The WILD Foundation — Save the Elephants
The Environment and Development Group

Initial Measures for Conservation of the Gourma Elephants, Mali

Interim Summary Progress Report 2004

THE WILD FOUNDATION

SAVE THE ELEPHANTS

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Interim Summary Progress Report 2004

Submitted in February 2005

1. Introduction

This report is summary in nature, and is submitted to keep the DNCN fully apprised of the progress of this project. The current Protocole d'Accord de Cooperation was signed in September 2003, and is in effect for two years. The parties involved have been:

- a consortium of The WILD Foundation (USA); Save the Elephants (STE- Kenya) and The Environment and Development Group (EDG - UK);
- the Direction Nationale de la Conservation de la Nature (Mali);
- with close collaboration by the Embassy of the United States in Bamako, Ambassador Vicki Huddleston.

For ease and brevity, this report will restate the overall mission and goals, then simply list the objectives of the 2004-05 field research and data compilation and briefly report on progress. Following that will be an outline summary of the 2005 work plan. Submitted with this report are the following:

1. Field Research Report, 2004, by Dr Richard Barnes and Mr Emmanuel Hema, submitted through Dr Iain Douglas-Hamilton.

2. GIS Report -- An initial summary report on analyzing the radio-tracking data collected by Dr Douglas-Hamilton's team in 2002 in relation to landscape and other data, compiled for use in the GIS database under construction - by Dr Susan Canney.

3. Poster-sized draft map of Gourma and its greater region, with elephant range, human communities, jurisdictions, and other data derived through GIS compilation of initial field data, integrated with satellite imagery, produced by Save the Elephants with input from EDG.

2. Project Mission and Goals – Overview

This initiative will focus on research activities and outcomes intended to inform land use and social development alternatives in the Gourma region, consistent with the sustainable conservation of biodiversity in general and of the elephant population in particular. In so doing, the project should facilitate the eventual implementation of the "*Projet de conservation et valorisation de la biodiversité du Gourma (*PCVBG). Two major (1,2) and two minor (3,4) components are envisaged:

1. improved knowledge of elephant biology in the Gourma
2. collection of existing data on the region's ecology and development;
3. basic communication materials about this exceptional national heritage and its conservation needs; and
4. summary of potential for elephant-based economic development (in particular eco-tourism) as a means of benefiting local communities and providing incentives for protection of the elephants.

3. Summary of Progress

Objective 1 – Improving knowledge of elephant biology in the Gourma

This objective involves three major tasks: field research, data collection and analysis; building local capacity through training DNCN personnel; and community engagement.

Accomplished to date -- Dr Richard Barnes and Emmanuel Hema were in the field for 3 months in 2004 (mid-March to mid-June). They established and tested the research protocols, conducted basic research, and met with numerous local officials. They were accompanied for the entire field mission by Elmehdi Doumbia, and for part of the expedition by a DNCN official, Mr Mamadou Baga Samake.

In the period August – November, Dr Barnes analyzed his data (collected through interviews and biological transects), and finalized his report working with Dr Douglas-Hamilton (see attached). During September to December, Mr Hema underwent training by STE staff in Kenya, and he fully analyzed the photographic data and GIS data collected in the field. During several weeks of this period he was joined for training in Kenya by Mr Doumbia, from Mali.

A thorough start has been made on the elephant identification process, the baseline for all further biological knowledge of the herd. Specific photographic ID has been achieved for approximately 400 elephants, with a library established consisting of digital and hard copy photos of each elephant, and individual names established for some of them. The elephant range and the critical threat points along the migration were further explored, with continuing emphasis on this planned for 2005. While it is too early to publish findings or issue recommendations, it appears clear that the estimation of elephant numbers is closer to 400 than the original figure of 375.

Moreover the elephant range is composed of concentration areas or core zones where the elephants spend time seasonally feeding on the vegetation and narrow corridors that link one core zone to the next. The radio-tracking results have been examined carefully by Dr Douglas-Hamilton and Susan Canney to define the time that elephants spend in each zone and in the corridors. Although relatively little time, (7%) is spent in the corridors these are nevertheless very important to the survival of the elephants as they link one vital area to another. It is highly unlikely that the Gourma elephants can survive without access to their whole range reached by their long annual migration.

The training in Kenya supplied to Elmehdi Doumbia was very specific, and included techniques of how to approach elephants by car and on foot and how to recognize them individually. Working with Mr Emmanual Hema and Save the Elephants staff, Mr Doumbia also learned how to age and sex elephants, and how to take digital photographs that could be used in the photographic photo file.

Objective 2 – Data collection and analysis to identify priority areas and activities for elephant conservation

This project aims to show how the elephant's movements increasingly take place in a world dominated by human activities, and how it might be possible (thanks to funding for the PCVBG) to eventually limit the obstacles encountered by the elephants in reaching the open spaces and other resources vital for their survival. To that end, Dr Susan Canney (GIS specialist) worked from the UK, in collaboration with Dr. Stephen Cobb and Dr. Keith Lindsay of EDG, to locate and collate existing land-use and other relevant data.

Data have been collected and/or located on elephant presence (including historical range); water and forage (including satellite-derived information); intensity of human use/presence; the environment and ecology of the Gourma; and basic GIS map layers such as infrastructure and administrative boundaries. Satellite images contemporary with the elephant collar data have been processed to highlight features of relevance. Some of these data-sets are incomplete; however research and dialogue has identified means to remedy this during 2005. Despite this, enough data have been gathered to allow preliminary analyses that indicate how elephant movements relate to particular areas throughout the year and to aspects of human activity. These analyses have generated further questions and will be used to direct future research and data collection during 2005 (see work plan below).

Dr Canney then joined the team in Kenya and worked with Dr Douglas-Hamilton in integrating the radio-tracking data with the new data layers that she had collected in GIS format. She also helped train Mr Doumbia and Mr Hema in GPS field data collection techniques and protocols. Please see the attached draft GIS wall-map, and Dr Canney's summary report.

Objective 3 – Communication of Results

It is imperative that knowledge of the elephants, their migration routes, biological and other needs, and other information be readily available to decision makers within the Mali government and NGO's, and all involved, including international NGO's and aid agencies. It is the only way that future development will safeguard this irreplaceable national heritage. To that end, the field research team was joined by professional conservation photographer Mr Carlton Ward, who donated his time and services. The project paid for part of his expenses only. As a result, there is now available -- as part of both the research and outreach objectives – a professional quality photo library consisting of over 2000 digital images and transparencies. This will be part of the large database handed over to DNCN at the end of this project.

Mr Ward is currently working with The WILD Foundation to develop the first brochure for Mali officials and the concerned public. Published in both French and English, with a targeted availability date by March-April 2005, this tool will be circulated to all relevant agencies and NGOs in Mali. It will also be used for communicating abroad the international importance of these elephants, their unique value to bio-diversity conservation, and their importance to the sustainable economic development of Mali and its people.

In addition, initial agreement has been reached with at least one major international magazine – from the Smithsonian Institution, USA – to publish in 2005 a thorough overview of the Mali elephants.

Objective 4 – A review of the Eco-tourism Sector

Planned for completion by end of the project in 2005, and subsequent reporting. Initial information gathering has begun through investigating other extant models of elephant-related tourism, and by beginning to gather data on existing and historical human-elephant interaction in Mali.

4. Summary Of Work Plan, 2005

The field team will be in Mali from mid February 2005, for at least seven months. They will:
1. Improve the identification system for the individual elephants within the Gourma population, record the age structure, train personnel in field techniques
2. Collect data on the use of their geographical range by the elephants.
3. Record human elephant interactions
4. Organize a network of local observers

Dr Keith Lindsay from EDG will make a visit to Mali to monitor the project and liaise with DNCN, while Dr Susan Canney visits Bamako in order to compile GIS data sets as below.

Data will be emailed from the field as it is collected to STE and EDG, so that the field project can be monitored and guided. Data tables and maps will be compiled while the field season proceeds of elephant population dynamics, associations and trends, ranging behaviour and significant factors affecting elephant survival. By the end of the 2005 an analysis will be completed that will compare the age structure and reproductive health of the Gourma elephants with other known elephant populations, such as Samburu and Amboseli in Kenya. The field researcher will once again visit Samburu to complete a debriefing and analysis of data for inclusion in the final reports to DNCN. This will include a complete description of the core range areas of the Gourma elephants and connecting corridors with an assessment of the risks to each of these areas and recommendations on how to conserve the range and migration route of the Gourma elephants.

The second trainee will be selected by the consortium, in collaboration with DNCN, in February-March 2005. The trainee will join the team in the field for the remainder of the field season, and receive a practical course in basic elephant studies and field monitoring techniques.

Simultaneously Dr S Canney will continue the task of data collection and analysis by:
- a visit to Mali to locate additional datasets known to reside in Bamako such as the SSE GIS data and human and livestock census data;
- possible supervisory trip to the field to check on data collection protocols;
- obtaining and analysing additional satellite data;
- continuing GIS analyses to identify, refine and assess:
    - the extent of elephant range
    - the major threats and stresses to the elephants; where these occur and at what times of year and day
    - priority elephant needs throughout the year

- priority areas for intervention/development control to manage existing conflict and prevent future conflict
- areas of uncertainty

Dr K Lindsay will support the field work by a 2-week site visit within a few weeks after the field team begins its work. He will monitor the methodology of the elephant research and ensure that the data collection system is operating smoothly.

A review of project progress will be conducted in the field (possibly in April), and in further meetings in July-August. At that point an assessment will be made of concerning timeline for analysis, reporting, and submission to DNCN officials.

We believe that radiotracking of additional elephants would add greatly to the understanding of the movement patterns, habitat requirements and management needs of the population. In accordance with the wishes of the DNCN, we would seek additional funding as appropriate to extend the activities of the project in this area.

Field Research Report
March - June 2004

Richard F.W. Barnes
Emmanuel M. Héma,
Elmehdi Doumbia
Mamadou Baga Samaké

November 2004

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Abbreviations andAcronyms

DNCN	Direction Nationale de la Conservation de la Nature
GIS	Geographic Information System
GPS	Global positioning system

1. Executive Summary

Two months (March to June) were spent in the Gourma during the late dry season. The first month was spent moving from place to place in the north-eastern part of the elephants' range. Only bulls were seen during this phase. During the second month we based ourselves at Banzena where both males and females were seen.

Elephants usually spent the daylight hours in thick vegetation where it was too hazardous to follow. Nevertheless, a large number of photographs of elephants were obtained, but at the time of writing most have yet to be sorted into identification sheets.

A series of transects around Banzena to estimate range use showed that elephants used a limited area around the lake. Once one has accounted for proximity to water, it is the number of tree and shrub species that determine where elephants spend their time. There was an inverse relationship between cattle abundance and elephant occupancy.

The same methodology should be applied over the whole dry season range to elucidate the relationships between elephant range use and landform, vegetation, livestock and human activities. The wet season migration corridors need to be accurately mapped with GPS over several wet seasons. It is essential that potential threats and choke-points be identified.

The first steps were also taking in establishing a photo-identification file and about 2000 digital images were taken of a large proportion of the Gourma elephant population

2. Introduction

The Gourma holds the last remaining elephants in Mali and the last Sahelian elephants, recently estimated at 350 (Blake *et al*., 2003). This population has evolved a nomadic strategy that includes a unique migration circuit. During the last three decades the changing rainfall pattern, increased settlement, expanding agriculture and developments such as the construction of a new road, have affected the elephants and are likely to have a greater impact in the years to come. There will be increasing conflict as people and elephants compete for access to water and land, and elephants are attracted to the spreading agriculture (Olivier 1983; Jachmann 1991; Pringle and Diakité 1992; Blake *et al*., 2003).

A consortium made up of the Wild Foundation, Save the Elephants and the Environment & Development Group and signed an agreement with *la Direction Nationale de la Conservation de la Nature* to undertake an ecological study of the Gourma elephants in order to provide technical information that will form the basis for their conservation. This report covers the first phase of the project, from late March to early June 2004, representing the late dry season.

The project's Terms of Reference are shown in Annex 1. Chapters 3 and 4 describe the activities in the field, and then at the end of each chapter the tasks prescribed by the TOR are addressed. One should note that in two months one could not address all the tasks set out for a 15-month project. Some tasks require that a previous task be completed first.

During the dry season the elephants occupy the northern half of their range, north of the Douentza-Hombori-Goa road (Fig. 1). They depend upon a series of small lakes that usually dry out partially or completely as the season progresses. During the first week of April we made a trip around the elephants' dry season range to introduce ourselves to the administrative authorities and to the local people. We visited Douentza, Boni, Hombori, Gossi, Inatiadafane, Bambara-Moundi, Banzena and Kikara. For the rest of April we travelled in search of elephants, starting in the north-east, and familiarizing ourselves with the terrain and conditions at that time of year. In May we based ourselves at Banzena. Except for a day spent in the *Porte des Eléphants* and south of Boni, we were not able to explore the elephants' wet season range.

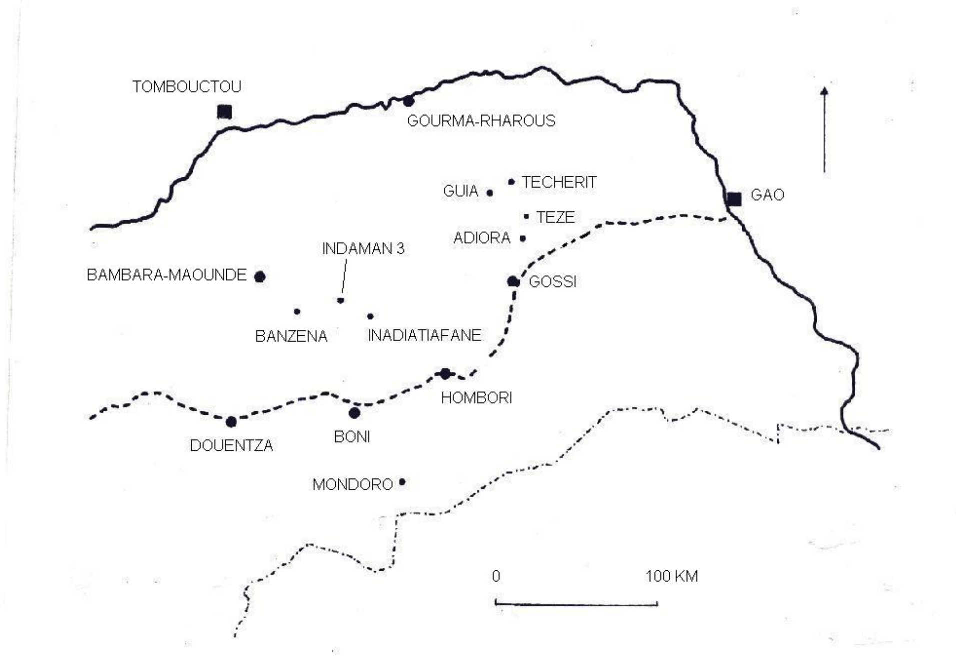

Figure 1: Map of the Gourma showing places visited during May and June 2004.
_ _ _ _ _ major road; ______ Niger River;Identification des individus

3. Identification of Individuals

3.1 Nomadic phase

We started our search for elephants at Adiora (see Fig. 1), on the eastern side of their dry season range, where a group of bulls was living around the *mare* (pool or lake). After spending two days there we moved northwards to Techerit, where a large number of elephants---perhaps a hundred---had been reported. In fact the elephants moved away from Techerit a few days before our arrival. However we stayed for three days in order to explore this area where they had spent about five months.

The Techerit pool was surrounded by dense thicket or dry forest 6 km long and 0.7 and 1.8 km wide. There was still a small pool of surface water left at this stage. Nomads watered their livestock during the day, but in the evening and at night the elephants had unimpeded access to the pool. The abundance of dung showed elephants clearly spent much time in the forest. They also browsed in the bush in the *bas-fond* several km to the north. The water was drying up rapidly, and it seemed that they had left sometime in the first week of April.

The absence of elephants enabled us to work safely in the dense forest. The abundance of dung provided the opportunity to estimate the age structure of the herd, and especially the proportion of young (see Annex 2a).

We then visited Guia where there is another *mare* surrounded by dense vegetation (Fig. 1). By then the lake was completely dry and there were no elephants there. We moved on to Tézé (Fig. 1) where we found four bulls in dense bush. We photographed them when they emerged for water. We then returned to Adiora because there were still two bulls that we had not yet photographed. We eventually found them several km to the south, at the Hekia pool with the other bulls. They were all moving steadily down the drainage system towards Gossi. It is possible to follow the movements of groups of animals by obtaining information on their whereabouts from the nomads, and then searching for their tracks. We tried to get ahead of the elephants so that we could photograph them at their next waterhole. However they visited the waterholes at night, to avoid livestock and people. We did not see them again until they reached the lake at Gossi where they joined other bulls that were already there.

