



Engineering Field Notes

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Solid/Semi-Solid/Liquid Ignition Devices

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Abstract

A wide variety of ignition devices is available for starting backfires in both prescribed as well as wildfire situations. Solid ignition devices, such as fusees, are recommended over semi-solid or liquid devices made of gasoline because the latter are more dangerous to transport, use, and store and are more hazardous to health and the environment if spilled. Solid ignition devices may include fusees, signal flares, and potassium permanganate in plastic spheres that are injected with ethylene glycol (anti-freeze). Semi-solid devices include waxed hydrocarbons, gelled gas/diesel mixes in bags or canisters, or gelled gas/diesel mixes used for the helitorch or flame throwers. Liquids include gas/diesel mixes used in the drip torch or flame throwers and propane. The following information is provided to compare the differences between solid, semi-solid, and liquid ignition devices.

Using, Storing, and Transporting

Solid ignition devices do not produce hazardous vapors that semi-solid or liquids emit. However, special precautions must be taken when handling the ethylene glycol (antifreeze) used with potassium permanganate. Special precautions are also required when handling and storing signal flares.

Semi-solids are typically safer to handle than liquids but emit hazardous fumes unless packaged in an appropriate container. Semi-solids typically must be labeled the same as liquids because the fumes emitted are just as hazardous, are heavier than air, and can accumulate in confined spaces such as pickup beds, sumps, or basement rooms.

Liquids rely on a container that must be leakproof and, in the case of gas or diesel, must contain vapors as well as have ant flashback screening. Propane is typically safer to handle than gas or diesel because the container is stronger and air-tight. However, there are additional hazards associated with handling compressed gas.

Damaged containers of solid material usually will not produce a hazard as quickly or as widespread as semi-solid or liquids will. However, special precautions need to be taken with potassium permanganate since it is an oxidizer and will burn the skin. Most fatal and very expensive accidents are associated with gasoline, diesel, or propane (compressed gas).

All ignition devices need to be stored properly in accordance with the *OSHA Code of Federal Regulations* and transported in accordance with *DOT Code of Federal Regulations*.

Health

There are health risks associated when skin is exposed to various chemicals used in ignition devices. Potassium permanganate will burn the skin, causing discoloration. Gas and diesel contain chemicals that can pose additional health risks, such as those that are carcinogenic. Some individuals are highly allergic to many of the compounds found in hydrocarbons and may have health problems that relate to kidney and liver functions or nervous system reactions. Personnel working around gas, diesel, or propane gas for any extended period should wear organic vapor respirators and be relieved frequently. Fumes emitted from hydrocarbons can asphyxiate.

Environment

Solid-ignition chemicals are much easier than semi-solids or liquids to contain and clean up when spilled. Special problems occur when semi-solids or liquids are accidentally spilled in water, generally requiring special equipment to clean up and possibly requiring that an emergency response team be summoned. Semi-solids and liquids spilled on the ground can be removed with the contaminated dirt and burned in slash piles or, in emergencies, burned in the place.

Effectiveness

Fuses, signal flares, and potassium permanganate injected with ethylene glycol can generally be used in light, dry fuels. As conditions change to wetter, heavier fuels, it may be necessary to coat with semi-solid fuels such as a thickened gas/diesel mix or with a liquid dispensed from either the hand-held drip torch or a flame thrower. Various dispensers and launchers have been developed for these purposes and are listed in *Ground Ignition Systems: An Equipment Guide for Prescribed and Wild-fires*, MTDC publication 9351-2806, March 1993. Questions regarding this material can be addressed to Missoula Technology and Development Center, Building 1, Fort Missoula, Missoula, MT 59801, attention Jim Tour, Project Engineer, DG address is R01A.

Deep Creek Low Water Crossing Osceola National Forest

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Introduction

The Florida Department of Environmental Protection expressed concern about water quality degradation at the old Deep Creek Bridge location on FDR 237. The original wood bridge was destroyed by fire in the late 1960's. The Forest Service decided against replacing the structure due to its length, subsequent high replacement cost, and the proximity of an alternate route with a bridge crossing (U.S. 441) within 6 miles. However, the traveling public did not want to abandon the crossing and perpetuated it by fording the creek during periods of low water flows. This traffic concentrated roadway surface water flow directly into the stream causing siltation.

The Florida Department of Environmental Protection proposed a cooperative venture with the Forest Service to eliminate the water quality degradation. They offered to contribute funds to the Forest Service to construct a permanent crossing that would preserve the water quality.

Design

A bridge of appropriate length and height was estimated to cost \$200,000, which was more than either Agency could afford. The most feasible alternative was a low water crossing that would allow dry passage over the stream during most of the year and a controlled roadway approach grade. This structure would resolve concerns about the water quality.

The Forest had previous experience with low water structures. In the mid-1980's, the Forest constructed two double-barrel, concrete box, low water structures with concrete approach slabs and cutoff walls. The average cost was \$400 per foot for the concrete structure. The length of a similar structure for FDR 237 was estimated to cost \$100,000. This was also above the funds available from both agencies.

As a result, the Forest decided to try a different approach. In an attempt to reduce cost, the Forest decided to use prestressed concrete, double "T" bridge sections. Using these standard sections, a structure was designed by Gary Carlson, Ocala National Forest. The design called for the double "T" sections to be installed perpendicular to the direction of traffic (parallel to the direction of stream flow) on concrete mud sills. Five 8-foot-wide (2.43 m), 16-foot (4.88 m) long by 24-inch (610 mm) deep double "T" sections were used. A 5-1/2-inch (140 mm) concrete wearing surface

was faced on the 2-inch (50 mm) precast double "T" back. To further economize, 18-inch (457 mm) square precast concrete piles were used for the mud sills. This proposal was reviewed by precast concrete industry engineers and by Dade Foote, Region 8 Bridge Engineer. They conceded that it was not a typical use of the bridge deck sections, but that the design should work.

