Darwin Initiative for the Survival of Species

Annual Report

1. Darwin Project Information

Project Ref. Number	162/12/014
Project Title	*Biodiversity and functional value of Amazonian primary, secondary and plantation forests*
Country(ies)	*UK, BRAZIL*
UK Contractor	*UNIVERSITY OF EAST ANGLIA*
Partner Organisation(s)	*MUSEU PARAENSE EMILIO GOELDI (MPEG/CNPq)*
Darwin Grant Value	*£125,999*
Start/End dates	*1/MAY/2003 – 30/APRIL/2006*
Reporting period (1 Apr 200x to 31 Mar 200y) and report number (1,2,3..)	1 November 2003 to 30 April 2004
Project website	*www.uea.ac.uk/e079/projects/jari*
Author(s), date	*Barlow, Jos; Peres, Carlos; Ferreira, Leandro.*

2. Project Background

- This project will be conducted in the 1.7 million ha landholding owned by Jari Celulose S.A., located on the border between Amapá and Pará in the north-eastern Amazon basin (00^{o}27'00" -- 01^{o}30'00" S; 51^{o}40'00" -- 53^{o}20'00" W). This landholding was purchased in 1967 for the establishment of large-scale fast-growing tree plantations of *Gmelina arborea*, *Pinus caribaea*, and *Eucalyptus urograndis*. Ultimately, we aim to elucidate whether and to what extent the direct benefits and indirect ecosystem services derived from either retaining primary forests or allowing natural regrowth outweigh those from different types of exotic tree plantations. Local Brazilian students have already been selected for training, and we have begun to sample the 12 faunal and 2 vascular plant taxa that have been earmarked for study within the extensive swathes of natural second-growth, primary forest, and *Eucalyptus* monocultures .

3. Project Purpose and Outputs

- The purpose of this project remains the same as stated in the original logical framework, this being "To quantify the biodiversity value of exotic plantation forests and native second-growth stands in Amazonia, critically assessing their value in terms of ecosystem functions and carbon sequestration, helping the Brazilian government and other developing countries to optimise their options in meeting international biodiversity and carbon commitments". Project outputs also remain the same, and include the assessment of species diversity of key indicator taxonomic groups, the assessment of the relative value of these forests in terms of carbon sequestration and key ecosystem functions, the training of local students and field technicians able to assess and monitor Amazonian biodiversity, a series of high impact publications and presentations, and a final workshop to be convened at MPEG, Belém.

- The proposed operational plan has been significantly augmented with the proposed sampling of 4 additional faunal taxa, including two key pollinator groups (stingless and euglossine bees), large terrestrial spiders, and all leaf-litter macro invertebrates. These groups have been added due to the important contribution they make to Amazonian biodiversity and ecosystem functioning, the high level of expertise within our principal collaborating institution (Museu Goeldi, MPEG/CNPq), and their relative ease and low cost of sampling.

4. Progress

- A 1-month trip to Brazil was made by Dr. Carlos Peres and Dr. Jos Barlow in May 2003, where discussions were held with partners in our collaborating institution (Museu Goeldi), and the private company who own the land where fieldwork will take place (Jari Celulose/ORSA Florestal). Necessary legal agreements were drawn up and signed between these three organisations in June and July 2003, and sampling sites were identified within the Jari region. The project proposal was translated into Portuguese, and applications for project approval and for collecting permits were made to the CNPq (Brazilian Science Council) in early August. Despite a high level of support from Brazilian counterparts and the UK scientific attaché in Brasília, there was a considerable (150 day) delay in CNPq's decision on project approval, resulting in a corresponding delay in the onset of fieldwork. The large amount of time and energy invested in this bureaucratic process is in line with the institutional complexity of this unprecedented project in neotropical forests.

