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# A Comparison of Two Road Reconditioning Systems: Roto Trimmer and Forester C-2000



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## **Roto Trimmer and Forester C-2000**

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## INTRODUCTION

This report compares the performance, capabilities, and cost of two road-reconditioning systems: the Roto Trimmer, owned and constructed by Triple Tree Incorporated located in Missoula, Montana, and the Forester C-2000 rock crusher, developed by FAHR Industries located in New Brunswick, Canada. Each piece of equipment has specific attributes and capabilities that make each machine appropriate for specific road surface conditions.

The information in this paper was gained from discussions with manufacturers, reviews of completed projects, and discussions with USDA Forest Service personnel who have detailed knowledge of the machines' capabilities and costs. The study focused on determining the performance of each machine for various road and geologic conditions.

This paper provides a cursory review of both road reconditioners with the objective of assisting field personnel in selecting the best equipment to match the specific road-surface conditions for their project. Table 1 provides a summary of performance and cost

Table 1—Capabilities, performance, and cost of Roto Trimmer and Forester C-2000.

Category	Roto Trimmer System	Forester C-2000 System
<b>Material, Rock and Geologic Types</b>	<p><b>Operates best in:</b></p> <ul style="list-style-type: none"> <li>Limestone, dolomite, quartzite, igneous intrusion</li> <li>Outcrops and boulders with fractured exposed bedrock</li> <li>Fractured/brittle rock, layer rock</li> <li>In rock easily fractured by teeth (i.e. limestone, dolomite, quartzite, igneous)</li> <li>Round rock imbedded in surface</li> <li>Ledge rock/bedrock intact in surface</li> <li>Angular rock that can be fractured (independent of size)</li> </ul> <p><b>Least efficient in:</b></p> <ul style="list-style-type: none"> <li>Hard non-fracturable round rock</li> <li>Hard metamorphic rock</li> <li>Competent rock, difficult to fracture</li> </ul>	<ul style="list-style-type: none"> <li>Cobbles, boulders, angular rock</li> <li>Rock that can be ripped and windrowed</li> <li>Rock less than 16-inch diameter</li> <li>Rhyolite, sandstone, shale, igneous volcanic, breccia, andesite</li> </ul> <p>* Bedrock * Material that has a significant amount of oversize rocks (greater than 16-inch diameter)</p>
<b>Operating Cost (per lane-mile)</b>	(Lane for Roto Trimmer, up to 15 feet)	(Lanes for Forester, up to 14 feet)
Range	\$4,900 - \$9,700	\$6,500 - \$17,000
Average	\$7,000	\$8,500
Easily fractured rock	\$5,000	NA
Hard rock	\$10,000	NA
29 lane-mile project, medium hardness rock	Cost independent of lane-mile if greater than 3 miles	\$6,500
5 lane-mile project, medium hardness rock	NA	\$17,000
8 lane-mile project, medium hardness rock	NA (Note: based on 1998 contract cost)	\$10,000 (Note: Based upon government ownership using force account crew)
<b>Production Rate (lane-mile per 8-hour day)</b>		
Range	0.75 to 1.25	0.7 to 0.9
Average	1.0 (manufacture estimate)	0.8
Hard rock	0.75	NA
Easily fractured rock	1.25	NA
Project less than 6 miles	NA	0.7
Project greater than 10 miles	NA	0.9
		(Note: Because of different crews there is a time to learn the project coordination among them)
<b>Availability:</b>	<ul style="list-style-type: none"> <li>Triple Tree, Inc. (Missoula, MT) has the only machine. It is subject to their schedule and operations.</li> <li>A forest can contract only for the complete Roto Trimmer system.</li> <li>Mainly used within 300 miles of Missoula. Company states they can mobilize anywhere depending upon size and complexity of project.</li> <li>Company has stated they can build another machine depending upon sufficient demand, but will not sell it.</li> </ul>	<ul style="list-style-type: none"> <li>Coronado and Rio Grande NFs own machines. Equipment and crushing crew can be contracted through the two Forests.</li> <li>Part of crew to be supplied by host Forest (organization)</li> <li>Use of machines and crew subject to Forest availability and schedule</li> <li>Forester C-2000 can be purchased from or contracted through FAHR Industries</li> <li>Purchase price as of 1998 was \$250,000 (with additional parts).</li> </ul>

information for both machines, based upon field demonstrations and experience. Table 2 is a qualitative comparison of both machines, based upon detailed field knowledge gained during demonstrations of the equipment.