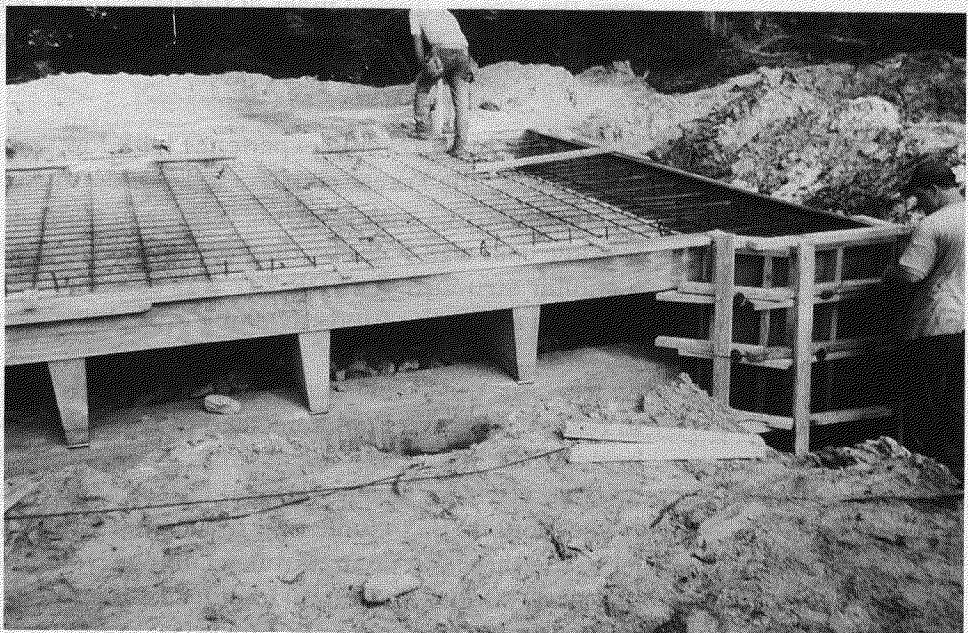
Design Criteria

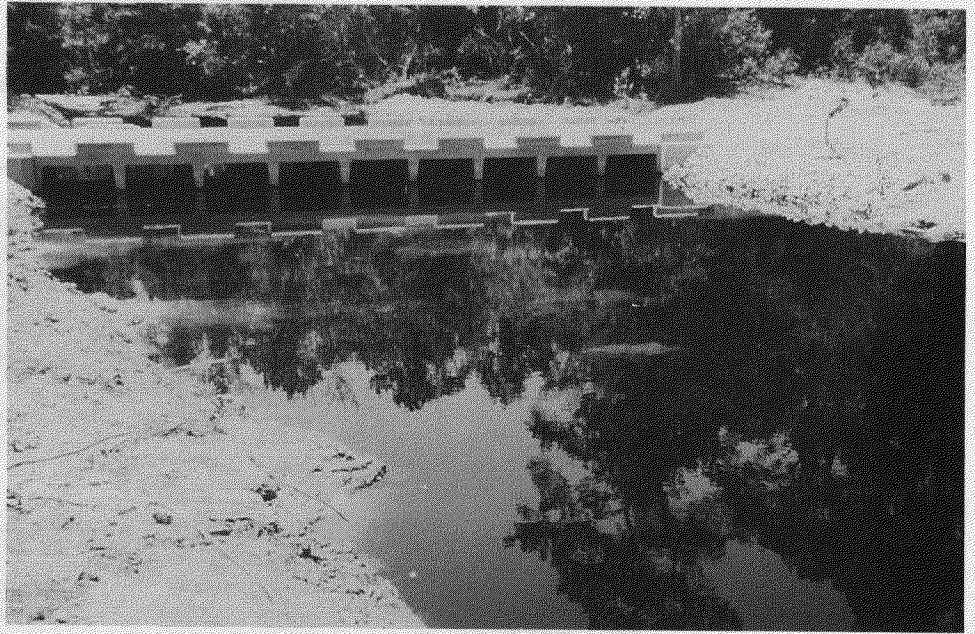
- Water quality improvement is a primary objective.
- The traffic crossing the drainage will need to be controlled during high water.
- Eliminate the erosion caused by surface runoff.
- The design must minimize costs while maximizing benefits.
- The flood stage cross-sectional area of the channel is 630 square feet.
- Traffic utilization, 100 percent of the time, is not a requirement for the site.

Construction

The project was advertised with an engineering estimate of \$36,000. Four bids ranging from \$60,744 to \$99,500 were received. After much deliberation, the contract was awarded to the low bidder (J.E. Williams Construction Company). The award was justified by the fact that the two lowest bids were very close and the risk factor was high due to the unique design of the project and high potential for flooding.

Work began on May 18, 1992, and was completed on July 21, 1992. The project was 27 days ahead of schedule; the final cost was \$57,653.





Ready-mix concrete was used at the abutments to encase the ends of the mud sills and to provide a wearing surface for the double "T" bridge sections.

Rock riprap was placed on woven geotextile fabric to stabilize the approach slopes and the channel around and through the low water crossing.

Construction was accomplished with an excavator, dozer, motor patrol, and loader. The precast units were unloaded and set with the excavator. The excavator was also used to place the riprap. Neoprene pads (3/8-inch (10 mm) thick) were used for bearing between the bottoms of the double "T"s and the mud sills. Work went very smoothly. There were no unexpected problems.

The structure has been flooded numerous times since completion with no adverse effects. The water crests over the concrete roadway with a 1-inch (25 mm) drop in the hydraulic gradient from the upstream water surface to the downstream water surface.

Benefits

- 57 square feet (5.3 m²) of end area is provided by the structure, that is only 37 feet long (11.3 m) and 2.5-feet (0.76 m) high.
- A minimum embankment height is located in the stream channel, and a reduced volume of riprap is required to match the top of the low water crossing elevation.
- A minimum use of ready mix concrete on the site.

- A low impact on the cross-sectional area of the stream channel due to the low profile of the structure.
- Only earth moving construction equipment was needed to construct the project.



Because of the success of the Deep Creek low water crossing, several smaller crossings were installed in a campground loop at Salt Springs Recreation Area, Ocala National Forest. The smaller double "T" sections alleviated the need for excessive fills that normally would have been required to compensate for the required drainage cross-sectional area.

These low water crossings allow the road to lay gently on the ground and still provide adequate drainage at a nominal cost.

Field Application and Review of Hand-Held Laser Survey Instrument Grand Mesa, Uncompahgre, and Gunnison National Forests Gunnison Engineering Zone

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Introduction

First, let me explain that this is not a technical report. This is an article, written in plain everyday language, as if I were talking to you in person. To me, a report is written by a person who knows or has become an expert on that which he is reporting. In this article, I try to explain the discoveries and frustrations of this Zone when we first used the survey laser and went on to actual application.

Last spring (1993) Tom Condos, Forest Engineer for the Grand Mesa, Uncompahgre, and Gunnison (GMUG) National Forests (NF), mentioned to me after an engineering staff meeting that he had seen a hand-held laser instrument that would measure and record azimuths, degree of slope, and slope distances, and would download into "Lumberjack" PC road design programs. We discussed the possibility of using the instrument for low volume road design projects. The subject came up of the task of sitting for days downloading field book data, by hand, into the computer program for the design process. (If only some of the young engineers could have been around when we plotted each cross-section by hand and measured the end area with a planimeter. Now, *that* was fun.) I told Tom at the time I would like to try the laser survey instrument.

Demonstrations

A few months later a demonstration of the laser instrument was arranged by a representative of the manufacturer. The hand-held laser instrument was quite impressive. The instrument was approximately 3.5 by 6.5 by 8.5 inches and weighed 6 pounds, and was set up for measurement only, no data recording. The manufacturer's representative suggested we contact Jeff Moll, San Dimas Technology and Development Center, as he had been working with a data collection system.

We contacted Jeff Moll and arranged for a combined demonstration of the MC-V data recorder and the laser survey instrument in Delta, CO, at the Supervisor's Office. We performed a field test and surveyed a short segment of road. Within minutes we were in the design phase of "Lumberjack" with plan, profile, cross-sections, and quantities on the PC screen. (To a person who started life as an engineer in the mid-1960's, with the Washington State Highway Department using a Rhodes Arc, chain, and hand level, this instrument was a gift from heaven or at least we thought so at the time. To me this was a must purchase.)

After much discussion between the engineers, review of cost data contained in a report by Jeff Moll in the *Engineering Field Notes*, Nov.-Dec. 1992 issue, calculation of our own cost comparisons, and personally pushing the purchase, we finally purchased the hand-held survey laser.

We sent an MC-V data collector to CMT Corvallis Microtechnology, Inc. and had the data collector loaded with the PC software driver and data collection program, supposedly compatible with the laser and Lumberjack. After receiving the MC-V from CMT, we discovered that they did not load the driver. We returned the data collection unit immediately. CMT corrected the situation.

Actual Field Use of Laser Instrument

Our first attempts to use the MC-V data collector resulted in many frustrated and aborted "test" surveys. We finally set up a wire pin flag control line at the local college football field and once again attempted to make the program work. We thought we had finally grasped the program and understood how to manipulate it, but had found it to be very user-unfriendly. During a call to Jeff to discuss the unfriendliness of the program, we discovered that CMT had sent us a "new" version, for which we had no documentation. Jeff had not tried the new version, although he did have instructions for it. He faxed the instructions for the new version, and we sent our survey crew out to the Sawmill Timber Sale. (Finally we were going to get some work accomplished.)

The crew began using the collector and during the course of the survey they had to make an adjustment to data that had been previously entered. While trying to over-write a shot, the program in the collector began to get out of sequence, and as they continued it got more and more out of sequence. The new program was not user-friendly and had obviously not been "debugged." After several conversations with Jeff, it was decided to abandon the MC-V. Jeff agreed to come to our Forest with a "new" data collector and software system, which he had just received. In the meantime the survey crew continued to use the laser to measure all the field data and entered that data manually into a field book. (At this time, my impression of the device was not good.)

Actual time spent in the field for the Sawmill Timber Sale was 15 days using the laser instrument for measurement and hand-recording the data in a field book. This was a two-person crew, 3.61 miles, 371 cross-sections. When the crew returned from the field, one surveyor spent 2-1/2 days downloading the field data. Field time for a two-person crew averaged 1270 feet of line per day.

The new data collector that Jeff introduced us to was a DAP Micro Flex PC 9000, by DAP Technologies Corporation. It is in essence an extremely durable hand held PC with DOS command capabilities. The data collection program "Roadsoft" was written by Laser Technology, Incorporated (LTI). The DAP collector is approximately 10 by 4 by 2.5 inches and weighs 3 pounds.

A major concern with a new survey system is the time required to experiment with and debug the system, which was required for the MC-V data collector. As with most engineering zones, the zone does not have the time necessary to work all the bugs out of a new system. Jeff Moll provided invaluable time in eliminating a great deal of this troubleshooting dilemma. Also, with LTI developing the new software for the DAP collector, the "third party" situation has been rectified.

With the new data collector in hand and the laser gun, we began the survey on the Kentucky Timber Sale. The timber sale road system had 2.5 miles of specified road construction. We had a four-person crew which consisted of an instrument person, two reflector people, and one individual who was strapped with the awesome burden of trying to keep up with stationing and driving the stakes. Stationing was at approximately 50-foot intervals. The crew accomplished all traverse, stationing, and cross-sections in 10-1/2 hours for this road system. This was an incredible production rate of one station every 30 to 45 sections, although the topography was fairly gentle with only two to three shots per cross-section, not including the centerline or traverse shot. For a two-person survey crew, this time would increase to about 24 field hours and for a three-person crew it would be about 15 hours. We calculated that a three-person crew could cover a station every 2 minutes, depending on the number of shots taken per station.