- The commencement of fieldwork was moved from the predicted September 2003 date to March 2004. All slippage can be attributed to the delay in project approval from CNPq. This was compensated for by an additional detailed spatial examination of the region in GIS and a context meta-analysis on all forms of anthropogenic disturbance in Amazonian forests which has been submitted to Conservation Biology, and will form the first project publication (which we anticipate will be published 1 year ahead of schedule). In addition, we have been able to cement further ties with Brazilian collaborators at MPEG and INPA (National Institute for Amazonian Research), and have been able to include a further four faunal taxonomic groups in our methodology. The selection of the first group of MPEG masters students has also been conducted on schedule by our Brazilian counterparts.

Over the last year project investigators have developed detailed methodologies for the sampling of 12 plant and animal groups, which will provide the first multi-taxa assessment of forest biodiversity in different land use options in the neotropics. These have been established following consultation with expert taxonomists and ecologists, and are designed to maximise sampling efficiency whilst being achievable within the time constraints of the project. The basic methods are summarised for each group in tabular format below, while Fig. 1 shows a schematic layout of the sampling configuration at each site. All sampling sites have been selected, using a

combination of GIS maps, satellite images, local knowledge, all of which were tested and ground-truthed by a thorough *in situ* examination of suitability. Site selection was based on the trade off between maximising the spatial extent of sites, the size of the sites (to minimise spill over effects), underlying topography and soil type, and physical accessibility. Transects of 2-5 km have now been cut, marked and mapped in all 15 sites, and the sampling of the large vertebrate fauna is now underway. A more detailed methodological description is available in Appendix 2.

Table 1. Basic methodological details for sampling

Taxonomic group	Sampling technique
Large vascular plants	1-ha plots for trees ≥10cm DBH and lianas ≥5 cm DBH.
Small vascular plants (<10cm DBH)	0.1 ha "Gentry" subplot located within each 1 ha plot
Small mammals	Tomahawk & Sherman live traps
Large vertebrates	5-km line transect censuses and camera traps.
Birds	Mist nets (24 nets along each transect) and direct observation using point counts.
Reptiles	Pitfall and Funnel traps and 1km line transect censuses
Anurans (frogs and toads)	Pitfall and Funnel traps and 1km line transect censuses
Frugivorous butterflies (Nymphalidae)	Canopy and understorey traps baited with fermented banana
Fruit flies (Drosophilidae)	PVC Canopy and understorey traps baited with fermented banana
Dung beetles (Scarabaeidae)	Pitfall traps and Flight Intercept Traps (FIT)
Euglossine bees	Netting of cineol and eugenol pheromone baits
Stingless bees (Meliponinae)	Netting of paper baited with sugar water
Leaf-litter macro invertebrates	Sieving of leaf litter samples.
Spiders	Pitfall traps

