19

Southern Pine Beetle Field Survey

Saul D. Petty

Entomologist, USDA Forest Service, Forest Health Protection,
Pineville, LA 71360

Keywords

aerial survey
GIS
GPS
mobile mapping
southern pine beetle

Abstract

Southern pine beetle (SPB) is one of the most formidable insect pests impacting southern forests. Federal, State, and private forest managers have always dealt with this pest in some capacity. One of the primary requirements for controlling SPB is locating infestations on the ground. Once the infestation has been located, data is collected and used in management decisionmaking. Several methods have been used to accomplish these tasks. This paper describes traditional methods, as well as new technologies being used for SPB field surveying.

19.1 INTRODUCTION

One of the principal goals of the monitoring procedure used by the USDA Forest Service, Forest Health Protection (FHP), for the southern pine beetle (*Dendroctonus frontalis* Zimmermann) (SPB) is to provide information to pest management specialists in a timely manner. The survey data are also used in various types of reports. The aerial sketchmapping procedure (described in chapter 18); the database management system, SPBIS, (described in chapter 20); and the map/text reporter (described in chapter 21) address different aspects of the automation procedure. In this chapter the issue of automated survey data collection and transfer is addressed. Two issues are considered: 1. the use of digital technologies to collect data, and 2. the transfer of the data to the database management system. In the past, a major impediment to the timely use of SPB surveys information has involved the transfer of data from paper survey forms to the database management system, Southern Pine Beetle Information System (SPBIS). Paper forms were satisfactory for collecting data, but survey personnel often did not have sufficient time to enter data into SPBIS. Consequently, management decisions could not be based on the most current information. The procedure described in this chapter addresses automated data collection and transfer to SPBIS.

19.2. USING DATA FROM AERIAL SKETCHMAPPING

The data collected using aerial survey is vital to finding infestations on the ground. The quality of this data can vary greatly due to surveyor experience, type of aircraft, and environmental conditions, among others. The use of global positioning system (GPS) and other digital surveying technologies continues to make it easier to locate infestations. While digital aerial sketchmapping (DASM) is becoming more commonplace, traditional sketchmapping using paper maps is still used in many instances.

19.2.1. Data from Traditional Aerial Detection Methods

With traditional aerial sketchmapping the surveyor records infestation locations on a paper map while flying over a given area. This method, when used by an experienced surveyor, is effective in recording infestation locations. However, if the surveyor has limited experience or is not familiar with the survey area, the recorded locations can vary significantly from their actual ground location. This makes ground truthing infestations very difficult. With no definite coordinates, ground surveyors must rely on their knowledge of the area or the quality of the maps they have at their disposal. These factors dictate the efficacy at with which infestations can be surveyed.

19.2.2. Data from Digital Aerial Sketchmapping (DASM)

DASM provides solutions to many of the problems associated with traditional sketchmapping. A variety of background imagery can be used to help the surveyor orient himself to the survey area. This system employs a GPS that constantly monitors the position of the aircraft during the survey, allowing the surveyor to know his position in relation to the ground at all times. This feature alone helps to improve the accuracy of recorded infestation locations. Despite these advantages, it is still possible for an inexperienced surveyor to record infestations incorrectly. If the background imagery being used is outdated, the surveyor may have difficulty distinguishing locations on the ground due to landscape changes. While both traditional and digital sketchmapping have drawbacks, the DASM system allows surveyors who have a wider range of abilities to collect quality data.

19.3. NAVIGATION TO INFESTATIONS

19.3.1. Traditional Navigation Methods

Traditionally, paper maps of the survey area are used to find infestations on the ground. These maps vary greatly in scale, detail, and overall accuracy. Often hand-drawn directions are used to guide surveyors. When used by experienced surveyors, traditional methods can be very effective. Surveyors with little or no experience will require time to acclimate themselves to their surroundings. Paper maps are still a very useful surveying tool.

Topographical Maps

One type of map that is used to navigate to an infestation is a topographical map. These maps show relief in some measurable form, such as contour lines that show changes in elevation for an area. These maps allow the surveyor to determine the most efficient route to an infestation. In areas with little relief, a direct path is usually the best, depending on the land cover. Topographical maps are particularly useful in areas with frequent changes in relief. The survey can use natural contours to reach an area more efficiently.

Forest Service Maps

Forest service maps, either State or Federal, are available for all public lands. These maps are not updated on a regular basis and vary greatly in accuracy. In most cases these maps display major highways and landmarks within the boundary of the forest. They also show selected forest service roads and trails. If accurate, these maps can be used to learn an area and get the surveyor close to an infestation. Often when the surveyor gets close to an area he will find a variety of other access points into the woods such as skidder trails, fire breaks, and logging roads that are not marked on the map.

