Holy Fire

Burned Area Emergency Response

Soil Resource Report

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The Holy Fire BAER Team

The Burned Area Emergency Response (BAER) team is made up of trained specialists in soils, hydrology, geology, botany, recreation, wildlife, engineering, and archaeology who rapidly evaluate burned areas in order evaluate the effects to watersheds, identify values at risk, and to protect life, property, and critical natural and cultural resources. The objective of the BAER program is to determine the need for and to prescribe and implement emergency treatments on Federal Lands to minimize threats to life or property resulting from the effects of a fire. A BAER assessment usually begins before the wildfire has been fully contained in order to ensure rapid response to values at risk.

Resource Setting

1. *Holy Fire Background*

The Holy Fire burned largely in the Trabuco Ranger District of the Cleveland National Forest. This fire started in Trabuco Canyon, and from there continued northeast towards Highway 15. The roughly 23,000 acres that burned consisted primarily of Forest Service lands, with some private and other state lands intertwined.

2. *Soil information*

Soil coverage was obtained from the NRCS (Natural Resources Conservation Service), which provides a detailed soil description and relevant soil information on all ownerships within the area. The soil surveys within the Holy Fire boundary consisted of 54 soil map units. The majority of these 54 map units, however, cover a very small percentage of the burn area. The most prevalent map units are located in table 1 below. These 5 soil maps units cover a total of 81.98% of the map units within the Holy Fire perimeter.

Information about map units was obtained through the NRCS official series descriptions (*https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053587*) which describes relevant soil information that is used to determine and examine the effects of fire impacts to the soil. Of these top 5 soil map units within the Holy Fire, 38.51% of them are encompassed within the Cieneba soil series. The Cieneba series is of the taxonomic class "Typic Xerorthents" and consists of shallow soils which are somewhat excessively drained. These soils are formed from granitic rock and are found on steep mountain slopes. These soils typically remain moist from November through May, and are accustomed to being dry for the remainder of the year. Cieneba soils consist of low to high runoff potential and moderately rapid permeability in the soil. The excessive water repellency resulting from this fire has caused the infiltration for these soils to decrease considerably. The most common vegetation type is chaparral and chemise with widely spread foothill pine or oak trees. The chaparral and chemise are likely to ground sprout and provide soil cover, which should minimize erosion within 3-5 years.

Aside from the prevalent Cieneba series, which was located mostly in the mid-section of the Holy Fire, the outer sections of the northwest and southeast sections of the burn area consisted of a metasedimentary parent material which is comprised of the Tollhouse series and the Friant series. Upon examination of the burn area, it was observed that these areas were more comprised of steep rock outcrops than the Cieneba series. This difference in parent material is results in soils with more silt and clay when weathered from rock. This finer texture soil is more erodible than the coarser textured soil of the Cieneba series and can be seen in the high erosion rates of the Coldwater Creek watershed. The vegetation that is supported by the Tollhouse and Friant soils and the vegetative recovery is similar to that of the Cieneba series.

Along with the soils discussed above, rock outcrops comprise a significant portion of the fire area. Extensive information about these soils can be found within the NRCS official series descriptions.