The crew did not clear or brush any line. In some cases the brush was so thick that the instrument person just made shots in the direction of the reflector until the laser gave its "bleep" sound to indicate connection with the target. This is not to say brushing is unnecessary in all cases, but the instrument could "see" and record through thick brush. The best part about the collection process was once you reached EOP (End of Project) and reduced the raw data, the "Roadsoft" program told us if we had an error in our survey and at what section/station the error occurred. More than likely our error was a failure to indicate the right or left side of the cross-section in the "Roadsoft" program. This alert to an error allowed us to correct the mistake as we walked along the traverse on the way back to the truck.

The downloading of data to the desktop PC at the District Office was painless compared to the many steps involved in using the MC-V. Because of the DAP collector's ability to communicate with the PC using DOS commands, downloading was just a matter of a few keystrokes.

Other uses for the laser instrument have increased greatly with the recent upgrade of "Roadsoft" software to "Lasersoft" software. With "Lasersoft" software repeating, radial or map building surveys for topography are possible, as with total station. In addition, the order of cross-sectioning and data-recording has been redefined from left to right only (to accommodate "Lumberjack"), to taking cross-section shots in either direction. "Lasersoft" downloads data to "Lumberjack" in the order required by "Lumberjack." In actuality, the laser instrument can now function as a total station system with somewhat less accuracy, depending on plumb of targets and the instrument staff, and using magnetic angle measurements. Raw data can be converted to ADCII, "Lumberjack," PCFLRDS, and RDS-PC.

Required Equipment

The GMUG NF has one Criterion 400 hand-held laser gun instrument and DAP data collector. This unit includes the "Lasersoft" surveying software and equipment accessories for the instrument. The Criterion 400 includes the capability to measure ranges to a minimum of 5 feet. A software package for use in an external data recorder is included with the engineering unit. This software provides the engineering survey routine and format data output compatible with several engineering software applications.

With the data collector we also have a Cristie Handydisc to download the data on a daily basis using a car cigar lighter adapter or six AA size batteries for power. The Handydisc stores all collected data on a 3.5-inch floppy disc. We also purchased DAP Technology's communication cradle for the collector. This will accommodate the collector for direct download to the PC or modem to modem/PC. It also has battery testing and management program which will discharge and charge the data collector's battery system.

Equipment Cost Data

Laser Technology Inc. Criterion 400	\$9,300.00
Ranging laser with inclinometer, fluxgate compass, 2.5 power scope, numeric keypad, data storage, serial port, "Lasersoft" software, download cable, user manual, 2 Ni-Cad battery packs, charger, staff mount yoke, shoulder rest, and shipping case.	
DAP Technology Corp.	
DAP Microflex PC 9000, 128KB System Memory, 1920 RAM disk, DAP-BG1-1920.	\$2,628.80
Cristie Handydisc, portable disk drive	451.80
Communication and battery maintenance cradle	126.90
In-vehicle charging cable	38.70
Leather holster for PC9000	93.60
	<u>\$12,637.00</u>

Cost Comparison Laser Vs. Manual Survey

Sawmill Timber Sale

Manual Survey:

Two people, 15 field days, 3.61 miles proposed road	\$2,500.00
Downloading costs	<u>200.00</u>
Total Cost	\$2,700.00

Laser Survey:

Two people, 40-hour work week (estimated time)	<u>670.00</u>
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Sawmill Timber Sale

Cost Savings \$2,030.00

Kentucky Timber Sale

Manual Survey:

Two people, 11 field days, 2.5 miles proposed road. (estimated time)	\$1,870.00
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Laser Survey:

Four people, 10.5 hours (actual time)	<u>750.00</u>
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Kentucky Timber Sale

Cost Savings \$1,120.00

This cost included the services of Jeff Moll and Keith Hess, who are not usual members of the survey crew.

The cost of a two-person laser survey crew is estimated at \$620 total. Again, there is a savings of \$1,250 for the survey.

The above costs include vehicle fixed ownership rate, use rate, and per diem.

Summary

The laser instrument with the data collector allows for extremely quick and accurate surveys. Surveys are reduced at the EOP to check for errors and corrected on the way out of the woods. No line was brushed as the laser shoots through incredibly thick brush, although brush work might be necessary in some areas. No transposing of figures resulted while entering field notes or hand entering the data into a road design program. Data from the collector was entered directly into a road design program very quickly electronically.

Recommendations

With the introduction of this highly sophisticated measuring instrument to the field, it must be remembered that there is no better or safer record of field data than an ordinary field book. It is possible that the data from the data collector may be stored on a daily basis in the field using a portable disc drive available from DAP. This relieves the terror of the thought of a "meltdown" or other catastrophe of losing data associated with electronics. As with all computer functioning equipment, you must "back-up," "back-up," "back-up." Also it is recommended that the design engineer for the project accompany the survey crew and make his or her

own written notes pertaining to difficult areas and drainages. This additional person is not on the survey crew, but is there to view and analyze the situation. This cannot be accomplished with the most expensive and sophisticated equipment known to man. Even with the reams of information collected by the laser and stored by the data collector, there is no replacement for a simple sketch and written description of the features. The laser has no peripheral vision and will never replace the human eye or subjective mind. These "tidbits" of hand-written information are invaluable in the design phases of the project.

With ever decreasing budgets, justification for the purchase of such equipment should be scrutinized in great detail. The advent of this electronic survey system makes short work of field survey. For this reason, consideration should be given to hiring survey crews from other Forests having the equipment to do the survey work. Speaking of hiring other Forests to do the work, our new motto here is "HAVE GUN—WILL TRAVEL."

Sources for Required Equipment

Laser Survey Instrument:
Laser Technology, Inc.
7070 S. Tuscon Way
Englewood, CO 80112
303-649-1000
Contact: John Ambrey

Data Collector:
DAP Technologies, Corp.
1408 N. Westshore Blvd.
Suite 610
Tampa, FL 33607-4512
813-289-2822
Contact: Mike Morrow

Other data collectors available that are compatible with LTT's
Criterion 400:

Data Collector:
Husky Computers, Inc.
18167 U.S. Highway 19 North
Suite 285
Clearwater, FL 34624
813-530-4141
Contact: Sue Pate

Data Collector:
Omidata International
124 S. 600 West
P.O. Box 448
Logan, UT 84321
801-753-7760
Contact: Jan Saalfeld

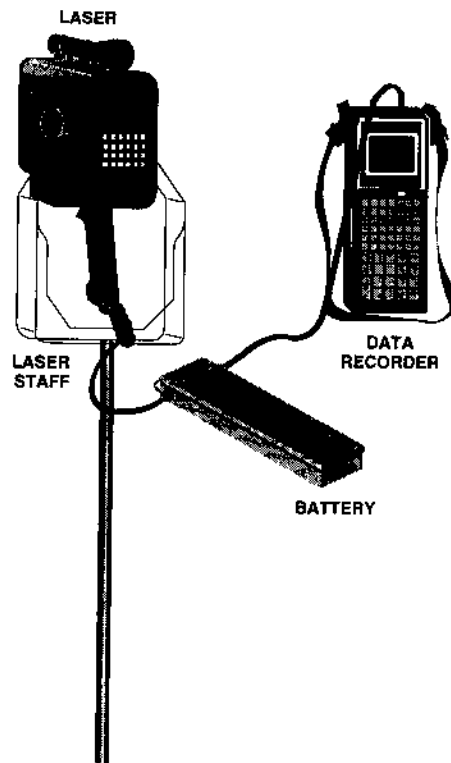


Figure 1.—Survey laser field hardware configuration.

