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BUILDING FIRELINES WITH LIQUID EXPLOSIVE... some preliminary results

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ABSTRACT: Building firelines in logging slash or dense brush can be costly and hazardous. A new liquid explosive was tested in these and other forest fuel types. It proved effective in brush, understory vegetation, and light-medium slash, but was not effective in deep, heavy slash. Fireline construction by this technique shows promise, but will require more testing and engineering before it is ready for operational use.

RETRIEVAL TERMS: fireline construction; slash; explosives; Gifford Pinchot National Forest.
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Logging slash and dense brush are among the more difficult forest fuels in which to build a fireline by conventional methods. In both types of fuel, fire can spread quickly. Construction can be costly and hazardous. To control a wildfire or to do a prescribed burn, a fireline must often be built directly through slash or dense brush.

Instead of building a fireline by hand, it might be possible to blast one by using explosives. Such a technique might reduce costs and hazards–and yield a more effective control line. Explosives for fire control work is not a new idea; in 1947, for example, military explosives were tested for felling snags, but the results were generally unsatisfactory.[1] Limited tests in 1957 with "Primacord"–a detonating fuse with a high explosive core–also yielded unsatisfactory results. The firelines it produced were not wide enough, and the blasting set numerous fires.[2]

In fall 1968, we tried a new high-velocity liquid explosive on the Gifford Pinchot National Forest, in southern Washington. The explosive–produced chiefly for military uses and not available commercially–was suggested for trial because its characteristics promised a good deal of flexibility in adapting to the varied conditions of vegetation and terrain. If it showed promise, then further trial of it or similar materials available commercially might be advisable.

The liquid can be pumped into tubing, laid over fuels or left on the ground. The tubes can be bent or turned without affecting the spread of the explosive –provided air gaps do not exceed 6 inches. Detonation is by an electrical blasting cap placed at one end. In tubes, the material will not detonate if ignited by flame but will, instead, burn slowly. Upon detonation, there is a quick flash but no after burning.

METHODS

We tested the material on four forest fuel types:

- *Brush:* extensive, dense thicket of limber 6-foot-high snowbrush *(Ceanothus velutinus* Dougl.), about 7 years old; on an underlying duff layer about 4 to 6 inches deep.

- *Duff-litter-understory:* Douglas-fir–hemlock forest litter; understory conifers, hardwoods, and brush; duff layer 6 inches deep.

- *Light-medium slash:* second-growth Douglas-fir–hemlock logging debris, less than 12-inch diameter; with duff layer 4 to 6 inches deep.

- *Heavy slash:* old-growth Douglas-fir–hemlock cull logs up to 34-inch diameters mixed with heavy loadings of smaller logging debris; duff layer 6 to 12 inches deep.

In each fuel type, two to four 100-foot line transects were located and staked. An aluminum wire stretched between stakes, above the fuels, on each transect served as a measuring line and as a guideline in laying the tubing for the explosive.

On each line, we measured (a) number, location, and size of fuels intercepted, (b) depth of litter and duff, and height of brush or slash at 10-foot intervals, and (c) percent of mineral soil exposed on each 10-foot segment of the line.

After the blasting tests, we measured the (a) width and length of the area affected by the blast, (b) percent of lineal fireline completed to mineral soil, (c) width of mineral soil "trench," (d) percent of fireline completed that would not require additional work, and (e) number, location, and size of fuels not removed by blasting. Effectiveness of blasted firelines for indirect attack was judged by local specialists who were familiar with fire control in these fuel types.

For most of the tests, a thin-wall (4 mil) lay-flat plastic tubing was used to carry the explosive. But we found it was not strong enough for rough field use–it snagged several times and had to be repaired. On steep slopes, in the light-medium slash area, we substituted linen hose, 1 and 1½ inches diameter, to hold head pressures. A durable tubing is needed when the explosive is used for military purposes. In one system, designed for the U.S. Army's Picatinny Arsenal, 1,000 feet of explosive-filled tubing, filled by a special air-pressure pump, can be laid, filled, and exploded by electrical blasting cap in less than 30 minutes. This system was not available for this study.

During blasting, minimum distances, as outlined in the Forest Service Health and Safety Code,[3] were adhered to by handlers and observers.

