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INVESTIGATION AND DEVELOPMENT OF NEW CADASTRAL SURVEYING PROCEDURE AND EQUIPMENT

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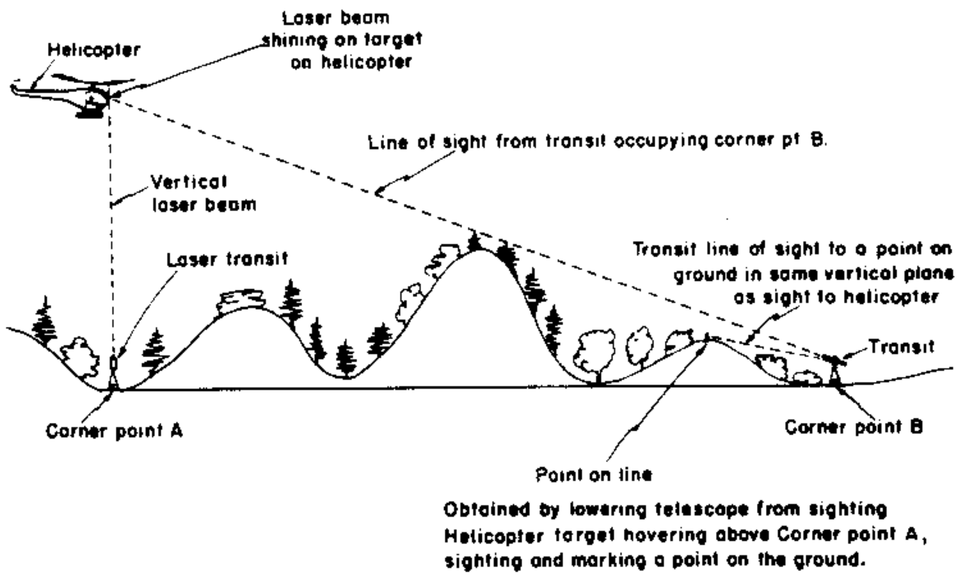
Surveyors could save much field time and expense if they had a rapid and economical way to obtain a line of sight between two adjacent survey corners which are not intervisible because of terrain and/or ground cover. The use of a laser beam seemed to offer some possibility of satisfying this need.

The first thought was to use a laser beam, pointed vertically above a survey corner. The laser beam could then be sighted visually through a transit from another corner located a mile or so from the first corner (see illustration below).



Discussions with various laser manufacturers concerning this idea produced different answers. Some said it would work, others said it would not.

In field tests of this survey method we found that the laser beam itself was not visible. Some object, such as a target, or some air pollutant such as smoke was required to make the beam, or a spot caused by the beam become visible.

We considered smoke, captive balloons, and helicopters as possible targets that would make the laser beam visible. We felt smoke was impractical for field use and captive balloons carrying a target would present too many problems in centering the balloon over the survey point.

A helicopter seemed to be the best way to put a target in the air. The vertical laser beam hitting the target could then be sighted through a transit from the remote corner.

A short test was conducted to determine the helicopter-pilot capability. We wanted to determine if the helicopter could find the vertical laser beam in the air and stay in the beam long enough to furnish a sight for a transit man stationed some distance away. A pilot with no experience in hovering an aircraft and a helicopter with no special hovering capability was selected for the test. Two reasons governed these choices:

1. This was all that was available in the area.

2. If this personnel and equipment worked, then helicopter services in the field would be quite simple to obtain because no special equipment or pilot training would be required.

The system was tested with the copter at 4,000 feet and then at 2,000 feet above the ground. Both trials gave negative results. It was almost impossible to fly the helicopter slow enough to find the beam in the air. The transit man had difficulty tracking the fast-moving helicopter and was unable to get a sight on the target during the very brief time the 'copter was directly over the survey point.

The 'copter can hover at an elevation of a few hundred feet above the ground but such a height limitation would restrict the use of the system to relatively flat terrain.

We feel this test does not rule out the use of a helicopter but strongly indicates that special equipment and pilot training would be needed to make it practical for general field use.

This experience directed our thinking back to how we might develop the system without the use of a helicopter target to reflect the laser beam. Considerable correspondence has been carried on with laser manufacturers concerning the idea. This has developed into a project of trying to find some way to obtain a line of sight by sensing the vertical laser beam with a photo multiplier at the remote corner point. This would eliminate the need for an airborne target or visual sighting of the vertical laser beam.

This idea was discussed with the Forest Service electronics laboratory personnel at Beltsville, Maryland. Also, contact was made with NASA scientists at the Goddard Space Flight Center. A feasibility study concerning types of lasers, filters, photo multipliers, and other devices which might be utilized to accomplish the objectives outlined above has been agreed on. The cooperation sought with NASA was on a "time and equipment availability basis." Last reports are that both NASA and the Beltsville Electronic Center are optimistic that equipment can be developed that will be compact enough to be carried by two men, will operate in bright daylight, and will locate a line-within a tolerance of 1 or 2 minutes of horizontal angle.

We hope to have more to report on this in a few months.

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Overview of Information Management Products and Services Produced by the Geometronics Service Center and Nationwide Forestry Applications Program

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Products and Services

Products and services provided by the GSC and the Nationwide Forestry Applications Program (NFAP) play a critical role in the use and management of spatial data in the Forest Service.

The GSC is responsible for the revision and maintenance of the Forest Service national base maps. There are two principle series of these maps: the Primary Base Series (PBS) and the Secondary Base Series (SBS). GSC also produces the Cartographic Feature File (CFF), Digital Elevation Models (DEM), and Digital Orthophoto Quads (DOQ). GSC provides a number of other services to Forest Service customers related to its mission.

The Nationwide Forestry Applications Program (NFAP) works with numerous field units and outside cooperators in the development and adaptation of various remote sensing data and techniques into Forest Service operations.

The following is an overview of the products and services provided by GSC and NFAP and the relationship to information management in the Forest Service today.

Primary Base Series Maps and Cartographic Feature Files

The PBS is composed of over 10,600 maps, each covering about 54 square miles, based on the U.S. Geological Survey (USGS) topographic map quadrangle. Eight feature categories are represented on the PBS maps: transportation, drainage, political and administrative boundaries, public land survey system (PLSS), Forest Service and other land ownership, other cultural features, map text, and contours. These maps are generally used as the base for planning and carrying out the business of the Forest Service. As such, the PBS is a vital item in the Forest Service information structure. One of the current initiatives at GSC is to continue development of a totally automated process to produce the PBS maps.

The CFF is a digital representation of the graphic features that are shown on the PBS series maps. CFF's are produced by manually digitizing or collecting these graphic features and then labeling this data with appropriate attribute codes. The GSC began the collection of CFF's in 1989. Of the 10,600 quads within the National Forest System, approximately 6,700 have been collected.

In addition to being used to produce hardcopy PBS maps, the completed files serve as the geographic framework for Forest Service spatial database development. The six feature categories contained in the CFF are transportation, drainage, political and administrative boundaries, public land survey system (PLSS), Forest Service and other land ownership, and other cultural features. Contours and map text will be included in the future. The CFF is stored by quad and edge matched to adjacent quads. CFF files can be used individually or can be combined into a larger project or administrative study area.

Secondary Base Series Maps

The SBS maps consists of 351 map sheets, each covering a portion of a National Forest. These maps are used for Forest administration purposes and serve as the base for Forest Visitor Maps and Pocket Guides. GSC has historically used digital data to produce very specific pieces of the SBS maps. Some map layers have been generated from the CFF files or USGS Digital Line Graph data. These layers include landnet, boundaries, and drainage.

Today, most SBS maps are still made manually. As more digital data becomes available, GSC will generate more map layers digitally. We are also working on developing new methods for digital mapping based upon the work Region 1 has been doing with Intergraph Microstation GIS Environment (MGE) and Map Publisher software. We have been working closely with Region 1, sharing new information with them on these digital methods. Region 1 published a map made by completely digital methods last year and GSC is nearing completion of our first completely digital SBS map product. In the future, we anticipate producing many SBS maps by digital methods and assisting the Regions in this effort. Digital data produced as a result of SBS compilation may be useful for broad, Regional GIS applications.

Digital Elevation Models

GSC has collected, in a cooperative effort with the USGS, an elevation every 30 meters over the entire Forest Service area of interest. They are DEM's. This form meets the USGS standards for content, accuracy, and format.

DEM's were collected for two principle reasons: to support the Orthophoto program and to be used for elevation, slope, and aspect layers in the national GIS. DEM's are also useful for watershed analysis and viewshed applications.

Digital Orthophoto Quads

GSC is beginning production of DOQ's, which are geometrically corrected aerial photography products. They are produced and formatted specifically to cover one PBS quad. DOQ's can be used as an image backdrop for updates of primary feature data and as a source for collection and revision of thematic data layers in a GIS.

GSC has purchased two Data General AVIION workstations through a USGS contract. USGS - Western Mapping Center in Menlo Park, California, developed and supplied the software for GSC. We are presently testing and working out procedures and software problems. The USGS plans to release the final version of DOQ software by November 1, 1993.

Currently, the DOQ photographic diapositives are being scanned by the USGS under an Interagency Agreement to trade scanned photography for DEM's produced by GSC. The scanned data is sent on 8mm tapes to GSC, where DOQ's will be produced. Purchase of an orthophoto source scanner in the future will allow GSC to do this work in-house. In the meantime, we will continue to produce some orthophoto quads by the traditional analog method.

