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Conducting a Southern Pine Beetle Survey Using Digital Aerial Sketchmapping (DASM)—An Overview

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Keywords

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Abstract

This is an overview on conducting a southern pine beetle (SPB) survey using Digital Aerial Sketchmapping (DASM); for a detailed treatment of DASM visit the following Web site: http://www.fs.fed.us/foresthealth/technology/dasm.shtml. Sketchmapping – "A remote sensing technique of observing forest change events from an aircraft and documenting them manually on a map" (McConnell and others 2000). Recent advances in microprocessor speed and PC system performance now make possible the use of portable computers for aerial sketchmapping in aerial survey work. The USDA Forest Service Remote Sensing Applications Center (RSAC) and Forest Health and Technology Enterprise Team (FHTET) have worked with software vendor, Michael Baker Jr., Inc., to develop an application that will make survey and monitoring of SPB spots more accurate and efficient. The core of the DASM is GeoLink® software (Michael Baker Jr., Inc.). GeoLink incorporates a global positioning system (GPS) signal into a displayed background map window and enables the user to sketch points, lines, or polygons onto the virtual map display. GeoLink then translates these data into ESRI® shapefiles, a common geographic information system (GIS) data format. Advantages include automatic tracking of aircraft position on the map base through a link to a GPS receiver, ability to display many types of background maps for better accuracy in digitizing SPB spots, and the reduction of time spent digitizing data into the GIS.

18.1. INTRODUCTION

The purpose of an aerial detection survey is to accurately locate insect and/or disease spots and to determine their relative size and number in order to evaluate the need for control. This is accomplished for the southern pine beetle (*Dendroctonus frontalis* Zimmermann) (SPB) by conducting periodic flights over pine forests in small, high-winged aircraft such as the Cessna 182 and 206. Suspected SPB spots (groups of dead and dying pine trees) are plotted onto hardcopy maps or aerial photographs (Figure 18.1). Once detected from the air, suspected spots are visited on the ground to confirm the causal agent and assess the need and priority for control (Billings and Pase 1979a). Hardcopy products are then provided to the local or district forester for data entry. The sketched features (points, lines, polygons) are then "heads-up" (on screen) digitized into a geographic information system (GIS). These data are then used to prepare reports at the forest, regional, and national level. Problems with this manual system include: numerous cumbersome maps to manage in the cockpit, the inaccuracy of sketched features, and the office time required to digitize sketched features. Inaccurately mapped SPB spots are particularly problematic since field crews must use the maps to locate spots on ground. Advances in GIS, global positioning system (GPS), and computer technology have led to the development of the Digital Aerial Sketchmapping System (DASM), which has helped solve some of the problems with the manual method. It is important to note that even with its inefficiencies and lack of accuracy, primarily with inexperienced surveyors, the manual system works.

18.2. BACKGROUND

Interest in the development of a digital aerial sketchmapping application led to a request in 1995 by the Pacific Northwest Region to the Forest Health and Technology Enterprise Team (FHTET) and the Missoula Technology Development Center (MTDC) to initiate an information-gathering project on the feasibility of developing a system. As part of this project, forest units throughout the National Forest System were surveyed to determine the needs of the sketchmapping community. Personnel from FHTET and MTDC visited the British Columbia Forest Service at William Lake, British Columbia, in June 1996 for a demonstration of their digital sketchmapping system. There were several disadvantages identified with this system, and in general, the system was slow and cumbersome. The Remote Sensing Application Center (RSAC) put together a list of requirements and began an extensive search for contractors that could meet these criteria (Thistle and others 1996). Based on the investigation, RSAC chose GeoLink® by Michael Baker Jr. Inc. of Jackson, Mississippi (Figure 18.2).

