REMEDIATION OF FIRE-INDUCED HYDROPHICITY
HEAP'S PEAK – SAN BERNARDINO NATIONAL FOREST

BIO REMEDIES, LLC
August 1, 2004

Background

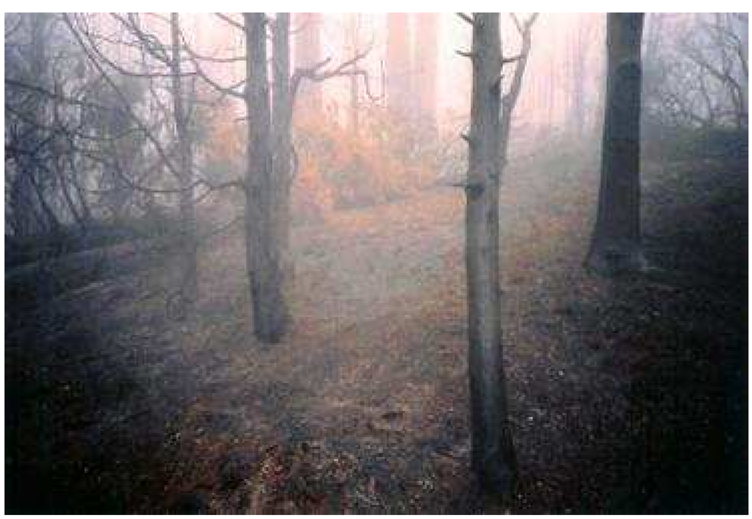
The test area was damaged by the "Old Fire" during late October and early November, 2003, which burned a total of 91,281 acres. According to Jeff Paulo of the Old Fire BAER team, during the early stages of the fire, Santa Ana winds dominated. During the course of the fire, winds shifted direction and pushed the fire over the crest of the divide at a narrow saddle at the Heap's Peak test location. Although the fire moved fairly quickly through the saddle, the crown fire was intense and damage to the soil was severe. Duff and underlying vegetation were completely destroyed, and High hydrophobicity (Fire Effects Guide - strongly hydrophobic at 1 inch from the surface) was noted throughout the site. Our initial site visit was during a light, steady drizzle which, despite the fact that soils are sandy, resulted in spots of puddling at the surface due to the hydrophobicity.

Hypothesis

Experts disagree on the mechanisms by which hydrophobicity is remediated. However, the use of bioremediation techniques has been commonplace for at least the last 10 years in remediation of hydrocarbon spills, and it was our hypothesis that exactly the same materials and methodologies could be applied to post-fire hydrophobicity caused by emplacement of aliphatic hydrocarbons into the soil during the burn. This study is based on this hypothesis and demonstrates a successful technology to alleviate or eliminate the problem of hydrophobicity and help to prevent disastrous erosion in burned areas.

Location

The Heap's peak test area is located in the San Bernardino National Forest approximately 3 miles NW of the town of Running Springs, adjacent to Forest Road 2N23 approximately 200 yards north of State Highway 18 (SE ¼ of the NE ¼ , Section 25, T2N, R3W, San Bernardino Principal Meridian).



December, 2003

Coverage

The test area covers approximately 50,000 sq. ft., which includes two control quadrangles of 10,000 sq. ft. each, and 3 treated quadrangles, each covering 10,000 square feet. A schematic of the test area is shown in Plate 1. GPS coordinates of the corners of the test area are shown in Table 1.

Table 1

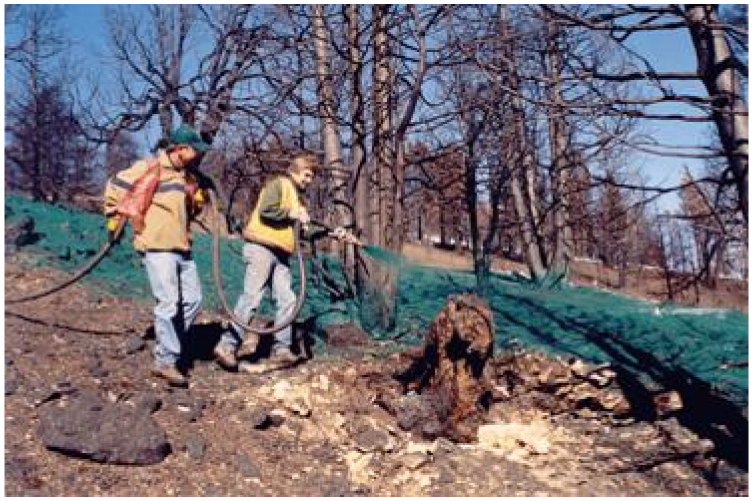
	Latitude (N)		Longitude (W)	
Point	Degrees	Minutes	Degrees	Minutes
SE	34^0	13.978	117^0	08.269
SW	34^0	13.955	117^0	08.314
NW	34^0	13.968	117^0	08.335
NE	34^0	13.996	117^0	08.299

