CENTRE FOR ECOLOGY AND HYDROLOGY - MONKS WOOD
NATURAL ENVIRONMENT RESEARCH COUNCIL

DEPARTMENT OF BIOLOGICAL SCIENCES, FOURAH BAY COLLEGE
UNIVERSITY OF SIERRA LEONE

Habitat Audit and Change Detection in Sierra Leone

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April 2004

CEH PROJECT No: *C02009*
CONTRACT NO: *11-006*

Darwin Initiative for the Survival of Species

Annual Report

1. Darwin Project Information

Project Ref. Number	*11-006*
Project Title	*Habitat Audit and Change Detection in Sierra Leone*
Country(ies)	*Sierra Leone*
UK Contractor	*Centre for Ecology and Hydrology*
Partner Organisation(s)	*Fourah Bay College, University of Sierra Leone*
Darwin Grant Value	*£60k*
Start/End dates	*2002 – June 2004*
Reporting period Report number	*1st April 2003 – 31st March 2004* *Report No. 2*
Project website	*-*
Author(s), date	*R.A. Wadsworth, A.B.Karim, H.G.Morgan* *April 2004*

2. Project Background

Ten years of civil war in Sierra Leone caused the displacement of somewhere between a third and half the rural population (there are no reliable statistics). This movement of people and the attendant changes in land use were believed to have had a major impact on land cover and hence on biodiversity. There were no quantitative estimates of what these changes were and reports on the environment of Sierra Leone endlessly repeat the estimates of land cover made by the FAO in the early 1970's. Sierra Leone can not meet its obligations under the Convention on Biodiversity unless it knows what it possesses; and land cover must be one of the major determinants of biodiversity.

Developments in technology particularly cheap hand-held GPS (global positioning system) devices, more sophisticated image processing software and geographic information systems (GIS) plus relatively cheap satellite remotely sensed data (RS) means that land cover mapping is now technically possible for almost anyone with a reasonably up-to-date computer. Traditionally land cover maps are general purpose objects that result from a multitude of compromises between: the end users, the funding agencies and the technical experts. We believe that general purpose land cover maps are often inappropriate and that a map should be tailored to answer a *specific* environmental question.

3. Project Purpose and Outputs

3.1 The overall purpose of the project was to: *Transfer skills and technology necessary to produce reliable maps of habitats and change in habitats from multi-spectral and SAR imagery"*. The overall objective was to: "*create a group of researchers capable of carrying out similar mapping exercises in other parts of the country and in the future as reconstruction commences"*. The log-framework is supplied as an appendix.

3.2 The objectives and activities have not changed, however, their relative importance and time expanded on them has been rebalanced. The change in emphasis occurred at the beginning of the first year as a result of consultations with the stakeholders before and during the start-up workshop. Stakeholders identified a handful of Sierra Leonians who have been trained overseas (in the USA, the Netherlands and Nigeria) in the use of geographic information systems, global positioning systems and remote sensing. Without exception on their return to Sierra Leone they lacked appropriate infra-structure and were forced to operate in isolation, because of this the inevitable organizational, financial and technical problems meant that their skills were rarely exploited for long if at all and quickly decayed. Stakeholders believe that what was needed was to try and develop a self sustaining "critical mass" of researchers using the techniques. This group which could be centred on the activities started by our project could then help in sharing the cost of data, providing safe backup facilities, loan of equipment and mutual support activities etc. At the final workshop of our project the new Principal of Fourah Bay College (Prof Dan Foody) took the opportunity to announce that he has allocated funds for the reconstruction of one of the buildings on campus that was destroyed by rebels to become the National Centre for GIS and RS at the University.

The study of the Gola Forest and Tiwai Island which were postponed in the first year were carried out this year. The postponement had the unexpected benefit of allowing the field work to be done in conjunction with two of the project stakeholders: the Environmental Foundation for Africa (EFA) and the Conservation Society of Sierra Leone (CSSL). Data produced as a result of these field trips is being used in the development of two more cooperative bids; one led by BirdLife International on conservation concessions in the Gola Forest and the other by EFA on the eco-tourism potential of Tiwai Island. This year we also obtained satellite data of the Outamba-Kilimi National Park which is being incorporated into a training scheme for Park Rangers led by EFA and Njala College and funded by Conservation International(?).