18.3. SYSTEM DEVELOPMENT

18.3.1. Software

The GeoLink software is able to display many different types of geospatial data as background maps; most SPB detection flights are conducted using digital orthophoto quarter quads (DOQQ) because of the need for accuracy. When collecting data using GeoLink, the aircraft's position is displayed as an icon on the map display along with features (point, line, polygons), type keys, and a user-

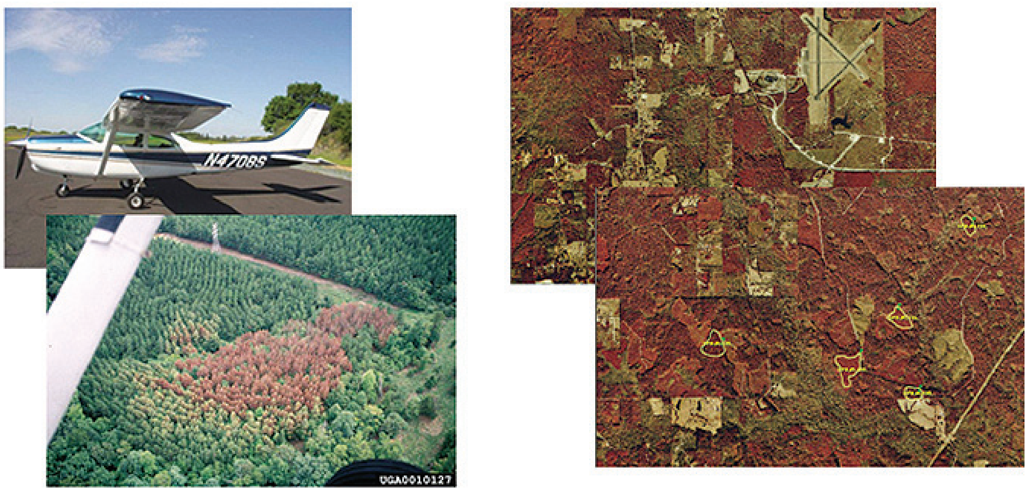

Figure 18.1—Sketchmapping forest pest infestations. Sketchmapping is a remote sensing technique of observing forest change events from an aircraft and documenting them manually on a map. (images by McConnell and others 2000, lower left photograph by Andrew J. Boone, www.forestryimages.org)

defined keypad for attributing features. The observer selects the particular type of feature to be sketched, sketches the feature on the screen, and then attributes the feature using the keypad. The screen remains frozen while the feature is being sketched and updates after the Enter key is pressed. When the aircraft icon advances to the edge of the window, the map display updates with the aircraft icon moving to the center of the window. Upon completion of the SPB survey, a translation step converts the sketched features into ESRI® shapefiles.

18.3.2. Hardware

There are three current hardware configurations being used with the DASM system. The first consists of a laptop PC (Figure 18.3A), a touchscreen manufactured by KDSPixelTouch™ (Ontario, CA), a GPS receiver, and a specially designed power distribution board that draws from the aircraft power system. The disadvantage to this laptop-based hardware setup is that it is cumbersome. It is awkward to use because of the many different components and cables in the confined space of a small aircraft. Also, the unreliability of the KDS touchscreen and the time it takes for repair are limiting. The second system is the Hammerhead™ pen tablet PC (Figure 18.3B), one of the new generation mobile PCs that show great promise for the DASM system. It is very simple from a hardware perspective, consisting of the PC, the GPS antenna/cable, and the power distribution box connecting the PC power cable to the aircraft power supply. The third configuration uses the Motion™ Tablet PC (Figure 18.3C). With a 12.1-inch screen, this Tablet PC provides ultramobile technology with high-end performance and light weight. The Motion™ computer offers Bluetooth capability (cordless functionality) and a high-resolution screen.

Figure 18.2—(A) The USDA Forest Service Remote Sensing Applications Center (RSAC) and (B) Forest Health and Technology Enterprise Team (FHTET) have worked with software vendor, (C) Michael Baker Jr., Inc., to develop an application that will make survey and monitoring of SPB spots more accurate and efficient.

Figure 18.3—Three current hardware configurations being used with the DASM system. (A) KDSPixelTouch™, (B) Hammerhead™Tablet PC, (C) Motion™ Tablet PC.