Image Analysis and Remote Sensing

Remote Sensing (aerial photographs, satellite imagery, airborne videography, and associated technologies) contributes data for GIS databases. The Forest Service Remote Sensing Steering Committee developed a vision for remote sensing in the Forest Service that states:

> *"Remote sensing is a source of current and repeatable information on the location, quantity, and quality of land cover and other resource variables, with emphasis on vegetation. It allows change detection and monitoring of the resource base over time.*
>
> *The primary use of data layers derived from remote sensing is in Forest Plan development, implementation and monitoring and in ecological mapping and related activities. Resource managers have access to the layers derived from remote sensing through GIS technology."*

The Nationwide Forestry Applications Program (NFAP) is involved in several types of remote sensing activities, including development and demonstration projects with field units, testing of new technologies, and training and awareness.

In one application of remote sensing to Forest Plan monitoring, NFAP and the Mark Twin National Forest used satellite digital data from two different times (separated by several years), to monitor the changes in forest land cover. The changes in land cover were correlated with the individual Management Areas. Each Management Area has a unique prescription for management. The changes obtained from the satellite data were used to determine if the desired management level in each of the management areas was met. The data stored in a GIS proved very valuable, saving considerable time that would have been spent in field verifications. Numerous other studies and applications show a wide use of this data source in the context of geographic information systems.

GSC has formed a cooperative venture with NFAP to provide image analysis assistance and guidance. GSC is also developing a database of information on the availability of satellite information, image analysis equipment systems in the Forest Service, and subject matter experts who might be available to assist in image analysis problems. GSC is starting a national database of Forest Service owned satellite image data. This will allow other Forest Service users access to the available data without having to purchase it.

Programming for Data Bases

GSC is involved in providing computer programming services to support information management. The system that manages the CFF database, CFF quality analysis, and editing tools was developed and programmed by GSC and Washington Office Geometronics staff.

Many DEM development, analysis, and display programs were written at GSC. GSC programming staff wrote the contract specifications for an elevation digitizing system, named Line Trace, and administered the contract.

The GSC Information Database, residing in Oracle, contains many items of information vital to production. This database has been functional at GSC for a number of years and has operated under several systems including System 2000, DG-DBMS, and Oracle. The earlier versions were heavily supported by computer programming. Each transition from one database system to the next was accomplished by computer programming. The SQL language, now available for access to Oracle, has lessened the need for large investments in computer programming to support this database. The SQL is somewhat of a language in itself and Oracle users here depend on the in-house SQL programmers to create and change access to the database.

GIS Training

The GSC provides training and technical assistance to Regional Forest and District level personnel in Geographic Information Systems (GIS) start-up. This involves installation of the Base map layers in the CFF into the GIS system. By national direction, these layers are the base on which all other GIS spatial data should rest. Training provided by GSC includes the actual installation of the CFF data according to the Forest

Service standard. It also includes instructions on integration of the other layers into the GIS and with the base map layers.

Adding Value to the Cartographic Feature File

The GSC is preparing a training course, requested by the Regions, on the basics of map making and good map presentation practices. It covers map projections, use of colors and screens in map presentation, preparing maps for specific audiences and uses, and related topics.
GSC provides services to attach existing database information to CFF files. This is accomplished by attaching an attribute in the database to the appropriate CFF feature(s). For example, under a pilot project with Region 6, the Transportation Information System (TIS) data has been attached to CFF road and trail information by extracting the TIS road number-mile post attribute for each segment and attaching it to the appropriate set of CFF features.

Use of Global Positioning System Data in the Mapping Process

Global Positioning System (GPS) surveys use signals from Department of Defense navigation satellites and commercially available receivers and software to determine very accurate positions of points occupied on the ground. Realizing the significant contribution that GPS will have to the mapping process, GSC has developed specifications for differential GPS coordinate data submission to GSC. These specifications identify the data and metadata (data about the data) that should be submitted. The intent of these guidelines is to aid in assimilation of GPS data into the mapping process. A common set of guidelines is needed to provide consistency and reliability of the data for a variety of applications both within and outside the Forest Service. Pilot projects are in process using the specifications.

Cadastral Analysis

The Cadastral Analysis Unit at GSC analyzes legal land description related data to produce coordinate based and/or hard copy maps of legally described land areas for spatial data users. This unit combines legal land survey and cartographic skills with computer skills to effectively develop this data for Forest Service users and other agencies such as the USGS and the Bureau of Land Management (BLM).

Contracting Related Services

GSC has developed contracts which allow interested Forest Service sites access to contract digitizing services. The principle benefits are reduced unit costs derived through economy of scale and lower contract administration costs. The contracts allow users to get resource polygon layers digitized economically. This directly supports the Service-wide need to populate the individual and national GIS databases.

GSC contracts for the digitizing of the six base map layers of data in the CFF. We also contract for the production of DEM's and DOQ's. Open-ended, option contracts for equipment have been developed by GSC. Orders may be placed by the Regions under these contracts.

NFAP contracts extensively for remote sensing work and training services. Contractors work on specific remote sensing applications and provide training to Forest Service employees.

Equipment at GSC and NFAP

GSC has two Data General minicomputer systems. The W03A system is an MV/9500 central processing unit (CPU) with 32 megabytes (MB) of memory, and 1.3 gigabytes (GB) total disk storage. It has one 9-track tape drive and one 8mm cartridge tape drive. Two 2400 baud modems are connected for dial-in users. This computer handles our Electronic Office and Mail as well as fiscal and contracting software.

The W03B system is an MV/9300 CPU with 48 MB of memory and 2.5 GB of disk storage. It has three 9-track tape drives. Two 8mm cartridge drives are also installed. One 2400 baud modem is connected. This computer handles all of our ORACLE Database and the locally developed fiscal and project-tracking databases. It also does DEM processing, electronic transfer of digital data (to other Forest Service sites) and numerous other archival and processing functions. It is connected to a Packet Switch with the W03A system for access to FTS2000. Both systems run Data General's AOS/VS II operating system. Approximately 65 DG terminals and 12 printers access these minicomputer systems. Many of the personal computers (PCs) can also emulate terminals to the system as well.

GSC has two Data General AVIION 530 workstations configured for Digital Orthophotography Quadrangle (DOQ) work. Each one has a single CPU running DG;s UNIX operating system. Each has two 1.4 GB disk drives, a 1/4" tape drive, a compact disk-read only memory (CD-ROM) drive, and 64 MB of memory.

GSC has a Kongsberg high precision flatbed plotter with photohead, two Calcomp check plotters, and a Hewlett-Packard plotter in the Cadastral Unit.

GSC has about 30 microcomputers, about half of which are 286 and half 386 or 486 PC's of various brands. They serve a variety of uses. They are controllers for stereo plotters, serve specialized functions in cadastral work, perform Line Trace Plus tasks, DEM work, and other functions. They are found in all GSC groups and are all networked. They have access to a NOVELL fileserver and use TCP/IP to access other computers and perform file transfers.

NFAP has two 386 PC's and one 486 PC. They have two SUN SPARC-2 workstations running UNIX. These are used for ARC/INFO and ERDAS work. One SUN has a 1/4" cartridge tape drive and a small laser printer attached. The other has a CD-ROM drive and a 9-track tape drive. One workstation has 32 MB of memory and the other has 16 MB. They have 200 MB hard drives.

An ETHERNET local area network (LAN) interconnects all automated data processing (ADP) equipment. It uses communications servers to connect terminals and printers to their hosts. Network traffic is segmented by using several bridges and one repeater. Some PC's are configured to monitor traffic and control communications servers. The Lan runs TCP/IP protocol.

The Intergraph cartographic digitizing and edit system consists of the following equipment:

(a) Two Intergraph data processing systems. Both systems serve as processing nodes on an Intergraph LAN, supporting workstations, and peripheral devices.

(b) Three nine track tape drives and four cartridge tape drives.

(c) A local area network.

(d) Thirteen Intergraph workstations. Eleven of these support a high-precision digitizing table with floating menu and 12 button cursor.

(e) One Optronics 4040 Plotter/Scanner. The scanner produces digital raster data in either continuous tone or run length encoded formats. The 4040 is also capable of generating continuous tone, high contrast, line and halftone plots onto film media.

(f) One Intergraph Mapsetter 5000 Plotter/Scanner. Like the 4040, this scanner produces digital raster data in either continuous tone or run length encoded formats. The Mapsetter 5000 is used primarily for generating continuous tone, high contrast, line and halftone plots onto film media.

(g) One Intergraph Interserve 6405 processing station. This server functions as a plot, file, and compute server.

(h) One Versatec 8900 series color electrostatic plotter.

(i) One Shinko 645 series color plotter.

Photogrammetric equipment at GSC includes:

(a) Three analytical stereoplotters used for aerotriangulation, digital data collection, and manuscripts plotting.

(b) Two pugging devices.

(c) Seven analog stereoplotters and four plotting tables used for hardcopy plotting, DEM's, and PBS updating.

Volume of Spatial Data Managed by GSC and Demand for the Data

The volume of spatial data managed by GSC is very large and continues to grow. Below, we have projected the sizes of databases for GSC products at full coverage. These numbers are based on average data map unit (quad) sizes and on the 10,600 quads in the Forest Service area of interest. As the Forest Service enters into ecosystem management, the need for these basic categories of data will expand well beyond the bounds of Forest Service lands and require easily a 50 percent increase in the areas covered and the sizes of the databases.