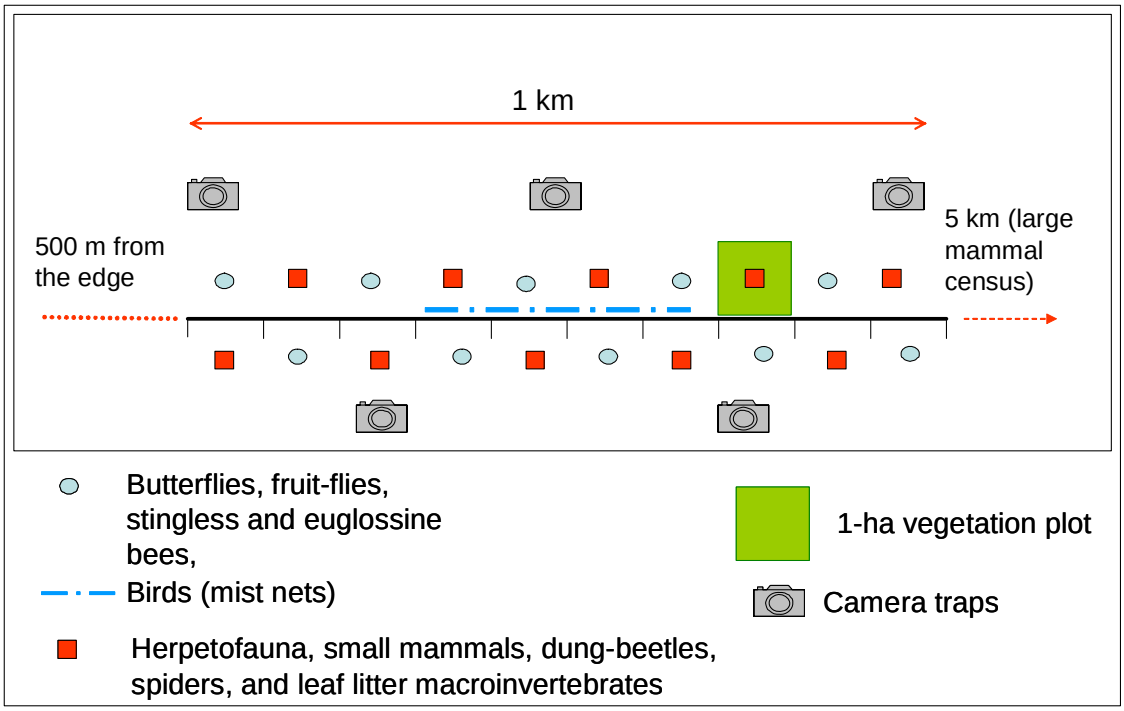

Figure 1. Schematic layout of the configuration of sampling at each forest site.

- Project approval in CNPq (the Brazilian Science Council) and IBAMA (Brazilian Institute of Natural Renewable Resources) proved the most significant difficulty we encountered in the first year, and was dealt with through frequent contact with CNPq via the UK scientific attaché in Brasilia and our MPEG collaborators. *We have also encountered a number of unanticipated substantial logistical problems in the field, principally regarding the state of the road network during the rainy season, and accessibility to a number of the most suitable sampling sites.* In particular this applies to the large areas of second growth, where road networks have been neglected for 14-18 years. As a result of this, travel time between sites has been considerably higher than expected, and it has been necessary for the project to purchase another second-hand 4x4 vehicle (a 4x4 Toyota Bandeirante, to complement the 4x4 Toyota already available), enabling two teams of researchers to sample independently of each other. This independence is critical in allowing effective simultaneous sampling of all the focal taxonomic groups, given the large number of PIs involved.
- Methodologies for multi-taxa sampling have been refined considerably following liaison with many experienced taxonomists and ecologists.

Project implementation timetable for 01/05/2004 – 30/04/2005

Date	*Key Project milestones*
May-July, 2004	Initiation of supervised training programmes, first butterfly census, and start of saurofauna sampling. Continuation of line transect censuses. Establishment of long-term forest monitoring (phenology) at all sites. First month-long dung beetle survey
August, 2004	Second butterfly census
September - October, 2004	Start of bird surveys; census of stingless and Euglossine bees in all locations.
November - December, 2004.	Third butterfly census, and conclusion of bird surveys
February, 2005	Fourth and final butterfly census, initiation of small mammal census. Initiation of spider census
March-April, 2005	Census of drosophilids and second dung-beetle census in all locations

5.

n/a

6. Partnerships

- The level of collaboration between UEA and MPEG investigators has been considerably higher than anticipated, and has resulted in the exchange of many ideas and experiences between investigators. This has proved enormously advantageous to the project, has enabled additional important taxa to be studied, and has aided in the development of robust sampling protocols based on tried and tested techniques developed by experienced taxonomists and ecologists.
- The project has been collaborating with TEAM (Tropical Ecology, Assessment, and Monitoring Initiative) members in the US and Brazil in order to standardise our vegetation and butterfly methodologies. We have also been in close contact with local IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) officials in charge of the Estação Ecológica do Jari, and will include the first ever quantification of the fauna of this reserve within our sampling

protocol. In addition, collaborative links have been established between expert taxonomists at a range of Brazilian and UK institutions, including INPA (Instituto Nacional de Pesquisas da Amazônia) for small mammals, the Universidade Federal de Paraiba and the Natural History Museum in London for dung beetles, USP (Universidade de São Paulo) for the herpetofauna, and EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária) for stingless (Meliponinae) bees. Finally, we have been in contact with the principal local education and health charity (Fundação Orsa), with the aim of promoting an environmental education programme for school children within the six principal cities and towns in the Almeirim municipality. We already anticipate that the project will lead to a long-term productive research and extension partnership between ourselves, Museu Goeldi, Fundação Orsa, and Jari Celulose S.A.