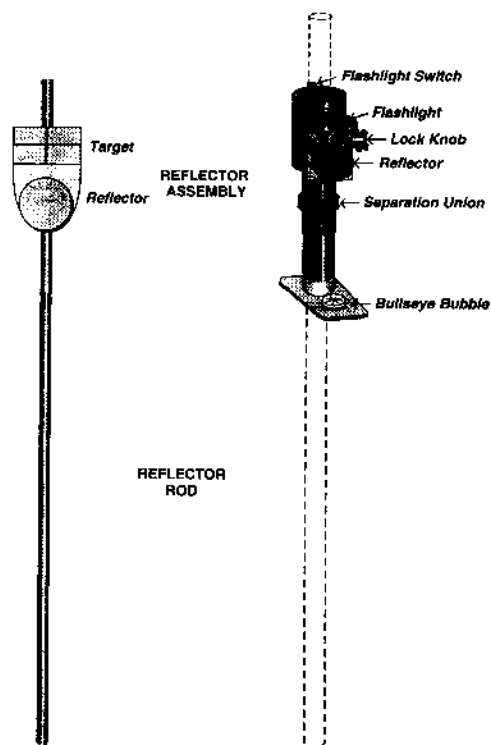
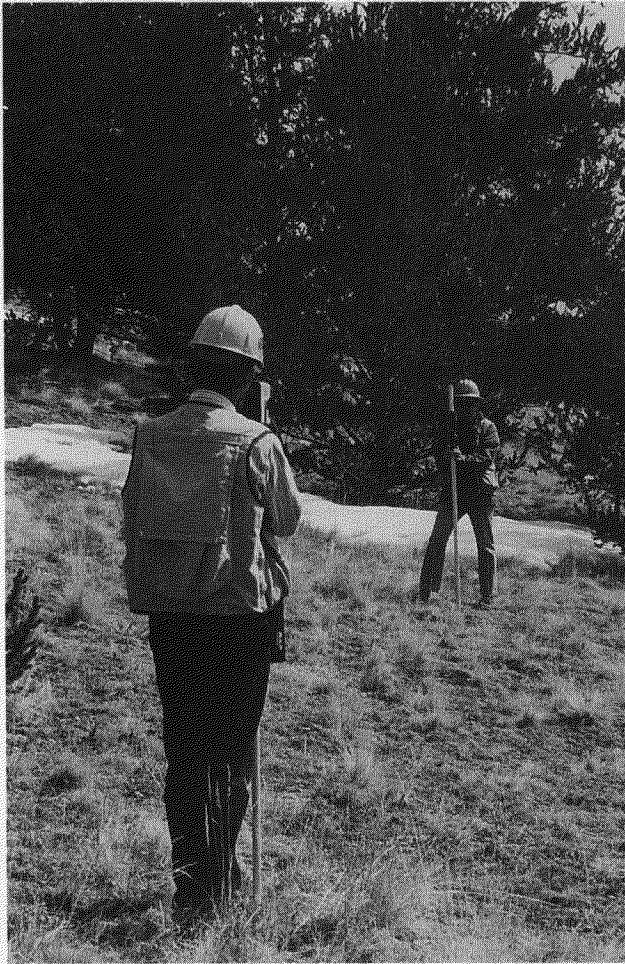
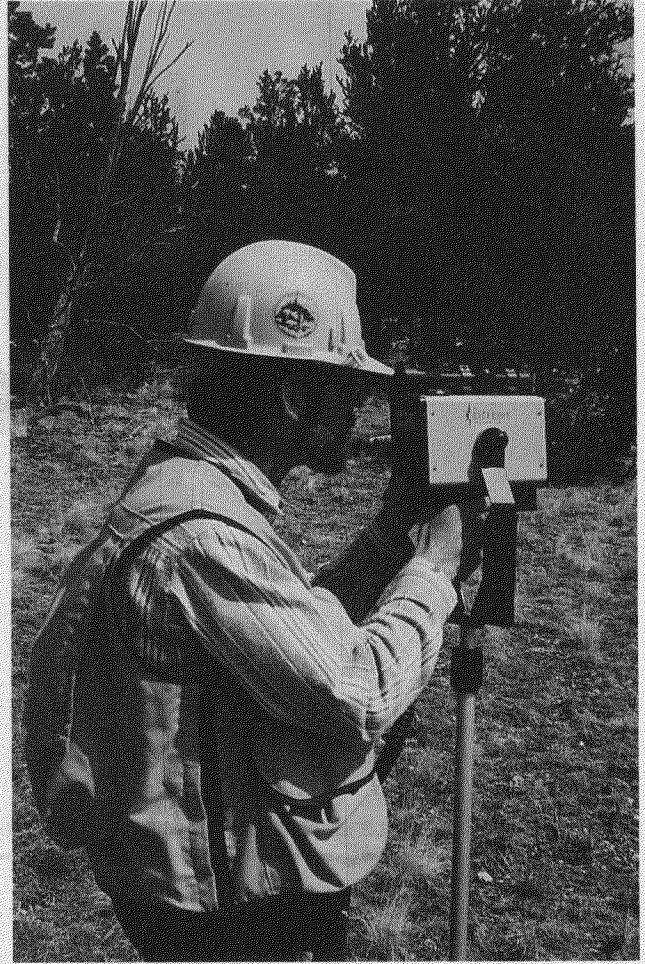


Figure 2.—Reflector assembly and reflector rod.





Excavators for Site Preparation

Dick Karsky
Project Leader
Missoula Technology and Development Center

Introduction

Excavators have been identified as promising tools for preparing sites for reforestation on slopes greater than 35 percent. Engineers at the Missoula Technology and Development Center (MTDC) have prepared a report, *Site Preparation Equipment for Steep Slopes*, that presents the results of a study conducted to identify equipment and techniques for Forest Service needs. The report is available at no cost. It features familiar and new machinery, specifications, performance data, and operating costs.

In recent years, site preparation has changed from a concept of total cleanup to procedures that leave more material on the ground after logging. This enhances soil protection, wildlife habitat, and seedling protection. However, leaving large amounts of slash and logging debris on a harvested area greatly complicates site preparation for both natural and artificial regeneration, especially on steep slopes. Because land managers need information on equipment and techniques to prepare sites in these conditions, a committee was established by the Washington Office Timber Staff to work with MTDC to determine if equipment was available or would have to be developed or modified to meet Forest Service needs. The committee decided that equipment was available for sites with less than 35 percent slopes. MTDC was asked to identify equipment and techniques for preparing sites with slopes greater than 35 percent. MTDC engineers talked to field personnel involved with site preparation in the Pacific Northwest and conducted interview with users from the USDA Forest Service, USDI Bureau of Land Management, State offices, the British Columbia Ministry of Forestry, and private landholders. They also conducted a literature and market search. The results showed three general categories of equipment.

Wheeled Skidders

Wheeled skidders are typically used for timber harvest and for site preparation operations where the ground is relatively flat (figure 1). This equipment is commonly used by Forest Service field units. Slopes below 15 percent may be treated traveling parallel to the contour, but slopes up to 25 percent may be treated up and downhill with spot scarification equipment. Six- or eight-wheel drive forwarders may treat slightly steeper slopes. Skidders with wide tires provide better stability on side slopes, but are prone to slip on wet slash.

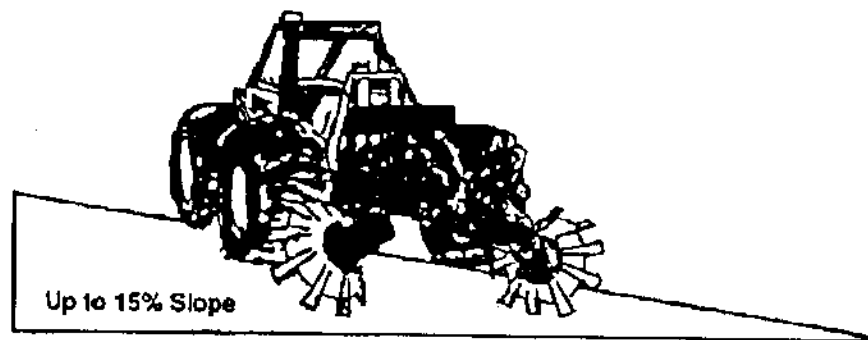


Figure 1.—Wheeled skidders are appropriate for treating slopes up to 15 percent.

Crawler Tractors

Crawler tractors are prime movers that use tracks to increase flotation and tractive effort (figure 2). They are commonly used on slopes up to 35 percent. Soft track vehicles such as FMC's may treat slopes up to 40 percent. Slopes up to 45 percent may be treated up and downhill, but only with spot scarification equipment.

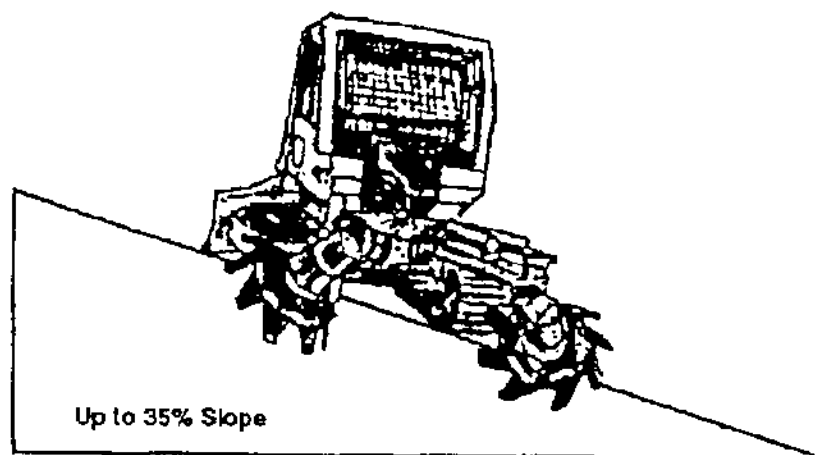


Figure 2.—Crawler tractors are commonly used to treat slopes up to 35 percent.