RESULTS

Brush

In the ceanothus test area, four 100-foot lines were established–two with .90-inch diameter tubing, and two with 1.27-inch tubing. These lines required 35 and 90 pounds of explosive, respectively. Most of the tubing could be placed close to the ground through the flexible brush.

Explosives in the larger tubing blasted a good fireline for the entire length of both lines *(fig. 1)*. The blasted mineral soil "trench" on each line was 4 feet wide; all brush for 10 feet on each side was defoliated. Soil from the trench coated the ground in the defoliated area. Blast effect was to the flanks. End effect was negligible. Debris was cast as much as 200 feet from the lines. Because the blast completed the entire line-building job, no additional work was considered necessary.

Figure 1.–*Ninety pounds of explosive produced a 4-foot mineral soil line. Brush was defoliated for 10 feet on either side of the line. A fine layer of soil was cast over the ground in the defoliated area.*

Figure 5.–*In light-medium slash, adequate lines were constructed with 120 pounds of explosive. Most of the logs,*top, *were blown apart or displaced. Line,*bottom, *is about 5-feet wide, and will require only a small amount of additional cleanup.*

Figure 6.–*Section of line in the light-medium slash with smaller fuels,*left. *The duff layer was 4 to 6 inches deep. Blasting, with 120 pounds of explosive,* right, *produced a 10-foot-wide break with a 2-foot mineral soil "trench" in the center.*

Figure 4.–*An 18-inch log was blasted through by placing two 3-pound "satchel" charges in contact with the explosive-filled tubing where it crossed the obstruction.*

Blasting produced a 1-foot-wide trench through the duff layer to mineral soil along the entire length of each line. Roots up to 2 inches were severed. Brush and trees were defoliated for 6 feet horizontally, on either side of the lines, and 6 to 8 feet vertically *(fig. 3)*. This line was considered adequate for controlling a ground fire in this fuel type, or for a control line from which to backfire or burn out. Only some limited cleaning of each trench remained to be done.

On one line, an 18-inch hemlock log was intersected. Two 3-pound "satchel" charges were attached to the tubing where it crossed over the log. Upon detonation, the explosive tore a 12-inch gap *(fig. 4)*.

Light-Medium-Slash

Four 100-foot lines were located in the light-medium slash area on slopes ranging from 35 to 45 percent. The 1-inch diameter hose needed 70 pounds of explosives. The 1½-inch diameter hose required 120 pounds. Of this, about 10 to 20 pounds of liquid explosive was lost from seepage until the hoses were saturated.

The 70-pound charge was inadequate for complete line construction in this fuel type. It reduced the line work required by no more than 50 percent.

The additional 50 pounds of explosive in each 1½-inch diameter line produced much better results–estimated line construction effort was reduced by 85 percent. The path of cleared debris averaged 5 feet wide *(fig. 5)*. The blasts produced 2-foot-wide mineral soil trenches for most of the length of each line. Ninety percent of all logs, 12 inches in diameter or less, were blasted apart or displaced by the explosive. In some places, blasting cleared a 10-foot swath through the lighter slash concentrations *(fig. 6)*.

Heavy Slash

Two lines were blasted using 1.27-inch diameter tubing with 90 pounds of explosive each. In two trials, blasting was not effective for line building. Debris along the lines was 7-feet deep in places, and included cull logs up to 34-inches diameter. The explosive contributed no more than 10 percent to the total line construction effort needed in this fuel type.

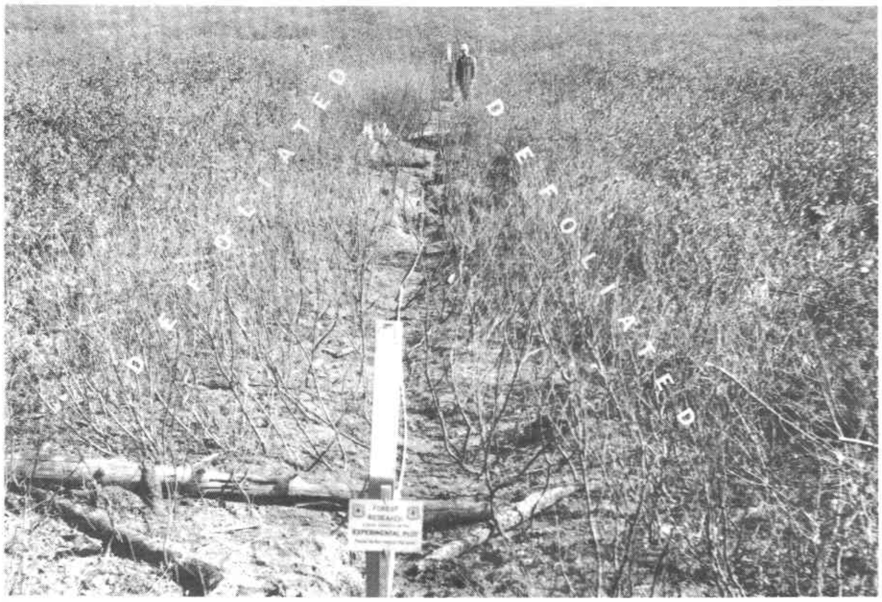

Figure 2.–*Thirty-five pounds of explosive were used to blast this line in the brush. Vegetation was defoliated for 6 feet on either side of the narrow fireline. Blasting contributed about 60 percent of the total line work needed.*

The two-explosive-filled .90-inch diameter tubes blasted a 12- to 18-inch-wide trench for the 100-foot lengths of fireline, and defoliated brush 6 feet on either side *(fig. 2)*. Blasting accomplished about 60 percent of the line building job. Here, some additional widening would have been required for an acceptable control line.

Duff-Litter-Understory

Two 100-foot lines, using 1.27-inch diameter tubing filled with 90 pounds of explosive, were placed in duff-litter understory. Duff was 4 to 6 inches deep, and included a matting of small roots. Tubing was laid directly on the duff under the herbaceous understory *(fig. 3)*.

Figure 3.–*Line location in dense vegetation beneath timber canopy* left; *blasting produced a 12-inch mineral soil fireline, and defoliated all vegetation for 6 feet horizontally and 6 to 8 feet vertically*, right.

OTHER USES

The explosive that we tested could have other applications besides fireline construction. Snags can be removed by inserting about 5 pounds of the liquid explosive from a plastic squeeze bottle into a small, augered hole near the snag's base. The material is detonated by an electrical blasting cap. The explosive may also be placed in plastic bags at the base of the tree. In one test, we blasted a hemlock snag (28 inches d.b.h. and 150 feet high) in the designated direction with two 6-pound external charges. Internal placement, however, permits smaller amounts of explosives to be used.

Another possible application could be to build temporary water-fills for fire control use. Two or three pounds of the explosive can be poured onto the ground surface, or into a small depression, and detonated. The resulting crater can hold several hundred gallons of water when lined with plastic sheeting.

FUTURE RESEARCH

Fireline blasting with liquid explosives is a promising technique, but will require more testing and engineering before it is ready for operational use.

Future research should be directed at the following:

- Compare the cost of line blasting and construction by hand, tractor, or chemical retardants in various fuels.
- Determine the most effective and economical explosives for fire control work, including comparison with available commercial blasting slurries[4,5] in a variety of fuel types. Some brands of slurries are commercially available for less than 25¢ a pound, and may be handled by pump truck mixing and loading systems.
- Determine each explosive's degree of reliability, sensitivity, effectiveness, compatibility, storageability, and chemical and physical properties.
- Develop complete safety guidelines for qualified handlers as well as for fire control personnel directly or indirectly involved in line blasting.
- Develop suitable engineering system for field mixing and fireline deployment.
- Develop the explosives in other usable shapes and forms (i.e., explosive impregnated cord, or hard-gelled explosive in prepared tube reels).

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Notes

[1]Johnson, C. B. *Army explosives for hazard reduction.* Fire Control Notes 8(1): 42-44. 1947.

[2]Banks, W. G., and Fenton, R. *Primacord tested for blasting fireline.* Fire Control Notes 18(4): 164-167. 1957.

[3]U.S. Department of Agriculture. *Forest Service Health and Safety Code.* Chapter 6.1–BLASTING. U.S. Forest Serv., Washington, D. C. 1962.

[4]Cook, Vernon O.: Cook, M. G.; and Ursenbach, W. O. *Slurry blasting agents.* Mining Magazine 117: 80-85. 1967.

[5]Cook, Melvin A. *Explosives–a survey of technical advances.* Ind. & Eng. Chem. 60(7): 44-55. 1968.

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