7. Impact and Sustainability

- Consultation and contact with a range of Brazilian scientists has helped raise the project profile within the Brazilian scientific community. Over time, it has become increasingly apparent that the project has helped Brazilian taxonomists to become involved in broader environmental issues, thus escaping their traditional isolation in established herbaria and zoological collections. Close collaboration between conservation biologists, ecologists and taxonomists is imperative for enabling effective conservation planning and research. However, scientists involved in these separate disciplines rarely have the opportunity to collaborate and combine their collective expertise. Researchers of the Museu Goeldi have demonstrated considerable interest and enthusiasm towards ensuring the success of this project, thus helping to advance the future remit of work conducted by members of this premier Amazonian natural history museum. Moreover, the project has been warmly received within the management team of Jari Celulose, a critical stage in ensuring the development of environmental awareness within the company. In particular Jari Celulose has the potential to provide an examplary management strategy for the growing number silvicultural and forest management companies in Brazil. The project will terminate with a workshop in Belem, where all relevant parties will be brought together to discuss results and draw up management recommendations for a policy document, which will be unvailed to the press and the relevant local and national Brazilian government departments.

8. Post-Project Follow up Activities

n/a

9. Outputs, Outcomes and Dissemination

- Two of the three Year 1 activities have been completed in full, namely the establishment of experimental design and considerations of spatial scale using GIS, and the selection of local students for the training of Brazilian counterparts. The third activity, our field research programme, is now fully underway, despite being held back by bureaucratic delays in the processing of research permits at Brasília level.
- Local dissemination of results to school children and adults in the Jari area will be facilitated through links established with the principal local education and health charity (Fundação Orsa). We have also made two presentations to the directors and managers of two companies (Jari Celulose and Orsa Florestal), outlining both the rationale behind the work, and why the results are important for the landscape-scale management of their plantations and managed forests. Both presentations were met with enthusiasm, and we intend to continue 6 monthly presentations and frequent personal exchanges in order to outline progress, describe our findings and discuss their implications.

Table 1. Project Outputs (According to Standard Output Measures)

Code No.	Quantity	Description
4A & 4C	8	Local Brazilian MSc and undergraduate students to receive 30-90 days training on quantitative biodiversity surveys.
8	16 weeks	Fieldwork; 12 weeks (Dr. J. Barlow), 4 weeks (Dr. C.Peres)
11	1	1st paper submitted (to Conservation Biology)

Table 2: Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	Cost £
				-

10. Project Expenditure

Table 3: Project expenditure during the reporting period (Defra Financial Year 01 April to 31 March)

Item	Budget (please indicate which document you refer to if other than your project schedule)	Expenditure	Balance

11. Monitoring, Evaluation and Lessons

- The success of this project in the coming year will be easily determined by evaluating our progress in the sampling of the faunal and floral taxa across the Jari landscape, and in the number of local Brazilian students that are trained as a result. Achieving this ambitious proposed sampling regime is necessary to fulfil the original project purpose, and to allow the project to move towards the data analysis phase and final dissemination of results.

- We have learned that applications for visas and project approval can be a lengthy process in Brazil, lasting considerably longer than was predicted from the estimates on official forms. In the future, pre-project grants would be helpful to help establish the necessary legal collaborative agreements between institutions, while more time should be allocated between notification of grant success and the start of the project in order to provide more time for the processing of permits and visas. This is particularly the case of Latin American countries that are explicitly concerned with issues of illegal specimen collecting and biopiracy such as Brazil.

12.

