

Darwin Initiative – Final Report

Darwin project information

Project Reference	17-012
Project Title	Belize large-mammal corridor project
Host country(ies)	Belize
UK Contract Holder Institution	University of Southampton (UoS)
UK Partner Institution(s)	n/a
Host Country Partner Institution(s)	Panthera University of Belize (UoB) Belize Forest Department (BFD)
Darwin Grant Value	£
Start/End dates of Project	1 st April 2009 to 31 st July 2012
Project Leader Name	Dr C. Patrick Doncaster
Project Website	http://darwin.defra.gov.uk/project/17012/ http://www.belizewildliferesearch.com/index_files/Page972.htm
Report Author(s) and date	C. P. Doncaster, R. Foster, B. Harmsen, 31 st July 2012

1 Project Background

This project had a three-fold purpose: (i) to plan a workable natural corridor to connect protected areas in Belize; (ii) to implement this into the framework of existing protected areas and zoning plans of Belize; (iii) to establish an in-country tradition of training skills for Belizeans to study their own wildlife.

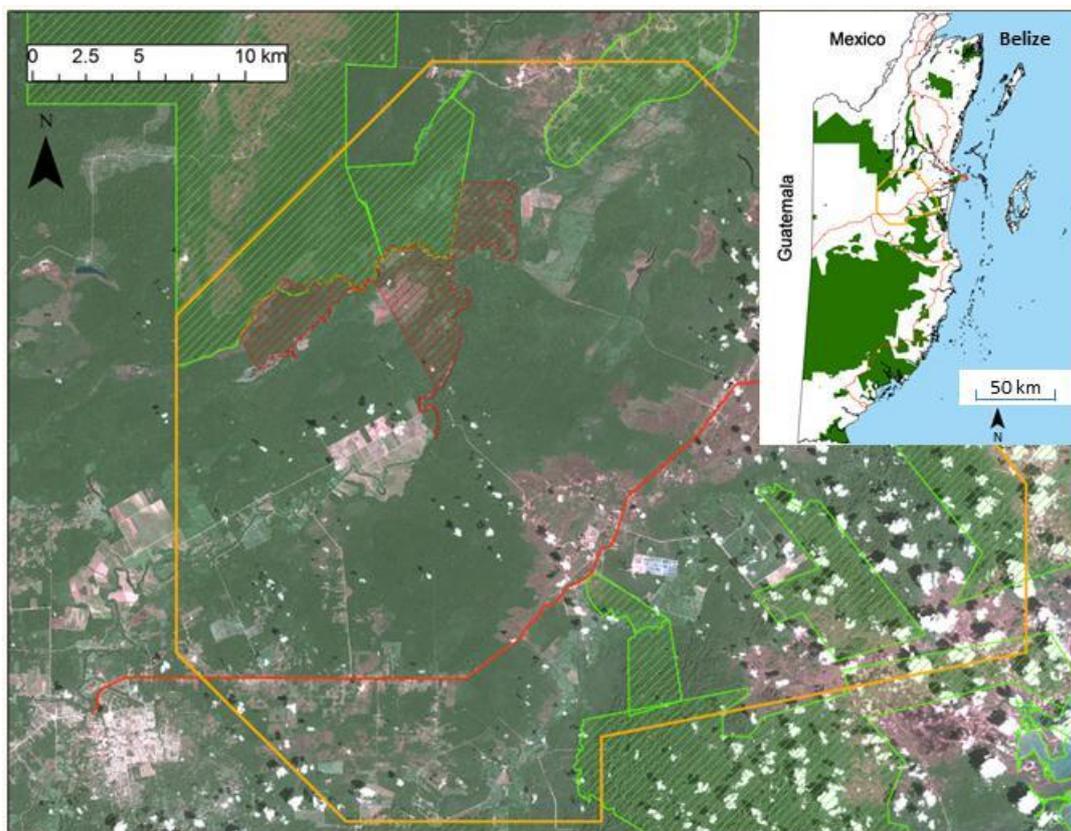


Fig. 1. The corridor study area (outlined in yellow on satellite image, and on inset map of Belize), showing the Western Highway (red), the newly acquired protected area 'Labouring Creek Corridor Wildlife Sanctuary' (red hatching), and previously established protected areas (green hatching and green on inset). Satellite shows dark-green forest, dark-brown savannah, and square blocks of arable land. Inset shows protected areas (green) and highways (red).

The outstanding achievements and legacy of the project were formal Government-level commitment to the corridor, institutionalisation of rigorous mammal monitoring, capacity building, and national-level awareness of the corridor and its function.

The main project outputs were an extensive database of ecological information, the Sanctuary, corridor-specific posts that will outlive the project, personnel trained (interns, undergraduates, graduates, staff), and awareness-raising materials on the corridor.

2 Project support to the Convention on Biological Diversity (CBD)

Project support for the CBD objectives, 2010 biodiversity target, themes, and cross-cutting issues

The project has supported the CBD objective to conserve biological diversity and the sustainable use of its components. The 2010 biodiversity target, set in April 2002, was to achieve a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and the benefit of all life on Earth. The recognition and implementation of the Central Belize Corridor will reduce the loss of forest biodiversity at a national and regional level, because it forms a crucial link of the Mesoamerican Biological Corridor connecting South and North America. In particular the project has addressed the theme of Forest Biodiversity and its corresponding Work Program. Within this work program, the project has addressed all three programme elements: 1) Conservation, sustainable use and benefit sharing; 2) Institutional and socio-economic enabling environment; and 3) Knowledge, assessment and monitoring. It has addressed these elements by: 1) reducing the threats to forest

biodiversity, and promoting the sustainable use of forest biodiversity; 2) increasing public education, participation and awareness; 3) improving knowledge on and the methods for the assessment of the status and trends of forest biodiversity, and 4) improving the infrastructure for data and information management for accurate assessment and monitoring of forest biodiversity. In particular the project has transferred technology and built local capacity to facilitate this programme of work by the developing nation of Belize. As well as reducing threats to forest biodiversity by addressing fragmentation, the project has promoted sustainable forest management with respect to the harvesting of forest fauna. The project has also documented the impact of hurricane and forest fires, which were considered priorities within the Forest Biodiversity Work Program at the 9th COP meeting.

The project has also supported cross-cutting themes of Sustainable Use of Biodiversity; Protected Areas; Communication, Education and Public Awareness; and Identification, Monitoring, Indicators and Assessments. This has been achieved by the government-level recognition of the Central Belize Corridor and the new Wildlife Sanctuary created within it, and capacity building at the Environmental Research Institute of the University of Belize which has begun an on-going programme of rigorous mammal monitoring.

The evidence for these different forms of support for the CBD is detailed in Section 4 of this report.

Partnership support of host country institutions for capacity building to meet CBD commitments

The project has increased the capacity of the University of Belize and the Belize Forest Department to meet their CBD commitments. The project increased the capacity of the host country institutions to study, monitor, manage and raise awareness about terrestrial mammal species. As a group, mammals face one of the highest extinction threats (globally, ¼ are Red Listed), terrestrial mammals respond early to habitat change, and Belizean mammals are both exploited by and subject to conflicts with humans. Our project used several CITES-listed mammals as indicator species, focusing on their long-term survival within Belize and the wider region (Appendix-I listed: jaguar, puma, ocelot, tapir; Appendix-II listed: white lipped and collared peccaries). They functioned as flagship species to guide an officially endorsed corridor that will implement a key link in the Mesoamerican Biological Corridor system, which is a vital requirement in maintaining biodiversity within the region (CBD Article 1: Objectives).

The focused monitoring of mammalian movement patterns for this project supports CBD Article 7 (Identification and monitoring). It puts Belize as a country on track in implementing plans for the preservation of national and regional biodiversity (CBD Article 6: General measures for conservation and sustainable use) by creating vital connectivity to safeguard viable populations. The inclusion of the Central Belize Corridor in educational programmes runs through the Environmental Research Institute of the University of Belize and the Belize Forest Department supports CBD Article 13 (Public education and awareness).

The expansion of the National Protected Areas System in Belize that has been achieved with the establishment of a Wildlife Sanctuary, and is being made fully functional with the recognition of the larger Central Belize Corridor, will ensure an unprecedented scale of in situ conservation for the country (CBD Article 8: In-situ conservation, part (a)). It will readjust levels of protection to minimize conflict with local livelihoods (Article 8b, e) and maximise efficient management of biodiversity (Article 8c), realised by enforcement of corridor protection in law (Articles 8k and 10a). With project support, the University of Belize and Belize Forest Department have initiated discussions with partners for the development of a conservation action plan for the corridor in partnership with local people and stakeholders, so that livelihood options are created in synchrony with the regional Mesoamerican corridor function (CBD Article 1). The project has been instrumental in building government-level confidence in the Environmental Research Institute as a consultancy for environmental issues, a repository for environmental data and publications, and a source of experts who can advise on environmental issues (CBD Articles 17.1: Information exchange and 18.3 Clearing-house mechanisms for scientific cooperation).

Project interaction with host country CBD focal point

We attended the Inception Workshop for Belize's Fourth National Report to the UN CBD, hosted by the UNDP and our project partner the Belize Forest Department. The Chief Forest Officer for the Belize Forest Department is the focal point contact for the CBD. We were asked to join the Mountain and

Watershed Plenary Group to discuss forest fauna. The final report published in May 2010 included reference to the Darwin corridor project, the research and training of the ERI, and the target to incorporate the ecological connectivity of protected areas into protected area management by 2015. The Darwin project has increased Government awareness about connectivity and corridor ecology, and has accelerated the process towards achieving that target before 2015.

3 Project Partnerships

The project has been a collaborative enterprise between Panthera, the Environmental Research Institute (ERI) at the University of Belize (UoB), and the Belize Forest Department (BFD), coordinated through the UK University of Southampton (UoS). The partnerships were based on demand from the Government of Belize and the national University of Belize. The collaboration brought together all of the leading experts on Belizean mammals in Panthera and UoB, and drew on 30 years of expertise in population ecology at UoS. All partners were involved with the project planning and decision making, with the in-country lead taken by the ERI and Panthera's Belize Program. The project established a consortium agreement between all partners prior to the disbursement of funds. This delayed the start date of the project by 5 months but was necessary to facilitate disbursement of funds from UoS to international partners and ensure transparent accounting.

Description of project partners

Panthera provided matched funds and was involved throughout the project. The funds contributed to field equipment and operating costs, and the employment of key personnel who facilitated the DI project:

- Mr Arturo Ramos, Field Operations Manager at UoB (jointly funded by DI and Panthera; Sep 2009+)
- Mr George Hanson, Jaguar Officer at the BFD (until Apr 2010)
- Mr Jazmin Ramos, Corridor Officer at the BFD (Apr 2011+)
- Ms Yahaira Urbina, ground-truthing consultant, (May-June 2010)
- Mr Omar Figueroa, PhD student at University of Florida (stipend from Panthera 2009-2012)
- Dr Rebecca Foster, Director of Belize Program for Panthera (Aug 2009+), Visiting Scientist at UoS
- Dr Bart Harmsen, ERI-Panthera Research Fellow at UoB (Feb 2010+), Visiting Scientist at UoS

The University of Belize (UoB) provides the infrastructure and human resources for its Environmental Research Institute (ERI), which was inaugurated in January 2010. The ERI aims to train the next generation of Belizean environmental biologists to become skilled in wildlife monitoring and conservation management. Key personnel involved in the DI project were:

- Dr Elma Kay, ERI Terrestrial Science Director (Jan 2010+)
- Mr Said Gutierrez, ERI-Darwin Junior Wildlife Biologist (funded by DI, Feb 2010-Jul 2012)
- Dr Bart Harmsen, ERI-Panthera Research Fellow (see above)
- Mr Arturo Ramos, DI Field Operations Manager (see above)
- Mr Michael Brakeman, DI Field Assistant (funded by DI and Panthera, Jun 2010-Jun 2012)
- Mr Christopher Estrada, DI Field Assistant (funded by DI and Panthera, Jun 2010-Jun 2012)
- Ms Yahaira Urbina, people and wildlife survey consultant (funded by DI Jul-Aug 2010, Nov 2011-Feb 2012)

The Belize Forest Department (BFD) is a Government Department, originally within the Ministry of Natural Resources and the Environment (MNRE, run by Hon Gaspar Vega). In March 2012 the Department moved to the newly created Ministry of Forestry, Fisheries and Sustainable Development (MFFSD, run by Hon Lisel Alamilla). In 2008, Hon Gaspar Vega indicated his interest in securing a wildlife corridor in Central Belize (see his original letter of support). The BFD is the body with which we discussed wildlife management and law enforcement issues relevant to the corridor. Key personnel involved in the DI project were:

- Mr George Hanson, Jaguar Officer (see above)
- Ms Rasheda García, Wildlife Programme Officer (Feb 2009+)
- Mr Jazmin Ramos, Corridor Officer (see above)

Summary of partner roles

Patrick Doncaster's role as Project Leader involved yearly visits to Belize, to oversee project design and implementation, and to teach quantitative methods and sampling design at the University of Belize (585 person-hours of contact time with staff and students).

Bart Harmsen and Rebecca Foster provided scientific expertise to the project, liaised with Project Leader, forged relationships with private landowners within the corridor, oversaw the field work and study design, managed in-country staff and funds, trained field staff and students, and taught the Wildlife Management course.

Said Gutierrez worked fulltime on all aspects of the project, from field work to management of databases and supervision and training of students.

Arturo Ramos worked fulltime in the field; he was trained in all aspects of fieldwork and was responsible for his two field assistants, Michael Brakeman and Chris Estrada. All three are residents of the corridor.