We stayed at Gossi for several days until we had identified 9 bulls. The elephants spent much of the daylight hours in seasonally-inundated woodland on the edge of the lake. The lake was retreating and muddy creeks hindered the approach to the elephants, or threatened to cut off one's line of retreat. Further, the drying crust of mud crackled loudly as we walked upon it, alerting the elephants to our presence and increasing the hazards in following them, and so we withdrew.

Only adult males were seen during this phase in the north-east.

From Gossi we traveled to Inadiatafane where the wildlife photographer Carlton Ward joined us on 26th April. We then moved on to Banzena where we camped for the whole of May.

3.2 Benzena

We based ourselves at Banzena (Fig. 1) because we believed that most of the Gourma elephant population concentrated there during the last weeks of the dry season, and that they can be easily seen at the lake in daylight. Neither of these assumptions held in May 2004.

There had been a heavy fall of rain on the night of 28/29th April. When we drove to Soma, just east of Banzena, on 30th April we found pools of water everywhere, and even one flowing watercourse. As a consequence, all the elephants left Banzena. During the next few weeks they gradually returned, but it is unlikely that the whole population was there, and no elephants were seen at the lake during daylight in May. Rather, during the day they stayed in the thick bush in the watercourse to the east of the lake, or in one of the dense nearby forests (Tabarac-Tabarac and Bamako) and came to the lake only at night. We saw elephants in daylight at the lake only on 5th June, the day we left Banzena.

We spent two days at Indaman Trois where there was a large group of elephants that came to the water holes around midday. At that time the wind was blowing strongly from the north, but there were occasional gusts that created eddies in the dense forest that carried our scent to the elephants, however careful we were to remain downwind. It was too dangerous to observe elephants under those conditions and we withdrew.

The Gourma elephants often flee at the first sign of vehicles. Thus they can only be observed by following them into the thickets where they spend the day, or waiting at dawn and dusk until they emerge. We worked in a team of three: one took photos, one drew sketches, and the third kept a look-out. Although bulls can be easily followed and photographed in the bush because they are usually alone or in small groups, there is the danger of being surprised by other elephants quietly feeding to one side or approaching from behind. Thus we avoided following bulls into thick bush. The families were often clustered into large groups in the forests, and following and observing them in dense vegetation involved risks that we were not prepared to take.

Nevertheless, we took over a thousand photographs at Banzena. However, many of these are multiple pictures of the same individual. Far fewer sketches were made because one was frustrated when elephants changed position or shifted out of view before sketches were complete. Many individuals were photographed only from one side. Sometimes one can match photographs of left and right if the animal has a distinctive tail or some other feature. The photographs will be organized, and identification sheets made, during July and August.

Table 1: Tasks related to identifying and recording the individual elephants within the Gourma population.

Objective 1: Identify and record the individual elephants within the Gourma population

Task 1.1. Establish a mobile team of technicians:

a) select team members (including 2 DNCN);
b) acquire appropriate equipment and provide it to the team.

Successes: We established a mobile field team with two vehicles, drivers and a cook. The team worked smoothly and efficiently. The two DNCN partners were M. Mamadou Baga Samaké and M. Elmehdi Doumbia.
Constraints: None
Recommendations: The same drivers and cook should be employed in subsequent phases because they are good workers and understand the exigencies of this sort of field work (early mornings, late evenings, long days and rare weekends).

Task 1.2. Train the team in photographic data collection methods.

Successes: The team was partly trained in Samburu. About two thousand photographs were taken in the field, mostly at Banzena.
Constraints: The Nikon D camera is a super-sophisticated and complicated piece of equipment that we had never used before. For the first three weeks the camera was unpredictable, and often it did not work properly. A number of good photographic

opportunities were lost during our travels in the north-east because the camera failed at the critical moment.
Recommendations: It was a mistake to go into the field before we fully understood this particular camera. It has a large number of switches and one needs to properly understand the settings for each switch in order to use it properly. Either one should use a simple camera in the field, or one should have a long period of practice beforehand.

Task 1.3. Establish the photographic database.

Successes: Over a thousand photographs were taken; but many are repeat photos.
Constraints: An immense amount of time was spent, day after day, searching for elephants, in the vehicle and on foot.
The elephants were usually in thick bush during the day.
Approaching elephants in thick bush, and remaining close for long enough to make sketches and get adequate photographs is extremely hazardous, and we were not prepared to take those risks.
The computer was not working for some of the time because we could not charge the batteries with the solar power system. We did not get the computer working regularly until mid-May. Consequently by the time we solved that problem we were overwhelmed by the number of photographs.
The elephants at Banzena have complex ears and one has to get the angle just right in order that the photograph shows the all the folds, tears and holes.

Task 1.4. Arrange training events for other DNCN staff, providing both training and information.

We have discussed the possibility of a training course to be held at Gossi in early 2005, for up to half a dozen of the DNCN staff stationed in the Gourma, lasting perhaps three weeks.

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4. Elephants' Use of Range

Since most of our time was devoted to finding elephants and trying to observe them, and our activities were concentrated in the northeast and Banzena, we were able to invest little time in investigating ranging behaviour.

We did, however, make some observations of their small-scale use of range around Banzena. While waiting for the large group at Indaman Trois to move to Banzena, we ran a randomly-placed pilot transect north from the Banzena lake. The purpose was to see how elephants were distributed in the dune system to the north of the lake. We intended to walk 15 km north of the lake, but we stopped early because there were no signs of elephants after 6 km. This was a surprise because we had assumed that elephants browse within a large radius of water However, it was at least 1km further than the furthest radio-tracking elephant trail . In addition, the transect suggested that elephants avoided areas where livestock---and especially goats---were abundant. Note how the highest elephant dung density was recorded where there were few goats (Fig. 2). This appeared to contradict the current belief that elephants and livestock co-exist in the Gourma. It also suggested that goats might be the reason for the absence of elephants after 6 km (Fig. 2). We also noticed that elephants were attracted to those areas in the dunes with high densities of trees and shrubs, and that they avoided the zone of *Leptodenia pyrotechnica* that covers the dunes closest to the Banzena lake.

In order to clarify these points, at the end of May we planned a series of transects that would show the elephants' use of space around the lake (see Annex 2c). Forty transects were run, and 652 dung-piles were recorded. We ignored the transects that fell in thick forest where we knew elephants were present (e.g. Tabarac-Tabarac) because of the risk. For each transect we recorded the numbers of individuals of each tree and shrub species as well as the density of dung for each species of livestock. The density of elephant dung is assumed to be a measure of elephants' occupancy. See Annex 2c for details of methods and results. The transects confirmed that elephant density declines with increasing distance from the lake, and that there were no signs of elephant browsing after 6 km to the north of the lake. This was corroborated when we saw no droppings when we drove on an east-west line at a distance of between 6 and 7 km parallel to the lake. Similarly, when driving north to Tomboctou we saw no signs of elephants beyond 5 km from Banzena. On the south side of the lake there were some signs of elephants between 6 and 7 km because elephants move regularly from Banzena to other forests and thickets to the south.

Similarly, when driving north to Tomboctou we saw no signs of elephants beyond 5 km from Banzena. On the south side of the lake there were some signs of elephants between 6 and 7 km because elephants move regularly from Banzena to other forests and thickets to the south.

The transects reveal how the distribution of elephants around the Banzena lake is influenced by the vegetation: elephants are attracted to those areas with a high diversity of tree and shrub species, and they avoid the degraded patches where *Leptodenia pyrotechnica* is common (Annex 2c). The hypothesis that elephants avoid areas of high goat abundance was firmly rejected. Indeed, there was a positive correlation with both goats and sheep. On the other hand, there was an inverse relationship between elephants and cattle (Fig. 3) showing that elephants avoid areas used by cattle. A similar result was obtained by Sam *et al.* (2002) in the Red Volta valley in northern Ghana.

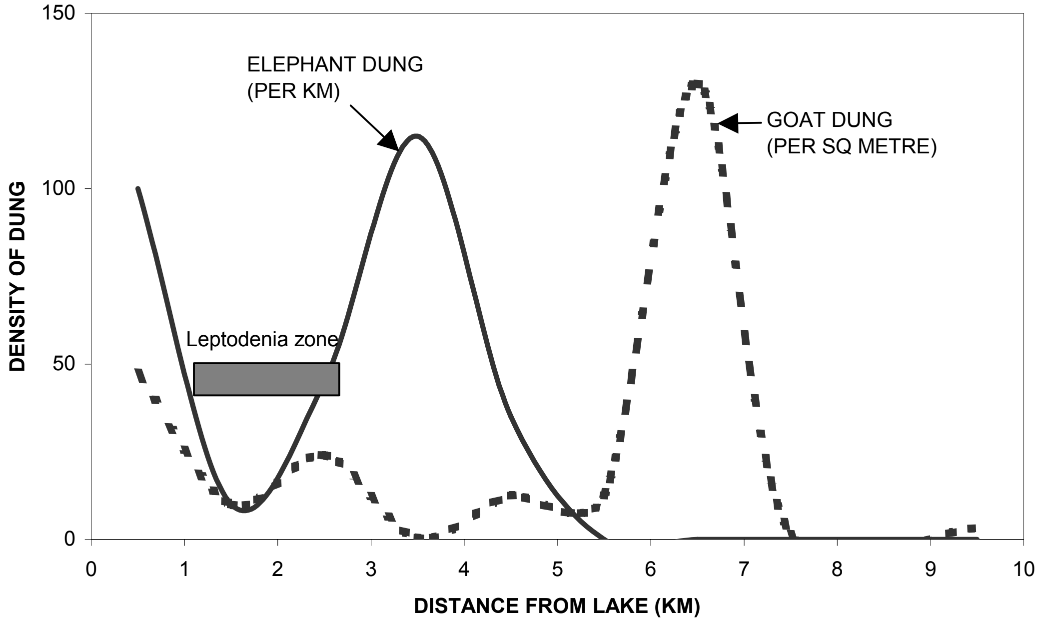

Figure 2: The results from the pilot transect that ran due north from the edge of the Banzena lake, showing the densities of elephant dung (expressed as numbers of dung-piles seen per km of transect) and goat dung (expressed as numbers of pellets recorded per sq metre).

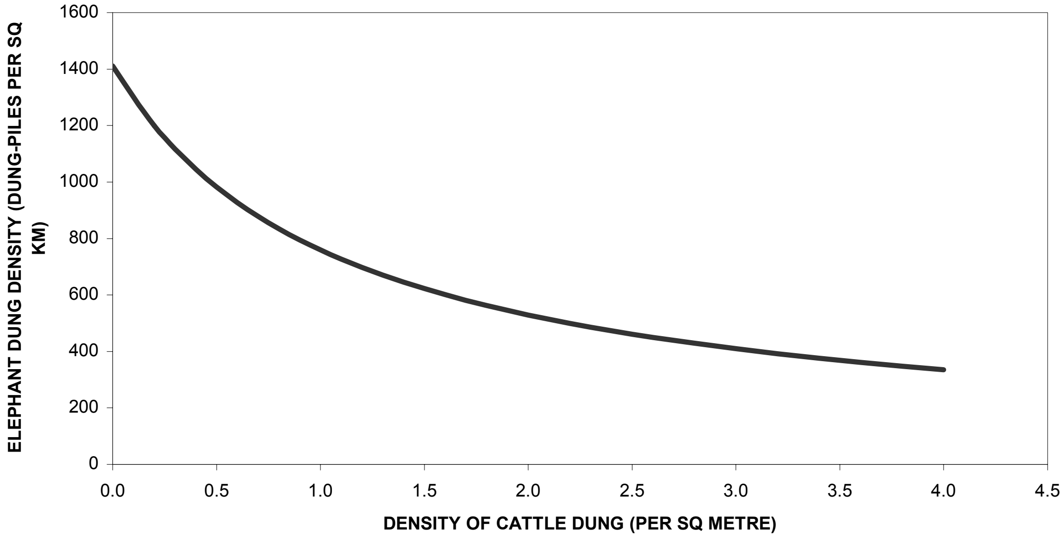

Figure 3: The relationship between elephant distribution and cattle abundance after accounting for distance from water (see Annex 2c).

Table 2: Tasks related to collecting data on the use of their geographical range by the elephants.

Objective 2: Collect data on the use of their geographical range by the elephants.

Task 2.1. Develop a simple and reliable protocol for collection of elephant sightings, including incidents of human-elephant conflicts.

Successes: We have not yet addressed this issue: this will be very demanding of time and resources (see Recommendations below).
Constraints: Exercises of this sort risk becoming an index of the ranging behaviour of the observers rather than (as claimed) a measure of the ranging behaviour of the animals.
The wet season is the period of human-elephant conflict.

Task 2.2. Organise a network of local observers.

Successes: We have twice visited *les Amis des Elephants de Boni*, and discussed on site the possibility of a system for observing the movements of elephants through *la Porte des Eléphants* during the wet season.
Constraints: The photographic database is not yet operational.
Establishing this network will consume a large amount of time and effort.

Task 2.3. Confirm the reliability of the observer network.

Depends upon the above.

Task 2.4. Establish a protocol for collection of data on changes in plant resources.

This is a huge but very important topic. We have barely started to think about it; we have not yet seen the southern half of the elephant range. Thought needs to go into exactly what questions are to be addressed, what plant resources are to be evaluated, the sampling scheme, the methods, the time and the resources that will be available.

Task 2.5. Collate all information on elephant deaths, historical and current.

We have not yet started to look at historical records.
The two DNCN members of our team are the MIKE field officers for Mali.

Task 2.6. Collaborate with MIKE, facilitate MIKE's objectives through liaison and provision of information.

See above.

Task 2.7. Assist MIKE team where appropriate.

See above.

Task 2.8. Explore the feasibility of round-the-year monitoring of elephant movements on the ground.

We proposed that we should follow the elephants along their wet season migration route to the south. The team would have a logistical base at Mondoro from which it would operate on camels. We are liaising with the Burkinabe team working on the other side of the border. In the 2005 dry season it will be possible to monitor the movements of elephants between sites such as Techerit, Inadiatafane, the Indamans and the other watercourses and forests that we did not explore during this trip.

Table 3: Objectives and tasks related to interpretation of the collected data

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Objective 3: Interpret the collected data.

Task 3.1. Develop a data analysis framework for analysis of population, distribution and ecological data.

See section 5.3.2.

Task 3.2. Produce periodic reports on the results of the analyses, in collaboration with others.

See Annex 2.

Task 3.3. Produce two scientific papers, in collaboration with others.
Make recommendations on publication strategy and information dissemination in any media.

Scientific papers not done yet, but Carlton Ward has made suggestions for a publication in the prestigious Smithonian Magazine

Task 3.4. Contribute to the project's Final Report.

Task 3.5. Facilitate the development of a Malian national elephant strategy, and work with AfESG and the Mali and Burkinabe authorities to develop the transfrontier corridor action plan drawn up in Ouagadougou in June 2003.

We have made contact with the leader of the Burkinabe team working on the southern side of the frontier. We had expected to collaborate with his team during this wet season.

Task 3.6. Provide information to DNCN to pass on to the African Elephant Database.
Not done yet

Task 3.7. Provide material for STE's website
Not done yet

Task 3.8. Recommend future directions for elephant research and conservation to WILD/STE/EDG consortium.

See section 5.3.2. and 5.4.

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5. Discussion

5.1 Population dynamics

We had been told that the best opportunities for photographing and identifying elephants would be at Banzena in the late dry season. However, this year they did not come to the Banzena lake in daytime. We spent considerable time searching for elephants. During the day they remained in the thick bush where it was too dangerous to approach them. In addition, when they were in large groups in thick bush one could only observe an individual for a few minutes before it moved behind another individual. If the animal reappeared a little while later facing in a different direction, often one could not be sure that it was the same individual or a different one. If the elephants remained in view for a long time, then one could sometimes resolve the question, but often they moved deeper into the thicket. Further, when families grouped together, one could not tell which female belonged to which family, or which juveniles belonged to which females, and so one could not identify individual families. Thus we doubt whether the late dry season is the best time to identify individuals. This task may be easier when the large groups dissolve into their respective family groups in the wet season. On the other hand, at that time of year visibility may be worse because of the dense foliage, and one will have to avoid the further hazards of approaching elephants in muddy conditions.

