



Darwin Initiative Final Report

Darwin project information

Project Reference	19-008
Project Title	Building biodiversity research capacity to protect PNG rainforest from logging
Host country	Papua New Guinea (PNG)
Contract Holder Institution	University of Sussex
Partner Institution(s)	New Guinea Binatang Research Center (BRC), Madang, Papua New Guinea
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Funder (DFID/Defra)	Defra
Start/End dates of Project	1 April 2012 – 31 March 2015
Project Leader Name	Dr Alan J A Stewart
Project Website	www.entu.cas.cz/png/wanang
Report Authors and date	A. Stewart, V. Novotny, M. Peck, 27 June 2015

1 Project Rationale

This project has supported overseas and local researchers, postgraduate students and par-ecologists in assisting the Wanang village community in Papua New Guinea (PNG) with rainforest conservation programmes on their land while collecting data on the distribution of selected plant, invertebrate and vertebrate taxa, important for local conservation as well as fundamental studies on biodiversity distribution. The project responded to a mounting crisis in forest conservation in PNG where recent surveys show an increasing rate of forest destruction, while conservation projects find it difficult to compete with logging which is increasingly being offered to the forest owners. Unlike all their neighbours, the forest-dwelling community of Wanang turned down logging offers for their traditionally owned lands and opted for conservation, establishing a 10,000 ha rainforest conservation area surrounded by active logging concessions. Our project assisted in consolidating their Conservation Area and developing it into an internationally important centre for ecological research. This is designed to provide a sustainable annual income for conservation, matching the total potential alternative income from logging in less than 15 years, whilst also building biodiversity research capacity in the country, which remains seriously underdeveloped. Our project thus addressed pressing biodiversity conservation issues while transferring biological expertise to Papua New Guineans including forest dwelling villagers, biology students and young researchers. Our goal has been to establish the Wanang Conservation Area as an example of a sustainable rainforest reserve driven by its indigenous landowners, in collaboration with local and international conservation organisations and the international research community.



Fig. 1. Map of Papua New Guinea, showing position of the project focal site at Wanang (Latitude:-5.25, Longitude:145.267). For further site details, see Center for Tropical Forest Science website: <http://www.ctfs.si.edu/site/Wanang> and Wanang Conservation Area website: <http://www.entu.cas.cz/png/wanang/homepage>



Fig. 2. Wanang Conservation Area topography (and its location in Papua New Guinea), Wanang Research Station, Wanang Conservation School, and variation in altitude across the 50-ha Forest Dynamics Plot.

2 Project Achievements

2.1 Outcome

The project achieved its intended outcome: to develop a sustainable approach to rainforest conservation supported by indigenous landowners, to further the ability of PNG nationals to conduct research and biological training, and to collect rainforest biodiversity data on responses to disturbance. This outcome was achieved by developing the Wanang Conservation Area (WCA) as a model conservation area run by indigenous landowners who gained significant skills and managerial experience in hosting biological research, thus becoming an example of financially sustainable conservation. Furthermore, the project helped to establish a local biodiversity research team that can accomplish biodiversity surveys for academic research, conservation projects and environmental monitoring for governmental bodies and business partners. This research team has also become a nationally important centre for research training. The project also supported biodiversity research that produced important data sets on the distribution of tropical biodiversity (insects, birds, plants, amphibians) and its response to disturbance.

2.2 Impact: achievement of positive impact on biodiversity and poverty alleviation

This is described below in detail against our seven Outputs defined in the logframe. Our project has achieved tangible progress in (i) sustainable conservation of the Wanang Conservation Area by developing community mechanisms for sustainable management of the WCA and its sustainable funding, (ii) establishing WCA as a national role model for conservation in PNG, (iii) documenting rainforest biodiversity in PNG, and (iv) poverty alleviation in the Wanang community, including improved education, health care, and income levels.

2.3 Outputs

The project envisaged six major outputs (numbered here as in Annex 1), all of which have been achieved, together with two additional outputs:

Output 1. Wanang Conservation Area (WCA)

The WCA is active and managed by the local landowners through a Conservation Board (comprising the leaders of all nine landowning clans) and with its own executive (Project Manager, Deputy Project Manager, Research Station Manager). Furthermore, the community also operates the Wanang Conservation School (elementary and primary school with over 300 children, managed by the School Board) supported by funds from conservation, as well as Wanang Community Truck, a small private business started from funds raised from conservation during the current project.

Output 2. Training

Our project has formed a team of 14 Wanang research assistants who have been trained in biodiversity survey techniques. Furthermore, we have trained 25 para-ecologists from the New Guinea Binatang Research Center (BRC) in various aspects of ecological research. This included extensive training for six paraecologists at several UK institutions, as well as shorter visits to academic institutions in the Czech Republic, Singapore and Australia.

2.1 Wanang research assistants

Our training, led by BRC paraecologists and PNG & overseas postgraduate students, focused on forming a team of local experts in species recognition of focal plant and animal taxa, as well as basic ecological survey techniques. The training included 15 locally recruited personnel: Ruma Umari - fruit flies, Fidelis Kimbeng - butterflies, Dominic Rinan & Byron Siki – plants, Bonny Yawas – plant carbon measurement, Mark Mulau, Samuel Jepi, Luda Paul & Lui Napa – birds, Ava Munga, Jonah Philip, Saky Francis, Isac Saldon & Jerry Keram – herbivorous insects.

Our approach to the training of Wanang and BRC paraecologists can be illustrated using our bird surveys in Wanang that included (i) a broad-scale survey across 10,000 ha of the WCA, (ii) small-scale detailed surveys within the 50-ha forest dynamics plot, and (iii) surveys using the WCA to provide baseline data on bird diversity in undisturbed forests, for comparison with three nearby fragments, thereby assessing the response of birds to forest disturbance.

This study included (i) Samuel Jepi and Luda Paul recruited from Wanang, (ii) BRC staff Bonny Koane, and (iii) overseas MSc and PhD students Richard Hazell, Katerina Sam and Krystof Chmel. We have published part of this research:

Sam, K., Koane, B., Jeppy, S. & Novotny, V. 2014. Effect of forest fragmentation on bird species richness in Papua New Guinea. *Journal of Field Ornithology*, **85**, 152–167.

The authorship reflects our policy of local training and involvement of local experts. We have demonstrated that bird communities in small village reserves (300 - 1,200 ha) retained approximately 80% of the bird species present in adjacent large forests. The missing species from the fragments included particularly large-bodied frugivores and understory insectivores.

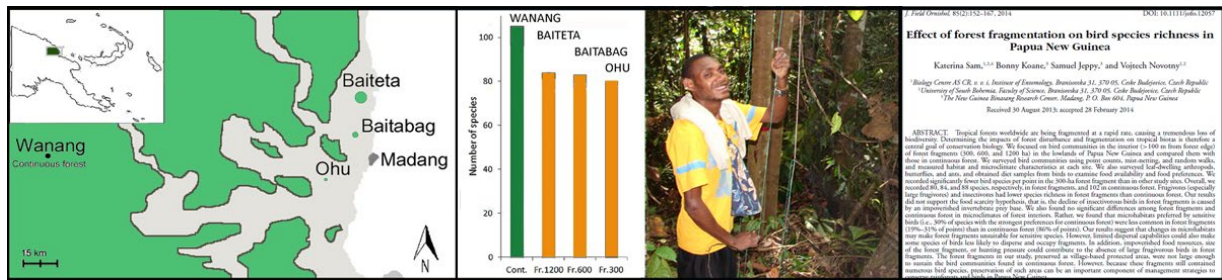


Fig. 3. Map of primary (green) and secondary (grey) forests in the study area; the number of bird species recorded in continuous forest (green) and in three fragments (orange); S. Japi mist netting birds in Wanang, and the resulting publication.



Fig. 4. Team of Wanang trainees with PhD student Krystof Chmel; newly trained ornithologist Luda Paul with a King Bird of Paradise, an important biological asset of WCA; fieldwork camp in WCA; accessing WCA forest canopy using a helium balloon; Ruma Umari rearing insects from rainforest fruits at the Wanang field station.

2.2 Para-ecologists

In total, 25 BRC para-ecologists (John Auga, Mary Dilu, Jerome Dobia, Bradley Gewa, Mavis Jimbudo, Graham Kaina, Martin Keltim, Andrew Kinibel, Bonny Koane, Adolf Kot, Joseph Kua, Roll Lilip, Grace Luke, Markus Manumbor, Martin Mogia, Kenneth Molem, Hans Nowatuo, Frank Philip, Kenneth Pomoh, Maling Rimandai, Steven Sau, Elvis Tamtai, Salape Tulai, Joseph Valeba, and Joachim Yalang) took an active part in training and research. The in-house and overseas training of students and para-ecologists by DI researchers was complemented by a rich training program by visiting researchers from other projects.

The outcomes of our training can be best illustrated by individual personal success stories of which we report two (although there are more).

