# Darwin Initiative Main Project Annual Report

**Important note:** *To be completed with reference to the Reporting Guidance Notes for Project Leaders: it is expected that this report will be about 10 pages in length, excluding annexes*

**Submission Deadline: 30 April (extended to May)**

## Darwin Project Information

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| Project Reference | 20-001 |
| Project Title | Managing the landscape-scale sustainability of Amazonian freshwater fisheries |
| Host Country/ies | Brazil |
| Contract Holder Institution | University of East Anglia (UEA) |
| Partner institutions | SDS/CEUC, ICMBio, UFAM, INPA, UFRN, ASPROC, AMARU and COLPESCA (all in Brazil) |
| Darwin Grant Value | |
| Start/end dates of project | 1 July 2013 – 30 April 2016 |
| Reporting period | Annual Report 2: March 2014 – April 2015 |
| Project Leader name | *Prof Carlos Peres* |
| Project website | Not yet available |
| Report author(s) and date | Prof Carlos Peres (UEA), João Vitor Campos e Silva (UFRN) and Dr Joseph Hawes (Museu Goeldi, Brazil). |

## 1. Project Rationale

Around one third of all vertebrate species worldwide are freshwater organisms. With rapidly increasing human populations, freshwater bodies and wetlands are rapidly becoming the most threatened ecosystems worldwide, particularly in the tropics. Lowland Amazonia supports the largest expanses of seasonally flooded forests, the largest and most valuable freshwater fishery, and the most species-rich fish fauna on Earth. Aquatic vertebrates (including fish, turtles and crocodilians) provide ~75% of the animal protein demands of rural Amazonians, who consume 369 – 800 g of fish person$^{-1}$ day$^{-1}$, the highest per-capita fish protein intake recorded anywhere. Consequently, inland fisheries along major tributaries of the Amazon continue to be severely overexploited, particularly high-value large-bodied slow life-history species that are highly desirable by commercial fishing boats. Yet basic life-history data and stock-recruitment relationships necessary to implement effective quantitative fisheries assessments and management are still lacking.

This Darwin Project aims to understand the biology of key aquatic resource populations in Western Brazilian Amazonia, and develop a spatially-explicit set of guidelines to inform landscape-scale fishery management protocols that can be applied to any major watershed across all lowland Amazonian countries. In particular, we have been using a network of 83 large oxbow lakes and 97 sandy fluvial beaches along the second-largest white-water tributary of the Amazon to (1) consolidate 'fishing agreements' to zone the spatial structure of commercial and subsistence fishing activities; (2) understand the relationship between

spawning biomass and fish recruitment, and how these stock-recruitment relationships depend on baseline environmental variables such as lake size, productivity, and macrophyte cover; (3) understand the demographic importance of 'no-take' areas (i.e. strictly protected lakes and fluvial beaches) in maintaining a sustainable fishery and the spatial dynamics of commercial fishing boats; (4) resolve political conflicts between commercial and subsistence fisheries; and (5) assist government agencies in both developing exploitation management protocols (for commercially valuable fish and Podocnemis turtle species) and dealing with key human-wildlife conflicts in aquatic ecosystems.

This ongoing study has been conducted along a 492-km section of the Central Juruá basin within and around two contiguous sustainable-use forest reserves (Figure 1). The Juruá River is the second-largest white-water tributary of the Amazon (=Solimões) River, within the ~1.6 million km2 State of Amazonas, Brazil. The area contains two main forest types: seasonally flooded (várzea) forests along the river channel and higher elevation (terra-firme) forests which are never exposed to the seasonal flood pulse (Figure 1); and unlike other major tributaries of the Amazon, these floodplain forests have not been degraded by logging and water buffalo livestock. The alternating wet and dry seasons and corresponding fluctuations in floodplain water-level are between January and June, and August and November, respectively.

The federally-managed Médio Juruá Extractive Reserve (RESEX Médio Juruá) was created in 1997. Situated on the left bank of the river (5º33'54"S, 67º42'47"W) this 253,227-hectare reserve is inhabited by nearly 2,000 people living across 13 well-established communities. The more sparsely populated state-managed 632,949-ha Uacari Sustainable Development Reserve (RDS de Uacari) (5º43'58"S, 67º46'53"W), created in 2005, is inhabited by some 1,300 people across 32 communities. Local livelihoods in both reserves are sustained primarily by floodplain and river channel fisheries, subsistence agriculture and non-timber forest products, such as oil-seeds and palm fruits. Although these two reserves have very different 2nd-order management structures, they represent a continuum of human population density and are virtually identical in their natural environments and extractive livelihood patterns. We therefore decided to work with both of these reserves even though this involves a much larger area and twice the amount of project bureaucracy and communication with environmental agencies.

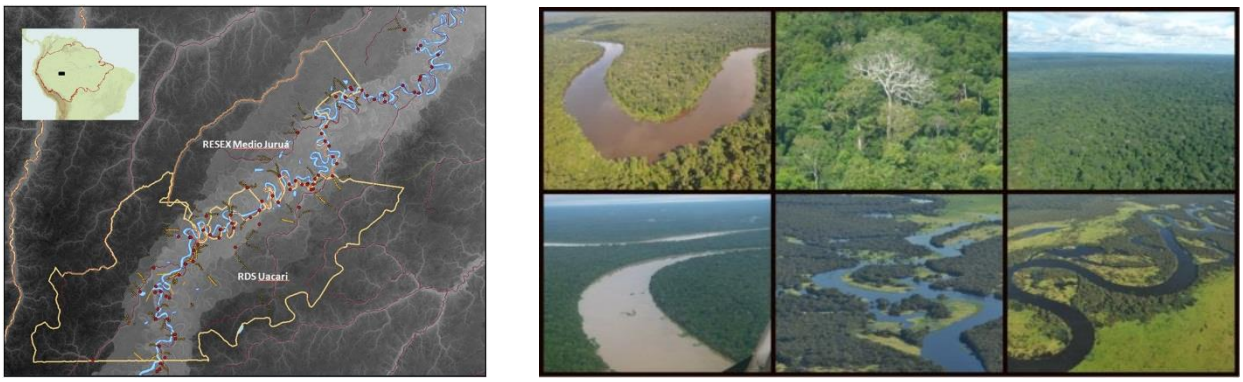


**Figure 1.** Core study area of **Darwin Initiative Project 20-001** along the Juruá River of Western Brazilian Amazonia (left panel). Local communities within the two focal forest reserves are indicated by red circles. Aerial views of *terra firme* and *várzea* forests in the Médio Juruá region (right panel).

## 2. Project Partnerships

A notable feature of this project is the strong and welcoming working relationship with all institutions involved in the management of natural resources in the project area. This partnership has been built by utilising the lengthy field experience of our staff in the area, and collaborative ties with certain individuals that now go back as far as 8 years. As the project has been designed considering partner demands, it was relatively easy to build a strong partnership considering both bottom-up demands and top-down constraints. Next, we describe our partners as following:

a) **SDS/CEUC** – Secretaria do Meio Ambiente e Desenvolvimento Sustentável do Amazonas e Centro Estadual de Unidades de Conservação (http://www.sds.am.gov.br/) — This underfunded state agency based in the state capital (Manaus), with only 58 full-time staff, is responsible for the impossible task of managing 41 large protected areas across the State of Amazonas, comprising a total area larger than England of 18.7 million hectares. This partnership is strategic to the project objectives because SDS/CEUC hopes to be able to roll out the applied knowledge generated by our project to other sustainable use forest reserves within Amazonas. All project activities undergo a technical evaluation by this partner, who is given ample freedom to discuss the proposals and objectives. In addition to legal support to work within their jurisdiction, SDS/CEUC also helps with the logistics of the project as it occasionally provides small boats for field activities.

b) **ICMBio** – Instituto Chico Mendes de Conservação da Biodiversidade (http://www.icmbio.gov.br/portal/) — This federal government agency is responsible for managing the federal protected area where we work (RESEX Médio Juruá). We also have a strong relationship with this partner which participates in the project in a similar way to SDS/CEUC. All project activities are sent to and analysed by this partner. This will also become a strategic partner as the project advances because, with ICMBio's oversight, it will be possible to eventually scale up and apply the management models demonstrated by this project to protected areas in the other eight states of Brazilian Amazonia.

c) **UFAM** – Universidade Federal do Amazonas (http://www.ufam.edu.br/) — The Universidade Federal do Amazonas is the oldest in Brazil. It is an important Project partner because project members based therein are responsible for the freshwater turtle ecology and management component of the project. Through Projeto Pé de Pincha (http://pedepincha.com.br/) UFAM has been studying the ecology and management of freshwater turtles for 15 years, and this project has enabled these activities to be extended to the Juruá. They will contribute knowledge on the seasonal movements, foraging ecology, and management of freshwater turtles, as proposed by our project. These activities are intimately linked to zoning and protection of fluvial beaches along the Juruá during the critical egg-laying season of two large-bodies species of Podocnemis turtles.

d) **INPA**- Instituto Nacional de Pesquisas do Amazonas (https://www.inpa.gov.br/) — INPA is the largest tropical ecology research institute anywhere and has extensive research experience in Amazonia (although most of the activities are concentrated around Manaus in the Central Brazilian Amazon). INPA has been providing the laboratory structure for all limnological analysis, and more recent research ties have been formed with fish ecology and fisheries researchers. INPA will also provide an MSc level student (Talles Colaço, to be co-supervised by Prof CA Peres and Dr Sidineia Amadio) who will work on ecology and management of Tambaqui (Colossoma macropomum) and its closely related species, Pirapitinga (Piaractus brachypomus), the commercially most important fish species in the Juruá fisheries (Figure 2).

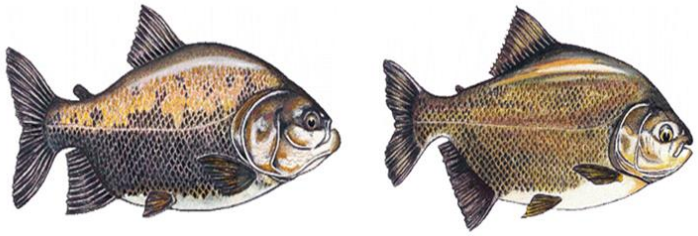

**Figure 2.** Two key commercially harvested fish species addressed by this project. *Colossoma macropomum* (left) and *Piaractus brachypomus (right)*. Source: IBAMA/PNDPA.

e) **UFRN** – Universidade Federal do Rio Grande do Norte (http://www.sistemas.ufrn.br/) UFRN has recently excelled in Brazil in the area of ecology. As a counterpart, UFRN provides a Brazilian doctoral scholarship to a core project member (João Vitor Campos e Silva). His dissertation involves the management of aquatic resources of the Juruá floodplains and the field and lab work are being funded by this project. UFRN also has great expertise in limnology and freshwater ecology, which is relevant to the project.

f) **ASPROC** – Associação dos Produtores Rurais de Carauari (http://www.asproc.org.br/) — ASPROC is the strongest local project partner, and operates as a spokesperson for local natural resource users because it is a grassroots, community-based organization which was borne out of local demands following the emancipation of former rubber tappers from powerful rubber landlords and local trade monopolies and middlemen. ASPROC is co-leading several programs of natural resource management, which are guided by a constant dialogue with project members. This partner strongly supports work on the ecology and management of the iconic Arapaima fish, and helps us build a close relationship with community leaders. The Arapaima ecology and management program has become a key cornerstone of the project, and is intimately related to the oxbow lake ecology and management components of the project.

g) **AMARU** – Associação dos Moradores da Reserva de Desonvolvimento Sustentável Uacari (http://amaru.org.br/) — Similarly to ASPROC, AMARU co-organises the practice of resource management in rural communities where our project has been implemented. This is also a key local partnership for the implementation of our activities. AMARU is closely in touch with local communities, and constantly reminds us of the demands and needs of the local population, so we can build our goals based on two important, but often diametrically opposite challenges in modern conservation science and practice: simultaneously improving living standards of traditional populations while protecting biodiversity.

h) **COLPESCA** – Colônia de Pesca de Carauari (Carauarí Fishermen Cooperative) — The township of Carauari operates as a convergence point for a fleet of over 800 variable-sized fishing boats and canoes that largely trades chilled fish with a few wholesale buyers, which export large amounts of fish to large urban markets like Manaus (2 million people). This partner is vital to the project success, and it exerts an enormous political influence in initially earning fishermen trust and then encouraging them to collaborate with the project, likely due to suspicion and resentment of outside researchers who are often mistrusted. There is a large historical conflict in the Juruá, where COLPESCA fishermen often violate property rights and transgress community boundaries in oxbow lakes located in protected areas in order to plunder fish stocks. Our project is opening the doors for a more formal dialogue and through our project COLPESCA commercial scale fishermen are presently working with local subsistence fishermen living within the project reserves. We intend to support and develop a fisheries protocol that avoids or minimises stakeholder conflicts, promotes the population recovery of harvest-sensitive fish stocks, and allows the wide acceptance of a large-scale spatial mosaic of locally-enforced fishing activities and fishing rights, whereby the land(water)scape stock renewal and source-sink dynamics can compensate for depletion effects induced by varying deployment and selectivity of fishing practices. This is crucial because fish has now become

the largest earner of monetary revenues in the Carauari municipal county, and commercial fishermen, who are themselves destitute and oppressed by powerful merchants up the trade chain, cannot be entirely excluded from the basin-wide spatial equation of fishery management. They also represent an important electorate, thereby harnessing support from local politicians.

# 3. Project Progress

We have advanced a great deal on the execution of a broad range of important activities right across the spectrum of proposed and new project initiatives. From August-November 2014, we conducted an intensive field work campaign during the dry season in our study region. This is the critical time of year for this project as it is only during the low-water season that conflicts over aquatic resources are exacerbated along the Juruá River; the fluvial beaches become exposed (for turtle and bird nesting); and oxbow lakes become isolated from the main river channel, stranding potentially large stocks of commercially valuable fish (when and where Arapaima and Colossoma are harvested).

## 3.1 Progress in carrying out project activities

### Output 1: Local empowerment and consolidation of an oxbow lake management system across the entire study landscape

We first conducted a detailed mapping effort of the most important fishing environments and sites both within and outside the protected areas, along the 500 km of the Juruá River hosting the project roaming activities. These environments include lakes, perennial streams, floodplains, the anastomosing system of paranãs and leveés, and others freshwater environments. This is a vast area because the floodplains throughout our study region (which are inundated by a persistent flood pulse lasting 5-6 months of the year) exceeds 40 km in average width. At present we have mapped over 350 sites where important local fisheries and fishing activities can occur.

Our study area is close to Carauari, a medium-sized city with 25,700 people and a fishing fleet larger than 300 boats. Thus, the pressure on reserves fish stocks is substantially higher. To ensure food and economic security of rural communities, fishing Agreements ("Acordos de Pesca") have been negotiated between local communities at two sustainable use reserves, communities from outside reserves, and the Carauari Fishermen Cooperative.

These agreements establish three categories of lake protection, during the dry season, when lakes become discrete landscape units. **Unprotected Lakes:** These lakes are open-access for all fishermen, including commercial boats. In these lakes, due to poaching, important vertebrate species such as Pirarucu (Arapaima sp.) and fresh water turtles (Podocnemis expansa, Podocnemis unifilis and Podocnemis sexturbeculata) are absent or sustain very small populations. **Subsistence Use Lakes**: This category allows access to only those fishermen from the community with direct usufruct rights to the lake, to ensure a stable local food supply, therefore preventing commercial fishing. **Protected Lakes**: Lakes within this category are managed lakes, therefore banning all fishing activities during most of the year. The lake is open only during the Pirarucú management season and the community responsible for protecting the lake can catch a previously agreed quota of managed fish. It is worth mentioning that these protected lakes sometimes can be invaded by outside fishermen. To deter poachers the communities build a floating house at the lake entrance and families take turn (24h • 7 days/week) to protect the lake, often using fire-weapons to deter recalcitrant poachers (Figure 3).

