The Effects of Aerial Hydromulch on Hillslope Erosion and Plant Recovery Following Wildfire in Chaparral Shrublands

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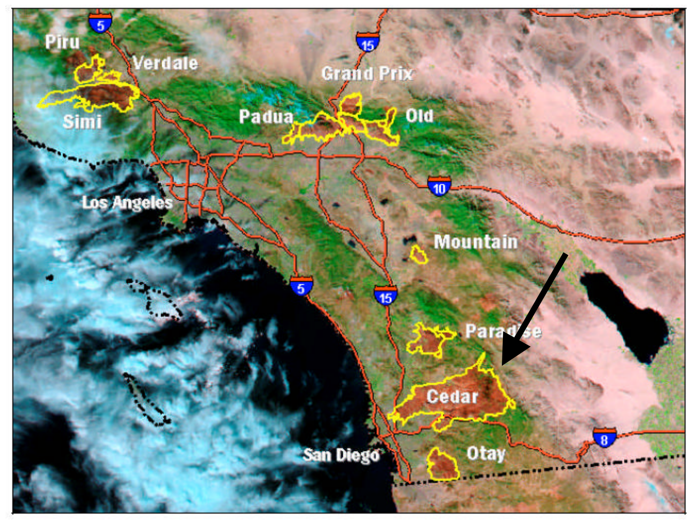
INTRODUCTION

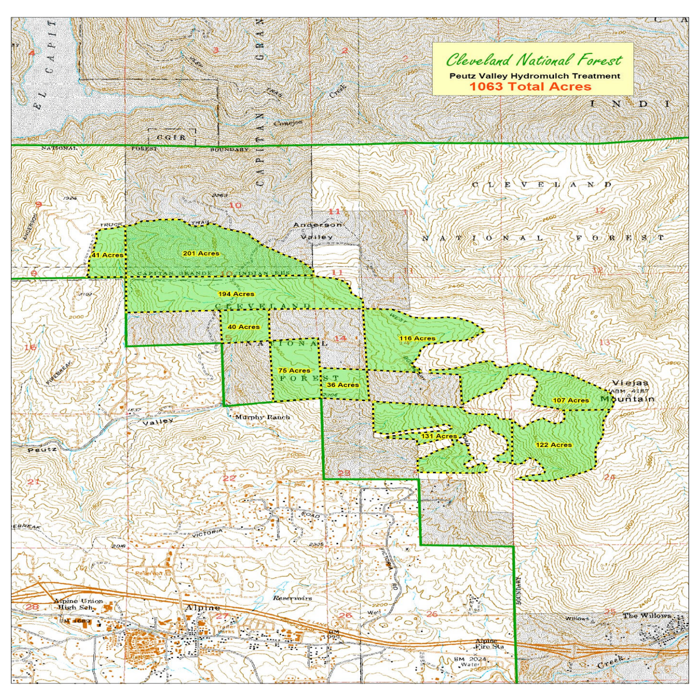
The 2003 Cedar Fire consumed 284,790 acres, destroyed approximately 2,700 residences, and claimed 16 lives. To protect the community of Peutz Valley, aerial hydromulch (wood and paper matrix mixed with a non water-soluble binder) was applied by helicopter at both 50 and 100% cover on the contributing watersheds to help reduce flood peaks and sediment yield downstream. The 50% cover was placed on the contour at 30 m intervals. Effectiveness monitoring of aerial hydromulching was conducted to determine if the treatment was effective in preventing erosion, and to investigate if plant recovery was hindered by the treatment. In addition, we compared the treatments on two different parent materials, granite and gabbro.



False-color infrared MODIS scene showing fire locations, acquired November 5, 2003 (Clark et al. 2003).

OBJECTIVES

- To determine the effectiveness of aerial hydromulch in controlling post-fire hillslope erosion.
- To evaluate changes in percent plant cover and individual species.



Map showing planned treatment coverage. Areas burned belonging to the Capitan Grande Reservation were treated with "100%" aerial hydromulching, while Forest Service lands were treated with strip aerial hydromulching to provide "50%" coverage. It is important to note that the average hydromulch cover area was far below the planned 100 and 50% cover targets. Mean values for actual coverage after application were 51% for the "100%" treatment and 30% for the "50%" strip treatment.

Hydromulch was applied in 30 m wide strips for the "50% treatment". On the surface, the hydromulch tended to be thicker at the center of the strip, decreasing towards the edges of the strip.

Hydromulch strip treatment applied at 30 m intervals on the contour.