Yahaira Urbina, a graduate from the ERI Wildlife Management course, conducted ground-truthing interviews within the corridor, and conducted 'people and wildlife' interviews nationally. She is currently analysing the 'people and wildlife' data through a scholarship at the University of Oxford.

George Hanson was our main contact at BFD until he resigned in April 2010.

Rasheda García manages the BFD Wildlife Programme; she became our main contact within BFD after George Hanson resigned.

Jazmin Ramos was appointed by BFD specifically to work within the Central Belize Corridor; he focuses on public awareness, wildlife law enforcement and livestock predation.

Omar Figueroa's PhD research on jaguars and pumas in the corridor complements the DI project research. In 2010 he became a politically-appointed Senator and was played a key role in promoting the corridor among Government officials.

Elma Kay contributed 15% of her time to the project, primarily in planning with Drs Harmsen and Foster, and in communications with key Government officials.

During the project, Said Gutierrez, Arturo Ramos, Michael Brakeman and Chris Estrada received training: (i) first aid (two 2-day field courses Arturo and Said only); (ii) zoonotic risks during handling and capture of wild mammals, emergency procedures during chemical immobilisation (Arturo and Said only); (iii) techniques for the live capture of animals; (iv) how to use veterinary projectors; (v) how to fit a radio-collar; (vi) radio telemetry, (vii) deployment and maintenance of camera traps; Said Gutierrez was additionally trained in (i) analysis of telemetry data (ii) database management, (iii) advanced GIS at the Lands Information Centre.

Partnership challenges and achievements

Working with the Government of Belize has been greatly facilitated by our partnership with Dr Kay and Senator Figueroa. For more on achievements, lessons, strengths and challenges of the partnership, see Sections 4.7 and 5 below.

Arturo Ramos and Jazmin Ramos (not related) will both continue in their current roles post-project, with funding from Panthera. Said Gutierrez has been granted a Darwin Fellowship for graduate study in the UK for 1 year from September 2012.

Involvement with other institutions

Belize Wildlife Conservation Network and Belize Wildlife & Referral Clinic founder and veterinarian, Isabelle Paquet-Durand (DVM, PhD) advised on the safe handling and chemical immobilisation of wild-caught mammals.

Capture International run by professional trapper, Dairen Simpson, joined the project (Mar-Apr and Jul-Aug 2011) to train project personnel in alternative methods of live capture.

The Belize Zoo lies in the heart of the corridor, has been instrumental in raising awareness about the corridor, and has supported DI research through discounted accommodation at the field site for project volunteers, and access to captive animals for behavioural studies.

University of St Andrews Statistician Dr David Borchers at the Centre for Research into Environmental and Ecological Monitoring advised on methods of density estimation.

4 Project Achievements

4.1 Impact: achievement of positive impact on biodiversity, sustainable use or equitable sharing of biodiversity benefits

The project planned and implemented a wildlife corridor in Belize which forms a vital link in the Mesoamerican Biological Corridor connecting South and North America. The project achieved its original objectives for three major impacts relating to biodiversity and equitable sharing of biodiversity benefits: (1) creation of a unique in-country database of mammals living beyond the borders of protected areas and their interactions with humans, and its analysis for corridor delineation; (2) integration of the corridor into Belize Government policy; (3) on-going support for the corridor with UB teaching field-studies and wildlife monitoring that establish a tradition of training Belizeans to study their own wildlife. The corridor was highlighted by the Deputy Prime Minister of Belize in his Keynote speech to the 2010 meeting of the global Convention on Biological Diversity.

4.1.1. Mammal-monitoring database and corridor-zoning plan

The Darwin project created five types of dataset that are all the first of their kind nationally outside of protected areas.

Camera trapping was done with cross-corridor grid surveys using 90 camera traps, repeated annually. These recorded all five species of felid, coyote, fox, coati, tapir, both deer species, both peccary species, tayra, grison, anteater armadillo, paca, agouti, kinkajou, and howler monkey. Telemetry was used to radio-track jaguars, pumas, peccaries, foxes, pacas, coatis, and kinkajous. Due to a Category-2 hurricane passing through the corridor in 2010 and widespread wild-fires in 2011, these two datasets provide valuable samples for before-after-control-impact analysis of hurricane and fire damage, of which few others exist outside protected areas. Tracking data show large cats focusing their highway crossings at a single point, where the forest comes closest to the road, and one jaguar being killed by traffic while three others were shot by hunters/farmers. Tapirs avoided road crossings; other species crossed more frequently. A dataset of >100 faecal remains from large cats revealed important differences in the diet of corridor cats compared to those living in protected forest.

National-scale questionnaire surveys were done in 2010 of bush-meat in the diet of Belizeans, and in 2011 of wildlife conflict, hunting and wildlife law awareness. The first survey revealed bush-meat consumption within all districts and by all sectors of society, with paca meat particularly favoured. The second survey covered 4% of all households in Belize, and revealed that crop raiding by peccaries, agouti, coati, tapir, parrots was the most urgently-felt issue, particularly for the many small-scale and part-time farmers. Jaguar depredations on livestock were also a widespread source of conflict, particularly in farmland neighbouring protected areas. Belizeans were aware that hunting has a restricted season and that some animals are protected from hunting. Within the corridor areas, a survey was conducted of the social and economic status and activities of residents, and their views on activities that they would like to see developed and whether wildlife causes problems. These data are being analysed.

4.1.2. Implementation of the corridor by the Belize Government

In April 2011 the National Protected Areas Secretariat heard a submission by Dr Foster and Senator Figueroa on the value of the Corridor to Belize. On the basis of this submission, the Secretariat recommended incorporating implementation of the Corridor as a priority in the operational framework for the implementation of the National Protected Areas System Plan. Early in 2012 the government-led National Protected Areas Secretariat commissioned a Technical Report on Rationalisation of Protected Areas. This Secretariat has powers to implement the National Protected Areas System Plan. The Technical Report is being prepared by the non-profit Belize-based conservation organisation Wildtracks, funded by the Global Environment Facility of the UN Development Programme. It is currently (31 July) at final-draft stage with a schedule for presentation to Government in August 2012, extended from an original July schedule. It will then be available from Dr Kay on request. It endorses the prioritisation of the corridor at the highest level, and it will be summarised in an Information Paper that will be presented

to Cabinet later this year. Before April 2011, the corridor had no definition or protection. Government-level recognition and protection of the Wildlife Sanctuary within the corridor, and the guidelines for corridor implementation highlighted in the Rationalisation Report, set the stage so that from now onwards all natural habitats within corridor borders and regardless of ownership will be used in a manner that is consistent and compatible with the retention/conservation of a viable/functional corridor. In April 2012 the Minister for Forestry, Fisheries and Sustainable Development, Hon. Lisel Alamilla, took a Darwin-funded scoping flight over the Corridor with Drs Harmsen and Kay, in order to see it for herself.

Capacity for biodiversity was raised by the creation in 2010 of a new Wildlife Sanctuary within the corridor. The declaration ceremony was attended by the Deputy Prime Minister, members of the press, local stakeholders, and members of UB including undergraduate students of the Wildlife Management course. The Sanctuary makes a permanent legacy to posterity by protecting the last remaining crown land (36 km²) within the corridor area from all logging, hunting, fishing and collecting within its borders. It has a crucial location abutting the Belize River that bisects the corridor, being the only section to still retain riparian forest on both banks.

The Central Belize Corridor merited specific mention at the 2010 Conference of the Parties for the global Convention on Biological Diversity (Nagoya, Japan). The Deputy Prime Minister of Belize, representing the Central American Commission for the Environment and Development, announced the re-launching of the Mesoamerican Biological Corridor project under the CBD Life Web initiative. In his keynote speech he stated: “Just last month, my government established our newest reserve - the Central Biological Corridor - that will provide critical habitat for the jaguar and other species”.

Through the auspices of the Belize Forest Department, and supplemented by matched funding from Panthera, the Darwin project’s investment of £8,673 in knowledge exchange with stakeholders involved school visits, livestock protection workshops, interviews on national radio and television, community consultations with the members of the public living in the corridor area, dissemination of corridor posters in public areas and brochures and postcards at public events, three permanent billboards erected on the Western Highway, six corridor sanctuary signs along the Belize River, and a sign in the region of forest that reaches closest to the highway (an important mammal crossing point). Post-project, this work is being continued by the Wildlife Corridor Officer at the BFD.

4.1.3. Institutionalised training of Belizeans in the value of their forest wildlife

The investment of the Darwin grant in a salary to recruit a Wildlife Biologist to the University of Belize, and in equipment and infrastructure (vehicle, trapping and tracking equipment), were prerequisites for the investiture in 2010 of the Environmental Research Institute as the principal research arm of the University of Belize. This Institute now runs the University’s Wildlife Management course for Belizean undergraduates, led by Dr Harmsen. The compulsory fieldwork and project components of the course focus on monitoring mammals within the Corridor, using the Darwin 4×4 vehicle. The course trained 80 students in wildlife monitoring and management from 2010 to 2012, and it continues to grow post-project. It’s graduates have gone on to salaried posts with The Nature Conservancy, the Global Environmental Facilities Small Grants Program, the Natural Resources Management Programme at the University, the Belize Forest Department, the Belize Department of the Environment, the Belize Agriculture and Health Authority, Panthera, local NGOs, and Masters and Diploma programmes at Nottingham University and Oxford University. One graduate won a prize for her thesis work to pay for a trip to present it at the Mesoamerican Society for Biological Conservation in Costa Rica in November 2010. The success of the Environmental Research Institute is evidenced in its launching in 2011 of the University’s first graduate programme, an online Masters in Biodiversity Conservation and Sustainable Development in the Caribbean, in partnership with Anton de Kom University in Surinam, University of Guyana, and University of West Indies.

The Darwin project led to the creation in 2011 of a new post within the Belize Forest Department, of Wildlife Corridor Officer, funded in perpetuity by Panthera. The project post of Field Operations Manager, jointly funded by the Darwin grant and Panthera, continues post-project and full-time, funded by Panthera. Immediately following the end of the Darwin project, the Wildlife Biologist secured a Darwin Fellowship to take up a place on the MSc programme in Conservation and Biodiversity at the University of Exeter (2012-2013, with Dr Doncaster as PI).

4.2 Outcomes: achievement of the project purpose and outcomes

The outstanding achievements of the project are summarised below within the three categories of its original purpose.

Purpose #1. To plan a workable natural corridor connecting the two protected wilderness blocks in north and south Belize.

The agreement with BFD on the location of the corridor, and the resulting billboards on the Western Highway announcing entry into and exit from the corridor.

The database of land tenure within the corridor, necessary for identifying absent landowners and potential beneficiaries of carbon credits, and for tracking sales of land and proposed developments.

The commitment of Panthera to the corridor following the initiation of the Darwin project, and their on-going commitment to the corridor and to the ERI, which are secured for the foreseeable future.

Purpose #2. To implement the plan within the legal framework of existing protected areas and zoning plans within Belize.

The Resolution passed in 2011 by Belize's National Protected Areas Technical Committee, to recommend incorporating the implementation of the Central Belize Wildlife Corridor as a priority in the operational framework for the implementation of the National Protected Areas System Plan. The government-commissioned Technical Report on Rationalisation of Protected Areas, which endorses this recommendation at the highest level, discusses the Central Belize Wildlife Corridor as a model for corridor conservation and outlines the way forward for corridor implementation in Belize through guidelines and recommendations for a legal framework.

The 2010 declaration of the Wildlife Sanctuary in the corridor, which is now undergoing an official survey. A management consortium is being assembled, involving BFD, ERI, Panthera, and the Community Baboon Sanctuary (with 25 yrs of experience of local village communities managing a wildlife sanctuary).

The Keynote speech highlighting the corridor and political will for its conservation, given by Deputy Prime Minister and Minister for the Environment, the Hon Gaspar Vega at the November 2010 meeting of COP10 for the CBD at Nagoya, Japan.

Purpose #3. To establish an in-country tradition of Belizeans studying their own wildlife.

The Terrestrial Programme of the ERI, which could not have been established without funding from this project on capacity building in personnel and equipment (see Sect. 4.6 for value of capacity building).

The camera trapping and telemetry datasets, which are the first of their kind nationally outside of protected areas. Although less extensive than we had planned, due to the unforeseen hurricane and fire and difficulties of trapping and monitoring inherent to a flood-prone and human-disturbed habitat, they provide rare samples for before-after-control-impact analysis of hurricane and fire damage.

Career initiation for the Wildlife Biologist employed on the project, who has learnt field techniques for terrestrial mammal research, and will now pursue a MSc in the UK in order to obtain the graduate qualification that is a pre-requisite to becoming a full lecturer at UoB.

The employment of the Field Operations Manager and two field assistants from the village of Democracia, who raise the profile of the project within a key community at the heart of the corridor, and will continue in their roles post-project; enabling the ERI to train students in the field.

The appointment of the Central Belize Wildlife Corridor Officer within BFD, funded by Panthera beyond the end of the Darwin project, in recognition of the importance and high public profile of the corridor nationally and internationally.

The high number of Belizeans who have received training in wildlife research and management (80+, including 54 qualifications). The ERI Wildlife Management course for UoB undergraduates, which was enabled by the Darwin project, will continue post project, and continue to focus on corridor-related themes.