Mr. Bonny Koane was recruited as a village assistant and was trained by Dr. K. Sam in the identification of birds. After many months in the field, he has become probably the best PNG expert on birds. During the present project, he collaborated with visiting MSc student Richard Hazell (University of Sussex) on the bird survey of the entire WCA. He has co-authored three research papers:

Sam, K., Koane, B., Jeppy, S. & Novotny, V. 2014. Effect of forest fragmentation on bird species richness in Papua New Guinea. *Journal of Field Ornithology* **85**, 152–167

Sam, K. & Koane, B. 2014. New avian records along the elevational gradient of Mt. Wilhelm, Papua New Guinea. *Bulletin of the British Ornithologist's Club* **134**, 116-133.

Sam, K., Koane, B. & Novotny, V. 2015. Herbivore damage increases avian and ant predation of caterpillars on trees along a complete elevational forest gradient in Papua New Guinea. *Ecography*, **38**, 293–300

and presented his results at the Association for Tropical Biology and Conservation conference in Cairns (Australia) in 2014. Furthermore, he has already been requested as an expert ornithologist for other biological surveys in PNG, including a further project by the University of Sussex.



Fig. 5. Bonny Koane started as a village assistant but has become the leading BRC specialist on birds, presented his work on birds as insect predators at the ATBC conference in Cairns in 2014 and co-authored three research papers on this research.

Mr. Roll Lilip is a senior BRC staff member and former Darwin visitor to the UK specializing on miners. His expertise from field sampling and rearing insects has been highly appreciated by a Japanese-Czech research team (Tokyo University, Chiba University, and the University of South Bohemia) that invited him to take part in their research, using the canopy crane in Japan, a unique facility for forest canopy access unavailable in PNG. Roll performed so well in 2014 that he has been invited back for the 2015 field season, illustrating that our training is competitive internationally.



Fig. 6. Roll Lilip taking part in insect sampling and rearing from the canopy crane in Tomakomai (Japan) and laboratory rearing of insects as a member of an international research team.

2.3 Overseas training

Six BRC para-ecologists visited the UK, Australia, Singapore & the Czech Republic for specialist training, two in each of the three years of the project: Joseph Kua & Martin Keltim (2012), Bradley Gewa & Joseph Valeba (2013), Maling Rimandai & Frank Philip (2014). Their programmes included:

- One week at the University of Sussex hosted by Alan Stewart and Mika Peck for training in forest carbon assessment, GPS mapping and remote sensing, plus visits to protected areas and field study sites.
- One week at the Herbarium, Royal Botanic Garden, Kew for training in the identification of world plant families, and some species-level identification.
- A five-day Basic Canopy Access course, based at the Harcourt Arboretum near Oxford or Stourhead in Wiltshire, delivered by Canopy Access Ltd.
- One week in the Entomology Department at the National Museum of Wales for training in insect curatorial techniques and collections management, plus visits to field sites.
- One day visits to the Millennium Seed Bank facilities at Wakehurst Place, Sussex, and to Rothamsted Research, Harpenden.
- A visit to BRC research collaborators in the Environmental Futures Department at Griffith University (Brisbane), including past Darwin MSc students L. Sam and F. Dem who are studying for their PhD degrees there, and giving informal seminars for the department.
- Seminars given at the University of South Bohemia, Czech Republic, plus visits to protected areas and field study sites.
- Visit to research collaborator and seminars given at the National University of Singapore.

Output 3. Postgraduate students

Our strategy for training of postgraduate students is based on building a group of resident BSc Honours and MSc students at BRC (all enrolled at University of PNG), working together on their dissertations on diverse topics relevant to the documentation and conservation of biological and cultural diversity in PNG. These students stay in residence at BRC for the entire length of their study, receive dormitory-style accommodation and food free of charge, as well as a modest stipend and funds for research expenses. This allows them to focus entirely on their studies. The DI team together with BRC research staff and visiting PhD students and researchers aim for a diverse, research-oriented and intellectually stimulating environment that we believe is unparalleled anywhere in PNG.

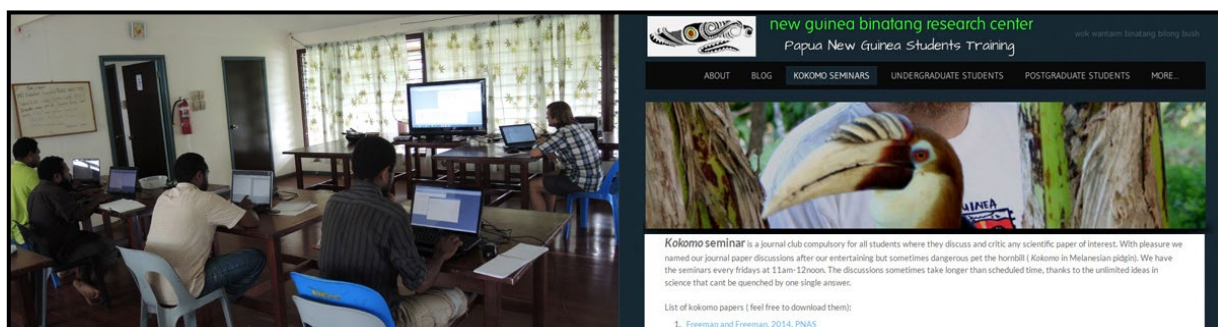


Fig. 7. Hons and MSc students learning statistics in the R language (left), and BRC website for weekly 'Kokomo Seminars' for discussing research papers (right, <http://binatang-student-blog.weebly.com/kokomo-seminars.html>).

At the beginning of the present project, we enrolled two Honours and two MSc students:

- Nigel Baro, Hons. study, ethnobiological and language skills in PNG, graduated 1st Class in 2015
- Clementine Sesega. Hons. study, plant-insect interactions between folivorous insects and *Ficus* hosts, graduated 1st Class in 2015
- Jimmy Moses, MSc student, altitudinal gradients in ant community composition, graduated with distinction in 2015
- Clant Alok, MSc student, plant-soil interactions in the 50-ha permanent forest plot in Wanang, graduation due in November 2015

Our BRC-based group featured prominently at the University of PNG graduation in April 2015 being the largest group of postgraduate biology students from a single institution. It also included J. Moses awarded MSc Distinction, who was interviewed for a cover story by 'The National' newspaper, one of the two leading dailies in the country.

The timely and successful graduation of this student group allowed us to recruit a new cohort of students in the 3rd project year, who are still continuing their studies:

- Alfred Kik, MSc study, ethnobiological and language skills in PNG
- Grace Luke, Hons. study, host specialization of herbivorous insects on altitudinal transects
- Gibson Aubona, Hons. study, chemical composition of *Ficus* trees on altitudinal transects
- Peter Amick, Hons. study, the impact of bats on herbivorous insects
- Elizah Nagombi, Hons. study, communities of amphibians in response to rainforest fragmentation



Fig. 8. A – Graduation of our students (from left: Moses, Sesega, Baro) in April 2015, reported in *The National* newspaper highlighting J. Moses awarded with MSc Distinction degree (B). Their successful graduation provided role models for our current students (C, from left: P. Amick, B. Bau, A. Kik, G. Aubona, E. Nagombi and G. Luke), shown working on their research (D, from left: Luke examining host plants of insects, Kik testing language skills of students, Amick surveying bats and Nagombi identifying frog specimens).

Our student training programme has been supported also by two previous DI grants. We can therefore assess not only graduation success, but also the subsequent careers of our students and therefore the sustainability and legacy of the DI-sponsored training:

- Darren Bito: MSc at BRC, followed by PhD at the Griffith University Brisbane, presently Dean of Science at the Pacific Adventist University in Port Moresby
- Rapo Pokon: MSc at BRC, presently Lecturer at the University of Technology in Lae, PNG
- Pagi Toko: MSc at BRC, presently Deputy Director at BRC
- Legi Sam: MSc at BRC, presently a PhD student at Griffith University Brisbane,
- Leontine Baje: Hons. at BRC, presently a Researcher at the PNG Fisheries Department
- Kipiro Damas: Hons at BRC, presently a Senior Researcher at the PNG Forestry Research Institute
- Francesca Dem: MSc at BRC, presently a PhD student the Griffith University Brisbane
- Chris Dahl: MSc at BRC, presently a PhD student the University of South Bohemia, the Czech Rep.
- Jimmy Moses: MSc at BRC, starting as a PhD student the University of South Bohemia in Sep. 2015
- Nigel Baro: Hons at BRC, presently a Researcher at the PNG Forestry Research Institute.

In summary, all our Darwin-sponsored Hons and MSc graduates have since established successful careers in science, including four students who continued on to PhD studies at overseas universities. Each of these personal stories is worth reporting, but we would like to highlight just one: that of Ms Francesca Dem.

