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Operational Use of Southern Pine Beetle Survey Information

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Abstract

Survey and monitoring activities are generally undertaken to identify where and to what extent insects and diseases are impacting the resources and conditions of the forest environment. Often the usefulness of a survey is directly related to how quickly the data can be collected, organized, interpreted, and viewed. The USDA Forest Service, Forest Health Protection (FHP), conducts surveys and monitors southern pine beetle (SPB) populations on public lands throughout the range of the insect in the Southern United States. This task is complex and involves aerial detection, data collection on the ground, database management, and application of the survey information. In this chapter we describe the technology used to facilitate operational use of SPB survey information. A Web-based computer system, the SPB Map/Text Reporter (SPB-M/TR), is used for this purpose. The SPB-M/TR is a Web-based geographic information system (Web-based GIS) designed to facilitate operational use of SPB survey information for suppression, prevention, evaluation, and reporting purposes. The SPB-M/TR organizes, summarizes, and interprets the SPB survey information collected from the public forest land in Region 8. The SPB-M/TR extracts SPB survey data from the SPBIS (the Southern Pine Beetle Information System) database and uses it in combination with spatial data from the Ranger Districts to build interpreted reports and maps. Access to the SPB-M/TR is through the Internet.

21.1. INTRODUCTION

Survey and monitoring activities for the southern pine beetle (*Dendroctonus frontalis* Zimmermann) (SPB), are generally undertaken to identify where and to what extent the insect is impacting resources and conditions of the forest environment. Often the usefulness of a survey is directly related to how quickly the data can be collected, organized, interpreted, and viewed. The survey and monitoring system developed by the USDA Forest Service, Forest Health Protection (FHP), for the SPB is one of the most sophisticated approaches used for any forest insect or disease (Figure 21.1); i.e., it is a model system that can be tailored for use on other pest species. Three technical components of this survey and monitoring system are particularly noteworthy and have been described elsewhere in this book: digital aerial sketchmapping (chapter 18), automated field data collection (chapter 19), and the SPBIS database management system (chapter 20). In this chapter we examine the final component of the sequence of digital technologies developed to automate SPB survey and monitoring (Figure 21.1). Our specific objectives are: 1. to describe the Web-based computer system

developed to organize and summarize SPB survey information, the SPB Map/Text Reporter (SPB-M/TR), and 2. to describe the technical approach used in developing the system. The SPB-M/TR facilitates real-time use of SPB survey information for operational forest pest management purposes and automates summary of survey results for reporting purposes.

21.2. AUTOMATED ORGANIZATION, SUMMARY, AND DISPLAY OF SOUTHERN PINE BEETLE SURVEY AND MONITORING INFORMATION: THE SPB-M/TR

In this section we provide a general overview of SPB survey and monitoring. This introduction is intended to illustrate the complexity of the enterprise as it relates to effective and efficient collection and use of field data. With this background we next consider how the SPB-M/TR facilitates use of survey information for planning, problem-solving, and decision support in an SPB integrated pest management (IPM) context.