Excavators

Excavators, although common in the construction industry, are relatively new in the forest industry (figure 3). They use tracks for locomotion similar to crawler tractors, but they have a large boom on which buckets and attachments can be mounted to hold site preparation tools. Some of the excavators are only equipped with "street tracks," which reduce their mobility in wet or steep areas unless more aggressive grousers are added to the tracks. Excavators can treat slopes up to 50 percent. Short slopes greater than 50 percent can be treated off skid trails, depending on boom reach. Excavators are usually equipped with a scalping tool and attachment, such as a thumb, which enables them to pick up and move large pieces of slash as well as to scalp. Another common configuration is an excavator equipped with a "slash buster" attachment. This attachment is a rotating disk with various tooth configurations attached to it. The disk breaks up and reduces the size of downed slash, removes brush and small diameter stems, and can be used to remove vegetation and expose mineral soil. Excavators are very maneuverable, exert a low ground pressure, will accept multiple attachments, and have reached capabilities that will reduce the number of passes required by the machine and thus reduce the movement required by the prime mover. Suitable sites for excavators include wet sites, steep sites with up to 50 percent slopes, heavy slash, light slash, and brushy sites.

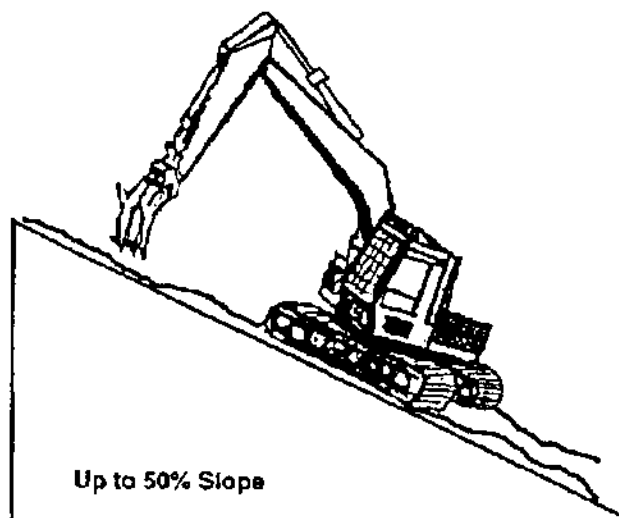


Figure 3.—Excavators can treat slopes up to 50 percent.

The MTDC report on steep slopes site preparation includes manufacturers' brochures on specific excavators, specialized machines, and accessories for excavators and climbing backhoes.

For more information, or to order *Site Preparation Equipment for Steep Slopes*, (Publication No. 9324-2804-MTDC) contact:

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Building 1, Fort Missoula
Missoula, MT 59801
(406) 329-3921

Erosion Control/Trout Habitat Structures

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Introduction

A partnership between the Forest Service and Trout Unlimited has been a key to the successful stabilization of several eroding stream banks in an attempt to protect an encroaching roadbed and preserve a threatened trout stream. In 1993, the Tellico District on the Cherokee National Forest in eastern Tennessee was the victim of a combination of destructive natural occurrences that adversely impacted the forest ecosystem. An extremely harsh winter followed by a violent tornado in February severely altered the landscape by stripping and uprooting several trees, falling them across roads and into streams. Then, an unexpected snow-storm in mid-March covered the forest with 24 inches of snow, and felled many more trees that had been weakened by the tornado. Evidence of these occurrences could be seen in the North River on the Tellico District as trees and debris lined the stream banks into opposite banks. Many of these banks, which had become severely undermined over time, were now more vulnerable to erosion, and portions of the encroaching roadbed were in danger of sloughing off into the stream. The North River was obviously being subjected to large quantities of sediment, which was in turn degrading the water quality and creating a habitat unsuitable for trout.

The potential harm to trout habitat by sedimentation is of great concern to the Appalachian Chapter of Trout Unlimited as well as the Cherokee National Forest. Since North River is one of the most popular fishing and camping sites on the Tellico District, we have united efforts in order to save the stream from further degradation. Protecting North River Road from potential erosion is also an important issue, since it is frequently used by the public to access campsites and by loggers to reach timber sale areas. As partners, our primary objective was to design and construct an environmentally appealing structure that would stabilize the eroding stream banks, protect the adjacent roadbed, and ultimately reduce sedimentation of the stream. In addition to ensuring bank stability, the structure would also enhance trout habitat by providing excellent overhead cover.

Participating Agreement

In July of 1993, a contract was prepared by Jim Herrig, the Fisheries Biologist on the Cherokee National Forest, and presented to Tom Rueping, the President of the Appalachian Chapter of Trout Unlimited. The Cherokee National Forest agreed to provide \$5,000 for materials as well as a site specification design for each of the three structures. The Forest also agreed to provide representatives to inspect the structures

during construction to ensure that specified standards were met. The contract stated that Trout Unlimited would utilize the \$5,000 granted by the Forest to purchase the specified materials and provide voluntary labor for the construction of the structures. The estimated value of the labor, including transportation, was approximately \$5,200.

Construction

A crew of 10 volunteers began construction on Saturday, January 8, 1994, and the first 40-foot structure was completed within 8 hours. Although freezing conditions and high stream flows presented certain problems during construction, proper precautions were taken by the crew to ensure that all procedures were executed safely and effectively. As a result, each of the three structures (two 40-foot span and one 20-foot span) was completed in under 6 to 8 hours with an average of eight to ten volunteers working per day. For future reference, however, it is advisable to schedule such a project during the summer months when weather conditions are more favorable and annual stream flows are lower. Low stream flows in the summer would enable workers to accurately position the trout cover (figure 1.)



Figure 1.—Side view of 20-foot span structure showing trout cover.

Table 1.—Summary of costs and quantities per 20-foot section

Item	Unit	Estimated Quantity	Cost per 20-foot Section
20' CCA treated logs (10" diam)	each	3.5	\$280
12' metal signposts (2 lb/ft)	each	4	72
lumber (2" x 8" x 10' and 2" x 10" x 10')	each	4	25
shot rock	load	1	300
rebar	feet	15	10
nails/spikes			5
filter fabric	sq. ft.	280	donated by the Forest Service
Cost of Materials =			\$692
Carrying Cost=			\$308
Total =			\$1000

Table 1 lists the costs and quantities of the materials specified per 20-foot section including carrying costs to the site. In some cases, the figures vary from site to site according to the extent of damage due to erosion. Stream banks where severe undermining has occurred (figure 2) require larger quantities of shot rock as backfill and longer pieces of signposts to anchor into the banks. All materials were readily available, relatively inexpensive, and easily transported to the sites. The Appalachian Chapter of Trout Unlimited provided all the necessary equipment including a generator, power tools, hand tools, as well as waders and gloves for use in and around the stream during the extremely cold conditions.

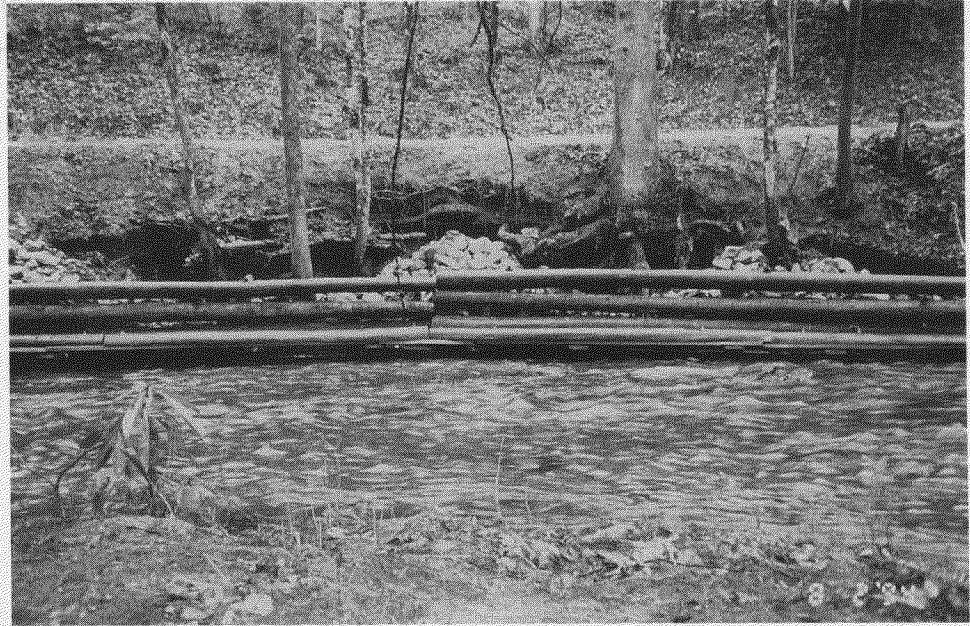


Figure 2.—Severe undermining caused by erosion; prior to backfill.