The Gourma situation provides ideal conditions for using indirect methods for estimating age structure: dung bolus and footprint measurements (Annex 2a and 2b). When elephants spend much time in thicket as at Techerit, the dung remains once they have moved on. There is no evidence for differences in defaecation rates between animals of different ages, except perhaps for infants (Coe, 1972; Jachmann & Bell, 1984). The figure of 2.3% for infants (< 1 year old) is probably an under-estimate because of infants' lower defaecation rate, and because their small boli disintegrate more rapidly (Jachmann & Bell, 1984). These factors will remain constant, and therefore changes from one season to another in the proportion of the smallest dung-piles will reflect birth and infant survival rates. These methods can therefore be used to monitor these parameters from year to year. Reilly (2002) points out the advantages of using dung measurements to estimate age structures, in particular because they provide an unbiased estimate since they are not affected by the behaviour of the animals (such as some groups being more visible than others).

Sand or dust forms much of the substrate of the elephants' dry season range and is ideal for measuring footprints. But infants may be under-represented if their footprints are obscured by the mother's.

However, in the case of our study we will be using direct aging techniques on the living population to acquire the age structure.

After a dry season that lasts more than eight months, and with shade temperatures that reached 46 °C, one would have expected to find elephants in poor condition. But in fact most were still in good condition during May. This is a consequence of the abundant rains in the 2003 wet season (Fig. 4). The resulting abundant green browse enabled the elephants to put on weight and this seems to have carried them through this dry season. Also, many water sources filled up and lasted longer during the 2004 dry season, so elephant movements were less restricted by water availability in the dry season. As a consequence, they could feed for longer in places that they would normally have to abandon in the dry season (such as Indaman Trois).

5.2 Effects of elephant browsing

Blake *et al* (2003) noticed that browsing pressure is often heavy upon certain species, such as *Balanites aegyptica* and *Acacia radiana*. Fig. 8 (in Annex 2c) shows that there were a large number of elephants browsing within a short radius of the lake. Some trees were unlikely to recover during the next wet season. Although we saw a few seedlings and saplings, regeneration seemed inadequate to replace the heavily-browsed adult trees. Elephants frequently browsed on the shrubs between our camp and the lake, and we noticed a marked reduction in the shrub canopy in the month that we were there. This raises the question of the trend in the woody vegetation around the lakes and whether elephants are contributing to its decline (Blake *et al.,* 2003).

5.3 Ranging behaviour

5.3.1 Habitat use around Banzena

Since elephants are very mobile, we were surprised to find that they use only a small area around Banzena. This could suggest that there is enough browse for them close to Banzena, or perhaps travelling further than 6 km from water is too stressful during the late dry season, especially for the infants.

We did not have time to examine elephants' use of the areas around the other lakes such as Inatiadafane, Indaman Deux and Indaman Trois, or the other forests and thickets further to the south of Banzena. If elephants browse within a similar radius, then it means that they are using a much smaller proportion of the available range than we had supposed, at least in the late dry season. If elephants need to use only a small part of the landscape during the dry season, then it means that there is greater opportunity for people and elephants to avoid each other. On the other hand, if livestock and elephants both need the same resources of browse and water, then it increases the likelihood of competition, and makes it more likely that human activities will disturb elephants.

When calculating the carrying capacity of the Gourma for elephants, both Olivier (1983) and Jachmann (1991) assumed that elephants forage over a much larger area than we have found here. Our results suggest that in the second half of the dry season elephants are using a smaller fraction of the landscape than previously thought, and therefore calculations of carrying capacity need to be revised. On the other hand, 2004 was an atypical year, and we must establish whether the same pattern of habitat use obtains in other years.

5.3.2 Habitat use on a large scale

The transects (Annex 2c) proved to be a quick and efficient means of collecting information on elephant habitat use. They were walked just before the rains arrived, and since little dung decays during the long dry season, they represent the accumulated index of elephant distribution or occupancy around Banzena during that long dry period. The method is quick and simple, little equipment is needed (a GPS, measuring tapes and notebooks), and DNCN staff can be quickly trained to do this work. In less than a week we collected an enormous amount of data that showed the ecological variables that are important to elephants: the relationship with each species of livestock, with the vegetation community (e.g. woody species diversity), and with particular tree species, both positive (e.g. *Acacia spp*.) and negative (*Leptodenia pyrotechnica*).

Although we ran these transects only in the immediate area around Banzena, this method can be applied on a much wider scale to show range use over the whole Gourma ecosystem in the dry season. Such an analysis would require a grid to be superimposed over the map of the study area and a transect walked in each grid cell. The same data would be collected, plus extra information such as soil type, grass layer, distance to nearest road or village.

These data would then be integrated into a geographic information system (GIS) to show the relationships between elephant occupancy and large-scale features such as soil, landform, vegetation types, human settlement, roads, and livestock distribution. Mathematical models relating these variables could then be used to fill in gaps where transect data could not be collected.

The GIS will then become a valuable tool for land use planning. For example, the effects of ecosystem changes could be modelled to make predictions about the effect of future developments and habitat changes on elephants. For example, once could ask questions such as: what will be the effect on elephants of a 50% increase in cattle numbers? How would the elephants be affected by the construction of a road between A and B?

The transects can be repeated easily at regular intervals (e.g. every two or three years), and the data from each year incorporated into the GIS. As the system changes, for example if cattle densities increase, or certain tree species change in abundance, the effects on elephants will become clear. In other words, this will provide a simple and efficient method for monitoring the effect of ecological changes in the Gourma.

5.3.3 Corridors

In this harsh environment, elephants' use of space is critical to their survival, especially during the dry season when there are few sources of water. Elephants are able to survive in the Gourma because they are mobile and can exploit ephemeral resources of food and water. Any developments (for example, road construction or new cultivation) that prevent their free movement, or restrict access to forage or water resources, will adversely influence their survival probabilities. It is the infants that are the first to suffer when elephants are obliged to travel long distances in search of water or forage during the dry season (see, for example, Barnes, 1983), leading to a higher rate of infant mortality.

Although several authors have drawn rough maps showing elephants' movements (e.g. Lamarche, 1978; Barbier & Perrier, 1990; Jachmann, 1991), we now have more precise maps from the radio-tracking that show the exact corridors used by elephants. Using this and other data acquired from our ground surveys we can now identify potential threats and choke-points be identified. None of the earlier workers had GPS units that can now be used to map precisely the movement corridors so that they can be protected. This sort of mapping exercise should be conducted over several years, because elephants vary their routes according to annual variations in rainfall, and the radiotracking (Blake *et al* 2003) shows that different individuals use different routes.

5.4 Ecological changes

Environmental degradation is an important issue in the Gourma (Olivier 1983; Jachmann 1991; Pringle and Diakité 1992; Blake *et al*., 2003). The woody vegetation cover has decreased---i.e. fewer trees and shrubs; in some places there are large areas of dead trees ("woodland cemeteries"); there are large areas of gravel plain ("armour layers" [Stocking & Murnaghan, 2001]) which have lost their soil cover and that are even visible on satellite images; there is a bare overgrazed ring around the Banzena lake; silting of the lakes from wind-blown sand and dust is an issue; there are large areas covered only by *Leptodenia pyrotechnica*, a species characteristic of dry degraded soil; and the DNCN staff believe that bush fires are becoming more common.

The main drivers of ecological change are variations in the rainfall pattern and human activity. So far we have only been able to obtain the rainfall records for Mopti (Fig. 4). Mopti lies outside the elephant range but probably reflects the pattern for the Gourma. Figure 4 shows a declining trend from the 1950s to the 1980s. The falling water-table, as a consequence of the declining rainfall, probably explains the dying woodlands. However, during the last ten years the rainfall has increased and has been much more variable (i.e. more unpredictable) than during the preceding decade. For example 2002 had the lowest rainfall in fifty years while 2003 was the highest since 1965.

In the 1990s the human population of the Gourma declined (*Atlas du Mali*, 2001). It is not clear to us whether the nomad population, or the livestock population, is currently increasing or stable. Our transects suggest that elephants avoid cattle (Fig. 3), but not goats or sheep (Annex 2c), and thus any increase in cattle will affect elephants. The relationship between elephants and cattle deserves further study.

The transects also showed a strong positive relationship between elephant dung and the abundance of favoured tree species, such as *Balanites aegyptiaca* and *Acacia spp*., and with the total number of woody species (see Annex 2c). If over-browsing (humans coppicing for livestock feed, or by goats or elephants directly) reduces the abundance of these trees, or if over-grazing and fire reduce the number of tree species, then the carrying capacity for elephants will be reduced.

Since Lamarche's (1978) work, most studies of the Gourma elephant population have been short, lasting two or three months. Given the importance of this population and the widespread interest in its conservation, a long-term study is necessary. Such a study should take a broad view, looking at the general ecology of the Gourma, how the Gourma is changing, and how the changes will affect elephants. Key questions concerning elephants' use of space are:

1. How do elephants use the land?
2. How much space is available to them?
3. What is the ecological condition of the available range (i.e. what is the carrying capacity?)
4. What is the trend in the condition?
5. How are each of the issues above influenced by human activities?

It is clear that the land has been degraded, and one may pose a related set of questions:

6. Is environmental degradation continuing, and if so at what rate?
7. Is it spreading to affect a wider area than at present?
8. How will it affect elephants?
9. How can it be managed to reduce its effect upon elephants?

The issue is complicated by the year-to-year variation in rainfall. This means one must plan for the worst years rather than the average.

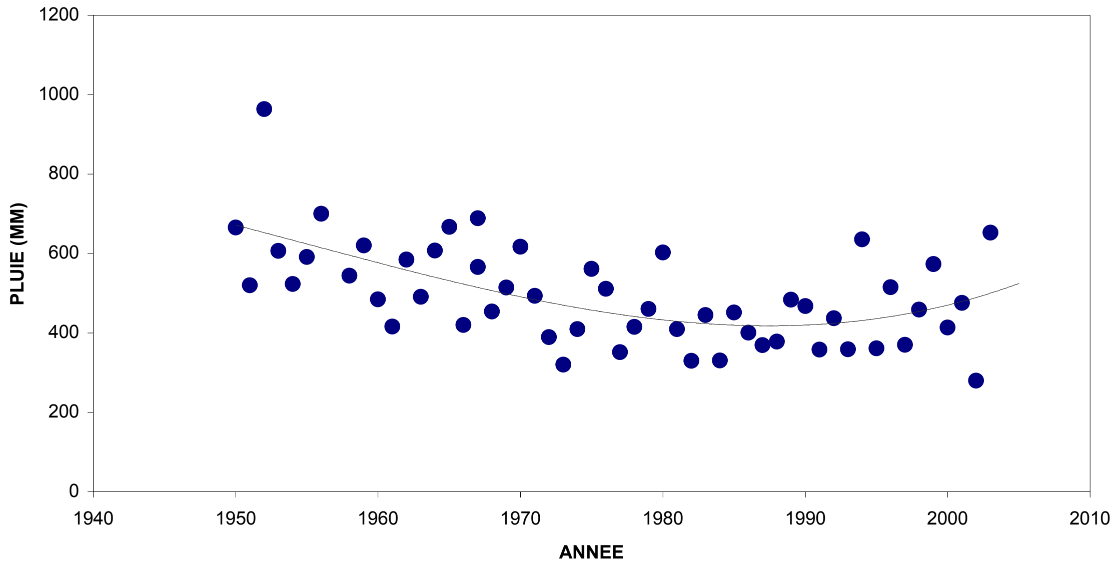

Figure 4: Rainfall figures for Mopti for 1950 to 2003, kindly provided by the Meteorological Officer at the Mopti Airport.

5.5 Disturbance by tourists

This elephant population is unusual – if not unique – in the manner in which its behaviour has been altered by tourists. Their avoidance of motor vehicles might suggest that they have been hunted from cars (Olivier, 1983), but this does not seem to be the case at present. Rather, tourists in cars chase and harass elephants while trying to get close in order to snap photographs. As a consequence, they flee at the first sign of an approaching vehicle.

6. Acknowledgements

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Dr. Francis Lauginie made all the preparations that enabled us to get into the field very rapidly. Our mobile team consists of M. Ibrahim Touré, M. Mourtada Diallo Papa and M.Lauka Poudougou: they worked long hours without rest days to keep us in the field. Mr. Carlton Ward solved the practical problems with our camera and provided much valuable advice on the technical equipment.

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Annexes

Annex 1: Terms of Reference

	Task	Timing and outputs
1.	***Identify and record the individual elephants within the Gourma population.***	
1.1	Establish a mobile team of technicians: a) select team members (including 2 DNCN); b) acquire appropriate equipment and provide it to the team.	Technical team established and collecting photo data by end of week 2 of field work.
1.2	Train the team in photographic data collection methods.	
1.3	Establish the photographic database.	Photographic database of a minimum of 200 individual elephants within the Gourma population, developed and used by field team including DNCN staff by end 2004.
1.4	Arrange training events for other DNCN staff, providing both training and information.	Training courses for DNCN staff during 2005.
2.	***Collect data on the use of their geographical range by the elephants.***	
2.1	Develop a simple and reliable protocol for collection of elephant sightings, including incidents of human-elephant conflicts.	Data on the use of their geographical range by the elephants collected by technical team by end 2004.
2.2	Organise a network of local observers.	Network of >= 30 observers established and equipped with set of ID photos by end 2004.
2.3	Confirm the reliability of the observer network.	Data collected by observer network by end June 2005
2.4	Establish a protocol for collection of data on changes in plant resources.	
2.5	Collate all information on elephant deaths, historical and current	
2.6	Collaborate with MIKE, facilitate MIKE's objectives through liaison and provision of information	
2.7	Assist MIKE team where appropriate	
2.8	Explore the feasibility of round-the-year monitoring of elephant movements on the ground	
3.	***Interpret the collected data.***	
3.1	Develop a data analysis framework for analysis of population, distribution and ecological data.	Analysis and interpretation of the collected data completed by

		end 2004 for technical team, and mid 2005 for observer network.
3.2	Produce periodic reports on the results of the analyses, in collaboration with others.	
3.3	Produce two scientific papers, in collaboration with others. Make recommendations on publication strategy and information dissemination in any media.	
3.4	Contribute to the project's Final Report.	
3.5	Facilitate the development of a Malian national elephant strategy, and work with AfESG and theMali and Burkinabe authorities to develop the transfrontier corridor action plan drawn up in Ouagadougou in June 2003.	
3.6	Provide information to DNCN to pass on to the African Elephant Database.	
3.7	Provide material for STE's website	
3.8	Recommend future directions for elephant research and conservation to WILD/STE/EDG consortium.	
4.	***Field project management***	
4.1	Manage project funds in Mali, accounting to EDG for expenditure against advances.	Accounting to be on a monthly basis, submitting accounts as regularly as possible under field conditions.
4.2	Submit brief progress reports to STE and EDG for formatting and circulation: the main body of the report, suitable for circulation to project partners in Mali, should be in French whilst Annexes for restricted distribution (Wild Foundation, STE, EDG and US Embassy) can be in English.	Monthly.
4.3	Maintain close contact with national, regional and local administrative authorities.	As required.
4.4	Assume responsibility for the success of the project in the field and maintaining the reputation of all project partners.	As required.
4.5	Conduct this work within the framework of the Protocol d'Accord between the DNCN and the Wild Foundation/EDG/STE	

Annex 2: Technical Annexes

Annex 2a: Frequency Distribution of Dung Sizes at Tesherit

The Tesherit pool was surrounded by dense thicket or dry forest 6 km long and between 0.7 and 1.8 km wide. The abundance of dung showed that elephants had spent much time in the forest. The absence of elephants enabled us to work safely in the dense forest, and the abundance of dung provided the opportunity to estimate the age structure of the herd, and especially the proportion of young.

For each sex there is a correlation between the circumference of dung boli and age. The relationship is similar for males and females up to about 8 years (Jachamnn & Bell, 1984). Assuming that each elephant has an equal probability of its dung being included *x* times in the sample, then a random sample of the forest should provide data that can be compared with similar data collected in subsequent years. If the young are born only during the wet season (i.e. seasonal birth-pulse) then by using the same method at the beginning of the wet season and at the end one can estimate the number of young born during that season. Comparison with a similar survey at the end of the subsequent dry season will provide an estimate of the proportion of infants that died during the dry season. Therefore we established five random transects that ran east-west across the forest. A total of 837 dung-piles were found and measured. The size-frequency distribution is shown in Fig. 5. The dung-piles larger than 60 cm represent the largest bulls. Those at 25 and 26 cm probably represent animals born during the 2003 wet season, and the smallest dung-piles represent infants born since then. Thus 2.3% of the dung-piles came from animals that were less than one year old.

