streptoprocne zonaris*
Vaux's Swift	*Chaetura vauxi*
Long-tailed Hermit	*Phaethornis superciliosus*
Violet Sabrewing	*Campylopterus hemileucurus*
Green Violet-ear	*Colibri thalassinus*
Emerald-chinned Hummingbird	*Abeillia abeillei*
Black-crested Coquette	*Lophornis helenae*
Canivet's Emerald	*Chlorostilbon canivetii*
Stripe-tailed Hummingbird	*Eupherusa eximia*
Crowned Woodnymph	*Thalurania colombica*
Blue-throated Goldentail	*Hylocharis eliciae*
White-eared Hummingbird	*Hylocharis leucotis*
Rufous-tailed Hummingbird	*Amazilia tzacatl*
White-bellied Emerald	*Agyrtria candida*
Azure-crowned Hummingbird	*Agyrtria cyanocephala*
Green-throated Mountain-gem	*Lampornis viridipallens*
Magnificent Hummingbird	*Eugenes fulgens*
Wine-throated Hummingbird	*Atthis ellioti*
Black-headed Trogon	*Trogon melanocephalus*
Violaceous Trogon	*Trogon violaceus*
Mountain Trogon	*Trogon mexicanus*
Collared Trogon	*Trogon collaris*
Resplendent Quetzal	*Pharomachrus mocinno*
Green Kingfisher	*Chloroceryle americana*
Tody Motmot	*Hylomanes momotula*
Blue-crowned Motmot	*Momotus momota*
Turquoise-browed Motmot	*Eumomota superciliosa*
Collared Aracari	*Pteroglossus torquatus*
Keel-billed Toucan	*Ramphastos sulfuratus*
Emerald Toucanet	*Aulacorhynchus prasinus*
Acorn Woodpecker	*Melanerpes formicivorus*
Golden-fronted Woodpecker	*Melanerpes aurifrons*
Hairy Woodpecker	*Picoides villosus*
Smoky-brown Woodpecker	*Veniliornis fumigatus*
Golden-olive Woodpecker	*Piculus rubiginosus*
Chestnut-colored Woodpecker	*Celeus castaneus*
Lineated Woodpecker	*Dryocopus lineatus*
Pale-billed Woodpecker	*Campephilus guatemalensis*
Plain Xenops	*Xenops minutus*
Spectacled Foliage-gleaner	*Anabacerthia variegaticeps*
Buff-throated Foliage-gleaner	*Automolus ochrolaemus*