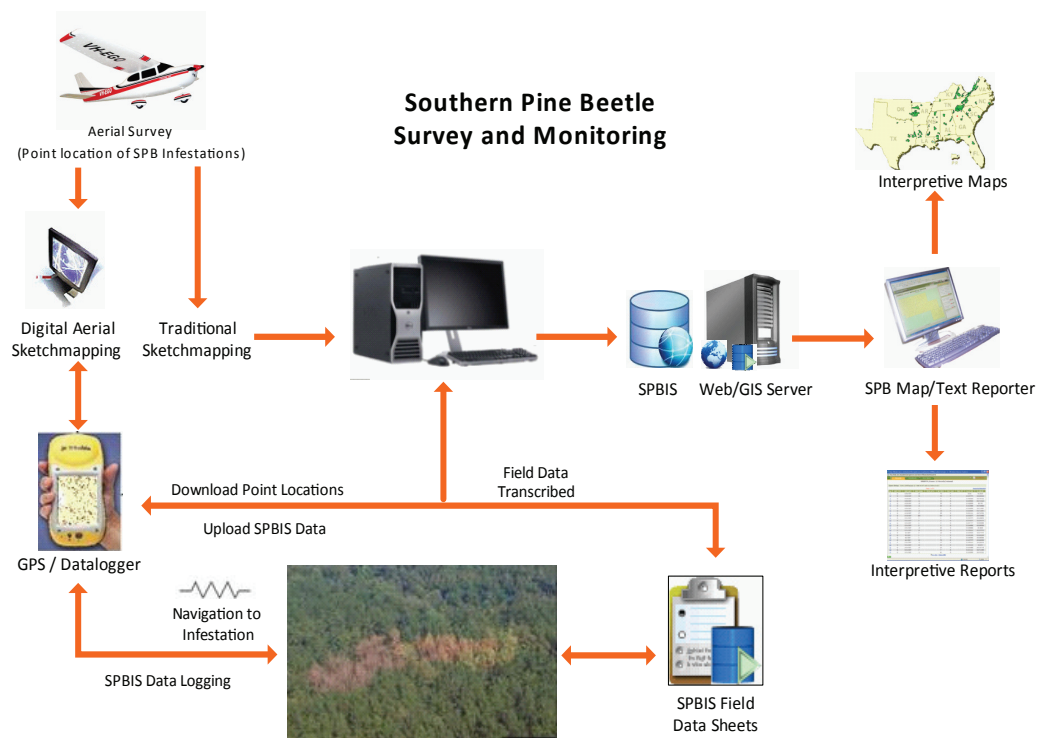


Figure 21.1—Schematic diagram of the activities associated with survey and monitoring the SPB. The Southern Pine Beetle Map/Text Reporter facilitates real-time use of SPB survey information for operational forest pest management purposes and automates summary of survey results for reporting purposes. (KEL image)

21.2.1. General Overview of Southern Pine Beetle Survey and Monitoring

The sequence of activities associated with survey and monitoring of the SPB involves an aerial detection flight, ground reconnaissance and data collection, SPBIS database management system with specified survey data, forest managerial response to an interpretation of the information from the survey, and development of a summary report. This general sequence of activities is also used for survey and monitoring the SPB on private forest lands as well (chapter 17).

Typically, an initial aerial detection survey is conducted during the spring season on Ranger Districts and other public forest lands within Region 8 by the USDA Forest Service. The procedures and technologies outlined in chapters 18, 19, and 20 are used. In most years, the number of infestations observed on the detection flight is small, and district and FHP personnel conduct the ground surveys, collect the required data, and enter it into SPBIS. Actions regarding management of the individual infestations are usually straightforward, and sufficient staff is available to carry out the specific chores associated with the survey and response. Also, summary reporting can be accomplished on a timely basis.

However, periodically SPB outbreaks occur that include broad expanses of public forest land, often distributed across multiple States within Region 8. When the outbreaks of this magnitude occur, the forest management response becomes an enormous and complicated task that requires efficient planning, organization, and execution. Under this circumstance, each of the digital technologies developed for SPB survey and monitoring are taxed and the decisionmaking component becomes of paramount significance. The SPB-M/TR specifically addresses the issues of information management, which includes logistical decisionmaking, performance monitoring, and reporting.

21.2.2. Functionality of the Southern Pine Beetle Map/Text Reporter

The SPB-M/TR is a flavor of a computer application referred to as a management information system (MIS). Specifically, an MIS is a computer-based application that translates data into information useful in supporting decisionmaking, performance monitoring, and report generation. An important feature of the

MIS is that it is designed to address structured problems; i.e., the solution to the problem can be specified in advance (Coulson and Saunders 1987, Coulson and others 1999c). The specific details of the SPB-M/TR architecture are described below. Essentially, this system is a composite of computer hardware resources, specialized software (e.g., ArcIMS® [Internet Map Server] using ActiveX™, ASP, and JavaScript® for customization), and a database management system (SPBIS).

The distinction between data and information is important. Data are measurements that define an ecological phenomenon, process, or relationship of interest. In the context of survey and monitoring, one important data type consists of the measurements that define SPB infestations,—tree species, tree age, tree density, number of infested trees, and so on. Information is data that have been given meaning by way of relational connection. Forest managers use data about SPB infestations and interpret it in order to make decisions about an appropriate action to be taken. For example, a 100-tree infestation detected in May and occurring in a 50-year-old loblolly pine plantation (*Pinus taeda* L.) would be considered significant information by a forest manager. The interpretation of the four types of data by the manager results in information that would likely result in a decision to apply a suppression tactic and thereby prevent further damage to the forest resource.

The functionality of the SPB-M/TR was defined through a series of knowledge elicitation workshops. We interviewed Forest Service personnel who were directly involved in responding to the large outbreak of the SPB that occurred in Texas and Louisiana during the mid-1980s. When large outbreaks occur, the logistical response is directed in large part to four types of activities: 1. reacting to the aerial survey results, 2. decisionmaking relative to application of suppression tactics for the SPB, 3. task monitoring and scheduling, and 4. accomplishment reporting. The knowledge elicitation workshops defined how the Forest Service personnel addressed each of these activities. This information was used to define the functionality of the SPB-M/TR. Following are examples of the type of information provided by the Forest Service relative to the four activities identified above.