The Pettibone P-500 Mobile Hammer Mill, used extensively in Region 6 over the last 20 years, was originally to have been evaluated in this report. However, the machine has not been used in numerous years, and there are no plans to do so; therefore, it was not considered further. The machine is currently in Baker City, Oregon, on the Wallowa-Whitman National Forest and has been completely refurbished. When it was operating, its purported production was similar to the Forester C-2000, and it operated on the same principle as the Forester, with revolving hammers. Forests interested in using the machine can call the Wallowa-Whitman engineering section. The Center has published two reports in 1974 and 1979 about its use and results.

## EQUIPMENT DESCRIPTION

### Roto Trimmer

The Roto Trimmer Mobile Rock Processor (Figure 1) is a self-contained unit that mounts to a CAT 966 front-end loader. The machine has a rotary drum with 184 carbide-tipped teeth in knuckle holders mounted in a spiraled-inward pattern. The drum is powered by a CAT 3406 diesel engine rated at 400 hp.

### Forester C-2000

The Forester C-2000 Road Crusher (Figure 2) is also a self contained unit and mounts on the front of a CAT 950F front-end loader or equivalent. The Forester C-2000 is powered by a CAT 3208 diesel engine rated at 255 hp, and consists of eight hammers bolted through a solid steel rotor.

## CREW, PROJECT OPERATION, AND PRODUCTION RATE

The Forester C-2000 and the Roto Trimmer systems recondition roads based upon different physical processes. The roads being processed therefore require different preparation and post-processing treatments. Each machine, along with its particular pre- and post-processing needs, will be referred to as a “system.”

### Roto Trimmer System

**Pre-processing:** Prior to operating the Roto Trimmer, a hydraulic rock hammer mounted on a Bobcat prebreaks large rocks (over 6 inches in diameter) that are imbedded in the roadway and that are not easily fractured with the machine. This operation is not absolutely necessary, but it does allow the Roto Trimmer to get an easier bite on rocks, thus improving overall performance. Ditch and drainage repairs are also completed before the Roto Trimmer starts operations. No further pre-processing of the road surface is necessary with this system.

**Roto Trimmer Operation:** After completion of the pre-processing activities, the Roto Trimmer is brought to the site. For a 15-foot-wide road and depths of 4 to 6 inches, the Roto Trimmer makes four

Table 2—Qualitative Assessment of finished projects (by author).

Category	Roto Trimmer System	Forester C-2000 System
Driveability by passenger cars	Excellent	Excellent
Production of erodible fine material	Poor	Poor
Quality of finished project after 5 years	Good	Unknown
Quality of finished projects after 3 years	Good	Good
Ability to process boulders less than 12 inches	Good	Excellent
Ability to process ledge rock	Excellent	Very poor
Impact to local forest personnel	Low	High
Production rate	Very good	Good



R9800150

Figure 1—Roto Trimmer Mobile Rock Processor



R9800153

Figure 2—Forester C-2000 Road Crusher

passes: two passes for width, and two for depth. The most efficient method has been to operate the machine against the grain of the rock.

**Post-processing:** A grader reshapes the processed material to achieve the desired road prism: inslope, outsloped, or crowned. A water truck then applies water for compaction. A vibratory roller with Elliot grids compacts the roadway, making several passes until desired compaction is achieved. The grader makes another pass to fill in voids. The road is then rolled again with a smooth drum to remove the grid marks from previous rollings with the Elliot Grid.

The crew consists of four people: One person on the Roto Trimmer, one on the grader, one on the roller, and one who operates both the Bobcat and water truck. Production rate of the Roto Trimmer System averages 0.75 to 1.25 miles per 8-hour day. This rate depends largely upon the level of energy required to fracture the material.

### **Forester C-2000 System**

**Pre-processing:** Before the crushing operation begins, the rippers on a motor grader or tractor loosen the top 4 to 6 inches of the road surface and dislodge embedded rocks. The ripped material, along with loose rock on the shoulder and ditches, is windrowed in the center of the roadway. Windrows that are 5 feet wide by 1 foot high are efficiently handled by the machine. The water truck wets the windrow for dust abatement immediately before the Forester C-2000 processes the material.