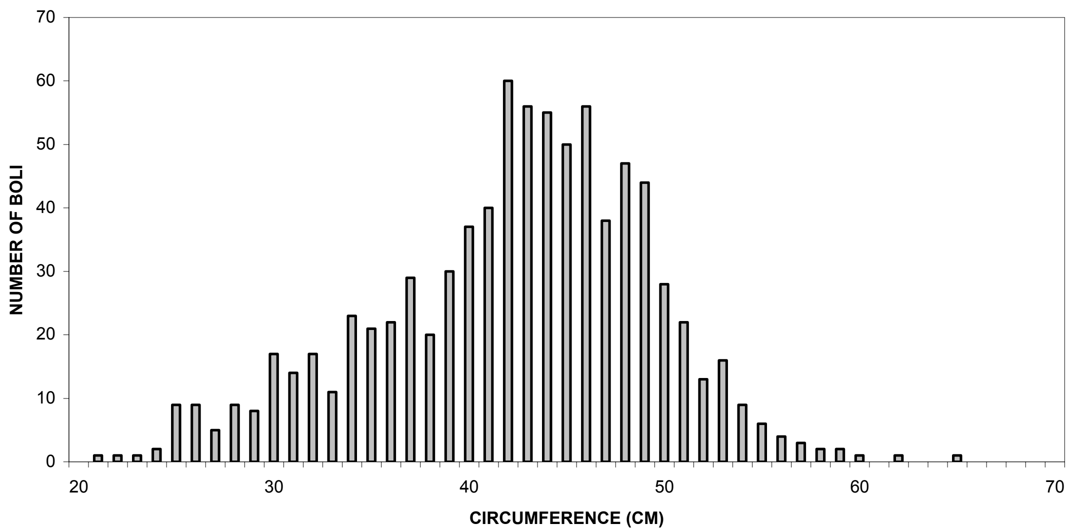

Figure 5: Frequency distribution of measurements of dung boli at Tesherit in April (n = 837).

Annex 2b: Footprint Measurements at Banzena

On the night of 31st May we heard a large group of elephants cross to the north side of the lake. The next morning we found their footprints heading north-west across the dunes. They had spread out and their clear footprints in the sand allowed good measurements to be made (Western *et al*, 1983; Lee & Moss, 1995). We measured the footprints of 85 individuals (Fig. 6). The 3 smallest prints probably represent those born in the last year (i.e. 3.5% of the sample), and those of 23 and 24 cm those born in 2002, while those between 26 and 31 cm may represent the animals born between 1997 and 2001.

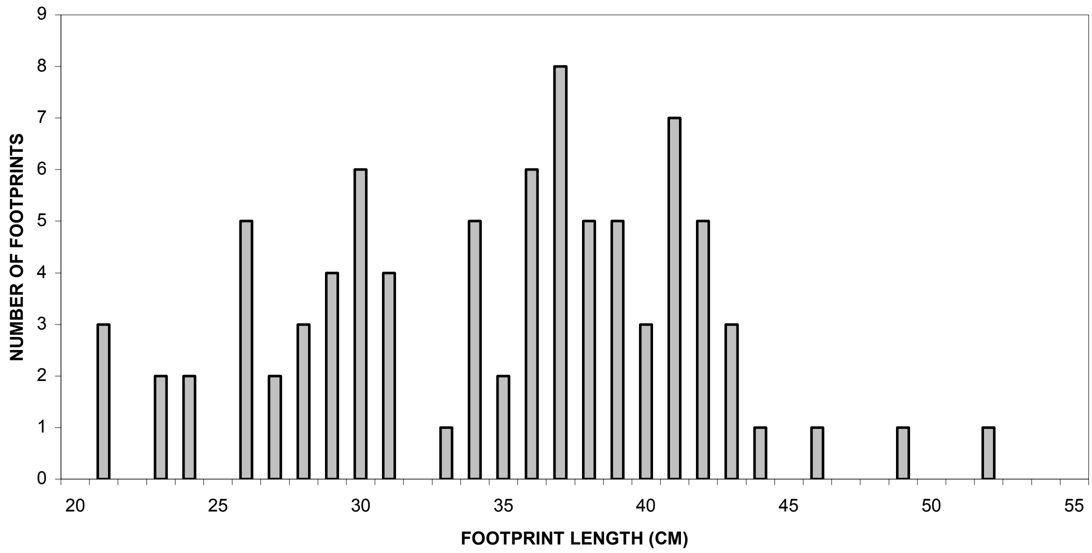

Figure 6: Frequency distribution of measurements of footprint measurements for a group of 85 elephants in the dunes north-west of the Banzena lake on 1st June 2004.

Annex 2c: Transect Survey around Banzena

1. Introduction

A pilot transect indicated that elephant distribution was affected by livestock density and the abundance of trees and shrubs. In addition, it had shown a marked gradient of elephant density away from the Banzena lake. Therefore the objective of this survey was to describe the elephants' use of space around the mare in relation to distance from water, the abundance of livestock and the availability of browse. The transects were started on 27th May and completed on 1st June, that is within two weeks of the arrival of the first rains.

2. Methods

2.1 Field

We decided to use a systematic design with a random start. Initially we planned to use five parallel north-south lines, but pressure of time forced us to use only three (Fig. 7). Therefore, having selected a random point on the edge of the lake, three parallel lines running due north from the lake were drawn on the map. The lines were two kms apart. On each line we placed seven transects at one-km intervals, with the first transect centred at 500 metres from the mare's edge. Thus the transects were spaced at 0.5 km, 1.5 km, 2.5 km … 6.5 km. Three similar lines were run southwards from the lake (Fig. 7). We ignored the transects that fell in thick forest where we knew elephants were present (e.g. Tabarac-Tabarac) because of the risk.

Each transect was 200 metres long. At the beginning and end of each transect the density of livestock dung was measured in three quadrats, each 1 x 0.5 metres in size, giving six quadrats per transect. The density of dung for each livestock species was then calculated for each transect.

Elephant dung was recorded using the line transect method: the perpendicular distance was measured for each dung-pile seen from the transect center-line (Buckland *et al*, 1993, 2001). The elephant dung density (D) for each transect was then calculated using the formula:

$$D = \frac{n.f(o)}{2L}$$

where n was the number of dung-piles seen, f(0) was the reciprocal of half the effective strip width, and L was the length of the transect (Buckland *et al*, 1993; 2001). The value of f(0) varies with vegetation type, and so the data for all transects in each vegetation type were pooled and a global value of f(0) calculated for that vegetation type using DISTANCE 4. Then that value of f(0) was used to estimate the dung density for each transect in that vegetation type. The three vegetation types were dense woodland adjacent to the lake (6 transects), open bush (33 transects) and forest (1 transect).

All trees and shrubs within 21 metres of the transect center-line were identified and recorded, giving a strip width of 42 metres, and the density of each species was calculated.

At the very end of our time in the field, on 4th June, we did one further line running westwards (Fig. 7). The data from this line were not used in the main analysis but rather to test the model developed from the northward and southward lines.

2.2 Analysis

The dung density estimates for the transects were typical count data: dung densities were not normally distributed, there were no negative numbers and there were some zeroes where no dung was recorded. Therefore log-linear models with Poisson errors were fitted by maximum likelihood (Crawley, 1994) in order to express the dung density as a function of vegetation or livestock variables. Adjustments were made for over-dispersion (Crawley,1994: page 262). The significance of each variable was evaluated by comparing the change in deviance with $\chi 2$ (Crawley, 1994) when that variable was added to the model. We have shown elsewhere that these models are most appropriate for elephant dung data (Sam *et al*., 2002; EBM & WD, 2002).

The variables for vegetation density and for livestock density were transformed logarithmically to ln(1 + X).

Plant species diversity was measured with the Schannon-Weiner index (Krebs, 1989):

$$H = -\sum p_i.\ln(p_i)$$

Where p_i was the proportion of the *i*th species in the sample.

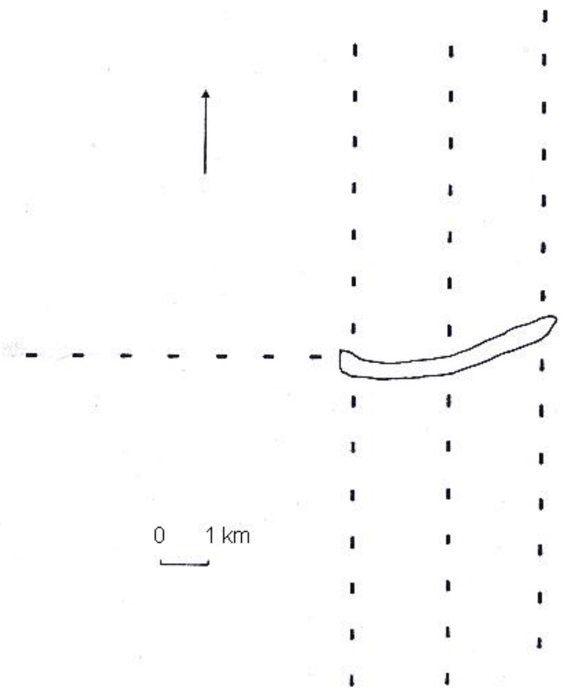

Figure 7: Map showing the position of the transects

3. Results

3.1 Distance from water

A total of 652 elephant dung-piles were recorded in 40 transects. The lakeside woodland was much thicker than the open vegetation, giving a significant difference in the frequency distribution of perpendicular distances (Kolmogorov-Smirnov two-sample test $D_{max} = 0.161$, $P < 0.001$), so the transects closest to the lake were treated separately from the rest. The forest transect was also treated separately. For each set of transects half-normal models provided the best fit for estimating f(0).

Figs 8 to 19 show the relationships between elephant dung and distance to water, vegetation variables (the number of woody species, the species diversity index, and the density of all woody plants combined), the commonest species (*Leptodenia*, *Acacia* spp, *Balanites aegyptiaca* and *Boscia senegalensis*) and the abundance of livestock. Distance from the lake was the variable that best explained the distribution of elephant dung (Fig. 8 and Table 4).

3.2 Vegetation

After accounting for proximity to the lake, then the number of woody species had the greatest influence on elephant distribution (Fig. 9). Having accounted for distance to water, *Acacia spp* and *Balanites aegyptiaca* still exerted a significant attraction for elephants (Table 5), while *Boscia senegalensis* did not. *Acacia spp* and *Balanites* often show signs of heavy browsing, while *B. senegalensis* is rarely touched by elephants. The relationship with *Leptodenia* is different: once one accounts for distance from water, there is a negative relationship indicating that elephants avoid *Leptodenia* (Fig. 16).

Once one accounts for distance to water and the number of woody species, then none of the other vegetation variables had a significant effect when added to that model. Thus the best model that explained elephant abundance in terms of vegetation was:

$$D = \exp(6.839 - 0.509x + 0.232N)$$

Where x was distance from the lake and N was the number of woody species, and both were significant at $P < 0.001$.

3.3 Livestock

There was an inverse relationship between elephant and cattle dung (Fig. 17), and this was confirmed in the model that included distance from the lake (Fig. 20):

$$D = \exp(8.762 - 0.503x - 0.892\ln(1 + C))$$

Where x was distance from the lake ($P < 0.001$) and C was the density of cattle dung (fragments per sq metre) ($P < 0.05$). This suggests that cattle may deter elephants.
On the other hand, both goats and sheep showed positive relationships (Figs 18 and 19):

$$D = \exp(6.656 - 0.328x + 0.614\ln(1 + G))$$

$$D = \exp(6.829 - 0.4372x + 0.9111\ln(1 + S))$$

Where x was distance from the lake ($P < 0.001$), G was the density of goat dung (pellets per sq metre) ($P < 0.001$), and S was the density of sheep dung (pellets per sq metre) ($P < 0.01$). This suggests that elephants are attracted to areas where goats and sheep like to feed.

4. Discussion

There is a steep gradient of elephant density away from the lake. There were no signs of elephant browsing after 6 km in the dunes to the north of the lake, and only a few signs of elephants between 6 and 7 km on the south side.

The hypothesis that elephant avoid areas where goats feed was firmly rejected. Indeed, there was a positive correlation with both goats and sheep indicating that elephants are attracted to the same areas. On the other hand, there was an inverse relationship between elephant and cattle dung (Fig. 20). A similar result was obtained by Sam *et al* (2002) in the

Red Volta valley in northern Ghana. So it seems that elephants avoid areas that have been, or are being, used by cattle.

Leptodenia pyrotechnica is a species that spreads onto impoverished dry soils. It often occurs at high density, and it often occupies large areas. Although camels feed on it, and goats feed on the flowers and fruits, elephants do not browse on it. There was a negative relationship between elephant and *Leptodenia* density (Fig. 16) As the land is degraded and *Leptodenia* spreads it reduces the value of the land for elephants.

Variable	Change in Deviance	P
Distance from lake	42.67	<0.001
North or south	0.09	NS
Number of woody species	14.43	<0.001
Species diversity index	23.27	<0.001
All woody species except *Leptodenia*	11.91	<0.001
Leptodenia	1.03	NS
All woody species	8.19	<0.01
Acacia species	15.53	<0.001
Balanites	42.04	<0.001
Boscia senegalensis	1.43	NS
Cattle	1.97	NS
Goats	38.17	<0.001
Sheep	19.81	<0.001

Table 4: Change in deviance when each variable was added to the null model. The residual deviance of the null model was 100.13

Variable	Change in Deviance	P
--	-------------	----------
North or south	0.04	NS
Number of woody species	19.52	<0.001
Species diversity index	18.92	<0.001
All woody species except *Leptodenia*	11.81	<0.001
Leptodenia	5.48	<0.05
All woody species	2.72	NS
Acacia species	8.03	<0.01
Balanites	11.92	<0.001
Boscia senegalensis	3.43	NS
Cattle	5.46	<0.05
Goats	14.19	<0.001
Sheep	13.88	<0.001

Table 5: Change in deviance when each variable was added by itself to the model that includes distance to the lake. The residual deviance of that model was 57.46. The effects of all variables were positive, except for *Leptodenia* and cattle which were both negative.

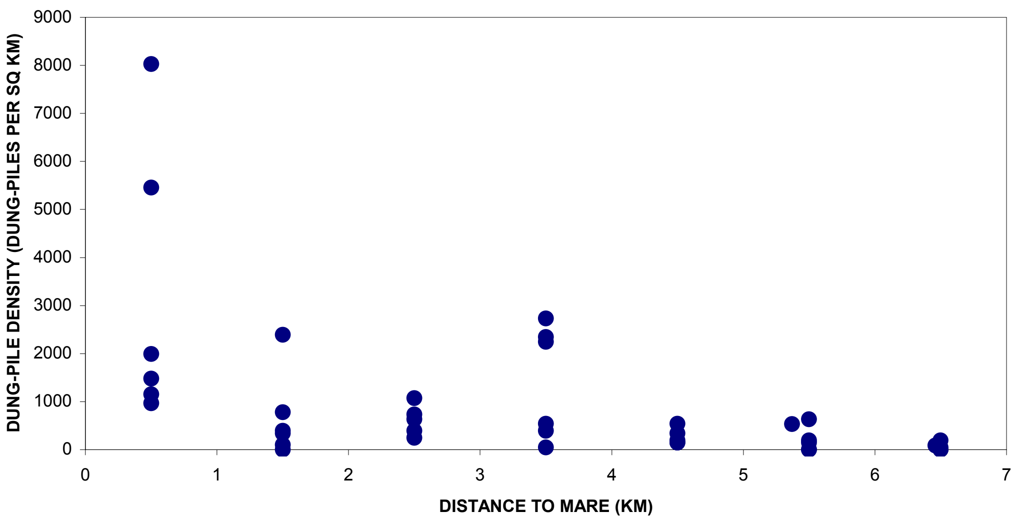

Figure 8: The relationship between elephant dung density and distance to the lake.

