United States
Department of
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Forest Service

**Engineering Staff**

**Washington, DC**

# Engineering Field Notes

## Engineering Technical Information System

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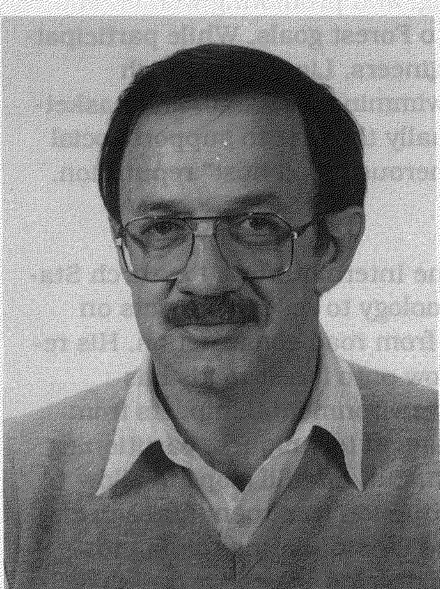
January-February
1991

# The 1990 Forest Service Engineers of the Year

Congratulations to our three 1990 winners pictured below. In recognition of their achievements, Sterling Wilcox, Director of Engineering, presented a plaque and a $2,500 cash award to each at the Regional Engineers' meeting on November 13. Included is a brief summary of their individual accomplishments.

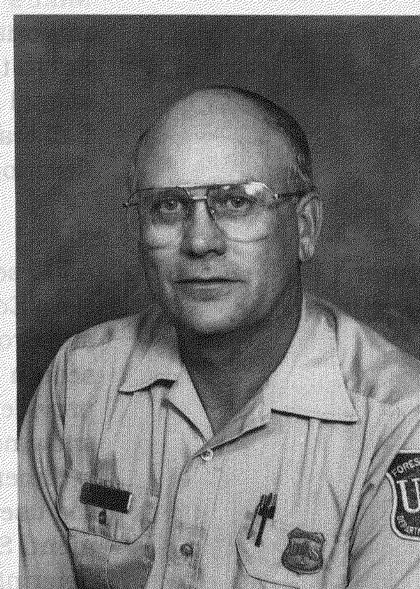
To broaden the Forest Service Engineer of the Year competition to all Engineering employees, last year the Regional Engineers recommended three categories: Engineering—Management, Engineering—Technical, and Engineering Technician. The 1990 competition was the first to include the three categories. We had excellent nominees from across the National Forest System and Research. Judges included a Regional Engineer and a Forest Engineer. The selection was *tough!*

These employees provide a sampling of the outstanding individuals we have in Forest Service Engineering. We look forward to next year's fine batch of candidates for the Engineer of the Year awards.



*Michael Cook*

*Edward R. Burroughs, Jr.*



*Billy E. Lumpkin*

**Michael J. Cook**

As Forest Engineer on the Nez Perce National Forest in Region 1, Mike has achieved progressive program growth and accomplishment. Mike's "Concept in Harmony" integrates Timber, Wildlife, Engineering, Fisheries, and Watershed issues so that various interest groups support road construction, anadromous fish projects, and timber harvest proposals. Being appeal-free on roads and timber sales (1983–1988) goes beyond "manager" to "leadership excellence" in interdisciplinary action, commitment, and results. *USDA News* featured Mike's integrated approach, and it was adopted by other Forests. The State of Idaho Fish and Game Department, the State EPA, and the State Water Quality Division have recognized and sanctioned his methods.

In addition to his full work program, Mike has designed and implemented new methods to significantly reduce and control sedimentation in high-value anadromous fisheries, including being lead author in two associated Intermountain Research Station reports on erosion. Again, many of these procedures have been adopted by other Forests and agencies. Mike was selected by the 13 Idaho National Forest Supervisors to chair the Scenic Byways Working Group, and he served as the Regional Forester's representative on the Governor of Idaho's Task Force on Water Quality Standards.

Mike demonstrates the management team concept, promotes teamwork efficiency, and acts as the catalyst to keep the team on target. Under Mike's leadership, his Engineering team operates well in his absence, demonstrates dedication to Forest missions, and contributes significantly to Forest Plan implementation and specialist integration. The Engineering crew produced a nationally recognized, award-winning bridge design. The crew also won the 1988 tipi-pitching contest at the Indian Week celebration.

Mike's active participation in hiring, mentoring, and promoting women and minority employees contributes significantly to Forest goals. While participating in the National Society of Professional Engineers, Lions Club, high school Booster club, and community youth swimming, baseball, and basketball teams, Mike and his wife, Phyllis, are usually the first to support social functions for visitors, earning the Forest a generous "good host" reputation.

**Edward R. Burroughs, Jr.**

As Research Engineer and Project Leader at the Intermountain Research Station, Ed develops efficient, user-oriented technology to reduce impacts on site productivity and water quality, especially from road construction. His research on subsurface seepage and overland flow onto forest roads has provided road location guidelines to minimize environmental impacts from snowmelt runoff. Ed summarized erosion reduction techniques, partitioning sediment yield between the traveled way, ditch, cut, and fill slope to allow the user to select the most effective erosion reduction treatment for each element. Standardized procedures were developed for simulating rainfall to determine variations in sediment yields and to develop erosion process coefficients.

Ed developed an improved method of estimating interrill forest soil erodibility for use in the forest model of the USDA Water Erosion Prediction

Project (WEPP), and he is the Forest Service resource member on the interaency WEPP Core Team. He also developed a three-dimensional system for slope stability evaluation of proposed timber harvest areas on steep slopes with shallow soils and heavy rainfalls. He completed a short study of erosion reduction achieved through the use of variable tire pressure on logging trucks.

Ed promotes technology transfer between research development and Forest Service Engineers, resource managers, and others, including field tours, the presentation of more than 35 papers at professional and technical conferences, and the authoring or co-authoring of 26 publications. He has a master's of science degree in civil engineering and a Ph.D. in watershed science. In addition to membership in several professional societies and university affiliate faculty appointments, Ed has served as secretary, vice-chairman, and chairman of the American Society of Civil Engineers Watershed Committee.

## Billy E. Lumpkin

As an Engineering Technician on the National Forests in Texas in Region 8, Billy provides exceptional support to Engineering, Forest resource management, and the community. Licensed as a water and wastewater systems operator for the State of Texas, Billy manages the Forest discharge permits, communicates with the State Health and Water Commission, answers technical questions, and provides supervision to operators of the 25 water systems and 6 wastewater discharge facilities. Through his insight and understanding, he has identified and accomplished hookups to community systems with significant cost savings. Billy conducts OSHA inspections and ensures OSHA compliance, and he serves as contracting officer's representative on numerous projects, ranging from the removal of underground storage tanks to major paving jobs (such as parking lots) and gymnasiums and other buildings.

