DARWIN INITIATIVE FOR THE SURVIVAL OF SPECIES

ELEPHANTS OF MIKUMI NATIONAL PARK, TANZANIA: CONSERVATION, EDUCATION AND RESEARCH

FINAL REPORT
PROJECT REFERENCE 162/11/008

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1. Darwin Project Information

Project Reference No.	162/11/008
Project title	Elephants of Mikumi National Park: Conservation, Education and Research
Country	Tanzania
UK Contractor	Anglia Polytechnic University, Cambridge UK
Partner Organisation (s)	Tanzania National Parks, Mikumi National Park,
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2. List of Acronyms and Abbreviations

Full Title	Acronym
Animal Behaviour Research Unit	ABRU
Anglia Polytechnic University	APU
Conservation and Inventory Monitoring Unit	CIMU
Convention of Biodiversity	CBD
Mikumi National Park	MINAPA
Non-Government Organisation	NGO
Sokoine University of Agriculture	SUA
Tanzania GIS Users Group	TZGISUG
Tanzania National Parks	TANAPA
Tanzania Wildlife Research Institute	TAWIRI
Wildlife Conservation Society	WCS

3. Project Background/Rationale

The intense and acute poaching of elephant throughout Africa during the late 1970's and most of the 1980's lead to a dramatic decline in elephant numbers and extinguished or reduced, and put under intense threat, most African elephant populations. The government of Tanzania and its wildlife agencies have been at the forefront of efforts to reduce poaching and conserve elephants in eastern and southern Africa. The conservation priorities of Tanzania include the maintenance, protection and informed management of the rich biodiverse natural heritage found within its protected areas (National Parks, Forest Reserves and Game Reserves). These protected areas include biodiversity hotspots of international importance and comprise almost 25% of the land area of the country. Tanzania's efforts to conserve and manage its biodiversity are often linked to important keystone and flagship species such as the elephant.

Tanzania contains a number of highly important elephant populations. This includes the largest remaining population of open country elephants in Africa. This population is found within and adjacent to the complex of protected areas collectively known as the Mikumi-Selous complex. This includes, Mikumi National Park (MINAPA), the Selous Game Reserve (a world heritage site) and the Kilombero Game Controlled Area. In its entirety this is the largest protected area in Africa (> 55,000 km^2) and contains a high diversity of species and habitats. The elephant population is an integral part of these diverse communities but its ecological influence is as poorly understood as the population itself. The extent and size of the population has only been surveyed intermittently using aerial surveys. Within such a vast area, important segments of the elephant population have been inappropriately sampled and are poorly understood. One of these population segments was that contained in MINAPA.

The elephant population in MINAPA is the most protected within the Mikumi-Selous complex but also occurs in the most diverse habitats of the entire complex. MINAPA contains vast areas of dense woodlands, forest and complex hilly terrain. Research on this population has been conducted through the Animal Behaviour Research Unit (ABRU) in MINAPA on a long-term basis. Prior to this Darwin Initiative project, the ground survey based elephant research at ABRU was limited to the more open and accessible habitats in the northern 1/3 of the park. Results from this work suggested that the Mikumi elephant population was much larger and more mobile than limited aerial surveys had concluded. As important, patterns once believed to be consequences of poaching, such as small family group size, were found to be more consistent or typical features of the elephant population. These results highlighted the need for more frequent and extensive surveys and the regular assessment of important conserved populations (such as the Mikumi elephant) by conservation managers.

One of the important priorities for wildlife management and conservation in Tanzania is an informed management policy based on quantitative data and a local management capacity to both obtain that data and use it to derive and implement such policies. Coincident with the ABRU elephant study results, was an effort by Tanzania National Parks (TANAPA) to revitalise and expand the Park Ecology departments and programmes within National Parks in order to create such a capacity. This effort was supported by the Wildlife Conservation Society (WCS) and the ABRU project was an active and supporting participant in the process. One consequence of this process was recognition of the need to co-ordinate park ecology and management efforts with ongoing and long-term research projects such as ABRU. Another was the identification of the ranger staff and ranger patrols throughout remote areas of National Parks as an important resource for monitoring large mammal populations. This led to a close collaboration between the ABRU project and the TANAPA Park Ecology

programme to define the important parameters of the Mikumi elephant population which required measurement and monitoring, and to design a ranger based monitoring programme which could be implemented to obtain this information.

Thus this Darwin Initiative project was designed to build on the long-term research and on-site expertise of the ABRU project in Mikumi National Park that is directed by the Darwin Project Leader.

4. Project Summary

This project expanded UK- directed research and used its protocols and long-term data base to establish a research and monitoring program on elephants within the entire area of Mikumi National Park. This in turn established a capacity within MINAPA and Tanzania National Parks to monitor large mammals and their habitats using trained park rangers. It further established a capacity within the Park Ecology program to analyse the information obtained and to construct species or habitat management plans based on that analysis. While centered within a single park the planning and implementation of the project was co-ordinated with the Chief Ecologist of TANAPA and park ecologists throughout the TANAPA system. Thus the protocols and systems for ranger based monitoring developed in Mikumi can be and are being incorporated into the ecological monitoring systems within the entire system of National Parks in Tanzania. It builds on two existing systems within TANAPA: the regular use of ranger patrols through all major areas of national parks and the revitalised Park Ecology programs currently established in all parks.

In the context of the broad goal of a Darwin Initiative project as specified in the Logical Framework (Appendix 1) this project was designed to achieve its purpose through the following specific goals:

- Developing a quantitative description of the elephant population in Mikumi National Park, Tanzania.
- Generating and testing hypotheses on habitat use, group size, group structure, group formation and ranging of the Mikumi elephants.
- To train rangers on patrol to collect quantitative data on large mammals and vegetation use.
- Increasing the capacity of Tanzania National Parks to assess and monitor the populations and habitats under its protection using current staff and resource levels.
- Refining an ABRU based protocol for the maintenance of an elephant identity catalogue and database

These specific goals are included within the purpose and outputs of the project Logical Framework (Appendix 1). The project was rapidly and successfully implemented. Consequently, the research and ongoing training programmes were operational on or ahead of schedule. This allowed the project to be especially efficient and cost effective and there were relatively few (minor) modifications to the planned outputs and operational plan of the project as specified in the Logical Framework (Appendix 1). The use of GPS by rangers and the related development of an active GIS database within the (Darwin Initiative sponsored) Ecology Resource Centre was rapidly successful. Because of this, the project could be augmented by increased aerial surveys and additional data components requested by TANAPA park management (particularly data on poaching and giraffe diseases).

Almost all modifications or alterations were additions or extensions to the planned collaborations, consultations and outputs. Such additions (for example the

inclusion of a research project for a within Tanzania graduate student) were possible due to the success of the project within the systems and infrastructure of Tanzania. The few minor changes or adjustments to schedules occurred for a variety of reasons such as administrative delays or climatic conditions. With one exception, (see below) none of these negatively effected progress or outputs of the project. Specific changes were:

changes:

- Addition of MPhil student from Sokoine University of Agriculture (SUA), Morogoro, Tanzania to assess elephant impact on baobab (field work designed in collaboration with and supported by the Darwin Initiative project).
- Addition of ABRU researcher to MPhil programme supported by Environmental Research Centre of Anglia Polytechnic University. This will facilitate analysis and dissemination of results on elephant ranging, seasonal patterns of movement and habitat use.
- Collaborative support and funding for upgrade to computer software for elephant identity database.
- Modification of planned workshops to take advantage of opportunities for improved efficiency of schedule and better participation by meeting at other venues. Extension of workshops and training sessions to local community contacts.
- Limitation of the planned undergraduate training and involvement in the project to short field exercises and structured lectures on the Darwin work. As discussed in annual reports, it was logistically difficult to co-ordinate university field courses with the ongoing Darwin Initiative project in Mikumi.