■ **I agree for ECTF and the Darwin Secretariat to publish the content of this section**

One of the most outstanding achievements of this project is the extent to which we have been able to integrate the project within a framework of reputable local, regional and national institutions, thereby maximising the input of experienced ecologists and taxonomists, and resulting in the proposed sampling of four additional faunal indicators of forest ecosystem stability and functioning. Such support means that this project now promises to be the most comprehensive cross-taxa comparison of the effects of disturbance ever conducted in neotropical forests, and will consequently provide definitive answers to the complex trade-off between rapid carbon sequestration and local biodiversity conservation in tropical countries. The institutional agreements and implementation of the project will also ensure a maximum degree of policy impact of project results, especially in the complex arena of Brazilian government agencies.

Annex 1 Report of progress and achievements against Logical Framework for Financial Year: 2003/2004

Project summary	Measurable Indicators	Progress and Achievements April 2003-Mar 2004	Actions required/planned for next period
Goal*:* To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve • The conservation of biological diversity, • The sustainable use of its components, and • The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources			
Purpose *(insert original project purpose statement)* To quantify the biodiversity value of exotic plantation forests and native second- growth stands in Amazonia, critically assessing their value in terms of ecosystem functions and carbon sequestration, helping the Brazilian government and other developing countries to optimise their options in meeting international biodiversity and carbon commitments.	*(insert original purpose level indicators)* New and unique knowledge on biodiversity value of plantation forestry in neotropical forests. Quantitative comparison of the social, economic and ecological benefits between plantation forestry, natural regeneration, and primary forest. Results that provide the Brazilian government with information helping them fulfil commitments to the Conventions on Biological Diversity and Climate.	*(report impacts and achievements resulting from the project against purpose indicators – if any)* Data collection underway.	*(report any lessons learned resulting from the project & highlight key actions planning for next period)* Continue data collection.
Outputs			
(insert original outputs – one per line)	*(insert original output level indicators)*	*(report completed activities and outcomes that contribute toward outputs and indicators)*	*(report any lessons learned resulting from the project & highlight key actions planning for next*

Assessment of species diversity of key indicator taxa.	Quantitative field data from 10 vertebrate, invertebrate and plant taxa.	Methodologies established for all taxa. All sampling sites selected, and transects prepared. Data collection underway for phenology plots and for large mammal abundance data.	*period)*
Assessment of relative value of these forests in terms of carbon sequestration and key ecosystem functions.	Comparable measurements of carbon value and hydrological processes within each forest type.	Establishment of year round sampling of leaf-litter turnover, phenology, RH, temperature, and rainfall at each site.	Receive and analyse soil carbon and biomass data already collected by Jari Celulose in plantations and primary forest. Continue monitoring schemes.
Local students and field technicians able to assess and monitor the biodiversity value of plantation and native forests.	Minimum of 30 local Brazilian students trained in quantitative biodiversity surveys, and methods of project design.	Six MSc students have been selected from MPEG to receive taxa-specific training and supervision.	Assist and train selected students, and begin selection process for more. Examine trade off between giving a small amount of training to a large number of students against giving a large amount of training to a smaller number of students.
Publications, presentations and MPEG workshop, Belem.	Fifteen papers in peer-reviewed scientific journals, and high-circulation Brazilian science magazines.	First publication sent to Conservation Biology. Initiation of data collection.	Collection of data for further publications.

Note: Please do NOT expand rows to include activities since their completion and outcomes should be reported under the column on progress and achievements at output and purpose levels.

APPENDIX 1.

ORIGINAL LOGICAL FRAMEWORK

Project summary	*Measurable indicators*	*Means of verification*	*Important assumptions*
Goal: To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve • the conservation of biological diversity, • the sustainable use of its components, and • the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources			
Purpose To quantify the biodivsersity value of exotic plantation forests and native second-growth stands in Amazonia, critically assessing their value in terms of ecosystem functions and carbon sequestration, helping the Brazilian government and other developing countries to optimise their options in meeting international biodiversity and carbon commitments.	New and unique knowledge on biodiversity value of planatation forestry in neotropical forests. Quantitative comparison of the social, economic and ecological benefits between plantation forestry, natural regeneration, and primary forest. Results that provide the Brazilian government with information helping them fulfill commitments to the Conventions on Biological Diversity and Climate.	Field survey data Publications in high-impact scientific journals Reports in Brazilian high-circulation popular science magazines (e.g. Ciencia Hoje). Reports to Brazilian governmental departments including Ministerio do Meio Ambiente (MMA) and Ministerio da Ciencia e Tecnologia (MCT).	That new knowledge will actually be used by state-level and federal government agencies to plan, design and regulate the use of plantation forestry in Amazonia That any resulting policy changes will be implemented effectively. That several of the lessons and insights from this project will be generalised to other key tropical forest countries.