Table 1- Soils found within the Holy Fire

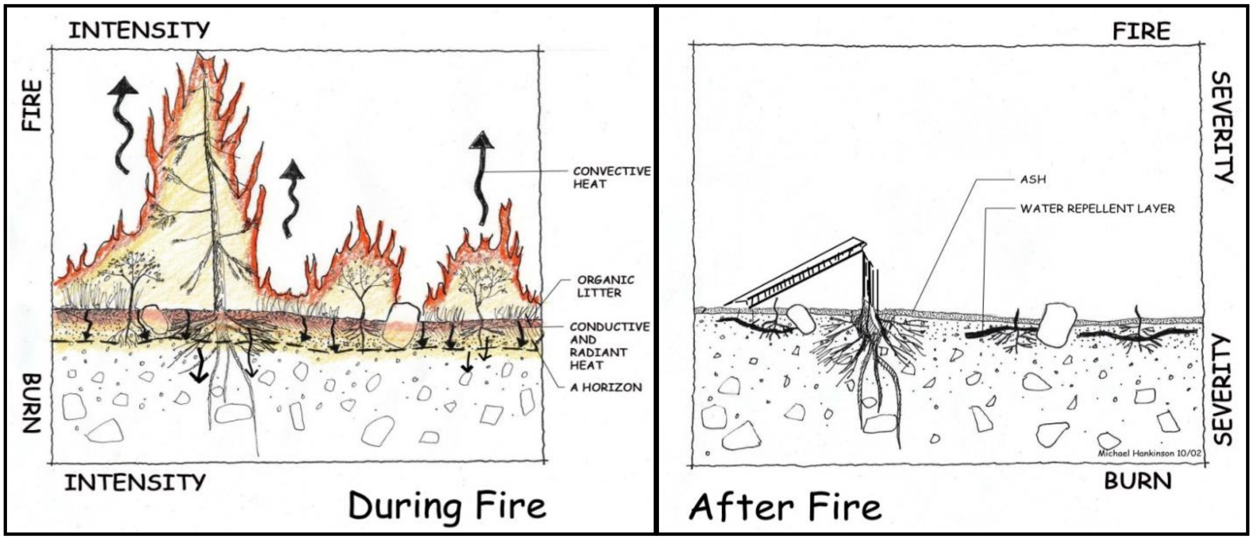
Map Unit	Soil Type	% Coverage
142	Cieneba sandy loam, eroded	11.38%
145	Cieneba-Rock outcrop complex	22.69%
153	Friant fine sandy loam	35.33%
192	Rock outcrop-Cieneba complex	4.44%
212	Tollhouse-Rock outcrop complex	8.14%

Methods and Results

1. *Burn Severity*

Soil burn severity (SBS) is a measure of the changes in soil properties as a result of the fire within the soil profile itself and DOES NOT necessarily reflect vegetative burn severity or mortality. Vegetative burn severity is one component taken into consideration when looking at SBS. SBS takes into account many above ground and below ground factors including: condition of residual ground cover, variability of native seed banks, condition of residual fine roots, degree of fire-induced water repellency, soil physical characteristics (texture, structural stability, porosity, restricted drainage), soil chemical factors (oxidation, altered nutrient status), and topography (slope gradient, length, and profile). While above-ground burn severity is related to peak temperatures and fire behavior, below ground soil burn severity is more strongly related to the potential energy release of surface organic material and the length of time the heat is in contact with the soil. Figure 1 below shows a graphical representation of burn severity vs. fire intensity.

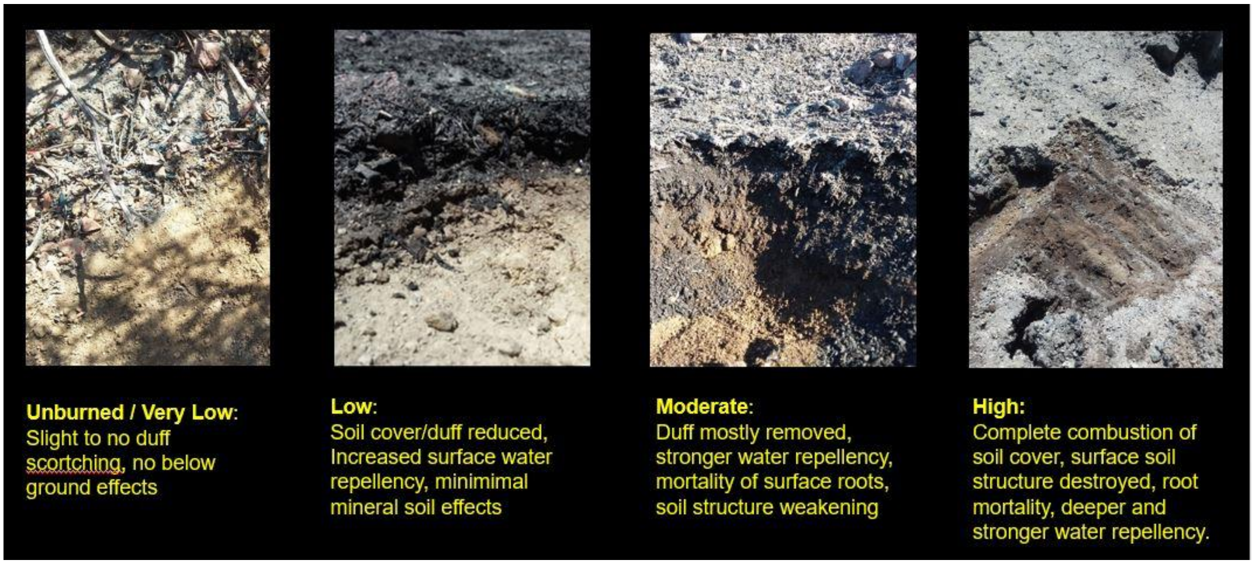
Figure 1- Burn Severity vs. Fire Intensity