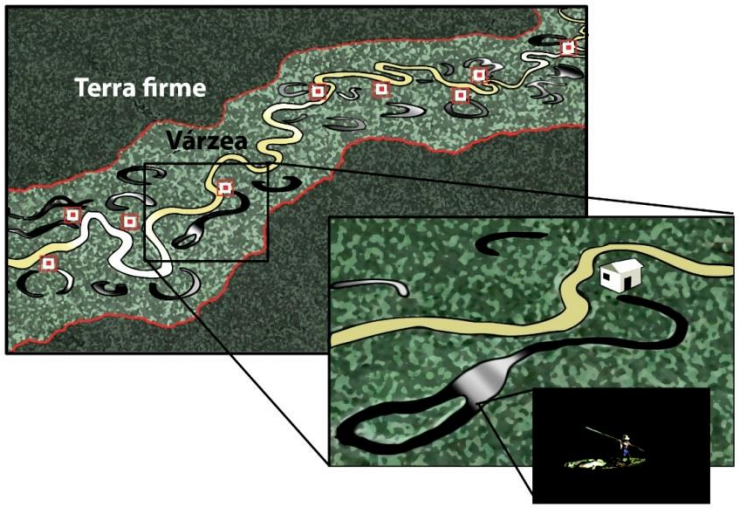


**Figure 3.** Summary diagram of community-based enforcement of protection within protected oxbow lakes along the floodplains of the Juruá River (from Campos Silva & Peres, in prep.)

We have implemented a household-level survey covering all types of aquatic resources extracted by ~400 households distributed across 35 local communities within and outside protected areas. These samples are part of a strong dataset that will enable us to investigate fisheries best-practices and the biological and landscape characteristics of key fish stocks. Based on a systematic series of local interviews, we selected 64 key oxbow lakes, which have experienced different levels of fishing pressure according to broad management category classes, and are characterized by different geochemical and limnological attributes that presumably control fish productivity (although this is being investigated). Many environmental variables have been collected in these lakes: we sampled a total of 64 oxbow lakes (size range = 3 – 550 ha) and this was repeated during both the dry and wet seasons.

We hypothesize that these variables largely control the baseline variation in fish productivity for both subsistence and commercial fisheries along the Juruá as oxbow lakes represent critical feeding and spawning habitat for several commercially important fish species. These limnological variables may therefore interact with key lake management issues that form the core of the spatial zoning of harvesting areas that we are understanding and implementing.

Moreover, we are interested in collateral effects of lakes management. So, we sampled many vertebrate taxa in both protected and unprotected lakes. Thus, we have a strong and detailed dataset with environmental constraints, landscape variables and the seasonal abundance of key vertebrate groups. An in-depth understanding the effects of lake management will be useful (see below for sampling protocols implemented at each lake).

a) Lake productivity -- We collected 64 water samples from 64 lakes during both the dry and the wet seasons. Variables sampled were water transparency, temperature, sediment load, conductivity, chlorophyll concentration, dissolved oxygen, and key macronutrient bioavailability (nitrogen and phosphorus). We found that primary productivity is low during the wet season, probably because the high-water level dilutes nutrient loads resulting in severely limited availability of some nutrients. At this time of year, the energetic input into the ecosystem is predominantly allochthonous. However, during the dry season, phytoplankton concentrations increase dramatically and the energetic sources became primarily autochthonous. This high primary productivity is very important for vertebrate populations when oxbow lakes become isolated from the main river channel. To substantiate the annual variation of this pattern we collected additional water samples from 20 lakes again. At the time of writing, the chemical and limnological analysis are being carried out at INPA's Limnology Lab; this work will form the abiotic basis for understanding variation in lake productivity for all fishery resources across our study landscape. In addition, water samples are currently being analysed by

INPA collaborators in a limnological lab at Liege University. We are interested in understanding how environmental variables drive the seasonal dynamics in phytoplankton assemblages.

b) Landscape variables -- The landscape variables that were measured include: distance to the nearest community, distance to the Juruá river channel, distance to the nearest urban centre (*Carauari*), shape and perimeter of lakes.

c) Bird community surveys -- We maintained bimonthly sampling on the entire piscivorous bird community of some 40 species at 32 oxbow lakes. Results so far show that species richness and abundance are high in both protected and unprotected lakes of varying size and geochemistry but vary in response to water level, possibly as a function of the seasonality in fish resource density, and these responses are likely to be species-specific.

d) Caiman censuses -- We conducted caiman censuses along the main river channel and within a focal group of 30 lakes to verify the benefits of protection for this group, which is likely to be affected by fish stock sizes. The number of large caimans is higher farther from the city, which concentrates hostile fishermen. Caiman abundance in protected lakes is impressive; some lakes may harbour over 4,500 caimans. During nocturnal census work, these lakes resemble night-time aerial views of large megacities, due to vast number of caiman eye-shines. More detailed analyses will be conducted from September this year.

e) Dolphin surveys -- During the dry season the two species of dolphins are restricted to a subset of lakes. To identify the drivers of dolphin habitat occupancy, we carried out visual censuses within all of our study lakes and conducted interviews with lake users. Apparently, the smaller dolphin (*Tucuxi, Sotalia fluviatilis*) is mainly restricted to the river channel; it is present only in large lakes connected to the river. However, Pink River Dolphins (*Inia geoffrensis*) are in most of lakes and in different habitat types, due their large body size and great adaptability in different environments. Our interviews revealed that Pink River Dolphins are an important agent of most conflicts, whereby fishermen report that they steal fish from gill-nets with impressive agility.

f) Turtle censuses -- We have now started the Podocnemis turtle sampling in our study lakes, and again there is a marked difference in turtle abundance between protected and unprotected lakes. It is known that the early development of turtle hatchlings occurs in the lakes, which are expected to be important for adults also. We found that protected lakes harbour a much higher turtle abundance, and predict that lake management class is likely to be very important, highlighting the conservation implications for aquatic chelonians.

g) Manatee surveys -- We conducted focal surveys assisted by highly experienced local assistants, who were former manatee spear-hunters, to estimate the abundance and distribution of Amazonian manatees (*Trichechus inunguis*) in both protected and unprotected lakes, both inside and outside the two extractive reserves. Sampling also occurred along the main river channel where manatee abundance is highest during the dry season. This is an ongoing part of the project that will require many more visits to individual lakes and river segments. However, early results indicate that manatee populations are present in many environments, both within and outside lakes, and in both protected and unprotected areas. The historical persecution of manatee appears to have been arrested - hunting of manatee is prohibited and the hunting techniques required are very complex - and populations are now in a clear process of recovery.

h) Sonar censuses of large aquatic vertebrates -- We also started the aquatic vertebrate censuses with a conventional short-range FishFinder® sonar attached to an aluminium boat or dugout canoe to record the depth distribution and bathymetry profile along georeferenced transects in our focal group of oxbow lakes. Using this methodology we

concurrently recorded the presence and number of fish shoals or large aquatic mammals such as dolphins and manatees.

i) Local interviews -- We carried out local interviews with more than 100 fishermen who routinely use lakes for both subsistence and commercial fishing activities. We collected information about the physical accessibility, level of protection, human-wildlife conflicts, and local agreements (i.e. fishing accords) to initiate the often thorny legalization process of fishery agreements, so that the spatial coverage of protected lakes can be consolidated or expanded.

j) Household-level surveys -- We have kept household-level survey data on the use of all types of aquatic resources obtained from ~400 households distributed across 35 local communities (villages). This sampling protocol will help us understand the variance in ecological and landscape features of different water bodies that govern the behaviour of key fish stocks. These survey will be completed in August, so this component will be analysed from September of the current year.

## Output 2. Design, local empowerment, consolidation and expansion of the spatial management system addressing freshwater turtles and ovipositing sites on fluvial sandy beaches

Historically, Amazonian Podocnemis freshwater turtles have been very important in terms of both socio-economic value (subsistence and sales) and the cultural integrity of rural Amazonians, with their meat and eggs representing a key source of dietary protein. The overexploitation caused by such high consumption led to a massive decline in turtle abundance, with a concomitant retraction of their geographic ranges (>90% in the case of P. expansa).

The protection of sandy beaches forms a key practice of river turtle management and has allowed the successful emergence of over 150,000 hatchlings per year of three species of freshwater turtles (P. expansa, P. unifilis and P. sexturbeculata), since 2007 (this was largely instigated by our previous Darwin Project: Ref No. 16-001). The problem is that these sandy beaches are inside the protected areas, therefore any co-benefits of protection will become very localised and serve the interests of local communities that are already advantaged by other protected areas benefits. We therefore aim to expand a number of project activities to areas outside those two reserves.

At first, we mapped all protected and unprotected beaches along the main Juruá river channel to consider a proposal of sand beach protection using a landscape scale approach. We then began a negotiation scheme with fishermen living outside the protected areas with the help of the local Fishermen Coop (COLPESCA). It turns out that these fishermen are also very interested in initiating the protection of sandy beaches outside formal protected areas. However, we have the added challenge of the financial sustainability of these expanded activities given the project resources, because the continuous beach vigilance effort carried out by our so-called “beach monitors” had to be paid for in cash or in kind (i.e. food supplies) and at the moment we do not yet know which institution, if any, could cover these costs. We are currently contemplating whether we can pay for this ourselves, as there is little subregional interest to fund or promote sustainable use activities outside formal protected areas.

Our project showcases one the most interesting turtle conservation programmes implemented across the Amazon, in terms of community-based protection of fluvial beaches as female turtle nesting grounds. These white-sand beaches are typically 150-300m in width and range from 1 to 5 km in length, and represent the convex bend of a segment of the meandering river channel, immediately opposite a cut-bank. To test the value of this initiative for three Podocnemis species and the potential trophic cascade effects of this protection on other

species across the ecosystem, we sampled 28 fluvial beaches (14 protected and 14 unprotected) using a wide range of techniques. We hope to quantify the ecological co-benefits and implementation costs of the fluvial beach protection programme, which has the potential to be one of the most important conservation tools for vertebrate species of Amazonian floodplains. This research initiative is unique and will help us and policymakers understand the full consequences of strictly protecting key egg-laying habitats within or outside multiple-use Amazonian forest reserves. The activities that were developed include:

a) Turtle abundance -- Local monitors were trained to record the number of nests by the two largest *Podocnemis* species on each of the 14 protected beaches along the medium reaches of the Rio Jurua. In collaboration with these monitors, we expanded this program to sample nest abundance on 14 adjacent unprotected beaches, thereby achieving a statistically robust pairwise design. The entire beach is surveyed on a daily basis during the turtle ovipositing season, and the date of each nest is also recorded during the morning following a nocturnal egg-laying event.

b) Turtle nesting success and hatchling emergence -- Previously-trained local monitors also record nesting success for the two larger *Podocnemis* species on all protected beaches. This includes hatchling counts and a measure of hatchling survivorship until they reach a water body.

c) Fluvial beach bird censuses -- We conducted comprehensive surveys of the entire community of birds nesting on fluvial beaches. Two observers slowly walked the full length of 28 beaches (14 protected and 14 unprotected) recording the abundance of all bird species present and their nesting activity. Surveys were conducted during the morning (06.00 – 10.00h) with two adjacent beaches (protected vs unprotected) surveyed each day. We recorded the presence of up to 12 bird species nesting on beaches and adjacent habitats over the course of the entire survey.

d) Animal track censuses (including nest and avian predators) -- Following the bird census, all 28 beaches were also surveyed for animal tracks including those of nest and bird predators.

e) Camera-trapping (including nest and avian predators) -- To detect further use of beaches by other animals we installed camera traps (CT) on 10 beaches (5 protected, 5 unprotected) with two cameras per beach. Camera traps were deployed for at least 30 days per CT station from August to November 2014.

f) Caiman censuses -- We conducted nocturnal surveys for two caiman species (*Melanosuchus niger* and *Caiman crocodilius*) along riparian zones adjacent to all 28 beaches surveyed. Spotlight surveys for eyeshine of caimans and other vertebrates were conducted slowly by boat along both the beach and the opposite bank of the river, recording the species and size class for each individual.

g) Dolphin censuses -- We conducted observations of dolphin activity at all our focal beaches, recording the number of individuals and number of surfacing events for the two Amazonian dolphin species (*Inia geoffrensis* and *Sotalia fluviatilis*). Twenty minute observations were conducted at three points along each beach, one at the centre and one at each end. This work was led by an undergraduate student (Patrick Cook) from UEA, under a project research internship.

h) Underwater sonar surveys (underwater topography, fish and aquatic mammal census) -- We used conventional short-range FishFinder® sonar equipment, as described above, along georeferenced river transects immediately opposite all 28 focal beaches. Following our methodology in oxbow lakes, we concurrently recorded the presence and number of fish shoals or large aquatic mammals such as dolphins and manatees.

i) Pitfall-trapping (beach arthropod abundance) -- To record the invertebrate community and biomass, we installed pitfall traps exposed for 48 hours along all 28 beaches (10 traps per beach, at 100 m intervals). This work was led by an undergraduate student (Patrick Cook)

from UEA. All specimens were preserved in alcohol for subsequent identification and processing through collaborators at the Entomological Collection of INPA, Manaus.

j) Nest predation experiment -- To quantify the levels of nest predation on protected and unprotected beaches we designed an experiment using artificial nests containing chicken eggs. We first attempted to simulate turtle nests by burying chicken eggs into the sand but this was unsuccessful and had to be adapted to imitate bird nests by placing eggs on the surface of the sand. We exposed 20 eggs for 48 hours at 20 stations per beach (spaced by 50 m). Any predation events were recorded, including the identification of the predator species from tracks or other signs.

k) Large catfish abundance and stomach contents -- Using an experimental fishing approach, large siluriform catfish were sampled along the main river channel immediate along the 28 focal beaches we surveyed – this was timed to coincide with the turtle hatchling emergence season as large catfish represent one of the most important sources of natural predation for hatchlings. In addition, our intention was to quantify any trophic effects on aquatic predators resulting from the sudden resource pulse created by an abundant supply of turtle hatchlings reaching the water.

l) Local interviews -- We continue to carry out local interviews quantifying the overall consumption of aquatic resources at the local household level. This sampling programme has also been expanded to 8 new communities downriver of Carauari, where a large section of the Juruá River remains entirely unprotected.

m) Quantifying illegal turtle offtake -- We conducted anonymous questionnaire-based interviews at the main urban centre (Carauari) to determine the level of illegal turtle captures for both urban subsistence and sales within the region. Turtle harvesting is nominally legal for local subsistence but legally banned for any commercial use. Since the town of Carauari accounts for 53% of the population of the entire 2,588,100 hectare municipal county of Carauari, this obviously represents a significant regional scale sink of both terrestrial and aquatic resources.

Our results to date are impressive. The effects of community management of sandy beaches has benefits for all other taxonomic groups. For example, for the two migratory bird species that reproduce on beaches, Black skimmer (Rynchops niger) and Large-biled Tern (Phaetusa simplex) (Figure 4), the average number of individuals recorded on protected beaches was 101 and 158. This compares to average abundances on unprotected beaches of 4.1 and 1.2 individuals, for each species respectively. Similar drastic effects are also apparent for other taxonomic groups.

