Soil Report for the Silverado Fire
Cleveland National Forest

Resource Specialty: Soil
Fire Name: Silverado, Cleveland National Forest
Incident #: CA-CNF-002873
Month and Year: September 2014
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Introduction

The soil assessment and report represents a post-fire rapid evaluation conducted to determine if critical values are at risk due to imminent post-fire threats and to develop appropriate actions to manage unacceptable risks. The post-fire soil assessment and report is not intended to provide a comprehensive evaluation of all fire or suppression damages, to evaluate post-fire damages after they occur, nor to identify long-term rehabilitation or restoration needs.

The objectives of the soil post-fire assessment and report include: i) assessing post-fire soil conditions ii) quantifying erosion potential, iii) identifying unacceptable risks to critical values, e.g., human life and safety, property, natural resources, and cultural and heritage resources, on National Forest System lands, and iv) recommending actions that manage the unacceptable risks either by reducing the probability of occurrence or lessening the anticipated consequences.

The loss of vegetation due to fire can have several negative effects on soil productivity and hydrologic function including increased runoff, increased erosion rates, loss of productive soil layers, higher peak flood flows, and water quality impairment, etc. Fire can also induce water repellency known as hydrophobic soils, which reduces water infiltration, increases surface runoff and erosion rates.

Potential Values at Risk

Critical values on National Forest System lands are divided into 4 categories (human life and safety, property, natural resources, and cultural and heritage resources) and were identified prior to the on-the-ground survey as the following:

<u>Human Life and Safety</u>

- Community of Silverado residents and visitors including surrounding areas

<u>Property</u>

- Community of Silverado structures (homes, etc.) including surrounding areas
- Silverado Canyon Road (County)
- Maple Springs Road (FS 5S04)
- Silverado Trail (FS 5S03)
- Southern California Edison (SCE) power lines
- Irvine Lake
- Maple Springs Visitor Center

Natural Resources

- Soil Productivity
- Water Quality
- Arroyo Toad habitat
- Native vegetative recovery and sensitive plants and wildlife
- Weed invasion

Cultural and Heritage Resources

- Archaeological sites

Resource Condition Assessment

Resource Setting

The fire started on September 12th and was reported as fully contained on September 20, 2014. The fire consumed 960 acres of NFS lands (T5S R7W Sections 1,2,10, and 11) on the Trabuco Ranger District of the Cleveland National Forest in steep, rugged Santa Ana Mountains near the community of Silverado.

Approximately 98 percent of the soil type within the burn area is the Friant series. The Friant series is a fine sandy loam consisting of somewhat excessively drained soils formed in material weathered from fine grained metasedimentary rock. This soil is generally found in the mountains on slopes of 30 to 70 percent. Vegetation is mostly California sagebrush, lower montane mixed chaparral, buckwheat, and other common brush plants. Annual precipitation is 16 to 25 inches primarily falling in the winter months (USDA NRCS 2013).

This report surveys (rapid assessment) those subwatersheds inside the fire perimeter near the Silverado Canyon and Maple Springs roads north and northeast of the community of Silverado.

Observation and Findings

Working as an interdisciplinary team of specialists including hydrology, soil science, biology, botany, archaeology, and geographic information systems, an on-the-ground survey was conducted to evaluate post-fire watershed conditions. The burned area was surveyed using both satellite imagery and on-the-ground monitoring to identify post-fire soil burn severity, soil water repellency, and critical values at risk.

Soil burn severity is described as the effect of a fire on ground surface characteristics; including char depth, organic matter loss, altered color and structure, and reduced infiltration. The classification of post-fire soil condition is based on fire-induced changes in the physical and biological soil properties and classified into one of 3 ratings (low, moderate, and high). The overall burn severity summary for the 960 acre Silverado Fire was 1 acre High, 396 acres Moderate, and 563 acres Low and Unburned.

In general terms, a low burn severity rating is identified when surface organic layers are not completely consumed and are still recognizable, roots are generally unchanged having not been consumed, ground surface may appear brown or black, and the canopy and understory vegetation will likely appear unharmed or “green”. A moderate burn severity rating may have up to 80 percent of the pre-fire ground cover consumed, fine roots may be scorched but rarely consumed over much of the area, and the color of ash on the surface is generally blackened with possible gray patches. A high soil burn severity would have all or nearly all of the pre-fire ground cover and surface organic

matter (litter, duff, and fine roots) consumed, and charring may be visible on larger roots, the prevailing color of the site is often “black” due to extensive charring, bare soil and ash is exposed and susceptible to erosion, white or gray ash indicates that considerable ground cover or fuels were consumed, and soil is often gray, orange, or reddish at the ground surface where large fuels were concentrated and consumed. The loss of effective ground cover is the single most important change that can greatly increase erosion and runoff (Parsons, Robichaud, Lewis, Napper, & Clark, 2010).