Certified in most categories, Billy is recognized throughout the Region as a Master Performer; he has been selected to "test" Engineering Certification Examinations and to provide input in developing Regional facility design guidelines. Because of his cheerful attitude, results-oriented approach, effective involvement of others, and broad capability and experience, he is sought by Rangers and others for assistance outside his normal Engineering work. For example, Billy used his special knowledge of CADDS and other computer applications to produce high-quality graphics for court presentations involving the red-cockaded woodpecker, wilderness, and southern pine beetle issues.

Billy's contributions to community activities have brought him many recognitions, including a letter of appreciation for assisting in the Youth Fishing Derby ("Get Hooked on Fishing, not Drugs"), local and State awards and plaques for participation in the Future Farmers of America, a certificate for participation in the High School Honors English project, and an appreciation award for directing and coaching the Angelina Youth Soccer Association.

# 1990 *Engineering Field Notes* Article Awards

The first year of the new decade was a good one for *Engineering Field Notes*. We had a variety of articles in 1990, including the following:

"The LEGIS Program: A Personal Narrative"

"NAD–27 Versus NAD–83"

"Naming the Land We Care for"

"Bridge End Fill Repair"

"Sign Planning and Sign Sizing Aids"

"Fence Brace Designs"

We would like to thank everyone who contributed an article this year. The result of each article was that information and experiences were shared at all levels and in all Regions.

It is now time for you to tell us which 1990 articles you feel were most informative, beneficial, and interesting or which articles helped your office save money or which articles helped you develop more effective ways of getting your work accomplished.

Once you have chosen 1990's top three articles, please complete the rating sheet on the following page. Rate only three articles, and rate them as 1 (best), 2 (second best), and 3 (third best). And if you feel that an article has helped or will help the Forest Service save money or other resources, please let us know. After you have voted, cut out the page (as indicated), fold and staple it closed, and mail it to the Washington Office. For your selection to be counted, your rating sheets must be delivered to the Washington Office by March 1, 1990.

Awards will be given to the authors of the three articles receiving the most favorable response from the readers. So remember, your vote counts!

We also would like to take this opportunity to encourage you to start thinking of an *Engineering Field Notes* article for 1991. Do you have information and experiences that could be beneficial to others in the field? Let's make an effort to save more time and money in 1991. And what better way than with an article that will be distributed Service-wide!

## 1990 Engineering Field Notes Awards

| Article | Author | Choice (1, 2, 3) | $ Saved |
|---|---|---|---|
| **January/February** | | | |
| The LEGIS Program: A Personal Narrative | Jerry Bowser | ____ | ____ |
| Region 6 Surface Recycling Project: Road 34 on the Fremont National Forest | Curt Allen | ____ | ____ |
| Saving the Fish Creek Bridge | Neil L. Siettmann | ____ | ____ |
| Region 1 Promotes Preservation Program | Joy Bolton | ____ | ____ |
| Off-Tracking: Forest Service Formula, Vehicles, Roads, and Simulator | James R. Bassel and Carl H. Cain | ____ | ____ |
| Hells Canyon Boat Dock on the Snake River | G. Irvin Mahugh | ____ | ____ |
| Road Program Costs: Continuing Efforts Addressing the Issue | Jerry Bowser | ____ | ____ |
| **March/April** | | | |
| Bridge Design Ethics | James W. Keeley | ____ | ____ |
| The Road Maintenance Management System | Mickey Martin | ____ | ____ |
| Tire-Retaining Structures | Ozzie H. Cummins and Gordon R. Keller | ____ | ____ |
| Treatment of Acid Mine Drainage by Wetland Construction | Michael Tripp | ____ | ____ |
| NAD-27 Versus NAD-83 | Vic Hedman | ____ | ____ |
| Sudan Reforestation & Anti-Desertification Project: A Summary | Ray Allison | ____ | ____ |
| **May/June** | | | |
| Data Needs for Strategic & Project GIS | Wayne H. Valentine | ____ | ____ |
| The Winema National Forest Chunkwood Project | Karl Buehler | ____ | ____ |
| Swing in the Backcountry: Removable Suspension Foot Bridges | J. Heather Woll | ____ | ____ |
| Status of the Fiscal Year 1989 Timber Bridge Initiative in Region 2 | Royal M. Ryser | ____ | ____ |
| Removal of Vinyl Asbestos Floor Tile | Robyn Horner | ____ | ____ |
| Control for Block Analytical Photogrammetry at GSC | Wayne H. Valentine | ____ | ____ |
| Naming the Land We Care for: Centennial Celebration of the U.S. Board on Geographic Names, 1890-1990 | Roberta M. Quigley | ____ | ____ |
| **July/August** | | | |
| Turnkey Conversion of Railroad Trestles to Highway Access Bridges | Jim Penzkover and Larry Shepherd | ____ | ____ |
| Designed Natural-Appearing Cement Structures for Wet Area Enhancement | Richard J. Streeper | ____ | ____ |
| New Revetment Design Controls Streambank Erosion | Russell LaFayette and David Pawelek | ____ | ____ |
| Bridge End Fill Repair | Jim Johnson | ____ | ____ |
| **September/October** | | | |
| The Benson Surveys | James R. Fields | ____ | ____ |
| Project Management in the Forest Service | Jim Mickelson | ____ | ____ |
| Effects of Delineation on a Low-Volume Road | Thomas Shuman | ____ | ____ |
| Sign Planning & Sign Sizing Aids | Earl Applekamp, Dan Davis, and Earl Williams | ____ | ____ |
| Getting There & Back--A New Perspective | Jerry Bowser and Ted Zealley | ____ | ____ |
| Quality Service--The Great Expectation | Samuel D. Fischer | ____ | ____ |
| **November/December** | | | |
| Cutting Boundary Agreements | Donna Harmon and Jim Fields | ____ | ____ |
| Fence Brace Designs | Dan W. McKenzie and Jeffrey White | ____ | ____ |
| The Forest Service Roofing Technology Seminar: An Opportunity To Get on Top of Your Roofing Problems | George J. Lippert | ____ | ____ |
| Law: Standards of Care | Norman Coplan | ____ | ____ |
| Monitoring Subgrade Frost Penetration Using Constant Data Loggers With Thermistor Installations | James F. Baichtal | ____ | ____ |
| United States Holocaust Memorial Museum | Progressive Architecture | ____ | ____ |
| "Getting There and Back" Lapel Button | Jerry Bowser | ____ | ____ |

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COMMENTS: ______________________________________________

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Name ______________________________
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# Where Is First & How Far Is Second—GPS

*Douglas Luepke*
*Cartographer*
*Region 8*

The Global Positioning System (GPS), which is space age technology, has become a great newsmaker and an everyday application tool. Many people correlate GPS only with high-precision surveying, when in fact it can be used for a variety of routine resource management applications. It has potential for the following:

(1) Location of den trees, superior trees, and archeological sites.

(2) Marking of insect and disease infestation spots.

(3) Plotting and delineation of buffer zones for red-cockaded woodpeckers.

(4) Wetland mapping and location.

(5) Approximate corner location (reduces search time).

(6) Inventory and location of roads and trails.

(7) Mapping of fire perimeters.