Appendix 2 shows the Articles of the Convention of Biodiversity which best describe this project in relative proportions. The project is best described by Articles 7 (Identification & Monitoring); 12 (Research & Training); 16 (Access to and Transfer of Technology); and 8 (In Situ Conservation). The contribution of this project to these CBD articles in Tanzania is however, interrelated and results in contributions to other articles, especially 6 (General measures for conservation at national level); 10 (Sustainable use of Biodiversity components); 13 (Public Education & Awareness); 14 (Impact assessment and minimizing adverse impacts); and 17 (Exchange of Information). The connectivity between project contributions to these articles of the CBD means that the proportional contributions are artificially approximate and that many are actually equal.

The transfer of GPS/GIS equipment, technology and expertise to the Park Ecology department and rangers was an especially cost effect transfer of technology which facilitated the elephant research (Articles 16, 12). Research in turn was structured to train rangers and wardens and created a capacity for long term monitoring that provides the needed information for management of large mammals and their habitats (Articles,12, 7, 8,14). The further extension of these methods and databases to other Park Ecology programmes (as well as the Tanzania Wildlife Research Institute (TAWIRI) monitoring programme) extends the contributions to the National level (Articles 6, 10). Assessment of elephant movement and habitat use evaluated the impacts of elephant on local communities and provided an opportunity to involve and inform communities on the activities of MINAPA and include community experiences in the assessment and planning activities of the Park (Articles 13, 14, 17, 8). The Park Ecology Resource Centre, with its GIS system and database is in constant use for a variety of management and conservation purposes and is staffed or used by trained wardens and Park Ecologists (Articles 7, 12, 16, 10, 14). This is further integrated into the monitoring and GPS/GIS programme of TANAPA as a whole and is a powerful tool and capacity for monitoring, assessment, planning and conservation within the National

Parks of Tanzania (Articles 6, 10, 14, 7, 16, 8).

Both individual and institutional participants in this project are highly pleased with its continuing success. With one limited exception all objectives were achieved and there were significant and continuing expansions and additional accomplishments.

There is now a permanent GIS database for MINAPA, The elephant population has been documented throughout the park and is being continuously monitored by rangers on patrol. Rangers have expanded GPS based patrol monitoring to law enforcement questions and specific monitoring problems identified by park management. The Park Ecology department has an active Resource Centre and a staff co-ordinating with other parks on the National scale to use GIS databases and ranger patrols to monitor and manage large mammal and habitats within the park system. The seasonal patterns of movement and habitat use of elephant have been studied and are being assessed. This is being related to the problems of crop raiding and elephant conflict in local communities. The qualitative and quantitative understanding of the habitats and biodiversity in the southern 2/3 of the park has been extended to a significant degree. Long-term elephant population patterns (such as small group size) have been confirmed and are being integrated into population models. Population and habitat information generated by this project has contributed to and is being integrated with the MINAPA Management Plan being prepared by the planning department of TANAPA. Other questions and conservation problems identified by this project are being addressed by the ABRU research project, MINAPA management and the Park Ecology department.

5. Scientific, Training, and Technical Assessment

Research:

The research component of this project focused on expanding and continuing long-term population assessment and monitoring of the elephant population in Mikumi National Park. Prior to this project, information on the Mikumi elephant population was derived from limited aerial surveys and more detailed ground surveys. The quantitative ground surveys were being conducted by researchers at the ABRU research facility and were limited to the accessible areas of high visibility in the northern 1/3 of the park. These surveys suggested that the population density and size was higher than that estimated by the more limited aerial surveys. Small group size, small body size, and apparent low average age of the population had initially been interpreted as indicative of heavy poaching in the mid 1980's but the persistence of these patterns suggested that these were possibly typical features of an elephant population closer to carrying capacity and more resource limited than expected. It was unclear how large and extensive the Mikumi elephant population was and how elephant were using Mikumi habitats and resources was unknown. The impact of previous poaching and the extent of recovery from this poaching were equally unclear. The continuity of the Mikumi elephant population with those of adjacent areas such as the Selous Game Reserve and the extent to which elephant moved across park boundaries into areas of human activity was also uncertain. The research of this project was designed to address these gaps and usefully describe the Mikumi elephant population for the parks population management and conservation efforts.

Vehicular transects were established and extended. Transects initially covered the network of tourist roads in the northern 1/3 of the park. These were extended throughout the park especially in the southern 2/3 of the park. Secondly, rangers were trained to conduct surveys during antipoaching patrols. These patrols were conducted, usually on foot, from the 6 ranger posts located in the park. These primary

methodologies were augmented by an elephant identity database for the individual identity records collected on transects, surveys and ad lib. A GIS database was created for the habitat, vegetation and location data being collected on transects and ranger surveys and provided a habitat/vegetation and location baseline from digitized maps and satellite images. In addition, Crop raiding and human elephant conflict was reported through local village contacts and recorded on the GPS and entered into the GIS database. Finally, aerial surveys were used to enhance and validate these other methodologies.

Transects:

Transects were monitored by the ABRU research associates and by the Mikumi Park Ecologist. For almost the entire data collection period this data collection was co-ordinated by the project director and by Jody Gunn the senior research associate resident at the ABRU field station. Fredrick Mofulu, Mikumi Park Ecologist and principle Tanzanian counterpart on the project, co-ordinated data collection on transects for Park Management. ABRU Researchers; K. Boswell, H. Carol, .L. Collett, A. Gunn, M. Klail, K. McQuaid and C. Reece made significant contributions to research design, protocols, establishing transects and collecting the data. Valentine Lyaruu, Park Veterinarian for Tanzania's Southern Parks and Josephat Augustine, Law Enforcement Warden and assistant Park Ecologist worked with Mofulu. Josephat Augustine also made important contributions in translating protocols and datasheets into Kiswahili.

There were 20 permanent transects in total with 444 observation points covering 445km. These are distributed throughout the park and encompass all major habitats. Sixteen of these transects can be monitored throughout the year. Four other transects were found to be periodically inaccessible during the rainy season. However, monitoring portions of these transects was possible by finding alternative routes to them. This extended the monitoring period and the areas surveyed considerably. Transects were monitored 1 to 2 times a month depending on work loads and weather conditions. Transects were monitored randomly without repetition until all available transects had been monitored. On all transects, elephant sightings and resightings were systematically recorded at and between points. Tracks, dung and vegetation use were quantified by point or transect segment. Individual elephants and elephant groups observed were photographed where possible and entered into an identity database. There is a protocol for recording the indirect measure of elephant tracks and trails and for assessing visibility at transect points. Recording dung takes into account variability in substrate and visibility. A similar adjustment was made for assessment of elephant woody plant use to take into account variability in the amount of woody vegetation available to elephant at different locations along transects. The protocol and datasheet for transects is attached in Appendix 6.

Ranger Surveys

Ranger surveys were established as a regular routine for all of the six ranger posts within the park. This routine is based on training procedures, protocols and manuals developed during the first year of the project. There are six ranger posts regularly staffed with 5-6 rangers. At each post a senior 'Darwin' Ranger has been trained in the use of GPS, the survey protocol and data sheet use. During patrols, all sightings of elephant, elephant dung, elephant tracks or vegetation use are recorded along with a GPS location. Habitat and vegetation data are recorded for each elephant datum and at

intervals during patrols. In addition, at the request of TANAPA, rangers record all observation of giraffe by GPS location, counts of individuals and condition in relation to ear infections that are occurring within the Mikumi giraffe population. The survey data also includes information on poaching events or observations and provides a record of patterns and intensity of poaching as well as the extent of the area patrolled recorded on GPS and entered into the GIS data base. Each month the rangers return to MINAPA headquarters where datasheets are collected and GPS data downloaded. Rangers are provided with printout summaries of areas where patrols and surveys were conducted. Rangers have been given review, and refresher training throughout the project (see Training section below). The ranger instructions, protocols and datasheets are attached in Appendix 7.