Database Sizes

Database	Size/Unit	DB Size
CFF	1.6 megabytes	17 gigabytes
Contours	2.5 megabytes	27 gigabytes
Map text (feature names)	0.8 megabytes	8 gigabytes
DEM	600,000 bytes	6 gigabytes
Digital Orthophotos (Black & White)	360 megabytes	4 terabytes
(Full Color)	1.2 gigabytes	13 terabytes

1 megabyte = 1,000,000 bytes
1 gigabyte = 1,000 megabytes (Billions)
1 terabyte = 1,000 gigabytes (Trillions)

The demand for GSC-produced spatial data products has expanded beyond the bounds of the Federal government to include a wide range of public and private interests. Much of this demand comes by way of cooperative ventures. For example, the Center was an integral partner in supplying data for a successful three-way GIS database building program with the state of North Carolina, the Forest Service, and the USGS. Discussions are underway with the State of Idaho to provide CFF's for significant areas of the State. Following value-added processing by the Idaho Department of Lands, these data will be integrated into the State's database. Copies of the modified CFF's will be returned to GSC for evaluation and possible use. The State has even agreed to share the techniques developed for the value-added procedure. GSC also responds to many routine requests for data submitted by a variety of customers, from State agencies and universities to the private environmental community. Together, these activities have expanded the scope of GSC operations and forecast an added dimension to be reckoned with as the Forest Service becomes an integral part of the National Spatial Data Infrastructure. CFF and DEM data are routinely supplied to the USGS for inclusion in the National Databases. The same will occur with digital orthophoto quad data produced at GSC.

A team at GSC is currently analyzing the scope of the spatial data management function and preparing recommendations on how to most effectively organize to manage spatial data and metadata.

Use of Oracle

GSC and NFAP use the ORACLE database system extensively. The primary uses fall into two categories: administrative functions and production assistance. In the administrative area, ORACLE tables and reports are used to supplement data from APOS, PWPS, and related packages for budget tracking, to report contract work, and to develop bidder's lists. An ORACLE database is used to manage individual development plans. We use the software to track microcomputer components, software, and hardware and for Local Area Network wiring, devices, and connections.

In the production area, ORACLE tables and reports are used to track digital map layers and products. DEM's, CFF's, orthophotos, and other specified mapping work are included. We can search by Forest, quadrangle name, or geographic coordinates to locate map product status and information. Mapping products available can be easily located and supplied to customers in a variety of formats (MOSS, AUTOCAD, VAX Data General, ARC/INFO, etc). We also use ORACLE for program planning purposes.

Data from other agencies can be loaded into Oracle databases. For example, aerial photography information from the Agricultural Stabilization Conservation Service's Aerial Photography Field Office and DEM data from the USGS are put into GSC Oracle databases.

Future initiatives, for ORACLE or similar software, include tracking of DOQ production, an Information Resource Management (IRM) reporting process that ties in to budget information, maintenance, and property records, and a user support hardware/software problem resolution database that allows the Computer Systems staff and users to find solutions from a knowledge base of recorded past experience, technical support contacts, etc.

Networking and Telecommunications

GSC and NFAP were given Departmental approval in July of 1987 for our original Local Area Network. A current initiative is to rewire the Local Area Network so that it will comply with 615 requirements. A contract was awarded in September 1993, for wiring installation. A second contract will be awarded for the purchase of hubs, concentrators, switches, and management hardware and software. The upgrade will be completed prior to 615 pilot equipment delivery. The upgraded LAN will reduce maintenance costs and provide greater ease in managing systems. It will insure that transfers of large digital data and imagery files take place without severely impacting performance for users. Currently, we use TCP/IP protocol extensively for file transfers between systems.

The LAN will serve our existing base of Intergraph mapping systems, NFAP equipment, the microcomputer network, Data General systems (for as long as they are needed), and 615 equipment. It is designed to handle our projected needs for increased speed and greater capacity in the future.

Several months ago, our site was given two utilities (RTN and RFTP) to access InterNet through the Data General computer systems. RTN allows us access to electronic information at Federal agencies, universities, and other sites from our DG terminals. RFTP allows us file transfer capability to those same sites through the S27A DG host located at Berkeley, California. Both utilities have proven to be very useful, especially in GSC's work with the USGS and BLM.

Recently we transferred a DOQ file we were having a problem with though RFTP to the USGS in Menlo Park, California so they could study it. This field was approximately 58 megabytes in size and covered one quarter of a USGS quadrangle map. Because of the size of the file, the first attempt failed and our host site needed to increase the directory space. On the second attempt, the file was successfully received. The problem with the file was resolved quickly by the USGS. They will revise several DOQ computer programs and we will retrieve them. These revised programs will improve our DOQ production process. We look forward to future days when faster, direct access is possible with sites outside the Forest Service.

We are pleased to be a participant in the Strategic Telecommunications Plan effort and hope to be included in future testing of telecommunications technology, particularly when it involves transfer of GIS data between sites.

615 Readiness

GSC and NFAP have entered a joint nomination to be a Pilot site for implementation of 615 technology. Our selection as a Pilot site is extremely important for the Forest Service as a whole. We have completed the initial draft of our implementation plan.

GSC can be defined as a shared service GIS site, since our digital mapping products and services are used by all Regions, Forests, other Federal agencies (such as the USGS and BLM), local governments, universities, and private firms. Our products are essential components of GIS for the Forest Service. Since these products will need to be loaded into and manipulated on 615 equipment, and GSC has an updated LAN system, we offer an excellent environment to develop configuration guidelines for hardware and software.

With 110 full-time equivalent positions (FTE's), GSC is about the size of a typical Forest Supervisor's Office, and offers the means to test conversion of current office automation and administrative system applications to the new 615 equipment. Our extensive use of ORACLE database software makes GSC an ideal location to test procedures and software for database conversion and development.

NFAP, with the direction of the Remote Sensing Steering Committee, is responsible for integration of remote sensing into resource data collection for GIS. As part of this program, development projects are conducted with National Forests, Experiment Stations, and other FS units. These projects utilize various digital remote sensing data that is stored in a GIS. These data are sources of vegetation and other resource layers needed for GIS databases. This process of generating resource data layers and educating Forest Service resource managers on how to use them, needs to be demonstrated on a 615 system.

With a good mix of staff trained in computer sciences and geographic sciences, GSC and NFAP offer the Forest Service a unique site to evaluate and complete computer and GIS training packages for the new systems.

Partnerships

The Forest Service and the USGS

The Forest Service and the National Mapping Division (NMD) of the USGS have a long and successful tradition of cooperation. Several agreements have been established over the years that have provided for the cooperative production and sharing of a variety of spatial data and map products. These include:

- Revision of Primary Base Series maps.
- Production and exchange of Digital Elevation Models (DEM's).
- Workshare production of Orthophoto Quads, both analog and digital.
- Delivery of CFF data for entry into the National Digital Cartographic Database.
- Exchange of Forest Service-produced DEM's for NMD-scanned aerial photography.

In 1992, a Memorandum of Understanding (MOU) providing for the "production, exchange, and dissemination of cartographic products and services" was signed by the Forest Service and the USGS. The MOU has widened the scope of cooperation to include significant realignment of mapping and data development programs, opportunities for shared technology, and access to information delivery and spatial data clearinghouse activities. Activities being pursued include:

- The Single Edition Map Program, where national responsibility for maintenance of primary series quadrangle maps over Forest lands is being passed from the USGS to the Forest Service. Under this program, the Forest Service will maintain the quadrangle map while the USGS agrees to print the Forest Service-produced map in full color for national distribution. This program will likely establish the Forest Service as the nationally recognized, primary custodian of the digital base geographic data over the lands it manages.

- Enhanced prospects for shared technology. GSC has installed USGS-supplied hardware and software for the production of Digital Orthophotos. The NMD has adopted LineTrace Plus and Delta3D for the production of DEM's. The Forest Service and USGS have participated in several joint technical exchange meetings to explore future opportunities, to include participation in the National Advanced Remote Sensing Applications Program.

- Colocation of the USGS Salt Lake City Earth Science Information Center (ESIC) with the GSC. By agreement ESIC, a node of the USGS/Federal geospatial information and product delivery network, will be within the reach of the Forest Service geographic sciences community. Initiatives to be explored include local selling of Forest Service cartographic products, establishing electronic ties to USGS geospatial clearinghouses, and testing ESIC access to selected Forest Service spatial data holdings. Colocation could provide the Forest Service with a unique avenue to tap the National Spatial Data Infrastructure.

Cooperation with the USGS has also heightened Forest Service awareness of emerging Federal standards and policies for the development, management, and exchange of spatial data. The Federal Geographic Data Committee (FGDC), already an empowered body chartered by the Office of Management and Budget, is also becoming a model of interagency cooperation in the eyes of the current administration. FGDC activity is likely to shape much of the strategic setting for Forest Service GIS operations.

The Forest Service and the Bureau of Land Management

GSC is the focal point for Forest Service Geographic Coordinate Database (GCDB) activities. GCDB is designed to provide the property boundary, or land net, basis for BLM's Automated Lands and Minerals Records System (ALMRS), and their GIS. Under an interagency agreement involving the Forest Service, BLM, and USGS, all three agencies will provide data to GCDB, which will be the primary land net data source for quadrangle maps and GIS systems for these agencies. Activities related to GCDB coordination at GSC include an increase in coordinate ties (usually GPS surveys) to make data from cadastral surveys much more valuable for GCDB, mapping, and GIS users. Software developed by the BLM has been distributed to Forest Service surveyors which allows them to compute coordinates directly on mappable coordinate systems. The software also allows cartographers to process and adjust land net data that will be compatible among agencies. We have provided Forest Service land net data from PBS maps, photo identified points, GPS positions, and land surveys to the BLM. We are testing utilization of BLM's GCDB data in several applications. Two major initiatives are:

- A new system of developing and describing protracted land net in unsurveyed areas was developed by an interagency task group. This coordinate-based system has been accepted and approved and is now moving into the software development and early implementation stage. It provides for cooperative production of BLM Protraction Diagrams that will provide a much improved basis for legal descriptions of land for leases and for various resource management activities, and these diagrams can be accurately portrayed in the GCDB and in maps and GIS systems of all agencies.