4.3 Outputs (and activities)

4.3.1. Collection of rigorously calibrated information on movement through fragmented landscapes by neotropical mammals

The ecological fieldwork component of the project has successfully collated an extensive database of information on mammal ecology within the corridor and human pressures on wildlife at a local and national level. This was achieved in the face of unforeseen natural disasters and human-induced complications including hurricane, wild fires, tropical storms, flooding, illegal activities (hunting and logging), equipment theft and human-induced mortality of study animals (poaching and traffic collisions). Live-trapping and telemetry was most impacted by these uncontrollable factors. The main datasets are summarised below. Data analyses are on-going.

In-country datasets

Mapping of corridor (Activities 1.1)

- 1) High resolution SPOT image of the corridor were obtained via Panthera from Planet Action in 2010 (pre-hurricane); aerial photographs were obtained during chartered flights over the corridor and the corridor wildlife sanctuary (pre-hurricane, post-hurricane, post-fires, one-year on post-hurricane and fires). These images allowed visual assessment of pre- and post-forest cover in the corridor.
- 2) Vegetation plots: 13 permanent plots of 0.08 ha were established in the Big Falls area to determine variance in above-ground carbon stock. These data allow an estimation of the total number of plots needed to complete a full carbon assessment for the corridor. They are the foundation for assembling a carbon project that would sell credits under the voluntary carbon market, using the Verified Carbon Standard (VCS) and the Climate, Community, Biodiversity (CCB) standards.
- 3) Land-tenure data (area, owner, surveyor) for the 2,782 land parcels that make up the corridor.

Systematic surveys (Activities 1.2)

- 1) Large-scale camera trap data: 73 stations were monitored over 12,184 trap-nights, covering 287 km² (minimum convex polygon) with mean inter-neighbour trap spacing of 1220 m. These produced data on 22 mammal species, including 24 individual jaguars. Three surveys were each run twice: 3 pre-hurricane, 1 post-hurricane, 1 post-hurricane during fires, 1 post-hurricane after fires. The first of the 6 surveys was run from Dec 2008 to Feb 2009 prior to the DI Award; subsequent surveys were only made possible by the DI award.
- 2) Small-scale camera-trap and burrow survey data: 125 stations were monitored over 500 trap-nights in 5 grids each 0.25 km² with fixed trap spacing of 100m. These produced data on 20 mammal species, including 19 individual pacas. Burrow activity data was additionally obtained from on all grids.
- 3) Small-scale camera-trap data (boundary of Corridor Wildlife Sanctuary): 14 stations were monitored, covering a linear route of 14km on both banks of the Belize River. This work is on-going, to date yielding data on 13 mammal species.
- 4) Corridor ground-truth survey (funded and conducted by Panthera): Survey of sightings of mammals in the corridor, involving interviews of 90 people who frequent the corridor.

Live trapping and radio telemetry data (Activities 1.3 and 1.4)

The following mammal species were caught and tracked with radio telemetry: pacas (7 individuals, 2,087 locations), coatis (4 individuals, 460 locations), grey foxes (3 individuals, 973 locations), tayra (1 individual, 15 locations), kinkajous (4, individuals, 341 locations), peccary (4 individuals, 43 locations). These data complement the GPS tracking of jaguars and pumas within the corridor (Omar Figueroa, PhD study).

Diet of jaguars and pumas

Opportunistic sampling for scats (faecal remains) obtained 75 jaguar scats and 35 puma scats, for comparison of prey diet with that from scat data in protected areas to the south of the corridor (Foster et al. 2010). The study included a calibration of biomass eaten by jaguars to biomass in faecal remains from feeding trials at the Belize Zoo to improve estimates of biomass consumed for each prey type.

People and wildlife surveys (Activities 3.1 and 4.1)

- 1) Socio-economic survey of corridor residents: 144 households were interviewed in 4 communities within the study area, to survey social and economic status and activities of residents, activities that they would like to see developed (e.g. ecotourism industry) and whether wildlife causes problems.
- 2) Survey of domestic and game meat consumption: This began as a local survey, and was upgraded to the national scale, interviewing a total of 806 Belizeans across all 6 districts.
- 3) Survey of game hunting, wildlife conflict (livestock predation, crop raiding) and wildlife law awareness: This began as a local survey, and was upgraded to the national scale, interviewing 3,000 Belizeans across all 6 districts (500 per district) equal to 4% of all households in Belize. The survey included questions to identify the most popular TV channels, radio stations and newspapers to aid in the BFD in targeted public awareness campaigns.
- 4) Corridor ground-truth survey (see 'systematic surveys' above): included questions about hunting activity specifically within the corridor.

Peer-reviewed publications (Activity 4.2)

See Annex 5 for the seven peer-reviewed manuscripts published during the project. Data analyses are ongoing; the following manuscripts are at various stages of preparation:

- Mammal resilience to hurricane and fire in Central Belize
- Predators and people: competition for game meat in Belize
- Burrow density as an index of paca density
- Paca ranging behaviour in a mosaic landscape
- Tapir density and ranging behaviour in Central Belize
- Coexistence of ocelots, jaguarondis and margays in Belize
- Conversion factor for analysing jaguar diet
- Kinkajou activity patterns and ranging behaviour after a hurricane (short note)
- Presence of coyotes in Central Belize after a hurricane (short note)

4.3.2. Instilling a tradition of objectively-based mammal monitoring in Belize

Inauguration and development of ERI

The ERI was inaugurated in January 2010, with the support of 4 key funders, including the DI and Panthera. The ERI launch event was well-attended by Government officials, local and national conservation NGOs, staff and students of the UoB and Galen University, and the press and media. The Hon. Vega, Deputy Prime Minister and Minister of Natural Resources and the Environment, gave a formal address praising the great achievement in founding the ERI, and looked with optimism to the future role of the ERI in natural resource management in Belize. Two years later, in January 2012, the ERI hosted an event to thank key partners, in particular DI and Panthera which have made possible the ERI's Terrestrial Programme. Attendees included Dr Cary Fraser, President of the University of Belize, Mrs Imani Fairweather-Morrison of the Oak Foundation, Mr Michael Corlett of the World Bank, Mr Jose chacon of the British High Commission, Dr Howard Quigley of Panthera, Ms Nayari Diaz of the Protected Areas Conservation Trust, Mr Ansel Dubon of the National Protected Areas Secretariat. As the ERI has grown, they have hired their own Biodiversity Monitoring Officer, a graduate of the Wildlife Management course (see below).

Appointment of Junior Wildlife Biologist at ERI (Activity 2.1.1)

Said Gutierrez was hired to join the DI project as the Junior Wildlife Biologist. During the course of the project he received training in field methods, data management and analysis and advanced GIS; and gave talks at various symposia and workshops and for the ERI Wildlife Management course. He has been accepted unconditionally for an MSc in Conservation and Biodiversity at Exeter University, funded by

the DI Fellowship programme. The ERI anticipates his return to the terrestrial programme (funding permitting) after his training in England.

ERI Wildlife Management course (Activity 2.1)

This is a 4-week intensive course within the BSc programme in Natural Resource Management at the University of Belize (UoB). Lectures covered the theory of mammal ecology and monitoring, with a focus on Belizean species and drawing on the DI project as an important case study. Field classes included the use of camera traps, live capture and handling of mammals, telemetry, interview and survey work, made possible only by the DI project. This course will continue beyond the end of the DI project.

Graduates of the course went on to further education/employment in the following areas:

Class of 2009 (9 students): Panthera consultant, protected area park manager, Caribbean Community Climate Change Center, ERI-DI field assistant, Natural Resources Management Programme at UoB, Belize, Community Baboon Sanctuary.

Class of 2010 (18 students): ERI (Biodiversity Monitoring Officer), MSc (Nottingham University), The Nature Conservancy, Global Environmental Facilities Small Grants Program, Belize Agriculture and Health Authority, Forest Department, ESRI Belize (GIS company), Department of the Environment, Toledo Institute for Development and Environment (TIDE), The Belize Zoo.

Class of 2011 (11 students): Caribbean Community Climate Change Center, Field assistant ERI, Belize Forest Department, Belize Department of the Environment.

The class of 2012 had 11 students.

Scholarships: Mesoamerican Society for Biological Conservation in Costa Rica; graduate diploma course in International Conservation Practise at the University of Oxford; Nottingham University Scholarship.

DI project internships and volunteer programme (Activities 1.2, 1.3, 1.4, 3.1, 4.1.1)

Students of UoB were encouraged to participate in fieldwork activities of the DI project as interns, joining other Belizean and overseas volunteers. Interns and volunteers were trained in field methods. Across the 3 years, these groups had the following numbers.

- 2010: 9 UoB interns; 11 UoS undergraduate volunteers, 2 Dutch student volunteers, 1 US volunteer.
- 2011: 2 UoB interns and 1 thesis project student, 2 Belizean student volunteer, 2 UoS undergraduate volunteers, 1 UK student volunteer, 1 Slovenian student volunteer.
- 2012: 9 UoB interns.

Training in ecological statistics at UoB with PI Dr Doncaster (Activity 2.1).

Designing mammal monitoring programmes requires an understanding of statistics. Through the DI project we trained >80 Belizeans from the ERI, Faculty of Science and Technology and the Faculty of Management and Social Sciences in study design and analysis:

- 1) 2-day course in study design for ecological fieldwork
- 2) 2-day workshop in statistical analysis of field data

Training in ecological fieldwork in 2-month visits for 11 UoS final-year undergraduates in 2010 and 2 in 2011. Their data collection and analyses contributed to the datasets listed in Sect. 4.3.1 above. They worked alongside UoB students, with mutually beneficial cultural exchange.

Capacity building to help bring a graduate programme to Belize

In June 2011, the ERI launched the first ever graduate programme at UoB: an MSc in 'Biodiversity Conservation and Sustainable Development in the Caribbean'. This online Masters in partnership with universities in Anton de Kom University in Surinam, University of Guyana, and University of West Indies provides training in wildlife management, field classes from Dr Harmsen and the opportunity to join the corridor project.

Research house

The Darwin team renovated a derelict cabin as a functional research house on a key piece of private land within the corridor (Big Falls, 150 km²). The research house has had frequent use by students of UoB and

UoS. Use of the house, and field activities on the land, ensures a permanent research presence on the property. The owners support this move as it helps reduce the threat of illegal hunters and loggers.

4.3.3. Delineation of the belt of contiguous wilderness that will constitute the wildlife corridor

The following data/activities have contributed to the delineation of the corridor boundaries within the study area. The data and proposed boundaries were presented to the Government of Belize's National Protected Areas Technical Committee, which agreed to incorporate a comprehensive corridor plan within the National Protected Areas System Plan through the rationalisation of the Protected Areas process. This development is detailed in Section 4.3.4.(2) below.

Land tenure of private lands within the corridor (Activity 1.1.1)

Said Gutierrez worked with the Belize Government's Lands Information Centre to compile a database of land tenure in the corridor, including interactive GIS layers. The database provided us with information on 2,782 land parcels (covering 92% of the 872km² corridor study area) helping us to track sales of land and proposed developments, and to identify absent landowners who own key properties within the corridor. A single privately owned property, Belize River Farm (aka Big Falls Farm) comprises 127km², which is 15% of the study area and 20% of the corridor.

Knowledge of wildlife distribution and movement (Activities 1.1, 1.2, 1.3, 1.4)

Section 4.3.1 above details the work on mammals, which includes evaluations of the propensity of key species to cross highways and identification of crucial highway crossing points.

Analyses of mammal data for delineation of boundaries (Activity 2.1.5)

- 1) Occupancy modelling: Panthera analysed survey data to calculate conditional probabilities for the presence of target species throughout the corridor.
- 2) Agent-based model of corridor scenarios: PhD student Angela Watkins (UoS) published an agent-based model for evaluating the permeability of alternative corridor scenarios in relation to least-cost optimal paths.

4.3.4. Advocacy, leading to implementation of corridor within the legal framework of Belize

Government recognition of corridor and zoning of private lands (Activities 4.1)

1) Following the presentation of a Corridor Brief (prepared by the DI team and Panthera) and discussions with members of Government by Senator Omar Figueroa, the Deputy Prime Minister, Hon Gaspar Vega, signed a Letter of Understanding between the Belize Government and the in-country DI partner Panthera, acknowledging the importance of connectivity at a national level.

2) Based on our proposal delivered to Belize's National Protected Areas Technical Committee (see Section 4.1.2 above), a resolution was passed in April 2011 to recommend incorporating implementation of the corridor as a priority in the operational framework of the National Protected Areas System Plan. We worked with the National Protected Areas Secretariat and the Forest Department to provide the Committee with the information they need to prepare a cabinet paper for Government endorsement of a formal commitment to the corridor. The submission of the cabinet paper was halted during the run-up to the general election in March 2012. Following the government re-shuffle after the re-election of the UDP party, the National Protected Areas Committee, chaired by the new Minister of Forestry, Fisheries and Sustainable Development, the Hon Lisel Alamilla, commissioned a Technical Report on Rationalisation of Protected Areas. This report sets out the rationale for protected areas and explains their importance in government policy, and is due for publication in August 2012. It has a section laying down general guidelines for the process of setting up corridors, which is based on the 3 years of knowledge gained by the Darwin project in the Central Belize Corridor. The draft cabinet paper recognising the Central Belize Corridor will instead be replaced by an Information Paper summarising the Technical Report.