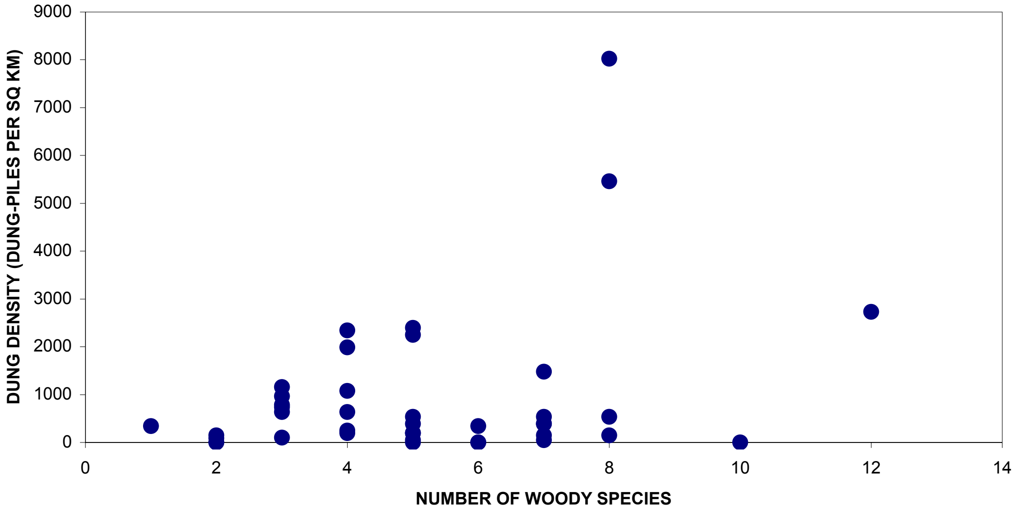

Figure 9: The relationship between elephant dung density and the number of woody species

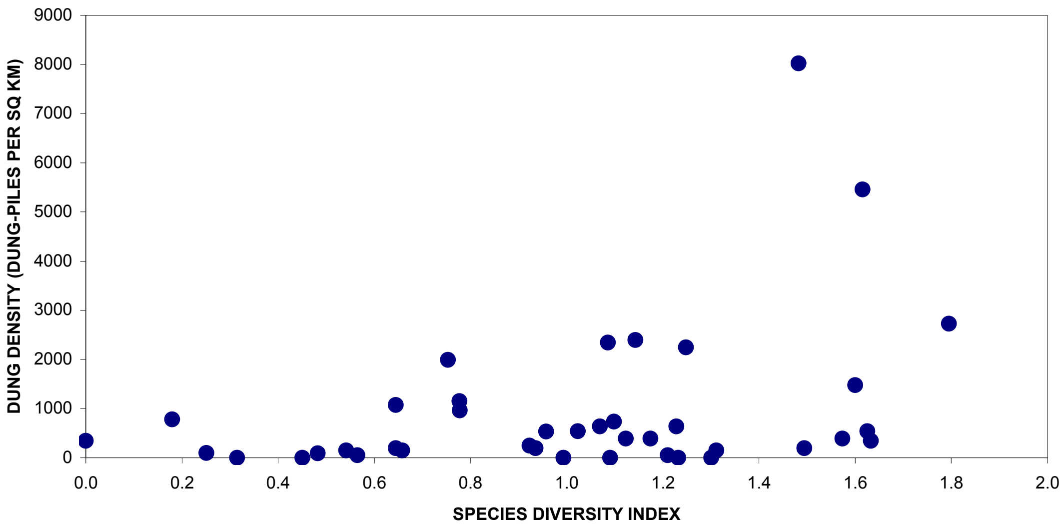

Figure 10: The relationship between elephant dung density and the species diversity index.

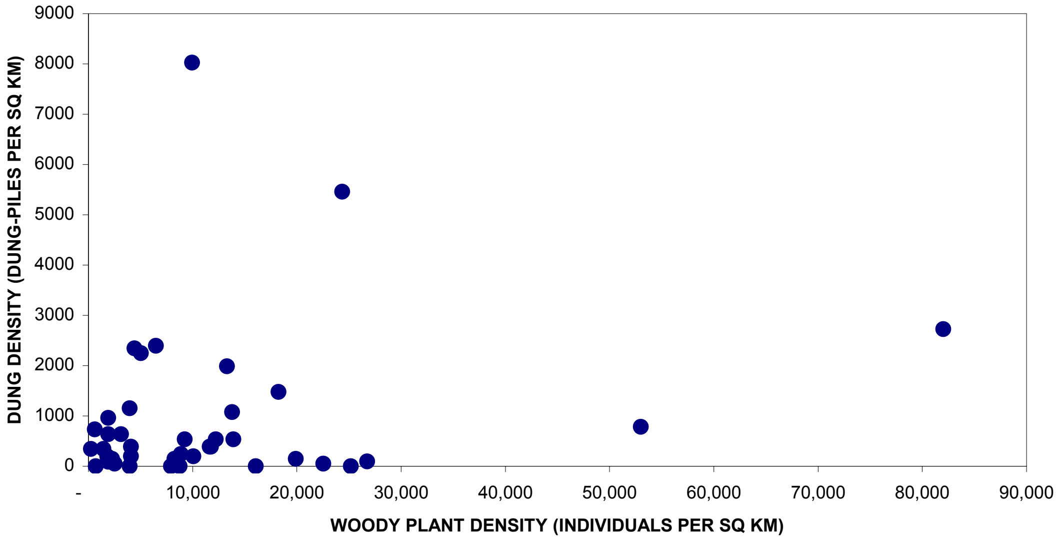

Figure 11: The relationship between elephant dung density and the density of all woody plants combined

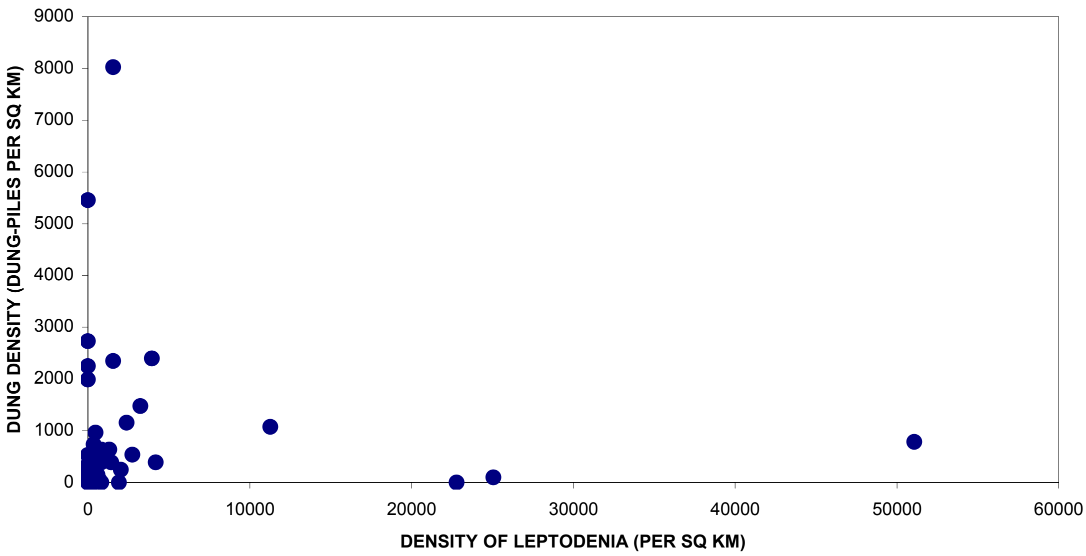

Figure 12: The relationship between elephant dung density and *Leptodenia pyrotechnica*.

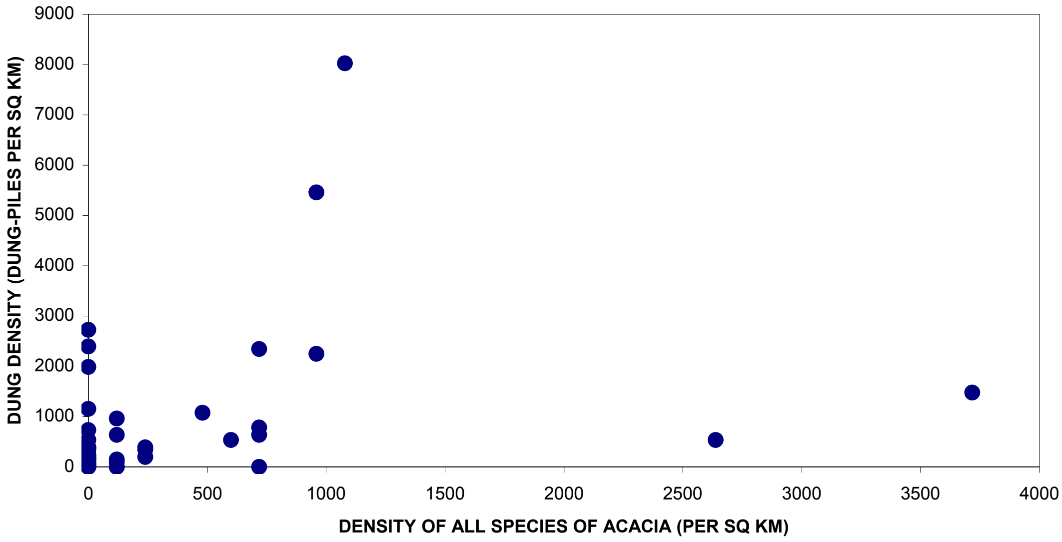

Figure 13: The relationship between elephant dung density and all species of *Acacia* combined.

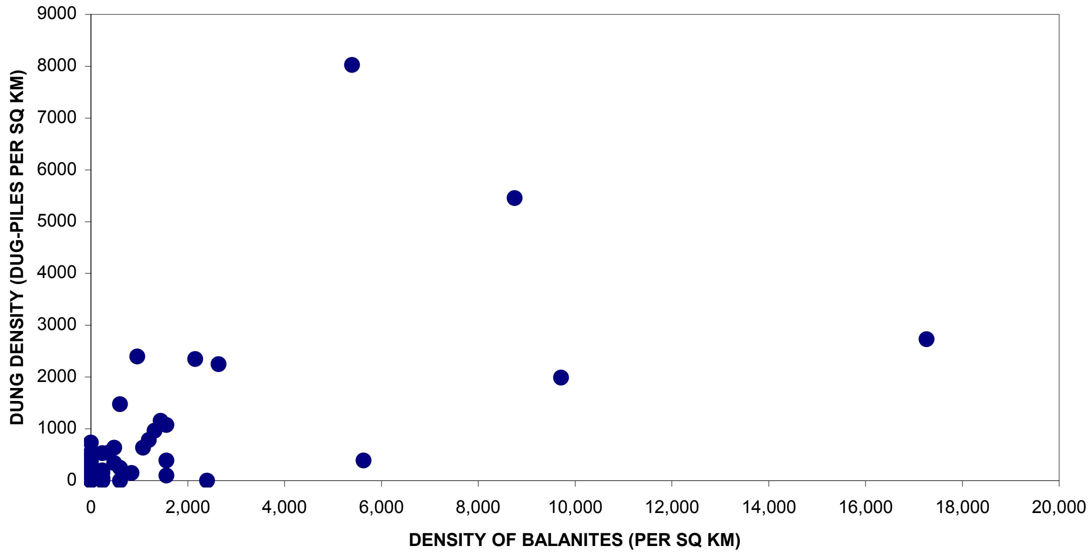

Figure 14: The relationship between elephant dung density and *Balanites aegyptiaca.*

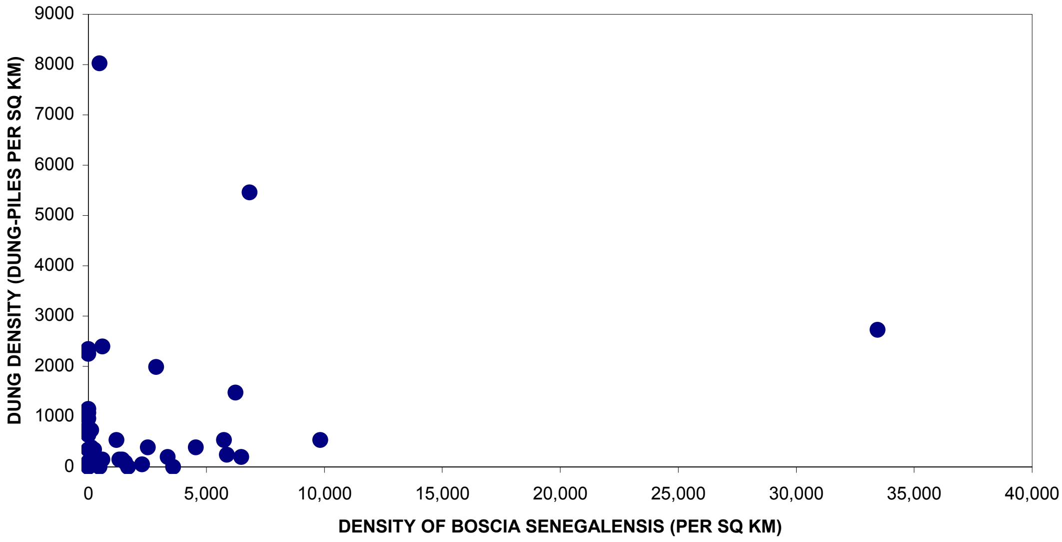

Figure 15: The relationship between elephant dung density and *Boscia senegalensis*.

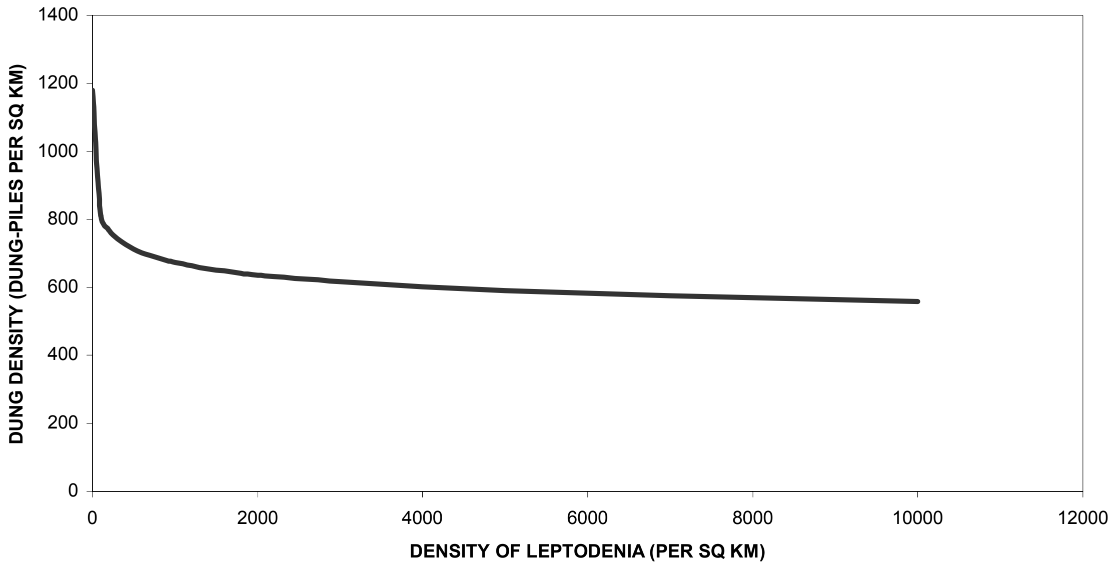

Figure 16: The model describing the relationship between elephant dung density and *Leptodenia pyrotechnica* after accounting for distance from water.