18.4. METHOD

18.4.1. Preflight Planning

Preflight planning is essential to a successful DASM project (Figure 18.4). You establish the survey area and prepare background maps, set your flight lines, and determine what data is to be gathered and what attributes will be associated with your spots. During preflight planning you can build a project to use within GeoLink that will contain the above information. This project can be reviewed by simulating a flight; this ensures that all data and settings are correct before the flight. ESRI GIS software is useful for preflight planning tasks. Safety issues are a top priority in preflight planning—no-fly zones, airports, tall structures, check-in points, "go/no-go" decision points. As the surveyor, you are not only gathering data but must become familiar with maps, charts, aircraft, and weather, and must be able to properly identify problem areas; and now, with DASM, you must also become familiar with computers and geospatial data. However, once you become familiar with the DASM system, it can be an asset to in-flight safety by accurately showing your position relative to restricted areas, hazards, and Federal Aviation Administration (FAA) Sectional charts. Preflight planning must be a top priority for a safe and successful survey.

Digital Imagery for SPB detection

Background maps can consist of vector and image (raster) maps. Displayed images may be in any of the supported data types including TIF, BMP, JPEG, and others. If you know the datum/projection of your imagery and whether it has a .tfw or .reg registration file, GeoLink will display the imagery. False color infrared DOQQs (Figure 18.5) are the preferred background map during SPB survey flights because the high resolution (2 m) of this imagery allows the surveyor to precisely digitize the spots. Also, the color infrared (CIR) may help one to differentiate between hardwood and pine species. Accuracy of the SPB spot location is critical because field crews will use the coordinates to find the spot on the ground. Administrative boundaries can also be displayed within a GeoLinks project.

During a GeoLink logging session, the entire map is redrawn each time the display refreshes a map, even if you are displaying only a small portion of that map on the screen. With such a large raster image in memory, very little remains for other computer functions. This situation can cause dramatic slowdown in display refresh rate and/or system crash. To avoid this, GeoLink detects when large raster images are loading and launches a utility called the SplitTiff Raster Optimization Utility. SplitTiff creates a new proprietary image file from the raster image,

Figure 18.4—Preflight planning.

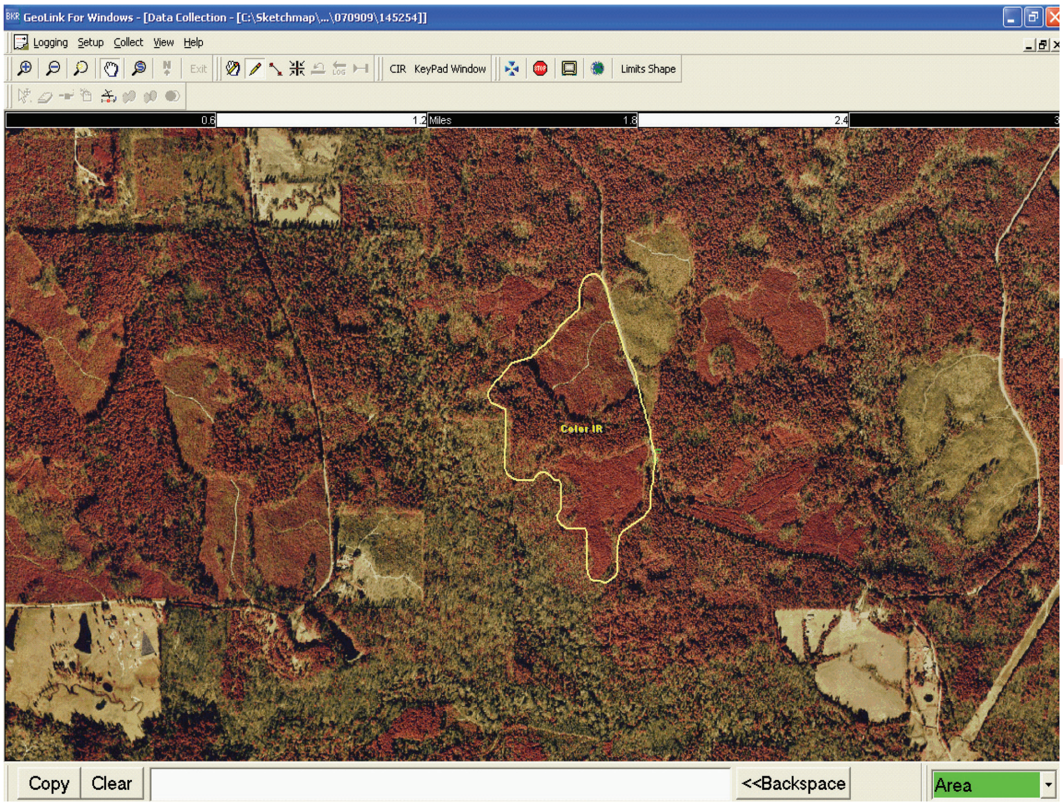

Figure 18.5—Color infrared imagery.