(8) Location and area calculations of timber stands and cutting units.

This article provides an introduction to GPS for managers and an overview of applications in Region 8, where the Geometronics Unit has been working with Forests to develop techniques for using Trimble Navigation's GPS Pathfinder.

## What is GPS?

GPS is a satellite-based, radio-navigation system that provides three-dimensional position and speed. In mid-1993, the entire 24-satellite constellation is scheduled to be in operation. This will result in 24-hour-a-day worldwide coverage. The satellites will circle the Earth in six orbital planes inclined at 55 degrees. Each plane contains four satellites equally spaced in 12-hour orbits. Position fixes are based on the transit time of radio signals from three or four satellites within the constellation. Range to the satellites is determined by scaling the transit time by the speed of light. The transmitted message enables the user's receiver to automatically calculate the position of each satellite at the time it transmits a signal. The user's position is automatically calculated from range data.

The Pathfinder used in Region 8 is a rugged, lightweight GPS position/navigation and data-logging system designed for field applications. The Pathfinder is a sequencing, dual-channel, L1 frequency, C/A code receiver that uses a low-profile, omnidirectional antenna. A polycorder is used to manage the recording of time-tagged position data files. The polycorder displays this information on an LCD, which has a 4-line, 16-character alphanumeric display.

## Selective Availability

Before discussing field applications, it is beneficial to consider selective availability (SA) and its effects on field applications. SA is the ability of the Department of Defense (DOD) to degrade the civilian signal. This activity reduces the accuracy level. DOD has maintained that it would initiate SA once a sufficient number of Block II satellites were in orbit. Why? DOD has said this would be done "in the interest of national security." SA was implemented on March 25, 1990, and has caused difficulties and changes in modes of operation. Errors of more than 200 meters have been recorded. However, DOD has stated that its objective is to set C/A code accuracy at a nominal 100-meter level once the full constellation is operational.

## Field Applications

### Area Calculations

An application tested was to geographically locate cutting units for a timber sale and then calculate the acreage of these units. On the Ocala National Forest, two areas were walked that were already measured for acreage using a hand compass and a cloth tape. Two Pathfinders were used with the data logger set at different collection rates. The results were as follows:

*Compartment 84/S26*

Measured acreage = 30.3 acres
1 pt/1 sec = 29.4 acres
1 pt/10 sec = 28.9 acres

*Compartment 83/S21*

Measured acreage = 39.7 acres
1 pt/5 sec = 40.7 acres
1 pt/10 sec = 41.5 acres

Canopy closures were not a problem in this area. The areas adjacent to these units were cut approximately 10 years ago and did not interfere with the signal. However, on the side of the unit where trees obstructed a direct signal, a fewer number of data points were collected. SA was not active at this time (figure 1).

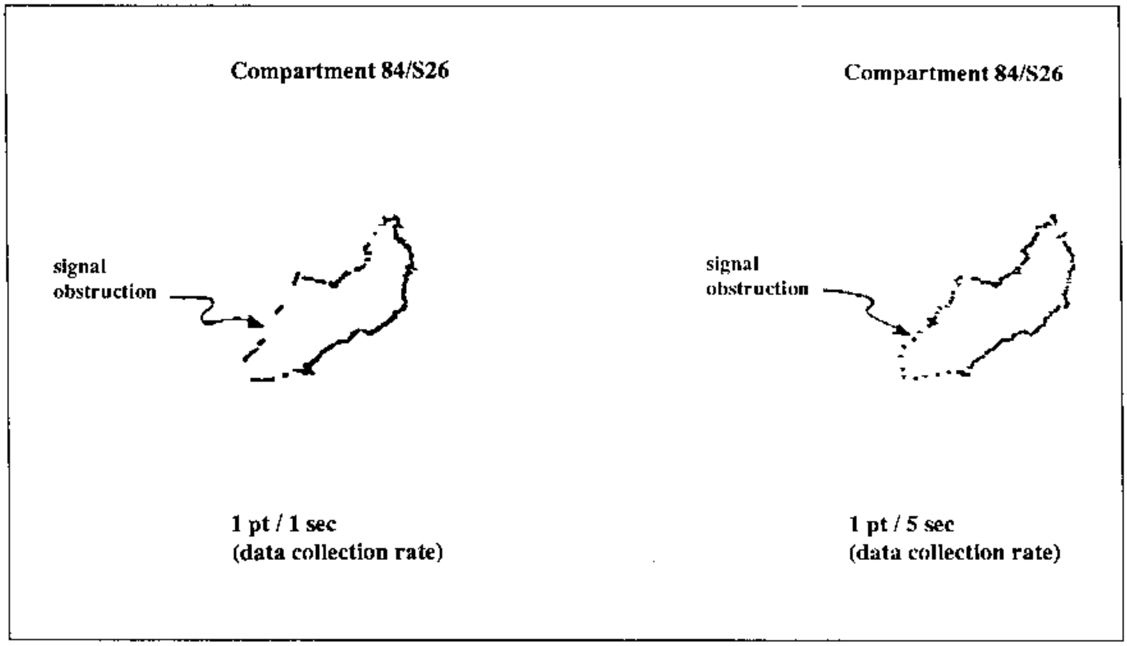


*Figure 1.—Data points collected for Compartment 84/S26, an area on the Ocala National Forest.*

Another area for acreage calculations was in the highland forests. These trees are predominately hardwoods. Work was accomplished in the winter months when foliage was absent from the trees. The results were as follows:

*Unit 4060–2*

Measured acreage = 39.4 acres
1 pt/1 sec = 39.9 acres
1 pt/5 sec = 37.9 acres

*Unit 4060–14*

Measured acreage = 32.2 acres
1 pt/1 sec = 31.9 acres
1 pt/5 sec = 29.1 acres

*Unit A27*

Measured acreage = 13.5 acres
1 pt/5 sec = 13.0 acres
1 pt/10 sec = 14.0 acres

When the data were displayed from a personal computer monitor, it was readily apparent that the GPS signal was affected by tree stems (figure 2). The points,or position fixes, seemed to bounce around compared to the data that had a clear signal. However, when the data were plotted at 1:24,000 scale and compared to a Muskie plot, it fit the primary base map very well. The acreage, in most cases, was within a 4-percent error, with the largest single error of 9.6 percent. Again, SA was not active.