Access in the Holy Fire for field assessment was inadequate for the majority of the fire area due to very steep and unstable slopes and lack of roads. Field surveys were conducted in accessible areas in order to verify general soil types, as well as to assess other factors affecting soil hydrologic function, erosion potential, and fire effects. Such factors include: intensity of vegetative burn, aspect and slope gradient, slope length and profile, soil cover, duff composition, soil heating and char, soil structure and aggregate stability, texture, porosity, organic matter, root condition, and hydrophobicity. These detailed GPS-located points were supplemented with numerous additional spot checks to rapidly assess hydrophobicity and soil characteristics in random locations along travel routes. Soil was also examined in unburned areas in order to gauge the soil in natural conditions, with similar soil types, before the effects of the fire. For areas not accessible by road, an aerial flight was conducted in order to fully examine the entire landscape of the Holy Fire. This allows for the verification and examination of soil burn severities in areas where it was unfeasible to conduct field assessments of the soil.

Rapid assessment and mapping of soil burn severity (SBS) is completed by using a Burned Area Reflectance Classification (BARC) map. This map is created by the Remote Sensing Applications Center (RSAC) in Salt Lake City, Utah, using satellite imagery and specialized pre-post differential processing methods (dNBR). Once this map is generated, it is the job of the soil scientists to alter the BARC map, as needed, to reflect the actual soil burn severities as assessed by the team and seen within the soil. The verified and modified BARC map is then referred to the Soil Burn Severity Map. Figure 2 below shows examples of the different soil burn severities.

Figure 2- Soil Burn Severities



SBS Results - The SBS map is essential for post fire erosion, debris flows, hydrologic modeling, and for use by other resources and specialist to assess potential values at risk. Table 2 summarizes the SBS within the Holy Fire perimeter. The initial BARC map was required adjustment to reflect the actual soil conditions observed in the field. The initial map seemed to show a trend of having more low/moderate areas than what actually existed. A significant amount of areas that were originally mapped as low and moderate, were advanced up to moderate and high, respectively, in order to reflect what soil scientists actually saw within the soil. Some of the inaccuracies of the BARC map are caused from the movement of burned mineral soil surface due to dry ravel, exposing the unburned mineral soil below. To the BARC imaging, this would appear to be a soil with low SBS when in reality, the burned soil has just been moved by erosional processes. This adjustment to the BARC map comes at the expense of potentially over mapping the soils at lower elevations from low to moderate. This adjustment to the BARC map is a conservative approach to describe the parts of the watershed that are most important for debris flow and hydrologic process modeling.