Ruddy Foliage-gleaner	*Automolus rubiginosus*
Tawny-throated Leaftosser	*Sclerurus mexicanus*
Scaly-throated Leaftosser	*Sclerurus guatemalensis*
Ruddy Woodcreeper	*Dendrocincla homochroa*
Olivaceous Woodcreeper	*Sittasomus griseicapillus*
Wedge-billed Woodcreeper	*Glyphorynchus spirurus*
Strong-billed Woodcreeper	*Xiphocolaptes promeropirhynchus*
Ivory-billed Woodcreeper	*Xiphorhynchus flavigaster*
Spotted Woodcreeper	*Xiphorhynchus erythropygius*
Streak-headed Woodcreeper	*Lepidocolaptes souleyetii*
Spot-crowned Woodcreeper	*Lepidocolaptes affinis*
Barred Antshrike	*Thamnophilus doliatus*
Plain Antvireo	*Dysithamnus mentalis*
Slaty Antwren	*Myrmotherula schisticolor*
Black-faced Antthrush	*Formicarius analis*
Scaled Antpitta	*Grallaria guatimalensis*
Red-capped Manakin	*Pipra mentalis*
Ochre-bellied Flycatcher	*Mionectes oleagineus*
Sepia-capped Flycatcher	*Leptopogon amaurocephalus*
Northern Bentbill	*Oncostoma cinereigulare*
Eye-ringed Flatbill	*Rhynchocyclus brevirostris*
Yellow-olive Flycatcher	*Tolmomyias sulphurescens*
Stub-tailed Spadebill	*Platyrinchus cancrominus*
Sulphur-rumped Flycatcher	*Myiobius sulphureipygius*
Tufted Flycatcher	*Mitrephanes phaeocercus*
Tropical Pewee	*Contopus cinereus*
Yellowish Flycatcher	*Empidonax flavescens*
Black Phoebe	*Sayornis nigricans*
Bright-rumped Attila	*Attila spadiceus*
Dusky-capped Flycatcher	*Myiarchus tuberculifer*
Great Kiskadee	*Pitangus sulphuratus*
Boat-billed Flycatcher	*Megarynchus pitangua*
Social Flycatcher	*Myiozetetes similis*
Sulphur-bellied Flycatcher	*Myiodynastes luteiventris*
Piratic Flycatcher	*Legatus leucophaius*
Tropical Kingbird	*Tyrannus melancholicus*
Rose-throated Becard	*Pachyramphus aglaiae*
Masked Tityra	*Tityra semifasciata*
American Dipper	*Cinclus mexicanus*
Band-backed Wren	*Campylorhynchus zonatus*
Spot-breasted Wren	*Thryothorus maculipectus*
Plain Wren	*Thryothorus modestus*
House Wren	*Troglodytes aedon*
Rufous-browed Wren	*Troglodytes rufociliatus*
White-breasted Wood-Wren	*Henicorhina leucosticta*
Grey-breasted Wood-Wren	*Henicorhina leucophrys*
Nightingale Wren	*Microcerculus philomela*
Slate-colored Solitaire	*Myadestes unicolor*
Ruddy-capped Nightingale-Thrush	*Catharus frantzii*
Black-headed Nightingale-Thrush	*Catharus mexicanus*
Spotted Nightingale-Thrush	*Catharus dryas*
Black Thrush	*Turdus infuscatus*
Mountain Thrush	*Turdus plebejus*
Clay-colored Thrush	*Turdus grayi*
White-throated Thrush	*Turdus assimilis*
Long-billed Gnatwren	*Ramphocaenus melanurus*
Green Jay	*Cyanocorax yncas*
Brown Jay	*Cyanocorax morio*
Azure-hooded Jay	*Cyanolyca cucullata*
Brown-capped Vireo	*Vireo leucophrys*

Tawny-crowned Greenlet	*Hylophilus ochraceiceps*
Lesser Greenlet	*Hylophilus decurtatus*
Tropical Parula	*Parula pitiayumi*
Golden-cheeked Warbler	*Dendroica chrysoparia*
Hermit Warbler	*Dendroica occidentalis*
Yellow-throated Warbler	*Dendroica dominica*
Grace's Warbler	*Dendroica graciae*
Black-and-white Warbler	*Mniotilta varia*
American Redstart	*Setophaga ruticilla*
Louisiana Waterthrush	*Seiurus motacilla*
Grey-crowned Yellowthroat	*Geothlypis poliocephala*
Slate-throated Redstart	*Myioborus miniatus*
Golden-crowned Warbler	*Basileuterus culicivorus*
Rufous-capped Warbler	*Basileuterus rufifrons*
Bananaquit	*Coereba flaveola*
Common Bush-Tanager	*Chlorospingus ophthalmicus*
Red-crowned Ant-Tanager	*Habia rubica*
Red-throated Ant-Tanager	*Habia fuscicauda*
Hepatic Tanager	*Piranga flava*
Flame-colored Tanager	*Piranga bidentata*
White-winged Tanager	*Piranga leucoptera*
Crimson-collared Tanager	*Ramphocelus sanguinolentus*
Scarlet-rumped Tanager	*Ramphocelus passerinii*
Blue-grey Tanager	*Thraupis episcopus*
Yellow-winged Tanager	*Thraupis abbas*
Yellow-throated Euphonia	*Euphonia hirundinacea*
Olive-backed Euphonia	*Euphonia gouldi*
Blue-crowned Chlorophonia	*Chlorophonia occipitalis*
Golden-hooded Tanager	*Tangara larvata*
Green Honeycreeper	*Chlorophanes spiza*
Red-legged Honeycreeper	*Cyanerpes cyaneus*
Blue-black Grassquit	*Volatinia jacarina*
White-collared Seedeater	*Sporophila torqueola*
Thick-billed Seed-Finch	*Oryzoborus funereus*
Yellow-faced Grassquit	*Tiaris olivacea*
Cinnamon-bellied Flowerpiercer	*Diglossa baritula*
Chestnut-capped Brush-Finch	*Buarremon brunneinucha*
Orange-billed Sparrow	*Arremon aurantiirostris*
Rusty Sparrow	*Aimophila rufescens*
Buff-throated Saltator	*Saltator maximus*
Black-headed Saltator	*Saltator atriceps*
Black-faced Grosbeak	*Caryothraustes poliogaster*
Blue-black Grosbeak	*Cyanocompsa cyanoides*
Melodious Blackbird	*Dives dives*
Great-tailed Grackle	*Quiscalus mexicanus*
Bronzed Cowbird	*Molothrus aeneus*
Yellow-backed Oriole	*Icterus chrysater*
Black-cowled Oriole	*Icterus prosthemelas*
Yellow-billed Cacique	*Amblycercus holosericeus*
Chestnut-headed Oropendola	*Psarocolius wagleri*
Montezuma Oropendola	*Gymnostinops montezuma*
Black-headed Siskin	*Carduelis notata*
Lesser Goldfinch	*Carduelis psaltria*
Little Hermit	*Pygmornis longuemareus*
Yellow-throated Brushfinch	*Atlapetes gutteralis*
Chestnut-capped warbler	*Basileuterus delattrii*