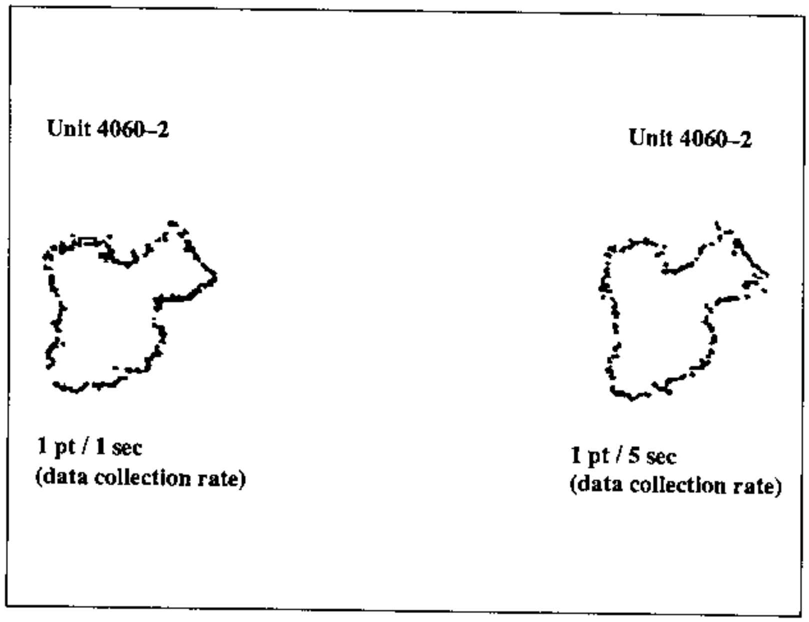


*Figure 2.—Data points collected for Unit 4060–2, an area in the highland forests.*

Acreage calculations were also done on the Oconee National Forest, located in the Piedmont region. The two stands measured were in a mixture of pine and hardwood. Data were collected during leaf-on conditions with a canopy that was comparatively open. In this case, SA was active. The results were as follows:

*Unit 146/12*

Measured acreage = 22.6
1 pt/5 sec = 20.7 acres

*Unit C–145*

Measured acreage = 13.0 acres
1 pt/5 sec = 13.2 acres

Overall, GPS used in an environment that allows signal reception is an excellent tool for delineation and area calculation. Not enough data have been collected to determine the optimum data collection rate. The advantage of the Pathfinder is its ability to collect data as the individual walks the area and returns to the office to postprocess the data. This method is much quicker than compass and tape. These data can then be used to calculate acreage and create a referenced plot using 2 1/2-minute geodetic tick marks, which will register to a primary base map.

## Point Location

Point locations for the red-cockaded woodpecker trees were accomplished using the Pathfinder, downloading and plotting the data with Trimble's software package called *PFINDER*. At each red-cockaded woodpecker tree, a single file was built that consisted of collecting approximately 40 to 60 points. After downloading the data, statistics were generated and observed to ensure that the data collected were valid. Then, a graphic plot of these data was displayed on a monitor to check the validity of the data. After the verification process, a program called *MULTISSF* was run to combine all files into one. Next, the combined file was run through a program called

*GROUPING*, which calculates the running average of each group and allows the user to enter a text field into the new output file. Figure 3 depicts a graphic plot of combined files using MULTISSF and a graphic plot of the GROUPING file.

The point location of known second-order (SO) geodetic positions with active SA has also been done. In this procedure, two Pathfinders were used. One unit was set at 1 point per 5 seconds, and the other set at 1 point per 10 seconds. All points were run through differential correction and analysis to get an accurate position fix. The GPS point was the mean value of the latitude and longitude collected at that point. The results were as follows:

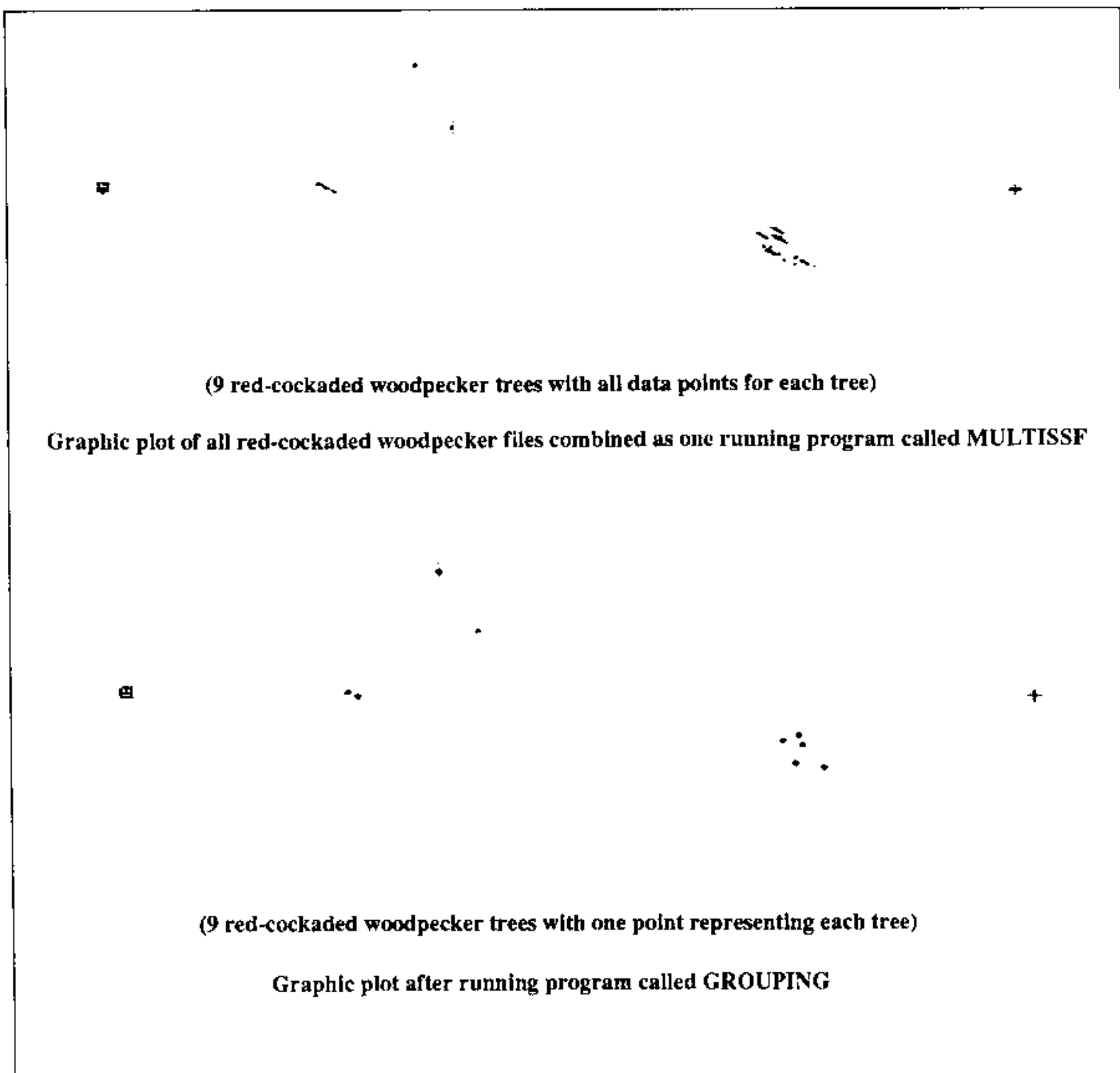


*Figure 3.—Graphic plots using MULTISSF and GROUPING.*

| *SO #1* | | *SO #2* | |
|---|---|---|---|
| 34 pts | 8.73' error | 44 pts | 27.36' error |
| 223 pts | 11.63' error | 134 pts | 11.93' error |
| *SO #3* | | *SO #5* | |
| 146 pts | 15.10' error | 32 pts | 1,219.39' error |
| | | 34 pts | 156.83' error |
| *SO #7* | | *SO #8* | |
| 69 pts | 25.55' error | 34 pts | 13.06' error |
| 287 pts | 23.58' error | 98 pts | 18.51' error |
| *SO #9* | | | |
| 42 pts | 106.12' error | | |
| 148 pts | 30.26' error | | |

$$\text{Error} = N^2 + E^3$$

Points SO8, SO9, and SO5 were nearing the end of the satellite visibility window, with SO5 being the last point received. There are at least two ways of verifying whether the data look valid or not. The first is by looking at the statistical output (figure 4). This will tell the number of points collected, the minimum and maximum variance and mean value in latitude and longitude, and the standard deviation. If there is a large standard deviation, something is wrong with the data point collection.