Table 2- Soil Burn Severities within perimeter of Holy Fire

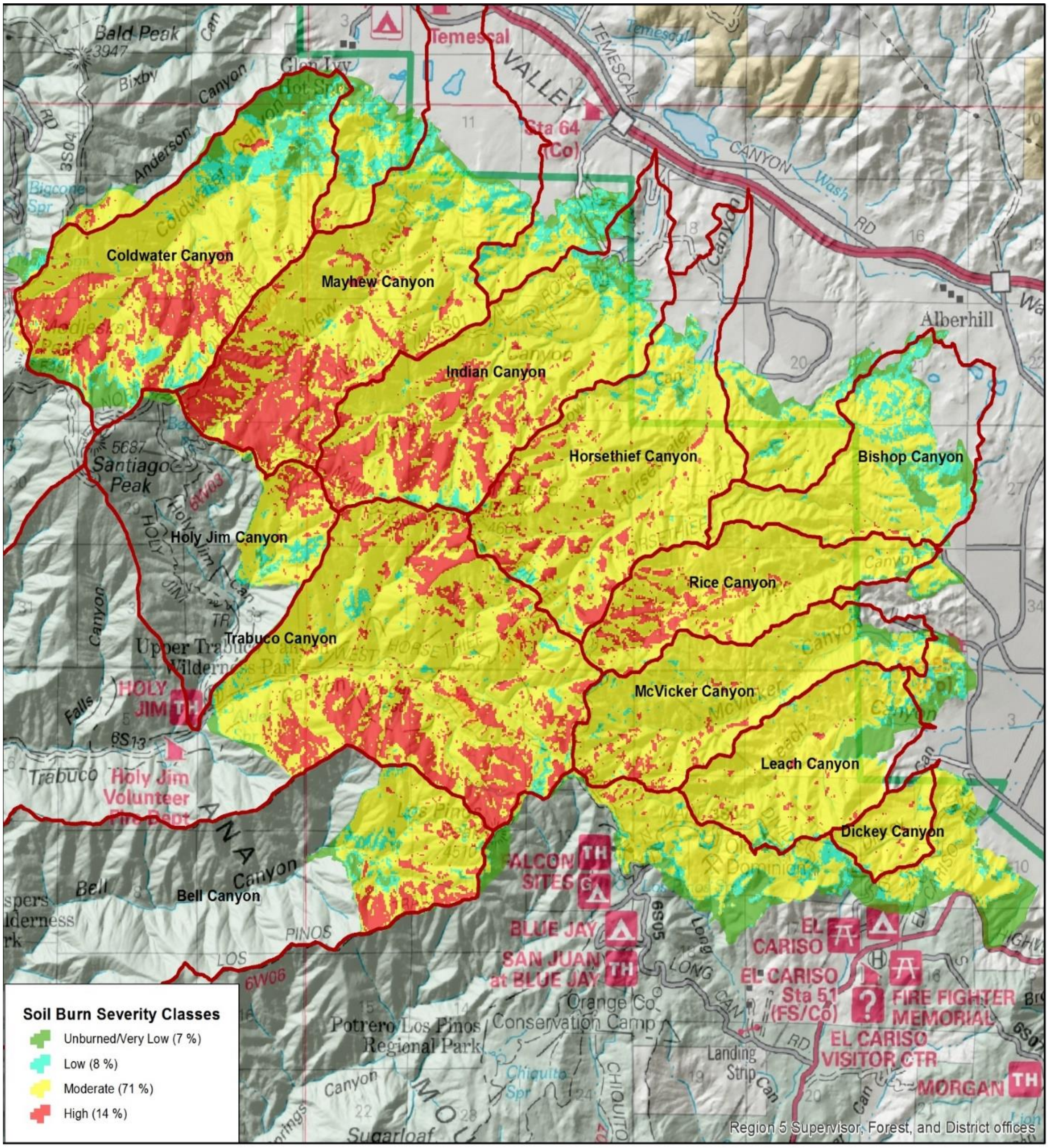
Soil Burn Severity	Acres	Percent (%)
Unburned/Very Low	1542	7
Low	1780	8
Moderate	16258	71
High	3290	14

The BARC map also showed an area of Coldwater Creek that contained “no data” because the fire was still burning and therefore obscuring the BARC data. This area was carefully examined using our knowledge of pre and post soil conditions, aerial reconnaissance, post-fire satellite imagery, and field data trends. This area was then altered to represent the actual soil burn severities determined by the soil team. The final soil burn severity map can be found in Figure 3 below and a table of the burn percentages within the Holy Fire watersheds can be found in Table 3 below.