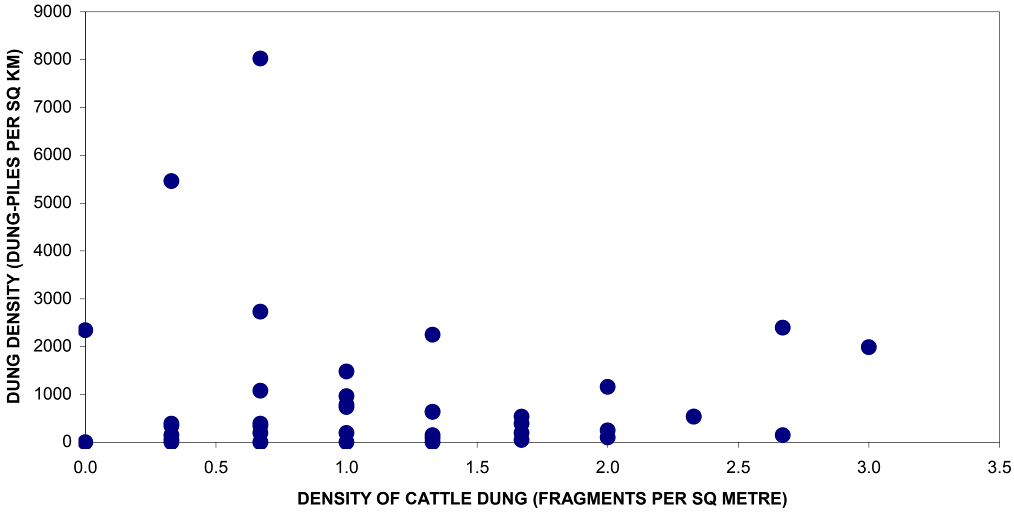

Figure 17: The relationship between elephant dung density and the abundance of cattle dung

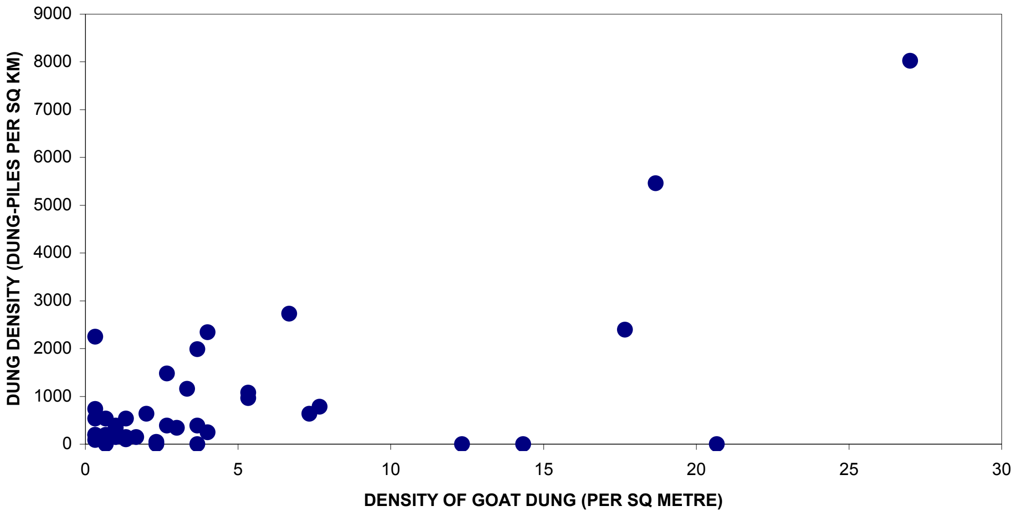

Figure 18: The relationship between elephant dung density and the abundance of goat dung

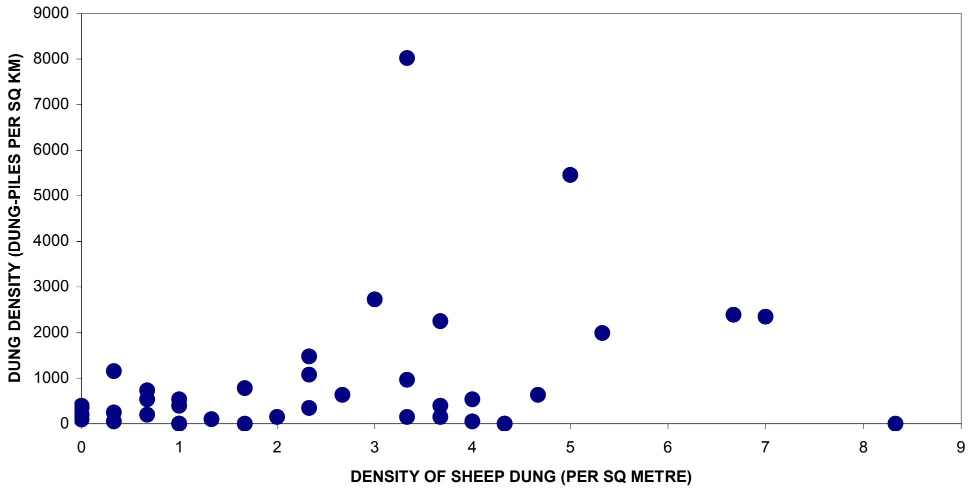

Figure 19: The relationship between elephant dung density and the abundance of sheep dung

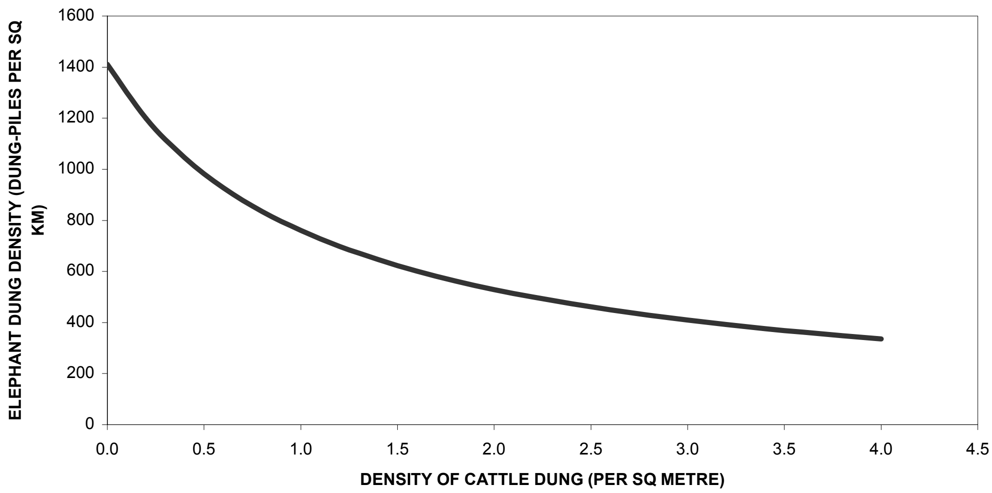

Figure 20: The model describing the relationship between elephant dung density and cattle after accounting for distance from water

Annex 3: Practical Issues

A small team in two vehicles can operate independently in the Gourma for weeks, at least in the dry season. Two vehicles are necessary to carry all the fuel, food and water. Then one can move from one temporary camp to the next at will, as the situation demands, which means that one works more efficiently.

From time to time one vehicle can be sent in search of water or for supplies, while the field work continues in the second vehicle. If one breaks down, then the other can be used to get help. In a large waterless area, this is a very important safety issue. Indeed, this sort of nomadic behaviour cannot be done safely with just one vehicle.

The maximum number of people in such a team is eight, four in each vehicle: two people in front and two behind. The middle rear seat must be kept free for carrying all the delicate electronic and optical equipment.

Three walkie-talkies are necessary: one for each vehicle and one for the cook in camp. A satellite phone is essential to remain in contact with colleagues in Sevaré or Tomboctou.

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Preliminary assemblage and analysis of GIS data

Report by
Iain Douglas-Hamilton and Susan Canney
Save the Elephants

February 2005

Table of Contents

Acronyms and abbreviations

STE	Save the Elephants
EDG	Environment and Development Group
AGEFORE	Amenagement et Gestion des Forets et de l'Environnement-GIE
GEF	Global Environment Facility
SSE	*Programme de Recherche Sahel-Soudan-Ethiopie (SSE) Mali-Norvege 'Environnement et Developpement' au Mali.*
USGS	United States Geological Survey

1. Introduction

A full account of the movements of three elephants radiotracked using GIS technology between March 2000 and July 2001 is reported in the report entitled *The Last Sahelian Elephants* by Blake et al (2002). This report gives the detailed seasonal movements and speeds and provides the most up to date record of the range and utilization of the Gourma by elephants. However the sample size of three animals is too small and the tracking period too short to describe the entire range, and those elephants living in the Gossi area to the east were not successfully radio-tracked at all. With our current project a high emphasis has been given on acquiring other GIS layers and further information on the full range of these elephants. Additional analysis of the radio-tracking data has been made against human settlement, administrative boundaries, and human population densities. Here we report on the additional data acquired in 2004 and how it relates to what we know so far about the elephants movements and range.

This report begins by addressing progress in compiling and organising GIS data. This work has enabled an assessment of data quality and availability. Subsequent sections document the additional information produced using the data acquired in 2004 followed by tentative conclusions, and the follow-up work required.

2. Compilation of GIS data

2.1 Data collection and generation

The data gathered is summarized in Table 1 together with its source and current availability. Data sources included:

- Save the Elephants (STE) - in addition to generating the GPS collar data, STE had already digitised some map information and collected additional information during the 2002 field excursion to collect the GPS collars.
- Environment and Development Group - Reports and maps collected by the preliminary missions to Mali in 2003.
- Data collected by the *Programme de Recherche Sahel-Soudan-Ethiopie (SSE) Mali-Norvege 'Environnement et Developpement' au Mali, (*a major study supported by Norwegian Aid to provide baseline data for its three sub-projects: rational natural resource use; the role of wild plants in nutrition, health and handcrafts, household nutrition).

SSE data are the digital GIS data collected by the Norwegian project for the northern part of the elephant range over a period of five years. Two copies of these were left in the University of Oslo and with the Malian government. The former appear to have been lost during a fusion of the Geology and Geography Departments, while the latter exist on a 'corrupted' hard disk at DNCN in Bamako, and may be retrievable. This project was terminated prematurely and only the soil map was published. There is a dwindling supply of A3 black and white hard copies of some of the other data layers, however are no hard copies of others such as settlements and roads.

These data are of good quality and represent extensive ground-truthing effort which would enormously enhance any GIS analyses performed by this project. Some of the simpler 'point' data have been re-digitized by the STE team in Nairobi. The more complex data such as the vegetation and soil maps would take extra effort or could be re-digitised in a simpler form, if the SSE data cannot be obtained from the computer in Bamako.

It is worth noting that a consultancy called AGEFORE have apparently had access to the SSE data to produce a report in 2001 to document the maps available on the different aspects of biodiversity in the Gourma for the *Projet de Conservation et de Valorisation de la Biodiversite et des Elephants du Gourma*. This was of extremely poor quality and dubious accuracy, especially regarding the elephants, and highlights the urgency for much better information to be disseminated before the GEF project gets underway. All attempts to contact this organisation by email and phone failed.

Elephant needs	GIS layers	Source	Availability/comment
Range	Historic range	Douglas-Hamilton files, Nairobi	Available
Presence/ absence	GPS collar data	Save the Elephants, Nairobi	Available
	Dung	2005 Field data	Available
	Local knowledge		
	Satellite imagery		
Water	Temporary waterholes	Landsat image (mosaic of Oct 1999&2000 images) /SSE data	Available
	Permanent waterholes	Landsat image/SSE data	Available
Forage	Seasonal quantity	1km resolution NDVI using USGS MODIS and AVHRR	Available from USGS needs downloading, and processing.
	'Snapshot'	30m resolution NDVI Oct 99/00 image	Available already created by SC from the existing Landsat image
	Vegetation	SSE data	Redigitizing required if not obtained in Bamako plus satellite image classification to extend the map to areas in the south.
	Soil	SSE data	Redigitizing required if not obtained in Bamako. Not an immediate priority.
	Watercourses	SSE data/maps/Landsat image	Bamako/digitise/image classification
Disturbance	Human population	Census data	Incomplete (see text)
	Settlement location	Maps, reports data, ground truth, SSE data	Some available – to be updated in Bamako and by ground-truthing
	Nomad density	Report: transhumance routes through the year by fraction and village.	Available but needs labour-intensive work. Not yet convinced that this is a priority
	Wells	SSE data (includes puisards) & boreholes	Available mostly
	Cultivation	Landsat image, aerial photography or other data	Bamako (see text)
	Livestock populations	Census data	Bamako (see text)
		Aerial data (STE 2002 / Mike Fay 2004)	Point locations collected during overflights
	Incidence of conflict	Reports, other?	Bamako (see text)
Salt	Cures salees	SSE data.	Available

Misc	Various UN, USAID, CF, GEF etc. data on vegetation and agriculture		Bamako
Basic GIS datalayers	Administrative boundaries	Maps, SSE data	These have changed over the years and there are several versions: clarification required in Bamako
	Roads	Maps, satellite image, SSE data	Some available – need completing by on-screen digitising/Bamako
	Route of new road		Bamako

Table 1: The data gathered, together with their source and current availability

Priorities
The main unknown is the degree to which human cultivation can be mapped and to what resolution, and yet this is a crucial dataset. Dialogue with Gray Tappan of the USGS about the use of satellite imagery for this shows some promise, particularly if used in conjunction with information gained from other sources such as bilateral and NGO aid projects, and the aerial photographs taken by Mike Fay of the elephant migration route.

Maps of human and livestock populations are also crucial datalayers. Contacts in Bamako suggest that the raw data are available at least by commune in Bamako, although it may be that data at smaller administrative levels may be held by local administrations. There has also been the suggestion that conflict data exist although the nature of these data is not clear from a distance.

Geo-referenced data collected during field-work is relatively painless and cost-effective to collect and yet creates significant 'added value' by completing, verifying and extending existing data-sets it can allow analysis that might not otherwise have been possible.

2.2 Assessment of data quality and organisation

The varied sources of data mean that the data are disparate in terms of resolution, accuracy, area covered, and projection which means that a certain amount of harmonisation is required before they can be used together. Some of this work has been done already by SC during the Samburu visit (see below). Needs in this area will be continually reviewed during the process of analysis in the light of the budget and time available, and performed by SC and the STE team in Kenya. Hard copy maps were produced during SC's visit to STE-Kenya in November 2004.

Projection
The GIS datalayers are in many combinations of projection, spheroid and datum[1]. Some appear to have been digitised without recording this information. Files with different projections cannot be overlain (except in Erdas-Imagine). The source maps are also in different projections.

It is suggested that for the moment the standard projection for the datalayers is Universal Transverse Mercator Zone 30; Spheroid and Datum WGS84 as this is the projection that the

1 Variations in projection-spheroid-datum specifications can result in 100s of metres or even over a kilometre misalignments, which is important for some of the analyses.

satellite image came in, and it is more accurate to reproject vector files (shapefiles and Arc coverages) than raster files such as images. However, the error will need to be monitored and if it becomes too significant, some data may need to be re-digitised by the STE team in Kenya

GIS database structure and metadatabase
GIS files have a tendency to replicate themselves with slight variation each time and no record. A start has been made to ascertain their origin, weed them out, and organise the remaining data into a logically structured set of folders that enable anyone new to the system to find their way around[2]. This needs to be completed and a system of metadata constructed that contains information about each dataset.

Future Activities
- Data collection in Bamako to:
  - Locate and attempt to retrieve the SSE digital data
  - Complete collection of human census data
  - Collect livestock census data
  - Determine accurate digital administrative boundaries
  - Collect other data (see table) including background data and information on conflict and trends.
- Ongoing organisation of database and error monitoring
- Generation of extra data-layers through analysis as described in the following sections.

3. Elephant numbers and their significance

Elephants once occupied a nearly continuous range across the West African Sahel, but their populations have collapsed due to poaching, human encroachment and neglect. Most remnant populations are small, highly fragmented and geographically isolated, with over half now containing fewer than 100 individuals (Blake et al., 2003).

Recent field work by Save the Elephants through the techniques of individual photo –identification, carried out by Emmanual Hema during 2004 indicates that the Gourma elephants of Mali and extreme north of Burkina Faso number between 400 and 500 making them one of the most important populations in West Africa and the only significant remaining Sahelian elephants. It is therefore accorded a high priority in IUCN’s regional strategy.

4. Analysis of Elephant GPS tracking data

The analyses described in the following sections use the location data gathered by STE’s GPS collars over the period 2000/2001. Positions for the full 18 months are used where the concern is for areas of elephant presence/absence; and 12 months where it is important to look at elephant behaviour through the year.

2 This is particularly important when using ArcView as ‘projects’ or collections of datalayers record the location of those datalayers by their path structure. ArcView projects are unusable if the datalayers are moved to different folders.

Data come from 3 elephants:

Elephant	Sex	Number of observations		Notes
		18 months	12 months	
Ahni	F	4,274	3,676	
El Mehdi	M	4,778	3,554	
Doppit Gromoppit	F	405	338	Intermittent therefore omitted from the analyses that require complete data.
TOTAL		9,457	7,568	

Where 12 months of data are shown this has come from Ahni and El Mehdi from 1 April 2000 to 31 March 2001.

5. Elephant range

5.1 Elephant range since the 1970s

Documenting change in elephant numbers, range and movement over time and comparing this with environmental change helps us to understand the factors that determine elephant needs.

Information on elephant range collected by Bruno la Marche, Jachmann and Iain Douglas-Hamilton over the past 35 years gives a preliminary basis from which to understand the factors influencing elephant movement in the Gourma[3] and is summarised in Figure 1. Also shown are the lines of movement documented by La Marche which can be evaluated by comparison with the 2000/1 GPS collaring study.

[3] La Marche made a special study of the elephants through the 1970s. His estimate is based on local knowledge, observations and aerial reconnaissance. Jachmann's 1991 estimate is based on local knowledge plus a short-term dung count. STE's 2000/2001 estimate is based on GPS tracking, aerial reconnaissance and ground observations.