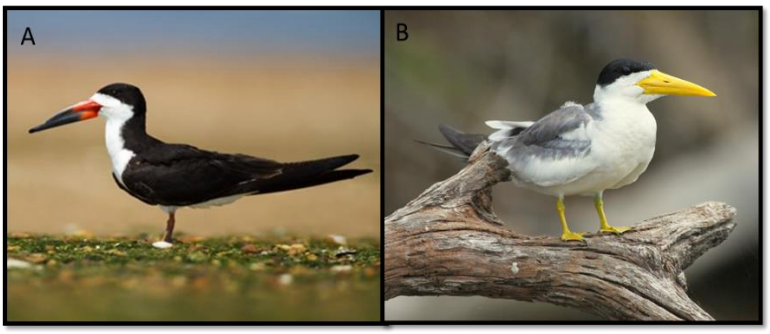


**Figure 4.** Two of the main species of fluvial beach nesting birds along the Juruá -- A) Black Skimmer (*Rynchops niger*) and B) Large-billed Tern (*Phaetusa simplex*) – both of which derive significant co-benefits from beach protection against turtle poachers.

## Output 3. Arapaima ecology

*Arapaima* fish are large piscivores and quasi-apex predators within oxbow lakes. They also contribute high ecological, economic and cultural value to Amazonian floodplains and are iconic elements of these environments. In the past, adults could attain up to 4 m in total length and >200 kg in weigh (Figure 5), though large specimens today rarely exceed 2.5 m and 90 kg due to overfishing. *Arapaima* management is increasing in the Amazon, and has high potential to become an important tool for biodiversity conservation and improve the quality of life of local communities. *Arapaima* management represents a clear window of opportunity to harmonise the interests of biodiversity conservation with the goals of poverty alleviation. Adapted to hypoxic and anoxic environments, *Arapaima* come to the surface to capture oxygen directly from the air. This process favours sampling procedures, because during the air breathing the fish can be counted. To better understand the ecology and management of *Arapaima* we have implemented several activities.

**Figure 5.** An adult male Pirarucú (*Arapaima gigas*), reaching 4m in length.

To understand the home range and movements between lakes during flood periods we successfully tagged a total of 58 juvenile *Arapaima* individuals from four lakes, and established a protocol for the return of number-tags recovered by local fishermen to ASPROC. All individuals were weighed and measured before release. This project component is therefore well placed to be expanded during the next field campaign. Moreover we fitted radio-transmitters to six *Arapaima* individuals, two in each of three connected lakes. We trained a local field assistant to conduct weekly surveys throughout the year to track their movements and established a strong involvement in all the local communities. This technique is still under experimental development, so we plan to learn from any mistakes to boost this sampling program during the rest of the project time frame. This work package included the training of local field assistant in radio-tagging and animal telemetry monitoring.

Another approach to understand the movements is through the use of genetic tools. We collected DNA samples (muscle tissue) from a large number of *Arapaima* harvested during the local management programme. All samples therefore have associated body-size and other morphometric data. We collected a total of almost 210 samples (30 samples in each of seven lakes), which will be analysed in collaboration with a molecular ecology lab at University of Amazonas, Manaus. The microsatellite DNA technique we will use will also help understand the patterns of gene flow both along the Juruá River, and across the width of the floodplain in relation to the historical fluvial geomorphology.

To determine the age of harvested individuals we collected scales from all 210 adult *Arapaima* from which we collected DNA samples. We also extracted otoliths from the skulls of eight *Arapaima* individuals to more accurately estimate their age and calibrate the more extensive (and straightforward) use of scales for this purpose.

## Output 4: Local empowerment and consolidation of *Arapaima* stock assessment and management program

*Arapaima* management is increasing in the Amazon, and has high potential to become an important tool for biodiversity conservation and improvement of quality of life of local communities, because, in places where the *Arapaima* population is recovering local fisherman are already achieving great economic benefits through community management.

Analysing the management program we found a strong effect of community management on Arapaima stock sizes (Figure 6).The management class explains 82.9% of *Arapaima* population size variation. The average *Arapaima* abundance in protected lakes is 304.8 individuals, compared to 34.1 in subsistence lakes and only 9.1 in unprotected lakes.

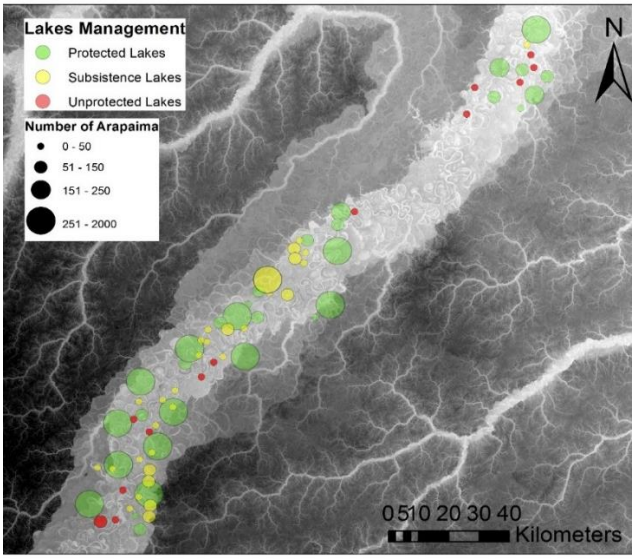


**Figure 6.** Distribution of *Arapaima* populations in oxbow lakes along the Juruá River. Symbol size represents the *Arapaima* population size from annual counts; green, yellow and red symbols represent protected, subsistence and unprotected lakes, respectively.

Protected oxbow lakes can generate money, and have recently become something similar to a bank account. Considering all the management rules, we found an average of around US$9,000 available in these lakes in *Arapaima* catches alone (Figure 7), and this value could potentially increase year on year as we enhance lake protection with the help of local communities and our partners.

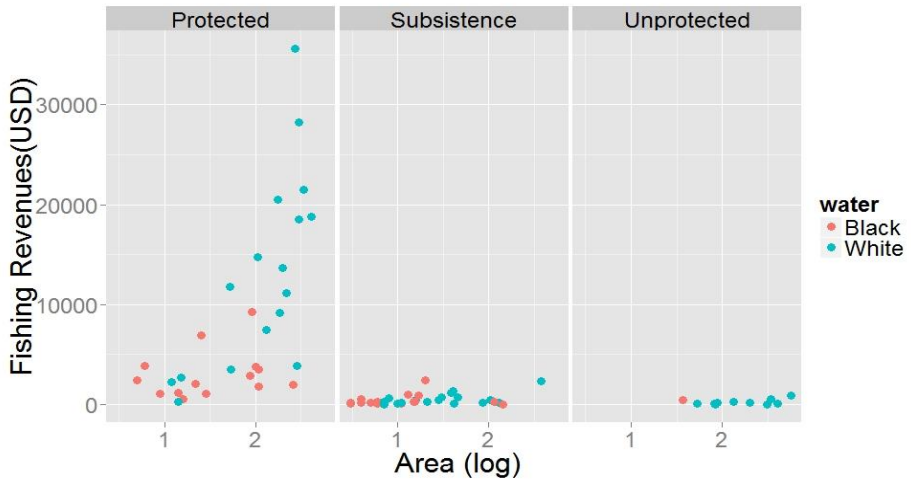


**Figure 7.** Total fishing revenues in three lake management class.
Blue and red symbols indicate white-water and black-water lakes, respectively.

Our project has been providing technical training to both artisanal and commercial fishermen of the central Juruá region. The *Arapaima* dry-season counts last dry-season, for example, were carried out across 80 lakes and provided an excellent opportunity to train young fisherman without experience in Arapaima management, and to disseminate project philosophy and collaborative spirit. We also conducted *Arapaima* counts outside both of our target reserves. This was a good opportunity to involve outsiders in the process of natural resource management. We provided technical training to the leader of the colonia de pesca (COLPESCA) in Carauari and over 20 fisherman who live in three local communities outside the reserves.

We initiated a multilateral negotiation process to extend the implementation of the fishery management protocol to disadvantaged areas outside the reserves. This was a huge challenge because fishing communities outside the reserves do not have the same level of social organization as fishermen who live in protected areas. We are trying to provide technical support from the bottom up to implement the system of lake protection outside communities, although much remains to be done. To date, we have improved the protection of six large lakes (1-3 km long) which provide both subsistence and traded catches for three communities, including around 60 people.

*Arapaima* management is a great window of opportunity to harmonise the goals of sustainable resource management and poverty alleviation, with other projects across the Amazon also showing positive results. It is significant because these local communities rarely have any cash-earning opportunities. *Arapaima* management can bring about the empowerment of local communities, and "fishing agreements" can be an important factor to complement the conservation of aquatic resources in the floodplains. We emphasise that fishing agreements are not a panacea and cannot replace the creation of protected areas for example, which are necessary for the maintenance of complex ecological processes. They can, however, be an excellent stratagem to increase and sustain the protection of these wetland environments, and *Arapaima* management deserves more attention from the federal and state governments of Brazil.

## Output 5. Design and establishment of a conflict-resolution management plan considering large vertebrates perceived to be “problem species” including key apex predators (e.g. *Pteronura* and *Melanosuchus*)

Black Caiman is the greatest problem species for people living along the Juruá River, followed by the Pink River Dolphin and Giant Otter (Figure 8). Of the 49 interviews conducted 100% of interviewees reported the caiman and pink river dolphin as a problem species followed by 89.8% for the giant otter. According to our interviews, the Black Caiman and the Pink River Dolphin directly interfere with fishing activity by damaging equipment and becoming entangled in nets more than otters. This incurs financial and livelihood loss to fishermen by reducing fish catches alongside loss and repair of nets. The effects of caiman attacks on fishing gear, especially gill-nets, for example, are particularly strong. Our surveys so far have shown that around 18% of fishing nets are destroyed by caimans to the point where they can no longer be used; the nets are very expensive and this represents a large cost to both subsistence and commercial fishermen.

Although giant otters display similar behaviour, conflicts occur at a lower level as the abundance of this species is lower. In addition, instead of interacting directly with fishermen the greatest conflict occurs indirectly by frightening away fish. Despite this, the otter is blamed for decreasing levels of important commercial fish such as the Matrinxã (Brycon spp.) (Rosas-Ribeiro et al., 2012). This fish species is important in the Juruá region and 50% of interviewees stated that otters have contributed to a decline in the Matrinxã population. Giant otter populations remain low in the Juruá but 12.5% of the interviewees reported that coexistence

with the otter depends on future population increases. A population rise could reduce commercially important fish stocks and increase direct. Further analyses will be conducted on this dataset later this year.

**Figure 8.** a) Black Caiman (*Melanosuchus niger*), b) Pink River Dolphin (Inia geoffrensis) and c) Giant Otter (*Pteronura brasiliensis*).

## Output 6: Empirical and theoretical tests of management protocols and expansion into other river basins of Brazilian Amazonia and other Amazonian countries

This output refers to the compilation of all project results and further modelling of these results for other localities. We have started towards this goal, (collecting the data and conducting the first set of preliminary analyses) and are planning to consolidate this output in the final year of the project.

## Output 7: Local training in biodiversity monitoring and waterbird conservation

The interesting relationship between aquatic birds and fisheries is very strong but poorly understood. Some bird species can take advantage of fishing activities, while populations of other species can decline due to competition or opportunist hunting. Moreover, most of this lacustrine avifauna are piscivores (fish consumers) and may serve as indicators of fish availability. We are therefore attempting to unify the ecological study of wetland birds and participatory monitoring.

To achieve this, we have sampled the local assemblages of some 30 bird species using aquatic habitats both during the dry and the wet seasons in a total of 32 oxbow lakes. To make these surveys possible, 10 local field assistants ("monitores") were repeatedly trained to execute this form of participatory monitoring that now includes egrets, raptors, kingfishers, and other piscivores in a systematic fashion. On the basis of this pilot work, we then decided that it would be feasible to repeatedly census 31 oxbow lakes under different categories of protection over a 12 month period. With this in mind, we can make a large set of considerations about the effects of landscape, environmental and management factors in several groups, including migratory birds. Moreover, this new output enables the improvement of management techniques and terminology among local people, and increases community involvement in our activities. The field activity for this output will be continued until the dry season of this year.

## Output 8: Seasonal movements of terrestrial vertebrates between floodplain (*várzea*) forest and upland (*terra firme*) forest

We have conducted a strong camera-trapping effort targeting terrestrial wildlife populations along the Juruá floodplains in both *terra firme* and várzea forests at different times of year, and this work will go on for two annual cycles. A Brazilian MSc student from Universidade Federal do Pará (Hugo Costa) has been recruited to conduct this study. On the basis of 1,800 trap nights, we recorded 25 terrestrial vertebrate species, including 23 mammals and two large-bodied bird species. Overall species richness was higher at *terra firme* forest sites during the flood pulse than at *terra firme* sites during the dry phase of adjacent *várzea* forests, which in turn was higher than in *várzea* sites. Camera trap stations grouped by both forest type and season was the main factor explaining the variation in overall capture rates across all terrestrial mammal species, which were higher at *terra firme* forest sites during the flood pulse, followed by *terra firme* sites during the dry phase and finally *várzea* sites during the dry phase. This was confirmed by the variation in capture rates for seed predators (granivores) and insectivores but not for the other two trophic guilds (carnivores and folivores). At *terra firme* sites, capture rates for granivores, folivores and carnivores increased with the rising floodwaters, whereas the reverse was true at *várzea* sites, except for carnivores. On the basis of pairwise seasonal contrasts, 11 of the 14 CT sites sampled in both seasons within *terra firme* forest showed an increase in overall capture rates during the flood pulse of adjacent *várzea* forests.

These results provides crucial scientific evidence for the notion that Amazonian upland (*terra firme*) and seasonally flooded (*várzea*) forests need to be juxtaposed within the same forest reserves, thereby boosting what we know about designing and managing highly heterogeneous natural forest mosaics in Amazonia for both biodiversity persistence and local extractive communities.

## Output 9: Terrestrial wildlife depletion envelopes near local communities

We have included a new set of research activities with the objective of understanding the relationship between community size, landscape context and game and nongame population sizes near local communities using a combination of camera-trapping, sign surveys, and local interviews. This is important because animal protein acquisition along the Juruá River is a compensatory interplay of both hunting and fishing activities, with the potential of introducing seasonal relief by alternating protein capture between these activities. To date we have collected data along ~50 transects of up to 6 km each at increasing distances into remote areas from both *várzea* and *terra firme* forest communities. This project component includes communities both within and outside our focal protected areas. None of those data have been analysed yet, but we will be modelling the degree to which wildlife population abundance are depressed near local communities and what environmental factors most contribute to those distance-abundance relationships. Much of this field work is being conducted by British PhD student (Mark Abrahams), who is based at UEA.

## Output 10: Social benefits of protected areas

We included the social approach into our project to strengthen the ancillary benefits of protected areas and community management. We have evidence that communities living inside protected areas have access to greater resource supplies including high value fish due to the lake protection system. Communities outside the reserves are often unable to access these resource because of low abundances in these fish species in the absence of protected lakes. A Brazilian MSc student (Julia Romero) currently based at Aarhus University, Denmark is conducting this work.

Our primary research question is whether or not conservation can effectively contribute to increasing socio-economic development. To address this question we conducted a total of 134 interviews (82 inside the reserves, 52 outside) covering three main levels of analysis: the community, the family household and the individual. At the community level, we interviewed community leaders on issues of community organization, generation of income, potential conflicts and community goods. At the household level, questions were related to the primary economic activities of each household throughout the year, as well material goods owned. Finally, at the individual level, the main purpose of the questions was to assess individual welfare in relation to access to healthcare, education, and overall satisfaction towards living inside or outside of the reserves.

