

# Aerial Mulching Techniques—Trough Fire<sup>1</sup>

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## Abstract

The Trough fire occurred in August 2001 on the Mendocino National Forest of northern California. A burned area emergency rehabilitation team evaluated the fire effects on the watershed. Concerns were soil from the denuded slopes moving into streams affecting fishery values, reservoir sedimentation and storm runoff plugging culverts leading to road wash outs. Past evaluations have shown hand straw mulching to be a superior method in protecting soil from raindrop impact, surface runoff and erosion. However, hand mulching is a long and expensive process with safety factors dictating mulching only on ridges and not steep stream banks. On the Trough fire two aerial mulching techniques were evaluated on stream banks. Both evaluations were done in cooperation with USDA, Forest Service, San Dimas Technological and Development Center. One technique was in conjunction with the California Straw Supply Co-op. Work consisted of straw baling techniques and dispersal of straw by helicopter. Field testing on the Trough fire involved 60 ac being treated at a cost of \$450 ac<sup>-1</sup>. This cost included unit layout, work crews, straw, trucking costs and helicopter flight time. In March 2002, San Dimas and Erickson Air-Crane contacted the Forest to test a new hydromulch formulation in a burned area. The helicopter hydromulch drops were effective in creating swaths along two steep burned streams. Cost for the treatment was \$3,000 ac<sup>-1</sup> plus mobilization. During treatment, some germinated native plants were covered with hydromulch. Over time, most of these perished. The Forest Botanist surveyed treated and untreated land. Untreated areas had more plant diversity than the treated area. In November 2002, the hydromulch area was inspected for product effectiveness. After a 6 inch rain, the mulch was mostly intact with native plants germinating through the mulch. Surface erosion and some rill erosion were halted by the hydromulch.

## Introduction

There are two types of aerial mulching techniques, straw and hydromulch, that were evaluated on the Trough fire. In August 2001, the fire occurred on the Grindstone Ranger District, Mendocino National Forest (Forest), west of the town of Stonyford, CA. Elevations burned were between 1,500 and 6,000 ft. Low elevation vegetation consisted of chaparral, while upper elevations consisted of conifers. Upper elevations of the fire were in the Snow Mountain wilderness.

A burned area emergency response (BAER) team was assembled to evaluate the effects of the wildfire on resource values. Values that could be protected by aerial mulching were the road system (County and Forest Service), OHV (off-highway vehicle) trails, a resident trout stream, and sedimentation of Stony Gorge reservoir.

The USDA, Forest Service, San Dimas Technological and Development Center (SDTDC) contacted the Forest about evaluating the use of helicopters in the dispersal of straw and hydromulch. The Forest agreed that there was a need to spread straw in a timely manner on remote locations and that use of a helicopter could be the most efficient method. Aerial straw mulching occurred in the fall of 2001. In the spring of 2002, SDTDC once again contacted the Forest about evaluating the use of helicopters

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in dispersing hydromulch on burned areas. As the Forest was interested in furthering technology, locations were provided to SDTDC and Erickson-Air Crane to do evaluations.

### ***Aerial Straw Mulch***

In the past, straw mulch has proven to be very effective in protecting burned slopes. Robichaud and others (2000) documented this finding, as did visual observations by Luckow and Jaramillo (2001) on the Cerro Grande fire in New Mexico and Faust on the Fork fire,<sup>3</sup> Mulch dissipates rain drop impact; keeps soil, nutrients and seed in place; and detains surface runoff to increase infiltration of water into the soil.

In 1996, the Mendocino National Forest BAER and implementation team recommended and applied rice straw mulch to 600 ac of the Fork fire. Hand mulching was very expensive (\$1,200 ac<sup>-1</sup>) using California Conservation Crews and very time consuming carrying bales to the mulch sites and spreading the straw. Also, due to worker safety, only the ridges were treated. Steeper stream bank areas were left untreated.

After the Trough fire, to protect downstream values the BAER team recommended use of straw mulch. However, based on past experience and cost on the Fork fire, straw mulching was not selected.

Kim Clarkin, Research Hydrologist, at the San Dimas Technological and Development Center contacted Forest Hydrologist Faust about a burned area to evaluate aerial straw mulching. While burned treatment areas were being laid out, SDTDC was working with the California Straw Supply Co-op, located in Colusa County, on straw bale preparation and delivery systems.