Logistical Response to Aerial Surveys

The first task associated with survey and monitoring the SPB is the aerial detection survey. The digital sketchmapping procedures used for collecting data (coordinates) on the spatial location of infestations were described in chapter 18. These data are entered into SPBIS and subsequently accessed by the SPB-M/TR. During outbreaks, the number of infestations detected is usually too large for all of them to be immediately ground checked by Forest Service personnel. Consequently, specific infestations are selected for priority ground checking, based on judgments relating to the severity of their impact and/or clustering. Examples of the criteria that Forest Service personnel use in setting the priority, extracted in the knowledge elicitation interviews, include: the size of the infestation (large infestations often expand rapidly and cause significant tree mortality), proximity to sensitive areas (e.g., Red-cockaded Woodpecker [*Picoides borealis*] colonies, campgrounds, scenic areas, and so on), proximity to private property, and spatially clustered infestations. These data are displayed as interactive maps using ArcIMS (Internet Map Server). This visual display component of SPB-M/TR is important, as it allows the forest manager to see features and land-use activities spatially associated with the infestations. Eventually, all infestations are ground checked.

Decision Support for Suppression of SPB Infestations

The second task associated with survey and monitoring the SPB is the actual data collection from the infestations identified on the detection flight. The procedure used is described in chapter 19. The data collected for each infestation has been specified by FHP. The survey specialist enters the data into a digital data logger. Subsequently the data are downloaded directly to SPBIS (chapter 19). The SPB-M/TR extracts specified data from SPBIS, and it is used by the forest manager for decisionmaking purposes. Again, access to spatial data and to the mapping component of the SPB-M/TR is an extremely valuable tool in the decisionmaking processes. The knowledge elicitation interviews defined the specific kinds of data the forest manager needed. Examples included instructions such as: show the locations of the largest infestations, show the location of the infestations with the largest infested trees, show the location of the infestations next to

sensitive areas, and show the infestations that are most accessible by forest roads. These types of data are used by the forest manager in decisions regarding which infestations to treat with suppression tactics, which to ignore, which to monitor in the future, and so on.

Task Monitoring and Scheduling

During outbreaks of the SPB, the response by the Forest Service is continuous from the early spring, when infestations are initially detected, throughout the fall, when growth declines. Keeping track of the various activities associated with the surveys and actions taken and not taken is a significant challenge. The SPB-M/TR addresses this issue as well. Examples of the types of questions identified in the knowledge elicitation interviews include the following: show the infestations that have been treated, show the infestations that have not been treated, show infestations identified for salvage, and show infestations near sensitive areas. This type of information management provides a continuous and real-time record of the Forest Service response to the outbreak.

Accomplishment Reporting

The response to outbreaks of the SPB consumes tremendous resources and accountability, and accomplishments are typically closely monitored by the Forest Service. In addition, the outbreaks affect private forest lands, and responding to concerns by landowners and citizen groups relative to actions and activities of the Forest Service is also a significant challenge. The SPB-M/TR addresses this issue as well. Initially, the reporting capability was directed specifically to biweekly reports for Forest Service administrative personnel. The report contained both text material (e.g., number of infestations detected, number treated, number not treated, volume salvaged, and revenue for timber sales) as well as map information illustrating the location of the infestations. The SPB-M/TR also provided for annual map and text summaries of actions associated with the response of the SPB outbreak.

21.3. TECHNICAL APPROACH USED IN DEVELOPING THE SPB-M/TR

The SPB-M/TR was developed as a Web-based geographic information system (Web-based GIS) application designed to facilitate access to spatial and tabular data as well as advanced

mapping of SPB survey information over the Internet. The overall approach of the SPB-M/TR is divided into three tiers (Figure 21.2):

- A Data tier containing the SPBIS database
- A Web/GIS server tier that provides the GIS components (ArcIMS) and the communication mechanism that performs the process of transferring data across the network
- A Client tier that consists of the application that allows end-users to request, visualize, and process the data

21.3.1. SPBIS Database (Data Tier)

The survey data resides in the SPBIS database management system described in chapter 20. The SPB-M/TR queries the SPBIS database and extracts the data as a comma delimited file (.cvs) and converts it into a GIS shapefile (digital storage format for geographic locations and data attributes). The GIS shapefile, which contains the SPB survey data, is stored in the Web/GIS server.