All interviews have already been successfully transcribed, with interviewees' responses tabulated and quantified, and analyses and interpretation currently ongoing. So far, our data suggest that at the individual level, the levels of literacy are higher inside the reserves than outside, and that the desire to move to urban areas is greater among people living outside reserves than inside. Motivation for this rural-to-urban migration varies but the most common responses related to access to constant primary and secondary education.

At the family household level, patterns relating to the availability of goods and distribution of economic sources vary more inside the reserves. Moreover, in addition to demonstrating the multiple economic activities conducted by interviewees, an initial analysis suggests that outside the reserves, most households get their income from just two to three sources, whereas families inside the reserves count on three to four sources of income and have a larger potential to increase this diversity.

## Output 11: Wattled curassow (*Crax globulosa*) conservation program

The Wattled Curassow (*Crax globulosa*), is an Endangered floodplain forest specialist that has dwindled to very small populations across the western Amazon as a result of overhunting (Figure 9). A rare large population of this species persists in várzea forests along the Juruá River, providing us with an excellent scenario to develop guidelines for the conservation of this species. A Brazilian PhD student (Gabriel Leite) who is currently based at Instituto Nacional de Pesquisas da Amazonia (INPA) is conducting this work. The activities that have been implemented include: (a) population censuses; (b) conventional telemetry, with four individuals captured now fitted with radio tags; (c) local interviews; (d) a study of the reproductive and foraging ecology of Wattled Curassows, and (e) a major study of the ecological distribution of this cracid along over a 1000-km Juruá river section. Gabriel is currently on field work continuously since July of last year.

**Figure 9.** Wattled Curassow (*Crax globulosa*), an endemic cracid from the Juruá flodplains.

## Output 12: Lowland paca (*Cuniculus paca*) conservation program

Pacas (*Cuniculus paca*) are large nocturnal caviomorph rodents that date back to the Oligocene rodent fauna of South America. This is one of the most hunted game species right across the Neotropics, yet a population monitoring protocol is unavailable. We have therefore implemented an embryonic program with the goal of developing a local population monitoring protocol. The activities consist of standardised nocturnal censuses along the suitable riparian habitats of pacas which will be executed by trained local monitors. Any information gained from this work package will go far beyond the original objectives of this project. The first set of sampling is being conducted this month.

## Output 13: Tambaqui *(Colossoma macropomum)* management programme

We started the *Colossoma* work package during last year of the project. This work was led by Brazilian MSc student (*Talles Colaço*) from INPA.

a) *Colossoma* censuses -- We conducted censuses at 20 lakes within the RDS Uacari and RESEX Médio Juruá. This component forced us into a strong learning curve about the biology of *Colossoma*. Capturing this species is very hard and we had a low success capture.

b) *Colossoma* offtake -- We recorded offtake levels and quantified fishing effort during the annual harvest in the six lakes where *Colossoma* management has been conducted within the reserves. In collaboration with ASPROC, we recorded the weight, and length for all harvested individuals.

c) *Colossoma* mark-recapture (number tagging) -- We started the mark-recapture program but unfortunately we obtained a low capture success, so few individuals were marked.

d) *Colossoma* scale samples -- Due to the low catch, few scales were collected.

The low success of this component highlighted to us the need to include data collection from traditional knowledge, which we considered most appropriate to add as an additional project component (see below).

## Output 14: Traditional knowledge as a tool for understand past changes on fisheries (NEW OUTPUT)

In the Amazon, fishing landings data is largely deficient. In fact, this situation is common to most tropical freshwaters and wetlands. There is widespread evidence that much of the catch from inland fisheries is unrecorded, partly because of the diffuse and small-scale nature of individual fisheries, the lack of easily definable landings, and because much of the catch goes directly to domestic consumption. Because of the deficiency of fishing landings data for the Amazon, it is impossible to construct realistic time series of catch and effort based on collected data. Nevertheless, time series of catch and effort are one of the most basic and informative data in fisheries because from them it is possible to calculate changes in catch per unit effort (CPUE) and to estimate changes in the abundance of fish populations when there is no information from stock assessments.

In this sense, the use of interviews with local fishermen emerges as a solution for the Amazon case, as well as for other places all around the world. Notably, information can be acquired from the memory of resource users about past events. Several reconstruction studies of fisheries statistics have been based on "memory recall", especially in situations where there is no historical data. Cognitive psychology confirms that although it is difficult to recall individual events that are routine, unique events that have high personal importance can be recalled straightforwardly. In this sense, fishers can easily recall and describe, for example, their “best catch ever”. Thus, the systematic collection of data based on local knowledge through

interviews can permit analysis of the data in such a way that the information can aid management and conservation efforts.

Furthermore, the use of interviews with different fisher age groups have been very useful in registering cases of the “shifting baseline syndrome”. The shifting baseline syndrome refers to the loss of information about past ecosystems and changes in biodiversity, which is even more evident in ecosystems where changes have occurred a long time ago. Therefore, to overcome some of the limitations in data availability and recover historical information, ethnoecologists have documented changes in ecosystems using fishers’ perceptions. Using such approach, it is possible to understand how ecosystems respond to human pressures and environmental changes over time. This approach can help us to understand the situation of *Colossoma*, both in relation to population changes, which certainly occurred, such as the difficulty in capturing this specie. This new output will be conducted by Carolina Freitas, a Brazilian PhD student from UFRN.

## 3.2 Progress towards project outputs

### Output 1: Local empowerment and consolidation of an oxbow lake management system across the entire study landscape

### *Indicator 1*: Background research leading to the development of a spatially explicit management protocol of community-based freshwater fisheries management

We began data collection on both artisanal and commercial fisheries. We spent a lot of time training staff members and implementing this component. We now have three people collecting fish landing data every day, which are intercepted from a commercial fleet of some 700 fishing boats and canoes stationed in Carauari. We are also collecting year-round data on subsistence fisheries from more than 400 households from 35 local communities along the ~492-km section of the Juruá River where we work, two days per week. We have just analysed the effect of community management on the *Arapaima* population size and the results show us that the community management mode is a powerful tool for conservation. We still need to integrate the data on other taxonomic groups, but apparently the effects of community management of *Arapaima* benefit these other groups too. Data collection will be completed in November 2015. After that we can start an in-depth analysis on the main fisheries.

### *Indicator 2*: Data from limnological sampling of 83 spatially-explicit oxbow lakes during both the wet and the dry seasons

We collected water samples from 64 lakes during both the dry and wet seasons. The chemical and limnological analysis was carried out at the INPA Limnology Lab and this partnership will help us understand the role of primary production in floodplain lakes. The collaboration will contribute to the importance of understanding limnological effects on resource population distribution and abundance. This indicator has been successfully completed.

***Indicator 3*: Technical training Workshop deployed to both artisanal and commercial fishermen of the central Rio Juruá region; Technical training Workshop with key stakeholders including the Fishermen Cooperatives, municipal county administrators of fishing licenses, managers of sustainable-use protected areas, and representatives of SDS/CEUC and ICMBio)**

We conducted a training course for the fisherman living outside the protected areas, which primarily focused on Arapaima counts and was very important to promote initial contact between different socioeconomic realities. In the protected areas it was easier to convince people about the importance of resource management, because they have already been exposed to this concept for several years, but the reality outside was very different and local villagers still need to see the positive aspects of management. We therefore introduced this understanding with a training workshop. The next step will be to increase the number of training courses not just for fishermen but also for other stakeholders. We are planning a larger meeting with all stakeholders involved in local fisheries: local communities, commercial fishermen, local organizations, universities and state and federal government agencies. The aim is consolidate the first landscape-scale fisheries management in Brazilian Amazonia. The results from our project will form the foundation for the rules and use guidelines of this document.

***Indicator 4*: Deliberations of negotiated settlement between commercial and artisanal fishermen thereby subsidising a legal agreement ratified by the Fishermen Cooperatives of Carauarí and Eirunepé**

This represents the greatest challenge of our project, which we plan to conduct during the final year of the project. We have already begun negotiations, but first we have to solve historical issues including decades of often violent conflicts. We are maintaining a positive and engaging relationship with the municipal and state administration as well as the Fisherman Coop of Carauari, and we have every reason to believe that we are gradually winning hearts and minds, and the co-operation of commercial fishermen and fish traders. This negotiation will be the final product meeting planned in the previous indicator.

***Indicator 5*: Preparation of the *Handbook of Community-Based Freshwater Fisheries Management Techniques***

This indicator depends on results from other project components, and the Handbook has been earmarked for the third year of the project.

***Indicator 6*: Dissemination of the *Handbook* to all institutions involved in resource management, particularly concerning fisheries**

Once the *Handbook* is completed and published it will be distributed accordingly, with the help of our institutional partners.

**Output 2: Local empowerment and deployment of a freshwater turtle ecology and management programme**

We have sampled 28 sandy beaches to understand the trophic cascade effect of community management. The analysis is being conducted and preliminary results suggest decisive findings. The next step is to understand the movement ecology of turtles and hatchlings after emergence, which is critical because their ranging behaviour will help us understand the distances necessary between protected beaches in any future harvest scenario. Moreover we are going to examine the socioeconomic costs of implementing this program and, lastly, we will prepare a post Darwin project proposal to expand the management protocol to other areas.

### *Indicator 1*: Understanding the trophic cascade effect of sandy beaches protection

To understand the trophic cascade effects we sampled 28 beaches. At all beaches, we sampled: turtle abundance, turtle nesting success and hatchling emergence, fluvial beach bird populations, animal tracks (including nest and avian predators), and conducted camera-trapping (including nest and avian predators), caiman population censuses, river dolphin censuses, underwater sonar surveys (underwater topography, fish and aquatic mammal census), pitfall-trapping (to quantify the abundance of beach arthropods), nest predation experiment, large catfish abundance and stomach contents, and local interviews, quantifying illegal turtle offtake. This indicator was completed successfully.

### *Indicator 2*: Understanding turtle nesting success

At all protected beaches turtle nesting success and hatchling emergence was completed. This will comprise a large dataset that will help us understand the nesting success, mortality and predation of hatchlings. Data collection is completed and the analysis is being conducted in consortium with our UFAM partners.

### *Indicator 3*: Turtle telemetry

A partner (UFAM) has started a GPS telemetry activity, and this year our project will expand upon this approach with radio telemetry of females and tags on hatchlings.

### *Indicator 4*: Understanding the costs of beach protection implementation

We have collected data on the costs of implementation but have not yet started the economic analysis, because this will be more realistic once we have a better understanding of the home ranges of females and hatchlings.

## Output 3: *Arapaima* ecology

### *Indicator 1*: Telemetry of *Arapaima*

We have started the *Arapaima* telemetry and the data is being collected by a trained person, who carries a telemetry receiver to all likely areas once a week.

### *Indicator 2*: Mark-recapture protocol

We have started the *Arapaima* mark-recapture, and the first results will be possible during the management capture in the next dry season.

### *Indicator 3*: DNA and scale sampling

We have started the DNA and scale collection and we already have 210 samples. During the next dry season we will expand the spatial scale of sampling.

## Output 4: Local empowerment and consolidation of *Arapaima* stock assessment and management program

### *Indicator 1*: Initial presentation of subproject and training workshop to local artisanal fishermen from 35 local communities on *Arapaima* census techniques

The project concept and activities was presented during four large meetings inside the reserves. Around 200 people (mostly community leaders) were present and heard about the project. Moreover, the project was also presented during community visits to 40 communities.

### *Indicator 2*: Training Workshop extension to key stakeholders outside the two protected areas (Fishermen Co-operatives, municipal county administrators of fishing licenses, managers of sustainable-use protected areas, and representatives of SDS/CEUC and ICMBio)

We carried out a training course for the Fisherman Co-operative and commercial fishermen outside the reserves, and we are currently organizing a complete course for other stakeholders.

### *Indicator 3*: Total number of protected oxbow lakes negotiated with commercial fishermen cooperative under mutually-agreed "fishing accords". These will be enforced during the dry-season, and will adhere to a sustainable offtake quota following ongoing stock-recruitment assessments

In addition to the core protected lakes, we have expanded protection to 7 other lakes outside protected areas which provide food and cash for four communities. A ground-breaking achievement, however, is that the Fisherman Cooperative has approved our proposal and we will now attempt to increase the number of protected lakes outside the reserves, which are completely neglected by state authorities. We surmise that this will bring very strong local benefits for the entire project study area. Ultimately, given the tangible local benefits of oxbow lake protection, we would like a contagion based model in which community-based lake management and zoning spreads spontaneously across the Juruá far beyond the boundaries of our study area. We would like to highlight that in the first year of our project, the Arapaima population in a large lake outside the reserves was about 60 individuals. After the arrival of our project, the populations increased dramatically to over 830 individuals. The resilience of Arapaima population linked with the success of community lake protection is impressive, providing a rare win-win story in tropical conservation.

### *Indicator 4*: Time-series from at least 26 lakes beginning to show population recovery trends by the end of Project Year 3

We have been able to reconstruct data on *Arapaima* counts since 2005. In the final year of the project we will have 10 years of solid *Arapaima* stock size data from at least 60 lakes, thereby enabling us to show Arapaima population recovery. We are currently in the process of analysing preliminary data on these counts with a view of publishing an initial paper on this topic. We expect to vastly exceed our initial targets in relation to this indicator.

## Output 5: Design and establishment of a conflict-resolution management plan considering large vertebrates perceived to be "problem species" including key apex predators (e.g. *Pteronura* and *Melanosuchus*)

### *Indicator 1*: Review on human-wildlife conflict in tropical wetlands

This indicator was completed successfully. See the attached undergraduate dissertation by Patrick Cook titled "*Human Wildlife Conflicts: A Review of Conflicts with Freshwater Mammals and Reptiles in the Tropics and Subtropics*".

### *Indicator 2*: Interviews in at least 40 communities to quantify the scale of conflicts

This indicator was completed successfully.

### *Indicator 3*: Population estimates combined intensive field surveys and information from interviews at 40 communities on the spatial distribution of occupancy records of *Pteronura and Melanosuchus*

Records on *Pteronura* are available. The *Malanosuchus* sampling was completed successfully, but the data will be analysed later this year.

### *Indicator 4*: Development and preparation of educational booklet with the goal of reducing conflicts between subsistence/commercial fishermen and *Pteronura and Melanosuchus*

This indicator is dependent on previous results. We plan to carry this out during the third year of the project.

### *Indicator 5*: Dissemination of a "problem-species" illustrated educational booklet to all Juruá communities

This indicator is dependent on previous results. We plan to carry this out during the third year of the project.

### *Indicator 6*: Illustrated talks at seven venues bringing together representatives of ~40 local communities of RESEX Medio Juruá and RDS Uacari

This indicator is dependent on previous results. We plan to carry this out during the third year of the project.

## Output 6: Empirical and theoretical test of management protocols and expansion into other river basins of Brazilian Amazonia and other Amazonian countries

This output will be done during the last year of the project and beyond. This is a meaningful challenge not just for the project, but to the structure and political will of the government agencies we work with and the ones we do not.

## Output 7: Local training in biodiversity monitoring and waterbird conservation

### *Indicator 1*: Training workshop for at least 10 local assistants for wildlife monitoring

This indicator was completed successfully.

### *Indicator 2*: Sampling 30 waterbird species in 32 lakes in all season periods

The last sampling is currently being conducted during the rising flood-waters, this month. Data will be analysed as part of Campos Silva's PhD thesis.

### *Indicator 3*: Interviews with hunters about waterbird consumption

This indicator was completed successfully.