- A GCDB Map Applications Pilot Project is underway that will evaluate applications of GCDB data to PBS map updates, and later to BLM 1:100,000 maps. The PBS update phase will compare land nets for two test quads from GCDB. It will include comparisons of fit between map layers, development of processes and formats to incorporate GCDB data in PBS and CFF's, processes for completing the loop submitting new control and/or other value added data back to BLM for GCDB maintenance, and USGS evaluation for single edition map issues.

Issues and Challenges

The following are some of the major issues and challenges facing the Forest Service in information management:

- **Standards and the FGDC.** Operating under the charge of Office of Management and Budget Circular A-16, the FGDC has been active in promoting the development and implementation of standards for spatial data. These include, but are not limited to, the Spatial Data Transfer Standard, standards for spatial metadata, and a common definition of feature data content. Forest Service policies for the development and management of spatial data will be influenced by FGDC standards and policy-making activities. The Forest Service has membership in FGDC and chairs one of the subcommittees.

  The FGDC is potentially a very powerful entity. It is imperative that the Forest Service become fully knowledgeable on subcommittee activities and provide input. This could be accomplished by having a single person, or small group, with authority to commit Forest Service resources, attend all the FGDC subcommittee meetings.

- **Data Accuracy Standards**. The current CFF have been collected to National Map Accuracy Standards. These standards are the same for all agencies in the Federal Government. Since the national mapping responsibility for the Forest Service area of interest now resides with the Forest Service, it is critical that all updated data are also to these standards. To accomplish this, a data certification program may be required.

  The establishment of data accuracy standards at a national level will aid in the merging of data sets, first at the district level, then the Forest level, next at the Regional level, and finally at the Washington Office level.

  It is critical that the Forest Service be deeply involved with the FGDC as they establish standards for data collection.

- **Cartographic versus Geographic Position.** Cartographic position is defined as the ground position of features as they appear on a map. In map construction, some generalization is necessary, as is movement of features so that all features may be portrayed. Geographic position is defined as the true ground position of features. It is beneficial for feature positions in a GIS to reflect the true ground position. Analyses become more accurate as the information used more nearly reflects the ground. However, plotting software is not adequate at this time to put back the generalization and feature offset required to make high quality maps from geographically positioned features.

  Since CFF are derived almost exclusively from PBS maps, they depict the positions of features as they appear on the map. As techniques and equipment become available and are commonly used, geographic (true ground) positions of the features will be measured and replace the cartographic (map) positions.

- **Digital Contours, Map Text, and Digital Correction Guides.** Digital contours and map text have been identified as necessary elements for an efficient use of GIS and automated mapping applications. Production techniques for digital contours and imbedded map text are neither efficient nor economical at this time. This development is necessary for efficiency.

  Currently manual correction guides are submitted to GSC by the Forests for updating maps. The methodology for a successful Digital Correction Guide has not yet been developed.

- **Transition to Automated Products.** As technology has improved, GSC has moved toward more automation of its map production processes. Since March of 1992, we have been creating totally automated 1:14,000 PBS map layers. These layers adhere to current national standards and represent some of the best automated graphic layers in the country. Challenges facing us as we move more fully into automation include: (1) We must assure that the data set reflects what is on the ground, both in content and locational accuracy; (2) The data set should be able to address all the requirements placed upon it by the GIS commmunity, spatial data transfer requirements, and hard copy production processes; (3) We must have adequate hardware and software to manage and store the data.

- **Retraining of the Workforce.** Currently GSC is making the transition from manual to automated production methods. It is apparent that this will require both intensive reeducation and significant training of employees with manual skills in the areas of automated techniques, computer science, and computer graphics technologies.

- **Technology Transfer.** As advanced GIS and other geographic sciences technologies are integrated into Forest Service operations, the need for an effective agency-wide technology transfer and support network will grow. While a number of units will have the resources necessary to bring advanced systems and databases on-line and configure them, many will not. A coordinated GIS technology transfer and support network should be established to facilitate the dissemination and sharing of techniques, methods, and processes. This network could also serve as a means of evaluating geographic sciences technologies and applications outside the Forest Service for potential use within. Promising applications could be adapted, packaged with training and technical support, and then passed to other Forest Service units as appropriate.

- **Program Costs.** The costs that will be involved in producing, storing, managing, updating, and distributing spatial data are substantial. A realistic evaluation of the total costs involved, including staffing, training, and capital investment costs, should be completed. It is essential that these costs be included in our budget planning efforts.

- **Automated Lands Project.** GSC may have an opportunity to utilize their cadastral analysis resources to prepare land net data in support of the Automated Lands Project (ALP). BLM's Geographic Coordinate Database (GCDB) must be evaluated and updated if new control data is available. Some processing is required to make it "GIS ready." CFF data also requires some evaluation and updating if new control data is available.

It requires significant processing to convert to GCDB-type files and make them "GIS ready." When neither GCDB nor CFF data exists, the GCDB must be generated from scratch. GCDB data currently exists for about 25 percent of the PBS quads, with another 18 percent planned by BLM in the next 2 years. This base data will be needed for most of the analyses performed on Project 615 GIS systems. In addition to the generation of this data, databasing and maintenance will be required to sustain the ALP database.

- **Dissemination of Digital Data.** As of the signing of the Single Edition Map Agreement with the USGS, the Forest Service is responsible for the information on approximately 10,600 quads or 20 percent of the County. It follows that the Forest Service will be recognized as the national repository for the digital data over the same area. Maintaining, databasing, storing, disseminating, and marketing of this data will be a major endeavor.

Environmentally Sensitive Roads

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Abstract

The purpose of this article is to share thoughts on environmentally sensitive roads. The article is founded on road location, resulting from my experience working as road locator, coupled with the advice of veteran locators Bob Sawyer (retired civil engineer from Region 6) and Brian Kramer (instructor of forest roads at Oregon State University). Their experience should be available to those involved with transportation system development activities, as it was gained through years of hiking around in the woods searching out the best location for roads, in addition to time spent looking at existing roads and realizing there may have been better places for them.

A list of influences roads have on the environment is followed by principles for environmentally sensitive roads. The skills and knowledge required of the proficient locator are discussed, in addition to a brief discourse on basic paper planning and field reconnaissance procedures. Also presented are some other considerations, not related specifically to location, for environmentally sensitive roads. Most of the information here is presented with low volume roads in mind.

Current trends indicate that the Forest Service will be building less road mileage in the future. In my opinion we will be spending proportionally more time, however, in the planning stages for those roads and their related projects. This is as it should be, if we are to do the best job possible on our roadwork. Before acquiring access to an area, we need to make sure the planned roads will be in the best possible location, based on the overall situation.

Many transportation engineers would agree that the single most important step in transportation system development, especially for low volume roads, is location. Time spent refining the flagline pays dividends during survey, design, and construction, and results in smoother operations and more effective maintenance. Put the road in the best place from the engineering standpoint; account for environmental considerations and economics; and ensure proper access is provided to the resource that initiates need for the road in the first place.

I expect some individuals will read this and tell me to stop slamming roads and roadbuilders. I don't want to slam anybody. I do want to increase environmental awareness, including looking realistically at what happens as the result of road construction. We will always need access to our forests. Even the environmentalist benefits from the land's resources. Let's access and use them wisely.

Influences of Road on the Environment

An understanding of how roads influence the environment is instrumental in formulating effective strategies for dealing with the influences and maximizing opportunities to develop an environmentally sensitive road system.

- Roads have a tendency to concentrate water. This is probably the single most important influence roads have on the environment.

- Roads can alter the natural drainage patterns that exist on and below the surface of undisturbed topography.

- Compacted road surfacing resists infiltration, which can lead (if not dealt with properly) to increased runoff that might saturate fills and contribute to slides, slumps, washouts, and other erosion.

- Roadway ditches collect surface water and intercept subsurface flow. The water may be concentrated and deposited as runoff in spots not always well suited to handling it.

- Roadway cuts and fills disturb soil, exposing it to weathering action and the elements, as natural protective cover is removed. Road construction can cause more accelerated surface erosion per unit area than other activities in the forest.

- The natural contour is replaced by an artificial "flat" that provides the traveled way. This flat is often the main alteration to natural drainage, and must be compensated for by steeper than natural cut and fill slopes. Controlling the movement of water on these slopes also presents unique difficulties.

- Roadway embankments sometimes encroach on waterways. Drainage paths are straightened, steepened, and shortened—possibly altering the natural channel hydraulics.

- Roads open up country to other effects, allowing the introduction of noise, dust, pollution, litter, and fire.

- Road construction consumes assets (including capital, machinery, and personpower) and resources (including petroleum products, aggregates, metals, chemicals, and plastics).

Principals of Environmentally Sensitive Roads

Three basic principles for environmentally sensitive roads have emerged from observation of different road segments and how they stand up to traffic and weather. The principles are interrelated, yet may be discussed individually.

Optimize Location

The first principle is that of optimizing location. No amount of extra effort in design work or construction technique properly compensates for a poorly located road, while use of good location techniques facilitate subsequent road development activities. Inspection of road damage after heavy storms reveals survival of well located segments, and generally, failure of (or excessive damage to) those on poor locations.

Consider the following as inputs to the road location planning process; use them to optimize the location, realizing not all are attainable simultaneously.

- A well thought-out road location allows a road to "lay lightly" on the land, minimizes cuts and fills and other disturbed areas, and can reduce the total area impacted, along with other environmental affects.

- Roads should be located on as gentle a side slope as possible, although some sideslope facilitates drainage of surface water.