Aerial Survey

Aerial surveys for several related purposes were conducted at 6 to 8 week intervals (depending on plane and pilot availability). Transect methods were developed for reconnaissance and general survey flights to assess habitat and visibility. Boundary and topography points were surveyed from the air to assess human population densities at boundaries and possible routes of movement by elephant into and out of the park. All relevant features and sightings are located by GPS and entered into the GIS database. Aerial surveys are being conducted in collaboration with the Wildlife Conservation Society, which is supplying the plane and pilot. During these surveys a number of poaching camps were located. Both wood poaching and meat/animal poaching camps were found. Boundary encroachment was observed and located or mapped in several locations although in general the surveys confirmed that human population pressure along park boundaries is localised and generally low. Boundaries and farmland locations were mapped in more detail using GPS and aerial survey for the 5 villages adjacent to the park participating in the assessment of elephant conflict with local communities (see Community Survey Section below). A recent sample aerial survey report is included in Appendix 8.

Community Surveys

In assessing the Mikumi elephant population, park management priorities and research questions were also concerned with the extent to which elephant moved outside artificial park boundaries and into areas with human populations. This aspect of the research was concerned with assessing elephant movements in terms of seasonality of resource use and habitat selection, and also with the extent to which these movements impacted upon or were influenced by human populations. From maps, park records, aerial and ground surveys eighteen villages were identified as being in close proximity to park boundaries. Using records from park management and the Community Conservation department, eight villages were selected for preliminary assessment. Jody Gunn (Project Leader Community Surveys) along with Acting Park Ecologist Josephat Augustine and Community Conservation warden Cynthia Critton visited these villages. Elephant were listed among the top four problem species in seven of the eight villages surveyed. Based on these assessments five villages were selected and agreed to participate in a long-term survey of wildlife crop raiding. Villages were selected, based on their distribution in relation to the park boundary and on the willingness of the village to participate. A village meeting was held in each selected village involving village administrators, farmers and other members of the community where the project was introduced and accepted. One or two village representatives were chosen by the village

to be trained to record data on events of Crop Raiding and other human-wildlife conflict events within their village using specially designed forms and methodology (See "Training Package for Village Representative around MNP" in Appendix 9). Every month the Project Leader visited each village to verify the data collected and map areas of crop raiding and other wildlife events. A progress and assessment workshop was held in February 2005 to evaluate progress, problems and results of the village survey. Although elephant were the principle focus of the project, the community survey collected data on all wild species which impacted on village farms. This was to avoid an elephant bias in reporting from villagers but also was an expansion which required no further expenditure and little further effort. Thus broader questions of importance both to park management and local communities could be addressed. Survey parameters included human population size and demography, crops grown, seasonal pattern of crop growing and villager assessment of problem animals (crop raiding) in time and space. The following questions were addressed in this aspect of research:

- Which areas around the park are affected by human-wildlife conflict?
- Which animal species are involved in such conflict?
- Where do these animals come from?
- At what times of the year is the problem worst?
- Which crops are being damaged?
- How bad is the damage to crops and property?
- What are the attitudes of farmers towards the wildlife they encounter?

GIS and Elephant Identity Databases

Two separate databases are being compiled and disseminated as an output of the research (and training) efforts. The first of these is a GIS database which uses MapInfo software. This GIS contains satellite images, boundary, road and feature locations, transect locations and elephant sighting locations. The 1:50000 topographic maps covering MINAPA and the surrounding area have been digitized and entered into the database. The elephant transect, ranger survey, community survey and aerial survey database are compiled within the GIS and linked to the salient habitat and geographic features of the park. Extensive applied use of the GIS database is occurring for a variety of purposes. Beyond Mikumi, the database has been disseminated widely to Tanzanian stakeholders and institutions such as the planning department of TANAPA where it is being used in the construction of the Mikumi General Management Plan and the Conservation and Inventory Monitoring Unit (CIMU) of TAWIRI.

The second database is the elephant sighting and identity database which uses Microsoft Access. This Access software was specifically developed and programmed by this project with the support of Synergise and Resource Africa. It will have wide application in research and monitoring projects which require recognition of individual animals. The database is a compilation of observation records where individual characteristics of elephant have been recorded along with identification photographs when possible. Identity records are transferred into the database along with the digitized photographs. The database can then be used to calculate and assess frequency with which known individual elephant and elephant groups are observed and patterns of movement and habitat use. Because the identity sheets and database follow a standardized protocol of recording identity characteristics, it can be used to co-ordinate and validate observations between individual observers. A sample identity data sheet and protocol is attached in appendix 10.

Summary Preliminary Research Results:

Research questions addressed in this project are initially being analysed and reported through the postgraduate work of Fredrick Mofulu and Jody Gunn (see Training below). The larger population questions of immediate concern to park management have been addressed in the MPhil work of Mofulu, while more detailed questions on habitat use, seasonality and human-elephant conflict are being considered in the work of Jody Gunn.

Evaluation of Elephant population size, density and distribution

Fredrick Mofulu has completed his MPhil thesis and returned to his duties as MINAPA park ecologist and Darwin Project Host Country Co-ordinator. He passed his viva on 11th July 2005 and the thesis was approved subject to minor corrections. The data analyzed for this thesis consisted of long-term park records, previous reports and counts of the Mikumi elephant population and the detailed quantitative data collected during ranger surveys. Components of the transect data were also assessed. These results address the principle questions of the project concerned with population size, density, distribution, continuity and group structure. From this work the following conclusions have been reached and are being assessed by MINAPA park management:

- The elephant population in Mikumi is large and estimated to number at least 4800 individuals.
- The elephant population occurs at similar density throughout the park (i.e. there is not a small population shifting between different locations in a larger area).
- The elephant population is contiguous and not separated into smaller subpopulations.
- Similar types and numbers of elephant groups were observed in both the northern and southern park zones but slightly larger groups were observed in the north which suggests the possibility of a slightly higher elephant density in the northern zone.
- Matrilineal family mean group size remains about 5 in line with previous estimates over the past 2 decades. Compared to other populations Mikumi consistently has small family group sizes.
- Larger aggregations of elephant typical of other populations are rare in Mikumi. Such aggregations appear to be highly seasonal and localised. Aggregations only occurred in the north-central area of the park and were not observed at all in the southern 2/3 of the park.
- The Mikumi elephant population is contiguous with that in the adjacent Selous Game Reserve.
- There are inconsistencies in population and mortality estimates for Mikumi elephant over the past 30 years.
- Aerial surveys have underestimated population size and over estimated poaching off take.
- Aerial survey underestimation is partly a result of using a subset of data from surveys designed to cover larger areas. When density estimates from the entire Selous-Mikumi complex are used more consistent and realistic population sizes are obtained for Mikumi.
- Re-evaluation and critical assessment of past research and population estimates confirm that there was none-the less a serious population decline during the mid 1980's as a consequence of heavy poaching.
- The 1989 Cites ban on the ivory trade and the Operation Uhai antipoaching campaign in Tanzania effectively ended serious elephant poaching, dramatically

reduced mortality and allowed the population to recover.

These results are presented in the completed MPhil thesis 'The Elephant Population and Distribution in Mikumi National Park, Tanzania'. Following acceptance of the final corrections this will be available on application to Fredrick Mofulu or G. Norton (Darwin Project Leader). A softcopy of the thesis will also be made available on the project website.