Web/GIS Server Tier

The SPB-M/TR includes two main Web interfaces that enable online access to the GIS layers and SPB data attribute information. The application uses ArcIMS 9.3 (Environmental Systems Research Institute, ESRI®) as the main component to serve the spatial data and Active Server Pages (ASP) as an interface to access the attribute data and to check user authorization (authentication). ASP and Java scripts are included within HTML documents to confer the capacity of generating Web contents on demand.

Authentication

User access to the SPB-M/TR requires authorization to be able to login the system. A valid ID and password are required to access the SPB-M/TR. If the user is valid, the application Web server creates a session to navigate the SPB-M/TR (Figure 21.3).

Client Side (Application Description)

The SPB-M/TR is organized into three main search modules (query modules): SPB Survey Module, SPB Monitoring Module, and Advance Search Module. Each one of these modules allows the user to retrieve attribute data from the SPB SPOT layer that contains the SPBIS data displayed as a map (Figure 21.4).

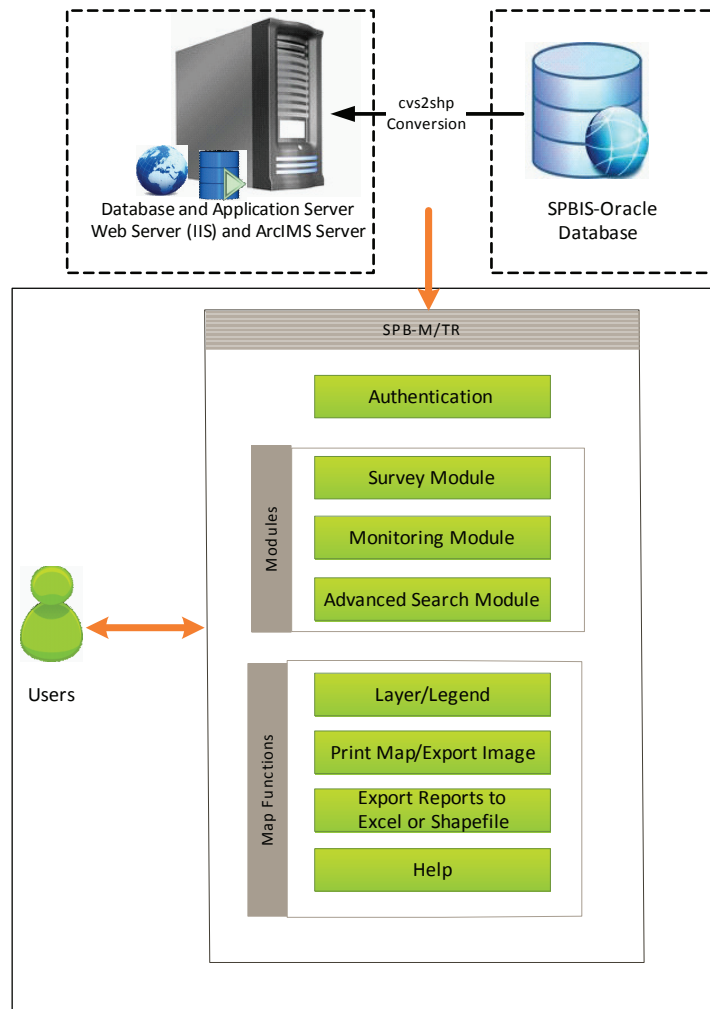
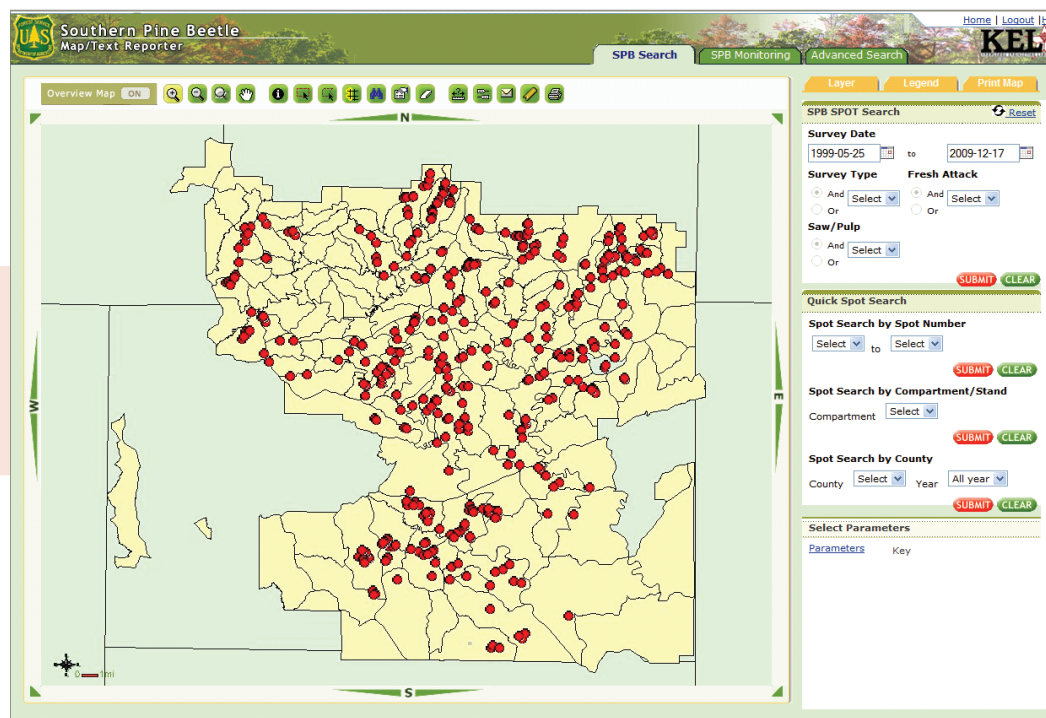