**Forester C-2000 Operation:** The machine makes one pass crushing the material in the windrow. Large 16-inch diameter rocks are typically broken into 3-inch minus material. Rocks are crushed between the rotating hammers and steel anvils bolted to the top of the crusher box. The rotor spins in the direction opposite to the travel of operation. A heavy-duty chain drapes the opening in front of the box keeping rocks in line for crushing rather than allowing them to be pushed out as the loader moves forward (Figure 3). When the rock material is crushed small enough to fit through the spaces between the hammers and the anvils, the crushed material passes out the back under a flexible belting screen into a new windrow.

**Post-processing:** A second grader works behind the Forester C-2000 spreading the crushed material on the roadway, and watering as needed. To achieve best production rates, two motor graders are needed: one for ripping and windrowing prior to crushing, the

other to spread the processed material after crushing. An Elliot grid roller or other compaction device is often used to compact the surface.

Five people have been used for the Forester C-2000 System: a loader/crusher operator, two grader operators, and two water truck drivers/mechanics. However, later projects have used a four-person crew just as efficiently with the elimination of one of the graders and associated operators. The average production rate is 0.8 mile per 8-hour day to complete the entire operation. The Forester C-2000 production rate is most dependent on the size of a windrow and the amount of rock material in the windrow. An overly large windrow with a significant amount of rock material clogs the crusher and stalls the engine, and a small windrow produces insufficient crushed material.

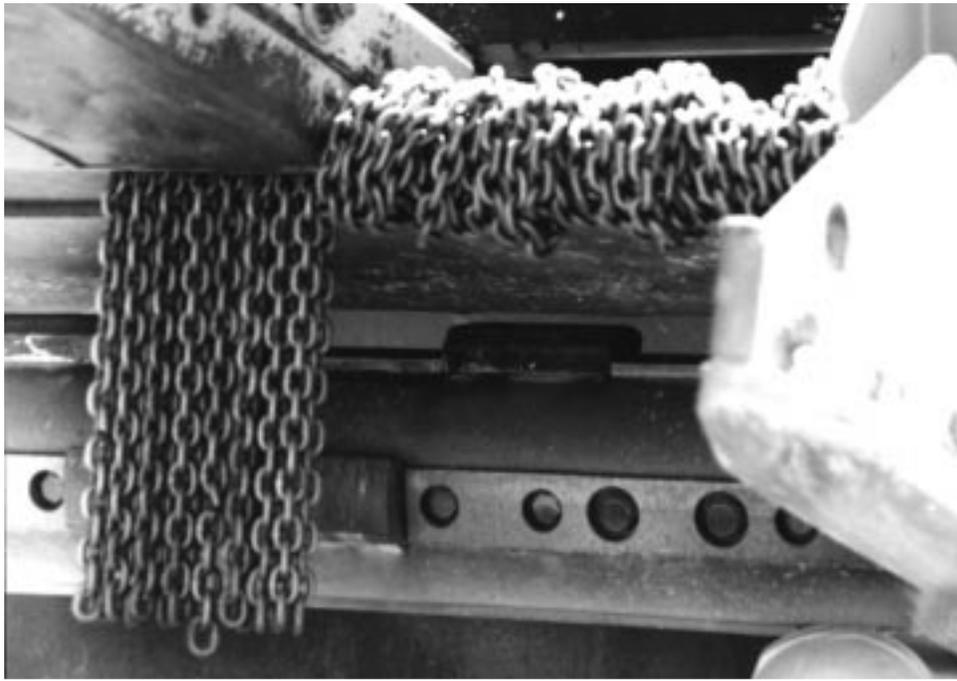
## **SYSTEM APPLICATION, LIMITATIONS, AND RESULTS**

### **Roto Trimmer System**

The Roto Trimmer System works best when grinding easy-to-fracture ledge rock embedded in the road surface. Material that is embedded in the roadway or that shows weathering, joint lines, or internal fracturing can be efficiently processed by the Roto Trimmer. The teeth impact the road surface with a “striking” action as the rotary drum moves along the roadway. The rocks are fractured and ripped along with other material. The loose rock revolves in the drum’s casing, which further fractures and blends all the material (Figure 4). The finished product is a well mixed, 4-inch minus material, resulting in a significant increase in fines. Rock that was not effectively fractured with the rock hammer is either re-incorporated into the surface, windrowed along the side of the roadway, or cast beyond the roadway. Since post-processing with this system includes double compaction of the road surface, the finished product is a hard, smooth drivable surface. The Roto Trimmer is less effective on rock that is not embedded in the roadway or is not easily fractured.