Soil water repellency is affected by the pre-fire soil texture and type, amount and depth of litter cover, soil moisture, soil organic matter, and the temperature and residence time of the fire. The Friant series are a fine grained soil and typically less prone to fire-induced water repellency than coarse-grained soils. Naturally water repellent soils are also frequently found under canopies of individual sage or chaparral shrubs and were confirmed during on-the-ground monitoring within the burn area. Soils exhibiting water repellency were identified on 42 percent of the burn area and primarily from the surface layer down to 1-cm in depth.

Erosion is a natural process occurring on landscapes. When a landscape is denuded by disturbance, such as fire, then the rate of erosion continues to increase with increasing precipitation. Past evidence of sheet, rill, and gully erosion along with dry ravel and mass failures including debris flows were observed during post-fire evaluations. Chaparral occupying steep slopes similar to pre-fire conditions within Silverado Canyon has a high potential for mass failures, particularly when deep-rooted chaparral species are replaced with shallower-rooted grass species. These mass failures are a large source of sediment delivered to stream channels (Neary, Ryan, & DeBano, 2005).

Post-fire erosion rates were modeled using both the Erosion Risk Management Tool (ERMiT) developed by the U.S. Forest Service (Robichaud et al, 2007), which is a web-based model that estimates erosion, in probabilistic terms, on burned and recovering forest, range, and chaparral lands with and without the application of erosion mitigation treatments (mulch, erosion-barriers, and seeding) and with a classic study conducted by Rowe, Countryman, and Storey (1949) based on real data collected from many burned and unburned watersheds in Southern California to estimate probable erosion rates from southern California watersheds as influenced by fire.

Most likely erosion rate estimates for the 1st year following the fire vary between 25 to 31 tons per acre as compared to normal background erosion rates of 2 to 3 tons per acre. ERMiT provides additional erosion rate estimates based upon percent probability of sediment exceedance and has a 2 percent chance of having a sediment yield as high as 233 tons per acre in the 1st year following the fire. The 1st and 2nd year following the fire typically produce the highest levels of sediment yield. Additional information and data on ERMiT and Rowe, Countryman, and Storey can be found in Appendix A.

Emergency Determination

On-the-ground surveys including water repellency testing and soil burn severity were conducted September 15th, 16th, and 19th to assist in identifying potential threats to critical values due to flooding during high stream flows, erosion, and potential debris flows.

Structures immediately downslope and/or downstream of the fire boundary particularly those along the north side of the channel as well as Silverado Canyon and Maple Springs road (including bridge crossings) in and around the community of Silverado are at risk of flooding and mud/debris flows capable of causing significant damage to human life and safety and property from precipitation events for the next 5 to 7 years following the fire.

The potential for damage to the nutrient, physical, and biotic soil characteristics (soil productivity) by fire is low or unlikely meaning good performance can be expected and little or no maintenance is needed, however the erosion hazard for this soil type following a disturbance such as fire where 50 to 75 percent of the surface has been exposed is described as having a “very severe” erosion hazard rating meaning that significant erosion is expected and off-site damage are likely, and erosion-control measures would be costly and generally impractical (USDA NRCS 2013).

Treatments to Mitigate the Emergency

Burned Area Emergency Response (BAER) treatment options are grouped into several categories including (land, channel, road and trail, and protection and safety). The BAER assessment team identifies appropriate treatments and measures that best respond to the potential threats or hazards using reliable methods (Napper 2006). When reviewing treatment options several factors are considered including treatment effectiveness. Due to the steep nature of the hillslopes and highly erosive soils within the burn area many available land and channel treatment options such as aerial hydromulching, straw mulch, fiber rolls or wattles, checkdams, etc. would be impractical, not effective, and may have a hazard associated with the treatment implementation. Recommend road and trail and protection and safety treatments intended to mitigate the emergency include:

Waterbars/Trail Stabilization (Silverado Trail):

- The potential for damage to the Silverado trail due to increased water flows, poor drainage, and excessive erosion exists from the burn area. The trail is a major source of sediment to the community below and will continue at a greater rate due to the fire. Waterbars installed near locations of active erosion will slow surface runoff and dissipate sediment from upslope source areas reducing the available supply of sediment and lessening the active erosion. Estimated time and cost: 12 days and $9,000.