Francesca was based at BRC for her Hons. and MSc studies, both supported by the Darwin Initiative and both focused on the ecology of sap-sucking insect herbivores. After successful graduation she continued on to a PhD study at Griffith University in Brisbane and submitted her dissertation in 2015 based on field work in Australia. Her Hons. and MSc research results have proved to be of international importance as the only quantitative estimates of host specificity of sap sucking insects from a tropical forest. That is why she was invited as a co-author to a high profile analysis of tropical – temperate trends in insect specificity published this year in the *Proceeding of the National Academy of Sciences*, one of the best research journals in the world, where the tropical data for sap-sucking insects relied entirely on her work:

Forister, M. L., Novotny, V., Panorska, A. K., Baje, L., Basset, Y., Butterill, P. T., Cizek, L., Coley, P. D., **Dem, F.**, Diniz, I. R., Drozd, P., Fox, M., Glassmire, A., Hazen, R., Hrcek, J., Jahner, J. P., Kaman, O., Kozubowski, T. J., Kursar, T. A., Lewis, O. T., Lill, J., Marquis, R. J., Miller, S. E., Morais, H. C., Murakami, M., Nickel, H., Pardikes, N., Ricklefs, R. E., Singer, M. S., Smilanich, A. M., Stireman, J. O., Villamarín-Cortez, S., Vodka, S., Volf, M., Wagner,

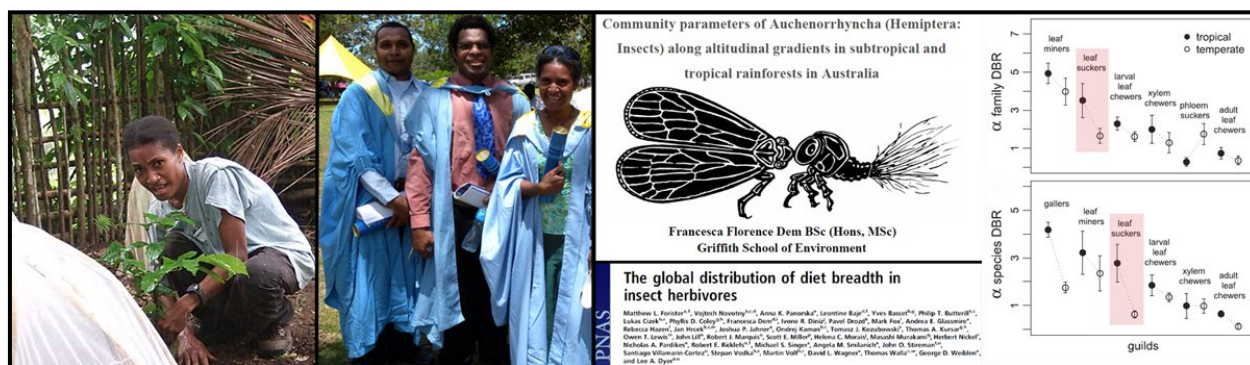


Fig. 9. Former DI-sponsored MSc student Francesca Dem doing field work on sap-sucking insects (left) and at her graduation in 2011 (with Dahl and Toko); her PhD thesis submitted at Griffith University (Australia) in 2015, and the co-authored paper in *PNAS*, using her dissertation data that proved to be the only data set suitable for comparing the host specificity of sap-sucking insects in tropical versus temperate zones (right, highlighted in pink).

3.2. International Tropical Ecology Course

We organized the *International Tropical Ecology Course* from 3rd to 27th July 2013. The course combined overseas and PNG instructors: V. Novotny (BRC, tropical ecology), J. Leps (Univ. of South Bohemia, Czech Rep., plant ecology), K. Damas (PNG Forestry Res. Inst., botany), K. Chmel, (Univ. of South Bohemia, Czech Rep., ornithology), and M. Samson (PNG Wildlife Conservation Society, mammals). The course included introductory lectures on PNG ecology, 11 individual student projects (carried out in teams combining as far as possible PNG and European participants), and a field trip to the Manam volcano. The course was based at the BRC main station in Madang and the field station in Wanang. It proved to be very popular as we received 89 applications from PNG. The 20 participants that were selected included 11 active researchers, postgraduate and undergraduate students from the University of PNG, PNG University of Technology, the PNG Forestry Research Institute, the Coffee Industry Corporation, the Ok Tedi Mining company, the National Quarantine Office, and the PNG Institute of Biological Research, as well as three Conservation International-supported students resident at BRC, one BRC staff member, and five village assistants from Wanang CA and other villages. The course participants assessed the quality of the course anonymously on a scale from 1 (excellent) to 10 (poor), with grade 1 being the prevailing evaluation (Fig. 11).



Fig. 10. Participants on the *International Tropical Ecology Course* and title pages of 11 presentations reporting on individual research mini-projects completed by the participants.



Fig. 11. Ornithology field instruction for the students, Mr. Samuel Jipi demonstrates a kingfisher, students light-trapping moths, and examining algae with a microscope, and the results of anonymous assessment of the Course (grades from 1 – excellent to 10 – poor) by paraecologists (green), PNG students (orange) and European students (blue).

Output 4. Biodiversity surveys

Biodiversity surveys accomplished during this project resulted in 19 peer-reviewed papers and book chapters (numbered and listed in Annex 5). They focus on the following themes:

- Biodiversity surveys in the Wanang Conservation Area and other lowland rainforests in PNG: Refs 3, 18 & 19 (butterflies), 5 (amphibians), 10 & 11 (ants), and 17 (birds)
- Plant-herbivore food webs in PNG: Refs 2 & 6 (sap-sucking insects), 4 (fruit-feeding insects), 12 & 14 (gallers) and 15 (folivorous insects)
- Vegetation dynamics and carbon storage, based on plant plots in Wanang: Refs. 1, 7
- Lessons from paraecologist training in PNG: Ref 16

These studies also led to a more general analysis of the structure and assembly of tropical herbivore communities [15], a refined global estimate of insect diversity [9], an analysis of latitudinal trends in insect diversity [8], and a review of the status of entomological research in the tropics [13]. Importantly, a significant proportion of these papers have been co-authored by PNG students, researchers or para-ecologists: Refs 2, 3, 5, 6, 7, 10, 15, 17, 19.

Additionally, a comprehensive assessment of carbon stocks across the WCA was completed as a baseline survey for use in reduction of carbon emissions from deforestation and forest degradation framework programmes (REDD++). We estimated above-ground live biomass for Wanang at 144.1 Mg ha⁻¹ (95% CI 28.7 Mg ha⁻¹). This confirms previous estimates showing that PNG lowland forest has comparatively lower biomass compared to the global mean for tropical rainforests (373.7 Mg ha⁻¹). The total carbon stock for the whole WCA is estimated at 1,552,347 Mg C. Accurate carbon accounting is vital for confidence in REDD++ programmes that we believe will provide a potential income stream for the Wanang Conservation Area (WCA).

Output 5. Village biodiversity guides

Our results were shared with village communities in the form of booklets, written in an accessible form either in English or Tok Pisin (the local PNG pidgin language). The goal is to share the biodiversity information with indigenous communities, and also equip these communities with printed materials that could be given or sold to visitors, particularly tourists interested in their rainforests. Multiple copies were printed and shared with the communities. We have produced the following booklets:

- *Wanang Conservation Area*. Written by B. Henning. This is a 19-page booklet written in English and Tok Pisin providing background information on the Wanang Conservation Area for visitors.
- *Birds of Wanang*. Written by K. Sam. A 27-page booklet in both Tok Pisin and English which is suitable both for villagers and bird-watching tourists, summarising information on the most interesting birds in the area.
- *Birds of Ohu*. Written by K. Sam. A 19-page booklet for the conservation area in Ohu village, suitable for villagers and bird-watching tourists.
- *A Pocket Guide to Frogs of Lowland Forest around Kau, Morox, Ohu and Wanang Villages of Madang Province*. Written by C. Dahl. A 47-page review in English of amphibians in four village communities.
- *Trees of Wanang*. Written by G. Weiblen. This 506-page book features all species of woody plants from the 50-ha forest dynamics plot in Wanang, including for each species a map of the distribution within the plot, a photo, scientific and vernacular species name, species characteristics and its traditional uses. This is a serious research resource as well as a detailed compendium of indigenous information on plants.

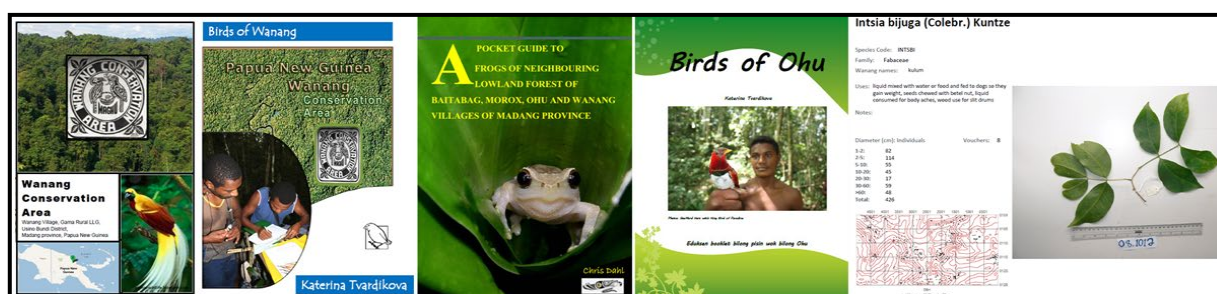


Fig. 12. Biodiversity booklets: title pages of four booklets, and example page for a commercially important tree species, *Intsia bijuga*, from the book *Trees of Wanang* (right).