Outputs Assessment of species diversity of key indicator taxa. Assessment of relative value of these forests in terms of carbon sequestration and key ecosystem functions. Local students and field technicians able to assess and monitor the biodiversity value of plantation and native forests. Publications, presentations and MPEG workshop, Belem.	Quantitative field data from 10 vertebrate, invertebrate and plant taxa. Comparable measurements of carbon value and hydrological processes within each forest type. Minimum of 30 local Brazilian students trained in quantitative biodiversity surveys, and methods of projet design. Fifteen papers in peer-reviewed scientific journals, and high-circulation Brazilian science magazines.	Survey reports, biodiversity database and correspondence files from collaborators; Survey reports, data and correspondence files from internal collaboraters Field survey reports, correspondence files from collaborators detailing student involvements and skills gained. Copies of all publications, conference abstracts and workshop proceedings sent to DEFRA (Darwin Initiative).	Proposed methods will allow reasonably rapid and standardised quantification of biodiversity. Adequate students can be identified from within partnership institutions. Results are adequate to provide novel publications. Impact of the MPEG Workshop and publications will be sufficiently significant to influence land use policy through IBAMA, MCT, INCRA, and Min. Agriculture.
Activities Establishment of experimental design and considerations of spatial scale; Training of Brazilian counterparts; Field research programme; Data analysis; Dissemination of results; MPEG Workshop.	**Activity Milestones (Summary of Project Implementation Timetable)** Yr1: Formal assessment of Jari Florestal Project, including spatial mapping and ageing of all forest plots and forestry compartments and integration into GIS database (2 months; May-June 2003). Yr1: Selection of Brazilian students from collaborating institutions. Initiation of short field courses and supervised training programme (2 months; July-August 2003). Yr 1 -Yr3: Sampling protocol of main surveys agreed by August 2003. Fieldwork begins, surveys targetting specific taxa, and including 18 month quantification of seasonal changes and phenological patterns (Sept 2003 - February 2005). Yr 3: Termination of field data collection (Dec 2005). Ongoing analysis conducted throughout the period of data collection will be enhanced and finalisedshortly after (Jan 2005) Yr 3: First high-impact publication (Sept 2005) followed by others both in Portuguese and English (Jan 2006-April 2006). Information summarised and presented to Brazilian Government.and NGO's during and following the MPEG Workshop (Feb 2006).		

Appendix 2.

Sampling design

Sampling will be conducted within three different habitat types: commercial *Eucalyptus* tree plantations, native second-growth, and primary forests. Each habitat type will be sampled five times, achieving a statistically meaningful number of replicates. Each sample will include a series of standardized and repeatable censuses, encompassing the vegetation and targeting eleven different faunal taxa. Specific methodologies are described below.

Vegetation

At each sample location a one-hectare plot (100 x 100m) will be marked, and all trees <10cm DBH (Diameter at Breast Height, or above the tallest buttress) that lie within the plot (excluding those with more than half of their basal trunk outside the plot) will be measured and identified. Forest floor regeneration will be examined in 0.1-ha subplots, placed at random within each one-hectare plot. All saplings and stems <10cm DBH and taller than 1-m in height will be measured, and whenever possible identified to genus or species. This will be coordinated by Dr Leandro Ferreira of MPEG, following widely used methodology (see the TEAM vegetation protocol at http://www.teaminitiative.org/wombatmx/team/application/resources/index.cfm).