Mammals

Felidae- Cats	
Panthera onca	Jaguar
Felis yaguarondi	Jaguarundi
Felis concolor	Puma
Felis pardalis	Ocelot
Canidae - Foxes	
Urocyon cinereoargenteus	Grey Fox
Procyonidae - Raccoons	
Procyon lotor	Racoon
Nasua narica	White nosed Coatimundi
Potos flavus	Kinkajou
Bassariscus sumichrasti	Cacomistle
Bassariscus gabbii	Olingo
Mustelidae - Weasels	
Mustela franata	Long-tailed weasel
Eira barbara	Tayra
Lontra longicaudis	Neotropical River Otter
Mephitidae - Skunks	
	Skunk species
Cebidae - Capuchins	
Cebus capucinus	White faced Capuchin
Ateles????	Spider Monkey
Alouatta palliata	Mantled Howler Monkey
Tapiridae - Tapirs	
Tapirus bairdii	Baird's Tapir
Tayassuidae	
Tayassu tajacu	Collared Peccary
Cervidae - deer	
Mazama americana	Red Brocket Deer
Odocoileus viginianus	White-tailed deer
Sciurudae - Squirrels	
Sciurus deppei	Deppe's Squirrel
Sciurus variegatoides	Variegated Squirrel
Heteromyidae - Pocket Mice	
Heteromys desmarestianus	Demarest's Spiny Pocket Mouse
Heteromys nelsoni	Nelson's Spiny Pocket Mouse
Muridae - Rats, Mice, Voles	
Oryzomys alfaroi	Alfaro's Rice Rat
Oryzomys sp.	
Scotinomys teguina	Olston's Brown Mouse
Mus musculus	House Mouse
Rattus rattus	Roof Rat
Peromyscus mexicanus	Mexican Deer Mouse

Peromyscus levipes	Nimble-footed Mouse
Peromyscus sp.	
Nyctomys sumichrasti	Vesper Rat
Reithrodontomys gracilis	Slender Harvest Mouse
Zygodontomys spp.	Cane mouse

Dasyproctidae - Agoutis

Dasyprocta punctata	Central American Agouti

Agoutidae

Agouti paca	Paca

Erethizontidae - Porcupines

	Porcupine sp.

Soricidae

	Shrew sp.