Spatial and Temporal Patterns of Elephant Distribution

Collection of transect and community survey data being used to assess seasonal and habitat related patterns of elephant movement and resource use was just completed at the end of the Darwin Initiative funded phase of the project. The data compilation and analysis is now being undertaken by Jody Gunn as part of her postgraduate degree and by the senior Darwin Initiative staff in the UK (D. Hawkins and G. Norton). Preliminary analysis of the community survey data was undertaken as part of the progress and feedback workshop held for the village representatives. Further qualitative assessment of habitat use and movement patterns was made during field work. This permits some tentative broad conclusions summarized below:

- Elephant distribution and habitat use does vary seasonally and this variation is influenced by rainfall, fire and the dry season distribution of freestanding water. These factors are expected to be influencing the availability of food and other resources.
- Habitats used vary along a catena and can be broadly subdivided into 3 habitat systems or zones: convoluted hilly woodland habitats; more open alluvial areas with a complex mosaic of watercourses containing riverine woodland and forest; and open grassland areas with few woody species and a tendency for seasonal flooding.
- Mikumi is highly seasonal with a progressively wetter period from December to May and a progressively drier period from June to November.
- Elephant appear to shift between the 3 vegetation zones, using wooded hilly habitats more frequently in the late wet and early dry seasons and using more open areas (especially the seasonal grassy floodplain) in the late dry and early wet seasons.
- There are seasonal variations in the location and extent to which elephant enter villages and farms. Crop raiding varies seasonally with more crop raiding occurring in the late wet season and early dry season. This seasonal variation in crop raiding corresponds to variations in habitat use within the park especially the increased use of the lateral wooded hilly and alluvial environments.
- Crop raiding by elephant varies in relation to the location and habitat of villages with some villages raided throughout the year, some raided seasonally and some rarely or not at all.

The community surveys also generated insights into a number of methodological and sociological (perceptual) issues which have implications for any attempt to assess wildlife impacts on human populations. These need to be considered and studied further and more quantitatively:

- Elephant are perceived as a larger problem and threat than other wildlife, even though other species may damage crops more frequently and extensively. For example damage from rodents, monkeys and bushpig (or warthog) is extensive but farmers feel able to physically or practically deter them, where as elephants

they cannot.

- Responses to elephant seemed to be based on size, physical threat and the dramatic localized impact of a raiding event on crops or farm structures.
- The perception of elephant biases the recording and reporting of crop raiding. Rodent damage is accepted as a feature of farming and rarely reported or commented on. Damage from other species such as monkeys is often not recorded or reported unless there is no damage from elephant occurring.
- Villagers living adjacent to and on park boundaries often have very little understanding of the habitats and species within the park. In this study it was found that few if any villagers had ever visited the park and were unaware of what the habitats unaltered by human activity looked like or how animals living in those environments behaved.

Details of the preliminary results from the community survey are in the Representative Workshop Report: 'Human Wildlife Conflict around Mikumi National Park' in Appendix 11.

William Nicolaus Mmari, an MSc student at Sokoine University of Agriculture Morogoro, Tanzania, approached the Park Ecology department and ABRU for assistance on his research project. We were able to collaborate with him on a question derived from the elephant studies. His postgraduate research programme was developed collaboratively with the Darwin UK staff. Mmari investigated the use of and damage to baobabs by elephant. During the course of the Darwin elephant research, we had observed numerous baobabs with extensive elephant damage but few recent damage events. Moreover, long-term ABRU records of individual baobab trees had recorded very rare, intermittent attacks on specific trees. The period of Mmari's research coincided with a particularly dry year and we predicted there would be an increase of elephant use of baobabs. For his research, Mmari quantified the pattern and extent of long-term damage to baobabs and the extent to which new damage occurred particularly in the dry season. Contrary to predictions, there was very little use of or damage to baobabs by elephant. The patterns observed suggest that baobab damage is actually rare but that scarred baobabs are frequent in the adult population due to the accumulation of this rarely occurring damage across decades. This result differs from the pattern of baobab use in some other elephant populations in Africa (for example, Ruaha National Park also in Tanzania, where fresh use of baobabs is frequently observed in the dry season). Mmari's results suggest that a high frequency of trees scarred by elephant needs to be assessed quantitatively over a considerable period before conclusions on elephant behaviour and impact are reached. After corrections and final approval a soft copy of Mmari's thesis, Assessment of the Extent of Elephant Damage on Baobab Trees (*Adansonia, digitata*) in Mkata Flood Plain, Mikumi National Park, Tanzania, will be posted on the project web page.

Critical Assistance, Assessment and Review:

Results from all aspects of the project research are being prepared for publication in peer reviewed journals. A number of colleagues and consultants have provided critical assessment, and evaluation of project research methodologies and the results being obtained. This has improved research design, refined analytical approaches and greatly enhanced the interpretation of results. The participants in this project are grateful for the willingness of so many to provide feedback and positively critical assessments. We would like to especially acknowledge the advice or critical contributions of the following: Dr. Richard Barnes of the IUCN African Elephant Specialist Group, Dr. S.T. Buckland and the staff of the University of St. Andrews Distance Sampling Workshops, Dr. S.K.

Eltringham of the University of Cambridge, Dr. Charles and Lara Foley of the Tarangire National Park Elephant Project - Tanzania, Kathleen Gobush of the University of Washington, Seattle, Dr Nancy Harrison of APU, Dr. Richard Hoare of the Messerli Foundation – TAWIRI Wildlife Veterinary Programme, Dr. Jon Hutton of Resource Africa, Dr. Phyllis Lee of the Amboseli Elephant Project - Kenya, N. McWilliam of Oryx Mapping, Professor Ben Mutayoba of the Department of Veterinary Medicine, Sokoine University of Agriculture, Dr. F Osborn of the MidZambizi Elephant Project – Zimbabwe, Dr. Rosie Trevelyan of the Tropical Biology Association and many others.

Training:

Training was the other principle component of this project and was linked to the research at three levels. Senior wardens were trained in monitoring and GIS. Park Rangers were trained in GPS and survey techniques for monitoring and habitat assessment. Advanced post graduate training was provided for 2 Tanzanian and 1 expatriate participant in the project. In addition, advanced training in Distance Sampling and other survey techniques was provided to senior Tanzanian researchers (see sections on impact and outputs for discussion of this training).

Training and support was provided for senior park wardens and staff in monitoring techniques, database management and especially the uses of GIS for monitoring and assessment. This training focused on the senior staff of the Park Ecology department but extended to senior wardens in the departments of Law Enforcement, Community Conservation and Tourism. Training was through active participation. The construction and furnishing of a Park Ecology Resource Centre, provided the environment, equipment and software needed to construct, maintain and use an advanced database system and protocol to describe, monitor and manage the floral and faunal biodiversity of the park. Climatic processes and external pressures such as poaching could be and were effectively measured and monitored using the Resource Centre. A one-week advanced training session in GIS software and technique was held in January of 2004. Participation and training of all senior wardens was ongoing through the use of the GIS database and the Park Ecology Resource Centre. Data from ranger and community surveys included information of relevance and importance to other departments and was used to integrate these other departments into the GIS procedures and train the relevant wardens. Senior Wardens were willing and collaborative trainees in this process. In total, ten senior wardens from 4 different departments were introduced to GPS/GIS monitoring techniques and GIS database management and analysis. Because senior wardens rotate assignments between different parks, some wardens trained in Mikumi have transferred to other parks taking the GIS knowledge and expertise with them. This movement between parks and departments also means that 4 additional senior wardens are now being trained to use the GIS resources and database.