Canopy cover will quantified with the use of a spherical densiometer at 24 evenly spaced points within each plot (Lemmon, 1957) and the use of digital hemispherical photography. Understorey vegetation density will be measured using a 2.5-m graduated pole held vertically and examined at 12 m distance by an observer with binoculars. Readings will be taken according to the number of 10-cm pole sections (range: 0 – 25) that are clearly visible, and the procedure will be repeated 50 times within each plot.

Vertebrates

Large vertebrates: Photo-trap censuses

To maximize our detection probabilities of nocturnal and cryptic wildlife species (e.g. felids, canids, procyonids, and other small carnivores) we will use camera-traps with

a commercially available scent (Hawbaker's Wild Cat Lure #2) in all forest sites surveyed, according to a protocol successfully tested in over 12 tropical forest countries by Jim Sanderson (pers. comm.). Cameras will be deployed in an uniform fashion at each site within trail grids, thus minimising the extent of the uncovered areas. They will be equally spaced, so that each camera site will be approximately 500 m from the nearest neighbouring site (J. Sanderson, pers. comm.) thus restricting the variance in photo-trap density and maximising the comparability across all samples.

The cameras will be placed 1m above the ground to obtain photos of a wide range of vertebrates, and will remain in each site for a period of 30 days, being checked every 4 days to renew the scent-bait, batteries and film as necessary. Print films will be developed and the photographs will be analysed according to presence or absence of all species recorded at each photo-trap station. Quick reference information such as camera number, GPS location, and date and time will be noted in the field and subsequently recorded on the reverse side of each print. A total of 19 Camtrakker phototraps will become available for this study sometime by mid 2004.

Large Mammals: Line transects

Diurnal and nocturnal censuses will be carried out in all forest sites selected. The census replicates on the same transects will be distributed across a period of 12 months. Line-transect censuses will be carried out using 3 transects of up to 5 km in length in each habitat type. Population density estimates will follow the routine outlined in Buckland et al. (1993) with a few adjustments to take into account differences in sampling effort. Line-transect censuses will target several groups of diurnal and nocturnal vertebrates amenable to censuses on foot, which comprise the bulk of the vertebrate biomass in Amazonian forests. In the Jari region, these include primates, ungulates, agoutis, sciurids, tinamids, trumpeters, cracids, woodquails, and some diurnal carnivores by day; and didelphid marsupials, echimyid rodents, pacas, night monkeys, armadillos and procyonids by night. Our line-transect census procedures will follow the general guidelines described in Peres (1999b) but will include a minimum of 300 km of cumulative census walks per sampling site, once data from all three transects are pooled together.

Birds

A standardised mist-netting protocol will be used to sample the understorey avifauna at each site. At each sampling location 24 mist nets (12 x 2.5 m; mesh size 36mm)

will be erected end to end in a straight line (with a gap of c. 50 cm between nets, used to adjust tension and account for changes in humidity), creating a line of nets extending for around 320 m once large obstacles such as tree falls are avoided. Nets will be opened for two and a half days (30 hours), from dawn to dusk for the first two days and from dawn to 1200 h on the third day, following Barlow et al. (2002). Additionally, a number of timed point counts will be carried out at the same sites in a two month period towards the end of the study. Furthermore, large birds (such as toucans Ramphastus spp., parrots Amazonas spp. & guans Penelope spp.) will be censused along line transects, during the large mammal surveys, facilitating the calculation of their population densities within each habitat type.

Herpetofauna

Leaf-litter lizards and leaf dwelling amphibians will be sampled using pit-fall trapping sites, each consisting of a single 1 km transect. Individual trap arrays will consist of 4 x 35 litre buckets arranged in a 3-pronged star design, with each bucket separated by a 6 m plastic drift fence 60 cm high. These will be placed every 100 m along a transect. All 40 buckets at each site will be checked for captures every day. Each site will be surveyed over one week, and one representative site from all 3 habitat types will be surveyed during every 4 week period. A total of 5 sites per habitat type will be surveyed in approximately 5 months, with the entire sample being repeated in both the dry and wet seasons. Plastic buckets along pit-fall trapping stations will be covered with a lid to prevent captures outside monitoring periods. All unidentified specimens will photographed with a digital camera and voucher specimens will be identified under a joint collaboration with Dr. Teresa Cristina Ávila-Pires at the MPEG.