3) Early in 2012 the Darwin team attended a National Land-Use Policy Development Workshop, providing the consultants preparing it with information about the corridor. This consultation led to the

National Land Use Policy for Land Resource Development, which was accepted by cabinet in May 2012. The Land Use Policy highlights corridors as strategies for natural resource and conservation and for climate-change mitigation:

“Biological corridors are being proposed as a set of ecosystems intended to ensure the connectivity of protected areas across the country. Necessarily, they include tracts of National Land and private land which have with no formal form of protection of the natural habitat. This proposal will be finalised to determine its feasibility in relation to other potential land uses, and the Lands and Surveys Department and private landowners will be approached to participate in the scheme.” [p. 31]

“Broaden the analysis of the vulnerability of ecosystems and species to the effects of climate change and, based on the findings, prioritise the configuration and management of protected areas and biological corridors to enable a greater bio-geographic scale and protect potential climate refugees.” [p. 33]

Government recognition of corridor and zoning of national lands (Activities 4.1)

Following the presentation of the Corridor Brief and discussions with members of Government by Senator Omar Figueroa, the Government protected two key parcels of national land within the corridor study area.

1) Key crossing point of Western Highway: A total of 700 ha of national land (previously held in trust) within the corridor were declared unavailable for sale to ensure that prospectors cannot purchase and develop the land. This is an important part of the corridor with forest reaching close to the highway, and so functions as a crossing point for wildlife. Evidence of crossings being focused at this point has been found for important target species such as jaguars, pumas, tapirs, margay and ocelot. The neighbouring land parcel is being logged and prospectors were looking to purchase the land to expand the logging concession.

2) Key crossing point of Belize River, and connection to northern protected forest block: A total of 3,600 ha of national land were declared a Wildlife Sanctuary. Its new status means that “no person shall hunt, shoot, kill or take any wild animal, or take or destroy any egg of any bird or reptile or any nest of any bird” (Belize National Parks System Act). This is a crucial link in the corridor, being the only section of the Belize River that still retains riparian forest on both banks. Developers were seeking to purchase the land for agricultural development. The neighbouring forested land has recently been purchased by a sugar company. Without the protected status of the corridor sanctuary, these lands would also have been sold for development.

Implementation and management of the corridor (Activities 3.1, 4.1)

1) Private lands: Management planning is on-going for ensuring that human activities on private lands are remain compatible with corridor function; its success depends on largely on stakeholder buy-in, public awareness and the mitigation of human-wildlife conflict (livestock predation, game hunting) (see ensuing sections). In addition, we have conducted a pilot study to assess the carbon sequestration potential of Belize River Farm, the largest privately owned-property within the corridor.

2) National lands: A sign has been erected on the national land that forms the key highway crossing point. The sign, designed by the Belize Zoo and funded by Panthera, states ‘We Care About Nature Out There’ and was designed to discourage illegal hunting and logging. The official survey to demarcate the borders of the corridor wildlife sanctuary is on-going (funded by £17,300 from a donor to Panthera) and Government signs indicating its new status have been erected along the river boundary by the DI team with the BFD. A motorboat funded by Panthera has enabled us to patrol the river boundary and monitor the wildlife (see Section 1). The DI team prepared a Concept Note and had preliminary discussions with the Community Baboon Sanctuary (CBS) to discuss management plans for the Sanctuary with a view to creating a consortium of multiple organisations to manage the area. The consortium would include the CBS and the BFD as the enforcement and patrolling agencies, the ERI as the scientific agency responsible for research and monitoring, and Panthera for technical support and help with mobilising resources for the management of the sanctuary. A broader process of planning conservation action, involving all corridor stakeholders, will be conducted later this year to set conservation targets and strategies for the entire Central Belize Corridor. This will also form the basis for a management plan for the Wildlife Sanctuary.

Public Awareness (Activity 4.1.2-3)

The following activities took place during the project.

- 1) Meetings with corridor communities: These were held to explain the function of the corridor, led by the Darwin team, including representatives from ERI, BFD, Panthera and the Belize Zoo.
- 2) Lectures about wildlife and the corridor at the Belize Zoo's summer camp for 40 children (2010 and 2011), and talks about the corridor at local schools.
- 3) Presentations about the corridor at symposia, workshops and professional meetings: Belize Wildlife Conservation Network Conference (2009), Belize-Mexican Symposium for Research Collaboration on Biodiversity and Natural Sciences (2011); National Spatial Data Infrastructure Conference (2011); MSBC Natural Resource Management Symposium (2011, 2012); Panthera Regional Meeting (2010, 2011); Jaguars and People (4 livestock predation workshops in 2010, 2011 and 2012).
- 4) Promotion of the corridor at public events: National Agricultural Show (2010 and 2012); 1st Annual GIS Expo in Belize (2012); the Ruta Maya (2012) 4-day boat race along the Belize River; Belize Zoo's annual Corridor Event for school children (2011).
- 5) Posters explaining the function of the corridor at bus terminals, including the main terminal in the capital Belmopan.
- 6) Dissemination of corridor postcards, posters, tee-shirts and wrist-bands.
- 7) Three double-face corridor billboards delineating the entrance/exit and centre of the corridor along the Western Highway. The DI team discussed the corridor with the general public in 6 community consultations, which elicited much positive discussion (see Annex 7 photograph album) and they introduced the corridor billboard to on national radio and national TV. The corridor billboards include logos of the Ministry of Natural Resources and Environment, the Ministry of Agriculture and Fisheries, the Belize Tourism Board, the Belize Livestock Producers' Association, the Protected Areas Conservation Trust, various local NGOs, and the Belize Zoo, all of whom endorse the corridor. The billboards on the Western Highway will be officially inaugurated in August 2012 by the new Minister of Forestry, Fisheries and Sustainable Development, the Hon Lisel Alamilla, at Belize Zoo.
- 8) The Deputy Prime Minister and (former) Minister of the Environment, Hon Gaspar Vega, gave the keynote speech at the ceremony to mark the official declaration of the corridor sanctuary. The ceremony was attended by Government officials, regional Ambassadors, the UoB, national NGOs, and the press.

Minimising human-wildlife conflict (Activities 3.1.1 and 4.1.4)

- 1) Livestock predation: Support for the corridor by the Ministry of Agriculture and the Belize Livestock Producers' Association (BLPA) is publically demonstrated by their logos featured on the corridor billboard. We ran 4 workshops about livestock predation for the Belize Forest Department, Department of Agriculture and BLPA, and various conservation NGOs. We also facilitated a meeting between the BFD Wildlife Programme and professional trapper Dairen Simpson as a resource for dealing with problem wildlife
- 2) Game hunting: With DI funds, the BFD prepared an infomercial about wildlife laws and hunting which will be aired on the radio in August 2012 (see scenario in Annex 7).
- 3) Wildlife trade: At the request of the BFD and the Belize Wildlife Conservation Network, the DI team supported a workshop to review the Wildlife Protection Order. This order has been developed to control the removal of animals from the wild for captivity. Raising awareness about captive wildlife will help protect wildlife, both within the corridor and at a national level. Already the BFD corridor officer has assisted in the release of endangered yellow-headed parrots in the corridor; they were originally pets, but handed over following an awareness campaign on trade in parrots.

Problems and resolutions during the project

Two major events influenced the distributions of corridor mammals, and our ability to study them.

Hurricane Richard (October 2010)

This category-2 hurricane passed directly over the corridor with wind speeds up to 98 mph, inflicting landscape-changing destruction, damaging 18% of the natural forests of Belize (SERVIR/CATHALAC).

Many forest trees were felled; many more were defoliated. This (i) reduced canopy shading; (ii) increased the amount of dead wood and leaf-litter; (iii) created a fire risk throughout the dry season; (iv) reduced the mobility of forest-dwelling mammals; (v) destroyed the infra-structure of forest trails that we had created; (vi) reduced our ability to monitor mammals.

We assessed the damage from the ground and the air. The infrastructure that we had established for systematic surveys, live trapping and telemetry (Activities 1.1.2, 1.2, 1.3 and 1.4) was devastated. Baited camera traps revealed unusual activities of mammals in the damaged forest, and presence of arboreal species on the ground. This motivated an otherwise unscheduled repeat of the large-scale surveys, to assess the ecological impact of the hurricane across the corridor, and forced us to drop the burrow, footprint and sighting surveys from the logical framework. The team continued clearing and re-opening the trail systems necessary for fieldwork over the ensuing 12 months. After the hurricane, large numbers of curassow were seen on the roads, probably because they were no longer able to move through the remaining forest. This is an important game bird, and anecdotal evidence indicated that hunters came from far and wide to take advantage of this easy and vulnerable prey. Rare forest animals such as toucans and howler monkeys were suddenly spotted in remnant patches of intact forest, often near neighbouring villages where they had not been seen previously.

Fires (April and May 2011)

Across Belize, 86,400 ha of forest burned, with the worst hit areas being in central Belize and within the path of hurricane Richard (Meerman 2011 ‘Aftermath of Hurricane Richard: Provisional Report on the Belize 2011 Wildfires’) Dead wood throughout the hurricane-damaged forests fuelled these fires for 6-8 weeks. The corridor and neighbouring protected areas suffered extensive fire damage.

Working with local residents, the DI team fought fires within the corridor. The fires prevented fieldwork at the height of the dry season, which is the best opportunity for live trapping. The fires made it impossible to activate live traps. We persisted with camera trapping, but lost equipment in consequence, as the fires frequently and quickly changed direction with the wind.

By the end of May 2011, smoke had cleared sufficiently for us to assess the extent of the fire damage. From the air, green canopies in some areas disguised places where fire had destroyed the understory vegetation. Other areas lost both the canopy and understory. Although the rains stimulated secondary regrowth of surviving trees, the fires exacerbated the damage wrought by Hurricane Richard, to substantially thin much of the broadleaf forest. Our cameras indicated that curassow had completely disappeared from the corridor area. Ten years of camera trapping in Belize has shown that camera traps are very efficient at detecting this ground dwelling game bird. Corpses of howler monkeys and kinkajous were found in burned-out forests. Most affected were the highly productive broadleaf and cohune palm forests, which provide habitat and food sources for mammals and birds. Camera trap data from 2011 showed elevated rates of illegal activity by loggers and hunters, compared to 2009/2010.

Other problems

Our ability to study mammals living in the corridor was further complicated by extensive flooding during the wet seasons. This restricted access to field sites and limited our ability to live trap safely (risk of animals drowning in traps) or maintain camera surveys (cameras submerged in flood waters).

Because we were working outside protected areas, we had to restrict our field sites to avoid the activities of poachers and illegal loggers. Both are most active during the dry season, the period when we needed to maximise our field activities. We handled this situation as best we could by obtaining advice from our field staff on the known hunting grounds of poachers and avoiding these locations wherever possible. This greatly reduced the extent of where we could work, and we still lost some equipment to thieves.

The run up to the General Election in 2012, and subsequent shifts in ministries and creation of new ministries, set back our plans for working with the Government for ~ 6 months. After the election, we had to adapt our strategy to changes within Government (detailed in Section 4.3.4(2) above).

4.4 Project standard measures and publications

All project standard measures are quantified in the table in Annex 4 and its end-notes. Publically accessible website features are detailed in Annex 5. Here we summarise briefly the project performance with respect to totals planned in the original application.

The project surpassed predictions on:

- Number of people attaining qualifications (54 realised / 40 planned).
- Number of undergraduate students having received training (89 / 40). The ERI Wildlife Management programme, the UoB internships, and the visits by UoS students, were all more popular than anticipated, with students particularly appreciating the opportunities to take part in fieldwork activities in the corridor including live trapping and radio-tracking.
- Number of postgraduate students to receive training (11 / 2-4). More international students than anticipated were attracted by the fieldwork opportunities on the project.
- Number of training weeks to be provided (374 / 55). This greatly exceeded the planned total due to the popularity of fieldwork amongst interns, undergraduates and postgraduates, and the demand for training in study design and statistics lectures and workshops put on by Dr Doncaster. The total given does not include the non-specific training received by Said Guterrez during his employment as Wildlife Biologist (~ half of his time).
- Number of people having received at least one year of training, excluding those above (12 / 4). With matched funding from Panthera, the project was able to take on more personnel than originally planned.
- Number of papers published or in press in peer reviewed journals (7 / 3+). The project was able to capitalise on pre-project foundational studies by Drs Harmsen and Foster.
- Number of workshops organised to disseminate Darwin project findings (10 / 3). Six community consultations were organised in April-July 2012 for information exchange with people living in the corridor, prior to the setting up of billboards on the Western Highway advertising the corridor.
- Number of conferences/workshops attended to disseminate Darwin project findings (22 / 3).
- Number of national press releases in host country (8 / 5).
- Number of local and national press releases in UK (3 / 1).
- Number of dissemination networks enhanced (3 / 1).
- Number of national TV features in host country (10 / 3-5).
- Estimated value (£'s) of physical assets to be handed over to Belize (£57,665 / £35,526). See Sect. 4.6.
- Number of permanent field plots established (207 / 60).
- Value of resources raised from other sources (i.e. in addition to Darwin funding) for project work – confirmed funding £224,577/ £155,107). All partners invested more than anticipated in the work.

The project under-performed on:

- Number of local press releases in host country (0 / 5). Belize is too small a country to distinguish between local and national press releases. The project targeted national TV and press, which cover local and national issues.
- Number of national Belize radio interviews (4 / 5). This was compensated by TV and press coverage.

4.5 Technical and Scientific achievements and co-operation

The abundance and movement of medium and large terrestrial mammal species were studied using camera-trap and telemetry technology. Data on wildlife exploitation and human-wildlife conflict were obtained via interviews conducted at the principal bus stations in all 6 districts of the country. Land tenure data was collated by working closely with three units within the Lands and Survey Department of the MNR: data on tenure status (Lands Registry) were combined with data from paper maps (Mapping & Surveying Centre) to create digitised maps (Lands Information Centre).