4. Progress

4.1 The main activities of the project started in November 2002 when the UK lead went out to Sierra Leone to teach at the University for 3 months (half paid for by DI). It was quickly apparent from discussions with individual stakeholders and confirmed at the start-up workshop that the key stakeholders had a subtly different conception of what the project ought to be about. The project has therefore been modified to include more training of more senior people than planned with the aim of developing a "critical mass" of researchers able to use the technology to help answer a wide range of environmental questions. Training went well. Electronic communication with Sierra Leone remains difficult and "distance learning" component has not been as fruitful as planned.

4.2 The project provided initial training to a further four trainees and refreshed and extended the training of three trainees from last year. The methodology continued in the same fashion as in the first year with a mix of classroom and field exercises aimed at developing useful case-studies.

The final workshop was attended by over 40 participants at which meeting the incoming Principal of FBC (Fourah Bay College) announced that funding was being made available to reconstruct a building to house a proposed Centre for GIS and RS at the college.

The project has continued to "fly the flag" for the Darwin Initiative. We were interviewed for Network Africa on the World Service and appeared in the Science updates on the Nature website (following a presentation at the British Ecological Society). We were specifically mentioned (and praised) in front of the President when he attended the convocation at the college. We are currently in communication with the British Council about preparing material to be displayed in the entrance of their building in Freetown when it is re-conditioned. Posters of the project were presented to the Science Management Audit Group on the recent review of CEH (an equivalent to the RAE carried out at Universities).

Studies of forest condition of Gola Forest and Tiwai Island are being used by NGO's to plan how to manage and report on the biodiversity of the areas as well as in helping to justifying further funding proposals. Studies of land cover in the National Park are being incorporated in training of the forest guards being funded by Conservation International (?).

This project produced the first quantitative estimate of the rate of coastal erosion along some of the finest "tourist" beaches in Sierra Leone. Erosion has been triggered by people taking sand for new buildings; we measured a peak rate at the north end of Lakka beach of 41 meters in one year!

We were the first "environmentalists" since the war to inspect the area of Rutile and Bauxite mines in the south of the country. We collected data on the success (and sometimes abject failure) of restoration schemes after 10 years of uninterrupted growth. On neither mine is natural regeneration a significant process, vegetation on the abandoned Bauxite mine was less than 1% and no better on the Rutile spoil. On the Bauxite mines rehabilitated areas that had been planted with *Acacia* is identifiable on the satellite imagery but areas planted with "wildings" (native species taken from the surrounding forests) were indistinguishable from the surrounding vegetation. Rehabilitation of the Rutile spoil was very poor even where it had been covered with top soil.

We have responded to the referees comments on the first paper (submitted to Biological Conservation) and are hopeful it will appear in the near future. A second paper on the restoration of Bauxite mines is well underway. If published it will be the first paper on the topic from anywhere in West Africa. The "teach your-self" manual (see appendix) was extensively tested and should prove to be a useful guide to using the technology. A series of simple case studies (see appendix) were prepared and widely circulated.

4.3 Progress was basically in line with the proposal but a number of technical issues meant that we had to curtail some activities. The computer "objected" to receiving 300 volts from the Engineering Department's generator and the mother-board failed. Fortunately the hard disk was still functioning and after a couple of weeks I managed to find and buy a compatible second-hand lap-top to fit the hard disk into (although I wasn't told and didn't ask where it came from). Dr A.B.Karim was invited by His Excellency the President to lead a large (300+) group on the Hajj (pilgrimage to

Mecca) which occupied a significant proportion of his time. Professor Hector Morgan was also otherwise occupied when he accepted an invitation to become acting Director of the Rice Research Institute (he was invited because of problems with the administration of the Institute; such as, staff not being paid for three months).

Transport remains difficult and a variety of vehicles were borrowed to ensure that the field work could be carried out (every trip used a different vehicle and driver). Electronic communication remains poor (the Internet café on campus was off-line half the time and was very slow when it was working); a round-trip to check e-mails at a reliable café in the centre of Freetown took in the order of 3 hours.

4.4 At the start of the year (before the second trip) we "co-opted" a visiting scientist to help us understand why the radar data was not as useful as we had expected. His considered opinion (after a considerable amount of effort on his part) was that we required information with a longer wavelength than the "C" band of the satellites we had available (see section 5).