Ranger training in GPS monitoring during patrols was continuous throughout the project. Senior park wardens were active collaborators in the training of rangers and this collaboration was also a part of senior warden training. Senior rangers were selected by park wardens (Law Enforcement and Park Ecology) for intensive training in the survey techniques, datasheet protocols and GPS records. These senior 'Darwin' rangers were then instructed in the training of junior rangers who worked with them during patrol surveys. Other rangers at a post alternated the role of assistant survey ranger. Thus all rangers were trained in the survey methodology and GPS techniques. The protocol required monthly returns of datasheets to the Park Ecology Resource Centre and ABRU research facilities with downloading of the GPS data to the GIS systems. This allowed regular procedural and training reviews with the rangers being trained. At each monthly

download, GIS summary maps of the data collected by location were constructed for the surveys from each post. These printed summaries were then discussed with and given to the senior ranger. These summaries served both as a training reinforcement and an incentive and the feedback system was highly motivating for ranger participants. ABRU or Park Ecology staff visited ranger posts on a regular basis to reinforce training (especially of non senior rangers) and to refine survey techniques. These activities were supplemented by annual training review workshops which also involved the senior rangers being trained. In total 8 senior rangers and 24 assistant survey rangers were trained. A copy of a review workshop report (in Swahili with English summaries) is attached in Appendix 12.

There were three postgraduate degrees associated with this project. William Mmari has completed his coursework and submitted his thesis. He is currently awaiting examination and working with the ABRU team in follow-up work for the community survey and assessments of human-wildlife conflict. Fredrick Mofulu the MINAPA Park Ecologist and principle Tanzanian Co-ordinator of the Darwin Initiative project has recently completed his MPhil at APU and has returned to his duties in Mikumi. The results and outputs of this work is summarised above. He continues to collaborate with and co-ordinate joint work with the ABRU research team and UK Darwin project staff. Jody Gunn is registered for an MPhil (with possibility of transfer to PhD) at APU and will be completing her data analysis and write-up over the next 18 months. Preliminary results for her work on spatial and temporal patterns in the Mikumi elephant are also summarized above. Her work has contributed greatly to the assessment of human elephant conflicts in local communities and greatly enhanced the positive social impacts of this work. The research degrees of Mmari and Gunn are added enhancements to the Darwin project outputs and helped expand the research conducted and the outputs derived from the research.

6. Project Impacts

This project co-ordinated with the development of the Park Ecology programme in Mikumi National Park and facilitated its integration with other park departments. The fundamental capacity building that was a major goal of this project has been achieved. Project activities are incorporated into the regular ongoing work of MINAPA wardens and ranger staff. The long-term protocols of the Animal Behaviour Research Unit have been enhanced and are being used by both ABRU and park staff in a collaborative manner. Ongoing routines operate well and are being sustained beyond the duration of the project. Research on elephant has successfully estimated the population of elephant throughout the park and established the existence of a large and extensive population. The elephant is an important flagship species and this research has helped create a capacity to monitor, manage and conserve large mammals and biodiversity using existing ranger patrols and management capacities. Habitat assessment has led to an expansion of information on the biodiversity of the park that emphasises both the importance of this area and the limitations of our knowledge of it. The GIS database is being used to document and respond to boundary encroachments. Similarly, data from ranger patrols have been used to assess and enhance antipoaching efforts throughout the park.

One notable achievement which is making a lasting impact and which will promote long-term sustainability is the Resource Centre of the Park Ecology department created and developed through this Darwin Initiative project. This centre provides an increased presence, status and capacity for an existing within host country programme that is specifically focused on documentation, management and conservation of biodiversity. Not only does the Park Ecology department have a high profile within the park, it has a clear role integrated into the larger management system of the park (and the entire TANAPA system). Description and monitoring is now firmly embedded within the department and Resource Centre, as is the use of GPS/GIS. The wide-ranging applications of the work to other departments, especially Law Enforcement is widely recognised and used within MINAPA and TANAPA. The project has made significant contributions to a management plan for elephant in the park as well as contributing to the new Management Plan for the entire park which are now being co-ordinated and prepared by the TANAPA Planning department in Arusha. TANAPA is increasingly committed to GIS monitoring methodology and recognizes the importance and usefulness of ranger based monitoring. These methodologies were evaluated and outputs of this Darwin Initiative project were presented at a Monitoring Methodology Workshop held February 2005 for all Park Ecology departments in the TANAPA system. Rangers and senior wardens trained in this project are continuing to apply that training. Fredrick Mofulu, the in-country co-ordinator of the Darwin project is actively co-ordinating the GIS database and continues to collaborate with the ABRU research facility on questions that have emerged from the success of this project. In particular, biodiversity assessment, boundary mapping and vegetation mapping are continuing. While the principle beneficiaries of the project are conservation managers and their institutions, there have also been impacts on local communities through increased discussion and communication between farm communities on the boundary and those working within the park. There is a much clearer understanding of the problems farmers have with wildlife and also of their perceptions of these problems. One especially notable impact was the exposure of village representatives to the habitats and animals of the park. Lack of awareness on the part of villagers was both surprising and informative and the policy of providing informative tours for local communities is likely to have extensive and lasting positive effects on the attitudes of farmers and their relationship with the park management.

7. Project Outputs

The extensive and enhanced outputs of this project are presented in Appendices 2, 3 and 4. These present in standardized format the many and diverse accomplishments of the past 3 years. These are discussed in some detail in other sections but it is worth noting here that most outputs were achieved ahead of schedule and are in almost all categories enhanced and extended outputs. The particular outputs for the past year which should be stressed are those of the community survey which are summarized in the Research Results in section 5.

The principle form of dissemination was by transfer of outputs as well as reports directly to the institutions and staff who are both the primary partners and target recipients. The most extensive transfer was the GIS data, which includes digitised topographic maps, satellite images, vegetation assessments, boundary and road maps, assessments of poaching and of antipoaching efforts. F. Mofulu, Park Ecologist and Host Country Co-ordinator has prepared and presented to the target stakeholders reports on the Darwin Initiative project activities and assessments of elephant populations within the park. Manuals, protocols and datasheets (in English and Swahili) have been transferred. Most of these products are or will be available on the project web page. Meetings and discussions with the targeted stakeholders, particularly TANAPA Park Ecology staff, other MINAPA wardens and rangers, senior TANAPA officials and TAWIRI CIMU staff have stressed the opportunities presented by these outputs, the uses of these to address a range of problems and questions both within MINAPA and elsewhere. These stakeholders are institutions and programmes within institutions with specific formal remits and procedures to address problems of biodiversity assessment and conservation. Consequently, there will be a continued use and dissemination of these products. The MINAPA Park Ecology Resource Centre and the centralized resource databases of the larger organisations will facilitate continued use. In addition to these target audiences, public and popular talks within Tanzania have publicised the activities and the goals of the project to a wider audience.

8. Project Expenditure

Table 1 below shows the Darwin Initiative Grant expenditure by category, year and for the overall project. For all years and overall the project remained in budget as specified by the project schedule. In no category did expenditure vary by more then 8% of the budget. The expenditures for rents, fees, costs and upkeep exceeded the budget by 6-7% while capital item costs were about 4% over budget. These variations were compensated for by similar small under expenditures in the other relevant categories. The budget for conferences, workshops and seminars had the largest under expenditure at about 7.5% less then budget. This was due in part to the opportunities for holding meetings and discussions on the project in concert with other meetings and venues which reduced costs both in terms of funds, logistical effort and time. All changes and variations were reported to the Darwin Initiative in annual and financial reports.