Aerial Photography

Aerial photography is also a useful tool for surveyors. Photos of a given area allow the surveyor to use natural and manmade landmarks to navigate. Photos also allow the surveyor to get an idea of how the surrounding landscape is composed. Any type of map or photo a surveyor can take into the woods will be useful in locating SPB infestations.

19.3.2. GPS Data Loggers

Currently there is a wide variety of data loggers designed to meet navigation and field data collection needs. Units vary greatly in cost and functionality. The units being used for SPB work by Forest Health Protection are the Trimble® GeoExplorer™ series.

Digital Imagery

Digital imagery can be a useful addition to the tools surveyors use to find infestations. Current digital imagery is readily available and can be manipulated to work in most digital mapping systems. Surveyors can use an image of the survey area to navigate and validate their position. The most commonly used types of digital imagery are color infrared or true color images.

Shapefiles

A shapefile is defined as "a vector data storage format for storing the location, shape, and attributes of geographic features." (Environmental Systems Research Institute Geographic Information System (ESRI® GIS) Glossary 2007). Shapefiles can also be a useful surveying tool. Shapefiles are currently available for a wide array of features on State and Federal lands. Features on private land are less common but can be easily created in a GIS.

Global Positioning System

Global positioning system is an integral tool in surveying SPB infestations. Global positioning system in conjunction with quality background imagery allows surveyors to determine their exact location on the ground, thus orienting them to the infestation. In recent years the quality of GPS receivers has increased while their cost has steadily decreased. High quality units are available for a variety of uses. The use of GPS has greatly increased the efficiency of locating infestations.

19.4. DATA COLLECTION AT AN INFESTATION

19.4.1. Automated Data Collection

The tools available for field data collection have continued to increase in recent years. Traditional data collection consists of a field technician manually recording observations. Advances in hand-held mobile device technology have increased the opportunities for automated data collection. Hand-held mobile devices are personal computers designed for field use. For mobile mapping applications, they integrate a user-friendly operating system, GIS software, and GPS capabilities to allow for efficient and accurate data collection. Mobile devices come equipped with many different software and hardware configurations to suit the needs of the individual user. It is important to consider the environment in which the mobile device will be used. Field conditions are more variable and often much harsher than those in an office environment. It is important to consider the functionality of the device in the field and, most important, protection of collected data. The memory capacity and processor speed of the device are also important. The device must have enough memory to sufficiently store data while being able to efficiently operate GIS software, which is often graphically intense. The software utilized by the device must also be compatible with the software on a desktop computer in order to facilitate data transfer. Mobile devices are constantly changing, becoming more compact yet more diverse in their capabilities.

This brief overview of the components of a mobile mapping system is intended to show that these technologies, while having several inherent drawbacks, will continue to improve. This chapter will discuss in depth one specific mobile mapping application in the field of forest entomology.

19.4.2. SPBIS Mobile Mapping System

Mobile mapping can be defined as "the ability to collect field data, with unique geospatial time tags and attributes, for integrating into or updating a GIS" (Rasher 2001). Mobile mapping allows for the collection of a variety of data types at any time and place. The differences between mobile mapping and automated data collection are subtle. Automated data collection can be done from a stationary position, while the term "mobile" implies that data is collected on the move. Mobile mapping systems are designed to facilitate automated data collection in the field. Three major components comprise a mobile mapping system: GPS, a GIS, and a hand-held mobile device for data collection. The sequential steps in surveying and monitoring the SPB are illustrated in Figure 19.1. The survey begins with aerial sketchmapping. The traditional method of aerial sketchmapping involves manually marking the location of SPB infestations on a paper map. Digital aerial sketchmapping is a new technology that utilizes GPS and GIS technologies to allow the surveyor to mark areas on a digital map, which are in turn converted into a data format that can be used in a GIS. Each location marked on the map has GPS coordinates associated with it. These data can then be uploaded into a hand-held device and used for navigation purposes. It is often difficult to locate infestations on the ground using traditional navigation methods. Global Positioning System coordinates allow the surveyors to reach the desired location more quickly. Once an infestation has been located, a survey form is completed. The current form consists of a single sheet of paper containing blank fields for each desired data type. The data are collected on the paper form and manually entered into the SPBIS database. It has been determined that the primary restriction in the current SPBIS data collection process is data entry. Entry of data into SPBIS is a time-