Output 6. Sustainable income for the WCA

The project has taken several steps towards preparing the WCA for long-term sustainable operation and fund raising. Furthermore, the project facilitated community development aimed at poverty reduction and sustained support for rainforest conservation:

- BRC assisted with its staff and technology (GPS) in the delineation and clarification in the field of borders between Wanang CA and neighbouring logging areas.
- Wanang Conservation Board, assisted by BRC, produced a Wanang Conservation Area booklet informing researchers and other visitors about the CA and the logistics of their visit, and also received booklets on birds, amphibians and plants in the WCA area aimed at ecologically oriented tourists.
- A comprehensive assessment of carbon stocks across the WCA was accomplished as a baseline survey for future use in REDD++ programmes (see Output 4, above).
- A team of Wanang research assistants has been trained and employed by research projects in WCA.
- BRC assisted the Wanang community with building a government-sponsored classroom in the Wanang Conservation Primary School and assisted with educational materials and stationary for children.
- WCA attracted a £19,000 donation from the Steamships Company to build a new classroom.
- BRC organized regular medical patrols led by a nurse from the Madang Hospital. These were the first regular medical assistance visits ever received by the community and covered the entire village population.
- WCA attracted significant external investment for field research infrastructure: (i) a solar panel electricity system for the Wanang Research Station, funded by The Prince of Monaco Foundation (£41,000), (ii) funds for maintenance of the Research Station from Swire and Sons (£19,000), and (iii) the 'Canopy Bubble' – a forest canopy access system funded by the Grant Agency of the Czech Republic (£124,000), awarded on the basis of current Darwin-enhanced performance of WCA and facilitating future research activities.
- BRC assisted the Wanang community by a donation of a new truck (£29,000) that is now being run as the first community-based small business project. It is transporting paying passengers and cargo to and from Madang town. It also greatly improved access by members of the Wanang community to services in town, including markets, shops, schools and medical facilities.
- WCA attracted, with BRC assistance, several research projects and student training projects from Oxford University, the University of South Bohemia, the University of PNG, the Czech Academy of Sciences and others. These provided employment (field assistants, guides etc.) as well as entry fees to the WCA.

In the last 12 months of the project, the total WCA income was £118,680 including £59,880 cash income, mostly salaries for supporting various research and training projects:

Project	GBP	Form of payments	Source of funds
Wanang truck	28,800	material donation	BRC
Wanang truck	4,680	operational profits	Wanang community
Conservation royalties	3,840	cash payment to clans	BRC
Research Station maintenance	6,000	salaries	Swire & Sons
Wanang school classroom	30,000	material donation	Steamships Co.
Canopy Bubble baloon	7,200	salaries	Czech Academy of Sciences
Carbon forest assessment	2,880	salaries	Sussex University
Insect surveys	19,200	salaries	University of South Bohemia
Forest fruit surveys	7,200	salaries	Oxford University
Bird surveys	3,600	salaries	University of South Bohemia
Community ethnobotany	480	salaries	BRC & University of PNG
Community anthropology	720	salaries	University of South Bohemia
International student course	1,920	salaries	BRC & University of South Bohemia
Entry fees for research projects	960	cash payment	various projects
Research acommodation building	1,200	salaries and material	BRC
Total cash income	59,880		
Total	118,680		

In summary, members of the WCA significantly improved its readiness to cater to researchers and other visitors by improving their collective skills, organization, and facilities. Furthermore, they were able, with the help of BRC, to attract research and donor projects, all of them tied to rainforest conservation, that both supported conservation in WCA and improved living standards in this severely under-privileged community. At present, WCA remains dependent on

BRC for assistance in management and soliciting research projects, but this partnership is stable and likely to be sustainable in the future.



Fig. 13. Wanang community development: (i) new accommodation for tourists and visiting researchers being built in Wanang village; (ii) new Wanang truck donated by BRC; (iii) the first medical patrol in Wanang; (iv) Pagi Toko (BRC Acting Director, left), Filip Damen (Wanang community leader, center) and Bill Rothery (CEO of Swire and Sons Australia, right) at a ceremony where the Wanang community received a £19,000 donation from Swire to build a classroom.

7. Socio-economic assessment of project impact

BRC staff have conducted informal interviews with the representatives of the Wanang community, enquiring about their perceptions of social change in the 2013-2014 period, i.e. in the second half of the DI project. Respondents from all nine clans were included and asked whether certain aspects of their life improved significantly, remained more or less the same, or got worse as a result of rainforest conservation and collaboration with BRC.

The access to education was considered satisfactory by most of the participants, due to the Wanang Conservation School. More than 50% of respondents considered it improved over the two years since the school opened two new classes (grades six and seven) and built a new classroom. All children wishing to attend the school are accepted.

The access to health care has improved over the past two years according to virtually all participants, as a result of health patrols started during the present project, and better access to medical services in the Madang town by the community truck. However, medical care was considered insufficient by more than 50% of respondents, particularly women. A permanent aid post staffed with a trained nurse was identified as the next community development priority.

Direct income from conservation, paid annually as “conservation royalties” to each clan was appreciated but considered too low by more than 50% of the respondents. The income from salaries has improved significantly according to 40% of respondents. These considered it satisfactory, but the community at large had concerns that the best long-term jobs – those for research assistants – were going mostly to members of the young more-educated generation who were fluent in English, whilst the older generation had fewer opportunities. This is an issue to be addressed further in future.

8. Conservation impact on the governmental and international levels

This output was not originally planned. Our experience with training for research in PNG allowed us to raise its profile also with the PNG Government and internationally. In particular, we have been instrumental in organizing the Association for Tropical Biology and Conservation (ATBC) **Resolution in Support of Biodiversity Education, Research and Conservation in Papua New Guinea** (available at <http://tropicalbiology.org/atbc-resolution22/> and reproduced below). Two BRC representatives, V. Novotny (who was at that time one of the elected ATBC Councillors) and P. Toko (the Country Representative for PNG in the Asian Chapter of ATBC) proposed the Resolution to the ATBC council at their Cairns meeting, arguing that the proximity of PNG offers a unique opportunity for such a resolution. It was finally approved by the 589 researchers from 55 countries attending the conference. The Resolution argues for better

support of research and education in PNG, and was endorsed by the *PNG Research, Science and Technology Secretariat* of the PNG Government. The Resolution received wide media exposure in PNG and also internationally, and we believe that it contributed to an elevated profile for biodiversity conservation and education in the country.

ATBC Resolution in Support of Biodiversity Education, Research and Conservation in Papua New Guinea

Papua New Guinea's (PNG) forests support a disproportionate amount of species not found elsewhere on the planet. A major challenge to the conservation of Papua New Guinean biodiversity is that it remains largely unexplored and therefore under-studied.

The ATBC congratulates the Government of Papua New Guinea for initiating the establishment of a biologically representative network of Conservation Areas in collaboration with the traditional landowners. This process is essential for the preservation of Papua New Guinean biodiversity.

We call on the Government of Papua New Guinea to provide new funding initiatives to support the training of the next generation of Papua New Guinean biologists. A better system of funding is also needed if established researchers are to continue exploring the biota. These initiatives are essential for the documentation, understanding and protection of the globally important PNG biodiversity.

Therefore, be it resolved that the ATBC:

- Urges the Government of Papua New Guinea to strengthen the PNG Research, Science and Technology Secretariat and to establish a competitive funding mechanism for biodiversity research open to all Papua New Guineans from government and non-governmental research organizations. The selection process should be based on scientific merit;
- Implores the Government of Papua New Guinea to expand the number of studentships available for postgraduate biology students;
- Urges the Government of Papua New Guinea to create a network of Conservation Areas by approving pending proposals for the Managalas, Wanang, Torricelli and Sulamesi Conservation Areas, by increasing the number of protected areas and designating, together with the landowners, additional Conservation Areas representing all principal ecosystems in Papua New Guinea.
- Exhorts the Government of Papua New Guinea to promote the effective management of protected areas and Conservation Areas.
- Encourages the Government of Papua New Guinea to compensate landowners with royalties for their conservation set-asides and assist them with sustainable development projects.
- Encourages private enterprise within Papua New Guinea to support the Government in its efforts to promote the study and preservation of the country's biodiversity.
- Encourages the PNG government to seek international collaboration with scientists and conservationists to achieve the above mentioned goals.