METHODS

To monitor hillslope erosion, we installed a total of 54 silt fences at the site. Silt fences were distributed as follows: gabbro control = 13; gabbro strip 50% cover = 11; granitic strip 50% cover = 10; 100% cover granitic = 10, and granitic control = 10.

Plant recovery was measured using 1 m^2 grids that were separated into one hundred 10 cm^2 grids. We sampled 5 plots at each of the 54 silt fences for a total of 280 individual sampling sites. Five rain gauges were placed within the perimeter of the site.

Silt fence construction viewed from contributing area. Note red chalk designating surface boundary.

To locate and place the 1 m^2 grids, we used the contributing boundaries that extended up from the silt fences for 100 ft on both sides as transects. On the right side looking up from the silt fence, we sampled at 5 m, 15 m, and 25 m. On the left side boundary, we sampled at 10 and 20 m.

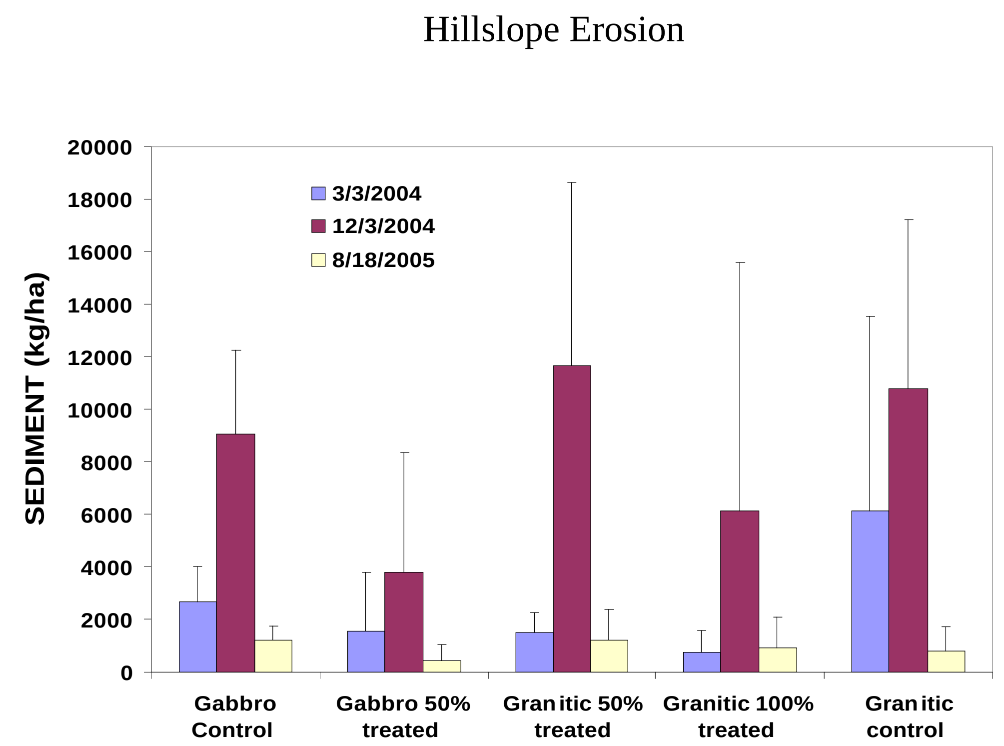


Fig. 1. Sediment production measured at three different time intervals following the fire. Five treatment categories were studied: (1) Gabbro control, (2) Gabbro 50% treated, (3) Granitic 50% treated, (4) Granitic 100% treated, and (5) Granitic control.

Table 1. Recorded monthly precipitation during time interval preceding the sediment removal date.

Sediment removal date	Monthly precipitation (mm) preceding sediment removal date.								Total
Mar 3, 2004	Nov 03 33.0	Dec 03 43.2	Jan 04 20.3	Feb 04 109.2					200.7
Dec 3, 2004	Apr 04 30.4	May –Sep 04 0.0	Oct 04 238.8						269.2
Aug 18, 2005	Nov 04 15.2	Dec 04 104.1	Jan 05 137.2	Feb 05 121.9	Mar 05 58.4	Apr 05 25.4	May 05 12.7	Aug-Sep 2.5	477.4

On the 3/3/2004 sampling date, it is evident that hydromulch reduced erosion in both the 50% strip and 100% cover treatments. However, the below normal rainfall amounts resulted in erosion totals in the control plots that were well below predicted amounts. It was also assumed that the hydromulch controlled the movement of water by allowing greater infiltration.