### **Forester C-2000 System**

The Forester C-2000 works best on cobbles and boulders that are either angular or rounded up to a maximum size of 16-inch diameter. If the material can be windrowed, the Forester C-2000 can usually crush it. The resulting material generally consists of 2-inch minus, with occasional 3- to 4- inch minus as the hammers and anvils wear down. Large boulders are deliberately sought after and carried into the windrow for processing by the Forester



R9800154

Figure 3—Forester C-2000 heavy-duty chain



R9800149

Figure 4—Roto Trimmer drum casing

C-2000. As with the Roto Trimmer, the Forester C-2000 increases the amount of fines material in the road surface, sometimes significantly. In-place bedrock cannot be crushed with the Forester C-2000.

Both systems usually increase the amount of erodible silts and sands on the road surface, as compared with pre-processing conditions. Additionally, neither system will produce an engineered material, nor can the final gradation be controlled. Both systems, however, do produce a very smooth, drivable surface that can be maintained with a grader and used by passenger cars.

## **PAST USE, AVAILABILITY, AND COST**

### **Roto Trimmer**

Triple Tree is the sole owner of the Roto Trimmer, with services that can be contracted only through the company. The machine cannot currently be purchased on the open market. It has been used mainly on road projects within a 300-mile radius of Missoula, Montana, where Triple Tree is located. This company has its own transport equipment, is completely mobile, and states they can go almost anywhere. The company can and will build another Roto Trimmer if the demand warrants, but they will not sell it. Triple Tree has been using the Roto Trimmer since 1990 and has processed over 300 miles of roadway. Much of this business has been contracted with the same clients. Typical job size is 10 miles, and the minimum job size is 3 miles.

In 1998 the Lolo National Forest (Montana) contracted with Triple Tree to re-establish native surface on 23 miles of road at six different locations. The total cost was \$158,000; average cost was \$6,900 per mile. The unit cost for each location ranged from \$4,900 to \$9,600 per mile.

### **Forester C-2000**

The Forest Service purchased and owns two Forester C-2000s. One is located on the Coronado National Forest in Arizona; the other is located on the Rio Grande National Forest in Colorado, which is shared between Regions 2 and 3. The Forester C-2000 is available for purchase from FAHR at a price of \$250,000 (August 1998), or it can be leased from FAHR for \$5,300 per mile, which includes the crusher and loader, crusher operator, and mechanic/assistant (includes transportation anywhere in Continental U. S. or Canada). Alternately, Forests interested in using the Forester C-2000 system can

contact the Coronado or Rio Grande National Forests for possible sharing arrangements. Both Forests have indicated a desire to lend their machines, and possibly part of the crew, to perform work in other areas during slack periods. It may be possible to combine the local road maintenance crew with an experienced crew from the Coronado or Rio Grande to help defray the cost of the project. To date, the Forester has processed about 100 miles of roadway. Minimum job size is the key factor in determining the unit cost of the project. Longer projects have lower costs. Projects with fewer than 8 lane-miles have unit costs that may exceed importing material from local sources.

Over the last three years, the Coronado, Rio Grande and Plumas National Forests completed three road-reconditioning demonstration projects totaling 42 miles using the Forester C-2000 system. The total cost was \$356,000, with an average cost per mile of \$8,500.

## **CONCLUSION**

Both the Roto Trimmer system and the Forester C-2000 system can make a rough, rocky road into a good road, with a hard, smooth, maintainable driving surface. The Roto Trimmer works best grinding ledge or layered sedimentary rocks or easily fractured imbedded boulders, while the Forester C-2000 crushes hard, large boulders up to 16 inches in diameter. Each machine occupies its own specific niche of projects. The Roto Trimmer is more efficient and economical than the Forester C-2000 for processing road surfaces composed of ledge rock and easily fractured well embedded rock, while the Forester C-2000 is the right machine to process road surfaces composed of harder cobbles and boulders that need a real crushing action. It is important to note that the Forester C-2000 cannot process road surfaces composed of ledge rock that cannot be ripped with ordinary rippers, while the Roto Trimmer has difficulty processing road surfaces composed of loose, hard cobbles and boulders. Neither system produces an engineered material of uniform gradation. However, both produce a better road surface when the quality and expense of a standard crushed aggregate is not economically justified.

*NOTE: Since these demonstration projects were conducted, FAHR has patented and trademarked the Forester C-2000 as the "FAHR Roadcrusher," and this model is called the Forester C-2000.*

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# **APPENDIX**

# APPENDIX

## Contacts

Contact for Roto Trimmer  
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