Figure 21.2—The three-tier architecture used to develop the SPB-M/TR. The overall approach is divided into: SBPIS database, Web/GIS server, and Client tiers. (KEL image)

The SPB Survey Module queries data pertaining to the logistic response to the survey, such as show the infestations by: Survey Date, Survey Type, Fresh Attack, Spot Number, Compartment/Stand, County, and Year. The SPB Monitoring Module uses the treatment and suppression data from SPBIS. Users can query the infestations by: Suppression Date, Treatment Type, Number of Trees Treated, Sold Date, and Calculated Acres, among others. The Advance Search Module allows building a customized query using SQL (Stuctured Query Language). The user can extract any type of SPBIS data in combination with attribute data from other GIS layers in the system such as roads, streams, compartments/stands, and sensitive areas. Examples of the types of queries users can create include: show the location of the infestation next to sensitive areas, show the location of infestations that are

Figure 21.3—
Authentication screen to
access the SPB-M/TR.
(KEL image)

Figure 21.4—SPBIS
data displayed as a
map within the SPB-M/
TR. The data can be
queried using the search
modules in the system.
(KEL image)



most accessible by forest roads, and show the locations of infestations that are within 100 m from a stream.

Map Functions (Toolbar Functions)

The Web interface provides the users with helpful toolbars to interact with the mapping system. Layer and Legend tabs let the user modify the visualization of the maps using different spatial data layers such as roads, streams, compartments, and stands. Interactive map functions such as Zoom, Pan, and Full

Extent allow the user to view the displayed maps in greater detail or to choose different areas for display. Feature functions such as Identify, Select, Find, and Saved Query provide the user an interactive way to query the data. Advanced functions such as Measure and Add Marker allow customization of the maps; the Print and Export functions are important for creating the reports in different formats, such as tabular text, Excel files, PDF maps, and shapefiles.

21.4. CONCLUSIONS

The survey procedure developed by the USDA Forest Service, Forest Health Protection, for the SPB is a contemporary approach that integrates fundamental technologies associated with automated aerial detection, ground data collection, database management, and information management. The first three of the component technologies, developed specifically for SPB survey and monitoring, were described in chapters 18, 19, and 20. In this chapter, we focused on the methodology that facilitates use of the survey information for planning, problem-solving, and decisionmaking; i.e., SPB-M/TR. The SPB-M/TR system greatly expedites survey and monitoring activities directed to the SPB. It also facilitates the operational use of the digital sketchmapping technology, the automated data collection system, and SPBIS database management system. Most important, the SPB-M/TR system provides real-time access via the Internet to SPB survey information in a map/text format tailored specifically for IPM purposes.

The SPB-M/TR was developed specifically for SPB survey and monitoring. However, the application addresses a fundamental problem associated with all survey and monitoring programs for forest insects and diseases, namely, the timely use of the information for management purposes. The approach used in developing the SPB-M/TR deals directly with two common issues associated with survey and monitoring programs in general; i.e., 1. Structuring survey data so that it can be used by forest managers for planning, problem-solving, and decisionmaking purposes, and 2. Having real-time access to the summarized survey data. The technical approach used for the SPB-M/TR can be applied to other forest and insect disease management problems. The approach can be tailored for use in survey and monitoring programs for other forest insect and disease pests. The output from the SPB-M/TR can be used with related forested management problems; e.g., the relation of bark beetles and fire management.