The second method of verifying data is to display the data and visually check to see whether the data have a "tight shotgun" pattern (that is, to make sure the data are not scattered all over and/or there are not small groups all over). SA has resulted in some unexpected and strange readings in data. All data must be verified. Never assume that the data collected are good. Before SA was activated, readings were 7 feet +/– using differential correction and

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(c) Copyright Trimble Navigation 1988, 1989 Version 1.16
SSFSTAT - GPS Statistics Program.

File: SO2.COR   NAD_83 Datum & Height Above Ellipsoid
start at GPS Week # 538 Thru May 3 1990 12:36:46
stop  at GPS Week # 538 Thru May 3 1990 12:39:38

Type         Record    Minimum          Maximum           Mean          StdDev

Latitude     134     33x06'38.77"N    33x06'39.18"N    33x06'38.96"N    2.700 m
Longitude    134     79x46'36.26"W    79x46'35.67"W    79x46'35.96"W    4.411 m
Altitude     134         25.38            74.26            53.17        11.558 m
Finished with file D:\GPS\FMSUMTER\SO2.COR.
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*Figure 4.—Statistical output for a second-order geodetic position.*

16 feet +/– in a single-receiver mode. It is recommended that, with SA active, at least 200 to 300 points should be taken. This can be done with 1-point-per-second intervals.

**Helicopter Application**

GPS can be used in a helicopter by locating the antenna in a high-visibility area. With the Bell 206B2 helicopter, the antenna is placed on the extreme front control panel for best visibility. A southern pine beetle aerial survey with the Bell 206B2 was planned to locate southern pine beetle spots with the Pathfinder; however, no locations were visible. The helicopter did hover around a wildfire burn area that measured 42.5 acres. The actual ground measurement was 40 acres. Winds were brisk and the pilot did not want to get lower than 500 feet. A loss of signal was noticed when the satellite constellation was behind the helicopter because of the antenna location. Once again, work was being done near the end of the satellite visibility window, and only three satellites were available. Had the wind not been so brisk, the helicopter could have been turned in the proper direction to receive a clear signal. This small amount of signal interruption did not alter the shape of the wildfire burn area.

The Bell 212 is a larger and more powerful helicopter than the 206B2. The best location to fasten the antenna was to the inside of the co-pilot's overhead window. The idea was to experiment with the ease and accuracy of maneuvering a helicopter around a cutting unit and young stands. The day was clear and calm. The location of the antenna resulted in clear signal reception. No stand measurements were available to compare; however, a graphic plot of the data was overlayed on a 1:24,000 photograph. The overlay matched the photograph. The relative ease and performance in operating the Pathfinder in different helicopters will assist resource managers in many ways, including the following:

(1) Location of insect-infested and diseased trees.

(2) Location of nesting trees for eagles, and so on.

(3) Fire line delineation and area calculation.

(4) Spray monitoring (flight line following).

**Road Location/Road Survey**

GPS can also be used for road location or the updating of road additions. In the highland regions of the Forests, it is important to collect data using four satellites to acquire elevation data. The Pathfinder will automatically retain the latest four satellite elevations. If the fourth satellite is lost, only latitude and longitude readings (two-axis data) with the last known fixed elevation are collected. As a result, traveling up or down a mountain road will cause the data to shift incorrectly. The way to ensure three-axis data is to not collect data with only three satellites. However, three satellites and a quad sheet can be used if elevations are input as you travel up and/or down the road.

The Pathfinder can be used for doing road inventories by time-tagging the data. Upon approaching a culvert, for example, extra points can be collected, or notations can be made in a log book as to what time the data logger had and the size of the culvert, before continuing on. This can be done for trail crossings, erosion-slide areas, sign markings, and so on. All of this can be accomplished during the annual road inspection. Once the data are post-processed using differential correction, they can be transferred into many of the conversion formats available and then transferred into a GIS or CADD system.

## Comments

In many respects, GPS is still in its infancy. We cannot afford to wait, however, for the price of this equipment to reach rock bottom. Neither can we rely on vendors alone to do the field testing. We must begin evaluating GPS for field applications today. Each Region, each Forest, and, in many cases, each District in the Forest Service has different ideas and applications for accomplishing their programs of work. GPS is a tool that will make a profound difference in these methods, in much the same way as did the advent of microcomputers.

This is not intended to be a technical article. The information presented here is meant to introduce and enlighten resource managers to some uses of GPS. There are high-precision GPS survey units on the market for cadastral work in addition to the GPS unit discussed in this article. We should not restrict our thinking to only the high-precision units while allowing this valuable tool to go unutilized.

One way to learn more about GPS for resource application is to attend one of the short courses being offered by the University of Montana School of Forestry and the Center for Continuing Education in cooperation with the USDA Forest Service's Missoula Technology and Development Center.

*Many thanks to Tony Jasumback of the Missoula Technology and Development Center for the many hours he spent providing assistance to the author in understanding and using GPS technology and in the sharing of equipment.*

# Fire Mapping Using Airborne Global Positioning

***Phil Drake***
***Regional Land Surveyor***
***Region 2***

On September 15, 1990, Ray Evans, Director of Fire and Aviation Management, Rocky Mountain Region, ordered the Region's Global Positioning System (GPS) units for use on the Swedlund Fire on the Black Hills National Forest (figure 1). Blaine Cook (Resource Management Forester on the Black Hills), Doug Williams (Land Surveyor on the Black Hills), and Phil Drake (Regional Land Surveyor) formed a fire mapping team to map the Swedlund Fire using the Trimble Pathfinder GPS.

## Procedure & Findings

The first thing done was to establish a control station with geodetic coordinates at the Custer Airport, where it would be convenient to operate while mapping the fire. GPS units should currently be used in multiple units, with one positioned on a station with a known position. This is done primarily to resolve errors of up to 100 meters imposed on the system by the Department of Defense (DOD). These errors are imposed ostensibly as a security measure to hinder real-time positioning. Because of inherent errors within the system, irrespective of DOD's deliberate degradation of the GPS signals, the use of multiple instruments improves positions from a 20-meter stated precision with one instrument to a 2-meter stated precision. The procedure of using a control GPS unit in conjunction with remote or roving units is called differential positioning.