Road/Trail Closure, Warning Signs (Silverado Trail, Maple Springs Road, and North Main Divide Road):

- Loss of road and trail due to increased surface runoff and erosion plus active movement of upslope material have a very high risk of occurrence. Preventing access to the trailhead and roads using gates or other type of barrier plus warning signs will prevent or limit possible human access and injury and further damage to the road and trail system. Estimated time and cost: 10 days and $27,500.

Storm Inspection and Response (Maple Springs Road and North Main Divide Road):

- USFS employee(s) will drive and observe roads during or immediately after storms, checking sediment and debris accumulations and performing thorough, rapid inspection of road-drainage features, culverts, and other structures. The crew is responsible for maintaining culvert function by opening culvert inlets and removing debris. Estimated time and cost: 4 days and $4,000.

Channel-debris clearing (Silverado Canyon Road):

- Notify appropriate local, state, or federal agencies and recommend monitoring and clearing all bridge crossings of debris from the channel and flood-prone area that could dislodge and plug bridges and culverts downstream. Estimated time and cost: 2 days and $1,000.

Early Warning System (Community of Silverado):

- Notify appropriate local, state, or federal agencies and recommend installation of Flood-warning system(s), commonly called early-warning systems (EWS) to provide local emergency networks, such as police, fire, or emergency preparedness organizations with information on rainfall intensity and duration allowing early detection of hazardous conditions. Provide the community of Silverado with information on EWS. The National Weather Service is responsible for setting thresholds relative to precipitation and issuing flashflood warnings. The Forest Service may be tasked with procuring and locating the EWS on NFS lands. The local emergency network maintains the EWS. The Orange County Flood Control Agency will have more information. Estimated time and cost: 5 days and $4,000.

Summary

The highly erosive soils and steep slopes throughout the Silverado Fire perimeter have the potential for significant erosion and risk to several critical values on NFS lands. The community of Silverado is located within Silverado Canyon and immediately below and downstream of the fire. Increases in flood flows and erosion rates including debris flows much higher than normal are expected for several years with the greatest increases the 1st and 2nd year following the fire before returning to normal background levels.

Land and channel treatments such as aerial hydromulching, straw mulch, straw wattles, etc. to lessen or mitigate the effects of post-fire runoff and erosion were considered for the burned slopes, but are generally found to be ineffective on slopes greater than 50 percent, which includes a large portion of this fire. Seeding was considered, but found to be ineffective and unsuitable as much of the area is steep and rocky. In addition, seeding rarely provides any effective cover the first year after the fire. Most of the pre-fire area was covered in mixed chaparral, chamise, and California sagebrush that are expected to recover to greater than 30% cover within two years.

Controlling access to NFS lands in and around the burned area, conducting storm patrols, implementing trail stabilization, and supporting early warning system efforts for the community of Silverado will all assist in lessening the risks to critical values on NFS lands.

References

Napper, Carolyn. 2006. **Burned area emergency response treatments catalog.** 0625 1801-SDTDC. San Dimas, CA: U.S. Department of Agriculture, Forest Service, San Dimas Technology & Development Center. 266 p.

Neary, Daniel G.; Ryan, Kevin G.; DeBano, Leonard F., eds. 2005. (revised 2008). **Wildland fire in ecosystems: effects of fire on soils and water**. Gen. Tech. Rep. RMRS-GTR-42-vol.4. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 250 p.

Parsons, Annette; Robichaud, Peter R.; Lewis, Sarah A.; Napper, Carolyn; Clark, Jess T. 2010. **Field guide for mapping post-fire soil burn severity.** Gen. Tech. Rep. RMRS-GTR-243. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49 p.

Robichaud, Peter R.; Elliot, William J.; Pierson, Fredrick B.; Hall, David E.; Moffet, Corey A.; Ashmun, Louise E. 2007. **Erosion Risk Management Tool (ERMiT) user manual (version 2006.01.18).** Gen. Tech. Rep. RMRS-GTR-188. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 24 p.

Robichaud, P.R.; Lewis, S.A.; Ashmun, L.E. 2008. **New procedure for sampling infiltration to assess post-fire soil water repellency.** Res. Note. RMRS-RN-33. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 14 p.

Rowe, P.B., C.M. Countryman and H.C. Storey. 1949. **Probable peak discharges and erosion rates from southern California watersheds as influenced by fire**. U.S. Department of Agriculture, Forest Service. California forest and Range Experiment Station. U.S. Government Printing Office: 1973 O-522-184.

U.S. Department of Agriculture, Forest Service. 2013. **Watershed and Air Management.** FSM 2500 Interim Directive No. 2520-2013-1. Washington, DC.

U.S. Department of Agriculture, Forest Service. 2004. **Watershed and Air Management.** FSM 2500 Amendment No. 2500-2004-1. Washington, DC.