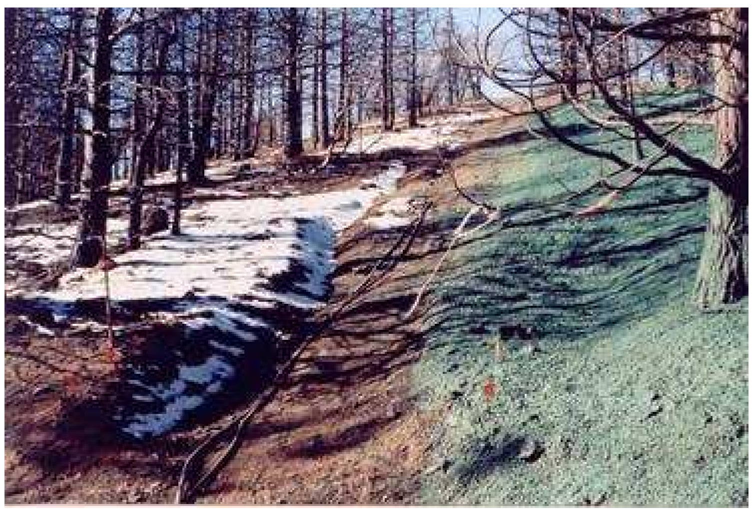
Treatments

As indicated on the schematic of the site (Plate 1), the area was divided into 5 rectangles, each covering 10,000 sq. ft. The two control strips are at either end of the test area and treatments were applied to the 3 center rectangles. Treatments were applied on December 16, 2003, by which time several precipitation events had taken place, including a few inches of snow on the test site. Treatment was applied over the sparse snow cover, which was melting during the application, and moist soil. The treatments consisted of:

- Hydro-mulch only (hydro mulch courtesy of Fiber Marketing International, Inc.)
- Hydro-mulch with 92 lbs. of MicroRestore (MR) (equivalent to a rate of 400 lbs./acre)
- Hydro-mulch with 92 lbs. of Terra Pro-inoculated MicroRestore (TPMR) (equivalent rate of 400 lbs./acre), with the equivalent of 100 lbs. per acre of an organic protein (nitrogen) source

Site just prior to treatment


Applying Hydromulch


Control Area – left, Treated Area – right

Objectives

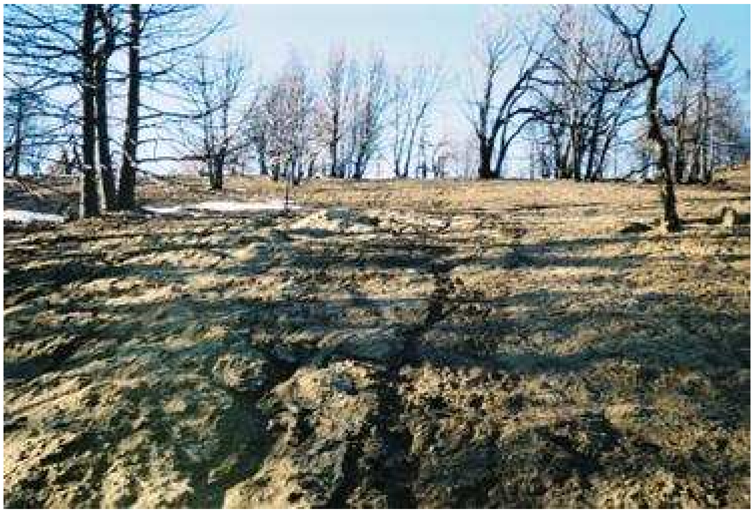
The objectives of the test were to investigate the effects of the various treatments on the following:

- Soil stabilization
- Remediation of the hydrophobic layer
- Re-establishment of a healthy, diverse soil biota (bacteria and fungi)
- Re-growth of native vegetation either from roots or seed transported into the area post-fire

Results

Soil Stabilization

Soil stabilization was good throughout most of the project during the test period, mid-December through April, demonstrating the performance of the Fiber Marketing hydro-mulch. Heavy rains during late January caused moderate rilling along the NE part of the project.