**Output 8: Seasonal movements of terrestrial vertebrates between floodplain (*várzea*) forest and upland (*terra firme*) forest**

***Indicator 1*: Camera trapping in more than 40 points distributed in floodplains forest and upland forest during dry and wet season in 2013.**

This indicator was completed successfully.

***Indicator 2*: Camera trapping in more than 40 points distributed in floodplains forest and upland forest during dry and wet season in 2013.**

This indicator was completed successfully.

**Output 9: Terrestrial wildlife depletion envelopes near local communities**

***Indicator 1*: Understand the relationship between community size, landscape context and game and nongame population sizes near local communities**

Fieldwork for this indicator has been completed successfully and analyses are currently being conducted. This dataset will be analysed as part of Mark Abrahams' PhD thesis.

**Output 10: Social benefits of protected areas**

***Indicator 1*: Interviews with at least 40 community leaders**

This indicator was completed successfully. We conducted the interviews with 41 community leaders.

***Indicator 2*: Interviews with at least 120 community residents**

We conducted a total of 134 interviews with community residents. A total of 82 interviews were conducted inside of the reserves and 52 interviews were conducted outside of the reserve.

***Indicator 3*: Interviews with government responsible for protected area management**

All the departments involved with protected area management were visited.

***Indicator 4*: Interviews with local organizations**

All local organizations involved with the protected areas were visited.

**Output 11: Wattled curassow (*Crax globulosa*) conservation program**

***Indicator 1*: Interviews about Wattled curassow hunting and consumption**

This indicator was completed successfully at about 50 communities. Results are being analysed as part of Gabriel Leite's PhD thesis.

***Indicator 2*: DNA samples collection**

This indicator was completed successfully. The analysis will be conducted by Gabriel Leite at the INPA genetics lab jointly with Dr Izeni Farias.

***Indicator 2*: Wattled curassow populations census**

Gabriel Leite is currently on field work, which is expected to be completed by October 2015, but results so far have been encouraging.

### *Indicator 3*: Wattled curassow telemetry

Gabriel Leite is currently on field work, which is expected to be completed by August 2015. We have obtained a pioneer breakthrough in capturing a meaningful number of individuals of this species and fitting transmitters to them.

## Output 12: Lowland paca (*Cuniculus paca*) conservation program

### *Indicator 1*: Training workshop for at least 10 local assistants for wildlife monitoring

This indicator was completed successfully.

### *Indicator 2*: Sampling 18 nocturnal transect lines

The wet season sampling was completed successfully. The sampling in dry season will be conducted from August 2015.

## Output 13: Tambaqui *(Colossoma macropomum)* management programme

### *Indicator 1*: *Colossoma* censuses

We conducted population censuses at 20 lakes within the RDS Uacari and RESEX Médio Juruá. This component forced us into a strong learning curve about the biology of *Colossoma*. Capturing this species is very hard and we had a low capture success. In an adaptive approach we have included a new output to understand the *Colossoma* ecology through traditional knowledge, as a proper *Colossoma* study at this stage of the project would require a Herculean effort.

### *Indicator 2*: *Colossoma* offtake

We recorded offtake levels and quantified fishing effort during the annual harvest in the six lakes where *Colossoma* management has been conducted within the reserves. In collaboration with ASPROC, we recorded the weight, and length for all harvested individuals. This indicator was done successfully. In addition, we have *Colossoma* harvest data based on household interviews from an additional ~40 lakes.

### *Indicator 3*: *Colossoma* mark-recapture (number tagging)

We started the mark-recapture program but unfortunately we obtained a low capture rate, so few individuals were number-tagged. We anticipate that this indicator will not give us great results.

## Output 14: Traditional knowledge as a tool for understand the past changes on fisheries (NEW OUTPUT)

This output will be conducted during the dry season, from August to November 2015.

## 3.3 Progress towards the project Outcome

During the first project year we have already implemented data collection regarding most faunal groups and resource populations. We have also conducted technical training in different approaches and strengthened our relationships with partners. A fact to be considered is the high level of social and political organization of the communities who live in this region. This socio-political predisposition can be an important role in achieving positive project outcomes.

Our presence throughout the region has been really welcome and the communities are genuinely interested in our project. By the end of Year 2 we think that the overall assessment is very positive and we are well placed and have the necessary conditions to accomplish our realistic purposes satisfactorily. The project activities will eventually move into a seamless exit strategy and many of the ideas and concepts instigated so far will transcend the lifetime of the project.

During Year 2 we maintained sampling activities and built a strong interdisciplinary data set. We also started the analysis and the results are positively striking for conservation science. Our project partners are also forging better ties with the local political offices, which will facilitate some planned outreach activities.

## 3.4 Monitoring of assumptions

Our group has been working in the Jurua basin for over two decades. So the project was built on strong foundations that make up the ecological and socio-economic reality of the region. Technically, we had no major problems in advancing project goals. The Colossoma component, however, has not performed as well as we had expected, due to the complex refugial ecology of this species. But we hope to be able to adapt our strategy to improve the understanding of this species.

## 3.5 Impact: achievement of positive impact on biodiversity and poverty alleviation

This is a ground-breaking sustainable development project that we intend to demonstrate at the highest level. Virtually all conservation/development programs in the tropics fail to achieve either the goals of biodiversity conservation or the socioeconomic interests of local communities. This Darwin Project, however, can be ultimately seen as either a success or failure depending on whether the project promotes both stock recovery of historically overexploited biological resources and improved livelihood conditions for the local population (including quantifiable changes in local revenues). Indeed, this project has every chance of eventually (late Year 3) demonstrating a rare win-win success story in terms of natural resource management in a tropical environment.

# 4. Project support to the Conventions (CBD, CMS and/or CITES)

The project provides a strong contribution to several CBD articles, including the Sustainable Use and Conservation of Biological Diversity, implementation of Protected Areas, Biodiversity Monitoring, Use of Local Traditional Knowledge, Research and Training, and Technical and Scientific Cooperation under the thematic areas of Ecosystems Approaches, Sustainable Use of Biodiversity, Protected Areas, and Forest Biodiversity, as all aquatic resource populations addressed here are sustained by increasingly degraded seasonally-flooded forests. As such the project also supports RAMSAR, the Convention on Wetlands of International Importance. The project will also provide a subsidiary body on scientific, technical and technological extension that can be applied not just to the Juruá region, but in the other eight lowland Amazonian countries.

The project will strengthen all five strategic goals of the Strategic Plan for Biodiversity (2011-2020) as agreed within the Aichi Biodiversity Targets framework. In particular, the project will provide a decisive contribution to Target 11 of Strategic Goal A in relation to the effective implementation of Sustainable-Use Protected Areas in tropical forest regions. The project will also aid the implementation of the Biodiversity Convention within Brazil via our collaboration with ICMBio and CEUC/SDS, the protected areas branch of the Brazilian Ministry of Environment (MMA) and the State of Amazonas, respectively. This will maximise integration between this project and other initiatives, including MMA's ARPA protected areas programme for the Brazilian Amazon.

Finally, large turtles can migrate thousands of kilometres and the *Podocnemis* GPS tracking component of the turtle ecology subproject will elucidate where male and female turtles go during the nonbreeding season. This fits well with research priorities from the Strategic Plan of the Convention on Migratory Species of Wild Animals (CMS).

## 5. Project support to poverty alleviation

There are some promising areas in which the objectives of biodiversity conservation and human welfare can be integrated via this project. The Arapaima management protocol is a strong window of opportunity to harmonise the goals of sustainable resource management and poverty alleviation. In particular, protected lakes can become something analogous to a high-interest bank account. In these lakes we found an average of around US$9,000 available in fish catches, considering all the management rules, and this value can grow every year as the protection process is consolidated and resource populations increase. This is significant because these local communities rarely have any cash-earning opportunities, so that a seasonal windfall of >US$10,000 is crucial in improving local welfare.

To secure these fishing revenues every year, the communities have to improve the management structure of the lakes, but this is being done as part of the project advisory activities. They are improving the cryo-preservation structure of ice-chilled (rather than less valuable salted) fish and a new fleet of small fishing boats will be available next year. Moreover, the lakes can also function as a health insurance option, because when anyone becomes ill, for example, a portion of the arapaima stock can be captured and sold, thereby covering the costs of emergency travel and medical care. Finally, communities that actively engage in lake management can easily double or treble their income is sustainably harvested fish, as 20% of the estimated adult stock size can be legally captured and sold (although we will be ascertaining if this quota approaches an optimum sustainable yield). Consequently, an annual windfall can be earned following stock assessments and offtakes of the population surplus at the end of the dry season.

## 6. Project support to Gender equity issues

Indirectly our project reinforces the participation of women in management activities as female participation in *Arapaima* management is growing in most communities. They help in several activities: leading the team, making food, conducting the fisheries, preparing fish, overseeing the weighing of fish, conducting data recording, and cleaning management sites. An important fact is that local revenues are shared equally between men and women. We have not quantified the gender partition in fisheries management but we can do so this year. However to illustrate this point, see the news articles below from a location close to our study area.

http://portalamazonia.com/noticias-detalhe/economia/mulheres-se-destacam-na-pesca-do-pirarucu-na-regiao-do-medio-solimoes-no-amazonas/?cHash=5de2af298a5fd4e94bccb32c09e73147
http://radioagencianacional.ebc.com.br/economia/audio/2015-01/cresce-numero-de-mulheres-que-vivem-da-pesca-do-pirarucu-na-amazonia

## 7. Monitoring and evaluation

We have credible evidence to believe that floodplain management could contribute to the conservation and improvement of local livelihoods. In the Mamirauá reserve, located the floodplains of the Middle Solimões region, local income from Arapaima management in 2013 was very substantial. Last year aggregate income across our study communities from fish sales alone was more than R$220,000 (£53K) and this money was shared equally among all families working in the management program. With the improvement of management conditions and a growing Arapaima stock, we anticipate very strong social benefits and financial incentives from management, which may become a contagious process across Amazonian floodplains.

## 8. Lessons learnt

This project is an 'easy sell' in the Médio Juruá region of Western Brazilian Amazonia because it brings direct consequences to both local income and welfare of várzea and terra firme communities. Over the years we have come to know virtually every villager across the 45 communities we frequently work with, which has greatly facilitated our working relationship and position of trust. In virtually all respects the project has been a glaring success so far, but the tambaquí (*Colossoma* spp.) component has been disappointing mainly because we were unable to capture and number-tag large number of individuals during the offtake season across multiple lakes, despite efforts from a small army of local fishermen under the supervision of Brazilian MSc student Talles Colaço (INPA) and PhD student João Campos e Silva (UFRN). A proper study of the population ecology of *Colossoma* will require a much more focused effort, which would be worthwhile given that this is the most expensive wild-caught fish in Brazilian markets (a single fish in Manaus can be worth R$3,000). We have been very pleased however with all other project components and input from our partners into the project. We have a number of ground-breaking studies, and by our last count some 30 papers to write up for journals with an IF>2.5. We also believe the project will make a meaningful practical contribution to the landscape scale management of Amazonian floodplains, but the degree to which this outreach impact will be rolled out to similar landscapes elsewhere will also depend on our government agency partners.

## 9. Actions taken in response to previous reviews (if applicable)

The previous review was very complimentary of our project – and we did not feel we had major issues to be resolved.

## 10. Other comments on progress not covered elsewhere

1) We have largely remained faithful to the same project design proposed originally but we have added a few verifiable outputs since Year 1;
2) Given our limitations in terms of time and funds, at this stage we do not feel we can afford to detract from other project components in order to salvage our original plans in relation to the ecology of Colossoma.

3) The project does not face any particular political or bureaucratic risks, which often plague similar efforts in Brasil; quite on the contrary, our local and regional alliances are much stronger now than they were in Year 1. However, we have had one major unfortunate accident when a large motorized aluminium boat carrying seven project members capsized last August (after sunset, at ~18.30h) along a fast-flowing tributary of the Juruá, with substantial loss of project equipment, including some R$7,000 of experimental fishing gillnets which had to be replaced. Boat wrecks in the Juruá are always nerve-wracking because they can be dangerous, not least because lethal attacks from relatively abundant large Black Caimans (3.0 to 5.90 m long) occur every year in the section of the river where we work, with loss of human life. All project members, however, safely arrived at our base the next morning.

## 11. Sustainability and legacy

Due to the large geographic expanse and insufficient amount of human resources, it is simply unfeasible to contemplate conservation efforts in the Amazon without including rural peoples as key component of this process. In fact, community-based management (CBM) can be a powerful tool to promote conservation. The Brazilian government has attempted to implement some initiatives using a CBM framework, but these approaches are at best patchy, poorly monitored and rarely successful. Our project staff has a strong and friendly relationship with different spheres of the Brazilian government which has facilitated implementation of management guidelines in several areas, as well as uptake by local communities.

We are using a mixed approach between environmental predictors and traditional ecological knowledge (TEK), so it is completely feasible and economically realistic to replicate project lessons in other areas. In addition to completing our research and outreach program over the final project year (2015-16), one of the principal actions will be to distribute the Handbook of Freshwater Fisheries Management Techniques for all government departments, and present the guidelines in key Brazilian conservation meetings. We also expect a gradual handover of some project activities to ICMBio and SDS, as well as the management councils of the two reserves where we work. Above all, however, we expect that there will be spontaneous initiatives to follow through with similar guidelines as the success story of fishery management hopefully becomes a contagious model well beyond our study area, and we have early signs that this is already happening.

## 12. Darwin Identity

The Darwin Initiative logo has been used on all our project materials, including presentations with reserve management bodies, regional stakeholders and local communities. Darwin Initiative is recognised as the largest contribution to the Projeto Médio Juruá (PMJ), which is the name used locally for our project since its establishment. Both federal and state government agencies and our collaborating institutions from Brazil are now very familiar with the Darwin Initiative and the support it has provided for our long-term research activities in the region. Results of this Darwin Project will be meaningfully disseminated through publications both in Brazil and internationally, and we are already taking steps in that direction.

## 13. Project Expenditure

**Table 1 Project expenditure during the reporting period (1 April 2014 – 31 March 2015)**

| Project spend (indicative) since last annual report | 2014/15 Grant (£) | 2014/15 Total Darwin Costs (£) | Variance % | Comments (please explain significant variances) |
|---|---|---|---|---|
| Staff costs (see below) | 0 | 0 | 0 | |
| Consultancy costs | 0 | 0 | 0 | |
| Overhead Costs | 0 | 0 | 0 | Overheads taken by UEA (lead organisation) are not considered here; this expenditure refers to field costs an related activities allocated to the projec |
| Travel | | | | Internal flights from Manaus to Carauari consume a large part of our budget. These flights (twice weekly) are extremely expensive (range R$750 – R$1100 per one-way ticket) because they are monopolized by the only small commercial airline that operates in this area. |
| Operating Costs | | | | A modest reduction to accommodate other increased costs. |
| Capital items (see below) | | | | The funds we originally allocated to equipment for this financial year were clearly insufficient. In addition, we have lost two telemetry transmitters used in the Arapaima fish tracking study; and a large set of gillnets used in our experimental fishing work was lost during a boat wreck in a tributary of the Juruá. I'm afraid these accidents are not infrequent in this part of the Amazon. We have also lost a drone, used to generate aerial photographs of oxbow lakes, which had to be replaced. |
| Consumables | | | | Fuel costs for both a full time large diesel-powered boat and gasoline for 2 or 3 aluminium boats powered by 25HP motors have been exorbitant, as fuel in the remote town of Carauari is the most expensive anywhere in Brazil. Our fuel bills have therefore been a lot higher than we expected, not least because of seasonal shortages in the town and hikes in the price of gasoline and diesel during periods of scarcity. This has required an additional £1200 spent on fuel. |
| Others (see below) | | | | |
| **TOTAL** | **72,147** | **72,147** | | |

Highlight any agreed changes to the budget and **fully** explain any variation in expenditure where this is +/- 10% of the budget. Have these changes been discussed with and approved by Darwin?