Phyllostomidae - American Leaf-nosed Bats

Anoura geoffroyi	Geoffrey's Tailless Bat
Artibeus intermedius	
Artibeus jamaicensis	Jamaican Fruit-eating Bat
Artibeus lituratus	Great Fruit-eating Bat
Artibeus phaeotis	Pygmy Fruit-eating Bat
Artibeus toltecus	Toltec Fruit-eating Bat
Artibeus watsoni	Thomas' Fruit-eating Bat
Bauerus dubiaquercus	Van Gelder's Bat
Carollia brevicauda	Silky Short-tailed Bat
Carollia castanea	Chestnut Short-tailed Bat
Carollia perspicillata	Seba's Short-tailed Bat
Centurio senex	Wrinkle-faced Bat
Chiroderma salvini	Salvin's Big-eyed Bat
Desmodus rotundus	Common Vampire Bat
Glassophaga commissarisi	Commassaris Long-tongued Bat
Glossophaga leachii	Grey Long-tongued Bat
Glossophaga soricina	Pallas' Long-tongued Bat
Hylonycteris underwoodi	Underwood's Long-tongued Bat
Micronycteris microtis	Little Big-eared Bat
Sturnira lilium	Little Yellow-shouldered Bat
Sturnira ludovici	Highland Yellow-shouldered Bat
Trachops cirrhosus	Fringe-lipped Bat
Uroderma bilobatum	Tent-making Bat
Vampyrodes caraccioli	Great Stripe-faced Bat
Enchisthenes hartii	Velvety Fruit-eating Bat

Vespertilionidae - Vesper Bats

Eptesicus brasiliensis	Brazilian Brown Bat
Eptesicus furinalis	Argentine Brown Bat
Lasiurus blossevillii	Hairy-tailed Bat
Myotis albescens	Silver Tiiped Myotis
Myotis keaysi	Hairy-legged Myotis
Pipistrellus subflavus	Eastern Pipistrelle

Mormoopidae- Leaf chinned Bat

Pteronotus davyi	Davy's Naked Backed Bat
Pteronotus parnellii	Parnell's Moustached Bat
Myrmecophagidae - Anteaters	
Tamandua mexicana	Northern tamandua
Bradypodidae - Three-toed Sloths	
	Sloth sp
Dasypodidae - Armadillos	
	Armadillo sp.
Didelphidae - Opossums	
Marmosa mexicana	Mexican Mouse Opossum
Didelphis sp	
Didelphis virginiana	Common/Virginia opossum
Philander opossum	Brown/Gray 'four-eyed' opossum
Marmosops invictus	Slaty Slender Mouse Opossum

Small mammals

Scientific name	**Common name**
Heteromys desmarestianus	Spiny pocket mouse
Peromyscus mexicanus	Mexican deer mouse
Scotinomys teguina	Alston's singing mouse
Nyctomys sumichrastu	Vesper rat
Reithrodontomys gracilis	Slender harvest mouse
Tylomys nudicaudus	Northern climbing rat
Oryzomys alfaroi group	Alfaro's rice rat
Baiomys musculus	
Unknown	
Mustela frenata	Long-tailed weasel
Tamandua mexicana	Northern tamandua (anteater)
	Common opossum
Didelphis marsupialis	
Marmosa mexicana	Mexican mouse opossum
Marmosa robinsoni	Robinsoni's mouse opossum

Bats

Family	Subfamily	Species
Mormoopidae		*Mormoops megalophylla*
		Pteronotus parnellii
Phyllostomidae	Carolliinae	*Carollia brevicauda*
		Carollia castanea
		Carollia perspicillata
	Desmodontinae	*Desmodus rotundus*
		Diphylla ecaudata
	Glossophaginae	*Anoura geoffroyi*
		Glossophaga commissarisi
		Glossophaga soricina
		Hylonycteris underwoodi
	Phyllostominae	*Micronycteris schmidtorum*
		Phyllostomus hastatus
		Trachops cirrhosus