called a GeoLink Optimized Raster (*.gor) file. GeoLink loads only the required neighboring GOR files into RAM when a map is displayed. GOR files are separate from the source TIFF and TIFF World Files from which they were created. You can view them only in GeoLink, but you can copy and move them as you would other files.

Shapefiles

Vector shapefiles such as roads, streams, contour lines, flight lines, forest boundaries, compartments, stands, hazard areas, and no-fly zones can be overlaid on raster images to help you pinpoint SPB spot locations and help provide for a safe survey (Figure 18.6). During an active outbreak, SPB detection flights may be conducted over the same area several times in one season. The ability to display previous survey data is important in keeping track of new and already recorded SPB spots. GeoLink gives you the ability to display shapefiles with many different colors, shades, and text that will help you distinguish survey data. Surveyors often want to display large shapefiles over their raster map data. A SplitShape utility has been created to decrease the screen regeneration time for ArcView® shapefiles with many records. The SplitShape utility can either be run automatically by GeoLink when large shapefiles (500 features or more) are added to the background map list, or run manually to batch process files. The SplitShape utility creates a new file to go along with the original three files (.shp, .dbf, and .shx). The new file has an extension SLF (Shape Look-up File). This file must be transferred along with the original SHP, SHX, and DBF files to speed up display. Since the shapefile format has not been changed in any way, data can still be shared between GeoLink and the GIS systems easily.

Data Collection

Digitizing

Digitizing features within GeoLink is a four-step process (Figure 18.7): 1. The feature type to be digitized is selected; for SPB surveys, either points or polygons will be used; 2 Digitize the feature on the screen. Locate the feature on the ground and place the point or polygon on the screen using the stylus; 3 Fully attribute the feature; specify what you want that point or polygon to represent; 4 Click the Enter button to save the feature to disk. Each feature you digitize will have data (latitude, longitude, date, time, and attributes) associated with it.

Real time feature editing

It is easy to make errors when digitizing and attributing features while flying at 100 knots. One simple way to deal with errors is to tag the feature with a “del” (for Delete) attribute, then