4.5 This is the second and final year.

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

5.1 The first year review suggested that some of the savings we achieved on the radar data (due to being able to purchase as "CAT-1" customers rather than commercial rate) should be converted into staff time so that the UK PI didn't use his annual leave for extra teaching. I'm afraid that in fact we spent the savings on more data, software and hardware.

With the help of a visiting expert (from Gamma Software in Austria), we have conclusively demonstrated that "C" band radar is not particularly useful for land cover mapping in Sierra Leone. This applies to both multi-temporal images (time series with short interval between images) and tandem data (roughly equivalent to stereo cover with air photographs). There was nothing wrong with the radar data and in the absence of optical data like Landsat a reasonable estimate of land cover could probably be made using it. The two situations we wanted to use radar for were in separating farm-bush from secondary forest and in identifying wetlands in the rainy season. In the first situation it has proved easier to distinguish farm-bush from secondary forest using optical data than was expected, the expectation was that farm-bush and secondary forest would look very similar and although there is some spectral over-lap it was not insurmountable. The strength of the radar return should increase with increasing vegetation cover; above a certain biomass no increase in the return is possible and the return is "saturated". In the areas of Sierra Leone we looked at this saturation occurred at relatively low levels of biomass. In the other proposed application of radar data (to delineate swamps and wetlands in the rainy season) it appears that the upland soil is so saturated in the rainy season and the growth of vegetation in the swamps so vigorous that it was not possible to clearly distinguish between them. Accurate delineation of inland swamps remains an unsolved problem (mangrove swamps are easily identified).

6. Partnerships

6.1 The local NGO the EFA (Environmental Foundation for Africa) acted as host for a Darwin Initiative pre-project with a colleague from CEH Edinburgh, this went well and we will be submitting a full bid in the next round. That trip also helped establish what will hopefully be more productive links with Njala and the Forestry Department. Last year we established a link with UNAMSIL to try and pool mapping resources, due to changes in staff at UNAMSIL this has rather fizzled out. We are in active

consultation and have exchanged visits with RSPB (the UK partner to BirdLife) about their plans to protect the Gola Forests.

Collaboration with the host country went very smoothly and has been productive. During the first year there were some delays in transferring funds from CEH to the partners this was obviously embarrassing. This year the University partners were used to the concept of being paid in arrears and it was less embarrassing.

6.2 The only other Darwin project in the region was the development of a management plan for the Sapo National Park in Liberia, the situation in Liberia made forming links rather difficult. We have maintained rather sporadic communication with a Fauna & Flora International project using remote sensing to map forests in Liberia (links hampered in part by their staff moving on). We are collaborating in an informal manner by supplying land cover information to a project being run by Dr. Chakanda (currently based in the Netherlands). That project is studying the impact of the war on subsistence agriculture and particularly the loss of genetic material and local cultivars. Collaboration with other organisations has been mainly through discussion of further funding opportunities, most notably the BirdLife/RSPB initiative to purchase a conservation concession in the Gola Forest (we supplied maps and went on a reconnaissance trip with the CSSL).

7. Impact and Sustainability

7.1 The project has a high profile; we have had meetings with Government officials including two key Ministers (Agriculture**,** Lands) and the Presidents Scientific Advisor, and were explicitly described before the President at the University Convocation. We are collaborating with the two largest indigenous environmental NGO's (EFA and CSSL). We have appeared on national television and radio and in the local media. This year we switched from telling these key stakeholders what we were going to do to presenting the first results. Interest in biodiversity (and environmental problems) was already high within the University, what the project has done is increase their capacity to effectively communicate with decision makers by providing quantitative and visual information on the state of the environment. The University recognizes that it has a poor record in getting its research out of the academic circle and is trying to rectify it (apparently it was the major criticism in a recent review of the Universities activities). Our project therefore helped in both emphasising the need to communicate and the ability to do so.

We have quite a high profile with the British Council, for example we're negotiating to provide an exhibit when their offices are refurbished, but have been much less successful with DFID and the British High Commission.

Our exit strategy has been hampered by the on-going review of the British Council HEI Link program. However, the University authorities have been inspired to find the funds to start reconstructing a building to house a National Centre for GIS and RS. If this had been a 3 year rather than a 2 year project that would have been a near perfect exit strategy as we could have moved our equipment and teaching base from the Herbarium into the Centre and had a significant "founding effect" on the research objectives of the Centre.