Table 1 Darwin Initiative Grant Expenditure: Amounts in Bold = Actual Expenditure, Amounts in Brackets [ ] = Amount Budgeted. Amounts shown are in British pounds sterling to the nearest pound

	Rents, upkeep	Travel & Subsistence	Conferences	Capital Items	Other	Total
Year 1	[redacted]					
Year 2						
Year 3						
Total						

9. Project Operation and Partnerships

The host country partnerships and collaborations for this project are extensive and are continuing beyond the parameters of the Darwin Initiative Project. The principal partnership is with Tanzania National Parks (TANAPA). This partnership is at two levels. Firstly, it directly involves the senior wardens and staff of Mikumi National Park (MINAPA). The Mikumi Park Ecologist, Fredrick Mofulu, is a senior warden within the park and the principle Host Country Co-ordinator of the project. The Senior Park Warden In Charge, John Shemkunde, actively supported and facilitated this project as did his predecessor, Isaac Muro. The active participation of the heads of other management departments was crucial to the success and continuity of the project in Mikumi. This included, C. Critton and H. Mollel (Community Conservation) M. Talali, T Mwakijambilie, G. Minja; (Law Enforcement) H. Lyarru (Veterinarian TANAPA Southern Parks) R. Juma (Tourism) and J. Augustine (Law Enforcement and Park Ecology).

The second level of collaboration with TANAPA is with the senior management based at Headquarters in Arusha. This collaboration is co-ordinated through the Park Ecology Division and the Chief Ecologist for TANAPA, Mr. I. Lejora. Both the Mikumi Park Ecology department and ABRU report directly to Lejora who receives, maintains and distributes reports, assessments and other outputs from the project. Lejora was active and supportive in drafting an MOU for the Darwin Initiative project, which includes provisions for sustainability and continuity. The needed personnel changes were discussed and co-ordinated by him in collaboration with Mikumi Park Wardens. The planning department at TANAPA headquarters in Arusha is co-ordinating and preparing the management plans for Mikumi to which this project has extensively contributed. The GIS database is of particular use and importance in the preparation of these plans.

The other principle host country partner is the Tanzania Wildlife Research Institute (TAWIRI), which has the responsibility for co-ordinating and administering all wildlife research within the protected areas of Tanzania. TAWIRI has been actively involved in the project since its inception. TAWIRI also administers the Conservation Inventory Monitoring Unit (CIMU) that has the overall remit for monitoring wildlife in protected areas. The Director of CIMU, Simon Mduma, was supported by this Darwin Initiative project to attend a workshop on distance sampling techniques in St. Andrews, Scotland. The practical outputs of this project were disseminated to CIMU to insure that the monitoring being done in Mikumi was included in the nationwide database and to ensure consistency and continuity. CIMU staff were consulted on techniques and timing of aerial surveys in the park and participated in surveys if schedules permitted. The

satellite images and relevant portions of the Mikumi GIS database were disseminated to the CIMU GIS section.

TAWIRI hosts an annual research meeting every December. This involves most active researchers and conservationists working in Tanzanian protected areas as well as park ecologists and wardens, other TAWIRI and TANAPA staff and most Tanzanian wildlife biologists and conservationists. This presented the opportunity for discussion assessment and dissemination of project outputs. This was particularly efficient as the headquarters of both TAWIRI and TANAPA are in Arusha. The TAWIRI venue also allowed the strengthening and forging of links between a variety of agencies and conservation projects within Tanzania and the East African region.

A third collaborator is the Wildlife Conservation Society (WCS), which has worked with this project since inception. WCS provides the plane and pilot for aerial surveys and is working on the expansion of the Park Ecology departments in all Tanzanian National Parks. ABRU is also active in this initiative and the Darwin Initiative project is directly linked to it.

There are close collaborations between the project and wildlife biology staff at both University of Dar es Salaam and Sokoine University of Agriculture in Morogoro. Other links and partners include APU – Sensitise Programme (part of the European Community European Social Fund), Resource Africa, Oryx Mapping, the Tarangire National Park Elephant Project in Tanzania, the Park Ecology departments in most of the other National Parks in Tanzania, the Amboseli Elephant Project in Kenya and the MidZambezi Elephant Project in Zimbabwe. Representatives of most of these groups attended the 1-day workshop on technological support we held for the Darwin Initiative Project (see outputs). The technological developments of computer software for the identity database have led to an MOU between Resource Africa and the Darwin Initiative participants at APU. Oryx Mapping is supporting the GPS/GIS database development and works on this with project staff on a weekly basis. Nick McWilliams of Oryx Mapping continues to help standardise the GIS database at ABRU and at the Park Ecology Resource Centre. He provided advanced training on MapInfo and ArcInfo GIS to ABRU staff, Park Ecology and park wardens.

10. Monitoring and Evaluation, Lesson learning

Monitoring and evaluation was an ongoing process that included the management of the budget, regular communication between key participants and monthly, quarterly and annual reports. The maintenance of budget and expense reports monitored field activity of staff especially ranger field time and research activities. The GPS technology requires central co-ordination and downloading of data onto computers. The monthly downloading of these GPS data and completed data sheets further monitored ranger survey activity. The GPS data are used to examine the extent and consistency of ranger surveys within and between the different ranger posts and to relate these to the established ground transects and aerial surveys. There were regular quantitative assessments of the data being obtained on the elephant population in Mikumi which is being substantiated by the publications and management plans being prepared as well as the already completed outputs such and postgraduate theses. Quarterly and annual reports were disseminated to all partners in the project. As documented in other sections and the appendices, key milestones were reached ahead of schedule and outputs are continuing to exceed plans and expectations. The contribution of these outputs and outcomes to the project purpose is reflected in the continued extensive involvement of Tanzanian individuals ranging from field rangers to senior managers and academics. The skills most of these individuals have acquired and are now using

on a regular daily basis represents a significant increase in capacity. The Park Ecology Resource Centre is in regular use and issues internal reports and assessments on a variety of related and relevant ecological parameters. These reports are evaluated by the senior management in Arusha as was the Darwin Initiative project.

The difficulty of co-ordinating schedules between participants in this project was noted in annual reports and this is one lesson we would bring to the attention of the Darwin Initiative. We would also like to note that when projects are rapidly implemented and successful (as this one was) there are additional outputs and enhancements which require careful integration into the Logical Framework. It is clearly important to be aware of and take advantage of existing venues or protocols within host country systems. By integrating meetings and the goals of review workshops into the TAWIRI annual meeting venue a greater number of individuals could be involved and consulted more effectively. There is a considerable infrastructure within Tanzania both at the institutional and Non-Government Organisation (NGO) level which can be utilised to effectively disseminate outputs and information of the project. Similarly, within this infrastructure there are tools and information that were of use to this project for example, the databases of CIMU and poaching records at TANAPA headquarters. There are also a wide number of NGO's, formal and informal networks which can contribute to projects for example, the Tanzania GIS User Group (TZGISUG). Awareness of and communication with such institutions, organisations and individuals improves and heightens the effectiveness of projects but such awareness can be difficult and time consuming to achieve. As important, it should be stressed that major participants in projects such as this both in the UK and host country often have a range of responsibilities and hence an often heavy burden of administrative duties (park wardens and the TANAPA Chief Ecologist for example have many administrative duties beyond that of this project). This needs to be considered and accounted for in the schedules and logistical planning of projects from the initial planning stages.

11. Actions taken in response to annual report reviews (if applicable)

Reviews of the project annual reports have been helpful and insightful. Reviews were positive and encouraging. The principle suggestions to which we have responded was a request for a modified reporting structure which addresses the various components of the project separately and a clearer discussion of the relationship between these separate components. In the last review the reviewer made a number of encouraging suggestions for follow-up and continuity work to which we are responding within the limits of funding available. Currently, the work has expanded to assess biodiversity and catchment flow in a rare unique habitat of afromontane forest, the importance of which was highlighted by the work of this project. This current work makes use of and depends on the GIS and ranger survey capacities generated by the Darwin project.