See Sects 4.1-2 above for technical and scientific achievements, and Sect. 3 for cooperation.

The project's database of camera-trap surveys before and after the hurricane will be valuable for modelling disaster control scenarios under climate change of increased hurricane frequencies.

The project's database of animal movements from radio-telemetry and camera traps will provide insights that help to fill the recognised research gap in population and community ecology (Agrawal *et al.* 2007

Front. Ecol. Environ., 5:145–152) in current understanding of the strengths and context-dependence of species interactions.

4.6 Capacity building

The Terrestrial Programme of the ERI could not have been established without funding from this project.

The capital equipment handed over to the ERI at the end of the project, including a 4-wheel drive vehicle which enables research capacity at ERI, radio-telemetry equipment, live-trapping equipment, camera traps, GPS units, computer and software, to a total value of £57,665.

Over 80 Belizeans have received training in wildlife research and management, including 54 qualifications obtained. The ERI Wildlife Management course for UoB undergraduates, which was enabled by the Darwin project, will continue post project, and continue to focus on corridor-related themes.

4.7 Sustainability and Legacy

The government-level recognition of the Central Belize Corridor that was obtained by our project will ensure its existence in perpetuity in Belizean law, as the gold standard for corridor implementation now starting to be proposed further north and south in the country.

The project was unusual in the high proportion of its funds being invested in Belize: 88% of the Darwin grant, and all of the 40% matched funding from Panthera. The Darwin project spearheaded the implementation of the corridor and the institutionalisation mammal monitoring. The high level of commitment from Panthera has developed into their picking up the continuation, for example by continuing to fund salaries of project staff (see below).

The Corridor will continue to receive a high profile nationally through the awareness-raising work of the BFD Wildlife Corridor Officer, whose post continues with Panthera funding.

Darwin Wildlife Biologist Said Gutierrez has obtained a Darwin Fellowship to take up a place on the MSc in Conservation and Biodiversity at Exeter University, to start in October 2012.

Arturo Ramos will continue his employment as Field Operations Manager within the ERI Terrestrial Programme, supported by Panthera funding, using the Darwin vehicle to access field sites.

Dr Kay's inaugural role as co-founder of the ERI and its Director of Terrestrial Sciences has taken her from a lecturer role at UoB to full membership of the government National Protected Areas Technical Committee, and member of the Prime Minister's Council of Science Advisers. Dr Harmsen's role in the project as Lead Contact for the Belizean partners led to his taking up a Panthera-funded Research Fellow and Lecturer post at the Environmental Research Institute in 2010, while Dr Foster moved into his previous post as the Director of Panthera's Belize Jaguar Program. They have retained Visiting Researcher status at Southampton University, and this has also been extended to Dr Kay and Mr Gutierrez for the foreseeable future. Dr Doncaster secured a 4-year DTA studentship with the Southampton Institute for Complex Systems Simulation for a project to simulate jaguar ranging behaviour within alternative designs of wildlife corridor in Belize. Ms Angela Watkins began this study in October 2010, with co-supervision by Dr Jason Noble in the University's Centre for Electronics and Computing Science. It will continue into 2013.

Since its inauguration during the Darwin project, the ERI has grown in reputation and reach. In June 2011 it spearheaded the inauguration of a regional MSc in Biodiversity Conservation and Sustainable Development, involving three other universities: Anton de Kom University of Suriname, the University of Guyana, and the University of the West Indies at St. Augustine; all associated staff now share the common pool of resources as associate members of each other's universities. The ERI Publications Repository on the web is set to become one of the databases of reports and peer-reviewed literature that contribute to the Clearing-House Mechanism for biodiversity as required by CBD Article 18.3. The ERI is expected to contribute to the imminent updating of Belize's National Biodiversity Strategy and Action Plan.

The partners will continue to work together, and are planning to apply for a new Darwin Initiative grant in the next round.

5 Lessons learned, dissemination and communication

Lessons learned

A key success of the Darwin project was its taking the risk of becoming associated with an institute – the ERI – that at the beginning existed only on paper. Our commitment to it with the Darwin project contributed to its credibility which has now seen it expand to have real influence on national policy.

The fluid political situation, including early elections and change of government minister, combined with a hurricane and subsequent wild fires, all modified the detail of our targets for output measures. The high level of commitment and collaboration amongst project personnel and organisations nevertheless allowed us to succeed in keeping to the main agenda by adapting to the changing circumstances. We have learned that fluidity is integral to projects of this nature, and have become adept at working in that environment. New Minister Alamilla has recently brought a shift in environmental thinking, and a move away from single event Cabinet Papers towards broader Information Papers. We see this as strengthening the project's legacy, by integrating the Central Belize Corridor into the larger ambition of a national-scale corridor that over the last 3 years has come to be seen as essential to the National Protected Areas System.

We much appreciated the structural flexibility in the Darwin grant that allowed us to submit Change Requests. The distribution of funds between three in-country partners was necessarily complicated, however, and our adaptability to change would have been facilitated by structuring the budget on fewer funding streams within each partner's allocation. In future projects we would also strive for a workplan with activity streams consolidated into fewer broader categories. We underestimated the time required by in-country partners Drs Foster, Harmsen and Kay for day-to-day management of project activities and oversight of project personnel; in future projects we would allocate more resources to this vital component. We underestimated the time required to prepare a consortium agreement, leading to a ~5-month delay in the start of spending. In any future proposal we would need to draft an agreement while the award is still pending, given the short delay between award letter and project start date.

Trapping and monitoring poses inherent difficulties in a flood-prone and human-disturbed habitat, which we under-estimated, or were not in a position to estimate, at the beginning of the project (see Sect. 4.3 Problems and resolutions). The corridor area where we focused most live trapping is the most difficult place to try to trap animals. Despite these challenges, the data obtained is exceptional in the information it provides on movements of individuals of numerous species up to the point of being killed by hunting or persecution, or destroyed by hurricane or fires.

Dissemination and communication

Datasets on mammals in the corridor are held in-country by the ERI, in its role as the national Clearing-House Mechanism for biodiversity as required by CBD Article 18.3. Information relating to the planning and implementation of the corridor is being disseminated to the government-level National Protected Areas Technical Committee, by Dr Kay who is a member of this government-led vehicle for creating and implementing conservation policy in Belize. Knowledge exchange on the purpose and value of the Central Belize Corridor is institutionalised in the ERI Wildlife Management course, which includes fieldwork in the corridor, and in the BFD post of Corridor Officer, which was created to facilitate communication with corridor stakeholders.

5.1 Darwin identity

Publicity for the Darwin Initiative

The Darwin Initiative logo was prominent on the ERI-Darwin field vehicle, the BFD corridor officer's vehicle, at the inauguration ceremony of the Sanctuary, on corridor brochures, postcards, wrist bands and tee-shirts, and at all presentations given at conferences, workshops and community consultations (see Annex 7 photograph album). The Darwin project was highlighted in the announcements of prizes for the

cycle race through the corridor in 2011. The corridor billboards include the Darwin logo. We encouraged journalists reporting on the corridor activities to mention the UK Darwin Initiative.

The ERI Wildlife Biologist was encouraged to apply for, and duly obtained, a Darwin Fellowship post-project.

Distinct Project

Only the GPS collar study of jaguars and pumas is distinct from the Darwin Initiative project. That work was done as part of a PhD study by Senator Figueroa, separately funded by Panthera.

Understanding of the Darwin Initiative within the host country

Staff and students of UB and the ERI, the MFFSD, and conservation NGOs are familiar with the Darwin Initiative. Members of the public who have received awareness material will also be aware of the Darwin Initiative from its logo, although their understanding of the function of the DI may be less clear.

6 Monitoring and evaluation

At the start of the project, the log-frame in the original submission was slightly modified on the recommendation of the LTS Portfolio Manager, in order to clarify outputs and synchronise numbering between log-frame and activities. The revision was accepted by Lesley Brown of LTS on 28/4/2009, and mentioned in our first half-year report.

After this minor amendment, no further changes were made to the logframe or project design. See Sect. 4.3.1 for collection of baseline information.

During the project period, the project's 1st Annual Report was evaluated by Darwin-appointed assessors. This review made three recommendations in June 2010, detailed in Sect. 6.1 below. We received no feedback on the project's 2nd Annual Report. The projects half-year reports raised no issues.

Project outputs in the form of research papers have all passed through external review by journal referees; data analyses by 13 UoS undergraduates for their undergraduate projects were subject to external review by academics at UoS. Of these projects 11 were graded 1st class and 2 merited a 2.1 grade.

6.1 Actions taken in response to annual report reviews

We responded to all issues raised by the single review for which we had feedback, on the 1st Annual Report (April 2010). These are the comments and our responses:

- 1. Recommendation that more effort is placed on ensuring capacity and willingness within BFD to assume responsibility of project outputs.* BFD subsequently committed to hire a Wildlife Corridor Officer, funded by Panthera, as part of the BFD wildlife programme, who now works directly below the BFD Wildlife Programme Officer Rasheda García. Rasheda is now on the Advisory Board of the ERI.
- 2. The project leader may wish to consider an assessment of, and strategy for, ERI to acquire national and international research and literature subscription funding in the future.* For the duration of the project and an indefinite period thereafter, the UoS has provided project personnel Bart Harmsen, Rebecca Foster, and Said Gutierrez with full access to its vast electronic resources, including the full range of research journals in its libraries and site-licensed software. UoS has agreed to extend associate researcher status to include Elma Kay for as long as UoB and UoS sustain the collaboration initiated by the Darwin project. UoB has also tackled the issue of literature subscription from alternative angles. The ERI spearheaded the inauguration in June 2011 of a regional MSc in Biodiversity Conservation and Sustainable Development which involves three other universities: Anton de Kom University of Suriname, the University of Guyana, and the University of the West Indies at St. Augustine; all associated staff now share the common pool of resources as associate members of each other's universities. The ERI Publications Repository on the web is set to become one of the databases of reports and peer-reviewed literature that contribute to the Clearing-House Mechanism for biodiversity as required by CBD Article 18.3.

3. *Further evidence should be provided for the more significant activities in future (more congruence between activities and outputs).* Evidence of the main outcomes of the year were presented in Annex 3 of the year-2 report, and Annex 7 of this final report. On congruence between activities and progress towards Output 4, the Lands Information Centre initiated a consultancy to provide us with information on land ownership and proposed development in the corridor. Said Gutierrez joined the consultants and received advanced GIS training during this period (section 3.2.3). On ‘action towards Output 4: implementation of the corridor’, we raised the level of advocacy from private meetings with ministers to reporting to the newly formed National Protected Areas Secretariat. At our first meeting with them in April 2011, we argued successfully for inclusion of the Central Belize Corridor into the National Protected Areas System Plan. Inclusion of the corridor will guarantee its consideration in all subsequent legislation for protected areas (Section 3.4).

7 Finance and administration

7.1 Project expenditure

The project finished on 31 July 2012, which is also the deadline for submission of this final report. Project expenditure will therefore follow in August 2012.

7.2 Additional funds or in-kind contributions secured

Over and above the 40% matched funding from Panthera confirmed pre-project, Panthera has taken up the legacy of the project. This involves funding an ATV, a motor boat, a salaries for a Junior Wildlife Biologist and Field Operations Manager at the ERI post-Darwin, the Corridor Officer position at FD (salary, operating costs and 4WD vehicle), and funds to support the management of the sanctuary.

Dr Elma Kay committed ~15% of her time to the project, more than the originally planned 8%.

7.3 Value of DI funding

Without the two concurrent Darwin projects that came to the ERI in 2009 (this one and 17-022), the ERI would not have come into existence. Our project has been instrumental in building government-level confidence in the ERI as a consultancy for environmental issues, a repository for environmental data and publications, and a source of experts to advise on environmental policy. The project has created a dynamic and highly productive team, which leaves a substantial legacy of trained personnel (Sects 3 and 4.6-4.7) and physical assets (Sects 4.1.3 and 4.5).

Before this project began the Central Belize Corridor had no definition or protection. It is now recognised as a priority by the government-led National Protected Areas Secretariat and the National Protected Areas Technical Committee.

The on-going commitment to the corridor by Panthera (see 7.2) would not have been possible without the Darwin funding.



