Section 3
Collection of entomological baseline data in the Mouhoun river basin (Burkina Faso): the use of GIS, remote sensing and GPS

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ABSTRACT
This paper describes how geographic information system (GIS), remote sensing (RS) and Global Positioning System (GPS) technologies were used to plan the collection of entomological baseline data for a tsetse and trypanosomiasis (T&T) elimination project in the Mouhoun river basin in Burkina Faso.

Historical data were collated as the background for data analysis. These data were used to define the survey area and to assess the probability of tsetse fly presence. Existing data and satellite images were used both to determine the sampling and trapping sites and to navigate to the areas used for deployment and release of the traps. For data management, a geodatabase (ArcGIS ArcInfo Desktop) and a relational database (MS Access) were created. The geodatabase was used to compile all geographical data, and the relational database served to integrate field data using a user-friendly interface for technicians. The methodologies and datasets presented in this paper represent essential prerequisites for subsequent project activities, including suppression and eradication of tsetse.

INTRODUCTION
The distribution of tsetse and trypanosomiasis is determined mainly by habitat structure and vegetation types. Tsetse flies live in forests, savannah and riparian woodlands where vegetation provides a suitable climate and habitat for their survival and reproduction. Burkina Faso, like many other tsetse-infested countries in western Africa, suffers subsequent constraints on its agriculture and the livelihood of its rural populations. It is located on a plateau, with most of the country between 300 and 400 m in elevation. It consists of vast plains, broken by occasional low hills. Riverine forest vegetation is predominant in most areas infested by tsetse. The impact of landscape fragmentation on the structure and distribution of a population of Glossina palpalis gambiensis along the Mouhoun (Black Volta) river basin can be traced to human and climatic factors.

Tsetse-transmitted trypanosomiasis is a unique and complex disease that requires strategic study at the continental level. Careful evaluation is necessary of the many different variables that exert a varying influence on its distribution and impact, both geographically and over time. For this reason, GIS, RS and GPS technologies provide powerful tools that can be used to measure a wide range of field parameters essential to sampling, surveys and T&T interventions. GIS has been used principally to predict the distribution and dynamics of different vectors (Lessard *et al.*, 1990), and numerous digital georeferenced databases have been developed to accomplish different tasks. In Burkina Faso, GIS, RS and GPS technologies have been used to define the project area for the collection of entomological baseline data in the Mouhoun river basin and to assist in the implementation of the project to create sustainable T&T-free areas in western Africa under the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) initiative.

PROJECT AREA

With the aid of GIS software, the project area was delineated using river basin maps, topographic maps and a map of tsetse fly distribution in Africa (FAO, 2000). The project area was divided into five blocks covering the Mouhoun river basin. The area of each block ranges from 10 000 to 30 000 km^2.

The survey area referred to in this paper is in Block I (Map 1).

Data-mining software used: ArcGIS ArcInfo Desktop 9.0, Erdas Imagine 8.4, MS Access

Three programs were used: ArcGIS ArcInfo Desktop 9.0[1], Erdas Imagine 8.4 and Microsoft Access[2]. The choice of these programs was made according to their individual capabilities and the compatibility among them.

- ArcGIS ArcInfo Desktop is the most widely used GIS (i.e. vector-oriented) software; it is able to handle a geodatabase and has good compatibility with MS Access;
- Erdas Imagine is image-processing software that is oriented to raster datasets, especially satellite imagery; its file format (.img) is easily readable in ArcGIS;
- Microsoft Access is a relational database management system (RDBMS); for this project, it was used to build the database for storing and managing entomological data collected in the field.

Importantly, these three programs are compatible with one another, which facilitated project data management. A key feature of ArcGIS ArcInfo Desktop is its ability to build geodatabases capable of integrating existing data. Various geographical layers in various formats were collected from different sources and subsequently loaded into ArcGIS geodatabases, which stored these layers as “Feature classes” grouped into “Feature datasets”. To fit the needs of the survey, two geodatabases were created: a base maps geodatabase and an entomological data geodatabase.

Base maps geodatabase

Most of the data for the base maps geodatabase were obtained from the Institut Géographique du Burkina. They are in shapefile format in a WGS 84 zone 30 projection and include administrative boundaries, land use/land cover, rivers, etc.

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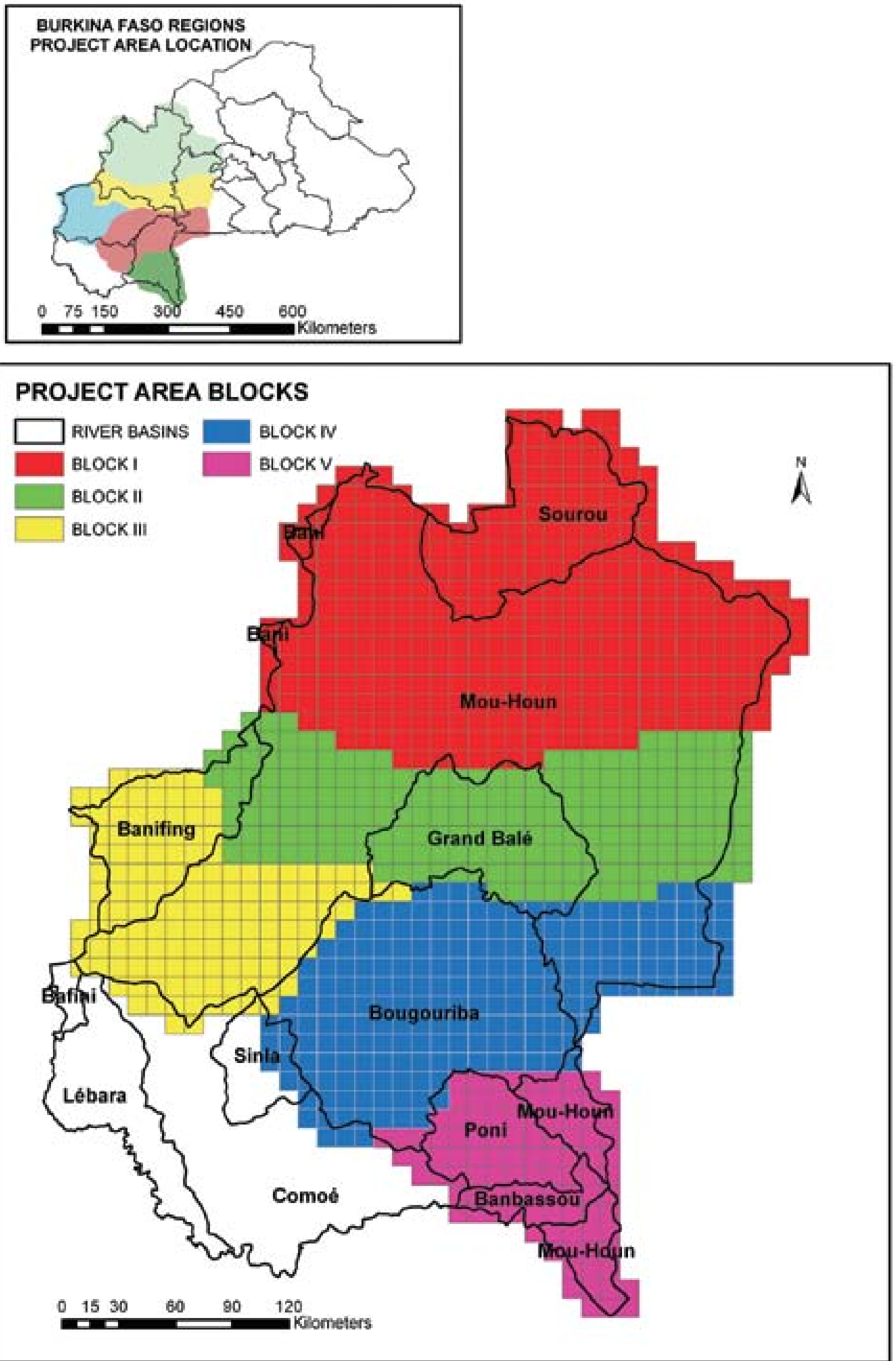
1 http://www.esri.com
2 http://www.microsoft.com

MAP 1
Project area



Entomological data geodatabase

The entomological datasets contained in this geodatabase were collected by different institutions (FAO, Centre International de Recherche Développement sur l'Elevage en zone Subhumide [CIRDES] and the International Atomic Energy Authority [IAEA]) between 1998 and 2005. These data were used for the selection of sampling sites and also for further analysis.

SATELLITE IMAGERY

Satellite images were used to determine suitable habitat for tsetse flies. Two sets of Landsat 7 ETM+ images were used, one acquired in 2000 and another acquired in 2003. Given that the survey area is known to be the habitat of riverine tsetse flies, the satellite images were used to highlight active vegetation along the drainage pattern during the dry season.

Image processing

Of the several image processing techniques used to enhance the depiction of vegetation and other land features (such as bare soil, roads and built-up areas), we chose the false colour composite (FCC) technique and made use of Landsat bands 3, 4 and 5.

In order to increase the spatial resolution, we used two techniques, "Brovey Transform" and smoothing filter-based intensity modulation (SFIM) (Liu, 2000), with panchromatic band 8. This processing gave an FCC pixel resolution of 14.5 m instead of 28.5 m.

DATABASE CREATION

A database was built to integrate the survey data into an RDBMS. The user interface reflects all the parameters contained in the field sheet used by the field survey teams.

The database contains three main tables:

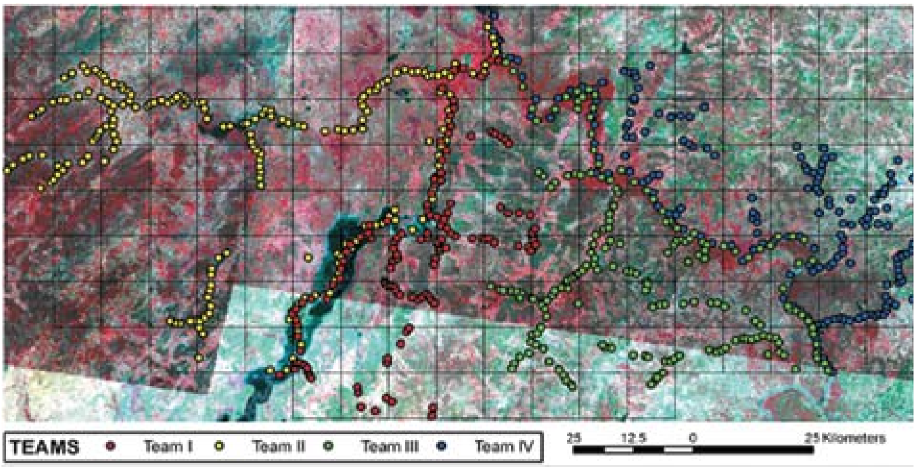
- the "Traps table", whose fields include coordinates (x and y), type of trap, date and time (deployment and release), location (region, villages, etc.) and the composition of the field team (team leader, technicians);
- the "*Glossina* table", whose fields include type of *Glossina* (species), sex and number;
- a final table whose fields include mechanical vectors (species and number).

These tables are linked by the field "trap code", which is the primary key of the "Traps table". A user interface was developed to facilitate data entry in the fields.

TRAINING IN GPS

Field data collection was conducted by four teams consisting of three people each. Each team had a team leader who was responsible for the quality of the data recorded in the field. All participants were trained for four weeks in the use of GPS as well as in the deployment and release of traps. Some individuals were taught how to use the RDBMS database and were required to enter data in cooperation with the team leaders.

MAP 2
Sampling sites allocated to the four teams (Block I)



SELECTION OF SAMPLING SITES AND FIELDWORK

Site identification

The FCC images, base maps and historical entomological geodatabase were manipulated using the ArcGIS program to select sampling sites. A grid of 10 km by 10 km was used as a reference. Within each grid cell, a maximum of 12 points (sampling sites) were selected. These sampling sites were allocated evenly among the four teams (Map 2). The sampling sites were then loaded into GPS receivers.

Fieldwork

Each team was provided with two GPS receivers. Each receiver was preloaded with the coordinates of the team's sampling sites. The teams were instructed to deploy a maximum of two traps in each sampling site. Guided by the GPS receivers, maps and local people, the teams deployed the traps in the sampling sites. The traps remained deployed for 72 hours, at which point the entomological data collection sheets were completed accordingly.

ARCGIS AND RDBMS MANAGEMENT

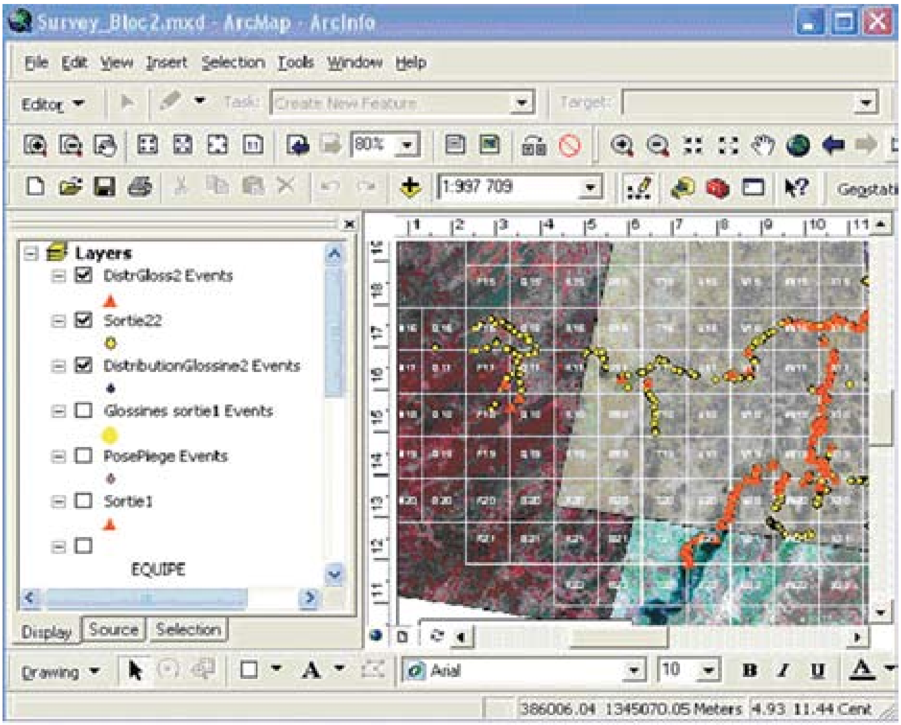
RDBMS and field data integration

Upon returning to the office, each team leader wrote a report and transmitted the entomological field sheets to the database manager, who was responsible for integrating the data into the RDBMS database.

Connection of the RDBMS to ArcGIS

After the field data were entered into the RDBMS database, the ArcGIS program was connected to it via ArcCatalog. (Such a connection enables the ArcGIS program to

FIGURE 1
Screenshot showing the conversion of tables and queries to feature classes



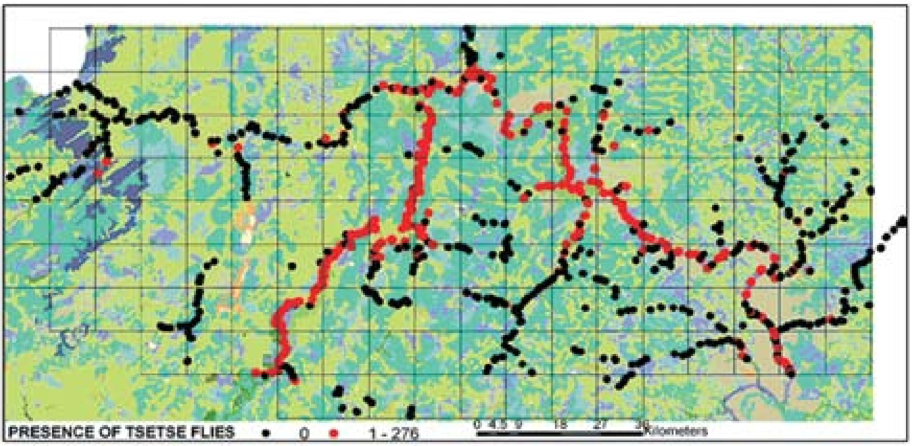
access the tables and queries available in the RDBMS database.) Using ArcMap, the tables and queries were converted into feature classes (layers) (Figure 1). Once this conversion was accomplished, users became able to plot the distributions of tsetse flies (*G. tachinoides* and *G. palpalis*), or any other related query or table, as maps, because geographic *x* and *y* coordinates had been linked to the RBDMS tables (Map 3).

CONCLUSION AND ACKNOWLEDGEMENTS

This paper shows how GIS, RS and GPS technologies have been used in an integrated way to collate entomological data for improved T&T decision-making in Burkina Faso. Historical data have been gathered and compiled in a GIS, satellite images have been acquired and processed and a database has been developed to convert field data into an electronic format.

The key concepts for planning and organizing this work are laid out in the "Collection of Entomological Baseline Data for Tsetse Area-wide Integrated Pest Management Programmes" (Leak, Ejigu and Vreysen, 2008) and the "Tsetse Intervention

MAP 3
Presence of tsetse flies (Block I)



Recording and Reporting System (TIRRS)". These documents have been prepared by the Joint FAO/IAEA Division. The project also received support from FAO/IAEA to organize a workshop to develop a detailed work plan/action plan for the collection of entomological baseline data.

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