Rilling from heavy rains

Remediation of Hydrophobicity
As mentioned above, hydrophobicity was High and ubiquitous over the entire test area at the time of treatment. The majority of measurements taken immediately post-fire showed a strong hydrophobic layer at approximately 1 inch depth.

Measurements taken in April of 2004, approximately 5 months after treatment, (rated using the approved methodology in the Fire Effects Guide) are shown below. The measurement technique was to test the length of time required for a droplet of water to dissipate and penetrate the soil at successive depths from the surface to a depth of 3". The measurements show good improvement in both the MR and TPMR treated areas at both upper slope and mid-slope, as hydrophobicity was reduced from High to Low. In fact, the middle-slope sample in the MicroRestore-treated area showed complete remediation as hydrophobicity was measured at zero.

L. CONTROL		TPMR		MICRORESTORE		MULCH ONLY		R. CONTROL	
Upper Slope		Upper Slope		Upper Slope		Upper Slope		Upper Slope	
Before	After	Before	After	Before	After	Before	After	Before	After
HIGH	HIGH	HIGH	LOW	HIGH	LOW	HIGH	MED.	HIGH	HIGH
Mid-slope		Mid-slope		Mid-slope		Mid-slope		Mid-slope	
Before	After	Before	After	Before	After	Before	After	Before	After
HIGH	HIGH	HIGH	LOW	HIGH	NONE	HIGH	MED.	HIGH	HIGH
Lower slope		Lower slope		Lower slope		Lower slope		Lower slope	
Before	After	Before	After	Before	After	Before	After	Before	After
HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH

Hydrophobicity / Water Repellency Ratings (Fire Effects Guide): **Before** (Dec., 2003) and **After** (April, 2004)

In the deeper measurements (3") near the bottom of the slope the hydrophobicity remained high, i.e. it did not appear to have been affected yet by the treatments. It is important to note, however, that the shallow measurements (above 2") in this area actually show good improvement as they show only slight hydrophobicity. In this particular area, prior to treatment, there was strong hydrophobicity at 1" depth, as well as strong hydrophobicity at the deeper levels. Our interpretation of this area is that it had the highest intensity fire and thus, apparently, a higher degree of hydrophobicity at all levels both shallow and at 2 ½ to 3 inches depth. It was assumed at that time that bio-activity would continue to increase at depth and the deeper water repellency will also be remediated with time.

Measurements taken in July of 2004 (lower slope only) indicate that this was a reasonable expectation. The table below demonstrates the improvement in the lower-slope area of the TPMR and MR treatments, as well as in the hydro-mulch only treated area. The TPMR treatment and hydro-mulch only showed moderate improvement from High to Medium hydrophobicity, whereas the MicroRestore treatment showed complete remediation at the depths tested (0-3").

L. CONTROL		TPMR		MICRORESTORE		MULCH ONLY		R. CONTROL	
Upper Slope		**Upper Slope**		**Upper Slope**		**Upper Slope**		**Upper Slope**	
Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
HIGH	HIGH	HIGH	LOW	HIGH	LOW	HIGH	MED.	HIGH	HIGH
Mid-slope		**Mid-slope**		**Mid-slope**		**Mid-slope**		**Mid-slope**	
Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
HIGH	HIGH	HIGH	LOW	HIGH	NONE	HIGH	MED.	HIGH	HIGH
Lower slope		**Lower slope**		**Lower slope**		**Lower slope**		**Lower slope**	
Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
HIGH	HIGH	HIGH	MED.	HIGH	NONE	HIGH	MED.	HIGH	HIGH

Hydrophobicity / Water Repellency Ratings (Fire Effects Guide): **Before** (Dec., 2003) and **After (July, 2004)**