- Road surface drainage is most easily provided for on flatter vertical alignments, thus reducing water concentration and erosion potential.

- Roads should be located with rolling rather than straight or uniform grades. A roll in the grade constitutes a dip that encourages the shedding of water, breaking up water concentrations.

- Locating close to a stream increases the risk of having road-related sediment enter the stream.

- A road located on the southern or western exposure tends to dry out more quickly; similarly, choosing natural openings (or performing the extra clearing of vegetation required to open up the road corridor to sunlight) encourages drying.

- Locate on the side of the canyon with the least number of tributaries to the main drainage for smoother alignments, less embankment haul and construction, and fewer drainage structures.

- Consider using maximum grades and minimum curve radii to minimize road length in undesirable areas, if safe driving conditions can be maintained.

- Investigate the available roadbuilding materials on alternative sections. Often adjustment in horizontal or vertical alinement allows more favorable conditions on an adjacent section—such as material more easily worked, or that providing a superior road.

- Wetlands, bogs, and areas experiencing exfiltration of groundwater should be avoided during road location. These areas require mitigation and result in increased potential for environmental damage.

Minimize Alteration to Natural Drainage Patterns

The second principle of environmentally sensitive roads is minimizing alteration to existing drainage patterns. Almost any modification to the natural drainage process results in altered natural hydrology, water concentration, and increased erosion potential.

- Ridgetop roads require less provision for drainage than sidehill or canyon bottom roads.

- Care must be taken to ensure proper drainage structure location and design, and that sufficient drains are provided to minimize water concentration and other alterations to the hydrology of an area.

- Pipe outlets and armoring should be designed to prevent damage to fills, erosive soils, meadows, and streams, and to encourage the spreading of outflow.

- Provision for surface drainage should be planned through the use of ditches, outslope, inslope, crown sections, and berms to control the flow of water off the road.

- Full bench construction alleviates the problems associated with saturated fills, but still modifies natural slope and hydrology characteristics, and can actually intensify the interception of groundwater. The "toe of the cut" is made further into the hill, as all required road width is provided by the cut and none by embankment construction.

- Minimizing embankments can reduce drainage bottom encroachment and the resulting modifications to waterway hydraulics.

The Self-Maintaining Road

The third principle is self-maintenance. Roads should be located, designed, and built to be as self maintaining as possible. A self maintaining road resists runoff concentration, erosion damage, and vehicular damage such as surface rutting. Observance of road survival on a case-by-case basis suggests roads that maintain themselves inflict the least damage and impact on the environment. Location for self maintenance is not simple; it is dependent on an in-depth knowledge of maintenance practices, local climate and hydrology, and available roadbuilding materials. This principle is well deserving of a thorough treatment, well beyond the scope of this paper.

The Proficient Road Locator

The proficient road locator possesses considerable experience in transportation system development activities, and must develop an in-depth knowledge of the characteristics of the area in which the road is to be located. Proper location requires the locator to have the following expertise:

- Transportation planning, including a specific knowledge of the road design elements and standards, and design criteria for the project.
- Road surveying, design, cost estimating, construction, operations, and maintenance.
- Aerial photo interpretation, and the use of contour maps and databases.
- Drainage structure design for surface and sub-surface flow.
- Materials engineering and soil mechanics.
- Application of newly emerging construction machinery, materials, and techniques.

Proper location also requires that the locator have the following knowledge of the project area:

- Types of land use planned, including land and property ownership.
- Natural resources, also cultural, visual, and recreational resources, and any associated constraints.
- The existing transportation systems.
- Geomorphological, topographical, and geological characteristics.
- Hydrology and climate.
- Climates of the political variety.

The proficient locator possesses in-depth experience with all aspects of transportation system development. The person familiar with survey, design, construction, emerging construction techniques and materials, maintenance, and operations will be the most skillful at locating the road to facilitate these subsequent activities. Knowledgeable consideration of alternative locations results in environmental, economic, and functional benefits. Road location duties should not be left entirely to an inexperienced engineer.

Basic Planning and Location

The locator works with the resource specialists, developing paper plans describing the envisioned transportation system on the ground. Information concerning the resource is used in conjunction with aerial photos and contour maps to determine the initial "paper location" of the road; additional information may be obtained from geological maps and the GIS.

The paper location consists of lines "ticked" in on the contours with dividers, constituting investigations of trial gradelines between control points. Control points include places the road needs to be, such as possible junctions with existing or planned roads and the resources themselves. Saddles, potential drainage crossings, and other topographical attributes which are conducive to a smooth or flowing gradeline (as well as areas possessing desirable roadbuilding materials) may also represent control points. Control points become apparent during field reconnaissance as well as during paper planning.

Once the paper locations are optimized, the locator field locates control points and roughs in gradelines. Aspects of the actual situation on the ground not reflected on maps and photos become apparent and must be dealt with.

Generally, contour maps oversimplify topography, and stereoscoped photos exaggerate and distort elevation differences and provide scant insights concerning geology and roadbuilding materials. The importance of field reconnaissance in ground-truthing paper locations should not be underemphasized.

Other aids to the locator—including suggested techniques for field location and layout of switchbacks, drainage, crossings, junctions, and horizontal and vertical alignments—exist in other literature and are not discussed here.

Other Considerations

Other important considerations for environmentally sensitive roads not directly related to road location are as follows:

- Tailor road design standards to actual needs and encourage environmental sensitivity. Building the minimum standard road required to meet resource and access needs can have economic as well as environmental benefits.

- Consider steepening cut and fill slopes to reduce the total area impacted and the distributed area exposed to weathering and erosion. Conversely, flatten slopes when soil characteristics dictate or when otherwise environmentally expedient.

- Encourage use of construction equipment that is properly sized to the job at hand. This aids in preventing unintended overbuilding, extra road width, and excessive disturbance to adjacent areas. For example, use of hydraulic excavators can allow for increased control over placement of excavated material, with the possibility of a more stable end product.

- Carefully plan and conduct road construction activities to minimize disturbances.

- Tailor ditch geometrics to actual needs. Design inlet basins to reduce cutbank sloughing, with subsequent ditch plugging and material transport downstream.

- Design and implement erosion control measures that function during and after construction. Consider the use of silt fences, settling ponds, slash windows, and buffer zones. A seeding plan that includes a seed mixture specifically designed for the area and allows for the establishment of revegetation prior to the rainy season is important.

- Plan transportation systems on an "area" rather than a "project" basis. Considering an entire area's needs leads to well-thought out transportation networks that make possible all foreseen access. Looking at projects individually might give the most efficient and economical system in the short term, but this philosophy accumulates in time into a piecemeal system lacking overall coherency.

It is not possible to locate every segment of every road on a perfect location. Difficult roadbuilding situations present themselves, and decisions between alternatives each representing an undesirable scenario from an environmental, economic, or engineering standpoint will sometimes have to be made.

Road locators and designers are not always able to foresee or provide for all repercussions resulting from road construction activities. While careful location, design, and construction of roads will minimize adverse affects, not all road-related erosion is preventable, and environmental damage and failures will occur. It is important to approach transportation facility development with these facts in mind.

Surfacing Trails with Non-Standard Stabilizers

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Introduction

Effective nonstandard stabilizers are nontoxic chemical agents that break down clay molecular structures to materials that are insensitive to moisture, or protect the clay form moisture penetration, resulting in a material that can act as a permanent binder in a well compacted aggregate. Several of these stabilizers, including Bio Cat, EMC 2, Perma Zyme, Road Bond, and Road Oyl for treatment of the aggregate course, and Condor and ISS for treatment of clay subgrades, have been used extensively by the Forest Service beginning in 1987, primarily in the Southern Region on over 30 miles of road, and to a lesser extent in Regions 3, 4, 6, and 9. With the exception of Road Oyl, which is a pine tar derivative, all of these stabilizers act only upon the clay fraction. If no clay is present, nothing is gained from the stabilizer. If native clay is not present, clay may be imported and mixed with the native material if this is practicable. If clay is not present or available, these stabilizers should not be used.

In the case of Road Oyl, the pine tar is a cementing agent in itself, and will perform with or without clay fines. However, the cost of Road Oyl is 20 times that of the other stabilizers. The Jack's Creek Road on the Santa Fe National Forest in Region 3 was surfaced last year using road Oyl with a road mixed aggregate, and has performed very well with heavy use. A section of ORV trail on the Deschutes National Forest in Region 6 was surfaced with Road Oyl and No. 10 screenings several years ago and has performed well according to reports from the Forest.

Materials and Methods

The binding force developed by the stabilized fines depends upon close contact between the aggregate particles, and good compaction has been found to be critical in developing a hard, durable wearing surface. A hard subgrade is essential to good compaction; the aggregate must be "squeezed" between the hard under-surface and the compactor in order to obtain the required density. Compaction with at least a "side walk" vibratory steel wheel roller is mandatory where motorized or horse traffic is to be expected. Motor operated Wacky Packers can be used if the trail traffic is limited to hikers. If the proper compaction equipment cannot be transported to the construction site, these stabilizers should not be used. Hand tamping and hand pushed lawn rollers will not provide the density required.

Standard engineering testing procedures have not provided adequate indications of field performance by these stabilizers. A short field test section is the best way to compare the effectiveness with untreated trail surfaces. Trail construction need not be limited to ineffective hand tamping. Gasoline powered Wacky Packers, and "side walk" rollers are available that provide far greater densities.

Clays develop from hydrolysis of feldspar rock minerals; and, hydrolysis proceeds most rapidly in warm, humid climates. In areas of cooler or drier climates, clays are usually found in weathered shales or clay stones developed during another geologic era when optimum conditions were present. Thus in many areas of the northern and western U.S., finding aggregates with adequate clay content to make use of these stabilizers may be difficult. Consulting with your Forest or Regional geologist should simplify this task.

