Earth Observation Support for Traditional Ecological Mapping and Biodiversity Conservation in Viet Nam (EO-STEM) Project: *Work Package No. 2*

Milestone 7 Report: Guide to Remote Sensing Field Data Collection

Forest Cover Survey in Thua Thien-Hue, Viet Nam

August 2006

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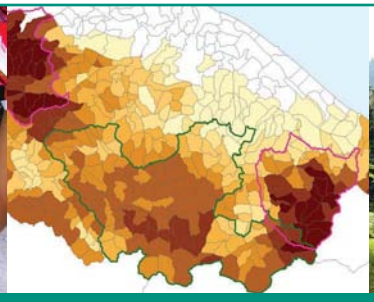

EARTH OBSERVATION SUPPORT FOR TRADITIONAL ECOLOGICAL MAPPING AND BIODIVERSITY CONSERVATION IN VIET NAM (EO-STEM) PROJECT

(CONTRACT NO. 9F028-4-5007/01)

MILESTONE 7 REPORT: GUIDE TO REMOTE SENSING FIELD DATA COLLECTION

FOREST COVER SURVEY IN THUA THIEN-HUE, VIET NAM

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1.0 INTRODUCTION

This document was produced as part of the *Earth Observation Support for Traditional Ecological Mapping and Biodiversity Conservation in Viet Nam (EO-STEM)* Project. The report fulfills obligations as per Hatfield Consultants Ltd.'s EOADP contract with the Canadian Space Agency (Contract No. 9F028-4-5007/01).

The main objective of the EO-STEM Project is to provide technical support to the Government of Viet Nam through the Green Corridor Project (GCP), which is being implemented by the World Wide Fund for Nature (WWF) and the Government of Viet Nam (Thua-Thien Hue Province and the Forest Protection Department). The goals of the EO-STEM project are directly linked with those of the GCP, which aims to maintain and sustain the rich biodiversity of the Green Corridor area in Thua Thien-Hue province, Viet Nam. A key output and focus of the project is training and capacity building for WWF, Thua-Thien Hue Province and GCP partners.

The objective of this document is to provide a practical guide for conducting ground surveys or fieldwork associated with interpretation or classification of remote sensing imagery for biodiversity conservation; hereafter referred to as **field data survey**. The guide is based on experience gained collecting such data in several areas of the world for different applications, but focuses on field data survey conducted in Thua Thien-Hue Province with staff from several Provincial and National Departments and Institutes.

Specific aims of this document are:

- To provide basic principles for conducting field data surveys;
- Provide a general protocol for field data survey;
- Provide practical demonstration of field data survey planning, data collection, and processing; and
- Provide example remote sensing data and identify tools for working with the data.

This document does **not** provide details regarding statistical theory of sampling, geographical distribution of sampling, or details of how to address the issue of *spatial autocorrelation*. These issues are mentioned in the text, and references are provided if the reader desires more information.

2.0 BASIC PRINCIPLES OF FIELD DATA SURVEY

2.1 THE NEED FOR A FIELD DATA SURVEY

Conducting a field data survey is based on a **need** for systematic data regarding the land cover of an area that one wishes to investigate using satellite imagery. The user's needs may be as diverse as, the production of a thematic land cover map, understanding areas of land cover change, or simply to allow you to interpret the information presented in a satellite image.

Before undertaking a field data survey, it is important to determine the goals and objectives of the field program. If one knows an area very well, or have other sources of information available, e.g. recent aerial photographs, then one may not need to complete a field data survey. Surveys can be costly, so if other sources of information are available, this may reduce the need for a field data survey.

It is difficult to provide universal rules that can be followed for a field data survey, because the objective of the activity, landscape, area of interest, imagery used, all influence the way the survey should be conducted. However the type of information collected is not the same as in other disciplines, e.g. biodiversity or forestry assessments – such information is to be used specifically for the interpretation of satellite imagery.

2.2 SATELLITE IMAGERY

Before planning a field data survey, one must evaluate the satellite imagery that is available. A number of important questions to consider include:

1. What is the area of interest for the satellite image or map?

2. What spatial scale is desired? The size of the study area, the complexity of the landscape, and other issues will influence the type of imagery that is appropriate. Spatial resolution of imagery will influence the aim of the field data survey; for example, Landsat Thematic Mapper (TM) images (30 m pixel size) require survey of habitat features that are appropriate for the available resolution, whereas Ikonos images (1 m pixel size) may require identification of smaller landscape features such as individual houses, fields, plant communities or trees.

3. What types of imagery are available and what is the available budget to buy new imagery?

4. What is the season and year of available archive images; are they suitable for observing the features that are required for the objectives of the study?

Usually, some compromises will be made because of availability of imagery, software tools, resources for purchase and analysis of imagery, and resources for conducting the field data survey. A useful introduction to satellite imagery and

planning satellite imagery projects can be obtained from the Center for Biodiversity and Conservation (CBC) Remote Sensing and GIS lab, which is part of the American Museum of Natural History (AMNH):

http://geospatial.amnh.org/

2.3 CLASSIFICATION SYSTEM

A classification system for land cover mapping refers to the discrete thematic land cover classes that are the aim of the mapping exercise. A well thought out and well-defined system is essential for any successful mapping exercise. Some important considerations are:

- Be realistic – the system must be appropriate for the imagery available and the capacity of the remote sensing data to discriminate those classes. Note that detailed ground-based classification systems for ecological or forestry disciplines are often unrealistic when working with satellite imagery, and if they are to be used they often require some form of aggregation; and

- Reduce ambiguity – the classification system must have clear definitions. During the ground survey, it should not be difficult to decide which land cover class a particular area belongs to, although there will always be complex transition zones between land cover classes and areas of mixed land cover.

2.4 PLANNING A FIELD DATA SURVEY

If the need for a survey has been identified, and the satellite imagery, and other resources are available to conduct the proposed work, then detailed planning for the field data survey must be conducted. As part of identifying the need for a field data survey, existing topographic and vegetation maps and other spatial data should have been compiled and consulted in advance. These maps and data are essential tools for planning a field data survey. The requirements of the planning process will be specific to the project, but some general activities should be conducted include:

1. Assemble your proposed field data survey team – discuss ideas regarding locations that are important to study, and review the classification system;

2. Consult the available maps and satellite imagery – identify areas of particular interest or uncertainty with regard to information and land cover types in the satellite image;

3. It may be useful to complete an 'unsupervised classification' on available imagery in advance of the field data survey, in order to understand the potential distribution of land cover types and areas of uncertainty;

4. Determine the logistical requirements (e.g., boat, vehicle, helicopter, etc.) that are necessary to conduct the field data survey safely and efficiently;

5. Propose a route for the field data survey (e.g., by vehicle), estimate the number of days required, and locations for overnight stays;

6. In each area where fieldwork will be conducted, research the ground conditions if they are not known, for example whether access is by 4-wheel drive, motorbike, or on-foot;

7. Consult with local officials regarding your field survey plan, and take advice from people who know the area;

8. Always plan for delays and make sure you have a contingency plan if issues such as bad weather, access restrictions or injury cause delays during parts of your trip; and

9. Follow appropriate safety protocols for your fieldwork.

2.5 SAMPLING FREQUENCY AND DISTRIBUTION

There are no strict rules related to sampling frequency and distribution of samples. Properties of landscape (in terms of topography and variation in land cover) mean that the requirements of field data surveys are often specific to the area of interest. In a complex and mountainous landscape, the land cover and topography may change over short distances, allowing the collection of information on different land cover types over smaller areas. In contrast, much larger distances may need to be covered to assess different land cover types in more homogenous areas, for example, large areas of grassland.