Annex 1 Report of progress and achievements against final project logframe for the life of the project

Project summary	Measurable Indicators	Progress and Achievements April 2009 - March 2012	Actions required/planned for next period
<p>Goal: <i>To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but constrained in resources to achieve</i></p> <p><i>The conservation of biological diversity,</i></p> <p><i>The sustainable use of its components, and</i></p> <p><i>The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources</i></p>			(do not fill not applicable)
<p>Purpose.</p> <p>A corridor zoning plan connecting two wilderness blocks in North and South Belize adopted and implemented by the Government of Belize, supported by a national, objectively-based, mammal monitoring programme.</p>	<p>Submission to government of evidence-based corridor zoning plan.</p> <p>Government recognition of the proposed corridor.</p> <p>Integration of mammal monitoring within training programmes of the ERI.</p>	<p>Done, as detailed in Sect. 4 below.</p> <p>Done, as detailed in Sect. 4 below. .</p> <p>Done, as detailed in Sect. 2.1 below.</p>	<p>n/a.</p> <p>n/a.</p> <p>n/a.</p>
<p>Output 1. Collection of rigorously calibrated information on movement through fragmented landscapes by neotropical mammals, using (1) mapping, (2) surveying sign, (3) trapping, (4) tracking.</p>	<p>Spreadsheet, GIS and photographic databases.</p>	<p>Spreadsheet, GIS and photographic databases established. Available on request.</p>	
<p>Activity 1.1 Establishment of survey grids.</p>			<p>Three large-scale and five small-scale (concentrated) camera trapping grids sustained until Hurricane Richard. Post-hurricane renovation of large-scale grids. New survey grid established along river boundary of new sanctuary</p>
<p>Activity 1.2 Sign and camera surveys.</p>			<p>Three large-scale surveys completed pre and post-hurricane. Five small-scale camera grids and sign-surveys completed pre-hurricane.</p>
<p>Activity 1.3 Trapping mammals for marking.</p>			<p>Live trapping for grey foxes, pacas, coatis, tayras, kinkajous, peccaries, small felids, tapirs</p>

Activity 1.4. Radio tracking.		Radio collars on 3 grey foxes, 7 pacas, 4 coatis, 1 tayra, 4 coatis, 4 peccaries; these data complement the GPS collars providing data on 10 jaguars and 2 pumas (O Figueroa, PhD study)
Output 2. Instilling a tradition of objectively-based mammal monitoring in Belize, and institutionalising this impetus within the UoB Environmental Research Institute (ERI).	Wildlife biologist to coordinate mammal monitoring. Awareness campaigns by BFD. Mammal monitoring within the corridor becomes a defining role of the UoB Environmental Research Institute.	Junior Wildlife Biologist, Said Gutierrez, was given responsibility for radio tracking, and took an increasing role in trapping and anaesthetising trapped animals. Appointment of BFD Corridor Officer, Jazmin Ramos; billboard designed for corridor entrance and exit points on the Western Highway; signs along river boundary of new sanctuary; brochures, posters, postcards, T-shirts and wrist bands distributed at national and local public events, and school visits. BFD Wildlife Officer Rasheda García now on the Advisory Board of the ERI. The National Protected Areas Secretariat and the National Protected Areas Technical Committee recognize the ERI as the lead entity for the development of the National Biodiversity Monitoring Program; this activity is designated to the ERI in the Operational Framework for the Implementation of the National Protected Areas System Plan.
Activity 2.1. Courses and projects with UoB students; analysis of camera-trap and telemetry data		51 UoB undergraduates took the 4-week Wildlife Management course which included a field trip within the corridor; 15 UoB students worked as interns for the corridor project; 2 UoB students conducted their research theses in the corridor; 8 Belizeans (of which 7 were UoB graduates) and 19 foreigners (Europe & USA) volunteered on the corridor project. Data analyses of camera trap data and telemetry data are on-going
Output 3. Delineation of the belt of contiguous wilderness that will constitute the corridor connecting the northern and southern protected blocks of land.	Corridor plan, and integration within it of knowledge on wildlife abundance, distribution, movement and exploitation, and projected urban development either side of the corridor.	Land tenure data and status obtained for all parcels within the corridor study area; Delineation of corridor boundaries, taking into account ecological data, socio-economic data and planned developments
Activity 3.1. Analysis of wildlife conflicts, mapping forest exploitation and potential for ecotourism		Surveys of game meat consumption, hunting activity and wildlife conflict within the corridor and at a national level Socio-economic survey within corridor communities, including an assessment of the level of interest in expanding ecotourism ventures in the area Pilot study conducted to assess carbon sequestration potential of key privately-owned forested property (141 km ²) within the corridor.

<p>Output 4. Advocacy, leading to implementation of corridor within the legal framework of existing protected areas and zoning plans within Belize, and publication of results.</p>	<p>Government agreement on zoning of the corridor area, following negotiations on land-use changes.</p>	<p>Acceptance of corridor boundaries by the National Protected Areas Technical Committee; incorporation of boundaries into Rationalisation Paper of the Protected Areas System.</p> <p>Wildlife Sanctuary declared, safe-guarding the northern section of the corridor.</p>
<p>Activity 4.1. Student questionnaire surveys of local people; discussions, reports, and negotiations with government, signing official agreements.</p>		<p>For student-run surveys, see Activity 3.1 above</p> <p>Dissemination of the Central Belize Corridor Brief (April 2010) to members of Government, raising awareness about the Central Belize Corridor among politicians</p> <p>Letter of Understanding (July 2010) signed between the Government of Belize and Panthera recognising the importance of connectivity, and to establish and develop programmes of cooperation to delineate and establish a corridor in central Belize</p> <p>Declaration of wildlife sanctuary in northern section of the corridor (July 2010)</p> <p>Presentation of corridor boundaries and associated data to National Protected Areas Secretariat and National Protected Areas Technical Committee (April 2011)</p> <p>Publication of Statutory Instrument of the corridor wildlife sanctuary (April 2011)</p> <p>Publication of the National Land Use Policy for Land Resource Development (April 2012). Although not a direct output from Darwin, it refers to corridors as a strategy for natural resource conservation and for minimising the impact of climate change</p> <p>Consultation on Rationalisation of the Belize National Protected Areas System for the Government-commissioned Technical Report; including a chapter on Biological Corridors with a special emphasis on the Central Belize Corridor</p> <p>Flight over the corridor with Minister for Forestry, Fisheries and Sustainable Development, Hon. Lisel Alamilla</p>
<p>Activity 4.2. Acceptance of papers in peer-reviewed journals</p>		<p>Six papers related to the project have been published and one book chapter is in press. A further 5 papers are in preparation.</p>

Annex 2 Project's final logframe, including criteria and indicators

Project summary	Measurable Indicators	Means of verification	Important Assumptions
<p>Goal:</p> <p>Effective contribution towards 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.</p>			
<p>Sub-Goal:</p> <p>To secure connectivity for all larger land mammals within Belize, currently threatened by segregation into isolated blocks in the north and south of the country, thereby enhancing connectivity with natural areas outside Belize.</p>	<p>Identified minimum conditions of habitat structure and quality for allowing free movement of medium to large mammals between existing protected areas.</p> <p>Indicator species: jaguar, puma, ocelot, tapir (CITES I), white lipped and collared peccaries (CITES II, hunted), red brocket and white tailed deer, coati, armadillo and paca (unlisted reference species).</p>	<p>Continued presence of target species throughout corridor areas, connecting freely with protected blocks at either end.</p>	
<p>Purpose</p> <p>A corridor zoning plan connecting two wilderness blocks in North and South Belize adopted and implemented by the Government of Belize, supported by a national, objectively-based, mammal monitoring programme.</p>	<p>Already declared interest by the Belizean government in a plan for zoning a corridor connecting the two protected wilderness blocks in north and south Belize, and conditions for implementation.</p> <p>Submission to government of evidence-based corridor zoning plan.</p> <p>Government recognition of the proposed corridor.</p> <p>Integration of mammal monitoring within training programmes of the ERI.</p>	<p>Continued existence and free movement of all studied taxa throughout the proposed corridor.</p> <p>Corridor protection implemented into law, thereby contributing towards Belize's commitment to the CBD.</p> <p>Recognition of corridor as integral to the proposed Mesoamerican Biological Corridor.</p> <p>Yearly increase in numbers of Belizean students studying wildlife and human-wildlife interactions within the corridor.</p>	<p>Government remains committed to the corridor (see Section 14).</p> <p>No major development severs the corridor before implementation of protection.</p> <p>UoB remains committed to its Environmental Research Institute.</p>

<p>Outputs</p> <p>1. Collection of rigorously calibrated information on movement through fragmented landscapes by neotropical mammals, using (1) mapping, (2) surveying sign, (3) trapping, (4) tracking.</p>	<p>Collection of data on density and movement of key neotropical mammal species within and through the corridor. Analysis by least-cost and other techniques to identify a corridor path with highest mobility.</p>	<p>Publications in peer-reviewed journals concerning movement and dispersion through corridor areas by neotropical mammals, co-authored by Belizean collaborators on the project.</p>	<p>Continued access to corridor area for fieldworkers throughout the data-collection period, and for post-project monitoring.</p>
<p>2. Instilling a tradition of objectively-based mammal monitoring in Belize, and institutionalising this impetus within the UoB Environmental Research Institute (ERI).</p>	<p>Appointment of a dedicated mammal-monitoring coordinator, and training for teaching courses in natural resource management at the ERI.</p> <p>Establishment of intensive training courses in natural resource management and wildlife monitoring, including GIS, offered to students, teachers and professionals in natural resource management.</p> <p>Collaboration of UoB with BFD to design an awareness campaign on wildlife law and potential conflicts, to be run by UoB students on their Bachelor programme in Natural Resources Management.</p> <p>Mammal monitoring within the corridor becomes a defining role of the UoB Environmental Research Institute.</p>	<p>Appointed coordinator trained in delivery of courses by Darwin core UK and Belize-based staff and consultants.</p> <p>ERI teachers trained in GIS techniques and field craft.</p> <p>Wildlife management training courses at the ERI outlive the Darwin project.</p> <p>Belizean scientists continue publishing in peer-reviewed journals on tropical mammalogy and conservation.</p>	<p>Continued commitment of the UoB to the ERI and to Belizean students in general for programmes monitoring neotropical mammals.</p> <p>ERI sustains success with securing outside funding sufficient to continue the wildlife teaching appointment after the end of the Darwin project.</p>
<p>3. Delineation of the belt of contiguous wilderness that will constitute the corridor connecting the northern and southern protected blocks of land.</p>	<p>Comprehensive corridor plan for connecting the two existing protected blocks in the north and south of the country.</p> <p>Integration within this plan of knowledge on wildlife</p>	<p>Published report of corridor plan.</p> <p>Distribution of report to government, BFD, and all local stakeholders.</p>	<p>Government through BFD upholds its current agreement to divulge development plans for the area.</p> <p>Continued access to private land to monitor movement and abundance of existing wildlife</p>

	distribution, movement and exploitation, and projected urban development either side of the corridor.		populations.
4. Advocacy, leading to implementation of corridor within the legal framework of existing protected areas and zoning plans within Belize, and publication of results.	Government agreement on zoning of the corridor area, following negotiations on land-use changes.	Lawfully binding document stating specifically which areas can be used for what purpose within the designated corridor area.	Government remains committed to the corridor and is willing to negotiate concessions against development as necessary and practical.

Activities (details in workplan)

- 1.1.1 Systematic mapping of the whole corridor zone in terms of habitat characterisations including urban parts (milestone for 1st 6 months).
- 1.1.1 Establishment of line transects and survey grids throughout the area, using a combination of a stratified design including all habitat types, and an even distribution throughout the zone. Project Leader to advise on data collection design during visits in years 1 and 2 (milestone for 1st 6 months).
- 1.1.3 Establishment of camera trap grids and locations throughout study area (milestone for 1st 6 months).
- 1.2.1 Systematic surveys for burrows of armadillos and pacas throughout the survey area in survey grids and survey lines (reporting milestones at yearly intervals).
- 1.2.2 Systematic surveys for footprints for all species along survey lines and in survey grids (milestones at yearly intervals).
- 1.2.3 Systematic sighting surveys (distance sampling surveys) for the ungulate species and coatis (milestones at yearly intervals).
- 1.2.4 Systematic nocturnal sighting surveys for armadillos and pacas (milestones at yearly intervals).
- 1.2.5 Camera trapping for identifiable species (ocelots, jaguars) for mark-recapture analysis and capture rates for prey species (milestones at yearly intervals).
- 1.3.1 Trapping of jaguars, pumas and tapirs with the use of snares, using existing expertise in Panthera (milestones at yearly intervals).
- 1.3.2 Peccary species stalked-down wind and darted, using existing expertise in Panthera (milestones at yearly intervals).
- 1.3.3 Ocelot, coatis, armadillos and pacas will be cage trapped as the safest means of trapping (milestones at yearly intervals).
- 1.3.4 Both deer species will be captured by down-wind stalking and darting, using existing expertise in Panthera (milestones at yearly intervals).
- 1.4.1 Radio tracking of all species with teams on the ground (milestones at yearly intervals).
- 2.1.1 Mammal-monitoring coordinator appointed to ERI (milestone for 1st 6 months), to coordinate the logistics of mammal monitoring and the interface between students and Darwin personnel, to be trained for teaching wildlife management by Darwin core personnel and consultants (milestones at yearly intervals).
- 2.1.2 Courses to UoB students in data collection, analysis and GIS for wildlife monitoring and natural resources management, initially run by Darwin UK and Belize-based personnel with assistance of mammal-monitoring coordinator; in final year run by coordinator now trained for teaching (milestones at yearly intervals).
- 2.1.3 Implementation of UoB projects to assist with end parts of activities 1, all of activities 2 and activities 4. Some responsible students will assist with activities 3 but this will always be done under expert guidance (milestones at yearly intervals).
- 2.1.4 Writing up of undergraduate projects and potentially master projects (milestones at yearly intervals).
- 2.1.5 Analyses of mammal-monitoring data from cameras and telemetry for least-cost optimal corridor path (milestones in years 2 and 3).
- 3.1.1 Study of potential conflicts with wildlife at corridor edges, through the Forestry Department and the Agriculture Department (milestones at yearly intervals).
- 3.1.2 Mapping hunting and forest extraction and studying the socioeconomic implications of this for corridor design (milestones at yearly intervals).
- 3.1.3 Mapping the potential and willingness by the local community to partially convert to ecotourism and explore possibilities through the Belize Tourism Board. (milestones in years 2 and 3, and final output).
- 4.1.1 Student questionnaires to residents to test willingness to buy into the corridor and economic incentives necessary to encourage buy in.
- 4.1.2 Meet regional MPs, to assess needs of constituents and public-relations strategy to encourage local buy-in to the corridor.
- 4.1.3 Meet Ministers of Agriculture, Lands, Tourism, to provide input to plans for an economic stimulus package in the corridor region.
- 4.1.4 Discussions with Dept Agriculture and Livestock Association, on minimising human/wildlife conflict in the corridor region.
- 4.1.5 Reports for the government as an input for discussion on corridor (final output).
- 4.1.6 Discussion and negotiation with government about corridor implementation (milestone in year 3).
- 4.1.7 Signing of official agreements (final output).
- 4.2.1. Writing of peer reviewed papers (final output).