## 14. OPTIONAL: Outstanding achievements of your project during the reporting period (300-400 words maximum). This section may be used for publicity purposes

I agree for the Darwin Secretariat to publish the content of this section (please leave this line in to indicate your agreement to use any material you provide here)

We are only about half-way through this process but this Darwin Project clearly shows that managing high-value freshwater fish and turtle populations within different elements of Amazonian floodplain ecosystems can rapidly achieve rare 'win-win' solutions in the interest of both conservation of seasonally-flooded várzea forests and biodiversity and enhanced livelihoods for local communities. This can be demonstrated by tangible findings.

## Annex 1: Report of progress and achievements against Logical Framework for Financial Year 2014-2015

| Project summary | Measurable Indicators | Progress and Achievements April 2014 - March 2015 | Actions required/planned for next period |
|---|---|---|---|
| *Goal/Impact*<br>Understand the spatial dynamics of productivity and exploitation of aquatic vertebrates — including fish and reptiles — along the Juruá River, a major tributary of the Amazon river, and create a spatially-explicit set of management guidelines to protect the landscape-scale sustainability of inland fisheries that can be feasibly enforced by local resource users. This will be based on community-based "fishing agreements" over an access-rights zoning system defining a spatio-temporal harvesting mosaic of commercial and subsistence fisheries including no-take areas (i.e. subsistence-only and strictly protected oxbow lakes). This will lead to measurable protein-acquisition benefits to small-scale artisanal fishermen resulting from population recovery of harvest-sensitive stocks. | | | |
| *Purpose/Outcome* (insert original project purpose/outcome statement)<br>(1) Understand the landscape-scale context and spatial dynamics of the (over)exploitation of local fisheries and the biophysical basis of fish/turtle resource productivity across one of the most productive white-water tributaries of the Amazon river, the ~3,000-km long Juruá River. | Annual counts of adult pirarucu (*Arapaima gigas*) fish in 83 oxbow lakes under varying categories of protection status, as per 'fishing agreements' between local communities and commercial fishermen.<br><br>A range of research and management activities centred on breeding sites where ovipositing female turtles (*Podocnemis expansa* and *Podocnemis unifilis)* converge. A total of ~28 protected and unprotected sandy beaches along the Juruá River will be | The counts for Year 1 and 2 are done. All of our focal lakes will be counted every year, during the tenure of the project and we will make sure we find the resources to continue this work for at least a few more years after the project terminates.<br><br>Done. | We will keep the *Arapaima* count and consolidate the fishing agreements between local communities and commercial fishermen.<br><br>- Economic analysis of sandy beaches protection implementation<br>- GPS telemetry of freshwater turtles (females and juveniles)<br>- Complete collection of tissue samples for DNA analyses |

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| (2) Understand the competitive basis for local conflicts between commercial (large-scale) fishing boats using long gillnets (>200m) and small-scale, subsistence fishermen using artisanal fishing gear (line-and-hook; cast-nets; spears; bow-and-arrow), which often result in outbreaks of rural violence and occasionally deaths along the Juruá River. | monitored.<br><br>Limnological measurements conducted at 83 oxbow lakes along a ~492-km section of the Juruá River.<br><br>CPUE data from offtakes of all aquatic sources of animal protein recorded on a weekly basis over 24 months at ~420 households from 35 local communities along a ~492-km section of the Juruá River | <br><br>Done<br><br>Ongoing. | |
| (3) Measure the importance of no-take areas (oxbow lakes and sand beaches) via strictly-enforced 'fishing agreements' setting aside two categories of protected lakes and beaches, in both managing the spatial structure of aquatic protein harvest, and allowing stock recovery of key harvest-sensitive fish species, such as pirarucu (*Arapaima gigas*) and tambaqui (*Colossoma macropomum*), and freshwater turtles. | GPS monitoring of the movements of a fleet of commercial fishing boats over at least a 1-year period, following authorization from the Fishermen Cooperative of Carauarí and Eirunepé; and Monitoring of fish landings from fishing boats at the local markets of these urban centres.<br>Spatial modelling of oxbow-lake fish productivity under varying degrees of protection from commercial fishing and connectivity to the main river channel. | This is a complex goal, because we have found that to fit a GPS receiver onto a fishing boat requires high levels of fisherman cooperation and trust. So we are planning to do this in the next dry season to independently validate spatial information from interviews.<br><br>Future action. | |
| (4) Understand the resource overlap basis for local human-wildlife conflicts in aquatic ecosystems, including large apex | Local interviews in a large set of communities and mapping from direct observations. | Largely done – a few more target communities will be interviewed. | |

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| predators (e.g. giant river otters, *Pteronura brasiliensis* and black caimans, *Melanosulchus niger*) which are frequently killed by fishermen to protect fish stocks.<br><br>(5) Create a set of spatially-explicit guidelines that can be feasibly enforced to manage the sustainable exploitation of freshwater protein resources across major watersheds of lowland Amazonia.<br><br>(6) Extend the results of this project to (i) other parts of the Juruá watershed; (ii) other major rivers of Brazilian Amazonia; and (iii) other lowland Amazonian countries, using lessons learnt from the project and project results translated into a substantive illustrated *Handbook of Freshwater Fisheries Management Techniques*. | Guidelines based on local and commercial offtake data; spatial zoning; spatial modelling; spatial behaviour of key fish species; and socioeconomic constraints on implementation.<br><br>To be implemented jointly with state and federal government agencies. | Ongoing but largely implemented.<br><br>Year 3-4. | |
| Output 1. Local empowerment and consolidation of an oxbow lake management system across the entire study landscape | 1a. Background research leading to the development of a spatially explicit management protocol of community-based freshwater fisheries management | 1a. We began the data collection, and the preliminary analysis. | |

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| | 1b. Data from limnological sampling of 83 spatially-explicit oxbow lakes during both the wet and the dry seasons. | 1b. Done. |
| | 1c. Technical training Workshop deployed to both artisanal and commercial fishermen of the central Rio Juruá region; Technical training Workshop with key stakeholders including the Fishermen Cooperatives, municipal county administrators of fishing licenses, managers of sustainable-use protected areas, and representatives of SDS/CEUC and ICMBio) | 1c. We began the technical training. But we are planning to undertake an intensive training workshop with the stakeholders briefly. |
| | 1d. Deliberations of negotiated settlement between commercial and artisanal fishermen thereby subsidizing a legal agreement ratified by the Fishermen Cooperatives of Carauarí and Eirunepé | 1d. This is one of the biggest challenges of our project. We started the negotiations, but this involves time and patience. Our goal is to finish the project with a real and measurable agreement between professional and artisanal fishermen, which we are referring to as 'Fishing Accords'. |
| | 1e. Preparation of the *Handbook of Community-Based Freshwater Fisheries Management Techniques.* | 1e. Future action. |
| | 1f. Dissemination of the *Handbook* to all institutions involved in resource management, particularly concerning fisheries. | 1f. Future action. |
| Activity 1.1 Seasonal limnological sampling of 83 oxbow lakes with one dry-season and one wet-season campaign. | | Done. |
| Activity 1.2 Household-level surveys of all types of aquatic resources extracted across ~420 households distributed across 35 local communities. | | We start the surveys and this will continue until October 2015. |

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| Activity 1.3 Investigate the relationship between household CPUE and oxbow lake primary productivity under different categories of lake protection. | | This is being done but is yet to be completed |
| Activity 1.4 Investigate the relationship between household CPUE e explanatory variables both at the patch and landscape scale. | | This is being done but is yet to be completed |
| Activity 1.5 Examine the functionality and ecosystem level consequences of lake protection status according to the 'fishing accords' promoted by the project. | | This is being done but is yet to be completed |
| Activity 1.6 Downloading and processing of GPS tracking data and composite maps of commercial fishing boat forays and density of fishing activity both within and outside the focal reserves. | | Future action. |
| Activity 1.7 Design, preparation, printing and distribution of a *Handbook of Freshwater Fisheries Management Techniques.* | | Future action. |
| Output 2. Design, local empowerment, consolidation and expansion of the spatial management system addressing freshwater turtles and ovipositing sites on fluvial sandy beaches | 2a.Training Workshop on turtle management to local stakeholders, namely the residents of RDS Uacari and RESEX Medio Juruá.<br><br>2b. Discussions with Reserve Management Council on spatial zoning of all dry-season sandy beaches.<br><br>2c. Number of fluvial sand beaches protected along a 492-km section of the Juruá River.<br><br>2d. Counts and electronic tagging of live turtle hatchlings dug from nests, quarantined, and released.<br><br>2e. Large-scale movements of adult *Podocnemis* turtles over a 24- | 2a.This activity is planned after the economic and ecological analysis.<br><br>2b. Done.<br><br>2c. Done.<br><br>2d. This is being done but is yet to be completed<br><br>2e. This is being done but is yet to be completed |

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| | month period. | |
| Activity 2.1. Local agreements setting-aside a set of protected egg-laying sand beaches along a 492-km section of the Juruá River. | | Done. |
| Activity 2.2 A 5-day training course (for 30 local assistants and village leaders) on the conservation & management of freshwater turtles. | | Done. |
| Activity 2.3 Monitoring abundance and reproductive output of *Podocnemis expansa* and *P. unifilis* females during the breeding season, along a subset of study beaches. This will include a minimum of 5,100 nests over a 3-yr period. | | Done. |
| Activity 2.4 Monitoring the hatchling activity of some 300,000 hatchlings over a 3-year period; Record biometric data on ~5% of these hatchlings; organize and conduct quarantine period of turtle hatchlings; successful release of post-quarantine hatchlings. | | This is being done but is yet to be completed |
| Activity 2.5 GPS and VHF-transmitter tagging of 10 adult female turtles (5 *P. expansa* and 5 *P. unifilis*), which will be monitored for 24 months. This satellite tracking component will ensure that we understand turtle migrations and the role of oxbow lakes during the non-breeding season. | | This is being done but is yet to be completed |
| Activity 2.6 Electronic tagging of 5,000 post-quarantine hatchlings [using transponders microchips] prior to releasing from fluvial beaches | | This is being done but is yet to be completed |
| Activity 2.7 Design and production of an illustrated booklet on *Freshwater Turtle Ecology & Management*. | | Future action. |
| Output 3. *Arapaima* ecology | 3a. Understanding of movements of adults and juvenile individuals between lakes during the wet season<br><br>3b. Understanding of home range of *Arapaima*<br><br>3c. Collecting of scale to quantify the age of harvested individuals | 3a. We have started the telemetry monitoring and the data are being collected.<br><br>3b. It will be possible with the telemetry data.<br><br>3c. Done. |

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| | 3d. Collection of DNA samples to understand the movements in a largest scale | 3d. We have collected 210 DNA samples from different lakes. But we are planning to extend the spatial sampling next dry season |
| Activity 3.1 Training of a local person to conduct the telemetry work one time per week | | Done. |
| Activity 3.2 Capture of six *Arapaima* individuals to input the transmitters | | Done. |
| Activity 3.3 Collection of DNA material | | Done. |
| Activity 3.4 Collection of scales | | Done. |
| Output 4. Local empowerment and consolidation of *Arapaima* stock assessment and management programme | 4a. Initial presentation of subproject and training Workshop to local artisanal fishermen from 35 local communities on Arapaima census techniques | 4a. Done. |
| | 4b. Training Workshop extension to key stakeholders outside the two protected areas (Fishermen Cooperatives, municipal county administrators of fishing licenses, managers of sustainable-use protected areas, and representatives of SDS/CEUC and ICMBio) | 4b. We started the technical training for the communities. Moreover, we are planning a meeting with all stakeholders, when we finish our analysis. |
| | 4c. Total number of protected oxbow lakes negotiated with commercial fishermen cooperative under mutually-agreed “fishing accords”. These will be invigilated during the dry-season, and will adhere to a sustainable offtake | 4c. We consolidated work on lakes that were the focus of many local communities and improved the protection of 7 additional lakes which provide food and cash for three communities outside the protected areas. We are going try to expand protection of more lakes, particularly in areas outside of the reserves which have long been neglected. |

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| | quota following a stock-recruitment assessment<br><br>4d. Time-series from at least 26 lakes beginning to show population recovery trends by the end of Project Year 2. | <br><br>4d. This is being conducted in more than 70 lakes |
| Activity 4.1 Reserve council and community meetings to ensure that this component of the project is understood. These meetings will include the selection of the key oxbow lakes. | | Done. |
| Activity 4.2 Annual counts of adult *Arapaima* fish (*Arapaima gigas*) in at least 23 oxbow lakes | | A total of 80 lakes have been counted. These lake will be counted every year from now on, during and after project completion. |
| Activity 4.3 Mapping of lakes with varying probability of *Arapaima* occurrence | | Done. |
| Activity 4.4 Training of 60 artisanal fishermen in *Arapaima* census techniques, to be included in annual counts | | We have trained about 45 fishermen both within and outside the reserves. |
| Activity 4.5 A target number of 26 large oxbow lakes to be included into stock assessments of *Arapaima* by Year 3 of the Project. These lakes will be managed thereafter following tightening of commercial access restrictions. | | Future action. |
| Output 5. Design and establishment of a management plan for "problem" apex predators including *Pteronura* and *Melanosuchus* | 5a. Development and preparation of educational booklet with the goal of reducing conflicts between subsistence/commercial fishermen and *Pteronura and Melanosuchus.*<br><br>5b. Dissemination of a "problem-species" illustrated educational booklet to all Juruá communities.<br><br>5c. Population estimates combined intensive field surveys and information from interviews at 40 communities on the spatial | 5a. Future action.<br><br>5b. Future action.<br><br>5c. We have begun interviews and surveys of population parameters. |

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| | distribution of occupancy records of *Pteronura and Melanosuchus.*<br><br>5d. Illustrated talks at seven venues bringing together representatives of ~40 local communities of RESEX Medio Juruá and RDS Uacari. | <br><br>5d. Future action. |
| Activity 5.1 Investigate the spatial distribution and habitat selection of both Giant Otters and Black Caimans in relation to the spatial distribution of (human) fishing activity | | Done. |
| Activity 5.2 Investigate levels of otter, caiman and human mortality and the intensity of conflicts between fishermen and large aquatic apex predators. | | We carried out systematic interviews with fishermen and with the local Secretariat of Health. Four resident fishermen were killed by large Black Caimans in the last 3 yrs so this is a raw issue that we are also addressing. This will lead to a study on whether or not to maintain the ban of black caiman hunting but this is beyond the scope of this project. |
| Activity 5.3 Interviews at 40 communities to obtain species occupancy and incidence density data for a 500-km section of the Juruá River. | | Done. |
| Activity 5.4 Mapping of all water bodies including oxbow lakes, overlaid with the occurrence probability of *Pteronura* and *Melanusuchus* | | Done. |
| Activity 5.5 Conduct a spatio-temporal and resource overlap analysis between otters/caimans and fishermen | | The data is already available but the analysis is yet to be done. |
| Activity 5.6 Design and production of an illustrated educational booklet to enhance the prospects of large predator conflict resolution across all local communities | | Future action. |
| Output 6: Empirical and theoretical test of management protocols and expansion into other river basins of Brazilian Amazonia and other Amazonian countries | 6a. Analytical approaches to data integration including productivity-based stock-recruitment models; spatial modelling showing the importance of no-take areas under a source-sink population framework; an analysis of the socioeconomic benefits of no-take areas accrued to local communities.<br><br>6b. Distribution of the *Fisheries* | 6a. This is being done but is yet to be completed.<br><br>6b. Future action. |