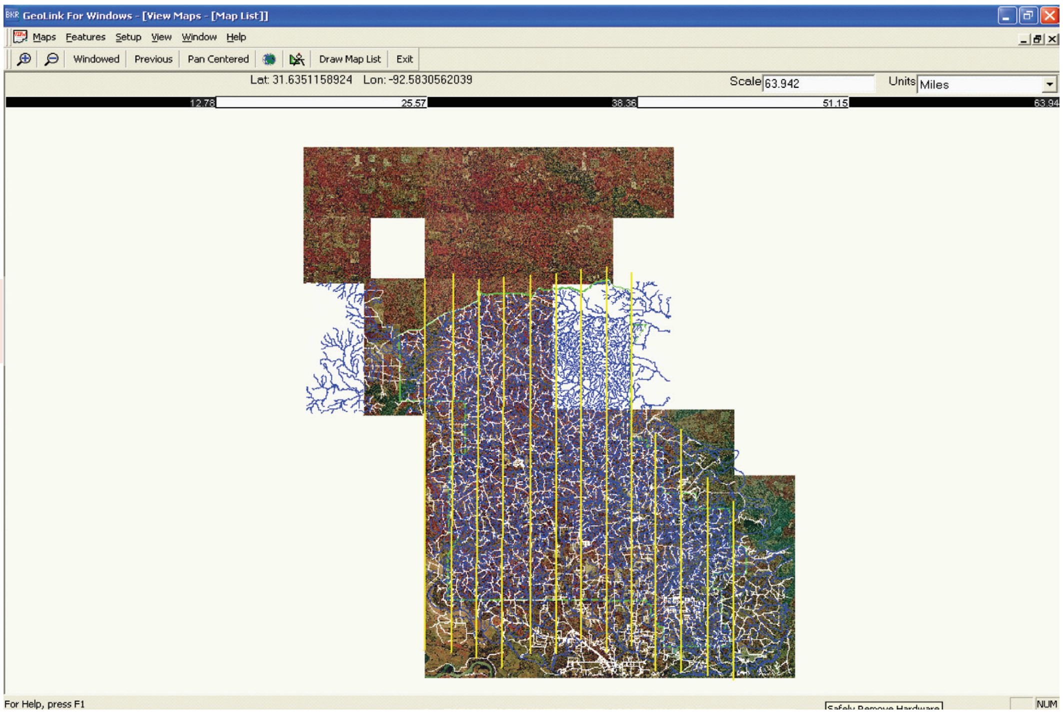

Figure 18.6—The use of shapefiles.

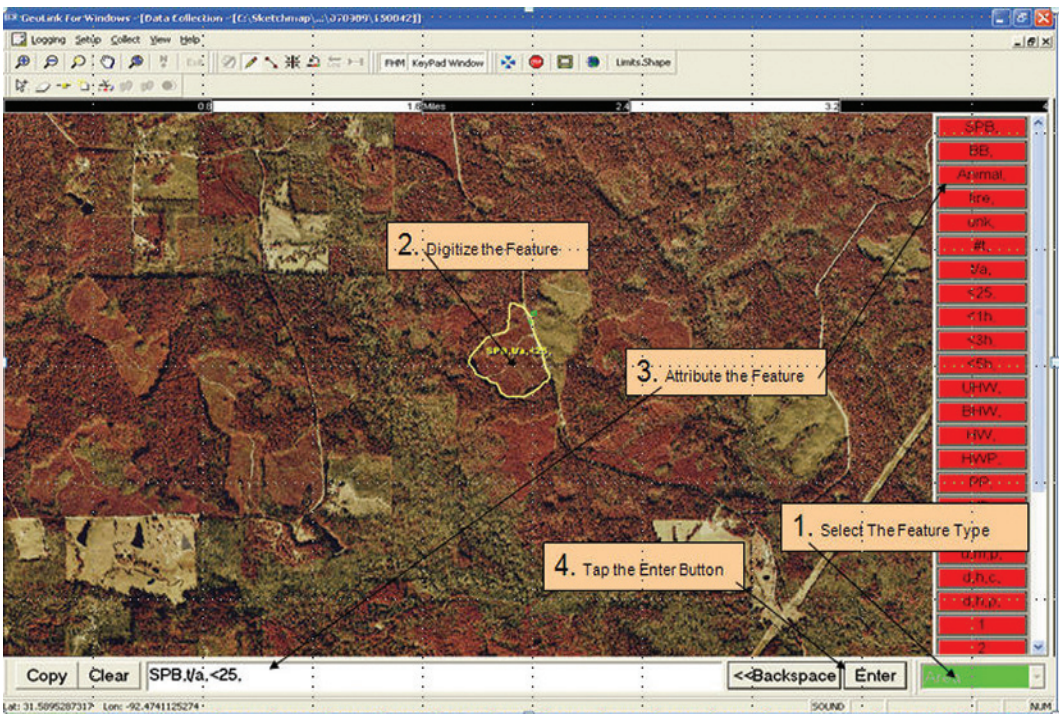

Figure 18.7—Digitizing—A four-step process. 1. Select points or polygon. 2. Digitize feature. 3. Attribute feature. and 4. Click Enter.

redigitize the feature over top of the one just attributed with "del". In such a case, the first step in post-processing is to delete all features with the "del" for an attribute. Another way to correct digitizing errors, whether spatial or attribute, is to use the Real Time Feature Editing process in GeoLink (Figure 18.8). You can use this feature in either Simulate or Log mode and the functionality will be the same.