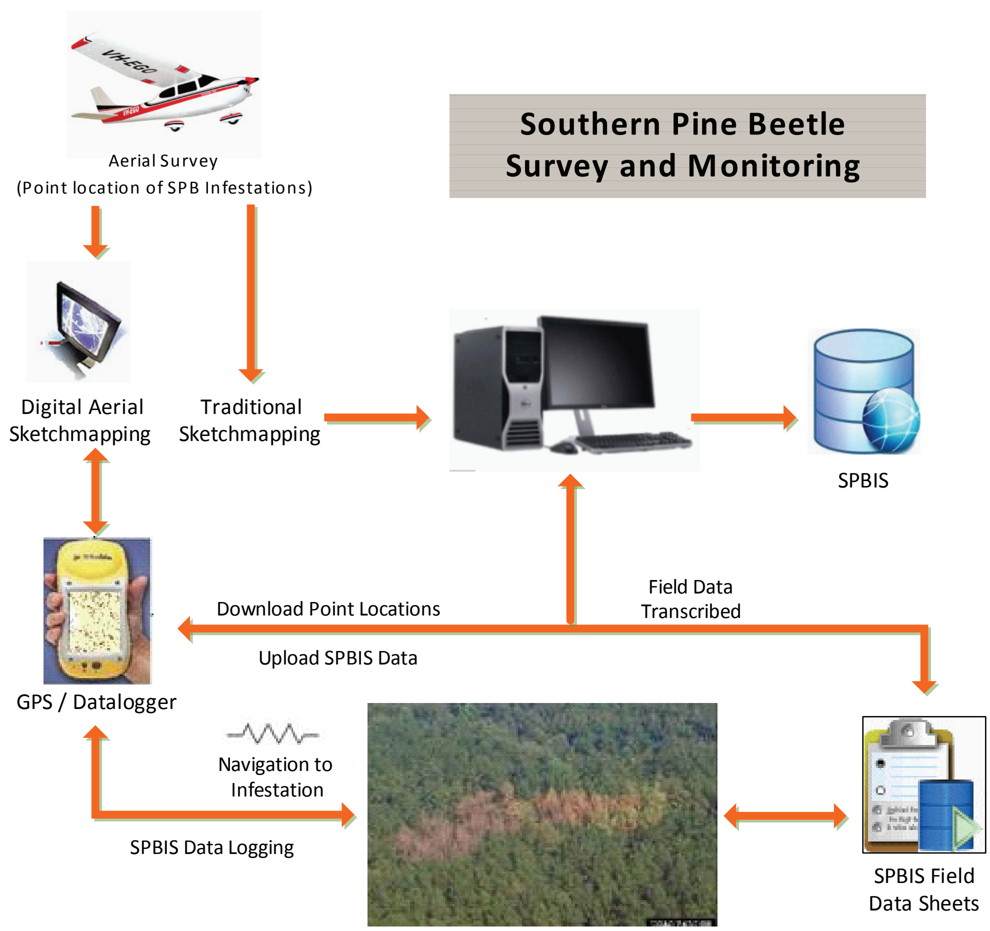

Figure 19.1— Schematic of the SPBIS Mobile Mapping System. (KEL image)

consuming process and is often neglected. When SPB outbreaks occur during the summer, district personnel have limited time in which to enter survey data into SPBIS. In order for SPBIS to be used as an operational management tool, data must be entered in timely manner. Given the current situation, SPBIS data are not used for operational forest management decision-making. The database serves as storage for historical outbreak records. The combination of a mobile GPS unit and a digital upload interface between the unit and SPBIS allows surveyors to collect data in a digital format and upload it directly into the database. This eliminates much of the need for manual data entry. The shortcomings of the SPBIS database will continue to be compounded if the development of a dependable system for data acquisition and processing is further delayed. With little or no data entry occurring, information for decisionmaking is limited. This severely limits the ability of managers to develop plans for prevention and suppression.

It is important to measure the size of an SPB infestation to determine total losses in a given area. Traditionally, infestation size was estimated by the surveyor. Acreages taken by this method vary greatly in accuracy. Global positioning system, along with mobile GIS, allows the surveyor to make an actual measurement of an infestation. While these measurements still have some degree of error due to signal quality, they are more accurate than an estimate. Polygons created within the mobile GIS can also be exported onto a desktop GIS and corrected for even greater accuracy.

Digital SPB Data Collection Forms

The SPBIS database is designed to keep a record of all survey information. All data are collected into a primary database file (DBF) table and a backup DBF table that is associated with a shapefile. Each field within the form has a column in the DBF table. Each column in the DBF table corresponds to a field in the SPBIS database by name.