One of the GPS units was set on the control station established at the Custer Airport. The antenna of another GPS unit was attached to a Jet Ranger helicopter. The Pathfinder's antenna, along with a foam backing, was taped to the tail boom of the helicopter, just ahead of the horizontal stabilizer, and about 12 feet back from the cabin (figure 2). Duct tape overlayed with filament strapping was wrapped around the tail boom to hold the antenna in place on the boom. The entire length of the antenna cable that was outside the aircraft was taped to the aircraft skin. Blaine and Doug acted as spotters, while Phil operated the instrument.

The mapping flight was flown during a three-dimensional satellite window at approximately 50 to 100 feet above the tree tops; this height made it relatively easy to spot the fire line. No reception problems were noticed because of

*Figure 1.—View of a portion of the Swedlund Fire showing the sinuosity of the fire line mapped with the airborne global positioning system.*

*Figure 2.—Antenna attachment to boom of Jet Ranger helicopter. A foam backing was used along with both duct tape and filament strapping taper. A more appropriate attachment could be easily devised as the antenna has a 5/8-inch by 1-inch female thread.*

the main rotor; in fact, 99 percent of the coordinate fixes were three-dimensional coordinates (latitude, longitude, and elevation). At this project latitude and longitude, there are currently about 8 hours during a 24-hour period where three-dimensional coverage is available. This window is continuing to expand as more of the NavStar satellites are launched. At least four satellites must be more than 12 degrees above the horizon to receive three-dimensional coordinates. Two-dimensional coordinates (latitude and longitude) can be received with three available satellites. This extends the window by about 4 hours; however, this should be done cautiously. The error that the instrument is carrying in elevation while collecting data in a two-dimensional window will translate to at least that much error in the horizontal position. This can be overcome by updating the elevation within the instrument with an altimeter, but it is much preferable to just plan the data collection for three-dimensional windows.

The entire 35-mile perimeter of the fire, enclosing 14,200 acres, was mapped in approximately 55 minutes of flight time. The GPS instrument was configured to collect 1 position every second; therefore approximately 3,000 coordinate positions were collected along the fire line or about 1 position every 60 feet. Within 2 hours of landing, the data had been postprocessed, using the control station data, and an overlay plot at 1:24,000 scale of the entire fire line, along with the acreage calculations, was delivered to the Plans Section of the fire.

The short turnaround time for the finished perimeter plot was impressive to everyone involved. The GPS fire map agreed very well with the traditionally generated ground fire map. (See figures 3 and 4.) However, as there were some slight differences between the two maps; the Plans Section sent the airborne GPS fire mapping team out again to map the fire in the opposite direction as a redundant check. The second GPS fire map overlayed almost exactly with the first GPS map. The few differences that occurred between the two flights (+/- 50 feet) seemed strictly a product of the resolution possible by flying an aircraft over a very sinuous line on the ground that was in some areas difficult to distinguish. The acreage calculations (which take about 2 minutes after the data are processed) for the second flight was 14,100 acres, less than 1 percent different than the first. Although there were some minor differences when the GPS fire map was compared to the traditionally generated ground fire map, it seemed that the ground mappers had really done an excellent job of photograph and map interpretation. Approximately one-third of the area of this fire was on land administered by the State of South Dakota. A separate data file was created within the GPS software for this area. Acreage was then calculated for this area and will be used to prorate the cost of suppression.

On the second day, Darwin Hoeft, Soil Scientist on the Black Hills, acted as the spotter to map the high-intensity burn areas on the interior of the fire. This was done to obtain the acreages for reseeding and rehabilitation. Thirteen polygons of high-intensity burn (5,300 acres), interior to the fire, were mapped in 1 hour and 20 minutes of flying time. As a polygon was closed with the aircraft and GPS, an estimate was made of the percentage of intermingled green within the polygon. These estimates ranged from 10 to 30 percent. The postprocessing and plotting took a couple of hours. Plots were made at several scales for the rehabilitation, reseeding, and salvage sale plans, as well as the final fire reports. (See figure 5.)

Bill Ewin of CEA Inc., a Trimble dealer from Tempe, Arizona, arrived on the Forest on Monday as a volunteer. He and Carol Thomas of Information Systems, Black Hills National Forest, converted the Pathfinder data to AutoCAD and Moss digital formats. The software that is supplied with the instruments makes this task relatively easy with some basic computer knowledge. In this format, the polygons (in digital form), mapped with the GPS instruments, will be used to update the Forest GIS and RIS data bases; they will be further used for the silvicultural prescriptions and other fire-related management activities.

The entire GPS operation for this particular fire was completed from the helicopter. However, there could be instances when smoke would obscure the fire line visibility. At these times, it may be necessary to carry out the operation from a ground-based vehicle or by walking the perimeter with the GPS unit. These methods would obviously cut down on the production time, and signal reception breaks would be more common, but based on the experience with other applications, this would be a viable option.

An interesting sidelight to this experience is that the helicopter pilot and the mechanic were initially concerned that the duct tape might damage the