The evaluation was to determine if helicopter application would be less expensive than hand treatment, if the mulch coverage would be similar to hand dispersal, and if steep slopes could be treated. A four hook carousel used to carry cargo nets was also evaluated.

Preliminary test drops showed that straw would give somewhat uniform coverage. Straw in the drops ranged from fine layers of individual straw stems to clumps about 3 in. deep and 2 ft. wide producing about 60 percent ground cover.

Variables in rice straw preparation that affected evenness of aerial distribution were moisture of straw at baling, chopped length of straw, straw bale weight and length of time bales were stored. Moist, long lengths (>10 in.) of straw, baled at high compression and stored for several months, creates flakes of straw that do not break apart in the air. Another factor to consider in using straw is that it be certified weed free in the county where it is applied.

To provide more information for this presentation, findings from the Haymen fire (Denver, Colorado) and Darby fire (Sonora, California) are included.

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<sup>3</sup> Unpublished data on file, Mendocino National Forest, Willows, CA.

## **Methods**

There are several steps that need to be considered in conducting aerial mulching. Some of the steps are unit delineation and location, an aviation safety plan, staging area location and operations.

### ***Treatment Units***

On the Trough fire, burned firelines, burned brush channels and upland slopes were marked with red panel flagging (approximately 2 ft wide and 4 ft long) for treatment. Average size of units was about 10 ac. Plastic markers were held down with steel staples and rocks. Flagging was used to outline the treatment area. Unit corners were located with a GPS unit.

On large fires, treatment unit corners can be determined from the BAER burn intensity map. With either unit designation method (field or map), units need to be plotted on a topographic map to aid the pilot in locating the treatment areas.

### ***Aviation Safety Plan***

For Forest Service operations, a helicopter manager and a helibase manager (if a large operation) are needed to write an aviation safety plan and determine a suitable helicopter area of operations. The aviation safety plan covers such items as project objective and description, helicopter and pilot certification, radio frequencies, flight following, ground support, environmental and aerial hazards and load calculations.

### ***Staging Area***

Factors to consider in locating a staging area are space for hay truck access, straw bale storage, helicopter work area, flight paths and support vehicles. Another important factor to determine is if noxious weeds are located on the staging area and to determine how not to spread the seeds to treatment areas.

Normally on the staging area, there is a fire engine or water truck to wet down the area to reduce blowing dust. There should be enough cargo nets to have empty nets being loaded while the helicopter is flying out loaded nets to the treatment areas. Square nets that work well have flat straps and are 12 x 12 ft, 15 x 15 ft or 20 x 20 ft. A variety of net sizes are useful if using small and large bales. Straw bales are placed on the net with the side edge up to facilitate the removal of the baling twine.

### ***Operations***

A hand crew with small bales or a loading “squeeze” for the heavy large bales can do net loading. Hand loading is very fast and tiresome. A 15 to 20 person crew is needed to keep up with the helicopter. Crew rotation on a daily basis would keep the crew fresh and less prone to accidents.

For firelines, four 12 x 12 ft cargo nets were each loaded with five small (65 lb) bales each. The nets were attached to a specially made heavy duty four hook carousel developed at West Wind Helicopters, Lincoln, CA. As the pilot flew down the fire line, one net corner was released. When that net was almost empty of straw, another net corner was released. Very accurate placement of straw was made using this technique providing there was no wind or a light constant wind. Wind gusts can cause straw to miss the fire line.

### ***Monitoring of Straw Distribution***

On the Trough fire, straw was applied at one ton  $\text{ac}^{-1}$  with 65 ac treated in 2 days. Since the straw preparation technique was not perfected, the straw came out as clumps. With most of the weight in clumps, ground cover was about 35 to 40 percent. There was concern that the clumps would not provide enough ground cover to protect the soil from erosion. However, after the first rainstorms, it was observed that the straw clumps did not blow away as did the fine material and they were large enough to stop rill formation and catch sheet erosion. In comparison, on an adjacent untreated private land hillside, rill erosion was extensive as seen by streaks oriented up and down the hillside.