8. Post-Project Follow up Activities (max 300 words)

8.1 By concentrating on the development of simple case studies the project has demonstrated to a wide range of stakeholders the potential of the technology to help answer their environmental questions. Trainees have included several of the contributors to both the National Environment Action Plan and the National Strategy on Sustainable Development. The amount of "manoeuvring" that went on to try and obtain the extra licence for the software is also indicative of their desire to exploit the technology. The one thing Sierra Leone is not short of is environmental problems, but donors are concentrating exclusively on reconstruction, (to the extent that for example DFID will reconstruct primary schools, but not fund teacher training), resumption of more "traditional" development programs is still some way off and environmental programs even further off. The two key NGO's EFA and CSSL rely on the one hand on the surplus generated from work done for the UNHCR and on the other from very limited funding from RSPB (and in the past GEF) this has been strongly focussed on identifying Important Bird Areas to the exclusion of almost everything else. If we could get a foot-hold in the proposed Centre (see below) we could influence both the research direction and the teaching that was carried out.

8.2 The University is committed to trying to establish a National Centre for RS and GIS. So far they have found funds to reconstruct a building. At the moment there are believed to be three Sierra Leonians in Freetown with training in GIS and remote sensing to MSc level, two already work for the University but whether they can be freed from their current commitments is uncertain. The other issue is whether they and the trainees from this project can cross the knowledge gap from doing to teaching without outside guidance.

9. Outputs, Outcomes and Dissemination

9.1 The main reason for the additional outputs has been due to the change in emphasis towards developing a "critical mass" of researchers using the technology, there have therefore been more trainees and at a higher "grade" than originally planned. Course notes were expanded and elaborated into much more of a "teach your-self" manual and the number and range of case studies increased. We had planned a series of outputs aimed at schools and the general public, these have not been implemented partly because of the unavailability of the two key PI's (Dr Karim & Prof Morgan) and also because discussion with the CSSL schools liaison person (who has experience at this level of dissemination) and with local school teachers, suggested that a direct approach would not be a very efficient use of resources.

9.2 Primary dissemination activities have been through meetings with stakeholders and the distribution of the (draft) case studies hand-outs (see appendix). The University is attempting to solve the general problem of disseminating its research work but does not have a specific remit to disseminate the work of the Habitat Audit project. We have one paper with reviewers and others in preparation that should also help disseminate our activities.

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

Code No.	Quantity	Description
4A	*3*	*Unplanned output, training given to Honours students in connection with their final year projects on biotope mapping and land cover change.*
4C	2 people	Target exceeded - 3 from last year received refreshed course plus advanced training 1 new postgraduate
4D	12 weeks	Failure of the motherboard on the computer reduced time available by two weeks in second year.
7	4	Target has not been fully met. A collection of case-studies has been produced as a general purpose hand-out. Material for schools deemed inappropriate and handouts for journalists overtaken by other events (the fact that we'd already been on the TV, radio, newspapers and internet)
8	12 weeks	Achieved
10	1	Course notes expanded to a "teach your-self" manual. Manual on mapping land cover in Sierra Leone being considered as a journal paper.
11B	2	One paper already submitted (responded to referees comments) the other is still in preparation; at least 2 others are possible (coastal erosion and restoration ecology).
12A	1	Data exists (and a copy exists in SL and UK) but is not in a database as there are unresolved technical issues about spectral variations with latitude.
14A	2	Achieved.
14B	1	Target exceeded. Presentation at BES (British Ecological Society) led to article on the Nature web site. Paper presented at GISRUK by MSc student attempting to model deforestation process using IBM (individual based model).
17B	1	University has committed funds to try and establish a National Centre for GIS & RS based on success of Habitat Audit project.
18A	*1*	*Unplanned output, Material provided to the Envirscope programme co-PI to be interviewed shortly.*
19A	*2*	*One given the other delayed.*
19B	*1*	*Unplanned output, interview given on World Service of the BBC*
20	£12,150	Full coverage of Landsat data for 1985/86 and for 2000/3, two computers (original and "new" one), scanner, printer, GPS.
21	1	Achieved.