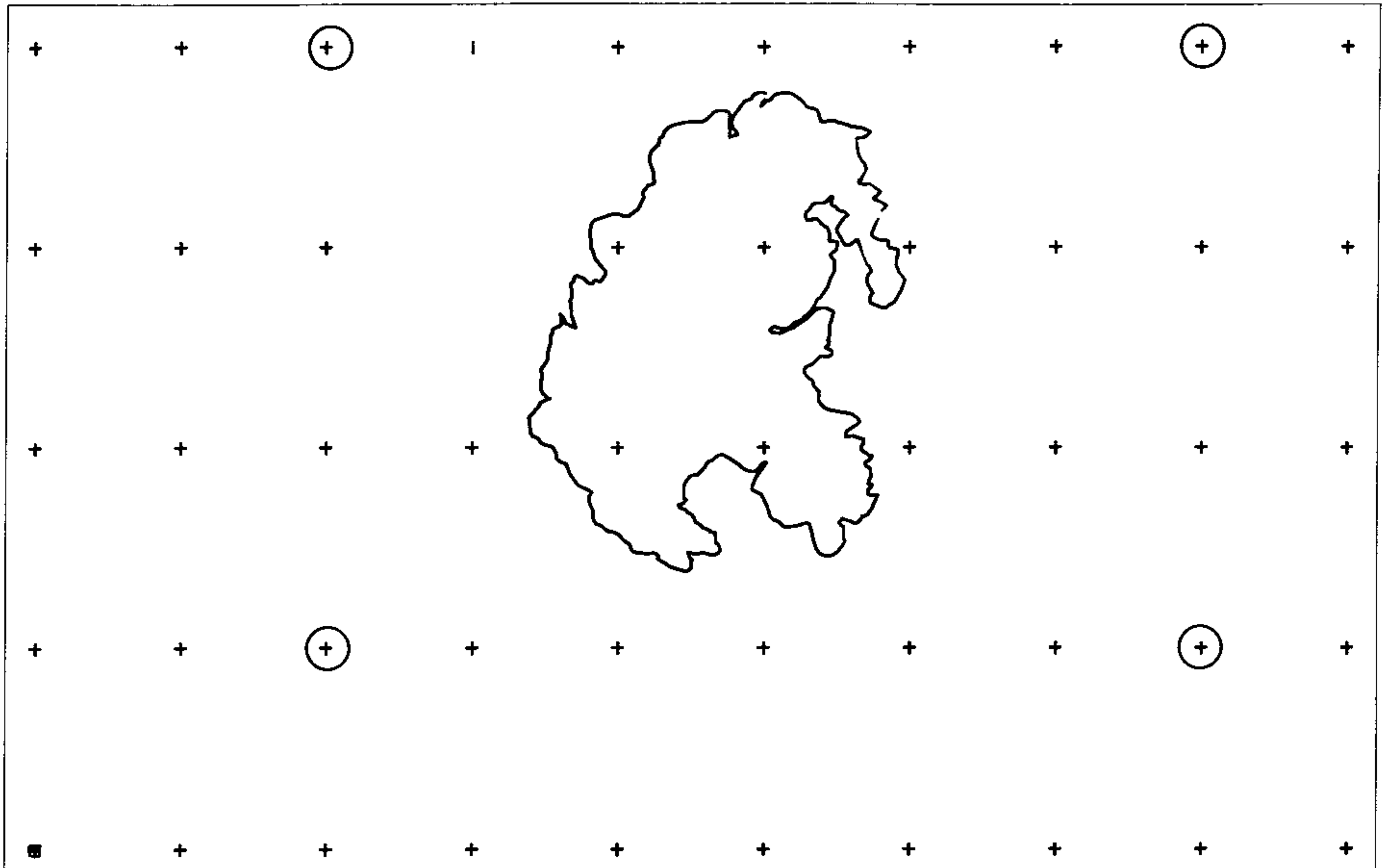

*Figure 3.—Perimeter plot of Swedlund Fire made with the Pathfinder GPS software. This overlay was made at the same scale as the secondary base series map; however, the plots can be made to any desired scale.*

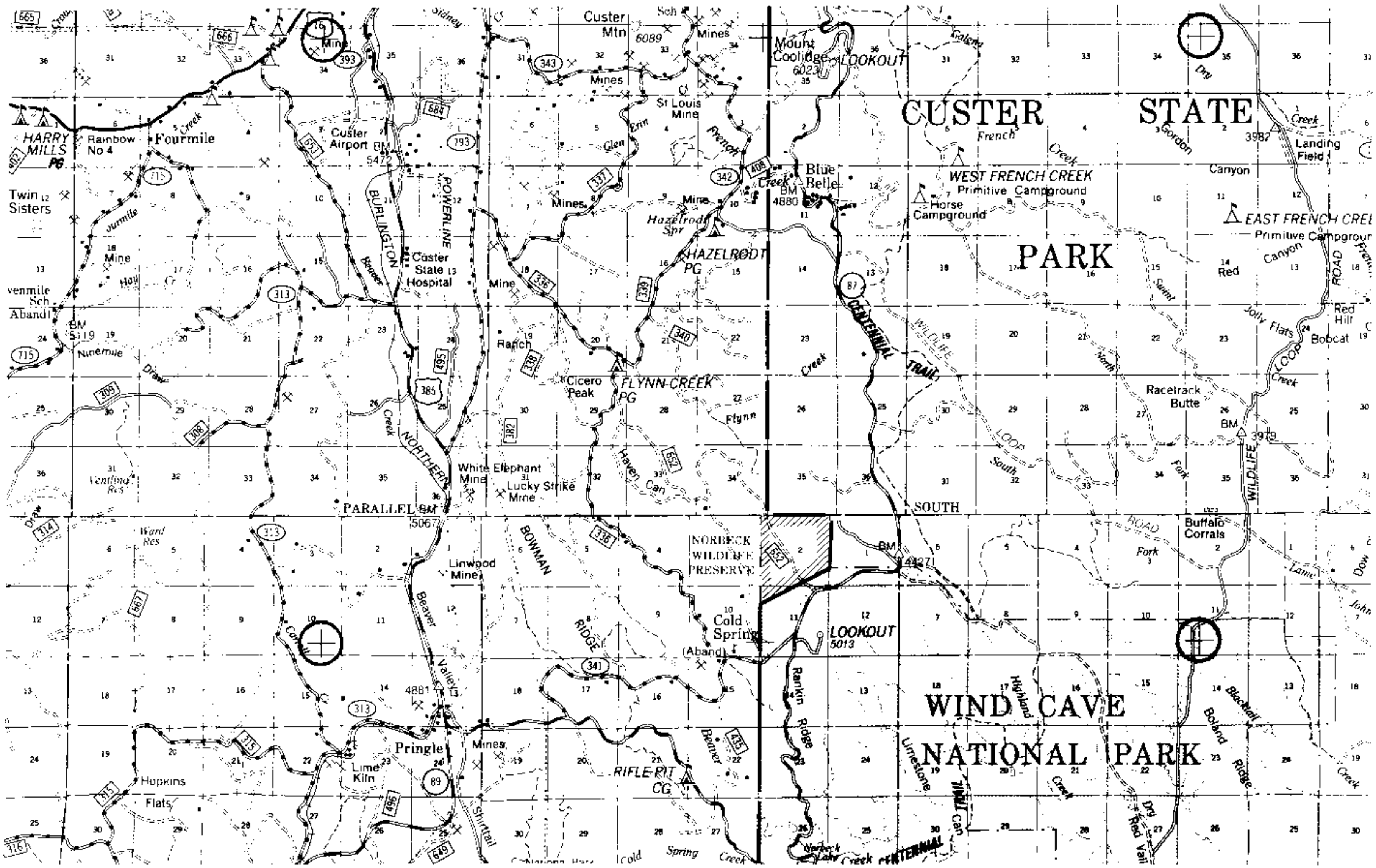


Figure 4.—Secondary base series map of the Swedlund Fire area.