The backup DBF table is the record that is uploaded into SPBIS. Several fields can be edited. Any time an infestation is edited, any previous information is overwritten. Radio buttons for adding an infestation, a head, or a breakout are located at the top of the first page of the form. One of these choices must be made in order for data to be recorded. If a choice is not made, no data will be recorded.

Southern Pine Beetle Infestation Data is the heading on the first page. The fields on the first page include the Region, Forest, District, Infestation Number, Head or Breakout Number, Parent Head or Breakout, and Species of Pest. The Region, Forest, and District fields each have drop-down menus that contain all the possible location choices. The Head or Breakout Number and Parent Head or Breakout fields have default values if the user enters no value. Secondary heads and breakouts rarely occur; therefore, default values must be available in order for the data to be uploaded into the database. The drop-down menu for Pest Species field contains three choices: Southern pine beetle, any of the several species of *Ips* spp beetles that attack pine, and Black Turpentine Beetle. These three pests are not the only species that will be encountered while conducting a survey, but they are the most prevalent.

Heads and Breakouts are the heading for the second page of the form. This page contains fields for the Compartment Number, the Stand Number, Wilderness Identification, Wilderness Name, Pine Basal Area, Total Basal Area, Infestation Locator Identification, Infestation Priority, and the Estimated Area. The Wilderness Identification field contains a simple yes or no option. If an infestation is in a wilderness area it greatly affects the treatments that can be applied. If the infestation is in a wilderness area, the Wilderness Name field is activated. It contains names of wilderness areas that correspond to the forest and district chosen on the first page. The Pine and Total Basal Area are determined for the stand in which the infestation occurs. The Infestation Locator is the name of the person who found the infestation. The Priority field contains three choices: High, Medium, and Low. An option is chosen based on infestation activity and the value of the material contained in the infestation and surrounding areas. The acreage that is determined by traversing the infestation with an activated GPS is entered into the Estimated Area field.

Survey: Page 1 is the heading for the third page. This page contains fields for the Survey Type, the Initial Detection Date, the Ground Check Date, the Suggested Treatment Plan, Flagging Color, and Logging Access. The Survey Type field contains the following choices: Aerial, Ground, and Video. These choices correspond to the manner in which the infestation was detected. The Initial Detection Date is the date the infestation was found, while the Ground Check Date is the date the infestation is first visited on the ground. These dates can be the same but often are not. The ground crew that conducts the initial infestation survey recommends the Suggested Treatment Plan. Treatment recommendations are based on current infestation activity and value of the stand in which the infestation is located. The Flagging Color field has a drop-down menu that contains several common flagging colors. Flagging Color is important to know for revisiting the infestation. The final field on this page is Logging Access. The initial ground survey crew also determines logging access based on the possibility that the infestation will be logged and its location. This field has a drop-down menu with the choices Poor, Fair, Regular, and Good. The Poor choice is made when the infestation is not a candidate for logging. Fair access is chosen when a logging decision cannot be made during the initial survey. Regular is chosen when the site can be accessed at any time. Good is chosen when the infestation can be easily accessed and the logs easily hauled from the site.

Survey: Page 2 is the heading for the fourth page. This page contains fields for Timber Type, Fresh Attack Determination, Number of Infested Trees, Number of Red or Faded Trees, Number of Green Infested Trees, and Number of Vacated Trees. The timber type choices include Pulpwood, Saw Timber, and Mixed. A choice is made based on the composition of the infestation. The Fresh Attack field contains a simple yes or no. This helps in determining what actions should be taken for control of the infestation. The subsequent four fields are used to determine the composition and size of the infestation. The Number of Infested Trees will equal the Number of Red and Faded Trees plus the Number of Green Infested Trees. Each field has an increment counter that allows the user to add one tree at a time while walking through an infestation. The final page of the form is for Comments. Any significant information concerning an infestation can be recorded here.

19.5. INTEGRATION OF DATA INTO SPBIS

19.5.1. Data Upload

Seamless upload of data into the SPBIS database is the most important aspect of this approach. One of the major problems with the current data collection system is data entry.