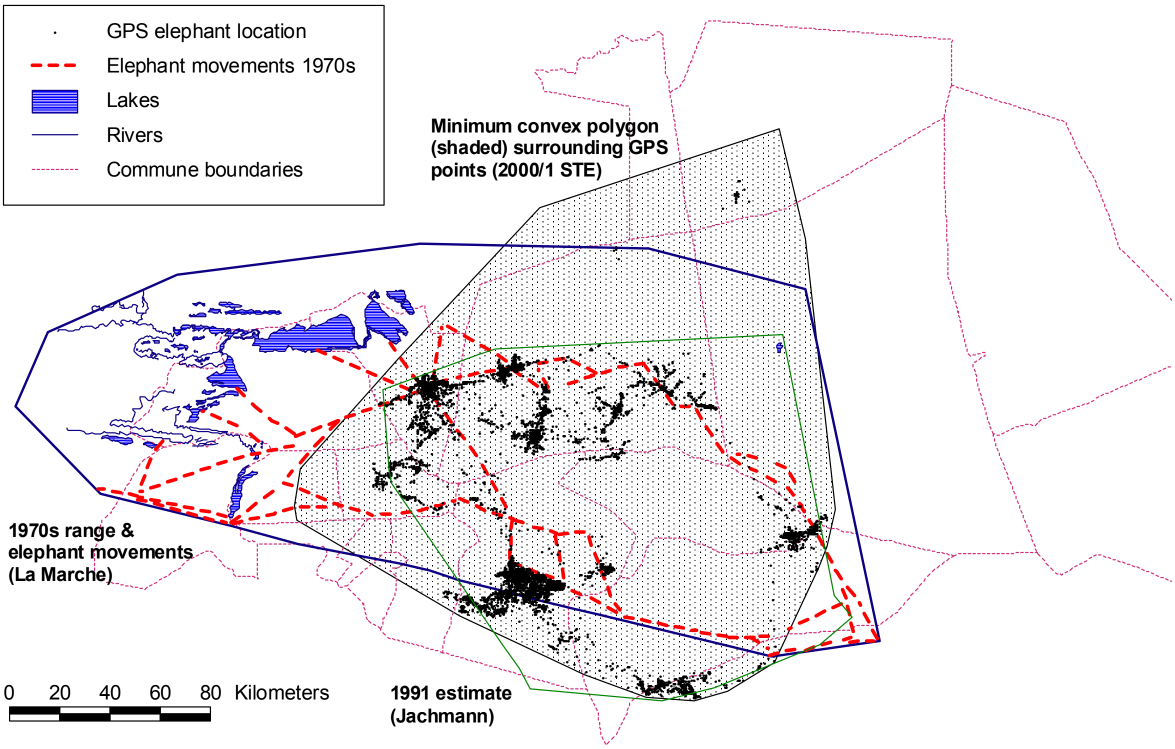


Figure 1: Change in elephant range Gourma, Mali, 1970s – 2001 overlain on administrative boundaries, riverine lakes of the Niger & 2000/1 GPS collar positions

The major change is that elephant range has shrunk. In the 1970s elephants were found as far west as the lakes bordering the river Niger but by 1991 the western part of their range had been lost, possibly due to changes in climate and land use.

There are also indications that other changes may have occurred although the patchiness of the data makes this difficult to determine with certainty. It appears, for example, that by 1991 elephants were travelling further south than previously; while it is only the radio-tracking studies that have detected a northward movement. Is this a remnant of northward migrations to the river Niger, or a result of displacement from other parts of the range?

Both Jachmann and La Marche suggested that elephant range extended further to the south west and south-east, but we have not yet ascertained if they actually visited all these parts of the migration route to the South. In any case it is possible that elephants vary their route from year to year. More information will be sought to answer these questions, including clarification from La Marche and Jachmann about the areas they actually visited.

5.2 Current elephant range

Current elephant range as indicated by the 2000/1 GPS collar locations is shown in Figure 2. It confirms the belief that the Gourma elephants make a large (450km), annual, circular migration, and suggests that certain areas are important at certain times of the year, and that the movement pattern is an adaptation to life in an arid zone.

Two features become apparent. The first is that elephants avoid the centre of their range, possibly due to human settlement (see section X); and the second is that the elephants visit encompasses many different administrative areas or communes during the course of a year. It follows that if an As a result any elephant conservation strategy is to succeed it will need commitment from several different regional authorities in the Gourma.

Future Activities
Achieve the best possible map showing the extent of current and historical elephant range by combining different methods of estimating elephant range - remote sensing, dung surveys and local information networks.

- GPS radio-tracking data is the best method for determining range and has already defined the main concentration areas, with the exception of areas to the East around Gossi and up as far as Adjora. Ideally 10 more GPS radio-collars should be deployed of a superior design to the previous models, lighter, tougher and more long lasting. This would depend on funds being found to pay for the cost and permission from the DNCN.
- In the meanwhile dung searches and local information networks can supplement and extend our present knowledge of the elephants. Elephant dung indisputably indicates the presence of elephants and asking local people can often improve the range map with information of the presence or absence of elephants.

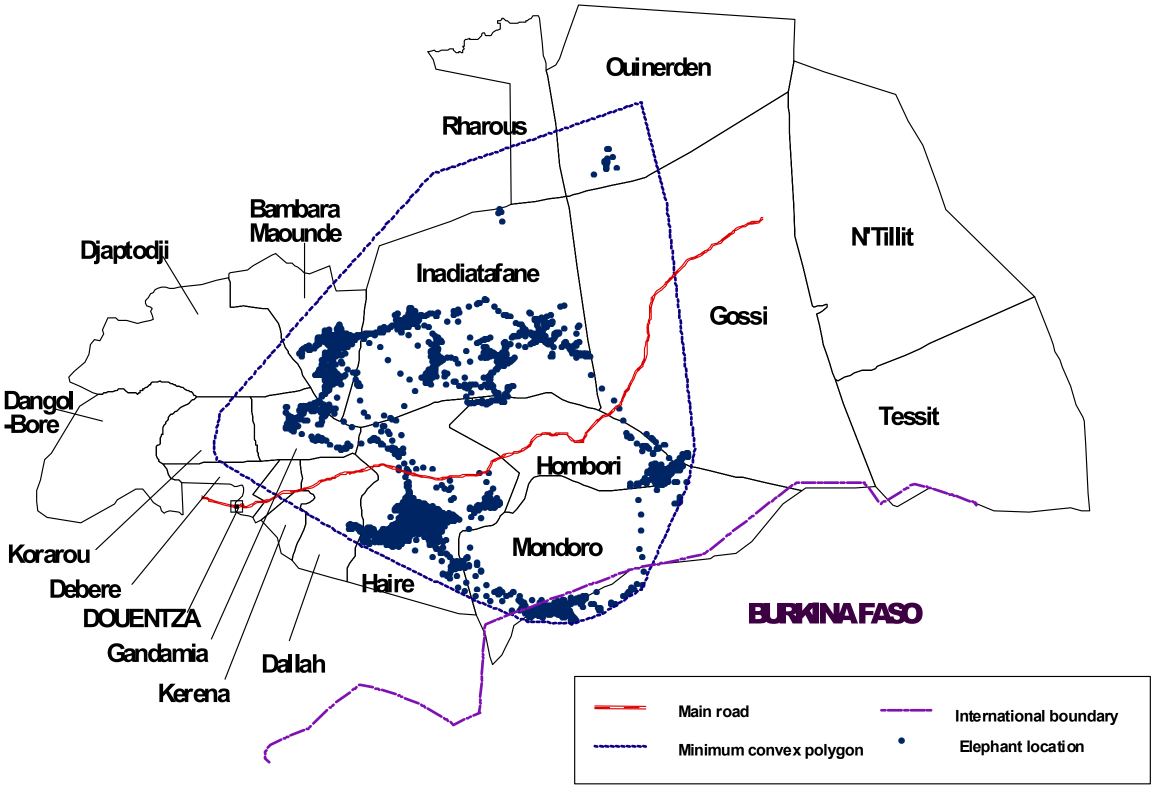


Figure 2 The location of the three elephants in 2002/1, minimum convex polygon enclosing them, main road, boundary with Burkina Faso and the administrative regions

6. Elephant range: concentration areas and corridors

The 2000/1 GPS location data indicate that there are some areas where elephants congregate for periods of time, and other 'corridor' areas where they move rapidly between 'concentration areas', often at night. These are shown in Figure 3.

Concentration areas are likely to possess resources of interest to elephants while corridors represent areas where elephants do not want to linger, either because there is nothing of interest to them there or because they feel harassed or threatened. For the two elephants for which we have relatively continuous data, only 7% of their time was spent in areas defined as corridors, as shown in Table 2.

Corridor	Ahni (F)	El Mehdi (M)	Total
Benzena-Porte des Elephants	1%	4%	3%
Benzena-Indamane	1%	1%	1%
Gossi	1%	0%	0%
Haire-Mondoro	2%	1%	1%
Mondoro Tin Senane	1%	0%	1%
North	1%	1%	1%
Other	**93%**	**93%**	**93%**

Table 2: Percentage time spent in corridors

They also spent very different amounts of time in different concentration areas with marked differences between the bull and the cow, as shown in Figures 4 and 5. Benzena was not as important as originally thought. The concentration area in Haire proved to be exceptionally important to the male, while the female spent more of her time in the more northerly areas around Indamane and Inadiatafane.

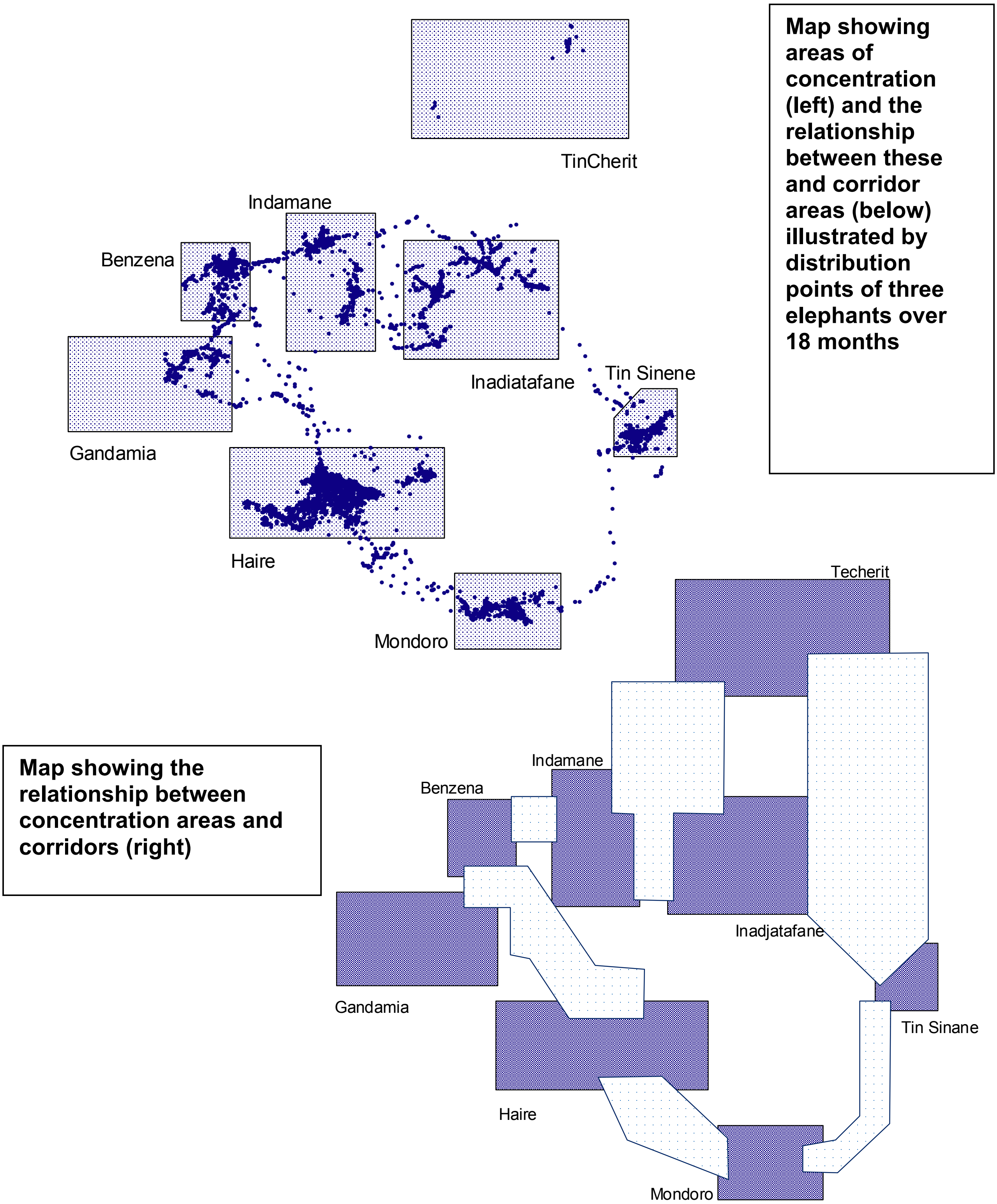


Figure 3: Elephant Concentration Areas and Corridors

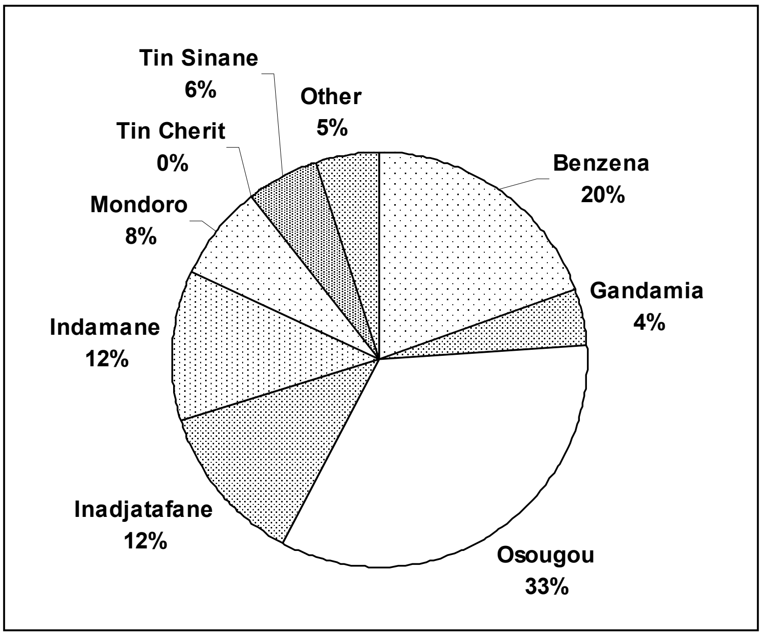


Figure 4: Percentage GPS positions in each concentration area over 1 year

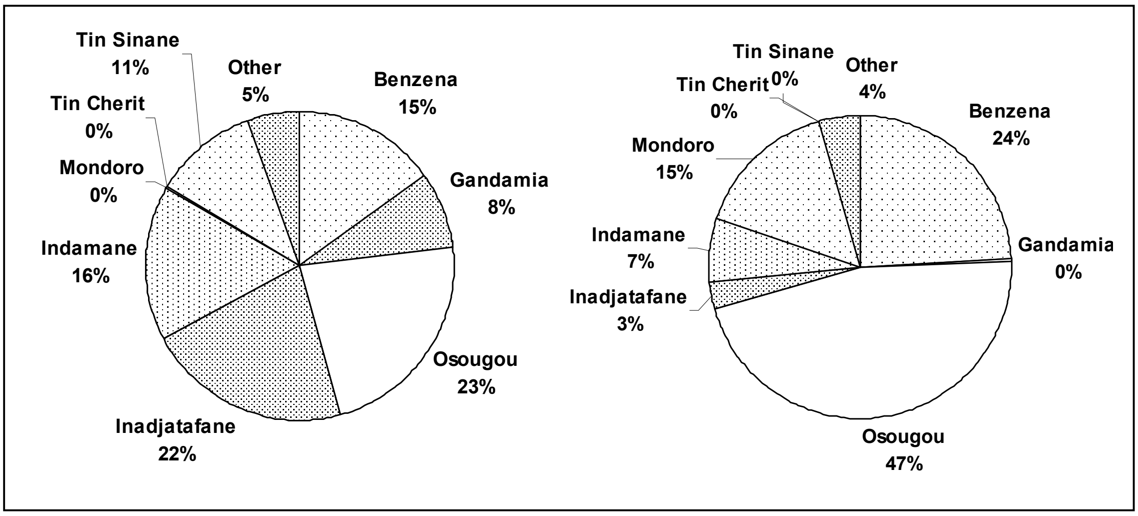


Figure 5: Percentage GPS positions in each concentration area: Ahni (F) on the left and El Mehdi (M) on the right

By examining and comparing concentration and corridor areas, we can understand what these important resources and threats are, and at what time of year they are important. Understanding corridors is of particular importance to ensure that any development does not inadvertently block elephant movement and create further problems for elephants and people. La Marche, for example, identified three key corridors through the high ground to the south, shown in Figure 1. Today one of these, known as 'La Porte des Elephants', is heavily used by the vast majority of elephants. Of the other two, one is virtually unused and the other infrequently used possibly due to human settlement (see sections 7 and 8 for further discussion). If this is the case any further settlement near these corridor areas would cause a great deal of hardship for the elephants and escalate conflict with humans.