12. Darwin Identity

The Darwin Initiative is very well known within Tanzania. The Director General of TAWIRI was a Darwin Initiative recipient and Project Director and the Initiative has made many contributions to the conservation of Tanzania's extensive biodiversity. This project was able to build on the prestige of the Darwin Initiative and the high profile of the long-term ABRU project. This offered many opportunities to expand the impact of the project as is evident in the enhanced outputs and the speed with which the project was implemented and its principle purposes achieved. TAWIRI recognised the contributions of the long-term work at ABRU to wildlife conservation at its Annual Meeting. This recognition was at a plenary session that honoured those long-term research projects

that have made significant contributions to describing and conserving Tanzania's biodiverse wildlife. This commendation involved the offices of the President and Vice-President of Tanzania as well as the Ministry of Natural Resources and Tourism and thus received recognition at the national level and was publicised in the national press and on television. Such events have added weight to and heightened the awareness the impact of the Darwin Initiative project in Tanzania. Communication with a wide range of interested parties and organisations was stimulated. Groups and individuals seeking more information on the Darwin Initiative project now frequently approach both ABRU and the Park Ecology department. The project was able to liaise with other projects and activities much more effectively due to the high profile provide by the Initiative. The Darwin Initiative Logo appeared on outputs and presentations of the project as well as the capital equipment provided.

13. Leverage

As has been noted in other sections there were extensive contributions from a host of individuals and organisations. This was in part a result of the prestige and profile of the Darwin Initiative project and sustained activity at a high level with many opportunities to participate in workshops and liaise with other projects. The project identified other opportunities for monitoring and biodiversity assessment in Mikumi as well as identifying the applicability of the methods, data base and systems to conservation issues (e.g. law enforcement, boundary definition) beyond those defined by the project. Mofulu and Gunn were both able to attract added support for their degree programmes. As an outgrowth of the Darwin project and using the capabilities created by it, ABRU and Park Ecology have been awarded a grant from CEPF to record and substantiate the biodiversity in the afromontane forests of MINAPA. The leverage potentially provided by the Darwin Project probably exceeds the capacity of the principles to take advantage of it.

14. Sustainability and Legacy

The sustainable legacy of this project is multifaceted and extensive. Firstly, we have quantitatively established the occurrence of elephant in and elephant use of the two thirds of Mikumi National Park that was previously unsurveyed. This is an area of diverse habitat with thick woodlands and difficult access. Elephant occur in these areas and are using them with a regular intensity. The project has shown that elephant density in Mikumi has been underestimated and that the total elephant population is at the larger end of estimates. There is in summary an improved and more accurate understanding of the Mikumi elephant population size and structure which makes possible for the first time an informed management policy. Secondly, the elephant research was used successfully for training and capacity building. This resulted in an active Park Ecology Resource Centre where staff are pursuing a range of urgent ecological questions and problems complementary or collateral to those of this project. Thirdly there are the benefits that are being derived from the GIS database and the aerial and ground surveys that contribute to it. For the first time an accurate park boundary is being mapped. Vegetation and habitat maps and assessments are being improved and upgraded. The first detailed and accurate road and track map of the park has been made and is being readied both for tourist as well as management use. These and other results of the GIS database will be used not just for a management plan for the Mikumi elephant population but also for the new management plan for the entire park. Perhaps the most impressive collateral result has been the application of GPS/GIS data to law enforcement and antipoaching efforts. Ranger surveys in the GIS

database identify the extent and pattern of antipoaching efforts and patrols. This information enables the law enforcement department to assess and plan improvements to the antipoaching efforts. The aerial and ground surveys have located and mapped the patterns of human population living adjacent to and occasionally encroaching into the park, clarified other boundary dispute issues and located and mapped poacher camps and other physical evidence of poaching. This is leading to a more detailed understanding of patterns of poaching and other human activities that could threaten the integrity of the park and the diverse species it contains.

15. Value for money

The Darwin Initiative phase of this project has been highly successful. The broad purposes specified in the logical framework have been achieved and outputs have exceeded those planned. Consistent with this purpose there is now a cost effective monitoring system in use within Mikumi National Park and more generally within the Park Ecology programmes of TANAPA. There is a clear understanding of the elephant population in Mikumi and the management issues which need to be addressed in relation to that population. MINAPA has a well established network of survey transects, and survey protocols which can be and are being used to address a range of management and monitoring questions. This success has been achieved with hard work and dedication and relatively few direct funds. The Darwin Initiative funds which made this success possible provided important capital equipment, facilities and training. This resulted in permanent facilities and self-sustaining capacities. The contributions of other institutions and most individual participants were for the most part contributions in kind and the allocation of existing funds and resources to the Darwin project. This reflects the importance that partners attached to the project and the outputs. All of these achievements are the result of an investment of an average cost [redacted] per year over 3 years. These results are sustained by improved use of existing systems. This continuity and capacity is an extremely cost effective result.

Appendix 1: Logical framework from project schedule

Project summary	*Measurable indicators*	*Means of verification*	*Important assumptions*
Goal			
To assist countries rich in biodiversity but poor in resources with the conservation of biological diversity and implementation of the Biodiversity Convention			
Purpose			
To create a permanent capacity to ensure the survival of African elephants and their habitats in Tanzania. To train Tanzania park ecologists and rangers in the continuous monitoring and assessment of the wild animal species and habitats under their protection. Quantitative understanding of the Mikumi elephant population	A continuous program of elephant research and monitoring within Mikumi. Application of techniques developed in Mikumi to other habitats, species and parks.	Reports and annual assessments to TANAPA head office. Publications arising from the monitoring programs Application of the management program for the elephants in Mikumi and their habitats by park staff.	Continuity of the ABRU research project in Mikumi. Continued support of the Park Ecology department by TANAPA and continued funding for Park Ecology & Antipoaching ranger patrols
Outputs			
A permanent program within the Mikumi-Tanzania Park systems monitoring the elephant and other large mammal populations using the regular anti-poaching posts and patrols of rangers. A permanent program of trained analysis and assessment of this information by the Parks Ecology department. A core of rangers trained in transcect monitoring	A permanent elephant identity database in use by Park Ecology program, rangers and researchers. Regular critical assessments of elephant status in Mikumi-Selous. Habitat evaluations in relation to elephant use.	Reports and annual assessments to TANAPA head office. Publications arising from the monitoring programs. Upgraded inventory of biodiversity in southern 2/3 of park including maintenance and use of park reference herbarium.	Ranger time and willingness to participate. Sufficient motivation on part of ranger's reinforced by proper management of the park ecology and research teams.
Activities			
Training of senior patrol rangers in transect and vegetation monitoring techniques. Collection of long-term quantitative data on elephant population size, structure and habitat. Collaborative analysis of quantitative data with Park Ecology team. Verification, dissemination and refresher workshops	Vehicles for access to posts and for road transect. Computer and digital camera equipment and software for permanent identity catalogue. Ranger training sessions Workshops and refresher training courses. Vehicle and infrastructure maintenance.	Workshop outputs. Ranger evaluations and performance. Analysis of village surveys. Park records and reports. Reports and annual assessments to TANAPA head office. Publications arising from the monitoring programs	Access to southern 2/3 of park. Maintenance of park roads, Limited interruption to climatic problems (i.e. El Nino effects during wet seasons). Rigour and reliability of digital and computer equipment for database management.