Table 2: Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	Cost £
Manual	A "Teach Yourself" manual on land cover mapping for the Environmental Sciences. Wadsworth. 2004	-	rawad@ceh.ac.uk or Dr.A.B.Karim, Department of Biological Sciences, Fourah Bay College, USL, Freetown	-
Hand out	Case Studies and Examples. Wadsworth & Karim 2004	-	rawad@ceh.ac.uk or Dr.A.B.Karim, Department of Biological Sciences, Fourah Bay College, USL, Freetown	-
Journal	Effect of Civil Disturbance on Mammalian Biodiversity: a case study from West Africa. Wadsworth & Conteh 2004	Submitted to Biological Conservation	-	-

10. Project Expenditure

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

Item	**Claim submitted to DI in March 2004.**	Expenditure	Balance

Some money (~£6k) was carried over from first year with the agreement of DI.

11. Monitoring, Evaluation and Lessons

11.1 We had initially intended to spend much more of the project in raising awareness of the project with the general public and stakeholders. In the event people were much quicker to see the usefulness of the technology than we had anticipated and news of the project and the case studies was easily distributed as can be seen from the outputs. We also intended to put considerable emphasis on trying to influence the NEAP and NSSD; at the moment the stress in Sierra Leone is so much on reconstruction that it is difficult to see how either document is influencing any decision. The key criteria for evaluating the project are (and should always have been) are the trainees still using the technology 12 months from now, we can say that after the first 12 months they (and their organisations) were still keen, whether the University can establish a Centre and whether that Centre is a success will not be known for some time.

The overall success of the project can be objectively assessed by observing how easy it is to obtain further funds to extend the analysis to other test sites and periods and how widely the techniques are adopted within the University and elsewhere in Sierra Leone, especially its influence on the NEAP and NSSD

11.2 Transport remains difficult; relying on the Department's Landrover being both roadworthy and available was inefficient and borrowing vehicles from other organisations was frustrating and time-consuming. It would have been better to have arranged an exclusive hire from a private individual/company.

Spare parts for the computer (a Dell) could not be obtained; there was no Dell base in Sierra Leone and CEH computer support were unable to persuade Dell to supply parts unless one of their (Dell's) engineers physically saw the machine. It would be worth checking on repair options before purchasing a computer to use in Sierra Leone.

It would be interesting to investigate the use of longer wavelength radar data from some of the new satellites that have been launched recently.

12. OPTIONAL: Outstanding achievements of your project during the reporting period (300-400 words maximum)

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

The Habitat Audit and Change Detection in Sierra Leone project has provided:

- The first quantitative estimates of land cover in Sierra Leone to be produced since the 1970's,
- The first quantitative estimate of the rate of coastal erosion,
- A first assessment of the success in restoring land following mining for Bauxite and Rutile (Titanium ore).

The project has "empowered" the University of Sierra Leone to try and establish a National Centre for Geographic Information Science and Remote Sensing with a strong emphasis on environmental issues.

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

Project summary	Measurable Indicators	Progress and Achievements April 2003-Mar 2004	Actions required/planned for next period
Goal*:* To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve • The conservation of biological diversity, • The sustainable use of its components, and • The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources			
Purpose *(insert original project purpose statement*	*(insert original purpose level indicators)*	*(report impacts and achievements resulting from the project against purpose indicators – if any)*	*(report any lessons learned resulting from the project & highlight key actions planning for next period)*
Transfer skills and technology necessary to produce reliable maps of habitats and change in habitats from multi-spectral and SAR imagery)	Ability of staff in the Department of Biology and Government Departments to generate maps of land cover and quantify change	Trainees capable of producing maps. Honours students incorporating land cover maps in projects. Desire of University to continue process and incorporate ideas into curriculum.	Should (perhaps) have been able to predict success of project in attracting trainees. Should have planned to have software available for all trainees from the start. Difficult to interact in a productive way with DFID until the environment moves "up" their agenda.
Outputs			
(insert original outputs – one per line)	*(insert original output level indicators)*	*(report completed activities and outcomes that contribute toward outputs and indicators)*	*(report any lessons learned resulting from the project & highlight key actions planning for next*

			period)
A group of researchers capable of carrying out similar mapping exercises in other parts of the country and in the future as reconstruction commences.	Example maps of habitats for three selected areas Example maps of changes in habitats in the three areas 1991 to 2001.	Targets exceeded.	- final year – no further activities possible unless we can find funding from somewhere …

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