	Stenodermatinae	*Artibeus intermedius*
		Artibeus jamaicensis
		Artibeus lituraus
		Artibeus phaeotis
		Artibeus toltecus
		Artibeus watsoni
		Centurio senex
		Chiroderma salvini
		Chiroderma villosum
		Enchisthenes hartii
		Platyrrhinus helleri
		Sturnira lilium
		Sturnira ludovici
		Uroderma bilobatum
		Vampyressa pussila
		Vampyrodes caraccioli
Natalidae		*Natalus stramineus*
Vespertilionidae		*Bauerus dubiaquercus*
		Myotis albescens
		Myotis kaeysi
Molossidae		*Molossus ater*

Appendix 4 – Spatial data holdings

Spatial data are available to download from:
http://www.bath.ac.uk/bio-sci/biodiversity-lab/honduras/

Four 1:50k topographical maps covering the park produced by IGN by photo-interpretation of stereo-pairs of aerial photos collected in 1970 were purchased at the end of the 2007 season. These were taken to the UK and scanned, then the originals map sheets were sent to Alex Tozer for safe-keeping. The scanned maps were each clipped, mosaiced together and geo-rectified to produce a 1m resolution 24-bit colour base map for the park and surrounding area with an overall root mean square error (RMSE) in x and y of 1.4m. This product is available to all science teams as a geotiff projected in UTM 16N.

All features were digitized from the basemap and annotated to produce a set of shapefiles covering the park and surrounding area projected in UTM 16N: Contour lines, spot heights, streams, roads, trails, settlements, houses in 1970 and landcover (forest/non-forest) in 1970. This set of ESRI shapefiles is available to all science teams.

Contours were cracked to vertices and, together with spot heights, were used in an exact local spatial interpolation procedure (regularized splines) to estimate elevation across the park and surrounding area at 10m resolution. This digital elevation model (DEM) is available to all science teams as a geotiff projected in UTM 16N. This product represents a considerable improvement of the 90m resolution DEM available last year (from SRTM). Although it has not been validated in the field with calibrated altimeters, typically DEMs derived from 1:50k topo maps with 20m contour intervals have better than 5m vertical accuracy.

A number of secondary data products have been produced from the 10m digital elevation model and shapefiles derived from the topographic maps. The following are all available as geotiffs projected in UTM 16N: slope, aspect, landform category, drainage basins, distance from streams, distance to trails, cost-distance to trails, density of houses, landcover (forest/non-forest) in 1970.

The most useful remote sensing products for Cusuco and the surrounding landscape are a collection of near-anniversary Landsat images (6 band multispectral, 30m resolution) collected in 1987, 1994, 2000 and 2006. The original scenes are available, however most scientists will probably find the processed scenes more useful. All bands of all scenes have been clipped to a region surrounding the park with the same extent as all other spatial data products. The scenes have now all been orthorectified, radiometrically corrected using sensor geometry metadata, atmospherically corrected using dark object subtraction and clouds in the 2000 scene and small artifacts in the 2006 scene have been masked. We also have an unprocessed SPOT scene (4 band multispectral, 20m resolution) covering the whole park collected in 2007 and two IKONOS scenes (4 band multispectral, 4m resolution) providing partial coverage of the park collected in 2000.

Climate data has been extracted from a global dataset available from www.worldclim.org The protocol used to generate the global dataset is described in Hijmans et al (2005). Data are the result of a spatial interpolation of weather station observations for the period 1950-2000. The data have not been specifically validated in Cusuco National Park, but the global dataset has been found to be highly accurate when validated against independent climate data in other parts of the world.