Table 3- soil burn severity, percentage of watershed (refer to hydrologic assessment for the location of pour points

Pour point Watershed	Unburned	Low	Moderate	High
Bell Canyon	80.82%	1.91%	13.91%	3.36%
Bishop Canyon	27.37%	15.61%	56.79%	0.23%
Coldwater Canyon	12.31%	11.47%	58.17%	18.05%
Dickey Canyon @ Toft Dr	3.12%	2.85%	92.34%	1.69%
Holy Jim Canyon @ Trabuco	77.92%	3.15%	15.58%	3.35%
Horsethief @ I15	13.32%	4.26%	72.55%	9.87%
Indian Canyon @ I15	12.51%	5.41%	61.69%	20.38%
Leach Canyon	9.98%	4.29%	83.47%	2.26%
Mayhew @ I15	22.37%	4.21%	52.57%	20.85%
McVicker Canyon	5.33%	3.62%	86.16%	4.89%
Rice Canyon	1.64%	1.20%	84.72%	12.44%
Trabuco above Oniel Regional Park	63.14%	1.48%	26.17%	9.20%

Figure 3- Soil Burn Severity Map



DISCLAIMER The Soil Burn Severity (SBS) map is a product of BAER rapid assessment; the map is not intended to be 100% accurate and the data represented is provisional in nature. The map is based upon satellite imagery, and then field verified and revised by the assessment team. The primary purpose of this map is for erosion and watershed response modeling; NOT for assessing vegetation impacts of the fire ("RAVG" mapping derived from the same imagery is better suited for this purpose). Aboveground appearances are not reliable indicators of belowground soil effects. Data users are advised to be exercise due caution and carefully consider the provisional nature of the information before using it for decisions that concern personal or public safety or the conduct of business that involves monetary, legal, or operational consequences. Further information concerning the accuracy, limitations, and appropriate uses of these data may be obtained from the Forest BAER Coordinator.

2. Dry Ravel

Dry Ravel describes the movement of individual soil particles, by gravity, from steep slopes to valley bottoms during dry conditions. This process is a dominant erosional process in unburnt, steep chaparral environments and occurs predominantly on slopes greater than 65%. Prior to fire removing litter and live vegetation, natural soil creep is stored behind vegetation. Dry ravel is greatly increased through wildfire because fire burns the vegetation and instantly releases the stored soil behind that vegetation. Root mortality exacerbates the available sediment for dry ravel and may increase the amount of material moved. Material loads the channels, which increases flow bulking. This deposition also occurs on roads and trails, which contributes to unsafe and unpassable conditions. Examples of dry ravel from the Holy Fire can be seen in Figure 4 below.

Figure 4- Dry Ravel on the Holy Fire; left photo –hillslope transport of material, right photo – resulting deposition.

Dry ravel results – Dry ravel is not quantified or calculated on a BAER team. It is, however, something that is observed in order to understand the soil's response to a wildfire. In the Holy Fire, dry ravel sites were abundant throughout the landscape (slopes >65%), such as can be seen in the picture above.

3. Hydrophobicity (water repellency)

Hydrophobicity, or water repellency, is a natural phenomenon where biogenic waxy compounds repel infiltration. Water repellency is not a problem in unburned soil because soil cover mitigates surface runoff and becomes reduced as the duff becomes wetted. Water repellent compounds volatize with heat and concentrate lower in the soil as they condense on cooler soils. This increases strength and depth of water repellency. An example of water repellency can be found in the Figure 5 below. The water is repelled from the hydrophobic soil surface, and unable to infiltrate, this water beads on the mineral soil.

Figure 5- Hydrophobicity on soils within the Holy Fire

Hydrophobicity Results - Water repellency was strong and thick in all burn severities and was prevalent throughout the fire area. Water repellency tends to strengthen with drought which may be exacerbating the strength of the water repellency. Thus repellency observed in the burned area was judged as greatly increased (in severity, extent, and continuity) by the fire, with a very significant effect on infiltration rates for watersheds as a whole. Increased water repellency can increase peak flow flooding and debris flow severity. Although water repellency may protect the soil from deep erosion, it allows for efficient removal of soil that is altered from fire. Fire-induced soil water repellency is often cited as a key factor controlling post-fire runoff and erosion.