Appendix 2: Project Contribution to Articles under the Convention on Biological Diversity (CBD)

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	**Project %**	**Article Description**
6. General Measures for Conservation & Sustainable Use	5%	Develop national strategies that integrate conservation and sustainable use.
7. Identification and Monitoring	20%	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	10%	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.
10. Sustainable Use of Components of Biological Diversity	5%	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.
12. Research and Training	25%	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	5%	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	5%	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.
16. Access to and Transfer of Technology	20%	Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most 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 Infor mation	5%	Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
Total %	**100%**	**Check % = total 100**

Appendix 3: Outputs

Please quantify and briefly describe all project outputs using the coding and format of the Darwin Initiative Standard Output Measures.

Code	Total to date (reduce box)	Detail (←expand box)
Training Outputs		
2	Number of Masters qualifications obtained	2 completed (Mofulu, Tanzania with APU, Mmari Tanzanian with SUA) 1 in progress (Gunn Australian with APU due with possibility of PhD 2007)
4a	Number of undergraduate students receiving training	120 In field lectures and exercises during University Field courses
4b	Number of training weeks provided to undergraduate students	3 (see 4a)
4d	Number of training weeks for postgraduate students	8 weeks including, induction, research training, statistical training & advice, supervision
5	Number of people receiving other forms of long-term (>1yr) training not leading to formal qualification(i.e not categories 1-4 above)	32, = 8 senior rangers @ 6 ranger posts trained by senior staff throughout project in GPS, transect survey and elephant identification, 24 junior rangers trained by senior rangers with senior staff support. Training continuous throughout project
6a	Number of people receiving other forms of short-term education/training (i.e not categories 1-5 above)	38 = 14 Senior park wardens and staff training in GIS/GPS systems by Oryx Mapping and ABRU, 3 trained at Distance Sampling workshops in St. Andrews, Scotland 2 three day sessions, 21 trained during, Elephant ID and Methods workshop over 5 days
6b	Number of training weeks not leading to formal qualification	4 weeks (see 6a)
7	Number of types of training materials produced for use by host country(s)	2 types (see 10)
Research Outputs		
8	Number of weeks spent by UK project staff on project work in host country(s)	257 weeks = G Norton project leader (100), Phyllis Lee (2), ABRU research staff (150) Oryx Mapping personnel (5)
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)	2 = Reports and contributions to TANAPA planning department and planning workshops for MINAPA management plan. Final version being agreed and prepared by TANAPA planning department; Report to TANAPA on status and management of elephant in MINAPA (in prep.)
10	Number of formal documents produced to assist work related to species identification, classification and recording.	2 = Protocol instructions and data sheet instructions (English & Kiswahili), GPS instructions
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	3 = Elephant identity and observation database (Microsoft Access); Ranger GPS transect data (Elephant, Giraffe, poaching and vegetation records) (SPSS & MapInfo-GIS); MapInfo GIS database (Park Boundary, Digitalized ordinance survey maps, satellite imagery, Road, vegetation, contour, watershed and landmark maps and GIS records, Project poaching aerial survey and other records by GIS location georeferenced to maps and images)

Dissemination Outputs	

14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	8 = Project planning workshop in Mikumi year 1, Technological Support workshop in Cambridge year 2, Ranger training& progress workshops years 1,2,3 Progress and assessment workshop year 3 Consultation and assessment workshops with local community representatives and Community Ecology Wardens (year 2 & 3).
14b	Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.	8= Development of MINAPA Ecology Strategic Action Plan (co-ordinated with project planning workshop see 14a), TAWIRI Annual Research Conferences year 2 & 3), Int'l Conference on Forest & Environmental History of the British Empire and Commonwealth year 2, RGS Workshop; Biogeography and GIS Cambridge Student Conference on Conservation Science year 2 & 3, Methods in TANAPA Park Ecology year 3
15d	Number of local press releases or publicity articles in UK	7 = Various; News and Events APU-Life Sciences Web page, Cambridge Evening News (2) Cambridge Agenda Weekly Magazine, APU Applied Sciences Newsletter, APU, Bulletin (2) Project Webpage updates.
17b	Number of dissemination networks enhanced or extended	3 = TANAPA Park Ecology system wide GIS monitoring and database network, Conservation Inventory & Monitoring Unit of TAWIRI, MINAPA Community Conservation Local Community Consultation & Education programme
Physical Outputs		
20	Estimated value (£s) of physical assets handed over to host country(s)	[redacted] = Field Vehicle, Computers, Projectors, GPS systems and accessories, Field Equipment (tents, bionoculars gauges etc.) office equipment, solar lighting, Digital cameras and accessories, MapInfo software, satellite imagery, digitized maps.
21	Number of permanent educational/training/research facilities or organisation established	[redacted] Park Ecology Resource Centre and Offices built and furnished
22	Number of permanent field plots established	20 elephant & vegetation transects, totalling 444 kilometres and 277 observation points, Farm field maps for 6 villages surveyed on park boundary, Aerial Survey zones and routes
23	Value of additional resources raised for project	[redacted]

Appendix 4: Publications

Provide full details of all publications and material that can be publicly accessed, e.g. title, name of publisher, contact details, cost. Details will be recorded on the Darwin Monitoring Website Publications Database that is currently being compiled.

Mark (*) all publications and other material that you have included with this report

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	Cost £
Manuel*	Norton,G, Augustine,J; Gunn, J & Mofulu, F: 2003 Kiswahili instructions for the use of Garmin GPS units	ABRU, MINIPA	www.mikumi.org [redacted]	Free
Manuals*	Norton,G; Hawkins, D; Gunn, J & Mofulu, F: 2003 Elephant data collection protocols and datasheets: Mikumi Darwin Initiative Elephant Project	ABRU, MINAPA	www.mikumi.org [redacted]	Free
Presentation	Norton, G; & Hawkins, D, 2003 Long term research in Mikumi National Park Tanzania: historical processes and the implications for conservation.	n/a	www.mikumi.org	Free
Presentation	McWilliams,N, Norton, G. Hawkins, D. & Mofulu, F. 2003; A low-cost GIS for research and management in a Tanzanian National Park.	n/a	www.mikumi.org	Free
Presentation	Norton, G.; 2003, Long-term perspectives on wildlife research for conservation	n/a	www.mikumi.org	Free
Confidential Report	Norton, G, 2004. Observations of poaching in the Mkata River, Mikumi National Park.	ABRU	On written application to TANAPA Arusha Headquarters	Free
Confidential Report	Mofulu, F. 2004; Contributions and assessment of Darwin Initiative Project in Mikumi National Park	TANAPA	On written application to TANAPA Arusha Headquarters	Free

MPhil Thesis	Mofulu, F. 2005; The Elephant Population and Distribution in Mikumi National Park, Tanzania.	APU	www.mikumi.org (posted on acceptance of final corrections)	Free
MSc Thesis	Mmari, W. 2005; Assessment of the Extent of Elephant Damage on Baobab Trees (*Adansonia, digitata*) in Mkata Flood Plain, Mikumi National Park, Tanzania	SUA	www.mikumi.org (posted on acceptance of final corrections)	Free
Access Database	Hawkins D. et al. 2005. Identity database for elephant & other large mammals	APU	t.b.a.	t.b.a.

Appendix 5: Darwin Contacts

Project Title	Elephants of Mikumi National Park: Conservation, Education and Research
Ref. No.	162/11/008
UK Leader Details	
Name	Guy W. Norton
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Name	Dawn M. Hawkins
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Partner 1	
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Partner 2 (if relevant)	
Name	I. Lejora
Organisation	Tanzania National Parks – Head Office
Role within Darwin Project	Parter organisation co-ordinator and overseer
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