There are 48 layers of basic climate parameters:
- Mean monthly temperature: Jan,Feb,Mar,Apr,May,Jun,Jul,Aug,Sep,Oct,Nov,Dec
- Mean monthly minimum temperature:Jan,Feb,Mar,Apr,May,Jun,Jul,Aug,Sep,Oct,Nov,Dec
- Mean monthly maximum temperature: Jan,Feb,Mar,Apr,May,Jun,Jul,Aug,Sep,Oct,Nov,Dec
- Mean monthly precipitation: Jan,Feb,Mar,Apr,May,Jun,Jul,Aug,Sep,Oct,Nov,Dec

There are also a further 19 bio-climatic parameters:
Annual mean temperature, Mean diurnal temperature range, Isothermality, Temperature seasonality, Maximum temperature of warmest month, Minimum temperature of coldest month, Temperature annual range, Mean temperature of wettest quarter, Mean temperature of driest quarter, Mean temperature of warmest quarter, Mean temperature of coldest quarter, Annual precipitation, Precipitation of wettest month, Precipitation of driest month, Precipitation seasonality, Precipitation of wettest quarter, Precipitation of driest quarter, Precipitation of warmest quarter, Precipitation of coldest quarter.

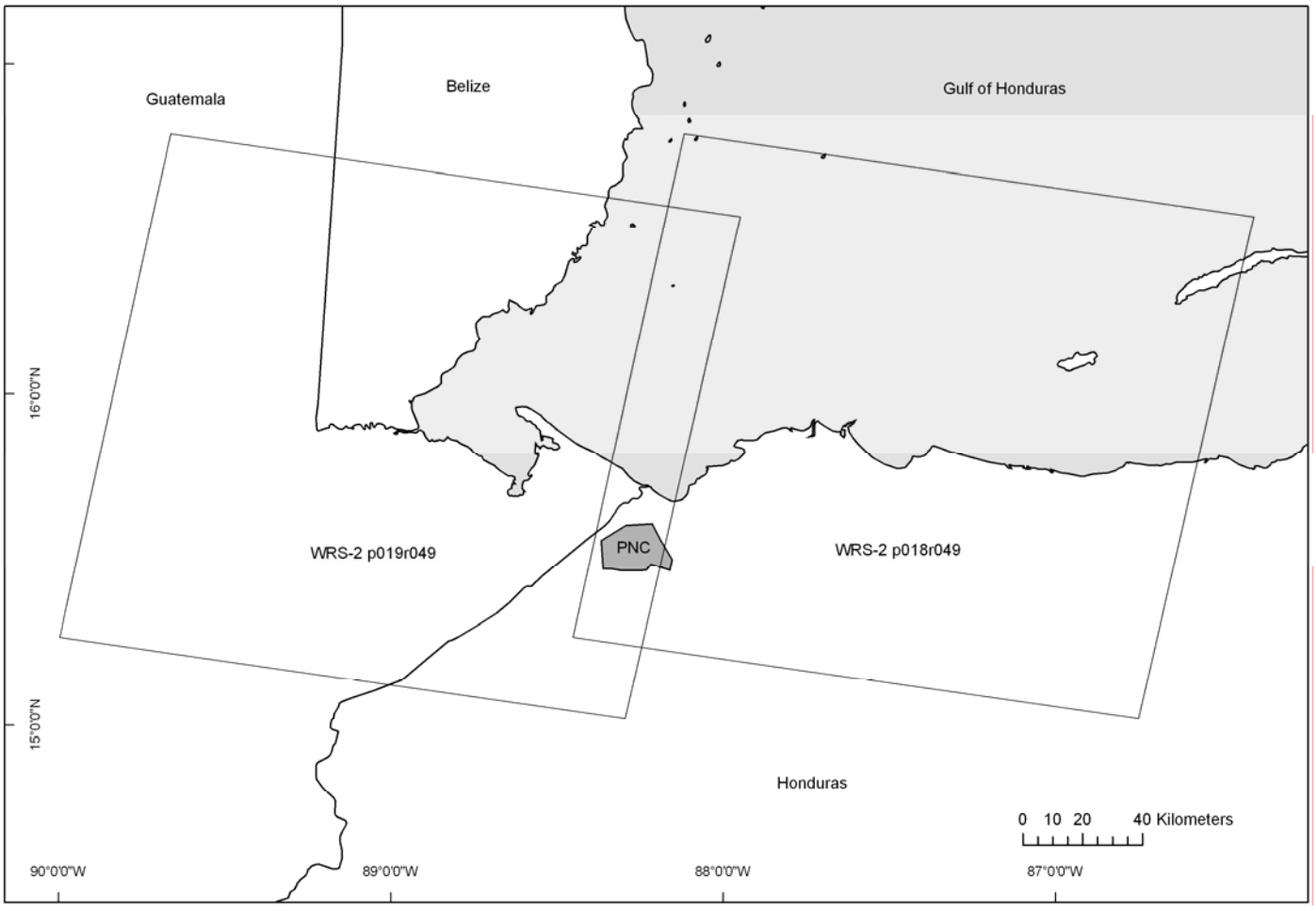
In additional, we have data on the above climate parameters in Cusuco under future scenarios in global climate models: There are three sets of global climate models produced by the Canadian centre for climate modeling and analysis (CCCMA), the Hadley centre (HADCM3) and the Commonwealth scientific and industrial research organization (CSIRO). Each model has been run under two CO2 emission scenarios (A2A and B2B) out to three different time horizons (2020, 2050 and 2080). All climate data are available as geotiffs projected to UTM 16N. The spatial resolution of the raw climate data is 30 seconds = 930 metres. However, by further interpolations using splines, a second set of climate parameters at 30m resolution has also been produced.