3 Project Partnerships

This project developed a long-standing collaboration with the national partner in PNG, the New Guinea Binatang Research Center (BRC) that facilitated work with the Wanang Conservation Area and the Wanang community. As with our previous DI projects, BRC was closely involved in deciding the overall direction and goals of the project, as well as the details of planning. The partnership has drawn upon the academic strengths of the University of Sussex, including expertise in insect biodiversity and carbon stock assessments, both critical for the project, and access to numerous training opportunities in the UK. These have been fruitfully combined with BRC's local knowledge of the social dynamics of conservation in PNG, which is so crucial for sustainable conservation and poverty alleviation in these remote indigenous communities. The collaboration has been highly efficient and problem-free. It has already been extended by a new project funded by the Waterloo Foundation, obtained during the present project and involving the same partners, for developing a full business plan to secure a sustainable income for the WCA based on services to biodiversity research and tourism.

4 Contribution to Darwin Initiative Programme Outputs

4.1 Project support to the Conventions (CBD, CMS and/or CITES)

PNG's Fourth Report on the CBD (2010) noted plans to increase protected area coverage from 4.5% to 10% of the country in 2011-2015 whilst noting that a majority of the existing conservation areas have minimal or no management structure. The Aichi Biodiversity targets for 2011-2020 include Target 5 (halving the rate of loss of forests by 2020), Target 11 (protecting minimum areas of important habitats) and Target 19 (building research capacity and knowledge base).

Our project, located in a CBD priority area, made a significant contribution to the CBD and Aichi goals by (i) developing the 10,000 ha Wanang Conservation Area into a sustainable, and sustainably funded, example of rainforest conservation, and (ii) significantly enhancing the country's expertise for biodiversity studies.

4.2 Project support to poverty alleviation

The project improved living standards in Wanang, a severely under-privileged, rainforest-dwelling community. We have made tangible and significant improvements in economic standards by providing employment and increasing income, in education by developing the local primary school, and in access to medical care.

4.2.1 Programme indicators

- Did the project lead to greater representation of local poor in management structures of biodiversity?

Yes, we helped an under-privileged indigenous community to develop and manage their own Conservation Area. Furthermore, we have trained several community members to become biodiversity surveyors and technicians.

- Were any management plans for biodiversity developed?

Yes, we have mapped WCA biodiversity and helped the WCA Board to set conservation rules.

- Were these formally accepted?

Yes, by the Wanang community. Furthermore, the WCA is in the process of being recognised by the PNG Government (Department of Environment and Conservation).

- Were they participatory in nature or were they 'top-down'? How well represented are the local poor and women in any proposed management structures?

WCA governance is guided by elections and community consensus, including equal representation by all clans comprised by the community. However, this local self-governance also leads to severe under-representation of women, due to deeply entrenched gender roles in this highly traditional community.

- Were there any positive gains in HH income as a result of this project?

Yes, there was a significant increase in income for the Wanang community.

- How many HH saw an increase in their HH income?

Approximately 40% of adults have benefitted from increased income.

- How much did their HH income increase (e.g. x% above baseline, x% above national average)? How was this measured?

Their income increased by approximately 50% over the pre-project situation. It is thus probably reaching the national average in this originally severely under-privileged community. This estimate is based on interviews with community members.

4.3 Transfer of knowledge

Three people achieved formal qualifications: 1 MSc and 2 BSc Hons. degrees at the University of PNG. They were all nationals of PNG, a developing country: 1 female, 2 males.

The project has made a concerted effort to transfer knowledge to PNG on several levels:

- (i) supervision and training of postgraduate students by DI personnel in PNG,
- (ii) training of para-ecologists and research technicians by DI personnel in PNG and the UK,
- (iii) training of postgraduate students and junior researchers on the *International Tropical Ecology Course*,
- (iv) training of locally recruited research assistants by PNG para-ecologists and students,
- (v) transfer of conservation experience to the Department of Environment and Conservation.

The success of research training is demonstrated by research papers co-authored by PNG nationals, as well as successful further professional careers in science and conservation for our former students.

4.4 Capacity building

Mr. Pagi Toko was voted Country Representative for PNG by the Association for Tropical Biology and Conservation. All three students that graduated from our programme have taken up high profile positions: Ms. Sesega a tutor at the University of PNG, Mr. Baro a researcher at the PNG Forestry Research Institute, and Mr. Moses a PhD student at the University of South Bohemia (Czech Republic).

The project led to a radical increase in local capacity for biodiversity surveys at the WCA, where we formed the first team of local experts trained in botany, ornithology, herpetology and entomology. Furthermore, it also improved the biodiversity survey capacity of BRC, our partner institution. Finally, it trained postgraduate students who now continue in their research careers in PNG, building the research capacity nationally.

The project also helped to build a conservation infrastructure in WCA: physical field research facilities for visiting scientists; organizational and informational management systems for hosting research projects; and biodiversity booklets for visitors. The project was also crucial for promotion of one of the priority conservation areas to be declared by the PNG Government, having national impact as an example of a successful conservation project.

4.5 Sustainability and Legacy

The project has improved the ability of the partner organization, BRC, to compete for and host biodiversity research projects. It also enabled the Wanang community to support the WCA at the local level. Both BRC and WCA are able to continue in fund-raising for research and also continue employing all trainees and staff that were part of the DI project. Likewise, all DI students have already been either employed in research-related jobs or continue in their studies. This has been the case also for the staff and students from our past DI projects that included the same partner, BRC, and where the degree of sustainability could be objectively judged several years after the end of each DI project.

The ATBC Resolution in Support of Biodiversity Education, Research and Conservation in Papua New Guinea, initiated by our project, has impacted biodiversity education and conservation at the government level, through the *PNG Research, Science and Technology Secretariat*.

5 Lessons learned

The project has been challenging as the principal interaction was between researchers and students from developed countries and indigenous villagers from a particularly under-developed community, even by PNG standards. We have approached this challenge by involving BRC, a local NGO staffed by para-ecologists who are highly experienced in interactions with overseas researchers but at the same time have the advantage of often coming from village communities themselves. This intermediate link has been crucial for the success of such a project spanning such culturally different environments.

Furthermore, we have come to the conclusion that the training of PNG postgraduate students and para-ecologists for biological research is, in the long term, a more efficient approach to securing the country's biodiversity than direct conservation action (although our project included both). Overseas-driven conservation cannot succeed in the long term unless it is

supported by local expertise and also has high-level political backing. Widespread support for conservation within PNG society can only be generated by first developing a solid foundation of scientific expertise.

5.1 Monitoring and evaluation

We have used anonymous questionnaires to evaluate the quality of our *International Tropical Ecology Course* (see above). Additionally, BRC staff queried members of Wanang community as to the perceived improvements and failures brought about by the project.

In our biodiversity work, we consider publication in high quality peer review journals to be the best external evaluation of our work. Likewise, the success of our students in their subsequent careers is an indication of the quality of our training.

5.2 Actions taken in response to annual report reviews

All reviews of our annual reports have been discussed with our partners. The following minor issues were raised in our last annual report:

- i. Is there a contingency plan if the conservation area has not been granted legal status by the end of the project? *No. At the end of the project, we are still awaiting a decision on this. The decision is out of our hands in that it will be made by the PNG government's Department of Environment & Conservation. BRC actively continues to lobby for the official designation of the WCA as a protected area and is confident that this will be achieved in due course.*
- ii. Are there plans to appraise the performance of the new BDO? *Yes. Performance of the Business Development Officer (project funded by the Waterloo Foundation) is appraised informally regularly and formally every 6 months. Good progress on this project has been made and his performance has been good.*
- iii. Empty cell (total planned for project) at Annex 3 Table 1 (Standard Output Measures) for Code 5. *This information has now been provided in Annex 3 of this report.*
- iv. It would be useful to have the link to publications in Table 2 (rather than simply 'pdf from authors'). This is available on the Center website. *These have now been provided in Annex 5 of this report.*

6 Darwin identity

Our Darwin project was acknowledged in all publications and all training activities, including the *International Tropical Ecology Course* and the overseas training of PNG staff in the UK. The partner organizations, BRC and WCA, have a clear understanding of the contribution made by the Darwin project, despite the fact that many activities – particularly research – were funded jointly with other contributors.