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| | *Handbook* to all relevant institutions and government agencies involved in the management of freshwater fisheries in Brazilian, Bolivian, Colombian and Peruvian Amazonia.<br><br>6c. Final Workshop held in Manaus to a target audience of natural resource management agencies, particularly government and nongovernment organizations responsible for fisheries management<br><br>6d. Presentations of project results at the Latin American Wildlife Management Congress, Association for Tropical Biology & Conservation meeting, and Society for Conservation Biology. | 6c. Future action; but this workshop may be held in the Jurua Region closer to our local partners.<br><br>6d. An oral presentation has been accepted at the Tropical Biology & Conservation (ATBC) meeting in July 2015 in Hawaii, USA. An keynote presentation will be given in the Brazilian Mammalogy Congress in Sept 2015 in Joao Pessoa, Brazil. Additional presentations on the project have been delivered at Museu Goeldi, Brazil; Oregon State University, USA; and Universidade Estadual Santa Cruz, Brazil. |
| Activity 6.1 Stock-recruitment model to inform sustainable *Arapaima* offtakes from seasonally discrete water-bodies such as oxbow lakes | | Done. |
| Activity 6.2 Elaboration of an *Arapaima* source-sink population model with and without no-take areas under varying degrees of primary productivity | | This is being done but is yet to be completed. |
| Activity 6.3 A State of Amazonas wide *Podocnemis expansa* turtle conservation gap analysis involving all major river basins providing adequate nesting sites. | | Future action. |
| Activity 6.4 A cost-benefit analysis of implementation of no-take areas quantifying the opportunity costs to local communities, socioeconomic challenges to implementation, levels of compliance, and tangible benefits to local communities (e.g. increases in fish biomass yields or per capita intake of fish protein). | | Future action. |
| Activity 6.5 Identification of all likely sites across Brazilian Amazonia where our zonation-based fisheries management protocol can be | | Future action. |

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| replicated. | | |
| Output 7: Local training in biodiversity monitoring and waterbird conservation | 7a. Waterbird survey in 32 lakes during the four moments of the flood pulse: Dry, wet, water increasing and water decreasing<br><br>7b. Survey the environmental variables: Habitat type, macrophytes coverage, primary productivity, limnological parameters<br><br>7c. Talking about the results in all communities | 7a. To be completed this month.<br><br>7b. Largely done, but additional mapping of aquatic plant cover of oxbow lakes will be done using both RapidEye (5m pixel) and higher-resolution imagery.<br><br>7c.To be continued during the next field season. |
| Activity 7.1: Training of 10 local wildlife monitors | | Done. |
| Activity 7.2: Measures and sampling of environmental variables | | Done. |
| Activity 7.3: Sampling of 32 lakes during the dry season | | Done. |
| Activity 7.4: Sampling of 32 lakes during the water increasing season | | Done. |
| Activity 7.5: Sampling of 32 lakes during the wet season | | Done. |
| Activity 7.6: Sampling of 32 lakes during the water decreasing season | | To be completed this month. |
| Activity 7.7: Data analysis | | This is being done but is yet to be completed. |
| Activity 7.8: Talk with communities | | Future action. |
| Output 8: Seasonal movements of terrestrial vertebrates between floodplain (*várzea*) forest and upland (*terra firme*) forest | 8a. Sampling more than 40 points spreading in floodplain and upland forest during dry and wet seasons in year 1 | 8a. Done. |

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| | 8b. Sampling more than 40 points spreading in floodplain and upland forest during dry and wet seasons in year 2<br><br>8c. Talking in communities about the results | 8b. Done.<br><br>8c. Future action. |
| Activity 8.1: Camera-trap sampling more than 80 points in year 1(Both dry and wet season) | | Done. |
| Activity 8.2: Camera-trap sampling more than 80 points in year 2 (Both dry and wet season) | | Done. |
| Activity 8.3: Talk with communities | | Several talks and dialogues have been done; but future action on additional communication. |
| Output 9: Terrestrial wildlife depletion envelopes near local communities | 9a. Understand the relationship between community size, landscape context and game and nongame population sizes near local communities | 9a. Fieldwork has been completed away from communities (radial distances = 500m – 6000m) and analyses are ongoing; additional work on peri-community (0 – 500m) wildlife abundance is being carried out at this writing. |
| Activity 9.1: Camera trap surveys | | Done. |
| Activity 9.2: Signs surveys | | Done. |
| Activity 9.3: Local interviews | | Done. |
| OUTPUT 10: Social benefits of protected area | 10a. Interviews with protected areas residents<br><br>10b. Interviews with local people from outsiders communities<br><br>10c. Interviews with local government<br><br>10d. Interviews with communities leaders | 10a. Done.<br><br>10b. Done.<br><br>10c. Done.<br><br>10d. Done. |

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| | 10e. Interviews with local organisations | 10e. Done. |
| Activity 10.1: Interviews with at least 50 families from protected area | | Done. |
| Activity 10.2: Interviews with at least 50 families from outside reserves | | Done. |
| Activity 10.3: Interviews with all leaders from more than 40 communities | | Done. |
| Activity 10.4: Interviews with all the government agencies | | Done. |
| Activity 10.5: Interviews with all local organisations | | Done. |
| Output 11: Wattled curassow (*Crax globulosa*) conservation programme | 11a. Collecting data of behaviour, food and habitat preference of wattled curassow<br><br>11b. Population censuses<br><br>11c. DNA collection<br><br>11d. Telemetry<br><br>11e. Wattled Curassow distribution across a longitudinal section of 1000km along the Juruá River (NEW INDICATOR) | 11a. This is being done but is yet to be completed.<br><br>11b. Done.<br><br>11c. Done.<br><br>11d. This is being done but is yet to be completed.<br><br>11e. Future action. |
| Activity 11.1: Sampling of fruit consumption by Wattled Curassow | | Done |
| Activity 11.2: Surveys about habitat preference | | Done |
| Activity 11.3: Population censuses in determined transect lines | | Done |

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| Activity 11.4: Collection of DNA samples trough harvested individuals | | Done |
| Activity 11.5: Telemetry of six individuals | | This is being done but is yet to be completed. |
| Output 12: Lowland paca (*Cuniculus paca*) ecology and conservation programme (NEW OUTPUT) | 12a. Nocturnal censuses in different types of habitat: Bank of streams, trail in upland forest, trail follow the streams during all season of the flood pulse | 12a. Work towards this output started this month. This will continue during Year 3. |
| Activity 12.1: Training of 10 local wildlife monitors | | Done. |
| Activity 12.2: Nocturnal censuses in different types of habitat during the wet season | | Done. |
| Activity 12.3: Nocturnal censuses in different types of habitat during the water decreasing season | | Future action. |
| Activity 12.4: Nocturnal censuses in different types of habitat during the dry season | | Future action. |
| Activity 12.5: Nocturnal censuses in different types of habitat during the water decreasing season | | Future action. |
| Output 13: Tambaqui *(Colossoma macropomum)* management programme | 13a. *Colossoma* offtake: Household-level surveys<br><br>13b. Sampling with gillnets in different types of lakes<br><br>13c. Implementation of mark-recapture approach | 13a. Done.<br><br>13b. Done, but with few results due to extreme difficulties of live-capturing and marking *Colossoma* fish.<br><br>13c. Done, but with few results |
| Activity 13.1: Household-level surveys in ~420 households distributed across 35 local communities. | | This is being done but is yet to be completed. Some 320 households belonging to all communities exploiting a set of 32 focal lakes will be interviewed for 16 weeks this dry season. |
| Activity 13.2: Sampling with gillnets in more than 20 lakes with different types of management and environmental condition | | Done, but we got a few data. This failure probably is due the complex ecology of this specie, and also due the past condition of overexploitation |
| Activity 13.3: Mark-recapture of individuals | | Due the low catch, this activity was not satisfactory. |

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| Output 14: Traditional knowledge as a tool for understand the past changes on fisheries (NEW OUTPUT) | 14a. New output. It is being constructed – to be led by Brazilian PhD student, Carolina Freitas (UFRN) | 14a. New output |

## Annex 2 Project's full current logframe

| Project summary | Measurable Indicators | Means of verification | Important Assumptions |
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| **Goal:**<br>Effective contribution in support of the implementation of the objectives of the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered Species (CITES), and the Convention on the Conservation of Migratory Species (CMS), as well as related targets set by countries rich in biodiversity but constrained in resources. | | | |
| **Outcome:**<br>Understand the landscape-scale context and spatial dynamics of the (over)exploitation of local fisheries and the biophysical basis of fish/turtle resource productivity across one of the most productive white-water tributaries of the Amazon river, the ~3,000-km long Juruá River.<br><br>Understand the competitive basis for local conflicts between commercial (large-scale) fishing boats using long gillnets (>200m) and small-scale, subsistence fishermen using artisanal fishing gear (line-and-hook; cast-nets; spears; bow-and-arrow), which often result in outbreaks of rural violence and occasionally deaths along the Juruá River.<br><br>Measure the importance of no-take areas (oxbow lakes and sand beaches) via strictly-enforced 'fishing agreements' setting aside two categories of protected lakes and beaches, in both managing the spatial structure of aquatic protein harvest, and allowing stock recovery of key harvest-sensitive fish species, such as pirarucu (*Arapaima gigas*) and tambaqui (*Colossoma macropomum*), and freshwater turtles.<br><br>Understand the resource overlap basis | Annual counts of adult pirarucu (*Arapaima gigas*) fish in 83 oxbow lakes under varying categories of protection status, as per 'fishing agreements' between local communities and commercial fishermen.<br><br>A range of research and management activities centred on breeding sites where ovipositing female turtles (*Podocnemis expansa* and *Podocnemis unifilis)* converge. A total of ~28 protected and unprotected sandy beaches along the Juruá River will be monitored.<br><br>Limnological measurements conducted at 83 oxbow lakes along a ~492-km section of the Juruá River.<br><br>CPUE data from offtakes of all aquatic sources of animal protein recorded on a weekly basis over 24 months at ~420 households from 35 local communities along a ~492-km section of the Juruá River<br><br>GPS monitoring of the movements of a fleet of commercial fishing boats over at least a 1-year period, following authorization from the Fishermen Cooperative of Carauarí and Eirunepé; and Monitoring of fish landings from | | |

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| for local human-wildlife conflicts in aquatic ecosystems, including large apex predators (e.g. giant river otters, *Pteronura brasiliensis* and black caimans, *Melanosulchus niger*) which are frequently killed by fishermen to protect fish stocks.<br><br>Create a set of spatially-explicit guidelines that can be feasibly enforced to manage the sustainable exploitation of freshwater protein resources across major watersheds of lowland Amazonia.<br><br>Extend the results of this project to (i) other parts of the Juruá watershed; (ii) other major rivers of Brazilian Amazonia; and (iii) other lowland Amazonian countries, using lessons learnt from the project and project results translated into a substantive illustrated *Handbook of Freshwater Fisheries Management Techniques*. | fishing boats at the local markets of these urban centres.<br><br>Spatial modelling of oxbow-lake fish productivity under varying degrees of protection from commercial fishing and connectivity to the main river channel. | | |
| **Outputs:**<br><br>**1.** Local empowerment and consolidation of an oxbow lake management system across the entire study landscape | 1a. Background research<br><br>1b. Limnological sampling<br><br>1c. Technical training workshop<br><br>1d. Negotiated 'Fishing Accords' between subsistence and commercial fishermen<br><br>1e. Preparation of *Fisheries Handbook*<br><br>1f. Dissemination of *Fisheries Handbook* | 1a. scientific papers and technical reports<br><br>1b. datasheets<br><br>1c. Photographs, datasheets<br><br>1d.Reports of meeting<br><br>1e. Reports of meeting and a document describing a consolidated proposal<br><br>1f. Send the *Fisheries Handbook* to all institution that work with fisheries and local communities in the Juruá | 1a. Scientific papers are important to strengthen the proposal, but sometimes the publication process takes a long time. So, the background for this output should be available in technical reports and other means of dissemination.<br><br>1b. This output is completed and the data are available.<br><br>1c. The technical training depends on the community interest. But, the 42 main communities that we have been working with are very interested in this training.<br><br>1d. It is a difficult output because there is a long history of conflicts between different users of fish. However, our project has been successfully implementing oxbow lake management.<br><br>1e. We have been working on the |

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| | | | results of the Handbook and we have no concerns about consolidating it.<br>1f. We have a close relationship with all fisheries institutions and they are waiting for this material. |
| **2.** Design, local empowerment, consolidation and expansion of the spatial management system addressing freshwater turtles and ovipositing sites on fluvial sandy beaches | 2a. Turtle training workshop<br>2b. Spatial zoning discussions<br>2c. Survey fluvial beaches<br>2d. Hatchling counts and tagging<br>2e. Adult radio-tracking<br>2f. Proposal to expand fluvial sandy beach protection (in numbers and total area) | 2a. Photographs, data sheets<br>2b. Reports of meeting<br>2c. Data sheets<br>2d. Data sheets<br>2e. Data sheets<br>2f. Technical report | 2a. This is done<br>2b. This output is done and the data are available.<br>2c. This output is done and the data are available.<br>2d. This output is done and the data are available.<br>2e. This output is done and the data are available.<br>2f. The proposal will be consolidated, but the expansion of beach protection depends on governmental support. |
| **3.** *Arapaima* ecology | 3a. Radio telemetry of wet season movements between lakes<br>3b. Radio telemetry of ranging behaviour within lakes<br>3c. *Arapaima* fish scale samples<br>3d. *Arapaima* DNA samples | 3a. Photographs, data sheets<br>3b. Photographs, data sheets<br>3c. Samples stored in genetics lab at INPA.<br>3d. Samples stored in genetics lab at INPA. | 3a. The major challenge is finding Arapaima during the high-water season with conventional telemetry.<br>3b. The major challenge is finding Arapaima during the high-water season with conventional telemetry.<br>3c. We have collected a lot of samples, and they are available in the genetics lab at INPA.<br>3d. We have collected a lot of samples, and they are available in the genetics lab at INPA. |
| **4.** Local empowerment and consolidation of *Arapaima* stock assessment and management programme | 4a. *Arapaima* training workshop inside reserves<br>4b. *Arapaima* training workshop outside reserves<br>4c. Negotiate protected oxbow lakes | 4a. Reports and photographs<br>4b. Reports and photographs<br>4c. Reports of meetings<br>4d. Data sheets | 4a. No concerns because it is a local demand.<br>4b. The communities from outside the reserves have a low level of socio-political organization, so few people may |