Typically, very little excavation was required for the preparation of the streambed, and hand tools were used exclusively in and around the stream to minimize additional sedimentation. Much of the native material removed from the streambed could be effectively utilized as backfill in addition to the purchased shot rock (figure 4). It was anticipated that the structures would be exposed to alternate wetting and drying; therefore, the 20-foot-long logs were pretreated with Osmose in order to prevent rapid decay. Although the specifications called for 10-inch-diameter logs, it should be noted that log size is somewhat dependent on stream size and rate of flow. Before placement of the treated logs, 14- by 20-foot sheets of filter fabric were rolled out along the embankment in order to prevent the small sediments and silt from seeping through the backfill and into the channel. After the treated logs had been carefully placed, they were tied together with rebar and secured to the bank with signposts (figure 4). The final step was to backfill the structures with shot rock, making sure that all signposts were hidden from view.

Through our partnership with the Appalachian Chapter of Trout Unlimited, we were able to achieve mutually beneficial objectives while establishing a working relationship that could potentially lead to future projects together.

Note from Region 8

Note from Region 8: During the spring of 1994, the North River Area of the Cherokee National Forest received several storms, causing extensive flooding. The structures survived the floods with very little damage.

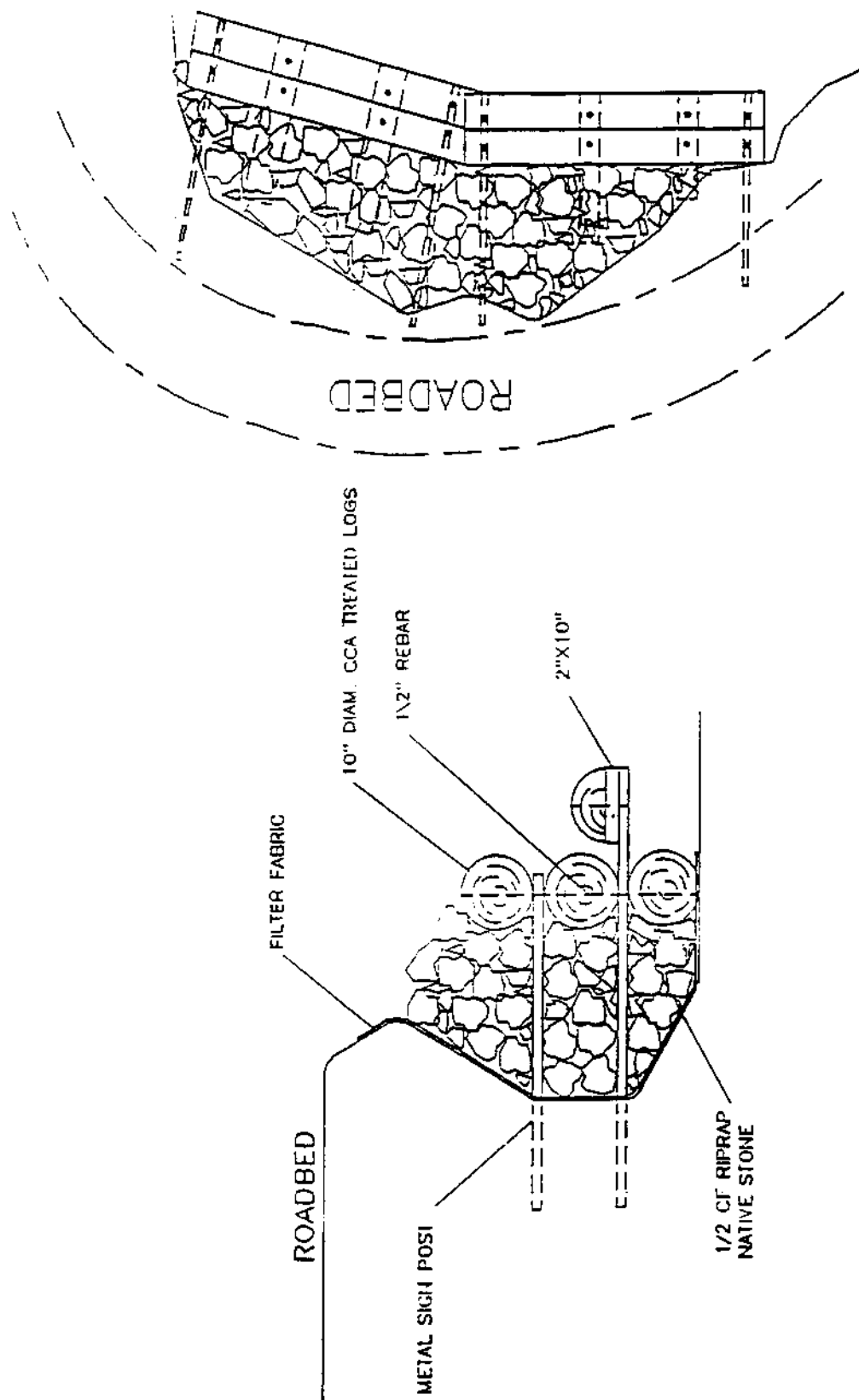


Figure 3.—Erosion control/trout habitat structure; 40-foot span.



Figure 4.—Installation.

The Thin Mud Timber Sale Chip and Spread Project

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Introduction

The Entiat Ranger District of the Wenatchee National Forest in Region 6 developed a pilot project to dispose of concentrated logging slash by methods other than burning, resulting in a wood chip product useful as erosion control and dust abatement on exposed soil surfaces such as roads and landings. Contributing to project needs was an abundance of piled slash—with its associated Ips beetle habitat—and high road density, road closures, erodible soils, high fire danger, and increasing smoke management costs.

The pilot project came to the attention of the Ecosystem Roads Management (ERM) project, located in the Roads Program at the San Dimas Technology and Development Center (STDC). ERM exists to showcase ecosystem enhancing roadwork—of which the chip and spread project is an excellent example—and to encourage increased environmental sensitivity in transportation system activities.

This article documents the development, implementation, execution, results, and monitoring conducted to date for the pilot project. A comparison of costs and benefits of slash disposal by burning versus chipping is included. Conclusions and recommendations are offered to those considering similar projects.

The project was successful and will be monitored annually to aid in addressing the most common questions concerning its limits and effectiveness. The Entiat Ranger District will continue to pursue this method of slash disposal in an adaptive manner; results obtained from monitoring, research, technological advances, and experience will be used to guide future chip and spread projects.

Development

The idea of placing wood chips on forest roads for erosion control and surfacing is not new. A query of Forests in Region 6 concerning erosion prevention and cumulative effects from roads resulted in the following replies:

- "... wood chips as a surfacing material" have been successfully used in road stabilization.
- "... sawdust and wood debris have been used both as lightweight fill and surfacing to cross unstable areas and to reduce runoff from roadways."
- "... use of chipped slash on road surfaces to aid in dust abatement and slash disposal" has been successful.
- "... it may be wiser to leave roads sealed and provide some covering such as rock, chips, bark, and straw to reduce surface erosion, rather than closing roads through ripping, seeding, etc."

The Thin Mud Timber Sale area was selected as the pilot project for the following reasons:

1. An abundance of green slash was piled close to roads (see figure 1).



Figure 1.—Large slash pile close to road.

2. The sale had been logged over snow and whole-tree yarded to protect soils; there was a desire to augment the care taken during harvest by not burning slash.

3. The size and density of slash piles, had they been burned, would likely have resulted in resource damage to soils, leave trees, adjacent stands, and other resources.
4. The area is accessible to the required equipment (especially the chipper) and year-round access exists for monitoring.
5. Location and condition of roads in need of erosion control, dust abatement, noxious weed control, and the existence of roads identified as candidates for closure during the District-wide Access and Travel Management (ATM) process.
6. The area was appropriate for a pilot project; the Thin Mud Timber Sale is within an intensively managed forest health demonstration area.

The District Soil/Water/Fish/Wildlife (SWFW) Section took the lead on this project in cooperation with other District Sections (Fire, Timber Management, Forest Health) and the Wenatchee Forestry Sciences Laboratory (FSL). The project was conceived in the summer of 1992 during Interdisciplinary Team discussions of slash disposal by chipping as part of the District's post-harvest review process. These discussions produced the following list of issues, concerns, and opportunities:

- Issues including implementation and effectiveness of the project and commitment to proper monitoring.
- Issues of funding allocations and the potential for cost-share partners.
- Concern over the Ips beetle (pine engraver) infestations.
- Concern over creation of fire hazard due to excessive chips quantities on roads and landings.
- Concern over suppression of natural and silvicultural stand regeneration.
- Concern for interference with purchaser activities and performance of work required for purchaser.
- Opportunity for creation of long-term solutions, not simply individual "good idea" projects.
- Opportune pilot project location, in terms of the overall situation, considering slash availability, access, road conditions, elevation, precipitation/moisture, and fuel loading.
- Opportunity for erosion control and dust abatement on roads.