7 Finance and administration

7.1 Project expenditure

Project spend (indicative) since last annual report	2014/15 Grant (£)	2014/15 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs (see below)			-0.3111	
Consultancy costs				
Overhead Costs			-6.7484	
Travel and subsistence			7.5813	
Operating Costs			-1.5907	
Capital items (see below)				
Others (see below)				
Audit Costs			0	
TOTAL				

Staff employed (Name and position)	Cost (£)
Dr Alan Stewart – Project Leader	
Dr Mika Peck – Project Co-Leader	
Katherine Lennon – Grants Clerk	
John Auga – Team Leader	
Filip Damen – Conservation Project Leader	
Jerome Doboria - Research Technician	
Phillip Frank – Research Technician	
Bradley Gewa – Team Leader	
Mavis Jimbudo – Research Technician	
Graham Kaina - Research Technician	
Bonny Koane – Research Technician	
Adolf Kot - Research Technician	
Joseph Kua – Research Technician	
Roll Lilip – Research Technician	
Grace Luke - Research Technician	
Markus Manumbor - Community Manager	
Martin Mogia – Team Leader	
Kenneth Molem – Team Leader	
Kenneth Pomoh – Research Technician	
Maling Rimandai – Research Technician	
Elvis Tamtai – Research Technician	
Salape Tulai – Research Technician	
Joachim Yalang – Research Technician	
Isua Brus – Research Technician	
TOTAL	

Capital items – description	Capital items – cost (£)
TOTAL	

Other items – description	Other items – cost (£)
TOTAL	

7.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
University of Sussex	
Czech Science Foundation	
Christensen Foundation	
Czech Academy of Sciences Foundation	
New Guinea Binatang Research Center	
TOTAL	

Source of funding for additional work after project lifetime	Total (£)
Research activities at WCA, Czech Academy of Sciences, 2015-2016 (funded by the Grant Agency of the Czech Republic)	
Research and training at BRC, European Research Council grant, 2016-2020	
Waterloo Foundation	
TOTAL	

7.3 Value for Money

This has been an ambitious project in a biologically crucial, but logistically difficult, country – Papua New Guinea. We consider a project that is relatively expensive but accomplishes important goals that have not been accomplished by others to be good value for money. Our project fits this description. Our postgraduate student programme in PNG is the largest for biologists in the entire country, our biodiversity publications represent a significant outcome of the country's research production, the *International Tropical Ecology Course* is one of the country's top training opportunities for aspiring ecological researchers, and Wanang Conservation Area is one of the two conservation areas with the highest profile in PNG.

Annex 1 Project's logframe, including indicators, means of verification and assumptions.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
<p>Goal: Effective contribution in support of the implementation of the objectives of the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered Species (CITES), and the Convention on the Conservation of Migratory Species (CMS), as well as related targets set by countries rich in biodiversity but constrained in resources.</p>			
<p>Sub-Goal:</p> <ul style="list-style-type: none"> To develop a sustainable approach to rainforest conservation supported by indigenous landowners. To further the ability of PNG nationals to conduct research and biological training in their own country for CBD/CMS/CITES adherence. Collect data on the responses of focal taxa to rainforest disturbance to allow evidence-based conservation decisions to be made. 	<ul style="list-style-type: none"> Model conservation area supported and operated by landowners Improved capacity of PNGeans for biodiversity research and training. Improved understanding of species responses to disturbance in rainforests informing national strategic conservation policy 	<ul style="list-style-type: none"> On-site visit to the model conservation area Trained PNG students, para-ecologists, and researchers. Biodiversity data and biological specimens held and used by BRC and PNG government departments PNG authored research papers DI project evaluation. 	
<p>Purpose</p> <ul style="list-style-type: none"> Establish a model rainforest conservation area (CA) with management structure and conservation plan in place Develop facilities and expertise of the landowners and PNG professionals to host biological research in the CA, thus raising funds for conservation Establish an internationally competitive PNG research team that will be the centre of excellence in biodiversity research and training in PNG. Gather key data on biodiversity response to rainforest disturbance to guide conservation policy. 	<ul style="list-style-type: none"> The continuing existence of the CA and its support by the indigenous landowners The ability of the CA to host and support ecological research A 'critical mass' of DI-trained researchers, students and para-ecologists working in PNG on conservation policy-relevant questions. Data on distributions for selected taxa and modelled predictions of impacts on their communities under rainforest disturbance scenarios. Research published in international peer-reviewed research publications. 	<ul style="list-style-type: none"> On-site visit, minutes from the Conservation Board meetings List of research projects hosted by the CA Honours and MSc degrees defended Test results of para-ecologists trained Insect and plant specimens deposited in research collections Public databases of species and specimens Reprints of published papers. 	<ul style="list-style-type: none"> Landowners are interested in rainforest conservation Monetary benefits from conservation and research can compete with the benefits from the alternative use of the forest, particularly logging Sufficient supply of suitably qualified and motivated personnel exists within PNG to sustain an ecological research team.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Outputs 1. Wanang Conservation Area (WCA) established.	WCA has a Conservation Board and a Management Plan in place.	On-site visit, minutes from the Conservation Board meetings.	Landowners are interested in rainforest conservation. Monetary benefits of conservation & research can compete with the benefits from alternative uses of the forest, particularly logging
2. Ten village assistants and 18 para-ecologists trained to support research in the WCA. Two para-ecologists visit UK and other countries for networking and for intensive training.	Training and evaluation programmes in PNG and UK completed.	Feedback from trainees and trainers; results of tests of trainees' progress and learning.	Local villagers and para-ecologists are interested and capable of working as research assistants. Challenging but realistic training programmes can be devised to suit the range of abilities of trainees.
3. Three completed Honours or Masters degrees by PNG students with dissertations focusing on biodiversity research	Honours or MSc dissertations completed	Theses and dissertations. Degree certificates.	A supply of talented undergraduate students exists who are interested in post graduate education and careers in ecology & conservation.
4. Biodiversity surveys for plants, insects and vertebrates along a disturbance gradient to document rainforest response to anthropogenic threats, including carbon storage estimates	Surveys completed, samples sorted, specimens identified, data analysed and results published.	Public databases of species available online. Specimens deposited in museums. Reprints of scientific papers.	Researchers, para-ecologists and village assistants can work in synergy and accomplish surveys in remote field conditions.
5. Guides for focal plant and animal taxa as an information source for local people, visiting researchers and PNG government departments	Guides produced, printed and distributed.	Electronic and printed copies of biodiversity guides.	Researchers, para-ecologists and village assistants can describe local biodiversity on levels that are useful for local villagers, the educated public, as well as researchers.
6. Sustainable income of £20-30,000 per year generated by supporting research in WCA, to replace potential income from logging.	Money deposited in the bank. Contracts signed with research clients	Financial records. Research contract reports.	WCA is attractive to local and particularly overseas researchers and can provide high quality services to a range of research projects.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
<p>Activities (details in workplan)</p> <ul style="list-style-type: none"> 1.1 WCA management training 1.2 WCA legal declaration by the Department of Environment and Conservation 1.3 WCA logistical support for research (accommodation, communication, carriers, catering) established 2.1 WCA field assistants training at BRC 2.2 WCA field assistants training in the field 3.1 BRC paraecologist training at BRC 3.2 BRC paraecologist training in UK 4.1 Hons. and MSc student research 4.2 Hons. and MSc student field ecology course 4.3 Hons. and MSc student dissertation writing and defense 5.1 Plant biodiversity surveys and carbon storage estimates 5.2 Insect biodiversity surveys 5.3 Vertebrate biodiversity surveys 5.4 Biodiversity guides and publications 6.1 Fund raising for WCA 			

Annex 2 Report of progress and achievements against final project logframe for the life of the project

Please note that some activities have been re-numbered from the original logframe.

Project summary	Measurable Indicators	Progress and Achievements in the last Financial Year (2014-2015)	Actions required/planned for next period
<p>Goal/Impact:</p> <p>Effective contribution in support of the implementation of the objectives of the Convention on Biological Diversity (CBD), the Convention on Trade in Endangered Species (CITES), and the Convention on the Conservation of Migratory Species (CMS), as well as related targets set by countries rich in biodiversity but constrained in resources.</p>		<p>Significant progress in the development of a viable business model for the Wanang Conservation Area (WCA) based on providing services to biodiversity research, monitoring and tourism. Ultimately, this will provide the Wanang community with a sustainable income stream to offset revenue foregone from logging concessions.</p>	<p>N/A</p>
<p>Purpose</p> <ul style="list-style-type: none"> • Establish a model rainforest conservation area (CA) with management structure and conservation plan in place • Develop facilities and expertise of the landowners and PNG professionals to host biological research in the CA, thus raising funds for conservation • Establish an internationally competitive PNG research team that will be the centre of excellence in biodiversity research and training in PNG. • Gather key data on biodiversity response to rainforest disturbance to guide conservation policy. 	<ul style="list-style-type: none"> • The continuing existence of the CA and its support by the indigenous landowners • The ability of the CA to host and support ecological research • A 'critical mass' of DI-trained researchers, students and para-ecologists working in PNG on conservation policy-relevant questions. • Data on distributions for selected taxa and modelled predictions of impacts on their communities under rainforest disturbance scenarios. • Research published in international peer-reviewed research publications. 	<p>The Wanang Conservation Area (WCA) continues to develop in terms of physical infrastructure, management structure, research facilities and local expertise. It demonstrates an increasing ability to attract external funding and international research groups. The accumulation of data on biodiversity of critical taxa and their responses to disturbance is building a body of evidence to inform future conservation decision-making.</p>	<p>N/A</p>
<p>Output 1</p> <p>1. Wanang Conservation Area (WCA) established.</p>	<p>WCA has a Conservation Board and a Management Plan in place.</p>	<p>A Conservation Board has been set up for the WCA (comprising the leaders of all nine landowning clans) with its own executive (Project Manager, Deputy Project Manager, Research Station Manager).</p>	
<p>Activity 1.1: WCA management training</p>		<p>Management training by senior BRC staff is ongoing. In addition, we secured funding from the Waterloo Foundation (http://www.waterloofoundation.org.uk/) for a grant of £24,450 to employ a full-time Papua New Guinean graduate as Business Development Officer for the WCA who will be critical for the continuing development of business skills in the Wanang community.</p>	
<p>Activity 1.2: WCA legal declaration by the Department of Environment and Conservation</p>		<p>BRC has organized meetings between DEC officials, Wanang landowners, Madang Provincial Government, Madang Forestry Office and Woodbank Ltd., the holder of the logging concession for the areas surrounding the Wanang CA, with the aim of finalizing the formal submission of WCA documents to the PNG Government. The submission is still awaiting</p>	