After aerial straw mulching was conducted on the Mendocino N.F., the technique was used on the Oregon fire (Weaverville Ranger District, Trinity N.F.). The next fire using aerial straw mulching was the Darby fire (Stanislaus N.F.). With each fire, straw preparation and application was perfected. Results on the Darby fire were excellent. On this fire, straw was applied at two tons  $\text{acre}^{-1}$  using the large 800 lb bales. Ground cover was 90 to 100 percent and the wind did not blow the straw, due to straw being interlocked and below a burned tree canopy. Janicki and Grant (2001) reported that no erosion occurred on the treated slopes, but the untreated slopes had heavy sheet and rill erosion. On this fire 70 ac were treated in 3 days or 23 ac per day.

### ***Cost of Aerial Straw Mulching***

Factors influencing the cost of aerial straw mulching are trucking costs, application rate, acres treated and helicopter/pilot rates. For three California fires, Trough, Oregon and Darby, the costs per acre were \$447, \$328 and \$710 respectively. The latter fire had an application rate double (2 tons  $\text{ac}^{-1}$ ) the other two fires (Clarkin and Dean 2003).

Two 2002 fires in New Mexico, Rodeo and Borrego, had costs per acre of \$290 and \$650. The Rodeo fire used large bales (800 lb.) at an application rate of  $\frac{1}{2}$  t  $\text{ac}^{-1}$  and treated almost 11,000 ac. The Borrego fire treated 155 ac at just over 1 t  $\text{ac}^{-1}$  but had high costs due to long flight turn around times (3 min.) and hand unloading of trucks and hand loading of nets.

The Mollie fire in Utah had the highest cost per acre of about \$950. These high costs resulted from having very light small bales, small nets, great elevation difference between the staging and treatment areas, resulting in long turn around times (7 to 9 min. per load). The project manager thought if they had a sufficient number and larger sized nets the cost per acre would be between \$700 and \$800.

In general, one would expect that an application rate of 1 to  $1\frac{1}{4}$  t  $\text{ac}^{-1}$  would average about \$500.

### **Results and Discussion**

Aerial straw mulching was impressive in that many acres can be treated in a short time period at a reasonable cost compared to hand application. Also, remote and steep areas can be treated, and spreading of straw by air is safer than by hand where crew members can slip and fall on the slick straw. The following are other findings:

1. Aerial application can treat the steeper more erosive slopes, and is much faster than hand application.
2. Wind to 15 mph is beneficial to disperse straw on large units, but a detriment on narrow fire lines.
3. Mulch gives ground cover >70 percent if applied at 1.25 t ac<sup>-1</sup>.
4. Mulch greatly reduced sheet and rill erosion.  
Straw may move with the wind or gravity on steep slopes.  
Straw clumps are a benefit, as they do not blow in the wind.
5. Bale straw at low (<15 percent) moisture content to reduce creating flakes.  
Bale straw loosely compacted for better dispersal.  
Weight of small bales about 65 lbs.; large bales about 800 lbs.
6. Chopped straw should have stems 5 to 8 in. long to aid dispersal.
7. Use freshly baled straw as older straw compacts and molds.
8. Keep straw dry during storage, transport and at staging area.
9. On small fires, for quality control, straw can be obtained from one supplier.  
On the Rodeo fire, straw was purchased from numerous vendors.  
For quality control, straw bales were hauled to a staging area, chopped and re-baled before being aerially dispersed.
10. Aerial straw mulching usually costs in the range of \$350 to 800 per ac.  
Cost variables are:  
Price of straw—about \$3.50 per bale.  
Trucking costs—\$2.00 mi<sup>-1</sup> on trips longer than 300 mi.  
\$3.00 mi<sup>-1</sup> for shorter trips.  
Type II restricted helicopter rates—\$1,250 to \$1,350 hr<sup>-1</sup>.
11. Method of loading nets—hand (contract or inmate crew) or machine (front end loader or squeeze).
12. Weather delays—flight restrictions on wind speed and visibility.
13. Bale size—larger bales are more efficient to use than small bales.
14. Flight time—turn around time normally 1 to 3 min.
15. Aerial straw mulching is a very worthwhile treatment.

## ***Aerial Hydromulch***

### **Methods**

Ryan Becker at San Dimas Technological and Development Center contacted the Forest rehabilitation team leader Faust about finding a test site for Erickson Air-Crane (Central Point, Oregon) to try a new chemical (LACCOSET, Sequoia Pacific Research, Draper, Utah) formulation in hydromulch. Two areas, comprising six acres, on the Trough fire were located to determine if the LACCOSET, which uses less water, would 1) provide 90 percent ground cover, 2) treat steep stream banks and 3) would last during a hot summer.

Treatment was in March 2002, when the seedbed was germinating and the brush was sprouting. Hydromulch formulation was a bonded fiber matrix blended with water and paper fiber. Application rate on a per acre basis was 2,000 gal of water, 500 lb mulch including chemical, and 50 lb cereal barley. Water was supplied by water trucks. Treatment time was one day.

On the Haymen fire, 1,560 ac were treated. This high quantity operation required five mixing tanks and 3,500 gal of water per acre. Forty ac ft. of water was drafted from a river. Fifty-one acres were treated per day.

On the Trough fire, each hydromulch swath was about 40 ft wide and 700 ft long. With two drops along one side of a stream swath width, with overlap, was about 70 ft. This equates to one acre of treatment. The layer covering the soil was about 1/16 in. thick.

The helicopter pilot was able to maneuver the ship down the winding channels. On the Haymen fire, hydromulch treatment was on ridge tops and channels. Another alternative would have been to use straw mulch on the ridges and hydromulch on the steep stream banks.

## Results

### *Effects on Vegetation*

Within the Trough hydromulch area, a rectangular piece of panel marker 2 x 3 ft was used to make an untreated plot. Two months after application, the Forest botanist counted ten more species than in the adjacent treated area. In the treated area, sprouted forbs were covered with hydromulch and most perished.

One foot square plots were established to measure plant growth and to evaluate the hydromulch. After application, barley seeds were observed in the plots (10 to 13 seeds) but they did not germinate as no rain occurred after treatment.

In November, after a dry, hot summer, it rained 6 inches in 3 days. At the end of November, seeded barley to 3 inch tall was observed growing in the cracks of the mulch and bare spots created by animal hooves, whereas solid areas of mulch only had a few blades of grass growing through. Since seeded grass was not growing in either open or covered areas, it is assumed that the seed desiccated during the summer.

### **Effects on Soil Erosion**

Bare loose soil on the 70 percent slope stream banks was held in place by the hydromulch. Ground cover was in excess of 95 percent. After the 6 in. of rain, ground cover decreased to 90 percent in one area, 40 percent in another area and 80 percent on another stream bank.

The hydromulch formulation (not LACCOSSET) used on the Haymen fire reportedly disintegrated with only ½ in. of rain. (Pers. comm.). This shows that various formulations have varying degrees of longevity to sunlight and precipitation.

A couple of spots on the Trough fire evaluation site were tested for soil hydrophobicity. Surprisingly, burned chamise leaf needles under the hydromulch appeared to still be hydrophobic, whereas burned chamise needles on the bare area were not hydrophobic. However, the hydromulch still readily accepted water when wetted with water from a bottle.

Surface erosion was observed on the slope above the treatment as linear deposits of soil and ash (waves) about ½ inch high. When these waves hit the hydromulch they ended. No surface erosion occurred on or under the hydromulch.

One rill from above the treatment area entered the hydromulch and dissipated. Another rill that was enlarging as it entered the hydromulch decreased in size as it moved through the treatment area to the channel.

Cost of hydromulching for the Trough and Haymen fire was between \$2,500 and \$3,000 ac<sup>-1</sup>. Mobilization was an additional \$20,000 to \$80,000. High treatment cost can be justified when important downstream values such as domestic water supplies, structures, or threatened or endangered fish are threatened by erosion.

## Summary

The Trough fire presented an opportunity to evaluate aerial application of straw and hydromulch. Spreading of straw by air was quick to cover large acreages consisting of remote and steep sites. Even though ground cover percent was not as high as hand spreading, use of helicopters gave adequate ground cover to impede erosion at a cost similar to hand crews. The main advantage of aerial straw mulching is that steep slopes can be treated much more safely and quickly than using a hand crew.

Spreading of hydromulch by air also worked very well. The hydromulch provided at least 90 percent ground cover and stuck to very steep stream banks. Cost of this application is higher than use of straw, but where downstream values are high and there is a need for cover on steep slopes to stop erosion, this method is excellent.

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