Monitoring activities:

Indicator 1.1 Fulfilling all sample-size assumptions necessary to run models to create habitat maps, estimate abundance from camera trapping and surveys.

Indicator 1.2 Get adequate numbers of sign, sightings and photo captures to calculate abundance.

Indicator 1.3 Capture high enough numbers of individuals from each species based on expectation from indicator 2.

Indicator 1.4 Sufficient sample size of accurate fixes from each tagged individual and each species. Accuracy of trackers will be tested with fixed known collars.

Indicator 2.1 Adequate functioning of coordinator as an organiser, teacher/assistant, practical work, quality of work and understanding by students within the program.

Indicator 3.1 High cooperation from stakeholder communities.

Indicator 4.1 Implementation of corridor according to minimum requirements as discovered through the project.

Indicator 4.2 Acceptance of papers in well-established peer reviewed papers.

Annex 3 Project contribution to Articles under the CBD

Project Contribution to Articles under the Convention on Biological Diversity

Article No./Title	Project %	Article Description
6. General Measures for Conservation & Sustainable Use		Develop national strategies that integrate conservation and sustainable use.
7. Identification and Monitoring	25	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities that have adverse effects; maintain and organise relevant data.
8. In-situ Conservation	20	Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation		Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity		Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures		Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.
12. Research and Training	40	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness		Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.
14. Impact Assessment and Minimizing Adverse Impacts		Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources		Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.
16. Access to and Transfer of Technology		Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most

Article No./Title	Project %	Article Description
		favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information		Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol		Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Other Contribution		Smaller contributions (eg of 5%) or less should be summed and included here.
Total %	100%	Check % = total 100

Annex 4 Standard Measures

Table 1 Project Standard Output Measures

Code No.	Description	Yrs 1 + 2 + 3 = total	Total planned from application
Established codes			
3	Number of people attaining qualifications ¹	29 + 11 + 14 = 54	40
4A	Number of undergraduate students having received training ²	28 + 36 + 25 = 89	40
4C	Number of postgraduate students to receive training ³	1 + 5 + 5 = 11	2-4
4D	Number of training weeks to be provided	129+164+84 = 374	55
5	Number of people having received at least one year of training (excluding those above) ⁴	1 + 5 + 6 = 12	2-4
7	Number of training materials produced for use by host country ⁵	3 + 1 + 2 = 6	4
8	Number of weeks spent by UK PI on project work in the host country	3 + 2 + 4 = 9	9
9	Number of species/habitat management plans (or action plans) to be produced for Governments, public authorities, or other implementing agencies in the host country ⁶	0 + 1 + 2 = 3	3
10	Number of individual manuals produced to assist work related to species identification, classification and recording ⁷	1 + 0 + 0	1
11A	Number of papers published or in press in peer reviewed journals ⁸	1 + 2 + 4 = 7	3+
11B	Number of papers to be submitted to peer reviewed journals	5	4-8
12A	Number of computer based databases to be established and handed over to host country ⁹	0 + 0 + 3 = 3	3
14A	Number of workshops organised to disseminate Darwin project findings ¹⁰	1 + 1 + 8 = 10	3
14B	Number of conferences/workshops attended to disseminate Darwin project findings ¹¹	3 + 9 + 10 = 22	3
15A	Number of national press releases in host country ¹²	3 + 3 + 2 = 8	5
15B	Number of local press releases in host country	0 + 0 + 0 = 0	5
15C	Number of national press releases in UK ¹³	0 + 1 + 1 = 2	1
15D	Number of local press releases in UK ¹⁴	1 + 0 + 0 = 1	0
17B	Number of dissemination networks enhanced ¹⁵	0 + 3 + 0 = 3	1
18A	Number of national TV features in host country ¹⁶	2 + 5 + 3 = 10	3-5

19A	Number of national radio interviews in host country ¹⁷	2 + 0 + 2 = 4	5
20	Estimated value (£'s) of physical assets to be handed over to Belize ¹⁸	£57,665	£35,526
21	Number of permanent educational, training and research organisations established ¹⁹	1 + 0 + 0	1
22	Number of permanent field plots established ²⁰	207	60
23	Value of resources raised from other sources (i.e. in addition to Darwin funding) for project work – confirmed funding ²¹	£49,620 + £77,404 + £97,553 = £224,577	£155,107
New - Project specific measures	n/a		

¹ Code 3: Qualifications attained

UoB Wildlife Management course: 8 of 10 passed in April 2009, 17 of 18 in 2010, 11 of 11 in 2011, 12 of 12 in 2012; 4 of 4 field staff passed the First Aid course for fieldworkers in 2010 and 2 of 2 passed Advanced First Aid course.

² Code 4A: Undergraduates trained

UoB Wildlife Management undergraduates: 10 + 18 + 11 + 12 in 2009-2012; UoB Internship students: 10 + 3 + 11 did an internship in 2010-2012; 2 students from Galen University attended the chemical immobilisation workshop; UoS undergraduates: 11 in July-Aug 2010, 2 in July-Aug 2011, and one US undergraduate in July 2010.

³ Code 4C: Postgraduates trained

2009-10: one graduate from UoB; 2010-11: three graduates from The Netherlands and two graduates from UK, one graduate from Slovenia; 2011-12: 4 graduates from Belize. Throughout the project: Omar Figueroa.

⁴ Code 5: At least 1 year of training

2010-12: 4 Belizeans (Arturo Ramos, Christopher Estrada, Michael Brakeman and Said Gutierrez) and one English (Angela Watkins); 2011-12: Jazmin Ramos

⁵ Code 7: Training materials produced

Foster, R. J. & Harmsen, B. *Protocol for Safe Live-Trapping, Handling and Chemical immobilization of wild Central American Mammals* (2010) for the Belize Forest Department.

Doncaster, C. P. (2010) *Study Design and Statistical Analysis*. Booklet to go with 2-day workshop on statistics, open to all at UoB, attended by 75 staff and students.

20 *Wildlife Management* lectures and seminars by Drs Harmsen and Foster for the undergraduate Natural Resource Management Programme, including assignments and field-course based on the Central Belize Corridor.

Foster, R. J. (2010) *The Central Belize Corridor*. Brochure disseminated to the public to raise awareness about the Central Belize Corridor. Available in English and Spanish.

Foster, R. J. & Harmsen, B. (2011) *How to Protect Your Livestock*. Brochure disseminated to farmers.

Doncaster, C. P. (2010) *Short Course in Statistics*. Booklet to go with 2-day workshop on statistics by Dr Doncaster for ERI undergraduates.

⁶ Code 9: management/action plans

Figueroa, O., Foster, R. & Harmsen, B. (2010) *Central Belize Corridor, Securing the Future of Belizean Wildlife*. Action Plan for the Sanctuary, distributed by Omar Figueroa to Cabinet.

Foster, R. Harmsen, B. & Kay, E. (2010) Labouring Creek Jaguar Wildlife Sanctuary for Community Baboon Sanctuary. Informal Concept Note.

Corridor Implementation in the 'Connectivity' section of the NPATC-commissioned Technical Report *Rationalisation Exercise for the National Protected Areas System of Belize* (P. Walker and Z. Walker, in press for expected publication Aug 2012). To be summarised in Information Paper to Government.

⁷ Code 10: manuals to assist species recording

Harmsen, B. & Foster, R. (2009) *Big Falls Wildlife Research Status Report*. Belize Forestry Department internal report.

⁸ Code 11A: papers published

See Annex 5 for list of peer-reviewed papers published during the project

⁹ Code 12A: Databases to host country

Camera trapping, telemetry, land tenure.

¹⁰ Code 14A: Workshops organised

Livestock protection workshops June 2010, April 2011, July 2011, May 2012 (attendees included representatives from: Belize Livestock Producers Association, Ministry of Agriculture, Belize Forest Department; Belize Audubon Society; Sustainable Harvest International, Humana People to People, Ya'axche Conservation Trust, Sarstoon-Temash Institute for Indigenous Management, Plenty Belize, Toledo Development Corporation, Belize Citrus Growers Association; Toledo Institute for Development and Environment)

Central Belize Corridor community consultations: six in April-July 2012.

¹¹ Code 14B: Conferences/workshops attended

Attendance for formal presentations:

Harmsen, B. (2009) *Jaguar corridor: connectivity within Belize and beyond*. Belize Wildlife Conservation Network Conference, Galen University, Belize

Figueroa, O. (2009) *Spatial ecology and conservation of jaguars and pumas in Central Belize*. Belize Wildlife Conservation Networking Conference, Galen University, Belize

Harmsen, B. J. (2010) *Wildlife Connectivity and the Central Belize Corridor*. VIII International Mobile Seminar on Protected Areas: Integrating People, Protected Areas and Landscapes. Cockscomb Basin Wildlife Sanctuary, Belize.

Doncaster, C. P. and Foster, R. J. (2010) *The Darwin Initiative: Wildlife corridor project in Belize*. UK Belize Association Conference, Oxford.

Figueroa, O. Harmsen, B. J., Foster, R. J., Kay, E., Rabinowitz, A., Gutierrez, S. and Quigley, H. (2010) *The Central Belize Corridor: a model for connectivity science and conservation*. IX Congress for the Mesoamerican Society for Biology and Conservation, San Jose, Costa Rica.

Harmsen, B. J. & Foster R. J. (2010) *Creation of the Central Belize Corridor, a case study*. Belize Chapter National Congress for the Mesoamerican Society for Biology and Conservation, Belmopan, Belize.

Foster, R. J. (2010) *The Central Belize Corridor*. Regional Panthera Meeting, San Jose, Costa Rica.

Harmsen, B. J. (2010) *Corridor research in Belize*. Livestock Protection Workshop, University of Belize, Central Farm Campus, Cayo

- Gutierrez, S. and Harmsen, B. J. (2011) *The Central Belize Wildlife Corridor*. First Belize-Mexican Symposium for Research Collaboration on Biodiversity and Natural Sciences, Belmopan, Belize.
- Foster, R. J. (2011) *The Central Belize Corridor*. Regional Panthera Meeting, Merida, Mexico.
- Harmsen, B. J. (2011) *Corridor research in Belize*. Livestock Protection Workshop, Belize Forest Department, Belmopan, Belize
- Harmsen, B. J. (2011) *Corridor research in Belize*. Panthera Livestock Protection Workshop, Belize Audubon Society, Cockscomb Basin Wildlife Sanctuary, Belize.
- Harmsen, B. J. (2012) *Corridor research in Belize*. Panthera Livestock Protection Workshop, Ya'axche Conservation Trust, Toldeo, Belize
- Harmsen, B. J. & Foster R. J. (2012) *Resilience of the Central Belize Corridor, a case study*. Belize Chapter National Congress for the Mesoamerican Society for Biology and Conservation, Belmopan, Belize.
- Foster, R. J. (2012) *Jaguar Corridor Initiative: conserving jaguars from Mexico to Argentina*. 1st Southern Belize Corridor Meeting, Ya'axche Conservation Trust, Toldeo, Belize

Attendance for informal discussions:

- Strategy Meeting for the implementation of the Central Belize Corridor* (2010) The Nature Conservancy, Belmopan, Belize
- Inception Workshop of the Belize Fourth National Report to the United Nations Convention on Biological Diversity* (2010), Belize Forest Department, Belmopan, Belize
- Amendments to the Wildlife Protection Act* (2010), Belize Forest Department, Belmopan, Belize
- Amendments to the Wildlife Protection Order* (2011), Belize Forest Department, San Ignacio, Belize
- National Environmental Research Agenda* (2010) ERI, Belmopan, Belize. Involved one-on-one consultations with governmental and NGO protected areas managers, then compiling their list of priorities into research lines. Two subsequent workshops prioritized the top ten terrestrial and top ten marine priorities, the research lines underpinning each, and expected management outputs.
- National Biodiversity Monitoring Program* (2012) ERI, Belmopan, Belize. Two workshops, the first to develop goals and objectives, the second for stakeholders to determine needs and indicators.
- Earth Day Event* (2012), UoB, booth about the corridor, run by Said Gutierrez.

¹² Code 15A: Belizean national press releases

- The Reporter (6/4/2009) *University of Southampton to help Belize with wildlife management*.
- National radio (27/3/2010) announcing Darwin sponsorship of the 'wildlife corridor' stage of the annual Belmopan to Belize City cycle race
- The Reporter (4/6/2010) *Belize and Mexico to discuss environmental cooperation*.
- The Reporter (8/2010) *The Darwin Initiative: Outstanding research at the Belize Zoo*.
- Guardian (4/11/2010) *Hon Gaspar Vega addresses Convention of Biological Diversity – COP10 in Nagoya Japan*.
- Belize Forest Department Newsletter Issue 2 (12/2010) *The Central Belize Wildlife Corridor*.
- Amandala (18/9/2011) *New wildlife legislation and public awareness discussed with Forest Department and NGOs*.
- The Reporter (2/4/2012) *University of Belize sets the pace for sustainable resource management*.

¹³ Code 15C: UK national press releases

- Jones, T. (2010) *Belizean jaguar populations 'well-connected'*. NERC Planet Earth Online <http://planetearth.nerc.ac.uk/news/story.aspx?id=809>
- Doncaster, C.P. (2012) Belize's large-mammal corridor project. *Darwin News Issue 2/2012*.