		Madang Provincial Government approval.
Activity 1.3: WCA logistical support for research (accommodation, communication, carriers, catering) established		In addition to further development of accommodation, catering and other research-support facilities, the WCA attracted significant investment in field research infrastructure during the project: a solar panel electricity system for the Wanang Field Station, funded by The Prince of Monaco Foundation (£41,000), and a 'Canopy Bubble' – a forest canopy access system funded by the Grant Agency of the Czech Republic (£124,000). These were awarded on the basis of current Darwin-enhanced performance of the WCA and for facilitating future research activities to help sustain the WCA. Also, the community operates the Wanang Conservation School (elementary and primary school with over 300 children) as well as Wanang Community Truck, a small private business started from funds raised from conservation during this project.
Output 2. Ten village assistants and 18 para-ecologists trained to support research in the WCA. Two para-ecologists visit UK and other countries for networking and for intensive training.	Training and evaluation programmes in PNG and UK completed.	Village assistants from the WCA received detailed training in ecological techniques. The further development of our world-renowned para-ecologist team continued, both at BRC and in Europe.
Activity 2.1: WCA field assistants training at BRC		15 locally-recruited people were trained as research assistants, focused on forming a team of local experts in species recognition of focal plant and animal taxa, as well as basic ecological survey techniques. This took place both in the field (at WCA) and at BRC.
Activity 2.2: WCA field assistants training in the field		
Activity 2.3: BRC para-ecologist training at BRC		25 BRC para-ecologists were trained, or received continued training, in field survey techniques and research in a diverse training program delivered by DI researchers and visiting researchers from other projects.
Activity 2.4: BRC para-ecologist training in UK		Three pairs of para-ecologists (1 pair per year) visited the UK, Czech Republic, Australia and Singapore for 2 months intensive training in plant identification, entomology, forest carbon assessment, GPS and remote sensing, amongst other techniques. The visits also enabled them to visit collaborators, other internationally-renowned laboratories (e.g. Millennium Seed Bank, Rothamsted Research) as well as experience a variety of temperate ecosystems for comparison with tropical ones in PNG.
Output 3. Three completed Honours or Masters degrees by PNG students with dissertations focusing on biodiversity research	Honours or MSc dissertations completed	The target of 3 students completing their research has been exceeded. The timely completion of 2 Honours and 2 MSc students has enabled the enrolment of a further 5 students who will continue with their research beyond the end of the Darwin project.
Activity 3.1 Hons. and MSc student research		Two Honours and two MSc students were enrolled at the start of the project and have since completed (2 graduated with 1 st class honours, 1 with MSc distinction, 1 due to graduate later in 2015). A further 4 Honours and one MSc student were enrolled in the last year of the project and continue their studies. The <i>International Tropical Ecology Course</i> was run in July 2013 jointly by PNG and overseas instructors. 20 participants included five village assistants from WCA and other villages, 11 active researchers, and postgraduate and undergraduate students from PNG universities, research institutes, industry and NGOs.
Activity 3.2 Hons. and MSc student field ecology course		
Activity 3.3 Hons. and MSc student dissertation writing and defence		
Output 4. Biodiversity surveys for plants, insects and vertebrates along a disturbance gradient to document rainforest response to anthropogenic threats, including carbon	Surveys completed, samples sorted, specimens identified, data analysed and results published.	

storage estimates		
Activity 4.1 Plant biodiversity surveys and carbon storage estimates		Extensive surveys of plant biodiversity and vegetation dynamics have been completed, based on a permanent 50 Ha plot in the WCA (refs 1, 7). A sample survey across the entire WCA of forest tree metrics has been completed for estimates of carbon storage.
Activity 4.2 Insect biodiversity surveys		Biodiversity surveys completed for butterflies, ants (published results in references 3, 10, 11, 18, 19); studies published on plant-herbivore food webs in sap-sucking insects (refs 2, 6), fruit-feeding insects (ref 4), gallers (refs 12, 14) and folivorous insects (ref 15).
Activity 4.3 Vertebrate biodiversity surveys		Biodiversity surveys completed for amphibians (ref 5) and birds (ref 17).
Output 5. Guides for focal plant and animal taxa as an information source for local people, visiting researchers and PNG government departments	Guides produced, printed and distributed.	Guides published and distributed, written and designed to appeal to a range of audiences from the interested amateur / eco-tourist to the professional research botanist.
Activity 5.1 Biodiversity guides and publications		4 guides published on the biodiversity of PNG, focusing on an introduction to the WCA, birds of WCA, birds of Ohu village, frogs of Madang Province. 506-page book on all woody plant species of the 50-ha forest dynamics plot at WCA.
Output 6. Sustainable income of £20-30,000 per year generated by supporting research in WCA, to replace potential income from logging.	Money deposited in the bank. Contracts signed with research clients	The WCA shows considerable promise for the sustainable generation of funds to support the Wanang village community and provide an alternative livelihood to match the opportunity cost of selling logging concessions.
Activity 6.1 Fund raising for WCA		In the last 12 months of the project, total WCA income was £118,680 including £59,880 cash income, mostly salaries for supporting various research and training projects.

Annex 3 Standard Measures

Code	Description	Total	Nationality	Gender	Theme	Language	Comments
Training Measures							
1a	Number of people to submit PhD thesis	0					
1b	Number of PhD qualifications obtained	0					
2	Number of Masters qualifications obtained	1	PNG	M	Ant ecology	English	
3	Number of other qualifications obtained	2: BSc Hons.	PNG	1M, 1F	Ethnobiology, Insect ecology	English	
4a	Number of undergraduate students receiving training	0					
4b	Number of training weeks provided to undergraduate students	0					
4c	Number of postgraduate students receiving training (not 1-3 above)	15	PNG	10M, 5F	Tropical ecology	English	10 students on the Tropical Ecology Course for 3 weeks, plus 5 students who started their Hons and MSc studies after previous cohort finished
4d	Number of training weeks for postgraduate students	90				English	
5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification(e.g., not categories 1-4 above)	40	PNG	36 M, 4 F	Biodiversity surveys	English	15 Wanang assistants, 25 BRC paraecologists
6a	Number of people receiving other forms of short-term education/training (e.g., not categories 1-5 above)	0					
6b	Number of training weeks not leading to formal	4000					An average of 2 years

Code	Description	Total	Nationality	Gender	Theme	Language	Comments
	qualification						training for each of the 40 trainees
7	Number of types of training materials produced for use by host country(s) (describe training materials)	0					

Research Measures		Total	Nationality	Gender	Theme	Language	Comments
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (ies)						
10	Number of formal documents produced to assist work related to species identification, classification and recording.	4 biodiversity booklets	PNG		Rainforest birds, frogs, plants	English, Tok Pisin	
11a	Number of papers published or accepted for publication in peer reviewed journals	19	Multi-national, multi-author		Rainforest ecology	English	See list in Annex 5
11b	Number of papers published or accepted for publication elsewhere	0					
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	0					
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	2	PNG				(i) Access database comprising data on plant community in 50-ha plot in Wanang, presently 280,000 records of individual plants, and (ii) MySQL

							database on insect distribution and trophic interactions in PNG, presently 400,000 records
13a	Number of species reference collections established and handed over to host country(s)						
13b	Number of species reference collections enhanced and handed over to host country(s)	3	PNG				National herbarium at the PNG Forest Research Institute, BRC plant collection, and BRC insect collection

Dissemination Measures		Total	Nationality	Gender	Theme	Language	Comments
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	0					
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	3					2014 Association for Tropical Biology and Conservation in Cairns, 4 presentations; 2015 ATBC in Phnom Penh, 2 presentations, 2015 Society for Tropical Ecology in Zurich, 1 presentation

Physical Measures		Total	Comments
20	Estimated value (£s) of physical assets handed over to host country(s)	0	
21	Number of permanent educational, training, research facilities or organisation established	0	
22	Number of permanent field plots established	1	Network of carbon-monitoring plant plots in WCA

Financial Measures		Total	Nationality	Gender	Theme	Language	Comments
23	Value of additional resources raised from other sources (e.g., in addition to Darwin funding) for project work	£342,328					

Annex 4 Aichi Targets

	Aichi Target	Tick if applicable to your project
1	People are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.	X
2	Biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.	X
3	Incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.	
4	Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.	
5	The rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.	X
6	All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.	
7	Areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.	
8	Pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	
9	Invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.	
10	The multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.	
11	At least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.	
12	The extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.	
13	The genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.	