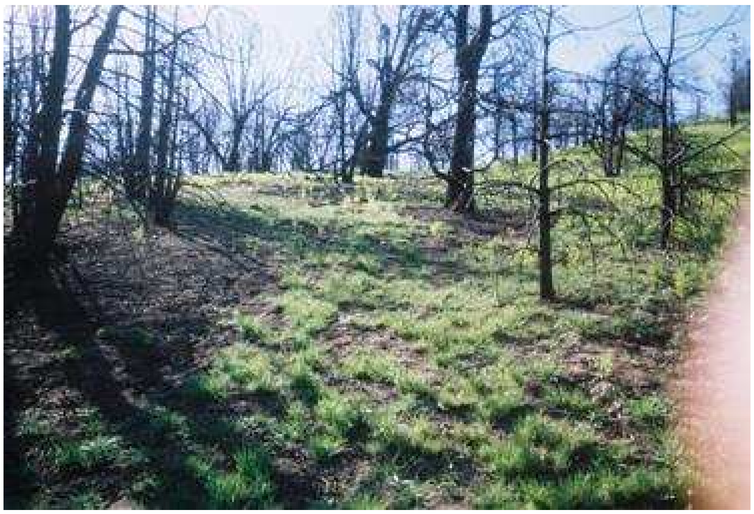
Soil Biota

A baseline composite sample was analyzed for total and active bacterial biomass and total and active fungal biomass. Results of the baseline test indicate that total bacterial and active bacterial biomass were in the low end of the "good" range prior to treatment. Total and active fungal biomass was very low, although beneficial fungi were present.

A soil sample of the TPMR area was taken in early January, 2004 and the results show that active bacterial biomass had increased to an acceptable level for the particular season, although total bacterial biomass had not increased. Active and total fungal biomass had both decreased, possible due to the increased bacterial activity. Soil samples taken in April of 2004 indicate levels of bacterial and fungal biomass in the desired range. Active fungal biomass was low across the board, although the TPMR area had slightly higher readings than the MR, mulch only and one of the control samples. Active bacterial biomass was high in the TPMR area. One interesting result is that the level of active bacterial biomass in the MR treatment was low. The recommendation for this area was addition of a food source such as high-energy sugar or amino-sugar, indicating that the indigenous food source (including hydrocarbon) had most likely been exhausted.

Re-growth of Native Vegetation

Re-growth of native vegetation by April of 2004 was good in the upper slope and mid-slope areas, particularly away from burned trees or clusters of trees. The lower slope area (originally heavily treed) was still bare for the most part, which we believe was related to the severity of the burn in that area destroying native seeds and roots. The amount of vegetation cover did not appear to be a function of whether or not the ground was treated. The severity of initial burn was interpreted to have been the major control at that point in time, as non-treed areas regenerated more rapidly.



April, 2004 – vegetation established in open areas away from clusters of burned trees

April, 2004 – vegetation in open areas

An important change in the vegetation was noted during the July, 2004 examination. It was noted that in the two-month period since April, ferns had been established and were growing to heights of 6 to 8 inches in the TPMR area and in the MR area. This step in the succession of species is very significant as it is interpreted to be due to a maturing of soil biota and a quicker return to natural conditions. As ferns are among the species known to establish an association with endomycorrhizae, it is interpreted that the fungal community in the treated areas had re-generated much more quickly in these two areas than in the untreated areas.

Ferns growing in TPMR area – control on left

CONCLUSIONS

All treatments had a positive effect on the hydrophobicity, with the best results being from application of MicroRestore and Terra Pro-inoculated MicroRestore. Therefore, treatments in order of preference for this type of application are:

1. MicroRestore – 400 lbs. per acre (granular agricultural grade or finer)
2. Terra Pro-inoculated MicroRestore – 400 lbs. per acre, of the same grade, with protein source
3. Hydromulch

RECOMMENDATIONS

Severely burned areas in which hydrophobicity is high, especially within 1-2" of the surface can be remediated using MicroRestore or Terra Pro-inoculated MicroRestore at the rates applied in this study. The application of hydromulch in addition to these treatments adds the additional benefit of soil stabilization during remediation and has shown to have a positive effect on the remediation process. Based on this test, we would recommend either the MicroRestore or Terra Pro-inoculated MicroRestore (plus protein) treatment for post-fire rehabilitation in any situation in which hydrophobicity or water-repellency is a problem.

ACKNOWLEDGEMENTS

We would like to thank the following contributors:

- Michael Melendrez - Soil Secrets – Los Lunas, NM for supplying Terra Pro inoculum and protein source

- Jeff Paulo – Old Fire BAER Team (permanently assigned to Shasta-Trinity N.F.) for bringing us into the project and encouraging the pilot test
- Steve Loe – San Bernardino N.F., San Bernardino, CA for his kind help and monitoring of this project
- Jay Sadler – Michelle's – Riverside, CA for an excellent job of applying the treatments
- Doug Graham – Fiber Marketing International, Inc. – Littleton, CO for donating the hydromulch and help with application

HEAP'S PEAK PROJECT AREA
SAN BERNARDINO N.F.

CONTROL **← 50 ft. →**	HYDRO-MULCH + TERRA PRO Inoculated MICRORESTORE	HYDRO-MULCH + MICRORESTORE	HYDROMULCH ONLY	**CONTROL**

Plate 1