¹⁴ Code 15D: UK local press releases

Southern Daily Echo (4/4/2009) *Grant to uni team will help at-risk species.*

¹⁵ Code 17B: Dissemination networks

Drs Harmen and Foster joined the Belize Wildlife Conservation Network (<http://wildlifebelize.com/>) as expert advisors

Production and sale of corridor postcards to enhance knowledge about the Central Belize Corridor among foreign tourists

Dissemination of corridor brochures, posters, postcards, wristbands and tee-shirts by Forest Department Corridor Officer at public events including National Agricultural Show (3-day event), Ruta Maya 4-day boat race, and school & community presentations; Corridor officer's 4WD vehicle is decorated with slogans about the corridor.

¹⁶ Code 18A: National TV features

Breakfast Show (2009) feature called "Open Your Eyes" with Omar Figueroa

Plus TV News (29/1/2010) *University of Belize launches Environmental Research Institute*
<http://www.belmopancityonline.com/Default.aspx?tabid=275&smid=1474&ArticleID=1091&reftab=273&t=University-of-Belize-launches-Environmental-Research-Institute->

News 5 (12/5/2010) *Contest winners get to spend a day with jaguars*
<http://edition.channel5belize.com/archives/32553>

7 News Belize (12/5/2010) *The lesson of the jaguar*
<http://www.7newsbelize.com/sstory.php?nid=16880&frmsrch=1>

News 5 (28/7/2010) *New reserve established but APAMO*
<http://edition.channel5belize.com/archives/36250>

7 News Belize (4/2/2011) *Omar the jaguar man*
<http://www.7newsbelize.com/sstory.php?nid=18868&frmsrch=1>

7 News Belize (4/2/2011) *Jaguar package reloaded*
<http://www.7newsbelize.com/sstory.php?nid=18869&frmsrch=1>

7 News Belize (23/6/2011) *Jaguar corridor celebrated*
<http://www.7newsbelize.com/sstory.php?nid=19957&frmsrch=1>

7 News Belize (25/11/2011) *"Di plane (crash) lan'!"*
<http://www.7newsbelize.com/sstory.php?nid=21125&frmsrch=1>

7 News Belize (8/6/2012) *For The Love Of Labouring Creek...*
<http://www.7newsbelize.com/sstory.php?nid=22654>

¹⁷ Code 19A: National Belizean radio interviews

British Forces Broadcasting Service (2009) Sharon Matola who runs Belize Zoo interviewed Drs Harmen and Foster about jaguar research and the corridor.

National radio (27Mar10) announcing Darwin and Panthera sponsorship of the 'wildlife corridor' stage of the annual Belmopan to Belize City cycle race.

Love FM and TV (2012). Interview about corridor billboards.

Information brief on corridor issues

¹⁸ Code 20: Physical assets handed over

This is the total expenditure on capital equipment and transmitters, all of which was purchased for Belize.

¹⁹ Code 21: Permanent educational, training and research organisations established

The Environmental Research Institute (ERI) at the University of Belize (UoB)
<http://www.eriub.org/projects/large-mammal-corridor-project.html>

²⁰ Code 22: Permanent field plots

Large-scale survey grids: 69 camera station locations and associated trails (infrastructure damaged by hurricane but re-opened)

Small-scale survey grids: 125 camera station locations and associated trails (infrastructure damaged by hurricane, not re-opened)

Plots for assessment of carbon sequestration potential: 13

²¹ Code 23: Value of resources from other sources

2009-10: US\$75,949 at \$1 = £0.653 (US\$69,570 from Panthera and US\$6,379 from UoB). UoB were unable to meet the originally projected commitment in matching funds (calculated for 10% of Elma Kay's time, not 8% as stated in the original budget), due to delays in the launch of the ERI and subsequent obtaining of project funds.

2010-11: UoS: £4,271 in overheads; BFD: ~£5,000 in staff time; UoB: £8,800 in time spent by Elma Kay and her ERI staff of Ian Sangster and Julissa Bardalez, overheads, office and lab rental for Said Gutierrez, use of equipment; Panthera: £59,333 in salaries, office space and telephone/internet costs for Dr Foster, Dr Harmsen and ½ salary for Arturo Ramos, project-related travel to UK, vehicle fuel and maintenance, use of ATV, shipping and import taxes, repairs to Big Falls road.

2011-12: UoS: £4,421 in salary and overheads; BFD: ~£350 in staff time; UoB: £17,782 in time spent by Elma Kay and her ERI staff of Ian Sangster and Julissa Bardalez, overheads, office and lab rental for Said Gutierrez, use of equipment; Panthera: £75,000 in salaries for Dr Foster, Dr Harmsen, Arturo Ramos, Jazmin Ramos, 4WD vehicle for corridor officer, fuel and maintenance for three 4WD vehicles, and general field equipment and supplies.

Annex 5 Publications

The following peer-reviewed publications are available from the UK PI on request (no charge):

- Foster, R.J., Harmsen, B.J., Valdes, B., Pomilla, C. and Doncaster, C.P. (2010) Food habits of sympatric jaguars and pumas across a gradient of human disturbance. *Journal of Zoology*, 280: 309-318.
- Foster, R.J., Harmsen, B.J., and Doncaster, C.P. (2010) Sample size effects on diet analysis from scats of jaguars and pumas *Mammalia* 74: 317-321.
- Harmsen, B.J., Foster, R.J., Gutierrez, S.M., Marin, S.Y. & Doncaster, C.P. (2010) Scrape-marking behavior of jaguars (*Panthera onca*) and pumas (*Puma concolor*). *Journal of Mammalogy*, 91: 1225-1234.
- Harmsen, B.J., Foster, R.J., Silver, S.C., Ostro, L.E.T. & Doncaster, C.P. (2011). Jaguar and puma activity patterns in relation to their main prey. *Mammalian Biology*, 76: 320-324. doi: 10.1016/j.mambio.2010.08.007.
- Harmsen, B.J., Foster, R.J. & Doncaster, C.P. (2011) Heterogeneous capture rates in low density populations and consequences for capture-recapture analysis of camera-trap data. *Population Ecology*, 53: 253-259.
- Watkins, A., Noble, J. & Doncaster, C.P. (2011) An agent-based model of jaguar movement through conservation corridors. Pp. 846-853 in: *Advances in Artificial Life, ECAL 2011: Proceedings of the Eleventh European Conference on the Synthesis and Simulation of Living Systems* (Eds. Lenaerts, T., Giacobini, M., Bersini, H., Bourguine, P., Dorigo, M. & Doursat, R.). MIT Press, ISBN 978-0-262-29714-1.
- Figuroa, O. A., R. J. Foster, C. Wultsch, J. B. Mesa-Cruz, M. J. Kelly, B. J. Harmsen, W. Sabido, S. Matola y S. K. Jacobson. (2012) Estatus de conservación del jaguar en Belice. En: *El Jaguar en el Nuevo Milenio: Perspectiva Continental* (Eds: Medellín, R., C. Chávez, A. de la Torre, H. Zarza y G. Ceballos). Fondo de Cultura Económico.

The following websites contain project-relevant information:

Darwin Initiative Belize Corridor Project on the DEFRA website, with photographic evidence of key events during the project (including the Deputy Prime Minister surrounded by 10 Belize and 11 Southampton undergraduates at the naming ceremony for the Wildlife Sanctuary; the Minister for Forestry, Fisheries and Sustainable Development with Dr Harmsen on a Corridor scoping flight; the field study chalet in the Corridor following Darwin-funded renovation):
<http://darwin.defra.gov.uk/project/17012/>

Darwin Initiative Belize Corridor Project instrumental to the establishment of the ERI – on the website for the Environmental Research Institute at the University of Belize:
<http://www.eriub.org/projects/large-mammal-corridor-project.html>

Belize Wildlife Corridor on belizewildlife.com, the website of Drs Foster and Harmsen:
<http://www.eriub.org/projects/large-mammal-corridor-project.html>

Belize's Deputy Prime Minister and Minister for the Environment, the Hon Gaspar Vega, citing the Central Belize Corridor in his Keynote speech at the 10th Conference of the Parties (COP10) for the Convention on Biological Diversity at Nagoya, Japan:
<http://www.sica.int/busqueda/Noticias.aspx?IDItem=54419&IDCat=3&IdEnt=2&Idm=1&IdmStyle=1>

ERI is an organizer of the 6th NRM Symposium – on ERI website:
<http://eriub.org/featured-story/eri-is-an-organizer-of-the-6th-nrm-symposium.html>

Minister flies over the Central Belize Corridor with ERI staff – on ERI website:
<http://eriub.org/latest-news/minister-flies-over-the-central-belize-corridor-with-eri-staff.html>

ERI's, Dr. Bart Harmsen presents the ERI's work in the Central Belize Wildlife Corridor – on ERI website:

<http://eriub.org/latest-news/eri-s-dr-bart-harmsen-presents-the-eri-s-work-in-the-central-belize-wildlife-corridor.html>

Establishing the Central Belize Corridor – on the ERI website:

<http://eriub.org/featured-story/establishing-the-central-belize-corridor.html>

Darwin Initiative partnership with Panthera – on the Panthera website:

<http://www.panthera.org/partners?page=1>

New Jaguar Sanctuary Declared in Belize – on website of Our Amazing Planet:

<http://www.ouramazingplanet.com/248-new-jaguar-sanctuary-declared-in-belize.html>

Art and essay competition for primary-school students at Belize Zoo – on 7Newsbelize.com:

<http://www.7newsbelize.com/sstory.php?nid=19957>

Belizean jaguar populations 'well connected' – on website of NERC Planet Earth Online:

<http://planetearth.nerc.ac.uk/news/story.aspx?id=809&cookieConsent=A>

Bare Essentials e-magazine article (May-June 2012) p. 80 on Dr Foster's Panthera plan:

<http://content.yudu.com/Library/A1wlvj/BareEssentialsMagazi/resources/index.htm?referrerUrl>

Annex 6 Darwin Contacts

Ref No	17-012
Project Title	Belize Large-Mammal Corridor Project
UK Leader Details	
Name	Dr C. Patrick Doncaster
Role within Darwin Project	Project Leader
Address	Centre for Biological Sciences, Life Sciences Building 85, Highfield Campus, University of Southampton, SO17 1BJ, UK
Phone	
Fax	-
Email	_____
Partner 1	
Name	Dr Bart Harmsen (year 1) and Dr Rebecca Foster (years 2 and 3)
Organisation	Panthera
Role within Darwin Project	Main project partner and co-ordinator in host country
Address	Environmental Research Institute (ERI), University of Belize, Central Campus, Hummingbird Avenue, P.O. Box 340, Belmopan, Belize
Phone	(00501) 665-7318
Fax	-
Email	
Partner 2	
Name	Dr Elma Kay
Organisation	Environmental Research Institute, University of Belize
Role within Darwin Project	Main partner for University of Belize
Address	Environmental Research Institute (ERI), University of Belize, Central Campus, Hummingbird Avenue, P.O. Box 340, Belmopan, Belize
Fax	-
Email	_____
Partner 3	
Name	Ms Rasheda García
Organisation	Belize Forest Department
Role within Darwin Project	Main partner for Belize Forest Department
Address	Forest Department, Forest Drive, Belmopan, Belize
Fax	-
Email	_____

Annex 7 Supplementary material as evidence of project achievements

See separate documents of the following Annex 7 materials.

- Photograph album 2009-2012 covering the following categories of project activities:
 - o Inauguration of the ERI (see Sects 2, 4.3.2, 4.7, 6.1, 7.3)
 - o Training (see Sects 1, 2, 3, 4.1.3, 4.2 Purpose #3, 4.3.2, 4.4, 4.6; Annex 1 Output 2)
 - o Public awareness (see Sects 2, 3, 4.1.2, 4.2 Purpose #3, 4.3.4, 4.4, 5.1; Annex 1 Output 2)
 - o Darwin Wildlife Biologist at work (see Sects 3, 4.3.2, 4.3.3, 4.7; Annex 1 Output 2)
 - o Labouring Creek Wildlife Sanctuary (see Sects 1, 4.1.2, 4.2 Purpose #2, 4.3.1, 4.3.4; Annex 1 Activity 4, 4.1; Annex 4 Code 9 footnote 6, Code 14B footnote 11).
 - o Fieldwork (see Sects 4.1.1, 4.3.1; Annex 1 Output 1)
 - o Hurricane and fire damage (see Sects 4.1.1, 4.3.1, 4.5, 5; Annex 1 Output 1)
 - o Resource extraction (see Sects 4.3.1, 4.3.4)
 - o Camera-trap photos of mammals (see Sects 4.1.1, 4.3.1, 4.5, 4.6; Annex 1 Output 1)

- Concept Note Labouring Creek 2010 (see Sect. 4.3.4 and Annex 4 Code 9, footnote 6)

- Central Belize Corridor Brief April 2010 to Government (see Sect. 4.3.4 and Annex 1 Activity 4.1).

- Statutory Instrument Labouring Creek Wildlife Sanctuary 2011 (see Sects 1, 4.1.2, 4.2 Purpose #2, 4.3.1, 4.3.4; Annex 1 Activity 4, 4.1; Annex 4 Code 9 footnote 6, Code 14B footnote 11).

- Infomercial for national radio by BFD on wildlife hunting laws 2012 (see Sect. 4.3.4)

- Available upon request:
 - o Interview with Darwin Wildlife Biologist Said Gutierrez (123Mb mp4 file).