Accordingly, SWFW Section personnel conducted a literature review during the winter months of 1992-93 to evaluate the effects of chipping and spreading slash. The major conclusions of this review can be found in appendix A, and helped guide the project and define project objectives:

1. Reduction of slash pile fire fuel hazard by means other than burning.
2. Utilization of chipped slash for erosion control on exposed soils such as roads and landings.
3. Evaluation of the feasibility, logistics, and economics of this type of project for future slash treatment and on contract development.
4. Chipping and spreading as one of the best balances of long-term productivity and short-term fire danger.
5. Reduction of slash pile Ips beetle breeding habitat by methods other than burning.

Objective number five was added in the spring of 1993 after Ips beetle colonization of slash piles was discovered in the Thin Mud Timber Sale area. Concern over the anticipated spread of beetles to adjacent healthy stands was expressed; the FSL offered forest health funds to support the project if it could be accomplished by mid to late June 1993, prior to beetle dispersal.

After project area selection, the number of piles, their locations, sizes, composition, and estimated volume were assessed, as was the number of miles of road to be treated. Potential contractors were involved in preliminary discussions and site visits to help determine equipment specifications and availability and other project logistics, including haul distances, haul/spread methods, and production rates.

It was determined that the best way to handle the project was through an indefinite quantities service contract with payment to be made by the cubic yard of chips spread. With the additional FSL funding support, \$25,000 was allocated for the project. A draft contract was developed with the following specifications:

Technical Contract Specs:

1. Average chip/shred output cross-sectional size not to exceed 3 inches. Chip/shred output length not to exceed 2 feet.
2. Chip/shred spreading depth to be 1 to 3 inches.
3. Stems greater than 8 inches large-end diameter to be scattered in designated locations immediately adjacent to landings and roads.

4. To gain access to the project area, temporary breaching of existing berm barriers and water bars was expected and would require reconstruction.
5. Chip/shred-surfaced roads to be closed by "tank trap" berms.

Equipment Contract Specs:

1. At a minimum, contractor to provide a tub-type wood waste grinder with at least 350 HP and at least a 10-foot diameter tub (or equivalent), capable of reducing 8-inch large-end diameter slash.
2. Tub grinders with or without self-loading capability may be used. If a non-self-loading grinder is used, feeding shall be done by a 30,000 lb class hydraulic excavator with thumb or grapple (see figure 2).



Figure 2.—Chipping operation.

The contract included standard WNF "boiler plate" clauses regarding prevention of resource damage, inspections, and fire prevention and control.

Execution

Approximately 1 mile of the 3.5 miles chipped was seeded and fertilized by District resource crews 1 week prior to chip application to allow a comparison of vegetative recovery.

The project was accomplished in 5 working days, operating hours 0700 to 1900, using the following contractor-provided equipment and three operators:

- Diamond Z PWG 1260 portable wood grinder, 505 HP, 12-foot tub flange top diam., 9-foot, 8-inch inside diam., remote-controlled from excavator;
- Komatsu PC200 excavator with grapple—slash loading;
- Case 721 loader with 4 yd³ bucket—chip loading;
- Freightliner dump with 20 yd³ box—chip hauling;
- Case 550 dozer with blade—chip spreading.

The chipper was mobilized to the most remote piles to begin. Chips were loaded into the dump truck, (see figure 3), (1 load = 20 yd³), and tallied, hauled, and dumped, working away from the operation (see figure 4), thus providing consolidation. The chips were dozer-spread (see figure 5) in five-load increments. Either a Forest Service Contracting Officer's Representative (COR) or Contract Inspector (CI) was on-site at all times to count the number of loads spread and to monitor contract compliance.

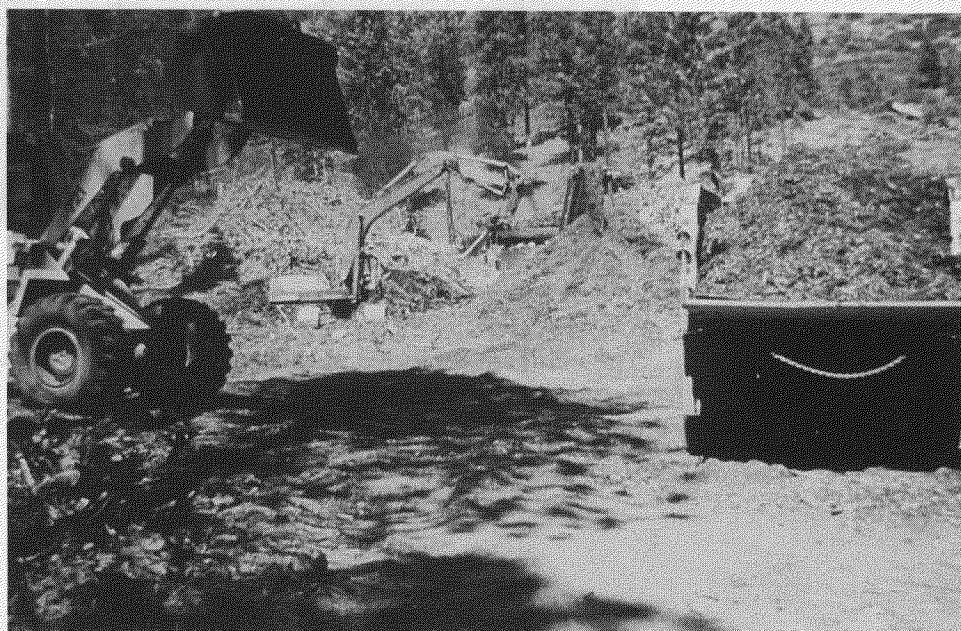


Figure 3.—Loading the dump truck.



Figure 4.—Dumping chips.



Figure 5.—Chips spread on the road.

Results

A post-project review of remaining unchipped slash piles visually observed approximately 648 beetle frass piles/yd³ of slash (or 24/ft³). No attempt was made to assess beetle density deep within the piles. When several densely packed piles were opened by the excavator during the project, they steamed considerably for extended periods of up to a day, indicating fairly high internal pile temperatures, although no temperature measurements were made. It is thought that high internal temperatures of densely packed piles may discourage beetle colonization beyond the pile surface layer.

The following work was accomplished by the 505 HP portable wood grinder and support equipment:

- 10 piles chipped (including two large piles greater than 2000 yd³ each);
- 6000–7200 yd³ of slash chipped;
- 4800 yd³ of chips produced and spread;
- 3.5 miles of road covered with chips.

The following information was collected:

- Unchipped piles contained an average 500 yd³ of slash and debris.
- Reduction ratio (slash:chips) ranged from 1.5:1 for clean and loosely packed piles to 1.25:1 for dirty, damp, and packed piles.
- 20 yd³ of chips covered about 70 feet of 16–20-foot wide road, 3–6 inches deep.
- Maximum production rate (chip & spread)—200 yd³/hr (short haul).
- Minimum production rate (chip & spread)—50 yd³/hr (long haul).
- Average production rate—70 yd³/hr or 800 yd³/day.
- Average grind rate—125 yd³/hr.

Chip output size met contract specifications exceedingly well. The product turned out to be much finer (<0.5-inch cross-sectional diameter and <1.0 inch in length) than expected.

Other noteworthy observations and results included the following:

- Dry chips tend to “ball up” on the dozer blade.
- The chips lock together in a fibrous matrix and absorb water like a sponge, keeping it from running down the road.
- Dust abatement on chip-surfaced roads was dramatic and persistent.
- Driving on spread chips helps to compress and consolidate the material.
- Some dirt and fines in slash piles produce a more spreadable product.
- Green slash and moisture in the slash produces a more spreadable products.
- Damp road surfaces aid in spreading chips.
- Dry slash is brittle and breaks in the grapple.

All equipment performed well and was appropriately sized and powered for this project. The chipper was large enough to maintain a good production rate, easily handled contract specifications for input/output size, and mobilized easily to all landing sites. The small dozer (D-4 class) had the necessary road drainage structures. The articulated loader with a 4 yd³ bucket quickly loaded the haul truck and was used for short-haul spreading in the vicinity of the chipping operation.

All project objectives and specifications were met or exceeded, with one notable exception: chip spreading depth was difficult to limit to 1–3 inches; the actual spread depth averaged 3–6-inches. This was due to the irregularity of road surfaces, inherent dozer blade limitations, and the matlike matrix of chips forming best at about 3–4-inch depth, depending on moisture content. The drier the chipped material, the more it tended to ball up on the dozer blade.

Monitoring

The following initial monitoring results were collected in September 1993, 3 months after project implementation:

- No chip ignitions had occurred, either natural, accidental, intentional, or otherwise.
- Chip depths of 4 or more inches retained noticeable moisture in the lower 2 inches of chips throughout the summer.

- Where soil moisture was naturally highest, as in draw bottoms and drainage ways, the chips had been invaded by fungal hyphae and decomposition had begun.
- In several locations, native vegetation including lupine, rose, and snowberry, was emerging through chip coverings up to 6 inches deep.
- Chip-surfaced roads left open to traffic showed variable rutting, from 0 to 3 inches; in no case was native material exposed.