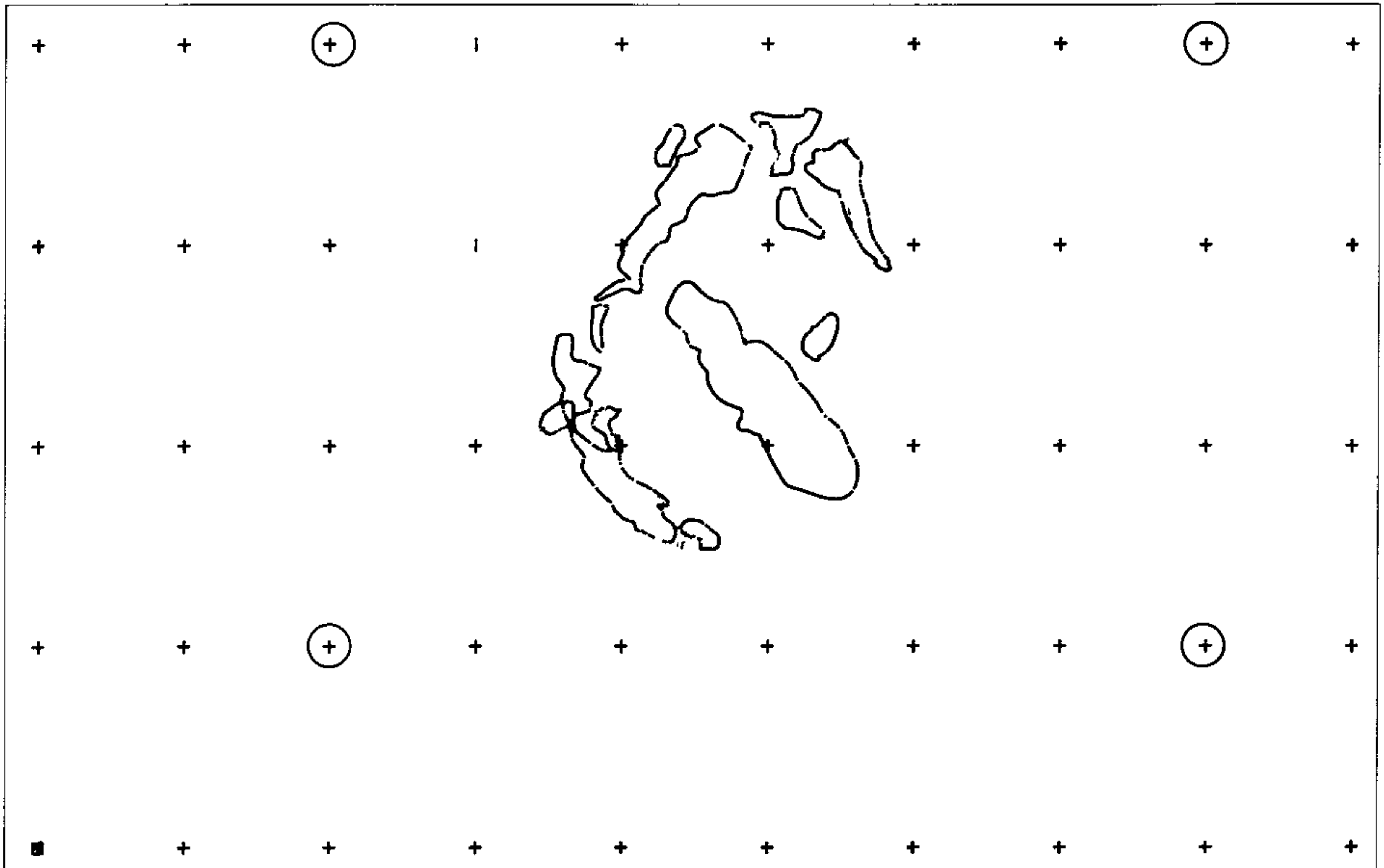

*Figure 5.—Plot of the Swedlund Fire high-intensity burn areas. It was mapped using airborne Pathfinder GPS. This information was used for the rehabilitation plans.*

aircraft paint, but this did not happen. The Trimble GPS units, in addition to storing positions for mapping, also provide real-time navigational information. Using the GPS instrument, the pilot was navigated to within 20 feet of where he took off, and he was given his true ground speed along the way. This impressed him because the GPS crew had trouble getting close to the ship to remove the instrument when the project was completed.

## Conclusion

The airborne application of GPS technology for mapping or map updates could be cost-effective for several other types of projects based on the ground that can be covered in a short period. It would be most effective where time or visibility precludes traditional photogrammetric methods. These applications might include wildlife counts and mapping, roads and trail inventory and mapping, wetland acreage measurements, stream length surveys, timber surveys and mapping, law enforcement activities, rescue operations, and so on. Two of GPS's greatest assets are its repeatability and the fact that it works on a common geographic base, which ensures spatial compatibility between groups of data that are collected at different times and places. It is an understatement to say that this factor is important as we move further into the electronic information age.

# Precautions for the Removal of Vinyl Asbestos Floor Tile

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## Washington Office Note

*The following article provides another opinion about the risks associated with the removal of asbestos-containing materials (ACM's). Even experts are divided as to the relative risk to humans of asbestos fiber releases.*

*A training session was held October 29 to November 1, 1990, to qualify Forest Service personnel as inspectors and managers of ACM's. This session and similar approved training provide considerable enlightenment regarding the risk of asbestos and the management of ACM's in place, as well as the current regulations and precautions to be used in the removal of ACM's. A revision of FSH 7309.11, Section 42.21, to be released about January 1991, requires that only qualified Forest Service or State-certified persons sample, manage, or remove ACM's; it also requires proper precautions and the use of personal protective equipment in all asbestos activities. In addition, this directive requires specific management plans for all ACM's in Forest Service buildings and operations.*

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The May–June 1990 issue of *Engineering Field Notes* contained an article titled "Removal of Vinyl Asbestos Floor Tile." Because of State involvement in regulating asbestos removal work, some areas may have more stringent requirements than others. Therefore, additional precautions may be necessary before undertaking an asbestos removal project by in-house or contract personnel, even if low exposure levels are anticipated.

## Precautions

In the absence of more stringent State regulations, OSHA construction standards in 29 CFR 1926.58 address asbestos work, including removal. This standard defines a "competent person" who is required to perform or supervise the work. A respirator program needs to be implemented following the guidelines of 29 CFR 1910.134(b), (d), (e), and (f). Such a program includes physical examinations and proper training. Respirator fit testing should be conducted according to 29 CFR 1926.58(h)(4). Proper recordkeeping is essential and is further explained in the asbestos standard.

Other requirements found in 29 CFR 1926.58 include decontamination areas for removal operations. A decontamination area consists of "an equipment room, shower area, and clean room in series." Warning signs need to be posted as required by the regulation. In addition, proper disposal of asbestos waste includes the use of labeled, impermeable bags or containers. Disposal should be in accordance with EPA and/or State regulations in approved landfills.

Additional precautions for vinyl asbestos floor tile removal are as follows:

(1) Not all vinyl asbestos floor tile is in the 9-inch by 9-inch size; asbestos has been found in 12-inch by 12-inch sizes as well.

(2) Respirators need to be properly fitted for each individual.

(3) Mop heads used in asbestos cleanup need to be properly disposed of in marked bags or containers.

(4) The record of exposure measurements needs to be maintained for at least 30 years.

(5) Air monitoring tests should not be assumed to be superfluous just because previous removal tests were within acceptable limits. No two removal jobs are the same, even within the same building.

## Conclusion

Any asbestos removal work, regardless of the exposure level, should be considered hazardous. The "one fiber" theory suggests that it only takes one asbestos fiber to cause long-term damage to the lungs. Therefore, even though the price of removal work may be high, one must assess the potential effect of cost-cutting measures on worker safety.

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