U.S. Department of Agriculture, Forest Service. 1995. **Burned-Area Emergency Rehabilitation Handbook.** FSH 2509.13 Amendment No. 2509.13-95-3. Washington, DC.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2013. **Web Soil Survey**. Version 3.1. Soil Survey Staff. http://websoilsurvey.nrcs.usda.gov/. (20 September 2014).

U.S. Department of Agriculture, Soil Conservation Service and Forest Service in cooperation with University of California, Agricultural Experiment Station. 1978. **Soil survey of Orange County and western part of Riverside County, California.** U.S. Government Printing Office: 1978 O-230-734.

Appendix A

Erosion Modeling

Erosion Risk Management Tool (ERMiT)

The post-fire erosion risk was assessed using the Erosion Risk Management Tool (ERMiT). ERMiT is a web-based application that uses Water Erosion Prediction Project (WEPP) technology to estimate erosion, in probabilistic terms, on burned and recovering forest, range, and chaparral lands with and without the application of erosion mitigation treatments. User inputs are processed by ERMiT to combine rain event variability with spatial and temporal variabilities of soil burn severity and soil properties, which are then used as WEPP input parameters. Based on 20 to 40 individual WEPP runs, ERMiT produces a distribution of rain event sediment delivery rates with a probability of occurrence for each of five post-fire years (Robichaud et al., 2007).

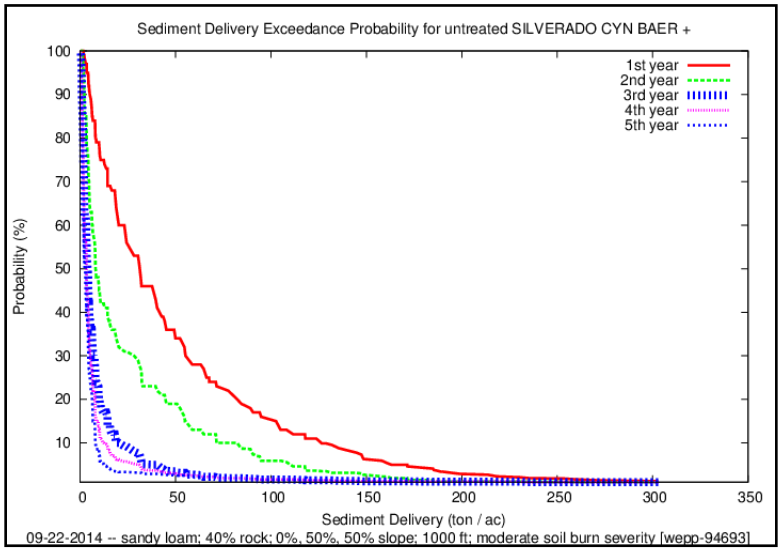

Figure 1. ERMiT sediment delivery exceedance probability for the 1st five years following the fire.

Table 1. ERMiT sediment yield probability for the 1st five years following the fire.

ERMiT (2007) Probability that sediment yield will be exceeded (%)	Sediment Delivery year following fire, untreated (tons ac^{-1})				
	1st Year	2nd Year	3rd Year	4th Year	5th Year
2	233.63	162.45	74.94*	74.94*	74.94*
4	185.01	117.91	43.59*	32.25*	15.77*
10	127.92	82.36	20.78*	12.90*	8.02*
20	82.69	47.78	10.24*	7.71*	6.28*
50	31.13	8.01	3.80*	3.29*	3.11*

Probable Peak Discharges and Erosion Rates from Southern California Watersheds as Influenced by Fire (Rowe, Countryman, & Storey, 1949)

Rowe et al., (1949) produced a classic study on the effect of fire on annual erosion rates by comparing erosion rates of burned watersheds with those of similar unburned watersheds in Southern California. The weighted average ratios between normal annual erosion rates and the annual erosion rates following burning were then computed. These ratios, corrected for variation in proportion of burnable areas, were used in computing probable erosion rates of the individual watersheds by years from time of burning until return to normal. Effects of partial burning of a watershed on erosion rates were assumed to be directly proportional to the area burned.

The Forest Service uses this model to estimate probable erosion rates from southern California watersheds as influenced by fire. Table 1 summarizes the erosion rates of the Silverado fire within the fire perimeter for the 1st five years following the fire including normal background levels (10th year).

Table 2. Rowe, Countryman, & Storey sediment yield for the 1st five years following the fire.

Rowe, Countryman, & Storey (1949)	Sediment Delivery year following fire					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	10th Year (Normal)
tons ac^{-1}	24.88	9.45	6.55	4.97	3.90	1.95
Cubic yards mi^{-2}	12,739	4,839	3,356	2,544	1,995	1,000