In early May 1994, almost 1 year after project implementation, the following monitoring results were collected:

- The chip covering had remained in place well.
- Chip-surfaced roads left open to traffic showed variable rutting, from 0 to 10 inches, mostly in the 2- to 3-inch range. No native surfacing was exposed. The deep rutting occurred in the drain dips that had been filled with chips on 8 percent gradient road segments that follow draw bottoms. The deep ruts were easily repaired by hand-raking of chips; repair of similar ruts in nearby non-chip-surfaced roads requires annual grading.
- The surface layer of chips was visibly dry while subsurface chips were saturated, regardless of aspect or gradient.
- In numerous locations, native vegetation including lupine, rose, yarrow, and arrowleaf balsamroot, was beginning to emerge through the chip covering. Seeded and fertilized portions of road showed no difference in the amount of emergent vegetation.
- The color of the surface chips had lightened from the initial dark, loamy brown to a pale, silvery grey. The color and texture of the surface chips blended well with the natural roadside duff.

Economics

Total cost of this pilot project was \$27,000. This included \$25,000 for the contract work and \$2,000 for 90 hours of GS-7 COR/CI time and 80 hours of GS-7 time for project development, contract development, monitoring, and report writing. On a per unit basis, the costs are:

- \$2,700/pile;
- \$3.75—4.50/yd³ of slash utilized,
- \$5.62/yd³ of chips spread, and
- \$7714.28/mile of road treated.

The District Fuels Management Section estimated the cost to burn the same ten landing piles at \$778. This total includes brush disposal (BD) at around \$17.60/burn deck x 10 = \$176; smoke management assessment of \$0.43/ton x 1400 tons = \$602. These costs include inventory, planning, administration, implementation, travel, and monitoring.

Clearly, treatment of these ten slash piles by chipping and spreading cannot compete with disposal by burning on a dollar-spent basis. However, there are many costs, real and potential, associated with burning that are difficult to quantify, such as:

- resource damage to leave trees and standing timber adjacent to burned piles;
- resource damage to soils beneath burned piles; and
- short-term reduction in air quality from burning piles.

Treatment of slash piles by chipping and spreading is intended to avoid the real and potential costs. Furthermore, the chip/spread treatment accomplishes erosion control and dust abatement; burning does not. Both burning and chipping appear to accomplish some measure of beetle control, but chipping has the advantage of timeliness, as slash piles must dry for at least one season prior to burning.

Conclusions and Recommendations

The project was considered successful by the COR, the contractor, a project-implementation monitoring team from the WNF Supervisor's Office, and personnel from other Districts and a variety of disciplines. The project will be monitored annually to answer the questions regarding its long-term success:

- How well does chip-covering accomplish erosion control on road surfaces?
- How long will the covering remain effective?
- How does traffic affect the covering and vice versa?
- Does the covering create a fire hazard?
- Does the covering suppress regeneration/revegetation? If so, for how long?
- Will the chipped landings return to productivity quickly?
- Does the covering suppress the spread of noxious weeds? If so, for how long?

The Entiat Ranger District will continue to pursue this method of slash disposal. Future contracts will most likely pay by the mile of road covered with chips rather than by the volume spread, as an incentive for thinner spreading. The District will also explore opportunities to create small sales for chipped slash. Interest has been expressed in utilizing the product for landscaping, campground/trail surfacing, agricultural weed control, hog fuel, and electric utility cogeneration fuel.

The following recommendations are offered to those who are considering projects of this type:

- Write objectives into the contract so that the contractor understands the point of the project.
- Avoid stringent contract specifications that would exclude any potential qualified bidders. Most contractors know their business better than project planners, and they are more aware of technological developments; don't stifle their alternate-solution creativity. But don't get burned; do your homework.
- Develop a potential bidder list early. The low bid on this project came from a contractor not on the original list; he learned of it through the "grapevine."
- Allocate funds and plan the project well in advance.
- Involve other disciplines early in order to develop multiobjective, multifinanced projects.

This project is regarded as an effort in ecosystem management and a step in the direction recommended by Benson et al. (1977):

"Management, in its efforts to meet resource needs without damaging forest ecosystems, will need to incorporate data on the residue component into the planning process. It may become as important to know the amount and nature of what is left on a site as it is to know the volume of merchantable material harvested."

References

- Benson, R.E. and Schlieter, J.A. Woody material in Northern Rocky Mountain Forests: Volume, Characteristics, and Changes Within Harvesting. Research Paper, USDA Forest Service Intermountain Forest and Range Experiment Station, 1977.

Acknowledgments

See also appendix A, Literature Review.

The following personnel were involved in this project:

- Contracting Officer (CO): Don Mann
- Contracting Officer's Representative (COR): Philip Archibald
- Contract Inspector (CI): Pete Severtson
- Contractor: Gary Goodnight, Goodnight Chipping, Edmonds, WA
- Contributors: Karin Whitehall, Barry Marsh, Paul Flanagan, Monte Bickford, Rick Edwards, Ernie Stutzman, Troy Corn, Randall Walker, Michelle Ellis, Chuck Stanton, Randy Niman, Betty Palmer, and Marti Ames.

Date	Major Conclusions	Source	Author(s)
August 1992	Research indicates throughout the world that losses in site productivity are linked with losses in site organic matter and soil porosity.	Do Timber Management Practices Degrade Long-Term Site Productivity? What We Know and What We Need to Know.	R.F. Powers, Principle Silviculturist, Pacific SW Forest and Range Experiment Station
1980	Mulching with chips (1) will decrease soil temps below the surface while conserving moisture; and (2) can decrease amount of energy available at the surface and increase heat load above the surface which may be lethal to seedlings and vegetation.	Microenvironmental Response to Harvesting and Residue Management	R.D. Hungerford, Research Forester, Intermountain Forest and Range Experiment Station
1977	The most effective residue treatment in terms of surface runoff and erosion control was chipping and spreading the residue as a protective mulch. This particular treatment, however, has serious disadvantages—the almost complete suppression of vegetation and elimination of natural lodgepole pine reproduction.	Logging Residue Disposal Effects on Surface Hydrology and Soil Stability of Lodgepole Pine Forests	P.E. Packer, Supervisory Research Forester B.D. Williams, Forestry Research Technician, Intermountain Forest and Range Experiment Station
1977	During the first couple of years after the chipping, the phenol content of the soil solution was highest under chip mulch, where seedling growth was the poorest.	Harvesting and Site Treatment Influences on the Nutrient Status of Lodgepole Pine Forests in Western Wyoming	N.V. DeBoyle, Principal Plant Ecologist, Intermountain Forest and Range Experiment Station
1980	Wood in soil is an efficient medium for storing nutrients and water and provides a place for growth of tree roots and certain fungi that together form "mycorrhizae" structures essential to tree establishment, survival, and growth in western forests. Decayed wood is an important site for biological fixation of nitrogen gas from the atmosphere.	Residue Decay Processes and Associated Environmental Functions in Northern Rocky Mountain Forests	M.J. Larsen, Research Mycologist, Forest Products Laboratory A.E. Harvey, Research Plant Pathologist, Intermountain Forest and Range Experiment Station M.F. Jurgesen, Professor of Forest Soils, Michigan Technological University

Date	Major Conclusions	Source	Author(s)
1980	In no case should soil disturbance, organic matter accumulations, or depletions be extreme over large areas.	Biological Implications of Increasing Harvest Intensity on the Maintenance and Productivity of Forest Soils	A.E. Harvey, M.F. Jurgensen, and M.J. Larsen, Intermountain Forest and Range Experiment Station
1980	Spreading a thick layer of chips (4-5") on site may have some benefits such as preventing erosion but the practice is definitely detrimental to the establishment and development of lodgepole pine under both natural and artificial regen methods.	Establishment and Initial Development of Lodgepole Pine in Response to Residue Management	W.C. Schmidt, Principal Research Silviculturist J.E. Lotan, Supervisory Research Forester, Intermountain Forest and Range Experiment Station
1982	When residue was chipped and spread on site, appreciable amounts of nitrogen were fixed.	Management Consequences of Alternative Harvesting and Residue Treatment Practices—Lodgepole Pine	R.E. Benson, Intermountain Forest and Range Experiment Station
1981	Forest Management actions should incorporate an awareness that depletion in site reserves of organic material, particularly decayed soil wood, can potentially reduce growth rates by reducing ectomycorrhizal and nitrogen-fixing activities. Replacement of woody soil components lost due to harvesting or fire requires time periods from ca. 100 to 300 years.	Rate of Woody Residue Incorporation into Northern Rocky Mountain Forest Soils	A.E. Harvey, M.J. Larsen, and M.F. Jurgensen, Intermountain Forest and Range Experimentation



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