Translating the digitized features

Enter the Translate Mode by selecting Translate from the main toolbar (Figure 18.9). The Translate Mode is used to convert GeoLink's® proto-shapefiles collected during a log session into true ESRI® shapefiles. During the Translate process, the shapefiles are projected into the coordinate system you specify. It is recommended that you run the translation during the same day, since you can see the

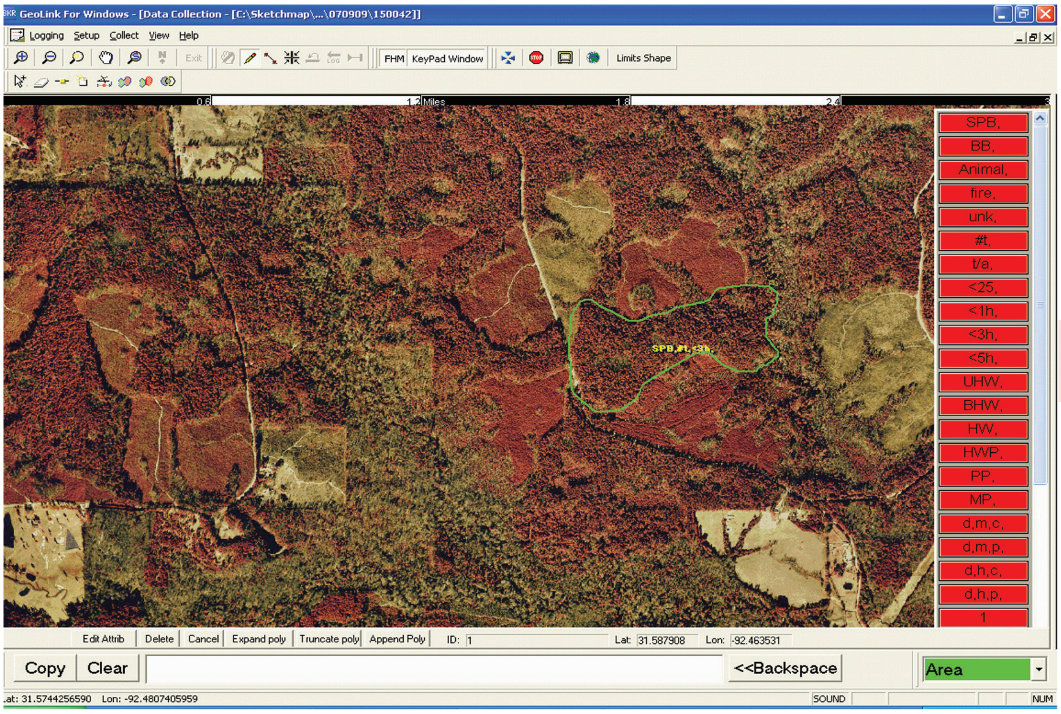

Figure 18.8—Real-time feature editing.

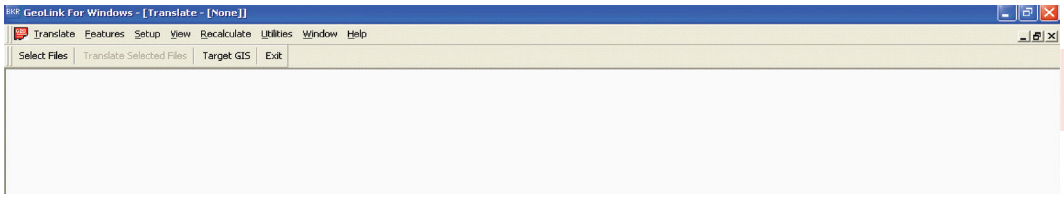

Figure 18.9—Translate window.

results while the mission is still fresh in your memory.

Post-Processing DASM Mission Data

The PC-Based DASM system developed by the USFS Forest Health and Technology Enterprise Team (FHTET) and the Remote Sensing Applications Center (RSAC) enables aerial surveyors to collect forest damage information in digital format. This new system changes not only how the data are collected, but also how the surveyor edits the data after collection. Using the traditional, paper map-based method, the surveyor would make changes to features drawn on the maps using pencil and eraser. The features and attributes would then be transferred by hand to another paper map to produce a clean, easy-to-read copy for digitization by GIS staff. The DASM systems output features in a digital file; editing and data QA/QC (Quality Assurance/Quality Control) that formerly was done with a pencil and eraser is now done on softcopy using GIS software. Clear communication between the surveyor and GIS staff about data format and content is essential. SketchTools, an ArcView® extension developed by RSAC (Figure 18.10) to facilitate post-processing in ArcView, is a series of utilities to help you process your points, lines, polygons, and associated feature tables.