14	Ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.	X
15	Ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	
16	The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.	
17	Each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.	
18	The traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.	X
19	Knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.	X
20	The mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.	

Annex 5 Publications

Authors funded by Darwin project are underlined>.

Type *	Detail (title, author, year)	Nationality of lead author	Nationality of institution of lead author	Gender of lead author	Publishers (name, city)	Available from (e.g. contact address, website)
1. Journal	Anderson-Teixeira, K., <u>Novotny, V.</u> , et al. 2014. CTFS-ForestGEO: A worldwide network monitoring forests in an era of global change. <i>Global Change Biology</i> , 21 , 528-549	USA	Panama	Female	Wiley	DOI: 10.1111/gcb.12712
2. Journal	<u>Baje, L., Stewart, A. J. A. & Novotny, V.</u> 2014. Mesophyll cell-sucking herbivores (Cicadellidae: Typhlocybinae) on rainforest trees in New Guinea: local and regional diversity of a taxonomically unexplored guild. <i>Ecological Entomology</i> , 39 , 325-333	PNG	Australia	Female	Wiley	DOI: 10.1111/een.12104
3. Journal	Basset, Y., Eastwood, R., <u>Sam, L.</u> , Lohman, D. J., <u>Novotny, V.</u> , Treuer, T., Miller, S. E., Weiblen, G. D., Pierce, N. E., Bunyavejchewin, S., Sakchoowong, W.,	Switzerland	Panama	Male	Wiley	http://dx.doi.org/10.1111/j.1752-4598.2012.00205.x

	Kongnoo, P., and Osorioarenas, M. A. 2013. Cross-continental comparisons of butterfly assemblages in tropical rainforests: implications for biological monitoring. <i>Insect Conservation and Diversity</i> 6 , 223-233.					
4. Journal	<u>Ctvrtecka, R.</u> , Sam, K., Miller, S. E., Weiblen, G. D., & <u>Novotny, V.</u> 2015. Fruit morphology and the structure of frugivorous communities in a New Guinea lowland rain forest. <i>Austral Entomology</i> 54, in press	Czech Republic	Czech Republic	Male	Wiley	PDF available from BRC
5. Journal	<u>Dahl, C.</u> , Richards, S. J. & <u>Novotny, V.</u> 2013. The Sepik River (Papua New Guinea) is not a dispersal barrier for lowland rain-forest frogs. <i>Journal of Tropical Ecology</i> 29 , 477–483.	PNG	PNG	Male	Cambridge University Press	http://dx.doi.org/10.1017/S0266467413000527
6. Journal	<u>Dem, F.</u> , <u>Stewart, A. J. A.</u> , Gibson, A., Weiblen, G. D. & <u>Novotny, V.</u> 2013. Low host specificity in species-rich assemblages of xylem- and phloem-sucking herbivores	PNG	PNG	Female	Cambridge University Press	http://dx.doi.org/10.1017/S0266467413000540

	(Auchenorrhyncha) in a New Guinea lowland rain forest. <i>Journal of Tropical Ecology</i> 29 , 467-476					
7. Journal	Fibich, P., Lepš, J., <u>Novotný, V.</u> , Klimeš, P., Těšitel, J., <u>Molem, K.</u> , Damas, K. & Weiblen, G.D. 2015. Spatial patterns of tree species distribution in the primary and secondary plots of a lowland rain forest. <i>J. Vegetation Science</i> in press	Czech Republic	Czech Republic	Male	Wiley	PDF available from BRC
8. Journal	Forister, M. L., <u>Novotny, V.</u> , Panorska, A. K., <u>Baje, L.</u> , Basset, Y., Butterill, P. T., Cizek, L., Coley, P. D., <u>Dem, E.</u> , et al. 2014. The global distribution of diet breadth in insect herbivores. <i>PNAS</i> 112 , 442-447.	USA	USA	Male	National Academy of Sciences	doi: 10.1073/pnas.1423042112
9. Journal	Hamilton, A. J., <u>Novotny, V.</u> , Waters, E. K., Basset, Y., Benke, K. K., Grimbacher, P. S., Miller, S. E., Samuelson, G. A., Weiblen, G. D., Yen, J. D. L. & Stork, N. E. 2013. Estimating global arthropod species richness: refining probabilistic models using	Australia	Australia	Male	Springer	doi: 10.1007/s00442-012-2434-5

	probability bounds analysis. <i>Oecologia</i> , 171 , 357-365					
10. Journal	Klimes P, Fibich P, <u>Idigel C, Rimandai M</u> 2015. Disentangling the diversity of arboreal ant communities in tropical forest trees. <i>PLoS ONE</i> 10 , e0117853.	Czech Republic	Czech Republic	Male	Plos.org	<i>PLoS ONE</i> 10 , e0117853.
11. Journal	<u>Klimes, P.</u> & McArthur, A. 2014. Diversity and ecology of arbicolous ant communities of <i>Camponotus</i> (Hymenoptera: Formicidae) in a New Guinea rainforest with descriptions of four new species. <i>Myrmecological News</i> 20 , 141-158	Czech Republic	Czech Republic	Male		PDF available from BRC
12. Journal	Kolesik, P. & <u>Butterill, P. T.</u> 2014. New gall midges (Diptera: Cecidomyiidae) from Papua New Guinea. <i>Austral Entomology</i> 54 , 79-86	Australia	Australia	Male	Wiley	DOI: 10.1111/aen.12095
13. Journal	<u>Novotny, V.</u> & Miller, S. E. 2014. Mapping and understanding the diversity of insects in the tropics: past achievements and future directions. <i>Austral Entomology</i> 53 , 259-267	Czech Republic	Czech Republic	Male	Wiley	http://dx.doi.org/10.1111/aen.12111

14. Journal	Nieves-Aldrey, J. L. & Butterill, P. T. 2014. First evidence of cynipids from the Oceanian Region: the description of <i>Lithonecrus papuanus</i> , a new genus and species of cynipid inquiline from Papua New Guinea (Hymenoptera: Cynipidae, Synergini). <i>Zootaxa</i> , 3846 , 221-234.	Spanish	Spanish	Male	Mapress	http://www.mapress.com/zootaxa/list/2014/3846(2).html
15. Journal	Novotny, V., Miller, S. E., Hrcek, J., Baje, L., Basset, Y., Lewis, O. T., Stewart, A. J. A. & Weiblen, G. D. 2012. Insects on plants: explaining the paradox of low diversity within specialist herbivore guilds. <i>American Naturalist</i> 179 , 351–362.	Czech Republic	Czech Republic	Male	University of Chicago Press	http://dx.doi.org/10.1086/664082
16. Book chapter	Novotny, V., G. D. Weiblen, S. E. Miller, and Y. Basset. 2012. The role of paraecologists in twenty-first century tropical forest research Pages 154-157 in M. D. Lowman, T. D. Schowalter, and J. F. Franklin, editors. <i>Methods in Forest Canopy Research</i>	Czech Republic	Czech Republic	Male	University of California Press, Berkeley	PDF available from BRC
17. Journal	Sam, K., Koane, B.,	Czech Republic		Female	Wiley	DOI: 10.1111/jof.12057

	<u>Jeppy, S. & Novotny, V. 2014.</u> Effect of forest fragmentation on bird species richness in Papua New Guinea. <i>Journal of Field Ornithology</i> 85 , 152–167					
18. Journal	Vlasanek, P. & <u>Novotny, V. 2014.</u> Demography and mobility of three common understory butterfly species from tropical rain forest of Papua New Guinea. <i>Population Ecology</i>	Czech Republic	Czech Republic	Male	Springer	DOI 10.1007/s10144-015-0480-7.
19. Journal	Vlasanek, P., <u>Sam, L. & Novotny, V. (2013)</u> Dispersal of butterflies in a New Guinea rainforest: using mark–recapture methods in a large, homogeneous habitat. <i>Ecological Entomology</i> 38 , 560-569	Czech Republic	Czech Republic	Male	Wiley	DOI: 10.1111/een.12051

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