Clay content is best determined by a hydrometer analysis provided by a soils engineering laboratory. The clay content should be a minimum of between 5 and 10 percent of the aggregate mixture. Alternatively the clay content can be estimated from the Atterberg limits test. Road surfacing aggregate specs often require a PI in the range of 4 to 9. An aggregate with a PI of 10 is classified as "silty" by both the AASHTO and The Unified classification systems, and will not have adequate clay fines for these stabilizers. A minimum PI of 17 or higher should indicate that adequate clay is present. If imported clay is added to a native aggregate, mixing should be done after addition of the stabilizer solution, as it will aid in breaking down clay lumps and distributing the clay evenly through the coarser fractions.

The aggregate gradation should include some coarse aggregate (gravel) to provide for the best wearing surface. A well graded aggregate, containing an equal sampling of each size from the coarsest to the finest, will always provide better service than a poorly graded aggregate where one size predominates. Traffic will wear away the top layer of fines to expose the larger coarse, which will remain as the wearing surface. With a poorly graded aggregate containing excess fines, or without the coarse aggregate, the fine material will gradually wear away until the surface is lost. This might require many years if limited to foot traffic. A poorly graded aggregate with excess coarse aggregate will not bind together properly because of excess voids.

Southern Region Trail Work

During the 1993 Trail Workshop at Unicoi State Park, Georgia, March 30, a presentation on nonstandard stabilizers was made by the author. As a result, Tony Rider of the Chestatee District, Chattahoochee-Oconee National Forest, proposed to test the stabilizers on a section of the Appalachian Trail at Woody Gap, Georgia. With approval by District Ranger Dave Smith, the four aggregate stabilizers, Perma Zyme, Road Bond, EMC 2, and Road Oyl were selected for use on four 80 foot sections of new trail.

Stabilization was begun May 18, and completion delayed by rain until May 24. Prior to stabilization, grass and sod were removed from the 3 foot wide trail section. Crushed aggregate and clay were imported by pickup and wheel barrow, and spread over the native organic sandy loam, except for the Road Oyl section where the clay was omitted. The stabilizer solution was mixed in a 50 gallon open-top drum (25 gallons at a time), and applied to 6 foot sections using a 2 gallon garden sprinkling can (with a perforated spout). The imported and native materials were mixed to a 3 inch thickness with a gasoline powered walking garden roto-tiller, and with garden rake and shovel. Compaction was achieved with a gasoline powered Wacky Packer. Tony and the author completed the surfacing stabilization work on the 320 feet trail in two days. As this section is adjacent to the state highway and a parking lot, access was not a problem.

About 2 inches of loose clay was added to the first section. This was found to be excessive, and imparted an undesirable light yellow-red color to the surface. This was later corrected by lightly spreading a dark organic sandy loam on top. The clay was reduced to about an inch (loose) on the remainder, with a more satisfactory result. The stabilizers reach full initial strength in 5 days (they continue to gain strength indefinitely), so some experimentation is possible (and recommended) before launching into a major project.

The Appalachian trail carries heavy foot traffic throughout the year. After 4 months of use, the trial is wearing well and looks like it has been there forever. Although the new subgrade was softer than desired, the compaction less than achieved on a road surface, the surface is firm and sheds water during rainfall without becoming muddy. In hindsight, a harder surface could have been obtained by building up the subgrade and precompacting prior to placing the surfacing. This would however have been considerably more work and expense. Dave Smith is pleased with the result and is planning additional stabilization work on a 900 foot section of ORV trail.

Trail Construction Specification

Out of this effort, a specification was developed for use of these stabilizers on trail surfacing. Incorporate the following text in the appropriate specification.

941.01—Work

"This work shall consist of furnishing and placing a stabilizer in a water solution on a prepared surface course: mixing suitable in-place material and stabilizer solution: and compacting the mixture to the lines, grades and dimensions as SHOWN ON THE DRAWINGS."

941.05—Additives

"Stabilizer shall be ROAD OYL, PERMAZYME, EMC2, or ROADBOND EN 1 or equal and shall be a water soluble stabilizer with a minimum 3-year history of performance in stabilizing surface course.

941.05—Additives

ROAD OYL may be used in soils or soil aggregate mixtures without clay content. ROAD OYL should be used for limited access, ORV and bike and horse trails where excessive surface abrasion is expected.

Five to 10 percent clay content must be present in soils used with PERMAZYME, EMC 2, or ROADBOND EN 1. Clay is defined as soil finer than 2 microns, as determined by dyrometer analysis. Any of the three may be used with clay-soil-aggregate mixtures containing more than 20 percent passing the 200 sieve. EMC2 should be used with clay-soil-aggregate mixtures containing less than 200 percent passing the sieve.

A Standard Material Safety Data Sheet shall be furnished by the manufacturer. The stabilizer shall be handled in accordance with the manufacturer's recommendations. The stabilizer may not be a by-product or additive used primarily for dust control of road surfaces.

When mixed, at the specified rate, with surface coarse containing proper moisture, the stabilizer solution shall increase the unconfined compressive strength, increase the compacted dry density, durability, flexibility, and reduce susceptibility to moisture intrusion and frost-heave damage.

The stabilizer shall be protected during transportation and storage against freezing. An airtight seal shall be maintained to protect against air contamination. Stabilizers which have been subjected to freezing temperatures or left open to air contamination will be rejected.

Water development, hauling, and application shall be in accordance with Section 207."

941.08a

"Materials to be treated shall be scarified and thoroughly broken up to the full width and depth as SHOWN ON THE DRAWINGS. Minimum required equipment shall be a garden rototiller, capable of minimum penetration of 2 to 3 inches."

Preparation of Surface

"When bringing the materials to be treated to a desired moisture content, water shall be added and thoroughly mixed with the materials until a uniform moisture is obtained throughout the entire material.
If the material to be treated is already at or above optimum moisture content, it shall be dried to 2 or 3 percentage points below optimum in preparation for addition of the stabilizer solution. Scarify or till the materials until the desired moisture is obtained.

In dry soils, the amount of water to be added shall bring the material to be treated to optimum moisture content after application of the stabilizer solution."

941.08b—Application

"Application of stabilizer solution shall be limited to the area specifically shaped and sized to receive the solution.

The dilution rate for ROAD OYL shall be 2:1 (2 gallons of water to 1 gallon of stabilizer, or 5 quarts 11 ounces of water to 2 quarts, 21 ounces of ROAD OYL for a 2 gallon can).

Because of the high dilutions for PERMAZYME, EMC 2, and ROADBOND, a minimum of 25 gallons of solution should be prepared. This will be sufficient to stabilize 75 feet of trail.

The dilution rate for PERMAZYME or EMC 2 shall be 100:1 (100 gallons of water to 1 gallon of PERMAZYME or EMC 2, for 25 gallons of water to 1 quart of PERMAZYME or EMC 2.

The dilution rate for ROADBOND EN 1 shall be 300:1 (300 gallons of water to 1 gallon of stabilizer). For 25 gallons of water, 11 fluid ounces of EN 1 are required.

One gallon of dilute solution shall be applied per 3 lineal feet of trail to be treated, for trails 3 to 4 feet in width. For narrower or wider trails the length shall be adjusted in proportion.

A measuring cup shall be used to add the stabilizer to the water. The solution shall be thoroughly stirred following addition of the stabilizer.

A 2 or 3 gallon garden watering can with perforated spout shall be used for application of the solution.

Stabilizer solution shall not be applied or mixed with in-place materials if atmospheric temperature may fall below 32 degrees F within 24 hours. Application of the solution shall be limited to periods when rainfall is not expected during the 48 hours following application.

Application of solution shall be limited to such an area that all operations can be "continuous and completed each working day."

941.08c—Mixing

"The in-place material, equivalent to the compacted depth SHOWN ON THE DRAWINGS and additive, shall be thoroughly mixed to the required depth, usually 2 to 3 inches.

Mixing shall be done with flat point shovel and garden rake.

Mixing shall be done by multiple passes so that the entire material is uniform in moisture. If the mixture appears to be too wet, additional dry soil shall be incorporated from the subgrade.

Water without stabilizer shall be mixed into the material to obtain optimum moisture. Stablilizer solution significantly retards evaporation and dry-back of materials and may cause the mixture to appear dry when near optimum moisture. Caution should be exercised in adding additional moisture.

When finishing the trail and shaping, surface drainage shall be provided for.

Stabilizer solution shall not be exposed to the open air for a period exceeding 6 hours or longer, or allowed to suffer excessive loss of solution due to washing."

941.10—Compaction

Delete current specifications and add the following:

"The treated material shall be compacted to at least 95 percent of the maximum density as determined by AASHTO T 99, Method C or D or by making six passes at optimum moisture with a Wacky Packer compactor or equivalent, or vibratory steel-wheel roller. Where the trail is to be used by motor bikes or ATV's, the roller compactor shall be mandatory.

Compaction shall produce a smooth, hard, moist surface. If soil pumping or mushing results during compaction, excess moisture shall be allowed to evaporate before resuming compaction. If the compaction surface appears dry, it shall be moistened with a light application of the dilute solution.

New trail constructed on soft ground may require multiple layer construction to permit achievement of adequate density for motorized traffic.

Upon completion, the surface shall be smooth and in conformity with the typical section, lines, and grades as SHOWN ON THE DRAWINGS."

941.14—Method

"Individual construction items, including Water, Section 207, will not be measured for payment separately, but will be considered incidental to this item of work."