Spatial data relating to the Operation Wallacea spatial sampling framework have been consolidated. Following considerable efforts to GPS everything, accurate shapefiles now exist describing the camps, camp access trails, mule trails, BC tourist trails, all sample routes, all OpWall sample sites, additional botany plots, bat mist nets in 2007 and all small mammal trap locations in 2007 and 2008. Products showing locations of all bat mist nets in 2008 and linear referenced locations of all herptile and large mammal observations are being prepared.

When all data has been entered into the biodiversity database the end of the 2008 season, it will possible for the first time to extract values of any landscape variable and append them to spatially-referenced biodiversity observations for each taxonomic group. This will permit very powerful modeling to address ecological/conservation questions.

Landsat images

Path/Row (WRS #)	Date	Sensor	SV	ID	Source
p019r049 (WRS 1)	04-Feb-1979	MSS	Landsat 1	01499092000120010	GLCF
p018r049 (WRS 2)	18-Mar-1987	TM	Landsat 5	01499060300380003	GLCF
p019r049 (WRS 2)	22-Jun-1994	TM	Landsat 5	53679153759	GLCF
P018r049 (WRS-2)	05-Mar-1994	TM	Landsat 5	LT5018049009406410_WO	USGS
p018r049 (WRS 2)	16-Mar-2001	ETM+	Landsat 7	L7CPF20010101_20010331_07	GLCF
p019r049 (WRS 2)	21-Mar-2006	ETM+	Landsat 7	701904900060909650	USGS
p018r049 (WRS 2)	14-Mar-2006	ETM+	Landsat 7	70180049000607351	USGS



Appendix 5 – Agreement on ownership and use of data and intellectual property rights

The Cusuco National Park survey is a large collaborative project with many participating scientists, from around the world, working in the field in relatively isolated camps. This document is designed to address two implications of this. First, the need for careful co-ordination before, during and after the expeditions. Secondly, the analysis and publication of the data will often involve more than one scientist and to avoid future arguments over use and ownership of the data and the intellectual property rights this document has been compiled and needs to be signed by all participants in the survey programme.

The main thrust of the agreement is to ensure that researchers are facilitated in their work as much as possible, and are encouraged to write up their own data and publish papers on their own research and/or that done in collaboration with others. Research findings **generated by field scientists**, students or volunteers in projects in which these researchers had **significant intellectual input**, which were performed in large part by them, **or under their direction** in collaboration with a field scientist, shall be considered the joint property of the collaborating individuals. The data collected by each of the researchers will belong to them with the following provisos that ensure collaborative papers can be prepared from data gathered by various team members:

1. All scientific activity in Cusuco National Park is done under the direction of the Senior Forest Scientist; therefore he is a collaborator, and the normal expectation is for him to be included in the author list. Any applications for funding pre-expedition must be done in liaison with him. All publication plans must be discussed with him and be cleared by him before submission. Copies of all publications must be sent to him. This set of provisos is to ensure collaboration rather than competition (in funding, fieldwork and publication), and so that the diverse findings from the various projects are known by those co-ordinating the work.
2. Any publications that arise from the work should list Operation Wallacea as the scientist's second institution, and where other researchers have made a significant input into the research they **should be included as co-authors**.
3. A copy of the data collected should be made available to Operation Wallacea in an agreed format before each researcher leaves sites. A networked computer system will be available at Base Camp and all data gathered by each researcher will be entered in the required format.
4. Researchers will be able to access and copy all their own data and may request additional data from other researchers to utilise for their work **as long as the main focus of their study is not the same as that of the original researcher**. Thus forest structure data might be utilised as part of a bird habitat selection study or herpetofauna diversity data might be used as part of a study into the use of various taxonomic groups as indicators of overall forest diversity. In these cases the original researchers whose data were utilised would be included in the authorship on any publications or in acknowledgements if being utilised for a dissertation.
5. If the researcher requests data from other researchers in the **same area of study then prior agreements on authorship listing for any papers to be published utilising these data or acknowledgements if being utilised for a dissertation must be reached before release of the data**.
6. Operation Wallacea has appointed a **Data Manager**, José Nuñez-Miño, who receives all requests for access to data and responds to these requests both with the requested data (where appropriate) and also with written agreements over the inclusion of additional researchers on the authorship list of any consequent publications.
7. If the data have not been written up by the researcher within a period of 3 years then Operation Wallacea retains the right to hand those data over to another researcher for them to write it up and ensure publication. This is to get round the problem where a researcher is simply not making progress on getting the data published.

Any individual involved in the project may, at his/her discretion, informally discuss the research data with other researchers and present the data at seminars which are not published in full or only in abstract form.

In addition, all individuals involved with the Operation Wallacea project will follow the spirit and letter of Article 8(j) of the Convention on Biological Diversity: "Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices."

I agree to the above terms on the usage and ownership of data and intellectual property rights

…… (Signature of researcher)

…… (Print name of researcher)

……
Signed on behalf of Operation Wallacea

Appendix 6 – Publications in preparation

Botany
- Plants of Cusuco – Action: Daniel Kelly, within about 18 months
- Plant communities in Cusuco relative to environmental gradients – Action Daniel Kelly, within about 18 months
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Bromeliads
- Comparison of sampling techniques. Action: Merlijn Jocque
- Artificial bromeliads as a model system to study community ecology. Action: Merlijn Jocque
- Crustaceans in phytotelmata and passive dispersal. Action: Merlijn Jocque

Invertebrates
- Dung beetles and attributes of forest habitats. Action: Joe, PhD first, then publications
- Dung beetles and large mammal communities. Action: Joe, PhD first, then publications
- Dung beetles as surrogates for the diversity of other taxonomic groups. Action: Joe, PhD first, then publications

Herpetology
- Field testing for Chytrid. Action: John Kolby
- Multistate occupancy models of prevalence of chytidiomycosis in frog populations with respect to environmental covariates. Action: John Kolby, Peter Long

Ornithology
- Distance-Occupancy coupled models to monitor bird populations. Action: Peter Long, Nick Bayly
- Distribution model for resplendent quetzal Action: Ugo Mellone, Nick Bayly
- Climate change and bird communities in Cusuco. Action: Nick Bayly

Small mammals
- Possum dentition. Action: CB Woods
- Small mammal communities and human disturbance. Action: Richard Field and CB Woods

Bats
- Potentially it will be possible for the bat team to publish on acoustics, dentition. Action: Melinda Hoffman

Genetics
- Methods for DNA extraction, amplification and genetic diversity measures in the field. Action: Kim Hunter

Conservation synthesis
- Patterns of biodiversity in Cusuco national park, Honduras. Action: Peter Long, Richard Field, Joe Nunez-Mino
- Land cover change in Cusuco national park, Honduras
- Ecosystem services provided by Cusuco national park, Honduras
  water flow, erosion protection, carbon sequestration