4. *Estimated Erosional Response -*

The ERMiT (Erosion Risk Management Tool) model was used to predict the erosion rates and spatially display erosion source areas. ERMiT is a WEPP-based application developed by USFS Rocky Mountain Research Station (USFS, RMRS-GTR-188, 2007) specifically for use with post-fire erosion modeling. ERMiT models erosion potential based on single hillslopes, single-storm "runoff events," and post-fire soil burn severity. Hillslopes include soil and topography inputs. Hillslope gradients and profiles were developed in GIS by soil map units, sub watershed, and soil burn severity class to account for fairly site specific differences in topography.

One custom climate was created using ROCKCLIME (FS-WEPP) representing the totality of the fire, as calibrated from the NRCS historic climate raster for the area. The erosion modeling is strongly dependent on soil properties, specifically soil texture and rock content. The soil survey that covers a majority of the fire is mapped at an Order 3 resolution.

Various storm runoff-event magnitudes may be chosen in ERMiT for erosion response estimates, which is appropriate for hazard and risk type assessments. 2-year, 5-year and 10-year events were chosen for this analysis, and most of the reported results are based on 2-year and 5-year runoff event. It should be noted that 2-yr and 5-yr recurrence interval storm events that the hydrologist would model are similar but not precisely the same as runoff events.

ERMiT quantitative output should not be interpreted as precise or overly site specific on the map. Stated model accuracy is +/- 50%, so estimates may be over- or under-estimated. Results are a product of rapid assessment procedures, and the primary intent is to produce a map that helps identify greater or lesser erosion source areas on a relative basis in the greater fire area. This tool is not a prediction of watershed response per say, rather it predicts the relative amount of soil that can be transported from the slopes to the base of slopes, which may or may not be stream channels. Furthermore, the model estimates only sheet and rill erosion, which occurs when rainfall exceeds infiltration rates and surface runoff entrains surface soil particles. The model does not account for shallow debris sliding or gullying, road effects, or fire-line erosion and gullying, which could each pose large additional sources of sediment entering the stream systems. Erosion rates were summarized by key watersheds (pourpoint watersheds).

Erosional Response Results –

The values for the total fire area erosion rates are relatively high for an area with a mean annual precipitation of 25 inches. The area receives both Pacific cyclonic storms and thunderstorms. The most erosive storms tend to be high intensity short duration convective storms. Stream channel characteristic observations confirm that past precipitation events produced large quantities of rock laden debris flows that are available for transport (see Holy Fire Hydrologic Assessment, Anderson and Holy Fire Geologic Assessment, Schwartz).

The model likely underestimated the amount of potential erosion. The strength, thickness, and extent of water repellency is greater than what is typically found in southern California chaparral. Also, the soils with a High Soil Burn Severity rating have considerably more available altered soil for transport than what is normally found in this region.

Regardless of the accuracy of absolute numbers, the model is used here for relative ratings of different areas within the fire for relative potential as sediment source areas. The rates shown are relatively high and exceed acceptable soil loss. It is clear that there will be high levels of erosion and subsequent sediment delivery to channels, even at high frequency storms.

Figure 5 illustrates the relative erosion rates for a 2 year erosion event. Although emergency response managers should be prepared for a much larger event than a 2 year event, the smaller event better demonstrates the sensitivity of different hillslopes to erosion. Table 4 summarizes the average erosion rates by pour point watershed.

Figure 5. Erosion Rates for a 2 Year erosion event.