941.15—Basis

"941(27)	Stabilizer Solution, ( ).....	S.Y.
941(27)LS	Stabilizer Solution, ( ).....	L.S.
941(27)A	Stabilizer Solution, ( ).....	STA.
941(27)B	Stabilizer Solution, ( ).....	MI."

Monitor Hand Pump Accessibility Modification

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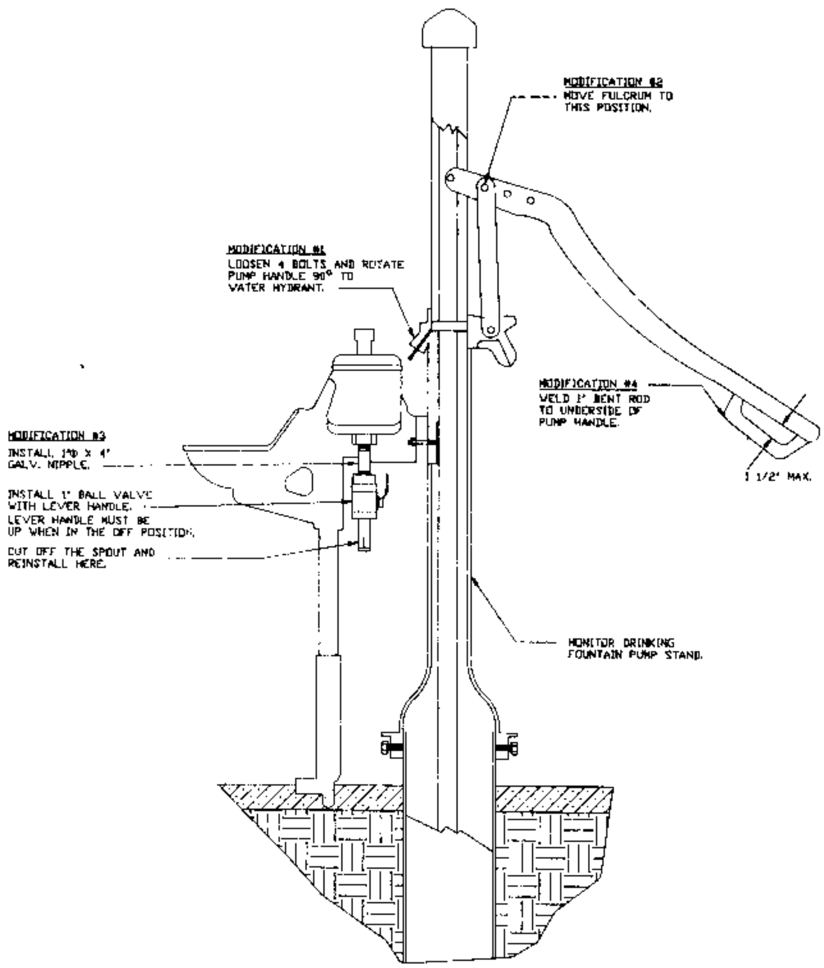
The Monitor model, IDFHTS, is used throughout the Forest Service in conjunction with recreation facilities. The modifications of the pump's operations that are discussed are recommended to make the pump more accessible to people with disabilities.

Four operations of the pump were modified to improve accessibility:

- Orientation of the pump's functioning elements.
- Force required to operate the pump.
- Hydrant operation mechanism.
- Pump handle grip.



First, the orientation of the pump handle was modified so that the pumping operation would be closer to the drinking fountain and the hydrant operations. This was accomplished by rotating the pump cap 90 degrees toward the water hydrant.

Secondly, the force required to operate the pump was reduced by changing the location of the pump pin in the handle. This changes the fulcrum point thereby changing the mechanical advantage. In our normal installations the pump pin was placed in the hole farthest from the pump rod. The force required to operate the pump was reduced by moving the pump pin to the hole closest to the pump rod. A pump that required 13 lbs. to operate in the farthest position was reduced to 3 lbs. by moving to the pump pin to the closest position, greatly improving the accessibility.

Thirdly, the hydrant operation mechanism was modified to improve accessibility. The hydrant operating mechanism is located on the pump reservoir and is operated by grasping a 1" diameter spring loaded valve and lifting upward holding it open while pumping the handle until the desired amount of water is obtained. This operating is extremely difficult and requires a lot of strength in the fingers to accomplish. It also requires the user to hold open the spring while operating the pump at the same time or refilling the reservoir several times to obtain the desired amount of water. This is an extremely difficult operation for many people. This was modified by first removing the spout and cutting off the smooth unthreaded portion. This portion was the seat for the shutoff valve. A 1" diameter, 4" long nipple was inserted to the reservoir outlet. Then a 1" diameter ball valve was threaded onto the nipple with the lever handle pointing upward. The spout was then threaded into the outlet of the ball valve and positioned so the bucket handle hook was again pointed in the outward position. The ball valve can be operated with a clinched fist, making it very accessible.

Fourthly, the pump handle was modified to reduce the need to firmly grasp the pump handle in order to operate the pump. By welding a 1" diameter bent rod to the underside of the pump handle the pumping action required is reduced. It is important to keep the opening to 1 1/2" to allow for a hand to be inserted so pressure can be exerted to both the palm and back of the hand while pumping without having to grasp the pump handle tightly.

The above described modifications can be done inexpensively (approximately $25-$30) to all existing pumps making them accessible to many more people.

It is important to note that the pathway to the pump and the area around the pump must also meet accessibility standards (UFAS & AADAG) for the pump to be accessible.

For additional information contact Cliff Stephenson, Boise NF, (208) 364-7027 or via DG, C.Stephenson:R04F02D06A.

Bibliography of Washington Office Engineering & Technology & Development Publications

This bibliography contains information on publications produced by the Washington Office Engineering Publications Section and the Technology & Development Centers located in Missoula, Montana, and San Dimas, California. The listing is arranged by publication series and includes the title, author or source, document number, and date of publication.

This issue lists material published since our last bibliography (*Engineering Field Notes*, Volume 24, November-December 1992). Copies of *Engineering Field Notes*, *Technology & Development News*, Engineering Management Series, and other publications listed herein are available to Forest Service personnel through the Engineering Staff Technical Information Center (TIC). Copies of "Project Reports," "Tech Tips," and "Special & Other Reports" are available from the Technology & Development Center that is listed as the source.

Forest Service—USDA
Engineering Staff, TIC
P.O. Box 96090
Washington, DC 20090-6090

Forest Service—USDA
San Dimas Technology & Development Center
444 E. Bonita Avenue
San Dimas, California 91773

Forest Service—USDA
Missoula Technology & Development Center
Fort Missoula, Bldg. 1
Missoula, Montana 59801

Tech Tips

Tech Tips are brief descriptions of new equipment, techniques, materials, or operating procedures.

Title	Source	Number	Date
5-Gallon Drinking Water Bags	MTDC	9351-2324	5/93
5-Gallon Suppression Water Bag	MTDC	9351-2326	5/93
Airtanker Cockpit Laser Visibility Evaluation Device—Revision 1	SDTDC	9357 1302	4/93
Cryptosporidium, What Is It?	SDTDC	9371 1305	8/93
Evaluating The GPS Receiver In A Dense Tree Canopy	MTDC	9324-2319	3/93
Chuckwood Roads	MTDC	9324-2327	5/93
Culvert Steamer— The Deicing of Frozen Culverts	SDTDC	9377-1306	10/93
Dangerous Techniques For Fire Shelter Training	MTDC	9351-2338	9/93
Gratings with Geotextile as Wetland Crossing	SDTDC	9224 1310	12/92
Helicopter Operations and External Accessories: An Update	SDTDC	9357 1304	7/93
Mobile Tree Seedling Coolers	MTDC	9324-2302	11/93
Mulch Evaluation Project	MTDC	9324-2343	11/93
Net Retrieval Tree Seed Collection System	MTDC	9324-2325	9/93
New Traditional-Style, Two-Unit Accessible Toilet and Redesigned 750- and 1,000-Gal Tanks	SDTDC	9323 1301	1/93
New Standards for Wildland Fire Protection Clothing and Equipment	MTDC	9351 2340	7/93
Paving of Corrugated Metal Pipe Inverts for Repair and Fish Passage	SDTDC	9371 1303	7/93
Tree Shelters for Seedling Survival and Growth	MTDC	9324-2815	2/93
Trimble Ensign GPS Receiver	MTDC	9324-2321	4/93

Title	***Source***	***Number***	***Date***
Vault Toilet Pumping Contract Specifications— Guidelines for Preparing Contracts	SDTDC	9223-1308	10/92
Wildland Fire Entrapment Fatality Initial Report Form	MTDC	9351-2322	4/93

Project Reports

Project Reports are detailed engineering reports that generally include procedures, techniques, systems of measurement, results, analyses, special circumstances, conclusions, and recommendations rationale.

Title	Source	Number	Date
Correlation of Off-Highway Motorcycle Sound Test Methods: EPA/SAE	SDTDC	9323-1204	10/93
Demonstration of Forest Service Fire Engine Equipped with a Central Tire Inflation System	SDTDC	9271-1205	11/92
Detection of Foreign Objects in Logs—Demonstration Test	SDTDC	9224-1206	12/92
Low-Volume Roads Survey Laser	SDTDC	9377-1202	6/93
Maintenance Management Systems for Forest Roads: A Summary of Systems to Assist Road Managers	SDTDC	9377-1203	7/93
Relationship of Helicopter External Load Inadvertent Releases and Size of Ring in Cargo Swivel	SDTDC	9357-1206	9/93
Snap Back Tests of Nonmetallic Leadlines for External Loads	SDTDC	9257-1207	11/92
Water-Scooping Aircraft Design	SDTDC	9357 1201	2/93

Special and Other Reports

Special and Other Reports include papers for technical society meetings and transactions, descriptive pamphlets, bulletins, and special purpose articles.