After the above normal October rainfall events, far greater hillslope erosion occurred as seen in for the 12/3/2004 sampling date. The 50% hydromulch treatment on the gabbro was effective in decreasing erosion by more than half of what occurred on the control sites. On the granitic sites, the 100% hydromulch treatment was effective in reducing erosion, but erosion on the 50% treated sites was greater than the control. It appeared that the intensity of the rain events toward the end of October was an important factor in determining overland flow, especially when antecedent soil moisture conditions were near or at field capacity.

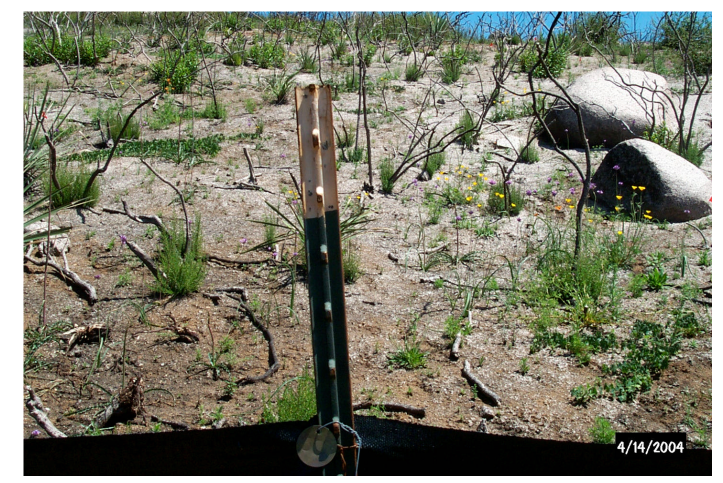
Fig. 2. Comparison of rock cover between gabbro and granitic parent materials.

Although rock cover was much greater on gabbro parent material, it may have promoted erosion under high intensity rain events, as evidenced by the formation of rills below some of the rock boulders.

RESULTS & DISCUSSION

Photo of the burned area underlain by granitic parent material taken in December 2004. There were few signs of vegetation recovery at this time.

View of contributing area of silt fence 39 (100% treatment-granitic) showing vegetation recovery on 2/19/2004. Chamise skeletons were just beginning to resprout.



Same view of contributing area of silt fence 39 (100% treatment-granitic) showing vegetation recovery on 4/14/2004. Chamise were vigorously resprouting.

View of site on 8-18-2005. Vegetation cover at this time was 72%.

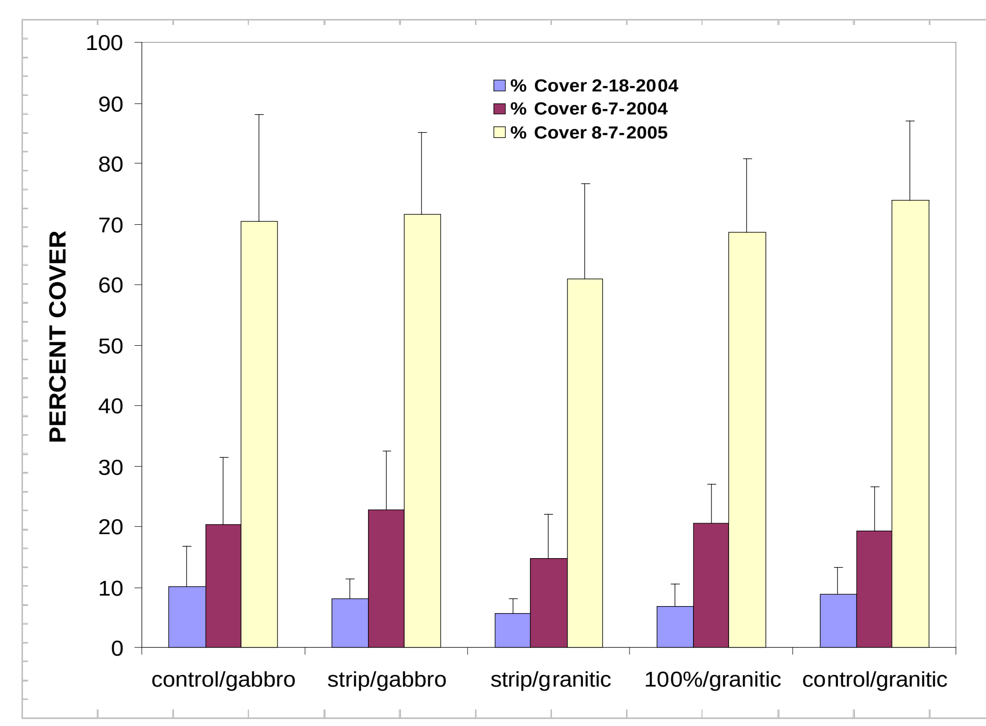


Fig. 3. Percent plant cover measured on February 18, 2004, June 7, 2004, and August 7, 2005.