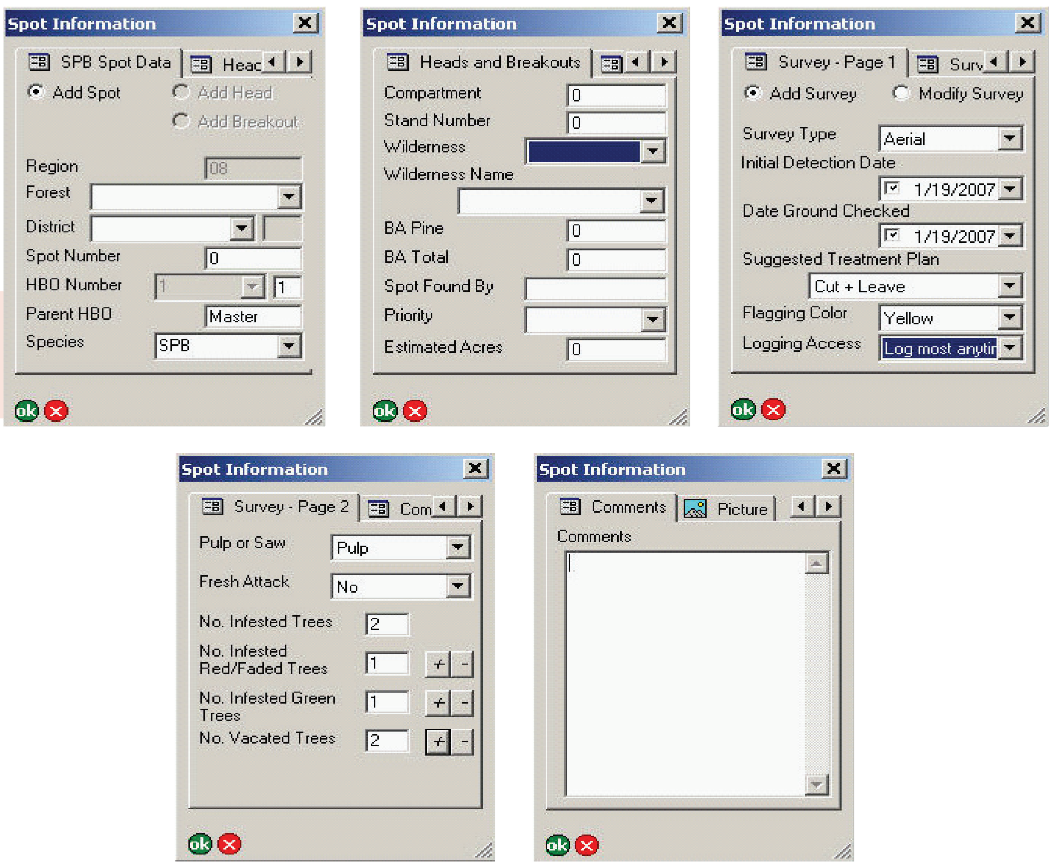

Figure 19.2—Digital SPB data collection forms. (KEL image)

Manually entering data into the database is time-consuming and impractical at the degree required during SPB epidemics.

In order to streamline the data collection process, an application for uploading data directly from a mobile device was developed. An interface was developed between the SPBIS Oracle® tables and the backup database file (DBF) table associated with the digital SPBIS data form. This application was created in Visual Basic 6.0 and is embedded in SPBIS Version 5.0. The complex structure of the SPBIS database did not lend itself to the development of a simple data upload interface. Fields within the database are interconnected with one another. Therefore, fields within the DBF table of the data form must be connected to a corresponding field within SPBIS in order to have successful routing of data. The upload application reads data from each record on the mobile device in DBF form and writes them to five individual structured query language (SQL) statements that insert the data into the Oracle® tables. After data has been uploaded the Oracle® tables are queried to determine what control number (CN) Oracle has assigned each record so the origin or "parent" of each record can be tracked. The CN for a specific record is required if any modifications are to be made. The CN allows the database to search for the parent record and add newly collected data or overwrite existing data. The mobile unit is linked to the SPBIS via a Universal Service Bus (USB) connection. Once the unit and the database are in sync, data is automatically extracted from the mobile unit and stored in the database. Figure 19.2 shows the initial graphical user interface (GUI) and subsequent screen prompts, as they will appear on a desktop computer.

19.5.2. Data Download

Data can also be downloaded from the SPBIS database onto a GPS data logger. This allows surveyors to revisit infestations with previously collected data, which they can then modify or add to as needed. This allows the surveyor to keep all data concerning an infestation organized and prevents obsolete data from reaching the database. The data is transferred in the same manner as it is uploaded.

19.6. CONCLUSION

The collection of quality data concerning SPB infestations begins with an efficient and accurate field survey. While traditional methods are still used, modern technology allows surveyors to collect high quality data in a fraction of the time previously required.

19.7. ACKNOWLEDGMENTS

I thank Crawford W. Johnson, Anthony Courter, Maria Tchakerian, Sindhu M. George, Audrey Bunting, Robert N. Coulson, Jaehyung Yu, Valli Y. Peacher, James R. Meeker, Forrest L. Oliveria, Chris A. Steiner, Stephen A. Clarke, William W. Bruce, Alexander C. Mangini, and Judy Adams for their contribution to this chapter.