Title	Source	Number	Date
1992 Publications & Audiovisuals	MTDC	9371-2808	1/93
1993 Nursery Program-Paper Presented At Western Nursery Conference	MTDC	9324-2849	9/93
Automated Seedling Height Measurement	MTDC	9324-2810	1/93
Chunckwood Roads	MTDC	9371-2818	3/93
Development and Validation of the FSCBG Model for the Simulation of Spray Drift	MTDC	9334-2850	9/93
An Earth Anchor System: Installation & Design Guide	SDTDC	9324 1804	8/93
Flail Trencher	MTDC	9351-2803	12/92
Field Mulch Guide-Committee Review Draft	MTDC	9324-2830	6/93
Field Mulch Guide Project Report	MTDC	9324-2836	6/93
Foam Applications for Wildland & Urban Fire Management	SDTDC	Vol. 5, No. 1	1993
Forestry Management Applications, *Journal of Forestry*	MTDC	9324-2834	8/93
GPS Training Project-Indonesia, Trip Report	MTDC	9324-2848	9/93
Ground Ignition Systems: An Equipment Guide for Prescribed & Wildfires	MTDC	9351-2806	3/93
Handtool Sharpening Gauge, *Fire Management Notes*	MTDC	9351-2847	9/93
Health Hazards of Smoke, Spring 93	MTDC	9351-2823	4/93

Title	Source	Number	Date
Lightweight Camping and Stock Equipment, Cooperative Project	MTDC	9323-2835	9/93
Meterological Data Collection for the 1992 Utah Gypsy Moth Eradication Program	MTDC	9334-2828	5/93
MTDC Employee Guide	MTDC	9371-2809	1/93
MTDC Loblolly Tree Seed Collection System, *Tree Planters Notes*	MTDC	9324-2831	6/93
MTDC Seedling Counter Field Tests, *Tree Planters Notes*	MTDC	9324-2812	11/93
Mobile Cooler for Transporting and Storing Seedlings	MTDC	9324-2814	2/93
Mobile Tree Seedling Coolers, *Tree Planters Notes*	MTDC	9324-2811	2/93
Mulches for Increased Seedling Survival and Growth	MTDC	9324-2820	3/93
The Relationship Between In-Canopy Micrometeorology and Droplet Deposition	MTDC	9334-2842	9/93
Reforestation Equipment Catalog	MTDC	9324-2837	6/93
Road Traffic Accident Site Investigation Guide	MTDC	9371-2841	9/93
San Dimas Fire & Aviation	SDTDC	9351 1801	4/93
San Dimas Mechanical Engineering Support	SDTDC	9371 1805	9/93
San Dimas Roads	SDTDC	9377 1803	4/93
Scarifies for Shelterwoods, *Tree Planters Notes*	MTDC	9324-2813	11/93
Seedling Protection in England, Trip Report	MTDC	9324-2848	9/93
Site Preparation Equipment for Steep Sloops	MTDC	9324-2804	2/93
Sound Levels of Five Motorcycles Traveling Over Forest Trails—Rock Creek ORV Area	SDTDC	9323 1802	8/93

Title	Source	Number	Date
Spark Arrester Guide, Multiposition Small Engine	SDTDC/ NIFC	NFES 2363*	5/93
Techniques and Equipment for Wilderness Travel with Stock	MTDC	9323-2839	9/93
Visual Prioritization Process—User's Manual	SDTDC FHWA-FPL-93-007	7700	11/93

* National Fire Equipment System (NFES) publications must be purchased from the National Interagency Fire Center (NIFC), BLM Warehouse Supply; 3905 Vista Avenue, Boise, ID 83705.

Technology and Development News

Technology & Development News* contains information on specific projects, new ideas, and new technologies being developed by the Technology & Development Centers to help solve many different kinds of resource management problems.

Title	***Issue***
1992 Publications and Audiovisuals	January-February 1993
Aerial Ignition	March-April 1993
Computer Modeling of Pesticide Spray Drift	November-December 1993
Cruiser's Gear Carrier	March-April 1993
Cruiser's Gear Carrier in Final Design Stage	September-October 1993
Decal Performance Specification	July-August 1993
Electronic Data Recorders	July-August 1993
Fire Engine Design/Drafting	July-August 1993
Fireline Explosives Starting Secondary Fires	September-October 1993
GPS Training Schedule	May-June 1993
GPS Update	March-April 1993
Ground Ignition Systems Guide	September-October 1993
Gypsy Moth Eradication Program	July-August 1993
Helicopter External Load Systems Tested	March-April 1993
Indonesia, International Forestry, and MTDC	November-December 1993
International Forestry, Indonesia, and MTDC	May-June 1993
Latest on New Publications	March-April 1993
Machine Vision	March-April 1993
Many CTI Systems in Use/More on the Way	May-June 1993
Mobile Cooler for Transporting and Sorting Seedlings	September-October 1993

Title	***Issue***
New Area Code for San Dimas	January-February 1993
New Catalogs	November-December 1993
New Fire Entrapment/Fatality Reporting Form Available	May-June 1993
New Publications Issued Last Quarter 1993	January-February 1993
New Tech Tips	July-August 1993
Prototype CTI Installations on FS Dump Trucks	March-April 1993
Publications Issued	May-June 1993
Recently Issued Publications	November-December 1993
Road Maintenance Commensurate Share Project Update	September-October 1993
Root Pruner	July-August 1993
SDTDC Holds Satellite Data Transmission Workshop	July-August 1993
Spark Arrester Information Available	September-October 1993
Steep Slope Site Preparation Equipment	July-August 1993
Steep Slope Site Preparation Equipment Guide	September-October 1993
Survey Laser Update	September-October 1993
Tree Shelters	March-April 1993
Tree Marking Paint	July-August 1993
Vehicular Traffic Classification Equipment	September-October 1993
Video Planned on Environmental Roads	September-October 1993
Video Recognition Technology for Field Use	March-April 1993

Engineering Field Notes

This publication is a bimonthly periodical that supplies the latest technical and administrative engineering information and ideas related to forestry and provides a forum for the exchange of such information among Forest Service personnel.

EFN by Title

1992 *Engineering Field Notes* Article Awards	Editor. EFN 25 (January-February 1993): 5-8.
1992 *Engineering Field Notes* Article Award Winners	Editor. EFN 25 (July-August 1993): 55.
1992 Forest Service Engineers of the Year	NSPE. EFN 25 (March-April 1993): 17-23.
Barrier Free Accessible Trail Surface Materials—Region 1 Materials Engineering Investigations	Monlux, Stephen. EFN 25 (September-October 1993): 53-64.
Canyon Creek Bluffs Rock Slope Stabilization—Sweet Home, Oregon	Arambarri, John W. and Long, Michael T. EFN 25 (September-October 1993): 9-30.
Chunkwood Roads	Karksy, Dick. EFN 25 (September-October 1993): 39-42.
Construction of a Portable Bridge West Engineering Zone, Three Rivers District, Kootenai National Forest	Grabinski, Tom. EFN 25 (July-August 1993): 33-38.
Coordinated Technology Implementation Program (CTIP) Study No. F-5; Nonstandard Stabilization	Scholen, Douglas E. EFN 25 (May-June 1993): 3-16.
Develop Computer-Based Instrumentation Systems for Measuring and Recording Timber Harvesting Machine Functions— Phase 1	Obiozor, Clarence; Kelley, Tyrone; McDonald, Timothy P.; and Stokes, Bryce J. EFN 25 (July-August 1993): 39-47.
Dust Abatement Product Comparisons in the Northern Region	Monlux, Steve. EFN 25 (May-June 1993): 26-36.
Ecosystem Roads Management Project	Moll, Jeffrey E. EFN 25 (July-August 1993): 7-31.
Environmental Roads Initiative Project	Brooks, Walt and Moll, Jeffrey E. EFN 25 (January-February 1993: 15-17.

EFN by Author

Monlux, Stephen. EFN 25 (September-October 1993): 53-64.	Barrier Free Accessible Trail Surface Materials—Region 1 Materials Engineering Investigations
NSPE. EFN 25 (March-April 1993): 5-6.	March: National Women's History Month—Three Who Jumped the Gender Gap
NSPE. EFN 25 (March-April 1993): 17-23.	1992 Forest Service Engineers of the Year
Obiozor, Clarence; Kelley, Tyrone; McDonald, Timothy P.; and Stokes, Bryce J. EFN 25 (July-August 1993): 39-47.	Develop Computer-Based Instrumentation Systems for Measuring and Recording Timber Harvesting Machine Functions— Phase 1
Scholen, Douglas E. EFN 25 (May-June 1993): 3-16.	Coordinated Technology Implementation Program (CTIP) Study No. F-5; Nonstandard Stabilization
Scholen, Douglas E. EFN 25 (November-December 1993): 29-34	Surfacing Trails with Non-Standard Stabilizers
Stephenson, Clifford R. EFN 25 (November-December 1993): 35-37	Monitor Hand Pump Accessibility Modification
Sumpter, Carl. EFN 25 (July-August 1993): 57-61.	(The) Use of GPS for Cadastral Surveys in the Rocky Mountain Region
Thompson, Michael A. EFN 25 (July-August 1993): 63-68.	Evaluation of the American Ranger Clearing Machine
Warbington, Randy L. EFN 25 (March-April 1993): 7-15.	Ground-Coupled Heat Pump Installations in Region 8
Warburton, Troy. EFN 25 (July-August 1993): 49-53.	Specifications for Differential GPS Coordinate Data Submission to the Geometronics Service Center

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