Future Work

- Determine the range limits to each core and corridor zone using a combination of GPS-tracking data, dung locations and local information networking (see section 5)
- Determine the distribution of the radio tracking GPS points by concentration area and polygon: (a) by day and night, and (b) by time of year
- Compare data for Banzena with Richard Barnes dung transects (the GPS location of these is in hard copy at Douentza).
- Obtain data on human-elephant conflict, and compare with elephant distribution (male/female; time of day; time of year) and location in terms of concentration areas/corridors.
- Assess the level of human harassment, and represent this spatially, using the results of analyses described in the following sections.
- Obtaining additional GPS-tracking data by collaring more elephants:
    - Analyse how much extra range each additional elephant adds to the elephant range
    - Assess the degree of variability in the route taken by elephants between years

7. Elephants & Human Population Density

It is possible that elephants try to avoid areas of high human population density and so using data from the 1997 census we calculated the human population density for each commune and overlaid the GPS elephant distribution data. The result is shown in figure 5 and suggests that elephants are avoiding areas of higher population density. Of particular interest are the high densities in the former western elephant range.

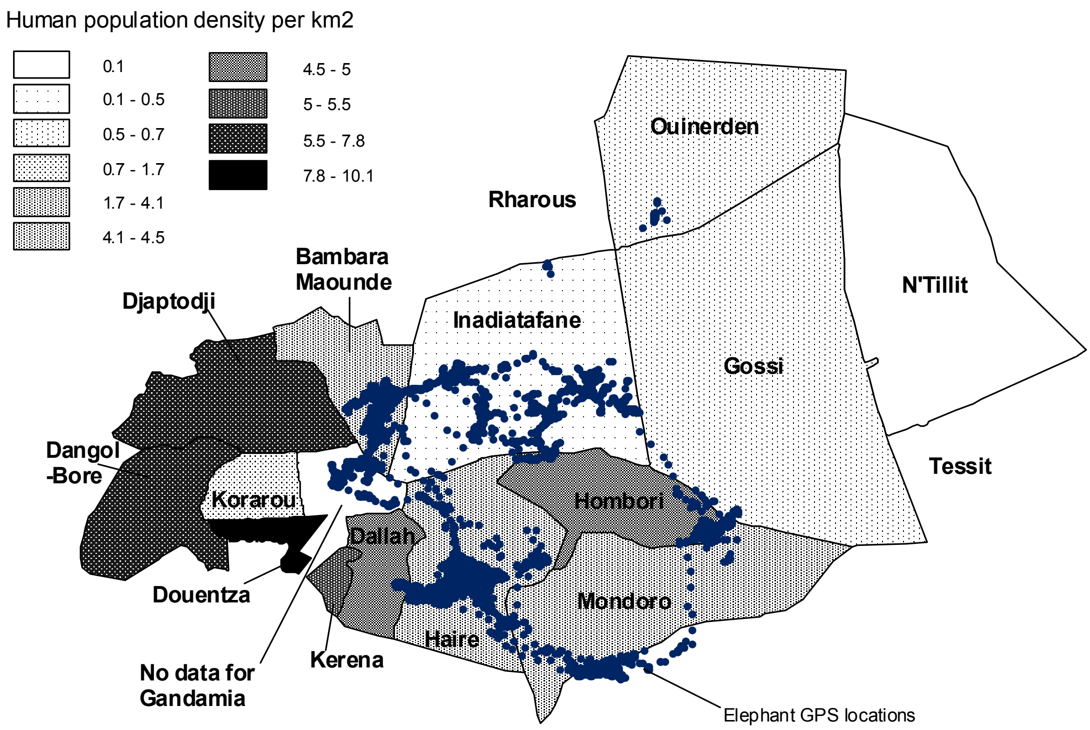


Figure 6: Map showing the relationship between one year of elephant positions & population density from the 1997 census. Dark shading indicates higher density.

Human population census data were collected in 1997, 1986 and 1974/5 and are potentially available to us through contacts in Bamako. We have located some of these but the dataset is incomplete, and administrative boundaries have changed since 1974. Preliminary indications are that the population has increased in some areas and decreased in others. A more general trend appears to be a reduction in nomads and an increase in settlement.

Future Work

- Collect missing census data to gain an idea of the rate and extent of changing demography and its distribution over the Gourma, compared with elephant distribution.
- Repeat using the data by village and by nomadic fraction to determine whether the elephants respond differently (if at all).
- Locate settlement growth areas to see whether parts of the elephant range are at risk.
- Collect census data for smaller administrative units if possible to allow a finer grained map of population density
- Repeat the analyses for livestock data

8. Elephants and settlement

Figure 7 shows the location of settlements taken from a 1961 map together with a 10km 'buffer' zone around them. It suggests that elephants are tending to avoid settlements, particularly in the south.

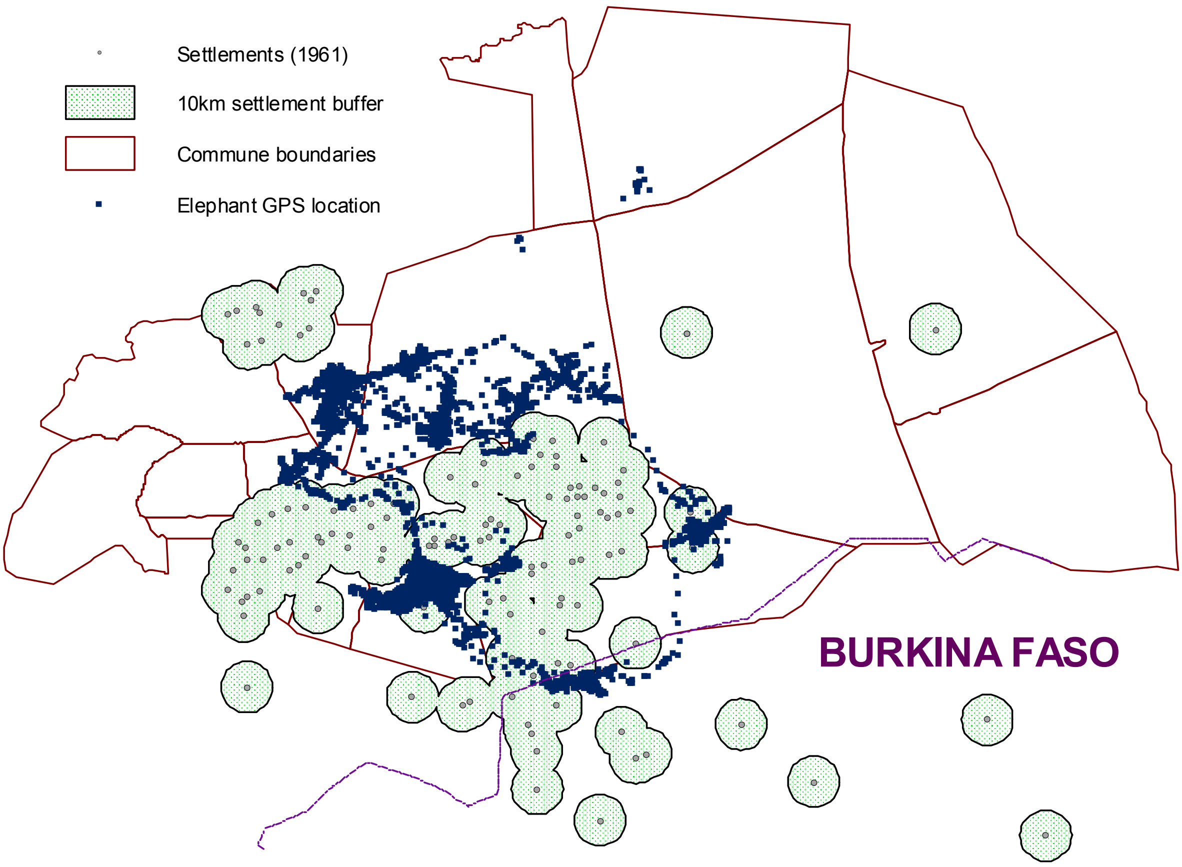
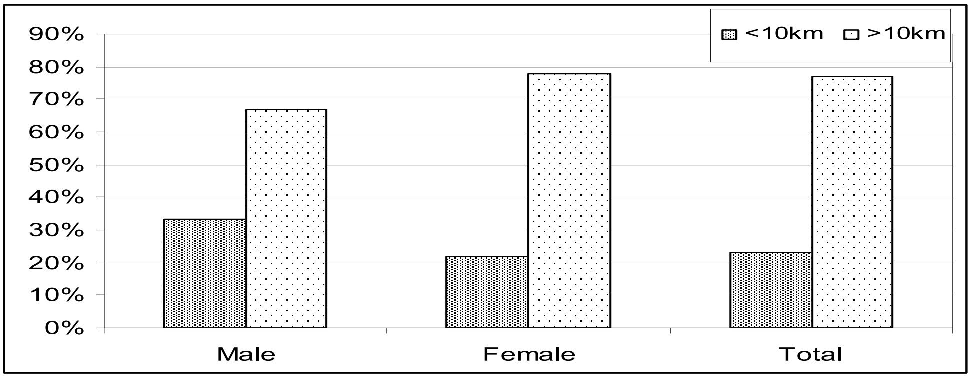


Figure 7: Map showing elephant positions over 18 months in relation to a 10km buffer around settlements (as digitised from the 1961 map)

The charts below compare the amount of time (as measured by number of GPS locations) spent by the male and female elephants closer and further than a 10km distance from settlement, and show that the male spends 67% and the female 77% of their time further than 10km from a settlement, indicating that the male may be more willing to approach.

Animal	<10km	>10km	Grand Total
El Mehdi (male)	33%	67%	100%
Ahni (female)	22%	78%	100%
Grand Total	**23%**	**77%**	**100%**



One problem with these data is that the settlement locations are as determined on the 1961 map. We know that the droughts and conflict of the 1970s and 1980s have encouraged settlement in the northern part of the range, for example around Gossi and Inadiatafane. If elephants are avoiding settlements we would expect the result to be even stronger if repeated with updated information on settlement location.

When the elephant locations are examined against the satellite image, it can be seen that elephants approach closer to settlement where there are corridors of dense vegetation in an otherwise open area (e.g. Gandamia). This may be because they are choosing thicket for cover and/or vegetation for food.

Preliminary analyses indicate a change in behaviour between day and night. The figure below shows speeds by day (left) and night (right) for Ahni, the female (blue represents areas of slow movement and red shows areas of high speed). Most of the high-speed 'streaks' occur at night in the south of the range.

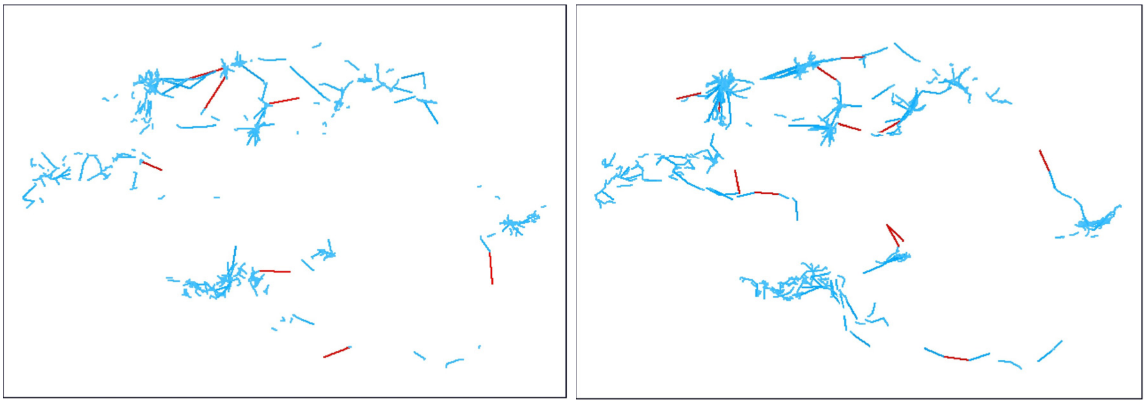


Figure 8 : Speeds by day (left) and night (right) by Ahni, the female elephant

Future Work

- Update settlement map and repeat.
- Examine areas where elephants approach within 10km to see what may be interesting the elephants.
- See whether the distance to settlement varies with area indicating that some areas seem to be 'safer' than others; and whether it varies throughout the year to see if the elephants are bolder at certain seasons.
- Compare with any data on human-elephant conflict
- Analyse distance from settlements by day and night/male and female.

9. Elephants and vegetation/soil

No quantitative analysis has been done using vegetation but an examination of the satellite image overlain with elephant locations indicates that particular vegetation types appear to be important to elephants as they often appear to follow corridors of a particular type of vegetation.

It is likely that different vegetation types may be important at different times of the year, for example at the beginning of the rains when elephants are no longer limited by water availability; and in different places, for example to provide corridors of cover in more densely populated areas. A study in Samburu comparing elephant distribution with a satellite derived index of green biomass has demonstrated shifts in preference throughout the annual cycle indicating times when forage becomes a priority.

Vegetation analysis is likely to help answer questions such as:

- Why do the elephants have to move on such a long north/south route?
- What are the most vital parts of their range that must be safe-guarded at all costs?
- What are the implications for the elephants' survival if they lose particular parts of their range?

Correlations between particular soil types and elephant location may also be interesting, possibly from the point of view of salt content, because elephant movements do not appear to be influenced by the location of salt licks.

Future Work

- Acquire digital data on vegetation data layers, particularly on vegetation structure.
- Use these, together with ground data and informed by further discussions with Gray Tappan to extend the vegetation map south using the Landsat image together with ground-truth, aerial photographs and report data. This should enable the identification of some key vegetation types such as thicket, and agriculture. Grass and thicket are difficult to distinguish by eye from the image but digital analysis should be able to do this.
- A soil map would greatly help the creation of a vegetation map from the satellite image.
- AVHRR and/or MODIS NDVI data (free) can be used to characterise the area into zones reflecting seasonal change in green biomass throughout the year, and is often able to identify agriculture.
- NDVI analyses to see whether, when, and to what degree elephants are selecting areas of high green biomass (i.e. actively growing vegetation)

10. Synthesis

Significant progress has been made in establishing the basis for GIS analyses to understand why the elephants make this migration and which factors are important in which places at which times of year. Data requirements and sources have been identified, and their quality assessed. Gaps in the data have been identified plus ways of completing datasets determined within the time and budget allocated. The preliminary analyses summarised in this report have enabled a plan for future GIS work to be drawn up and work planned for 2005 (as set out in the 'Future work sections of this report). They have also pin-pointed the essential data to be collected by the field team during 2005 to add information about elephant range and enable data layers such as the vegetation map to be extended to the southern part of the elephant range; and the essential data to be gathered in Bamako. The GIS-based information can then be combined with the field observations to better understand the limits of the elephants' range, their needs through the year and the degree of stress they are experiencing.

Annexe: Terms of Reference for S. Canney's visit to STE-Kenya

Data Gathering and Organization:
1. Review the GIS data layers already acquired for the Gourma (please bring any you think we may not have out here).
2. Assess the needs of the project for fresh data layers,
3. Make a list of GIS data needed and make a plan for acquiring it.

Training:
1. Train and assess Emmanual Hema in GIS programming, using ESRI software to be made available by STE. I am very keen to get him thinking on all he wider issues that become apparent with the GIS approach, and he is a good and meticulous worker, so I think he can be entrusted with fairly massive amounts of data entry.

Analysis:
1. Assess the relevance of GIS techniques and analysis used by Save the Elephants in the semi-arid habitats of Northern Kenya to the project needs in Mali.
2. Participate in a preliminary analysis of the Gourma radio-tracking data, with respect to defining corridors and concentration areas.
3. Help define the areas of prime concern for elephants and define quantitative criteria for each subzone, in terms of area covered and time spent.
4. Help analyse the speeds of elephants in and out of corridors.
5. Define criteria to classify land use in the Gourma, with a view to analysing the elephant data against different land uses.
6. Brainstorming and perhaps partial analysis of radio-tracking data in relation to water sources, habitats, roads, villages or other data layers.

Outputs:
1. Preliminary definition of areas of prime concern for elephants.
2. Quantitative definition of these areas in relation to administrative areas or other data layers in Mali.
3. Preliminary definition of critical corridors.
4. A new digital working map, or series of maps of the Gourma, utilizing the satellite images already supplied by USAID and overlaying, or creating overlays of other data layers, such as villages, roads, water-points, protected area boundaries, administrative boundaries.
5. Hard copy high quality prints of these maps for use by the field team in Mali and for planning purposes for STE, EDG and WILD
6. A full progress report for STE on your mission, listing achievements, and making recommendations for future GIS and research activities within the WILD led consortium.
7. A summary report on all research progress made by the project in the year 2004.
8. Inclusion of any other spatial analysis in the above two reports that can be completed by the end of your field visit.

STE will provide GIS staff to help with the data analysis and map making, and we will help set up the deal with the printing company in Nairobi to make the hard copy maps.