Table 2. Second year (sampling date 8-7-2006) percent cover as to cover type: gravel (<3 in), rock (>3 in), bare soil, stump, litter, downed wood (<2 cm), downed wood (>2 cm), total plant cover, and individual plant species cover.

Cover Type			Percent Cover				
			Gabbro Control	Gabbro 50% treated	Granitic 100% treated	Granitic 50% treated	Granitic Control
Gravel (<8 cm)			3.4	0.8	0.0	0.0	0.1
Rock (>8 cm)			7.0	12.8	0.0	0.2	0.1
Bare soil			12.2	7.9	12.2	23.3	26.3
Stump			0.5	0.3	0.1	0.2	0.0
Litter			5.9	5.8	12.3	7.7	10.0
Downed wood <2 cm)			0.5	0.4	0.7	0.4	2.2
Downed wood >2 cm)			0.3	0.0	0.4	0.0	0.4
Treatment			0.0	0.0	0.0	0.0	0.0
Plant cover (genus/species)	(Common name)	(Category)					
Adenostoma fasciculatum	Chamise	shrub	10.2	7.2	27.2	17.4	13.2
Allium haematochiton	Red-skinned onion	forb	0.0	0.2	0.0	0.0	0.0
Arctostaphylos glandulosa	Eastwood Manzanita	shrub	4.5	0.2	0.0	0.0	0.0
Avena Sp.	Oats	grass	0.0	0.6	0.0	0.0	0.0
Bromus rubens	Red brome	grass	3.3	5.5	1.1	9.3	2.2
Calamagrostis koeleri oides	Fire reedgrass	grass	0.0	0.0	0.0	0.0	0.0
Calochortus weedii	Weed's mariposa lily	forb	0.0	0.1	0.0	0.0	0.0
Calystegia macrostegia	Morning glory	vine	18.7	30.2	1.2	3.1	0.0
Ceanothus crassifolius	Hoaryleaf ceanothus	shrub	0.0	0.1	0.0	0.0	0.2
Ceanothus oliganthus	Hairy-leaf ceanothus	shrub	0.0	0.0	0.0	0.0	2.1
Centaurea maculosa	Spotted knapweed	forb	0.5	0.0	3.2	7.6	2.3
Chaenactis artemisiifolia	White Chaenactis	forb	0.1	0.0	0.7	0.0	0.0
Chlorogalum pomeridianum	Soap plant	forb	0.0	0.0	0.0	0.0	0.1
Clematis pauciflora	Squawbush	vine	0.0	0.2	0.0	0.0	0.0
Cneoridium dumosum	Coast spice bush	shrub	0.2	0.0	5.2	0.3	1.2
Cryptantha spp.	Catseye	forb	6.1	1.6	13.0	12.8	1.3
Dichelostemma capitatum	Blue dicks, wild hyacinth	forb	0.2	0.0	5.9	2.8	10.4
Emmenanthe penduliflora	Whispering bells	forb	0.1	0.0	0.0	0.0	0.0
Erigeron foliosus	Leafy daisy	forb	1.4	0.0	0.0	0.0	0.0
Eriophyllum confertiflorum	Golden Yarrow	forb	0.2	0.2	0.0	0.0	0.0
Hazardia squarrosa	Sawtooth goldenbush	forb	1.8	0.7	1.7	0.3	2.4
Helianthemum scoparium	Sun rose	forb	1.2	0.0	6.0	6.1	2.3
Helianthus gracilentus	Slender sunflower	forb	0.1	0.0	0.0	0.0	0.6
Hesperolinon micranthum	Smallflower dwarf-flax	forb	0.3	0.1	0.1	0.0	0.3
Heteromeles arbutifolia	Toyon	shrub	0.7	0.6	0.0	0.0	0.0
Hirschfeldia incana	Shortpod mustard	forb	0.1	1.2	0.0	0.0	0.1
Koeleria macrantha	June grass	grass	0.0	0.0	0.0	0.0	0.1
Lasthenia californica	Goldfields	forb	5.8	16.7	0.0	0.0	0.0
Logfia gallica	Narrowleaf cottonrose	forb	0.1	0.0	0.8	1.9	10.3
Lonicera subspicata	San Diego honeysuckle	shrub	0.9	0.1	0.0	0.0	0.0
Lotus scoparius	Deerweed	forb	3.5	0.5	5.3	0.0	1.9
Malosma laurina	Laurel sumac	shrub	1.2	0.1	0.0	0.0	0.0
Phacelia cicutaria	Caterpillar phacelia	forb	0.0	0.2	0.0	0.0	0.0
Phacelia minor	Canterbury bells	forb	0.0	0.1	0.0	0.0	0.0
Quercus berberidifolia	Scrub oak	shrub	5.2	2.2	0.0	0.0	0.0
Rhamnus crocea	Redberry buckthorn	shrub	0.5	0.2	0.2	0.0	4.8
Rhus ovata	Sugar bush	shrub	0.0	0.0	0.4	0.0	0.0
Salvia apiana	White sage	forb	1.1	0.2	0.0	0.0	0.1
Salvia columbariae	Chia	forb	0.1	0.0	0.1	0.0	0.0
Scrophularia californica	Bee-plant	forb	0.0	0.0	0.1	0.0	0.0
Taraxacum officinale	Dandelion	forb	1.2	0.5	0.0	0.0	0.1
Trichostema parishii	Mountain Bluecurls	forb	0.0	0.1	0.0	0.0	0.0
Vulpia myuros	Rat tail fescue	grass	0.7	0.1	0.2	0.0	1.3
Xylococcus bicolor	Mission manzanita	shrub	0.1	0.3	1.0	5.4	3.2
Yucca whipplei	Chaparral yucca	forb	0.5	0.6	0.4	1.5	0.0
Unknown # 3			0.0	0.8	0.0	0.1	0.0
Unknown # 4			0.0	0.4	0.0	0.0	0.0
Total plant cover			70.5	71.6	74.0	68.6	60.9

By June 7, 2004, vegetation cover was near or above 20% at all plots, which was exceptional with the very low rainfall season following 5 years of drought (Fig. 3). In most cases, it appeared that the hydromulch did not affect % cover. Lowest % recovery occurred in the 50% strip hydromulch treatment. This may be due to over application of hydromulch. In some areas the mulch could be 1 to 2 inches thick.

Following the very wet rainfall season of 2004-2005, vegetation cover dramatically increased at all sites, averaging near 70% cover (Fig. 3).

Most importantly, the hydromulch treatment cover has vanished (Table 2). High precipitation from October 2004 through the spring of 2005 aided in the breakdown of the mulch.

Rock cover decreased because of sampling method. First cover encountered was counted with pin drop. In many locations, vegetation had grown sufficiently to cover rocks.

It appears that growth of chamise (*Adenostoma fasciculatum*) was enhanced by the treatment on the granitic soils. This may be due to increased moisture availability to the plants (Table 2). Morning Glory (*Calystegia macrostegia*) was abundant in the gabbro soils, but was seldom seen in the granitic soils. The forb goldfields (*Lasthenia californica*) also was abundant on the gabbro soils, but was not observed on the granitic soils. This appeared to be a nutrient relationship inherent to differences between gabbro and granitic soils. Catseye (*Crypthanta spp*.), on the other hand, was more abundant on the treated granitic soils. It's growth appeared to be enhanced by the hydromulch treatment. The results suggested that % cover of the invasive grass, red brome (*Bromus rubens*) increased in treated areas.

Sensitive and endangered spp. that are restricted to Gabbro soils include:

Parry's tetracoccus (*Tetracoccus dioucus*)
Felt-leaved monardella (*Monardella hypoleuca ssp. lanata*)
San Miguel Savory (*Satureja chandleri*),
Otay manzanita *(Arctostaphylos otayensis)*
Dunn's Mariposa Lily (*Calochortus dunnii*)

We did not observe any of the above species within the experimental plots. Because of their scarcity, however, it is possible they were not picked up in the survey.

CONCLUSIONS

- The true application cover rates of hydromulch (30% - 50% treated and 51% - 100 % treated) were far below the projected cover amounts.
- The hydromulch treatment was effective in reducing erosion the 1st year during mild rain events on both gabbro and granitic parent materials. Results were mixed the 2nd year following severe October rain events. The treatment was effective in reducing erosion on the gabbro 50% treated site and the 100% treated granitic site, but was not effective on the 50% treated granitic site.
- It appeared that both hydromulch treatments did not affect 1st or 2nd year percent plant cover on either gabbro or granitic parent materials.
- The hydromulch treatment vanished the 2nd year after the heavy winter rains.
- Percent cover of morning glory, goldfields, catseye, and red brome all increased in the presence of hydromulch

References

Clark, J., Parsons, A., Zajkowski, T., Lannom, K. 2003. Remote Sensing Imagery Support for Burned Area Emergency Response Teams on 2003 Southern California Wildfires. RSAC-2003-RPT1 Remote Sensing Applications Center, Salt Lake City, Utah