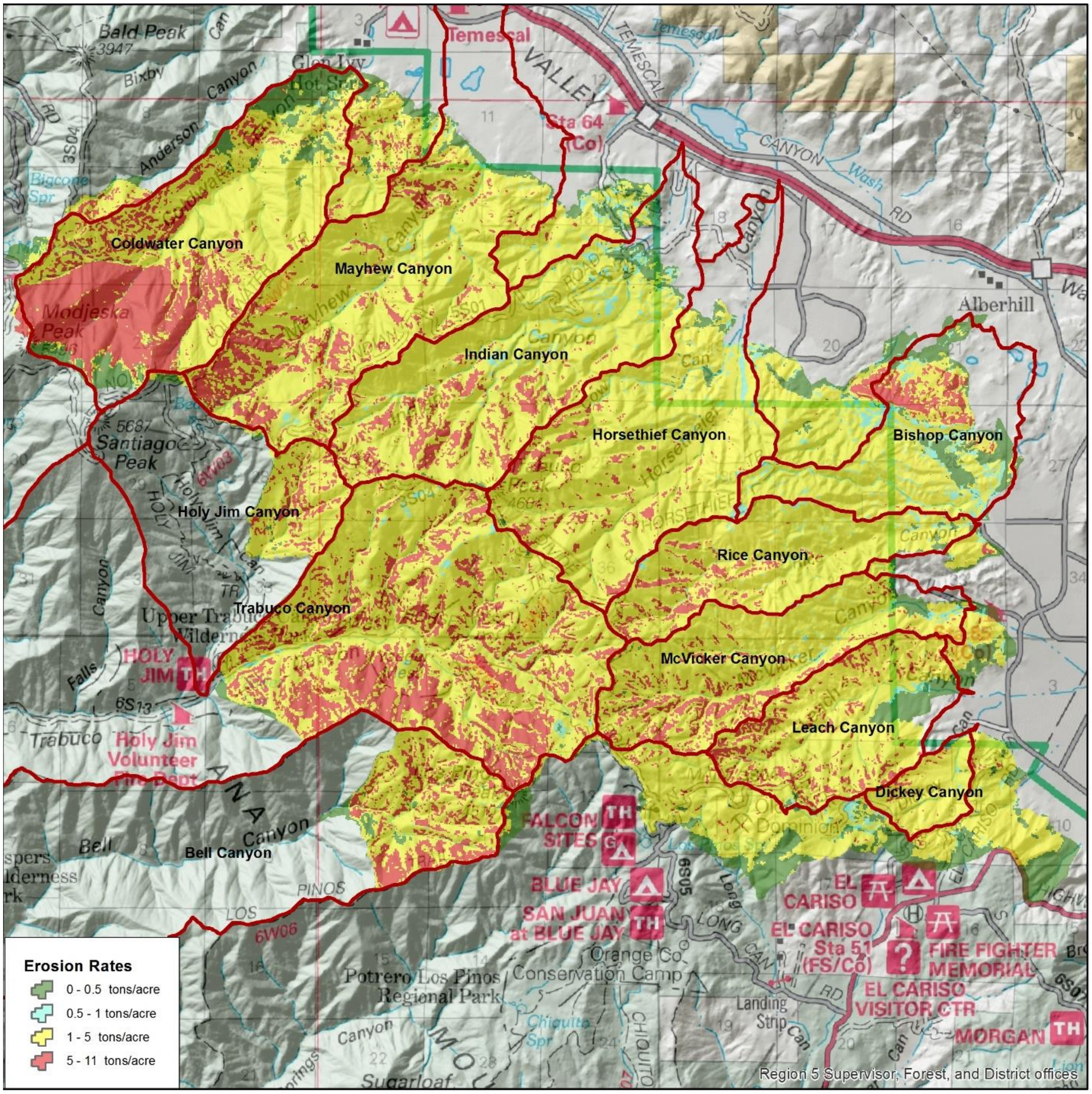


Table 4- spatially displays the erosion rates within the fire area.

Watershed	2 year event		10 year event	
	Unburned	Burned	Unburned	Burned
Trabuco Canyon	0.04	1.84	2.64	8.02
Bell Canyon	0.04	0.92	3.38	6.08
Mayhew Canyon	0.01	3.26	1.82	10.89
Coldwater Canyon	0.03	4.45	2.33	16.60
Horsethief Canyon	0.02	3.25	2.25	13.47
Indian Canyon	0.01	3.40	1.53	11.06
Holy Jim Canyon	0.05	0.95	2.61	5.18
McVicker Canyon	0.02	3.82	3.31	14.28
Bishop Canyon	0.03	2.40	0.92	7.58
Leach Canyon	0.02	3.64	3.49	14.28
Rice Canyon	0.02	3.81	1.97	11.90
Dickey Canyon	0.02	3.53	2.89	13.34