The survey should aim to record multiple observations of land cover types for each of the classes identified in the classification system. Rare land cover classes might be less frequently observed, but may require a special effort in order to improve confidence in the satellite imagery interpretation. A review of sampling considerations is provided by Lillesand and Kiefer (1994).

It is important to remember the objective of the field data survey, is related to the **interpretation of satellite imagery.** In general, this means that you should aim to survey a range of locations within your overall area of interest and collect 'well-spaced' observations in those areas. With geographic sampling, the issue of *spatial autocorrelation* when is important – two observations quite close to each other (e.g., in the same patch of forest) cannot be considered independent, which is a requirement for certain statistical analysis. A general rule is to record observations when moving into new habitat areas, or when you have moved into a new landscape area (e.g. new slope aspect, new valley, etc.) if in the same habitat type.

2.6 SURVEY EQUIPMENT

There are many general equipment requirements for fieldwork, e.g. those related to general safety and navigation. A field data survey requires additional equipment, examples of which are given in Section 4.0, these include:

- A well-designed *data collection form* – this can improve the accuracy and efficiency of fieldwork, and can also make computer data entry easier;
- Global Positioning System (GPS) – there are a variety of handheld GPS units that are available that allow the user to save each observation position (waypoint), which can be exported later to a file for processing once the fieldwork is complete;
- Digital Camera – with high picture resolution, e.g. at least 3.2 mega-pixel, preferably with a date and time stamp;
- Compass – to record the bearing of each photograph (optional);
- Wrist watch – to record the time of observations, which can be cross-referenced with the GPS waypoint and photograph acquisition time; and
- Imagery and/or maps – it is helpful to have printouts of imagery during the fieldwork in order to identify areas of particular interest in the imagery; if possible, they should be laminated to protect them from the elements.

2.7 REQUIREMENTS FOLLOWING A SURVEY

Following a survey, careful compilation of data is required. Specific activities depend on the type of GPS, spreadsheet software and GIS software available; however, there are some general rules, as follows:

- Compile the data as soon as possible, while the field experience is 'fresh' in the memory;
- Provide metadata, or descriptions of all files and folders, when you compile the data;
- Always keep the original GPS data and photographs – don't delete them! and;
- Back-up all the data to a CD and label it appropriately.

3.0 LAND COVER SURVEY IN THUA THIEN-HUE, VIET NAM

3.1 OBJECTIVE

As part of the EO-STEM project, a field data survey was organized to gather field data in Thua Thien-Hue Province, Viet Nam, particularly within the Green Corridor. The aim of the surveys was to collect information that could be used to create a new land cover map of the province based on updated satellite imagery. The **need** was based on the fact that existing maps were out-of-date and did not provide the necessary detail regarding land cover classes. The final land cover map will be used as part of a conservation planning process.

The planning and implementation of the survey were influenced by factors discussed above in Section 2.0, in particular:

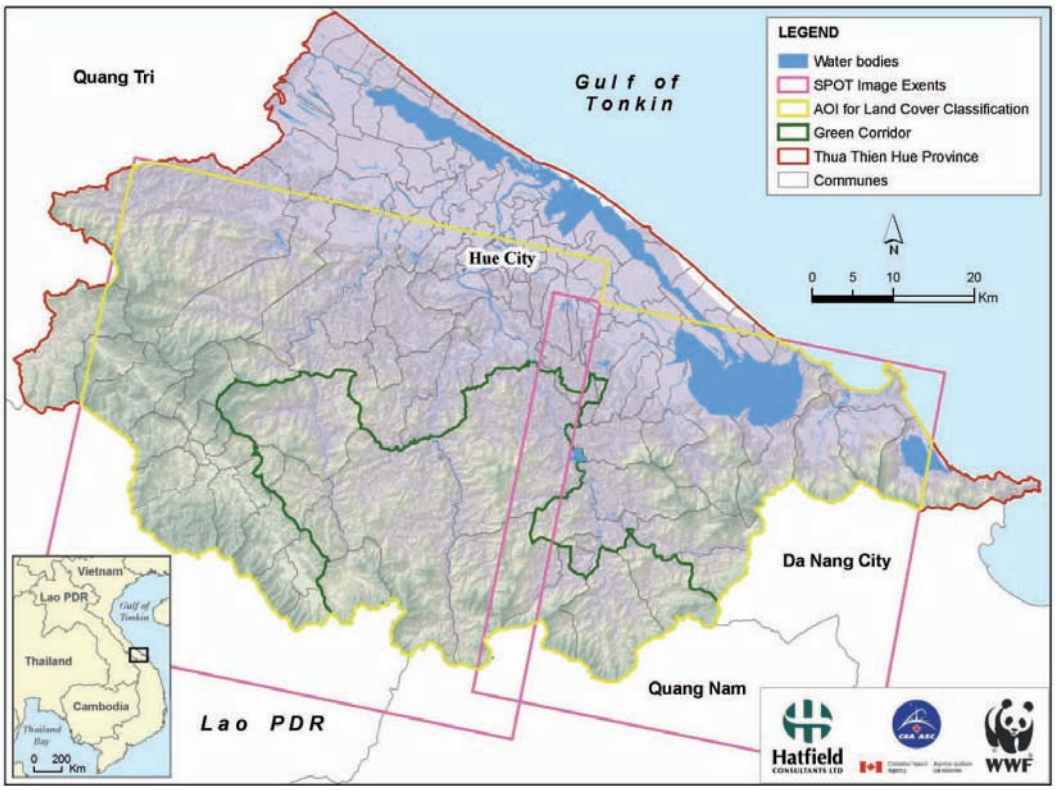
- Desired classification system – the provincial government requires that the classification system follow that created by the Ministry of Natural Resources and Environment (MONRE);

- Landscape and challenges of logistics – the province is quite mountainous in some places and access can be difficult. Careful planning was required involving experienced surveyors from the Provincial Forest Inventory and Planning Group (FIPG); and

- Satellite imagery – through EO-STEM, the area of interest was covered by two new satellite images acquired from the SPOT-5 satellite, which are 4-band multi-spectral (visible and near-infrared wavelengths) with 10 metre spatial resolution. The images were acquired in July 2004 and February 2005 and covered almost all of the area of interest (as shown in Figure 1). Difference in the year of acquisition was not considered important based on landscape change, but there were some noticeable differences in the imagery related to the growth stage of crops in agricultural areas – this seasonal variation needs to be taken into account during the interpretation stage.

For more information of the satellite imagery and the classification of land cover as part of the EO-STEM Project, please refer to EO-STEM Technical Report: Milestone 7 - Remote Sensing Classification of Thua Thien-Hue Forest Cover (Hatfield Consultants Ltd, 2006).

Figure 1 **Area of interest and coverage of SPOT imagery, Thua Thien Hue Province, Viet Nam.**



3.2 CLASSIFICATION SYSTEM

The field data survey for Thua Thien-Hue was based on the Vietnamese system for *Classification of Evergreen Natural Wooden Forest* from the Ministry of Natural Resources and Environment. This system was developed for forestry related purposes and is a hierarchical system.

A graphical representation of the hierarchical classification system is presented in Figure 2; the definitions of the classes are provided below in Table 1. From a remote sensing perspective, the classification system required simplification because certain forest classes would not be easily distinguishable from the available remote sensing imagery. Furthermore, for the area of interest, there were no forest areas considered pristine (Group IV). Based on discussion with end-users of the final map and local forestry specialists, certain classes were identified as high priority, which meant that they were included as target classes for the remote sensing work. In addition to the forest classes, additional land cover classes were recorded, such as plantation forest, agricultural land and bare ground.

Figure 2 **Vietnamese Classification of Evergreen Natural Wooden Forest (Ministry of Natural Resources and Environment).**

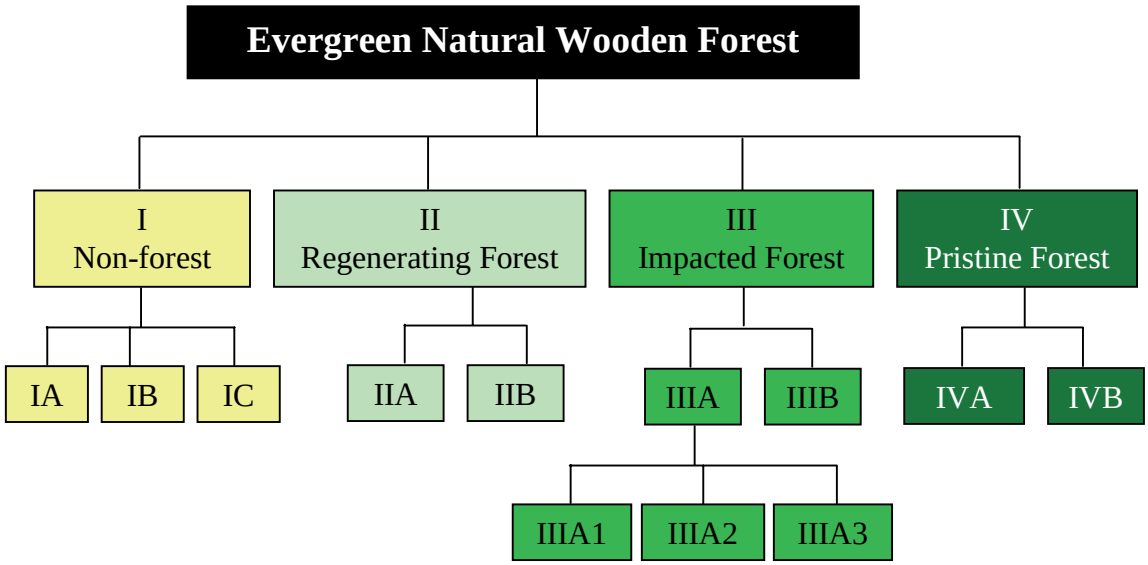


Table 1 Class definition for Vietnamese Classification of Evergreen Natural Wooden Forest (Ministry of Natural Resources and Environment).

Group I: Non-forest. Only grasses, bushes with very few trees, scattered bamboos; coverage index is under 0.3. This group has 3 sub-groups:
IA: Characterized by grasses, bushes or wild bananas.
IB: Characterized by bushes, scattered wooden trees and bamboos.
IC: Characterized by high density regenerating trees. Trees taller than 1m and more than 1,000 trees/ha.
Group II: Regenerating forest with pioneer species that have smaller diameter. Based on status and origin, there are 2 sub-groups:
IIA: Regenerating forest after agricultural activities, characterized by pioneer species that are fast growing and prefer light. Trees are of similar age and there is only 1 story.
IIB: Regenerating forest following heavy exploitation for timber. Young community with species preferring light; diverse species composition; trees of different ages; dominance is not clear. There are maybe some big trees remaining, but the numbers are not relevant. Forest is only classified into this group if the community with the commonest diameter not more than 20cm.
Group III: Impacted secondary forest. Communities have been exploited, which has changed the structure of the forest. Depending on exploitation levels and the potential products, there are two sub-group recognized:
IIIA: Heavily exploited communities; present potential for exploitation is limited and the structure of the forest is significantly changed. There are 3 sub-groups:
IIIA1: Most heavily exploited forest. The upper story may have some large trees, but generally the forest is of low quality with numerous of vines, bushes, and bamboos.
IIIA2: Heavily exploited, but significant time for regeneration. Characterized by the middle story becoming dominant with majority of trees in this story having a diameter of 20-30cm. The forest has at least 2 stories; the upper story coverage is not continuous, being mostly established by the trees from the lower story before; there are maybe a few large trees.
IIIA3: Exploited forest or forest developing from IIIA2. The communities have a relatively closed coverage, having at least 2 stories. The main difference form type IIIA2 is the number of trees is higher and there are some trees with diameter more than 35cm.
IIIB: Characterized by communities that have been selectively logged, with some valuable wooden species exploited. The stable structure of the forest hasn't changed; biomass is high with a high percentage of large trees.
Group IV: Pristine forest, stable forest. Pristine forest or matured secondary forest that hasn't been exploited. The forest has a stable structure, multi-story, diverse diameter sizes, but sometimes lacking lower story. There are 2 sub-groups:
IVA: Pristine forest
IVB: Regenerating secondary forest.

Note: Translated and provided to EO-STEM by GCP (2006).

3.3 AREA OF INTEREST AND SURVEY PLAN

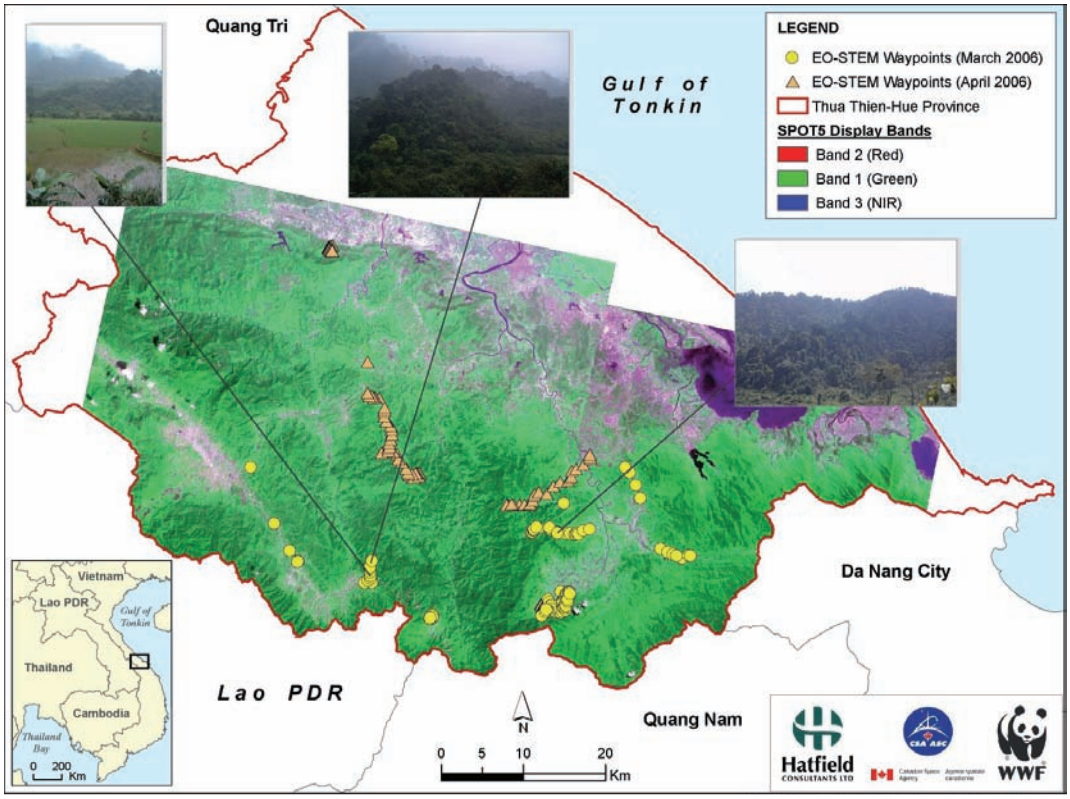
The area of interest for the EO-STEM project is the Green Corridor Project area with the Province of Thua Thien-Hue; however, a map covering the entire forested area of TT-Hue was required.

Figure 3 shows the extent of the satellite imagery, provincial administrative borders, the Green Corridor boundary and the general locations of the field data surveys. The surveys were designed to cover the whole range of land cover

classes required and a range of elevations. Some observations were obtained in close proximity to paved roads, but access to other areas required 4-wheel drive, or hiking along trails.

Within each survey area, individual waypoints were collected according to the general principles identified in Section 2.0.

Figure 3 Location of field data surveys conducted as part of the EO-STEM project in Thua Thien-Hue Province, Viet Nam.



3.4 SURVEY TEAM

The field data survey was conducted in March 2006 by a team including:

- Dr. Andy Dean and Mr. Pierre Dubeau (EO-STEM; Hatfield Consultants Ltd.);
- Dr. Do Xuan Lan (FIPI);
- Mr. Huy (Hue FPD);
- Mr. Phong (Hue FIPG); and
- Mr. Linh (Sub-FIPI).

4.0 PROTOCOL FOR FIELD DATA SURVEY

It is very important to establish a protocol for the field data survey; each team member must understand their role, and adhere to the protocol. The following sections describe the protocol followed during the EO-STEM field data survey, and provide some suggestions when conducting field data surveys.

4.1 EQUIPMENT SETUP

GPS:

- Take one, or preferably two, GPS units to the field;
- Make sure you know how to use the GPS – read the instructions;
- Set up the GPS with the appropriate coordinate system for your mapping work;
- Check the memory and download and archive any waypoints that remain in memory;
- Take spare batteries – do not buy low quality batteries! and
- Set up the GPS to store tracks – make sure you have enough memory to store the total number of track points from your survey. Adjust the time interval between track points based on the estimated time in the field, and the amount of memory, to ensure tracks do not get over-written.

Camera:

- Make sure your camera has sufficient memory to store up to several hundred high quality photographs;
- Set the camera date and time accurately;
- Set the camera picture quality to high resolution (e.g. at least 3.2 mega-pixel);
- Take spare batteries – do not buy low quality batteries! and
- Take a back-up camera and additional memory (if possible), in the event of technical problems.

Data collection form:

- Print sufficient data collection forms;
- Use water resistant paper, if possible (e.g. 'Rite In the Rain');
- Write with a pencil; and
- Bring copies of field maps, laminated if possible.

4.2 DATA COLLECTION FORM

The EO-STEM data collection form was developed using an Excel spreadsheet; see Appendix A1 for a copy of the form. The form has fields for collection of general information and waypoint information. The form fields are defined below and the protocol for completion of each form is described in Section 4.3.

4.2.1 General Information

The following information should be recorded at the start of each survey day and on each data collection sheet:

- **Team Members –** the names of all members of the survey team;
- **Date –** the date of the survey;
- **Camera –** the ID of the camera used, which may be important if a department or organization has several cameras used for surveys; and
- **Co-ordinate System –** the projection, datum, and co-ordinate system used for the field data collection.

4.2.2 Waypoint Information

The following describes information that should be recorded when waypoints are collected:

- **GPS Unit –** the ID of the GPS unit used, which may be important if a department or organization has several GPS units used for surveys;
- **Waypoint –** the waypoint number for the GPS used (i.e. 001, 002, 003, etc.);
- **GPS Time –** time in hours, minutes, seconds recorded from the GPS (i.e., hh:mm:ss);
- **Photo Time –** time the photo was taken in hours and minutes, using a wrist watch (i.e. hh:mm);
- **Bearing –** photo bearing in degrees (i.e. 0 to 360°) in the direction of the class being described;
- **Distance –** estimated distance to the class being described in increments of 500 m (i.e. 500, 1000, 1500, etc.);
- **Check boxes** for each land cover class – the codes must be well defined and understood by all members of the survey team;

- **Description** – additional description of the land cover, including the name of other classes recorded in the vicinity (e.g. plantation) or context information; and

- **Sketch Box** – additional information on the surrounding features can be schematically drawn. This can also be a useful area to indicate the location of the collected waypoint, for geo-metric validation.

4.3 DATA RECORDING PROTOCOL

The data collection form should make information collection straightforward and reduce uncertainty and errors in data recording. The continuous recording of tracks allows the survey team to re-trace the entire field collection route, which could be useful when interpreting the satellite imagery. Individual waypoints are collected at locations of a specific land class or area of interest. Below are some basic steps to follow, which will improve the ability to use the field data collected:

1. Preparation:

    - Create a new GPS track at the start of the day. Make sure that the maximum number of tracks is high enough so that the whole day can be tracked at the desired observation frequency (e.g. 15 second track intervals for 8 hours requires capacity for 1,920 tracks);

    - Record the **Date**, **Team Members** and **Camera** used at the top of <u>every</u> data collection form;

    - Check that the camera date and time are correct; and

    - Check that the camera is set to take maximum resolution photographs (at least 3.2 mega-pixels).

2. Data Collection at a waypoint location:

    - Record a **waypoint** at each survey location and record the GPS unit ID and the waypoint number;

    - Record GPS time;

    - Record photo time. If more than one photo is acquired, use a **new row** on the data collection form for each photo, and record the new time for each photo;

    - Record the bearing of each photo. If you are recording a land cover type that is "all around " the waypoint location, record "999" for the bearing;

- When recording data, complete a new row for each waypoint, photo, or class;
- Estimate the distance to the class;
- Record the land cover class by ticking **one** box only; and
- If a location and/or photo has more than one class that you wish to record, complete a **new row** in the data collection form for **each class and photo**.

3. Using a hard copy map:
    - At each waypoint, if you have a large scale topographic map or image, you may wish to record your route (track) and each waypoint on the map in an approximate position, for example using the GPS coordinates; and
    - Also, you may wish to mark on the map the feature that you were describing, especially if this feature was on a facing slope of a valley. This will aid the interpretation of the photographs, bearing and distance information recorded on the field data sheet.
4. Follow up:
    - At the end of the day, review the collected information to make sure it is clear and all information required was recorded; and
    - If possible, download the GPS tracks, waypoints, and photographs to a computer.

The above steps describe the protocol for the collection of field data using a manual technique. Data collection and attributing can also be captured digitally, using Personal Digital Assistant (PDA) devices and specialized software. This will be discussed further in Section 6.0.

5.0 PROCESSING OF FIELD DATA

The processing of collected data will vary according to the type of GPS unit and the software packages available.

5.1 DOWNLOADING GPS DATA

Useful free software for working with GPS data includes *GPSTrackMaker,* which was developed by Odilon Ferreira Junior (www.gpstm.com); another popular free package is *OziExplorer* (www.oziexplorer.com). Depending on your model of GPS, it may be better to use the software that comes with your GPS unit (e.g. *Garmin Mapsource*). It is also useful to note that ArcMap v9 offers GPS support that allows for the direct connection to a GPS unit and real-time data collection and digitizing.

The following are guidelines for processing GPS waypoint data:

1. Create a folder called GPS_Data;

2. In a sub-folder (e.g. Raw), store the GPS data in its raw or native format;

3. In a sub-folder (e.g. Excel), use GPS software to save the **Waypoints** and **Tracks** as comma delimited text files. Or by using Excel, save the files as a *.xls files (**Tracks.xls, waypoints.xls**).

    - Waypoints.xls should have the following fields: WpN, X, Y, GPSUnit, Date, Time, and Elev.

    - Tracks.xls will have x, y, GPSunit, date, time, and elevation fields, but unfortunately some GPS software tools do not import the time, date and elevation data for tracks.

5.2 FIELD DATA ENTRY

Data should be transferred from the data collection forms into an Excel spreadsheet manually, as follows:

1. Create a folder called Survey_Data;

2. Create an Excel file called **SurveyData.xls**, which will be a template for data transfer from the data collection forms. A sample spreadsheet is provided in Appendix A2.

    - **SurveyData.xls** will have the following fields: Date, GPSUnit, Camera, WpN, GPSTime, PhotoTime, Bearing, Distance, Class, and Description.

    - WpN needs to contain unique values (primary key). If you have two waypoints with the same number, then create a suffix to the waypoint, e.g., a001, b001, where "a" and "b" are the GPSUnit.

5.3 PHOTOGRAPHS

A crucial process is providing the correct basis to link the photographs taken to the collected waypoints.

1. Download the photographs from the camera into a folder called Photos;

2. Modify and rotate the photos as required. Note that this will reset the Date Modified for the photo, which should be **reset to the date and time that the photo was taken** (the EXIF date). Useful software to use is *Thumbplus* (www.cerious.com), which has a free 30-day trial;

3. Create a text file called **PhotoCatalog.txt** containing a list of the all the individual photo file names and their directory path. This can be completed in a number of ways, for example using MS Outlook;

    a. Select '*Advanced Find*' from the '*Tools*' menu and select '*Files*' from the '*Look for*' drop down list box and *select* '*All Files (*.*)*' from the '*Of type*' drop down list box;

    b. Click on '*Browse*' and navigate to the directory containing all field photos taken from field data survey, and click on '*Find Now*';

    c. The search results will be listed at the bottom of the '*Advanced Find*' dialog box and will have both the file names and their directory path; and

    d. Select all results and copy/paste them in an Excel spreadsheet for further manipulation and sorting;

4. Create an Excel file called **PhotoCatalog.xls**, which has the following fields:

    a. WpN, PhotoName, Path, and DateTime; and

    b. Create an additional field called "Hyperlink" or "Path", which has the full file path and name (e.g., C:/myfielddata/photos/photo1234.jpg);

5. The Final stage is to enter the waypoint number for each photo, matching the **Date and Time** of the Photo and those from **SurveyData.xls.** A separate field should be created containing the waypoint.

See photo catalogue in Appendix A3 for an example of the result of these steps.

5.4 CREATION OF GIS DATA

5.4.1 ArcGIS 9x

The instructions herein are based on the creation of GIS data in an ESRI Shape format using ArcGIS 9x. Following the previous steps, we have four files: **PhotoCatalog.xls SurveyData.xls, Tracks.xls, and Waypoints.xls.**

To create a Shapefile of Waypoints and Tracks, complete the following:

1. In Excel, select the records that you would like to export as shapefile. Save this selection as *.dbf version IV format;

2. Ensure that the *.dbf file contains a minimum of two fields: one for the x-coordinate and one for the y-coordinate. The values in these fields must be numerical; therefore, geographic coordinate (e.g. latitude and longitude) must be represented as decimal degrees. Make sure you format the numeric data columns with the correct number of decimal places before you save as the *.dbf file;

3. Open ArcMap;

4. Load the new table in ArcMap using the '*add data*' button;

5. In the Table of Contents (layers list), right-click the file name and choose Open to view the table, and check that the data were imported correctly;

6. To import the tabular data containing geographical locations, selected '*Tools* > *Add XY data*'. Choose the x and y fields, and select the appropriate coordinate system, which was identified during the GPS collection;

7. Click *OK* to visualize the *XY data* as a layer within ArcMap; and

8. To permanently create the layer containing the *XY data* it must be exported to a shapefile. *Right-Click* the layer name in the table of contents and select '*Data* > *Export*'.

5.4.2 ArcView 3x

The following instructions describe the steps involved in creating an ESRI shapefile using ArcView 3x:

1. In Excel, select the records that you would like to export as shapefile. Save this selection as *.dbf version IV format;

2. Ensure that the *.dbf file contains a minimum of two fields: one for the x-coordinate and one for the y-coordinate. The values in these fields must be numerical, therefore geographic coordinate (e.g. latitude and longitude) must be represented as decimal degrees. Make sure you format the numeric data columns with the correct number of decimal places before you save as the *.dbf file;

3. Open ArcView 3x;

4. Add the table to the existing active project by selecting '*Add Table*' from the 'Project' menu;

5. In the Table of Contents (layers list), open to table and check that the data were imported correctly;

6. Select '*Add Event Theme*' from the '*View*' menu, and choose the x and y fields, and select the appropriate coordinate system, that was identified during the GPS collection;

7. Click *OK* to visualize the *Event Theme* as a theme in ArcView; and

8. To permanently create a shapefile, the *Event Theme* must be exported to a shapefile. *Select 'Export'* from the '*File*' menu.

5.4.3 Appending Attributes

The next step is to link **SurveyData.dbf** to **Waypoints.shp:**

1. Add **SurveyData.dbf** and **Waypoints.shp** to ArcMap using the '*add data*' button;

   - In the Table of Contents (layers list), right-click on **Waypoints.shp** and choose '*Joins and Relates* > *Join*';
   - Choose WpN as the attribute field that the join will be based upon;
   - Choose **SurveyData.dbf** as the layer that the table will be joined with;
   - Choose WpN as corresponding attribute field in **SurveyData.dbf** that the join will be based upon; and
   - Click *OK*.

2. To permanently join the attributes to **Waypoints.shp**, the layer must be exported to a new file.

5.5 GEOCODING GPS PHOTOGRAPHS

To create a shapefile with hyperlinked photographs, both the **PhotoCatalog.xls** and the **Waypoints.shp** are needed. As indicated above, the following fields that should be present in the **PhotoCatalog.xls** and **Waypoints.shp** file respectively are:

- WpN, PhotoName, Path, Date, and Time; and
- WpN, X, Y, GPSUnit, Date, Time, and Elevation.

The process of creating a shapefile from tabular XY data is described in the previous section, therefore the steps involved in creating hyperlinks to the photographs are:

1. Open **PhotoCatalog.xls** in Excel and select the records that you would like to export as shapefile. Save this selection as *.dbf version IV format;

    - Ensure that the *.dbf file contains a minimum of two fields: one for the x-coordinate and one for the y-coordinate. The values in these fields must be numerical. Make sure you format the numeric data columns with the correct number of decimal places before you save as the *.dbf file;

    - Add **PhotoCatalog.dbf** and **Waypoints.shp** to ArcMap using the '*add data*' button;

    - In the Table of Contents (layers list), right-click on **Waypoints.shp** and choose '*Joins and Relates* > *Join*';

    - Choose WpN as the attribute field that the join will be based upon;

    - Choose **PhotoCatalog.dbf** as the layer that the table will be joined with;

    - Choose WpN as corresponding attribute field in **PhotoCatalog.dbf** that the join will be based upon; and

    - Click *OK*.

3. To permanently join the attributes to **Waypoints.shp**, the layer must be exported to a new file;

4. To activate the hyperlinks feature in ArcMap, *right-click* the new shapefile and select '*Properties*'. In the '*Layer Properties*' dialog box, *choose* the '*Display*' tab and *check* '*Support Hyperlinks using field*'. In the drop down menu, *choose* the field that contains the directory, path and filename of the digital photo, (e.g. Path); and

5. Click OK.

5.6 RESULTS OF THE THUA THIEN-HUE SURVEY

The tracks for the field data survey conducted in TT-Hue are shown in Figure 4. During the two field data surveys, the following was completed:

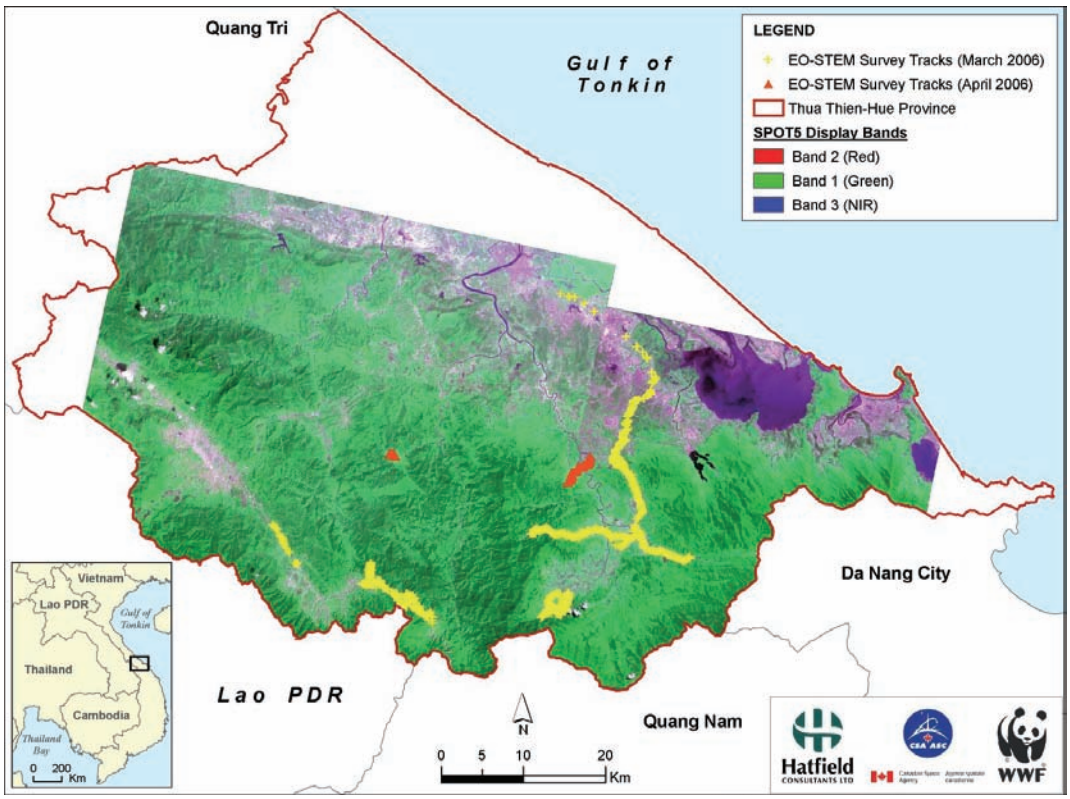
- A total of 6 days were spent in the field;

- Over 100 waypoints were collected; and

- Several hundred photographs were taken.

The survey covered several areas distributed across the Province and in the Green Corridor. Due to logistical and topographic constraints, some areas were inaccessible to the field team. Careful research regarding the accessibility of areas meant that the field survey was completed as planned, and the desired range of land cover types were visited and waypoints recorded. The field survey data was used in a classification of forest and land cover for Thua Thien-Hue Province, using satellite imagery from SPOT-5; the results of this work are detailed in the EO-STEM Technical Report: Milestone 7 - Remote Sensing Classification of Thua Thien-Hue Forest Cover (Hatfield Consultants Ltd, 2006).

Figure 4 Survey tracks from the EO-STEM field data survey, Thua Thien-Hue Province, Viet Nam.



6.0 FUTURE WORK

Data collection and real-time information gathering and digitizing can now be effectively done digitally using PDA devices and specialized software. ESRI ArcPAD, for example, provides support for industry standard vector and raster image display and allows for the use of satellite images (in combination with other GIS layers) in the field, as a base to collect information. The interface with the GPS allows for real-time navigation and recording of geographic locations.

There are many other software packages available for real-time data collection that can be used on PDA devices or laptop tablets. A few are *OziExplorerCE*, *VITO SmartMap*, and *Virtual Earth Mobile (VEM)*.

Using such tools, most steps described in this report could be completed in the field, reducing the amount of time for data management, preparation, and post-data collection processing.

Figure 5 Data collection using integrated PDA and GPS devices.

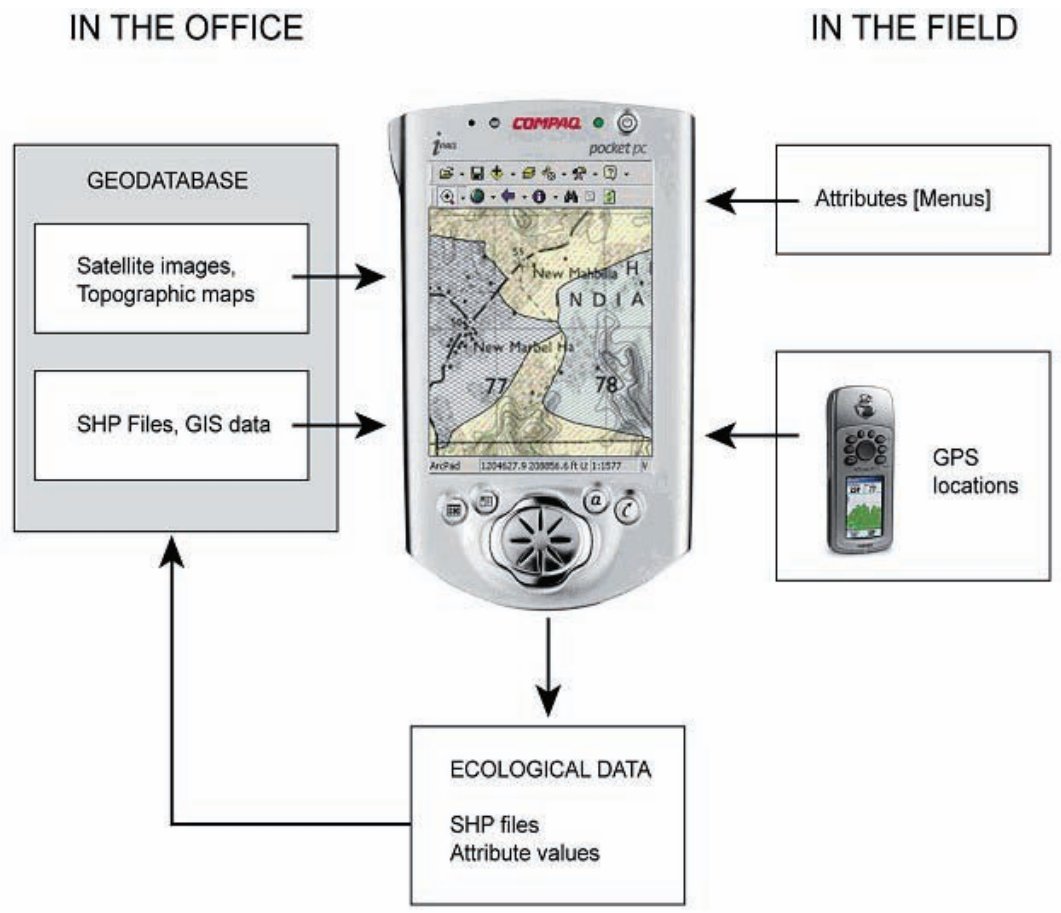


Figure 6 EO-STEM team members recording data in real-time.

7.0 FURTHER INFORMATION AND REFERENCES

For more information on field data survey, GPS and mapping ideas, remote sensing, see the following sources of information:

- **Remote Sensing and GIS Lab,** Center of the Biodiversity and Conservation, **American Museum of Natural History**. The Remote Sensing and GIS lab is a leader in developing and promoting the effective use of geospatial tools by amateur and professional conservation practitioners – see http://geospatial.amnh.org/.

- Lillesand, T.M. and Kiefer, R.W. (1994) **Remote Sensing and Image Interpretation**, John Wiley and Sons, Inc, - this book provides a great introduction to Remote Sensing, including some information on surveying and sampling.

- **Mapping Hacks** by Erle, Gibson and Walsh (2005), O'Reilly Media, Inc. There are many ways and techniques used in mapping GPS data. For interesting and fun techniques in mapping your GPS waypoints and tracks, as well as geo-referencing digital photos, **Mapping Hacks** has some great ideas. For more information please refer to http://mappinghacks.com/.

8.0 CLOSURE

Hatfield Consultants Ltd.:

Approved by: 

Thomas G. Boivin, Project Director	August 8, 2006
	Date

Approved by: 

Dr. Andy Dean, Project Manager	August 8, 2006
	Date

APPENDICES

Appendix A1

Data Collection Form

Classification of Evergreen Natural Wooden forest: 4 groups

Date: ______________________ **Camera:** __________

Team members: ______________________

GPS Unit	Waypoint	GPS Time	Photo Time	Bearing	Distance	1			2		3				Description
						A	B	C	A	B	A1	A2	A3	B	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	
						❑	❑	❑	❑	❑	❑	❑	❑	❑	

Appendix A2

Sample Field Data

EO-STEM Survey Data: March 2006

Date	GPSUnit	Camera	WpN	GPSTime	PhotoTime	Bearing	Distance	Class	Description
1-Mar	a	1	a002	15:48:53		40°	200	31	Patch (size?) at a distance, ~ 200 m
1-Mar	a	1	a002	15:50:18		340°	150	1b	~ 150 m distance
1-Mar	a		a002	15:50:18		340°	200	31	Patch (size?) at a distance, ~ 200 m
1-Mar	a	1	a004	16:05:38		190°	100	31	On top of mountain, ~ 100 m from settlement on the right side
1-Mar	a	1	a004	16:08:40		230°	300	2b	On the top … ~ 300 m
1-Mar	a	1	a004	16:14:06		215°		1b	Behind settlement
1-Mar	a	1	a004	16:14:46		230°		1a	Road in centre
1-Mar	a	1	a004	16:16:06		160°		99	Paddy
1-Mar	a	1	a005	16:46:51		195°		99	Cinnamon plantation in village settlement
1-Mar	a	1	a005	16:47:44		100°		99	Fields - cinnamon in background
1-Mar	a	1	a005	16:48:06		110°		99	Fields - cinnamon in background (no entry in datasheet)
3-Mar	a	2	a007	10:15:25		215°	75	99	Acacia - 6 years old
3-Mar	a	2	a007	10:18:08		215°	75	99	Acacia - 6 years old
3-Mar	a	2	a008	10:39:08		999°		99	Acacia all around - 8 year old
3-Mar	a		a011	11:10:49		666°		1a	Left plantation, entering new forest class (1a)
3-Mar	a	1	a013	11:26:02		180°		31	Left forest class (1c) moving into (31)
3-Mar	a		a014	11:34:11		999°	0	1a	Around trail (~ 50 m radius), small patch
3-Mar	a	1	a015	12:14:27		190°	0	31	Along trail
3-Mar	a	1	a016	12:31:30		190°	200	31	Whole photograph (200 m)
3-Mar	a		a017	12:45:19		999°		31	Was logged 'long time ago' …
3-Mar	a	1	a018	13:10:06		170°		31	Along trail
3-Mar	a	1	a019	14:32:30		200°		1c	Patch showing at bottom of photo; plantation visible on the west side (right)
3-Mar	a	1	a019	14:32:54		230°		31	Patch on the top
3-Mar	a	1	a019	14:32:54		200°		31	High elevation (1 km)
4-Mar	a	1	a022	09:11:58		25°		1a	General landscape
4-Mar	a	1	a022	09:12:01				1a	Close up on the team standing on steep slope (unknown bearing)
4-Mar	a	1	a022	09:17:26		310°		1a	General landscape
4-Mar	a		a023	09:18:53		260°	1,200	1a	Plantation at 1,200 m (opposite), east facing; Altitude 190 m
4-Mar	a	1	a024	09:37:52		210°	0	1b	1b all around
4-Mar	a	1	a025	09:51:05		30°	0	2b	2b forest all around
4-Mar	a	1	a026	10:06:48		235°	0	31	2b forest all around; very large trees left
4-Mar	a		a027	10:27:33			0	31	31 forest all around
4-Mar	a	1	a028	10:41:58		20°	0	2b	Transition 2b to 31
4-Mar	a		a029	10:47:47			0	31	All around
4-Mar	a	1	a030	11:15:16		125°	0	31	All around
4-Mar	a		a031	12:49:08			0	31	All around
4-Mar	a	1	a032	13:03:14		340°	0	31	All around
4-Mar	a	1	a033	15:01:53		100°	100		Looking at plantation edge with natural forest 100 m to west slop
5-Mar	a	1	a034	10:04:36		190°		2b	Bottom left part

Date	GPSUnit	Camera	WpN	GPSTime	PhotoTime	Bearing	Distance	Class	Description
5-Mar	a	1	a034	10:04:36		190°		31	Top
5-Mar	a	1	a034	10:06:54		340°		1c	Bottom
5-Mar	a	1	a034	10:06:54		340°		31	Top
5-Mar	a	1	a035	10:20:22		300°	150	1c	Foreground (~ 150 m)
5-Mar	a	1	a035	10:20:22		300°	1,500	31	1,500 m in distance
5-Mar	a	1	a036	10:59:59		180°	150	2b	
5-Mar	a	1	a037	11:37:29		270°	300	31	
5-Mar	a	1	a038	11:54:48		200°		31	Patch covering the whole slope
5-Mar	a	1	a039	12:03:26		130°	70	1b	Shrub after shifting cultivation
5-Mar	a	1	a039	12:05:06		90°	100		100 m in distance; hill in distance is (1b) to (1c) on top
5-Mar	a	1	a040	12:51:06		55°		1b	Forest station, some small planted at station - same as wpt 39
5-Mar	a	1	a041	13:53:50		195°		31	31 forest at the top & 2b forest down
5-Mar	a	1	a041	13:54:32					Area next to Photo-1 (previous), to the right; no bearing, no forest classes
5-Mar	a	1	a041	14:02:06					Slope with degraded forest: photo taken around the same time, but no data available
5-Mar	a	1	a043	14:08:48		30°			Planted & '1a' to '1c' mosaic
5-Mar	a	1	a043	14:10:53		250°		1a	1a forest with some plantation; jeep in picture
5-Mar	a	1	a044	14:14:22		265°	100		Planted (see 'a043') ~ 100 m in distance
5-Mar	a	1	a045	14:19:05		10°			1a to '1c' mosaic; also planted
5-Mar	a	1	a046	14:24:54		70°		1a	No data on sheet… unsure if this is the right photo***
5-Mar	a	1	a046	14:25:09		150°		31	Top: '31'; Lower: '1c'; Left of picture is '1a' bareground; *photo taken at 14:22:42*
5-Mar	a	1	a047	14:35:00		335°	200	1c	Patch of typical '1c' forest (~ 200 m in distance)
5-Mar	a	1	a047	14:35:16		130°	500	31	31 and '1a' forest to east small planted (~ 500 m in distance)
5-Mar	a	1	a047	14:35:22					Extra photo taken less than a minute after previous (1)… see for yourself
5-Mar	a	1	a048	14:50:05		150°			31 forest at the top , ~ 3 year old plantation in mid-slope, cultivation at bottom
6-Mar	a	1	a049	8:31:40		10°		1a	Patch covering the whole slope (note: photo taken at 08:30:32)
6-Mar	a	1	a050	8:46:58		10°		2b	Patch covering the whole slope
6-Mar	a	1	a050	8:47:46		250°		2b	Note indicate "whole slope" while the photo shows a patch of planted trees
6-Mar	a	1	a051	9:01:13		10°	100	1b	1b patch located ~ 100 m in distance
6-Mar	a	1	a051	9:01:13		10°	700	2b	2b forest patch located ~ 700 m in distance
6-Mar	a	1	a051	9:01:13		10°	1,000	31	31 forest found at > 1 km in distance
6-Mar	a	1	a052	9:34:48		180°		2a	Standing in planted forest; '2a' forest on lower facing slope; '31' forest on top
6-Mar	a		a053	9:57:43				2b	Trail goes through '2b' forest; '31' forest on mountain top
6-Mar	a	1	a054	10:03:18		320°		31	31 forest on the top; '2b' forest in the bottom
6-Mar	a	1	a054	10:03:18		240°	200	31	31 forest on the top; '2b' forest in the bottom (no photo matching description found)
6-Mar	a	1	a055	10:49:31		345°		31	Near BMNP Forest Station (FPD sign in photo)
2-Mar	b	1	b003	9:11:34		40°	100	1a	1a at lower elevation (~ 100 m in distance)
2-Mar	b	1	b003	9:11:34		40°	200	31	31 forest at higher elevation (~ 200 m in distance)
2-Mar	b	1	b004	9:30:31		82°	300	31	31 forest at top of mountain (~ 300 m in distance)
2-Mar	b	1	b004	9:30:31		82°	200	2a	2a forest at lower elevation (~ 200 m in distance)
2-Mar	b	1	b004	9:33:52		100°	100	2b	2b forest at mountain base (~ 100 min distance)
2-Mar	b	1	b005	9:49:29		70°	100	31	(~ 100 min distance)

Date	GPSUnit	Camera	WpN	GPSTime	PhotoTime	Bearing	Distance	Class	Description
2-Mar	b		b006	10:05:18		999°	0	2b	Along trail
2-Mar	b		b007	10:19:27		235°	0	31	Along trail & '2b' forest on left side of trail (possible)
2-Mar	b	1	b008	10:31:51		999°	0	31	31 forest all around
2-Mar	b	1	b009	11:02:23		999°	0	31	End of track
2-Mar	b	1	b010	13:59:21		250°	150	99	*Acacia mangium* (2 or 3 year old)
2-Mar	b	1	b010	13:59:38		180°	150	99	*Acacia mangium* (2 or 3 year old)
2-Mar	b	1	b010	14:01:54		105°	250	31	Poor natural forest '31', on top of hill, along road
2-Mar	b	1	b010	14:01:54		105°		1b	1b adjacent to highway
2-Mar	b	1	b011	14:17:00		75°	200	99	Pine forest ~ 200 m from road
2-Mar	b	1	b011	14:17:46		30°	50	99	Cinnamon plantation ~ 50 m from road
2-Mar	b	1	b011	14:17:46		30°	200	1c	Poor natural forest '1c' on ridge ~ 200 m
2-Mar	b	1	b012	14:55:30		155°		2b	2b forest on mid to lower slope elevation & 2a at very bottom; '31' near top
3-Mar	b		b014	11:06:54		999°	0	1b	Thick shrub surrounding
3-Mar	b	2	b014	11:06:54		190°			No data
3-Mar	b	2	b015	11:18:45		110°	0	2b	2b forest all around (large enough …?)
3-Mar	b	2	b016	11:33:28		225°	0	31	Some very large trees left
3-Mar	b	2	b017	11:52:20		365°	0	31	31 forest all around
3-Mar	b	2	b018	13:09:00		195°	0	31	31 forest all around
3-Mar	b	2	b019	13:22:57		170°	0	31	31 forest all around
3-Mar	b	2	b019	13:23:50		145°	0	31	31 forest all around
3-Mar	b		b020	13:38:54		999°	0	31	31 forest all around
3-Mar	b		b021	14:25:52		999°	0	31	31 forest all around
4-Mar	b	2	b024	9:09:25		200°	200	31	31 at higher elevation, near mountain top & '1a' at lower elevation, to bottom
4-Mar	b	2	b024	9:10:08		210°	200	1a	1c at mid- to lower elevation & '31' at higher elevation
4-Mar	b	2	b025	9:51:04		999°	0	31	All around trail (walking uphill); "the local people exploited in the middle of the mountain"…
4-Mar	b	2	b026	10:23:41		230°	0	31	All around trail
4-Mar	b	2	b026	10:24:30		180°	0	31	All around trail
4-Mar	b	2	b026	10:24:45		100°	0	31	All around trail
4-Mar	b	2	b027	11:36:09		340°	0	31	All around trail
4-Mar	b	2	b027	11:36:10		170°	0	31	All around trail
4-Mar	b	2	b028	12:39:28		310°	0	31	All around trail & crossing stream
4-Mar	b	2	b028	12:39:46		130°	0	31	All around; nearby stream ??
4-Mar	b	2	b029	13:16:59		240°	0	31	All around; reach 830 m in altitude, near commune boundary
4-Mar	b	2	b029	13:20:31		150°	0	31	All around; end of journey
4-Mar	b	2	b030	14:20:56		60°	0	31	All around; on the way back
4-Mar	b	2	b031	14:28:55		190°	0	31	All around; Dense Forest …
4-Mar	b		b032	15:21:24				31	1c at the bottom & '1' forest at the top
4-Mar	b		b033	15:31:11		100°		31	31 at higher elevation & '1b' at lower elevation
5-Mar	b		b033	15:31:11		80°		99	Planted about 3 year old
5-Mar	b	2	b038	10:31:03		300°	500	31	2b at lower elevation, along left field ??

Date	GPSUnit	Camera	WpN	GPSTime	PhotoTime	Bearing	Distance	Class	Description
5-Mar	b	2	b039	10:38:03		315°	300	31	1c at lower elevation & '31' at ~ 500 m in distance
5-Mar	b	2	b040	10:49:07		20°		1c	1c at lower elevation, close to the road (30 m in distance) & '31' near the top
5-Mar	b	2	b041	11:29:04		115°	150	31	31 on slope ~ 150 m in distance
5-Mar	b	2	b042	12:05:30		140°	200	1a	1a forest in depression & '2b' at mid-elevation (200 m)
5-Mar	b	2	b042	38781.504		140	200	31	2b at mid-elevation (200 m) & '31' forest on the top
6-Mar	b	2	b043	38782.549		95	250	many	Plantation at lower elevation & small patch at upper elevation; '31' at upper elevation & small patches of '1b' in between
6-Mar	b	2	b044	13:23:32		40°	30	1a	Patch on slope
6-Mar	b	2	b044	13:24:16		330°		99	Planted on top & bareland on left of photo
6-Mar	b	2	b045	13:35:26		230°		1a	Bareland & plantation on top of hill
6-Mar	b	2	b047	13:42:01		20°		99	Planted all the way to the top

Appendix A3

Sample Photo Catalogue

EO-STEM Photo Catalog: March 2006

WpN	PhotoName	Path	DateTime	Hyperlink
a002	EOS0249.JPG	C:\eostem_photo\EOS0249.JPG	3/1/2006 15:45:30	C:\eostem_photo\EOS0249.JPG
a002	EOS0253.JPG	C:\eostem_photo\EOS0253.JPG	3/1/2006 15:50:18	C:\eostem_photo\EOS0253.JPG
a004	EOS0254.JPG	C:\eostem_photo\EOS0254.JPG	3/1/2006 16:05:56	C:\eostem_photo\EOS0254.JPG
a004	EOS0255.JPG	C:\eostem_photo\EOS0255.JPG	3/1/2006 16:08:40	C:\eostem_photo\EOS0255.JPG
a004	EOS0256.JPG	C:\eostem_photo\EOS0256.JPG	3/1/2006 16:14:06	C:\eostem_photo\EOS0256.JPG
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