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| | 4d. Population recovery time-series | | be interested in a training course.<br>4c. Due to the low level of social organization few people could participate in the meetings. However, it is critical to improve lake management outside reserves.<br>4d. We have a time series around of around 8 years for most lakes; the challenge will be to maintain data collection after our project is discontinued |
| **5.** Design and establishment of a management plan for "problem" apex predators including *Pteronura* and *Melanosuchus* | 5a. Background research<br>5.b Educational booklet on conflicts<br>5c. Dissemination of educational booklet<br>5d. Population estimates from field surveys and interviews<br>5e. Illustrated talks on problem species and human-wildlife conflicts | 5a. Scientific papers, data sheets, technical reports and student dissertation.<br>5b. Copy of booklet<br>5c. Make booklet available to all communities<br>5d. data sheets<br>5e. Talks at 20 communities | 5a. The background research is available and completed.<br>5b. No major concern<br>5c. No major concern<br>5d. No major concern<br>5e. No major concern |
| **6.** Empirical and theoretical test of management protocols and expansion into other river basins of Brazilian Amazonia and other Amazonian countries | 6a. Stock-recruitment models and spatial modelling of no-take areas<br>6b.Distribution of *Fisheries Handbook*<br>6c. Resource management workshop<br>6d. Presentations at international conferences | 6a. Scientifc papers and technical reports<br>6b. Make *Fisheries Handbook* available to all institution that work with fisheries<br>6c. Report of meeting<br>6d. Published material | 6a. Fish dispersal, lake spatial distribution, and lake productivity and lake offtake data to be made available to Dr Taal Levi (Oregon State University)<br>6b. No major concern<br>6c. The success of the workshop depends on the participation of the institutions that work with fisheries.<br>6d. No major concern<br>6e. No major concern |
| **7.** Local training in biodiversity monitoring and waterbird conservation | 7a. Waterbird surveys in oxbow lakes<br>7b. Environmental surveys in oxbow lakes<br>7c. Dissemination of results in local communities | 7a. Data sheets<br>7b. Data sheets<br>7c. Report of talk and photographs | 7a. This output is done and the data are available<br>7b. This output is done and the data are available<br>7c. No major concerns |

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| **8.** Seasonal movements of terrestrial vertebrates between floodplain (*várzea*) forest and upland (*terra firme*) forest | 8a. Camera-trap sampling in Yr 1<br>8b. Camera-trap sampling in Yr 2<br>8c. Dissemination of results in local communities | 8a. Photographs, data sheets<br>8b. Photographs, data sheets<br>8c. Report of talk and photographs | 8a.This output is done and the data are available<br>8b. This output is done and the data are available<br>8c. No major concern |
| **9.** Terrestrial wildlife depletion envelopes near local communities | 9a. Camera-trap sampling, signs surveys and interviews near local communities | 9a. Data sheets, camera trap photographs | 9a. This output is underway and the data will be available |
| **10.** Social benefits of protected areas | 10a. Interviews inside reserves<br>10b. Interviews outside reserves<br>10c. Interviews with local government<br>10d. Interviews with community leaders<br>10e. Interviews with local organisations<br>10f. Data analysis | 10a. Photographs, voice recorder data and data sheets<br>10b. Photographs, voice recorder data and data sheets<br>10c. Photographs, voice recorder data and data sheets<br>10d. Photographs, voice recorder data and data sheets<br>10e. Photographs, voice recorder data and data sheets<br>10f. Reports and thesis | 10a. This output is done and the data are available<br>10b. This output is done and the data are available<br>10c. This output was done and the data are available<br>10e. This output was done and the data are available<br>10f. This report/thesis is under preparation by Julia Romero. |
| **11.** Wattled curassow (*Crax globulosa*) conservation programme | 11a. Curassow behavioural surveys<br>11b. Curassow population censuses<br>11c. Curassow DNA samples<br>11d. Curassow radio-telemetry<br>11e. Curassow large scale distribution data throughout the Juruá (NEW INDICATOR)<br>11f. Estimates of habitat occupancy and population size (NEW INDICATOR) | 11a. Data sheets<br>11b. Data sheets<br>11c. Samples stored in genetics lab at INPA.<br>11d. Data sheets<br>11e. Data sheets<br>11f. Statistical modelling and population projections | 11a. This output is underway and the data will available<br>11b. This output is underway and the data will available<br>11c. Crax globulosa is a very rare species, so DNA samples are difficult to obtain<br>11d. In the beginning of this component the assumption was that the capture of some individuals would be very difficult. But at this moment we have four individuals captured and the telemetry and ecological study are underway.<br>11e. This 3 month boat expedition is yet to be deployed. |

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| | | | 11f. This will be done by Gabriel Leite provided high-quality data are available |
| **12.** Lowland paca (*Cuniculus paca*) conservation programme | 12a. Paca censuses (including other nocturnal forest mammals) | 12a. Data sheets | 12a. No major concern; this is underway; however, we still require a better data quality control and verification protocol. |
| **13.** Tambaqui *(Colossoma macropomum)* management programme | 13a. Interviews of household *Colossoma* offtake<br>13b. *Colossoma* gillnet surveys<br>13c. *Colossoma* mark-recapture surveys<br>13d. Cross-referencing lake management programme with Colossoma reported yields (CPUE). (NEW INDICATOR) | 13a. Data sheets<br>13b. Data sheets<br>13c. Data sheets<br>13d. Data sheets | 13a. No major concern<br>13b. The *Colossoma* is the most complicated high-value fish species to study, due to low capture arte<br>13c. We still do not know if this output will be feasible, due to low number of captures; however, Talles Colaço will be working further on this.<br>13d. No major concern |
| **14.** Traditional knowledge as a tool to understand past changes on fisheries (NEW OUTPUT) | 14a. Interviews with experienced fisherman at 42 communities | 14a. Photographs, voice recorder data and data sheets | 14a. No major concerns; this will be carried out over 3 months during the next dry season. |

**Activities** (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1)

1.1 Seasonal limnological sampling of 83 oxbow lakes with one dry-season and one wet-season campaign.

1.2 Household-level surveys of all types of aquatic resources extracted across ~420 households distributed across 35 local communities.

1.3 Investigate the relationship between household CPUE and oxbow lake primary productivity under different categories of lake protection/management.

1.4 Investigate the relationship between household CPUE e explanatory variables both at the patch and landscape scale.

1.5 Examine the functionality and ecosystem level consequences of lake protection status according to the 'fishing accords' promoted by the project.

1.6 Downloading and processing of GPS tracking data and composite maps of commercial fishing boat forays and density of fishing activity both within and outside the focal reserves.

1.7 Design, preparation, printing and distribution of a *Handbook of Freshwater Fisheries Management Techniques.*

2.1 Local agreements setting-aside a set of protected egg-laying sand beaches along a 492-km section of the Juruá River.

2.2 A 5-day training course (for 30 local assistants and village leaders) on the conservation & management of freshwater turtles.

2.3 Monitoring abundance and reproductive output of *Podocnemis expansa* and *P. unifilis* females during the breeding season, along a subset of study beaches. This will include a minimum of 5,100 nests over a 3-yr period.

2.4 Monitoring the hatchling activity of some 300,000 hatchlings over a 3-year period; Record biometric data on ~5% of these hatchlings; organize and conduct quarantine period of turtle hatchlings; successful release of post-quarantine hatchlings.

2.5 GPS and VHF-transmitter tagging of 10 adult female turtles (5 *P. expansa* and 5 *P. unifilis*), which will be monitored for 24 months. This satellite tracking component will ensure that we understand turtle migrations and the role of oxbow lakes during the non-breeding season.

2.6 Electronic tagging of 5,000 post-quarantine hatchlings [using transponders microchips] prior to releasing from fluvial beaches
2.7 Design and production of an illustrated booklet on *Freshwater Turtle Ecology & Management*.

3.1 Training of a local person to conduct the telemetry work one time per week
3.2 Capture of six *Arapaima* individuals to input the transmitters
3.3 Collection of DNA material
3.4 Collection of scales

4.1 Reserve council and community meetings to ensure that this component of the project is understood. These meetings will include the selection of the key oxbow lakes.
4.2 Annual counts of adult *Arapaima* fish (*Arapaima gigas*) in at least 23 oxbow lakes
4.3 Mapping of lakes with varying probability of *Arapaima* occurrence
4.4 Training of 60 artisanal fishermen in *Arapaima* census techniques, to be included in annual counts
4.5 A target number of 26 large oxbow lakes to be included into stock assessments of *Arapaima* by Year 3 of the Project. These lakes will be managed thereafter following tightening of commercial access restrictions.

5.1 Investigate the spatial distribution and habitat selection of both Giant Otters and Black Caimans in relation to the spatial distribution of (human) fishing activity
5.2 Investigate levels of otter, caiman and human mortality and the intensity of conflicts between fishermen and large aquatic apex predators.
5.3 Interviews at 40 communities to obtain species occupancy and incidence density data for a 500-km section of the Juruá River.
5.4 Mapping of all water bodies including oxbow lakes, overlaid with the occurrence probability of *Pteronura* and *Melanusuchus*
5.5 Conduct a spatio-temporal and resource overlap analysis between otters/caimans and fishermen
5.6 Design and production of an illustrated educational booklet to enhance the prospects of large predator conflict resolution across all local communities

6.1 Stock-recruitment model to inform sustainable *Arapaima* offtakes from seasonally discrete water-bodies such as oxbow lakes
6.2 Elaboration of an *Arapaima* source-sink population model with and without no-take areas under varying degrees of primary productivity
6.3 A State of Amazonas wide *Podocnemis expansa* turtle conservation gap analysis involving all major river basins providing adequate nesting sites.
6.4 A cost-benefit analysis of implementation of no-take areas quantifying the opportunity costs to local communities, socioeconomic challenges to implementation, levels of compliance, and tangible benefits to local communities (e.g. increases in fish biomass yields or per capita intake of fish protein).
6.5 Identification of all likely sites across Brazilian Amazonia where our zonation-based fisheries management protocol can be replicated.

7.1 Training of 10 local wildlife monitors
7.2 Measures and sampling of environmental variables
7.3 Sampling of 32 lakes during the dry season
7.4 Sampling of 32 lakes during the water increasing season
7.5 Sampling of 32 lakes during the wet season
7.6 Sampling of 32 lakes during the water decreasing season
7.7 Data analysis
7.8 Discussions with and talks delivered at communities

8.1 Camera-trap sampling more than 80 points in year 1(Both dry and wet season)
8.2 Camera-trap sampling more than 80 points in year 2 (Both dry and wet season)
8.3 Discussions with and talks delivered at communities

9.1 Camera trap surveys
9.2 Signs surveys
9.3 Local interviews

10.1 Interviews with at least 50 families from protected area
10.2 Interviews with at least 50 families from outside reserves
10.3 Interviews with all leaders from more than 40 communities
10.4 Interviews with all the government agencies
10.5 Interviews with all local organisations
10.6 Data analysis and writing up.

11.1 Sampling of the feeding and ranging ecology of Wattled Curassow
11.2 Surveys about habitat preference
11.3 Population censuses along pre-determined transect lines
11.4 Collection of DNA samples from harvested individuals
11.5 Telemetry of six or more individuals
11.6 New boat expedition: Curassow large scale distribution data along the Juruá
11.7 Estimates of habitat occupancy and population size

12.1 Training of 10 local wildlife monitors
12.2 Nocturnal censuses in different types of habitat during the wet season
12.3 Nocturnal censuses in different types of habitat during the water decreasing season
12.4 Nocturnal censuses in different types of habitat during the dry season
12.5 Nocturnal censuses in different types of habitat during the water decreasing season

13.1 Household-level surveys at ~420 households distributed across 35 local communities.
13.2 Sampling with gillnets at more than 20 lakes with different types of management and environmental condition
13.3 Mark-recapture of individuals
13.4 Cross-referencing lake management programme with *Colossoma* reported yields (CPUE).

14.1 NEW OUTPUT

## Annex 3 Standard Measures

Please expand and complete Table 1: new projects should complete the Y1 column and also indicate the number planned during the project lifetime. Continuing project should cut and past the information from previous years and add in data for the most recent reporting period. Quantify project standard measures over the last year using the coding and format from the Darwin Initiative Standard Measures (see website for details: http://darwin.defra.gov.uk/resources/) and give a brief description. Please list and report on relevant Code No's. only. The level of detail required is specified in the Standard Measures Guidance notes under 'definitions and reporting requirements' column. Please devise and add any measures that are not captured in the current list. Please note that these measures may not be a substitute for output level objectively verifiable indicators in the project logframe.

**Table 1 Project Standard Output Measures**

| Code No. | Description | Gender of people (if relevant) | Nationality of people (if relevant) | Year 1 Total | Year 2 Total | Year 3 Total | Total to date | Total planned during the project |
|---|---|---|---|---|---|---|---|---|
| Established codes | | | | | | | | |
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In Table 2, provide full details of all publications and material produced over the last year that can be publicly accessed, e.g. title, name of publisher, contact details, cost. Mark (*) all publications and other material that you have included with this report.

**Table 2 Publications**

| Title | Type (e.g. journals, manual, CDs) | Detail (authors, year) | Gender of Lead Author | Nationality of Lead Author | Publishers (name, city) | Available from (e.g.website link or publisher) |
|---|---|---|---|---|---|---|
| O manejo como ferramenta de conservação das várzeas amazônicas | Workshop presentation | Silva, J.V.C. | Male | Brazilian | Museu da Amazônia | http://www.museudaamazonia.org.br/index.php?q=94-conteudo-58570-o-manejo-como-ferramenta-de-conservacao-das-varzeas-amazonicas |
| | | | | | | file:///C:/Users/Owner/Downloads/livro-de-resumos-11-simcom-2014.pdf |
| Fruit–frugivore interactions in | Journal | Hawes, J.E. & | Male | British | Journal of Tropical | http://dx.doi.org/10.1017/S026 |

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|---|---|---|---|---|---|---|
| Amazonian seasonally flooded and unflooded forests | | Peres, C.A. | | | Ecology 30: 381-399 | 6467414000261 |
| Seasonal abundance and breeding habitat occupancy of the Orinoco Goose (*Neochen jubata*) in western Brazilian Amazonia | Journal | Endo, W., Haugaasen, T. & Peres, C.A. | Male | British | Bird Conservation International 24: 518-529 | http://dx.doi.org/10.1017/S0959270914000173 |
| Human wildlife conflicts: a review of conflicts with freshwater mammals and reptiles in the tropics and subtropics | Dissertation | Cook, P. | Male | British | University of East Anglia | |
| Giant otter population responses to habitat expansion and degradation induced by a mega hydroelectric dam. | Journal | Palmeirim, A. F., Peres, C. A., & Rosas, F. C. | Female | Brazilian | *Biological Conservation*, *174*, 30-38. | |
| Pervasive transition of the Brazilian land-use system. | Journal | Lapola, D. M., Martinelli, L. A., Peres, C. A., et al. | Male | Brazilian | *Nature Climate Change*, *4*, 27-35. | doi:10.1038/nclimate2056 |
| | | | | | | |

## Annex 4 Onwards – supplementary material (optional but encouraged as evidence of project achievement)

This may include outputs of the project, but need not necessarily include all project documentation. For example, the abstract of a conference would be adequate, as would be a summary of a thesis rather than the full document. If we feel that reviewing the full document would be useful, we will contact you again to ask for it to be submitted.

It is important, however, that you include enough evidence of project achievement to allow reassurance that the project is continuing to work towards its objectives. Evidence can be provided in many formats (photos, copies of presentations/press releases/press cuttings, publications, minutes of meetings, reports, questionnaires, reports etc.) and you should ensure you include some of these materials to support the annual report text.

## Checklist for submission

| | Check |
|---|---|
| **Is the report less than 10MB?** If so, please email to Darwin-Projects@ltsi.co.uk putting the project number in the Subject line. | |
| **Is your report more than 10MB?** If so, please discuss with Darwin-Projects@ltsi.co.uk about the best way to deliver the report, putting the project number in the Subject line. | |
| **Have you included means of verification?** You need not submit every project document, but the main outputs and a selection of the others would strengthen the report. | |
| **Do you have hard copies of material you want to submit with the report?** If so, please make this clear in the covering email and ensure all material is marked with the project number. | |
| Have you involved your partners in preparation of the report and named the main contributors | |
| Have you completed the Project Expenditure table fully? | |
| Do not include claim forms or other communications with this report. | |