18.5. DISCUSSION

SPB detection flights are conducted throughout the growing season to locate small outbreaks of southern pine beetle. The goal is to locate spots and treat them before they increase in size. Crews must find these SPB spots, which may be as small as three trees, based on the accuracy of the points specified on the survey map. A distinct advantage in using the DASM system is that the surveyor no longer has to keep track of his/her position on the map. This can be difficult in the flat, relatively featureless areas of the Southeast United States. The DASM system places the aircraft on the map base, so the surveyor can devote more time looking for SPB spots and accurately recording them with DASM.

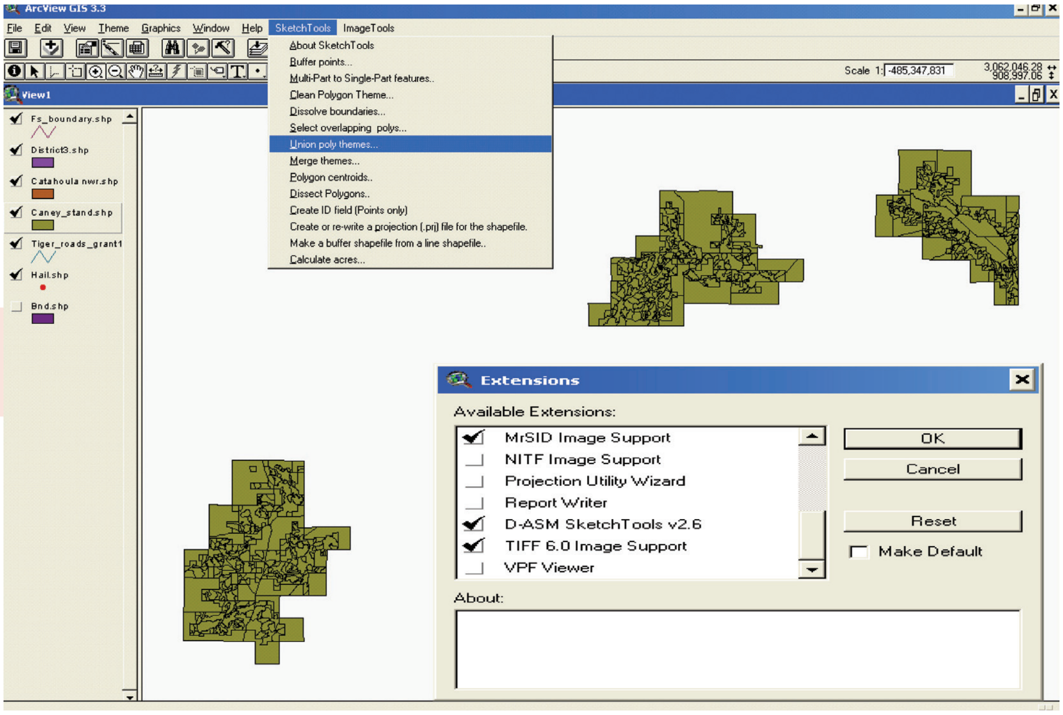

Figure 18.10—Sketchtools—an ArcView® extension.

Using the DASM system, accuracy of the SPB-spot mapping has substantially improved, and ground crews are able to navigate directly to the spots by loading the coordinates obtained from the aerial survey into a GPS receiver. Previously, GIS technicians had to "heads-up" digitize the spots from the hardcopy photos and then print out maps that were used by the field crews to find spots. This process often took days; using the DASM system, spots can be located during a morning detection flight and field crews can be visiting the spots that afternoon.

With there being no glory in bouncing around in an aircraft trying to find SPB spots in the middle of summer in the South, the more technology can help, the better. In the hands of a well-trained, willing surveyor the DASM system can improve SPB surveys.