Small mammals

One hundred Tomahawk and 30 Sherman small mammal traps will be placed in clusters of 13 (ten Tomahawk and three Sherman) at ten places along each 1km transect, with each sampling node separated by 100m. Traps will be strategically placed within each sampling node, consisting of a 20m transect cut perpendicular to the main transect. Traps will be run for a week at each site, equalling 10,500 trap nights of effort. All work will be conducted in conjunction with Maria de Nazereth da Silva at INPA, where any unidentified specimens will be sent and processed.

Invertebrates

Butterflies

Butterflies will be surveyed using specially designed banana-baited butterfly traps, which attract adult butterflies in the family Nymphalidae, comprising up to 40% of the total butterfly fauna (De Vries and Walla 2001). Trap lines will be run in each survey area, with 10 traps spaced 40 m apart per line of 400 m. Traps will be suspended 70cm from the ground, thus avoiding interference from terrestrial frugivorous mammals, and will be run for a total of 6 days during each sample. They will be baited with locally obtained bananas, mashed and fermented for 2 days prior to use. Bait is added to the traps on the 1st day of each sample, and refreshed on the 3rd day. Up to 100 traps will be run at any one time, allowing each butterfly census to be condensed into a 1 month period. This protocol will then be repeated every 3 months (i.e. four times over a single year), thereby taking account of seasonal trends in abundance, and capturing the maximum number of species within each habitat type.

Fruit-flies (Drosophilids)

Fruit-flies (Drosophilidae, Diptera) will be sampled using specially designed traps constructed with a PVC pipe and modified by Martins (1987). The inner and lower portions of this trap is connected to a transparent inverted funnel through which the flies, attracted by mashed bananas in fermentation, will enter and become trapped in a plastic vial attached to the funnel. Trap spacing and the sampling protocol will reflect that used for butterfly sampling, although due to the typically large numbers of drosophilids captured, and the amount of time necessary for post-capture identification at MPEG, fruit-flies will only be censused once at each forest site location. Sampling will therefore be restricted to a single 3-month period (to be selected by Dr Marlúcia Martins, Zoologia/MPEG) in order to minimise any seasonal bias. All voucher specimens collected will be preserved in alcohol and transported to the MPEG collection for identification.

Dung-beetles (Scarabaeidae)

Both baited pitfall traps and flight intercept traps will be used to sample the dung community. Specimens will be sorted into morphospecies in the field laboratory, and examples of each type will be pinned and sent to the department of Systematics and Ecology, Federal University of Paraiba (UFPB) for identification by Dr M.I. Medina Hernandez.

Stingless bees (Meliponinae)

These bees will be sampled using a methodology developed in conjunction with Dr. Giorgio Venturieri (Embrapa-Cpatu) in Belém. Ten 20cm X 20cm pieces of blotting

paper soaked in sugared water will be spaced along each transect and suspended 1m from the ground. Each paper attractant will be left in the forest for 3 hours (10-1pm), before attracted bees are captured with sweep nets.

Euglossine bees

These bees will be sampled using a methodology developed by Dr. William Overal from MPEG. Bees will be sampled using chemical attractants (cineol and eugenol), spaced evenly along each transect and suspended 1m from the ground. Each attractant will be left in the forest for 3 hours (10-1pm), before attracted bees are captured with sweep nets.

Spiders

These will be sampled in the same pitfall arrays used to capture the herpetofauna, though using only the central bucket of each array to because of the large number of potential captures. All Spiders and other macro-invertebrates will be collected and sent for identification by Dr. Alexandre Bragio Bonaldo of MPEG.

Leaf-litter macro-invertebrates

These will be sampled by sieving $1m^2$ leaf litter samples (10 per site) using sieves of decreasing mesh size. All macro-invertebrates will be collected and sent for identification by Dr. Alexandre Bragio Bonaldo of MPEG.