Values at Risk

Soil quality and hydrologic function throughout the fire was assessed by determining soil burn severity, soil erosion hazards, and evaluating potential on- and off-site effects of topsoil loss and sediment production. The combination of soil types, steep slopes, and lack of soil cover will create watershed responses with greatly elevated erosion potential and sedimentation, the degree depending upon the severity of coming storm events over the next 3-5 years or more. On-site effects include the physical, chemical, and biological response of the soils due to the fire, and likely recovery rates. Off-site effects due to sedimentation and stream bulking are downstream, and include potential adverse effects to life and property, and natural and cultural resources. More specifically, NFS road and trail infrastructure is at high to very high risk, as well as habitat security for several T&E species. Downstream off of NFS lands, recreation sites are at high to very risk from debris flows, mudflows, and flooding.

Off-site effects of the fire will be accelerated sediment production into stream systems, stream bulking, downstream deposition of sediment in stream habitats, and increased landslide, mudslide, and debris-flow potential. Sediment-laden ("bulked") runoff and stream water has much greater erosive power and damage potential than similar flows of clean water in the stream system.

On-site effects of the fire to soils will be some loss of topsoil via accelerated erosion, and some damage to soil nutrient status and microbial communities. This may pose a detriment in the form of declined soil fertility and ecosystem productivity in the short-term. Soils are generally characterized as low site quality before the fires, being mostly poorly-developed soils in a relatively low-rainfall climatic zone. Because the soils have very low water-holding capacity on south aspect, vegetation will be slow to recover. High intensity storms will cause erosion that will result in long-term soil productivity loss. Fortunately, the dominant vegetation types are adapted to these harsh site conditions and will contribute to long-term recovery of site conditions.

Also, threats to soil productivity as a result of unauthorized vehicle use was identified. With protective shrub canopy removed, there will be greater access for soil damaging use. It is assumed that area closure for this fire will be effective in reducing unauthorized vehicle use in this area.

Emergency Determination

The team evaluated Values at Risk (VARs). Effects of the fire on the soils have created emergency conditions, posing hazards to critical values at risk. These soils are naturally prone to flashy runoff and erosion, and have been affected by the fire with complete removal of soil cover and high levels of water repellency. This will significantly increase peak flows, runoff, stream bulking, flooding and debris flow hazard, and downstream sedimentation. These are National Forest Service resources that will be impacted by precipitation events that exacerbate hydrologic and geologic processes. The team did note off-forest resources for risk and was relayed to agencies responsible for more in-depth evaluations. The team noted transportation, recreation, residential, and soil VARS. The non-soil VARs are covered in depth in the final BAER report (2500-8) and individual resource reports.

A High risk was determined for soil productivity. The soils are shallow and highly erosive. The productivity of the soil is naturally low but downslope migration of soil during erosion is likely to reduce the thickness of soils, particularly at higher elevations and steeper slopes. Because the soils have low water-holding capacity, the removal of duff will likely reduce the natural recovery compared to more loamy soils. This reduction of soil productivity will last until shrub communities re-establish and subsequently increase duff and organic compounds within the soil. Also, the removal of duff and the high erosion rates in the area will increase the risk of flooding and debris flows due to the dramatic increase in surface flow and contribution to hydrologic bulking (increasing flow viscosity due to sediment input).

Treatments to Mitigate the Emergency

Because the areas of highest erosion are too steep and rocky for effective land treatments, natural recovery will be relied upon for soil risk management. Administrative closure as well as hazard signage will be used to mitigate risks to soil productivity from unauthorized recreation threats. Threats to values at risk including life and property downslope of burned NFS lands are not manageable by BAER treatment actions.

References

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Appendix-A – Maps

The USDA Forest Service uses the most current and complete data available. GIS data and product accuracy may vary. They may be developed from sources of differing accuracy, accurate only at certain scales, based on modeling or interpretation, incomplete while being created or revised, etc. Using GIS products for purposes other than those for which they were created, may yield inaccurate or misleading results. The Forest Service reserves the right to correct, update, modify, or replace, GIS products without notification. If this map contains contours, these were generated and filtered using the Digital Elevation Model (DEM) files. Any contours generated from DEMs using a scale of less than 1:100,000 will lead to less reliable results and should be used for display purposes only. For more information, contact: