BAER SOILS REPORT

Stafford Fire
Shasta Trinity National Forest
09/25/2012

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Potential Values at Risk

A complete list of potential values at risk is contained in the Stafford Fire 2500-8 Report. The potential values at risk are based on information received from local Shasta Trinity – Hayfork Ranger District employees and map review/field review within and adjacent to the burned area by the Stafford Fire BAER Team.

Resource Condition Assessment

Resource Setting

The BAER team Soil Scientist and Hydrologists mapped burn severity in the field via ground reconnaissance on September 22-25. On September 22, a BARC map was received and reviewed. Based ground surveys, it was concluded that the BARC map was showing too much high burn severity. Adjustments were made to the BARC map based on ground surveys. Minor changes to the BARC map were made to lessen the areas of high burn severity, based on some areas being 'moonscaped' and others having dead and downed wood stems.

Based on Google maps survey of the historical area, there were 7 visible 'clear-cut' fields in the Negro Gulch area ranging in size from 7 to 15 acres in 1993 (Figure 1). These areas showed very little recovery up to the 2010 satellite image (Figure 2). These fields would have contained brush fields instead of higher trees per acre.

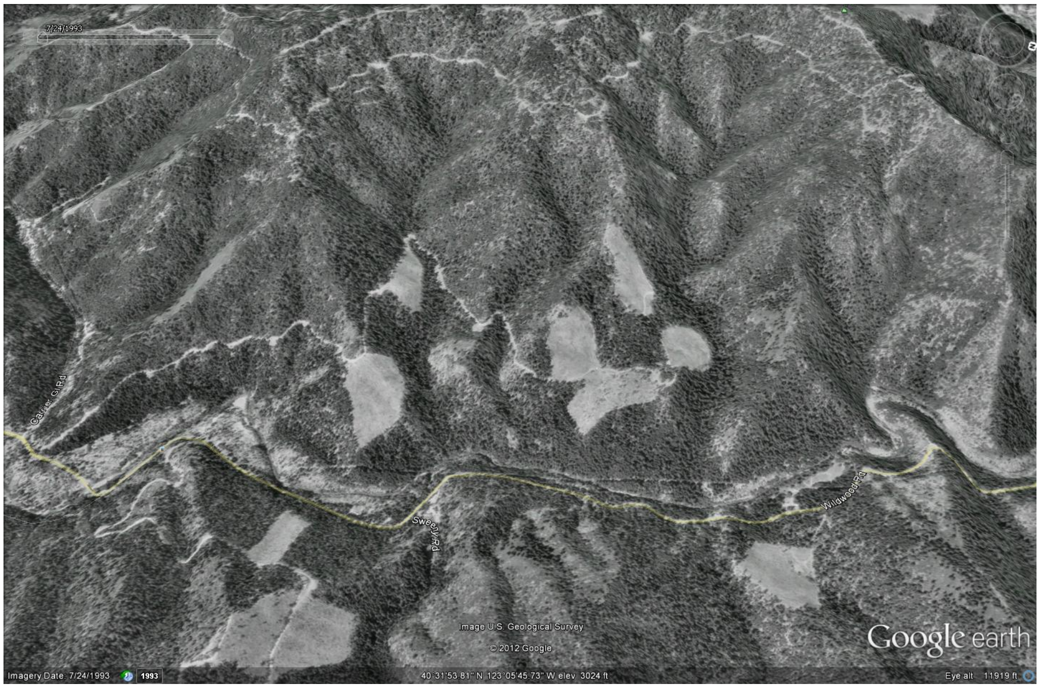

Figure 1 – 1993 Negro Gulch area, tributary to Hayfork Creek; showing clear-cut units

Figure 2 – 2010 Negro Gulch area, tributary to Hayfork Creek; showing clear-cut units

On the McCovey Gulch side (Forest Service Roads 31N17, 31N17A) of the fire, there were about 15 visible ‘clear-cut’ units ranging in size from 4 to 15 acres in 1993 (Figure 3). These showed brush cover in 2004 (Figure 4) and had more vegetative recovery than the Negro Gulch side.

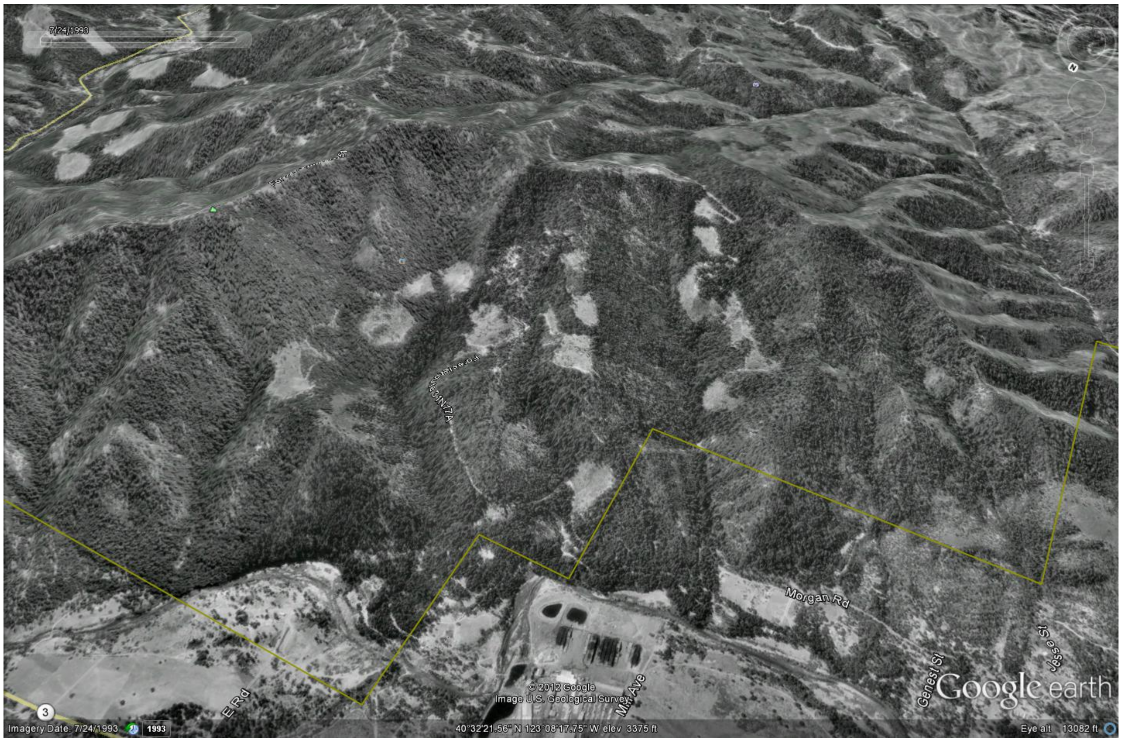

Figure 3 – 1993 clear cuts along FSR 31N17, 31N17A

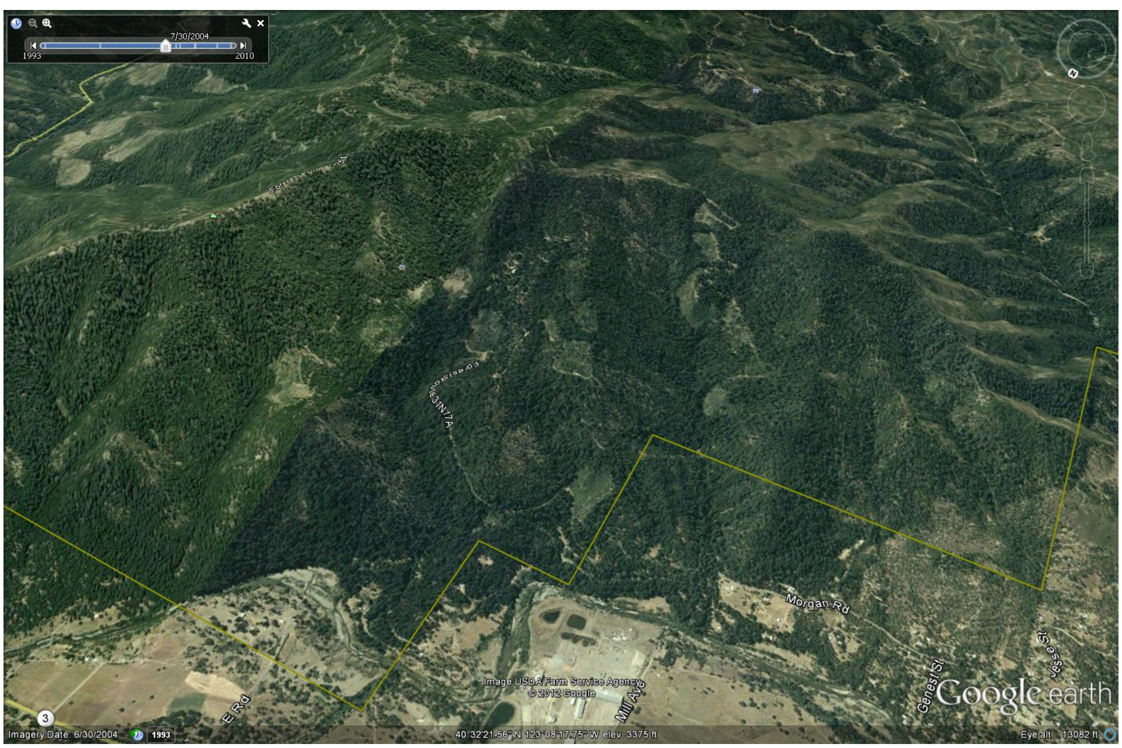

Figure 4 – 2004 clear cuts along FSR 31N17, 31N17A

Dominant soils within the burned area, fully described by the NRCS in Shasta-Trinity National Forest Area, Parts of Humboldt, Siskiyou, Shasta, Tehama, and Trinity Counties, California (CA707), are Dunsmuir family (~6%), Holland family (~16%), Neuns family and complexes (~37%), Typic Xerorthents-Neuns family association (~27%), rock outcrop, riverwash association, and other mapped units of less than 1%. Soil survey maps and interpretations are available at http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

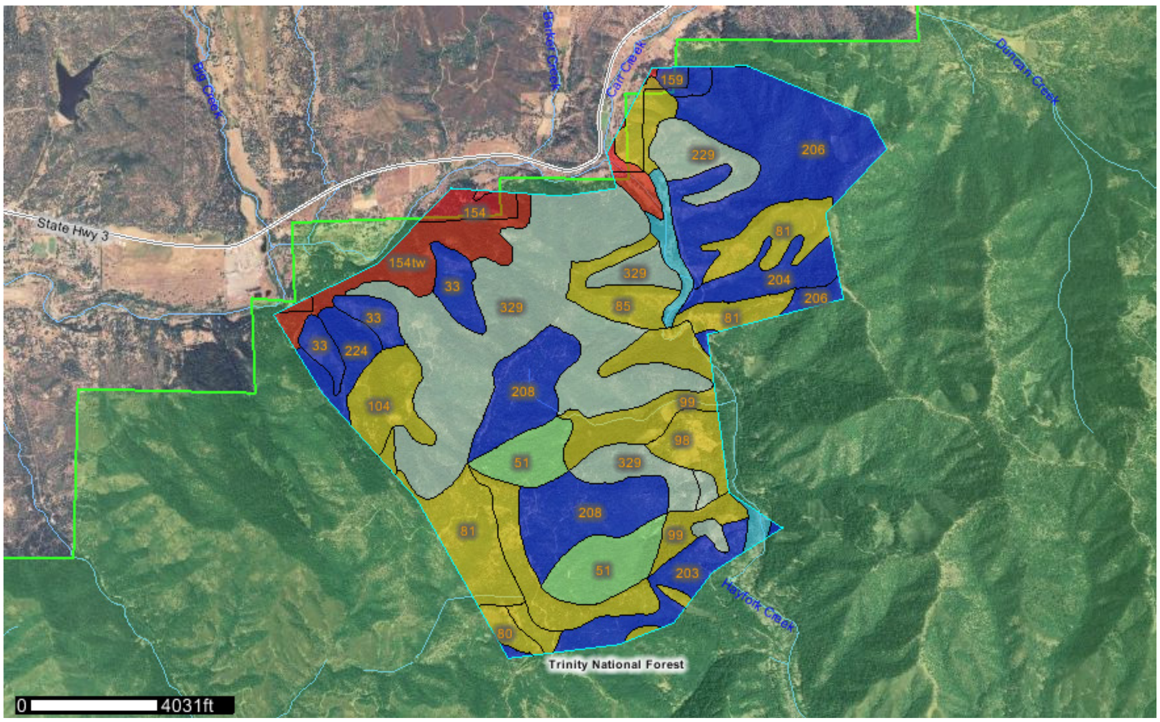

Figure 5 - Approximate area of fire showing soil units and surface sand percentages (NRCS, websoilsurvey.nrcs.usda.gov).

Table 1: Dominant Map Units within the fire area with percent surface composition

Shasta-Trinity National Forest Area, Parts of Humboldt, Siskiyou, Shasta, Tehama, and Trinity Counties, California (CA707)						
Map Unit Symbol	**Map Unit Name**	**Surface sand %**	**Surface clay %**	**Surface silt %**	**Surface texture**	**Percent of Area**
33	Deadwood family, 60 to 80 percent slopes.	67	14	19	Very gravelly sandy loam	3.5
51	Dunsmuir family, 40 to 55 percent slopes.	60	22	18	Gravelly sandy clay loam	5.5
98	Holland family, 40 to 60 percent slopes.	42	20	38	Gravelly loam	5.5
99	Holland family, 60 to 80 percent slopes	42	20	38	Gravelly loam	5.5

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Shasta-Trinity National Forest Area, Parts of Humboldt, Siskiyou, Shasta, Tehama, and Trinity Counties, California (CA707)						
Map Unit Symbol	**Map Unit Name**	**Surface sand %**	**Surface clay %**	**Surface silt %**	**Surface texture**	**Percent of Area**
104	Holland family-Holland family, deep complex, 20 to 40 percent slopes.	42	22	38	Gravelly loam	3.0
154tw	Holkat-Hoosimbim complex, 50 to 75 percent slopes	40	22	38	Loam	4.0
203	Neuns family, 40 to 60 percent slopes.	67	14	19	Very gravelly sandy loam	3.5
204	Neuns family, 60 to 80 percent slopes.	67	14	19	Very gravelly sandy loam	2.5
206	Neuns-Deadwood families complex, 40 to 60 percent slopes.	67	14	19	Very gravelly sandy loam	12.5
208	Neuns-Goulding families association, 40 to 60 percent slopes.	67	14	19	Very gravelly sandy loam	9.0
224	Neuns family-Typic Xerorthents association, 50 to 80 percent slopes.	67	14	19	Very gravelly sandy loam	2.0
229	Neuns family, schist substratum, 60 to 80 percent slopes.		20		Very gravelly loam	2.0
260	Rock outcrop-Gozem family complex, 60 to 80 percent slopes.				Unweathered bedrock	1.0
329	Typic Xerorthents-Neuns family association,60 to 80 percent slopes.		14		Extremely gravelly loam	23
351	Xerofluvents-Riverwash association, 0 to 20 percent slopes.	66	15	19	Sandy loam	2.0

51 and 208 are above the 5 foot diameter culvert (Value at Risk)

Dunsmuir family (map symbol 51) soils are derived from ultramafic rock (Residuum weathered from serpentinite), are moderately erodible, deep to very deep reddish brown, light sandy clay loam to gravelly clay loam soils that are moderately acidic. They are well suited to growing mixed-conifer forests and have moderate soil available water holding capacity and are well drained.

The Neuns-Goulding families association (map unit 208) soils are derived from residuum weathered from igneous, metamorphic and sedimentary rock. They are well drained, and gravelly sandy loam to about 2 feet deep.

Sediment TMDL

In December 1998, the Final South Fork Trinity River and Hayfork Creek Sediment Total Maximum Daily Loads (TMDL) report was finalized. "The TMDL addresses sediment loading in the entire South Fork Trinity River basin, including Hayfork Creek and other tributaries. The dominant process in the basin is mass wasting (landsliding and debris flow), accounting for approximately 64% of the basin-wide sediment delivery. The Hayfork Creek Area, by contrast, produces less sediment overall, and is more influenced by road-related erosion than by mass wasting. Road-related sediment delivery has continued to increase from 1944 to the present time."

"The Hayfork Creek sub-basin, which is particularly distinct from the Upper and Lower South Fork Trinity River sub-basins, is relatively stable geologically. The forested headwaters contain high gradient reaches of the stream, leading to the broad, flat Hayfork Valley, leading to a steeper reach entering the mainstem South Fork Trinity River at the Hyampom Valley."

Road crossing failure was identified in the TMDL as a source of fine sediment into Hayfork Creek. The target was to have less than a 1% failure, indicating crossings adequate to pass the 100-year flood. With the addition of high soil burn severity above certain culverts, a lower return interval storm will provide the same response as a 100-year return interval storm.

A mass wasting study was conducted in 1998 by the EPA. The study included the Upper South Fork Trinity River above Sulphur Glade and Plummer Creeks and all of Hayfork Creek (Raines 1998).

From 1944 to 1990, collected data from different tributaries and assessed controllable and uncontrollable sources of sediment. Road related average annual sediment loading for the Hayfork Creek area was 36,624 tons/year or 95 t/mi^2/yr. Background levels for hillslope erosion modeled as 31 t/mi^2/yr and bank erosion was 145 t/mi^2/yr.

After 1990, following the listing of the Northern Spotted Owl, timber harvest rates and the need for timber access roads declined significantly. Though the TMDL does not list specifically the reduction in the Hayfork area, it does note that timber harvest was at 1/3 the level previous.

Watershed Condition Classification

The majority of the fire is within the hydrologic unit code (HUC) 6 Barker Creek - Hayfork Creek (180102120205) watershed, which is 20791 total acres, of which 15833 is in NFS control. Small portions of the fire are within the Carr Creek (180102120203) watershed, which is 18128 total acres; 7898 in NFS control and the Rush Creek-Hayfork Creek (180102120303) watershed, which is 32244 total acres; 18104 in NFS control.

Watershed condition classification was conducted by the Forest Service in 2010, rating each of these watersheds as either Functioning, Functioning At-Risk, or Impaired. 12 Indicators are used with varying percentages to determine the current rating and future ratings. Wildfire effects can cause changes to soil erosion, forest cover, riparian vegetation health, and indirectly to road stability and channel stability. As the number of burned acres in the Carr Creek and Rush Creek-Hayfork Creek watersheds are quite low, approximately 5% and 2%, respectively, and the soil burn intensity in these watersheds are generally low, no changes to watershed condition class are anticipated.

Approximately ¼ of the area of Forest Service managed lands of the Barker Creek-Hayfork Creek watershed are affected by the Stafford Fire. In 2010, the watershed was rated as Functioning At-Risk. Soil erosion was considered in a functioning condition. With the direct effects from increased soil erosion and loss of productivity, and the indirect effects from need for increased road maintenance, it is possible that this watershed will move closer to an Impaired Function.

Findings of on-the-ground Survey

Resource Condition Resulting from the Fire and Risk Assessment

Table 2 displays acres and percent of soil burn severity for the entire fire, approximately 4,402 acres. Soil burn severity classes are described in Appendix B.

Table 2a: Soil Burn Severity for the Stafford Burned Area

Soil Burn Severity	Acres	Percent
Unburned	798	18
Low	1555	35
Moderate	1146	26
High	903	21

Table 2b: Soil Burn Severity for the Stafford Burned Area by HUC 6 watershed

Soil Burn Severity	Barker Ck-Hayfork Ck	Carr Creek	Rusch-Hayfork Ck
Total watershed acres	20810	18101	32139
Total fire perimeter acres	3405	429	569
Unburned	503	143	153
Low	1040	212	302
Moderate	968	68	109
High	893	6	4
% of burned area Mod/High severity	55%	18%	20%

The watershed team spent 3-4 days in the field performing ground reconnaissance of the fire area. Post-fire site conditions including canopy and ground fuels consumed, ash color and depth, water repellency, soil texture and structure and ground cover potential were observed and documented. Values at risk identified by the watershed team and other BAER team specialists were reviewed in the field.

1) Within forested vegetation communities, water repellency of discontinuous extent was present at the ash/soil surface interface. Natural pre-burn water repellency was noted. High burn severity areas showed moderate to high levels of water repellency, with between four and ten times more infiltration time. In some high water repellency areas, the water beaded on the surface and did not infiltrate. Removal of ground cover will likely affect infiltration as much as water repellency.

2) Generalized observations about the burn pattern:

- Valley bottoms and drainages were commonly unburned, under-burned, or low severity
- Some forested areas were under-burned with minimal heat transfer to the soil and high needle cast potential
- There were two watersheds and isolated patches showing high burn severity
- Loss of soil structure (aggregate stability), an indicator of soil heating, was not observed, even in severely burned areas.
- Multiple inches of duff layer was converted to ash, but roots were observed in the top soil layer beneath the duff.
- There were discontinuous areas of high burn severity. Local forest personnel indicated old plane crashes and extensive old mining facilities that may have had additional accelerants that would have increased burn severity.
- There is a high rock content throughout the burn area. In the drainages of Hayfork Creek, previous placer mining left large rock fields along the banks. The rock content on the slopes ranged from 20 to 50%. Runoff from rock covered areas will not be accelerated by the fire, but loss of canopy cover in area of rock will increase runoff.

3) Dry ravel and potential rock fall on slopes greater than 60% were observed throughout the burned area.

Modeling Sediment Yield

ERMiT was used to model both pre-fire and post-fire sediment response for sub-watersheds within and adjacent to the burned area. ERMiT allows users to predict the probability of a given amount of sediment delivery from the base of a hillslope following variable burns on forest, rangeland, and chaparral conditions. This model predicts how much hill-slope erosion will be delivered to the channel by overland flow. See the Hydrology Report for geographic boundaries of watersheds. Appendix A lists modeling assumptions. The following table summarizes ERMiT modeling for forest, shrub, and grass vegetation types within the burn. Various burn severities and slopes, occurring within the burn are modeled.

Table 3: ERMiT Erosion Model Outputs for the First Year Following the Fire (probability of sediment delivery rates exceeded = 10%); Unburned computed using Disturbed WEPP for the 25-year return interval storm

	Erosion in tons/acre by Soil Burn Severity:			
Vegetation Type	**Unburned**	**Low**	**Moderate**	**High**
Forest (Slopes, 0-30%)	0.0	2-5	4.5-10	5-11
Forest (Slopes, 30-70%)	1.6	6-30	10-40	15-45
Shrub (Slopes, 0-30%)	2.0	2-9	5-10	7-11
Shrub (Slopes, 30-70%)	7.2	11-50	25-65	30-75
Grass (Slopes, 0-30%)	6.0	5-11	6-13	8-15
Grass (Slopes, 30-70%)	20	20-45	25-55	35-65

Forested: Forested areas were mapped as all soil burn severities. There are watersheds showing unburned, ground fire that only scorched the lower branches, moderate burn that left needles for future ground cover, and high soil burn severity where only dead snags remain. Though low soil burn severity areas will recover quickly to lessen watershed hydrologic response, those areas that burned hotter and left a more hydrophobic layer will erode significantly in the first few years following the fire.

Shrub: Most of the shrub vegetation within the burned area was mapped as moderate severity. Removal of ground cover in these areas was high and it is expected that erosion and sediment delivery to stream channels from these slopes will be high. Vegetative recovery is likely to occur through sprouting of shrubs and establishment of grasses and herbaceous vegetation. Recovery of watershed hydrologic response is likely to take many years, based on the slow recovery seen following the clear-cutting from the past. The soils are very shallow, not allowing large shrubs to establish quickly.

Grass: Grass areas within the burn were generally mapped as low burn severity. The fire reduced protective ground cover by removing litter and the above ground portion of the grass. Soil heating was very low and the root structure of the grass remained intact. Recovery of watershed response is expected to occur rapidly as grass vegetation recovers.

Table 4: Estimated Sediment Yield within the Fire Boundary by Watershed

Sub-Watershed	Watershed Acreage within Fire	Percent of Burned Watershed with High and Moderate Soil Burn Severity[A]	Pre-Fire Background Sediment (tons/acre)	Post-Fire Yield [B] (tons/acre)	Total Sed. Delivered (tons)	Change in Sediment Yield (compared to pre-fire)
Barker Creek-Hayfork Creek	3406	55	2.3	23.3	79400	10 times
Carr Creek	429	18	3.4	17.5	7500	5.1 times
Rush Creek-Hayfork Creek	569	20	3.4	18.1	10300	5.3 times

[A] – Soil Burn Severity as described by the Burned Area Reflectance Classification Map
[B] – Based on Rock:Clime, ERMIT Erosion Risk Management Tool. Post-fire erosion is modeled as the amount of erosion produced by a 25-year storm event occurring within the first year following the fire. Background erosion is considered the amount of erosion produced by a 25-year storm event with full vegetation (Disturbed WEPP). Moderate and high burn severities are combined and modeled as high. Unburned and low burn severities are combined and modeled as low.

The BAER Team did not have a highly experienced GIS Team member. Estimates of vegetation and slope were made for each sub-watershed based on field visits and topographic maps to produce a weighted average for sediment yield.

- Barker Creek-Hayfork Creek: 50% forest >30% slope, 20% forest <30% slope, 10% shrub >30% slope, 10% shrub <30% slope, 10% grass <30% slope
- Carr Creek: 30% forest >30% slope, 20% forest <30% slope, 30% shrub >30% slope, 10% shrub <30% slope, 10% grass <30% slope
- Rush Creek-Hayfork Creek: 30% forest >30% slope, 20% forest <30% slope, 30% shrub >30% slope, 10% shrub <30% slope, 10% grass <30% slope

High rates of hill-slope erosion are expected to occur where vegetation was mapped at high and moderate burn severity. Sediment delivery to the stream channel system is expected to be pronounced in the Barker Creek-Hayfork Creek sub-watershed because it has high proportions of moderate and high burn severity.

Emergency Determination

Based on the large proportions of areas burned at moderate and high severity in certain watersheds, an emergency for long-term soil productivity exists. Indications from removal of timber prior to 1993 and the limited recovery naturally, the results of the Stafford fire will like have a similar effect. Steep, rocky slopes with shallow soils are unlikely to produce forested conditions naturally. Accelerated erosion is anticipated where large contiguous blocks of high and moderate burn severity exist. Increase in hill-slope erosion and sediment delivery can impact downstream values such as roads, fisheries habitat, water quality (TMDL sediment listed streams), and create a threat to life and safety due to rapid watershed response, higher peak flows, and flooding. The high levels of erosion has the potential to alter vegetation communities such as converting a forested community to shrubs and grass.

Treatments to Mitigate the Emergency

Watersheds within the burned area were assessed to determine site suitability for hill-slope treatments.

Criteria used to narrow down possible hill-slope treatment areas included:

- Slopes of 30-60%
- Areas that burned brush vegetation…ie. Areas of grass would not be suitable for treatment, forested areas with high needle cast potential would not be suitable for treatment

- Downstream values at risk are considered to be high
- Ability to treat at least 30-40% of watershed area above value at risk

Limited acreage suitable for hill-slope treatment within the burned watersheds exists. Based on criteria and limited suitable acreage, it was decided that hillslope treatments would not effectively mitigate emergency conditions downstream. Other BAER Specialist's Reports and the Burned Area Report 2500-8 describe protection treatments proposed developed by the BAER Team. Hill-slope treatments that were considered but not recommended included seeding, hydromulching, and woodstraw. Typically seeding produces a low effective ground cover in the first winter when ground cover is most needed. Woodstraw was not commercially available in the quantities required to provide proper mulch coverage.

Discussion/Summary/Recommendations

Accelerated erosion from high and moderate burn severity areas can impact downstream values at risk. Possible hill-slope treatments were fully explored with known and valid criteria applied to determine suitability.

Accelerated erosion is expected to occur for up to five years, with the majority of erosion and sedimentation occurring the first or second winter due to hydrophobicity and the potential channel storage of sediment. Chaparral vegetation responds within 1 to 5 after fire providing canopy and soil cover.

Noxious weed detection surveys and eradication will ensure native vegetation will occupy sites and begin restoring inherit soil productivity.

Dry ravel coupled with the expected increase in hillslope erosion and sediment delivery to stream channels will lead to increased peak flows and sediment bulking. See the Hydrology Specialist's Report for additional information on post-fire stream channel processes.

Sediment loading will contribute to the Forest Service's non-point source levels as established in the South Fork Trinity – Hayfork sediment TMDL. Preventing loss of road fill from increased landslide and mass wasting as a result of the fire is an emergency that can be treated (see Roads Report).

References:

Raines, M. 1998. South Fork Trinity River sediment source analysis, draft. Tetra Tech, Inc. October, 1998.

Robichaud, Peter R.; Elliot, William J.; Pierson, Fredrick B.; Hall, David E.; Moffet, Corey A., 2006, **Erosion Risk Management Tool (ERMiT) Ver. 2006.01.18.,** U.S. Forest Service, Rocky Mountain Research Station.

Robichaud, P.R., 2007, *Erosion Risk Management Tool (ERMiT) – A Probability-based Erosion Prediction Model*, Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference, San Diego, CA 18-22 October 2004

Appendix A. Sediment Modeling Assumptions:

- The ERMiT (Emergency Risk Management Tool) model was used to develop sediment delivery rates for one specific climate.
- PRISM Climate Generator[1] was employed to develop the climate needed to drive the sediment delivery model. The climate described here was chosen to best represent the Stafford Fire burned area.

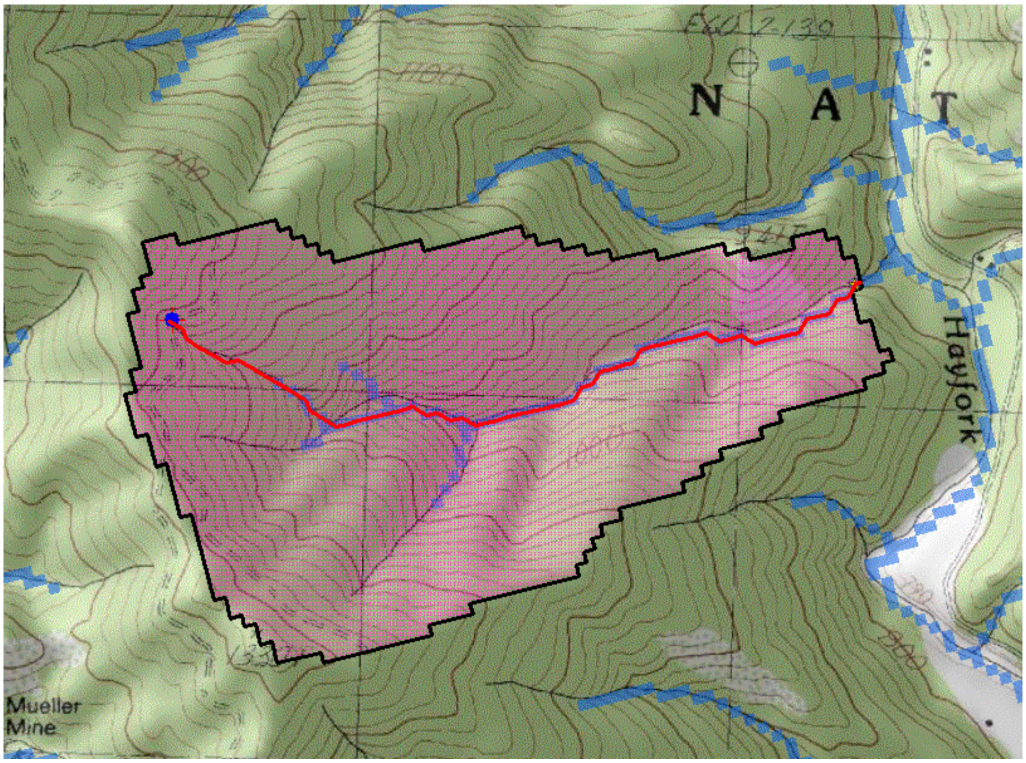
Climate Data from PRISM Climate Generator
for modifying CHICO EXP STA CA at 39.7°N 121.82°W and 190 ft elevation
Prism Location: 40.5°N 123.1°W and 3729 ft elevation (Hayfork Ck)
Annual Precipitation: 41.46 inches
Elevation: 3729 ft

Month	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	PRISM Precipitation (in)	Number of wet days
January	42.19	25.83	8.28	10.50
February	48.66	28.92	5.61	9.33
March	53.82	31.23	5.10	8.78
April	61.15	34.85	2.34	5.45
May	69.63	40.68	1.11	4.04
June	78.27	46.66	0.69	1.62
July	84.93	50.48	0.24	0.39
August	83.24	48.3	0.44	0.41
September	77.75	44.32	1.24	1.62
October	67.16	37.49	2.28	3.87
November	53.42	30.33	5.95	6.46
December	43.16	26.19	8.18	9.39
Annual			41.46	61.86

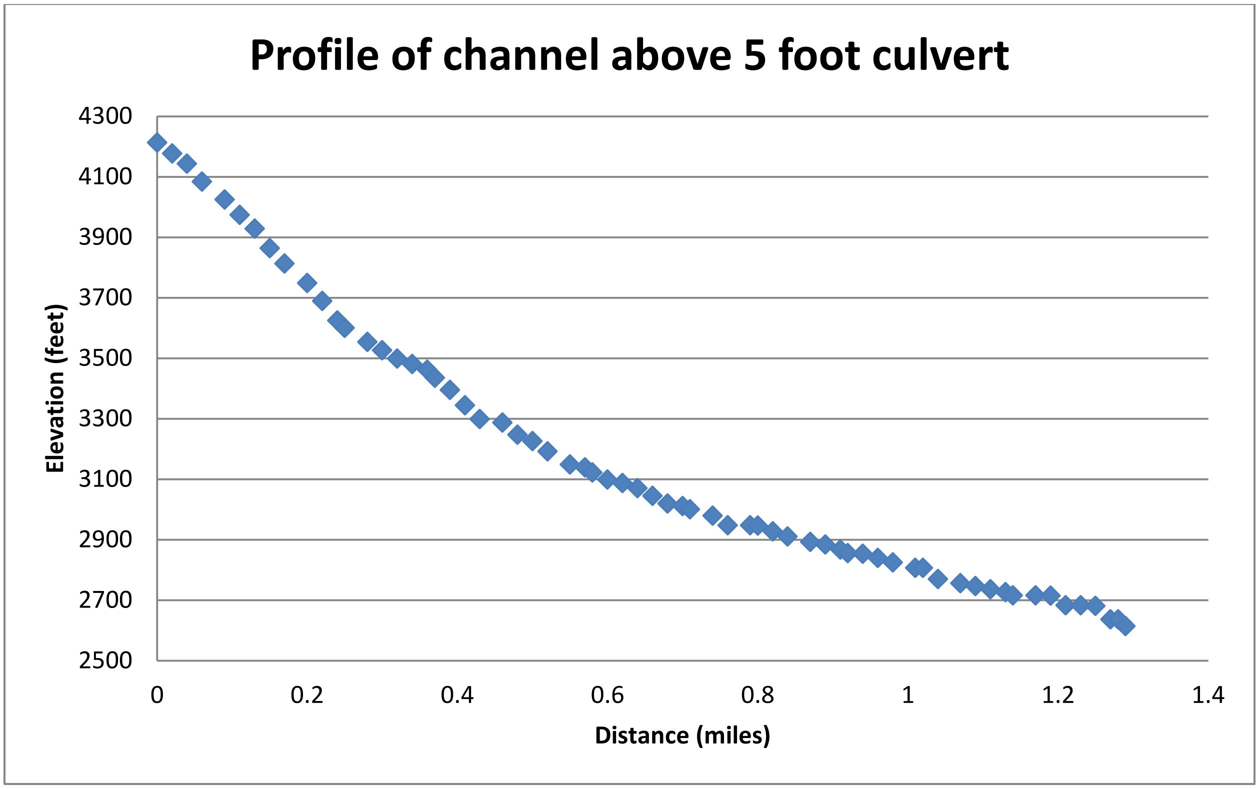
Length of and magnitude of slope was determined with topographic mapping and the USGS Streamstats program (http://streamstats.usgs.gov/california.html). California StreamStats provides peak-flow statistics with annual exceedance probabilities of 50, 20, 10, 4, 2, 1, and 0.002 percent. These peak flows have recurrence intervals of 2-, 5-, 10-, 25-, 50-, 100-, and 500-

year floods. Two reports document the regression equations used in StreamStats for estimating peak flows. These reports present the regression equations used to estimate peak flows, document the errors associated with the estimates, and describe the methods used to develop the equations and to measure the basin characteristics used in the equations.

- Slope length was characterized in two phases:
    - Length of the channels along the longest profile were determined with Streamstats.



Red line shows profile path; subwatershed above 5 foot culvert



  - Slopes above ephemeral channels were about 300 feet in length
  - Slope lengths were far in excess of the maximum 1000 feet for the model.
  - Multiple slope lengths were used (300', 1000') to generate range of delivery of sediment, knowing that results may be underestimated because flow length of channel is up to 6 times longer than model allows

- An investigation of soil within the Stafford Fire burn perimeter, as well as the surface soil description of the soil survey, indicated that the most common texture available for use in the model was sandy loam.
- Individual watersheds were analyzed to show the primary pre-fire vegetation types. These created three groups; forested (e.g. mixed conifer), chaparral and grass
- A soil rock content of 40% was used
- Sediment delivery rates were based on a 20-year storm event (5%).
- Background sediment rates for the soil within the Stafford Fire perimeter were generated using the Disturbed WEPP program. This program allows for longer slope lengths (up to 2400 feet).
  - Disturbed WEPP 2.0 Results v. 2011.05.01 based on WEPP version 2010.100 , CLIGEN * version 4.31 *
  - http://forest.moscowfsl.wsu.edu/fswepp

Appendix B. Burn Intensity Mapping Criteria

The fire intensity was determined by multiple ground reconnaissance surveys using interior roads and high ridge locations for overview. Once mapped, the information was digitized into GIS where the final calculations on acres and percentages were determined.

The burn intensities were broken up into three categories; low or unburned, moderate and high. Broad areas of the burned area were broken up into similar burn intensity patterns and were characterized by a percentage of low or unburned, moderate and high. Following is a description of general observations used to determine low, moderate and high values.

Low or unburned - Leaves/needles are green and unscorched, and remain on vegetation. In areas dominated by brush or trees, litter is not continuously burned. Plant twigs and leaves are usually identifiable in the litter component. Steep unstable slopes are often mapped as low intensity where the native vegetation was sparse (little to no cover prior to the fire).

Moderate - Leaves/needles have been scorched but may remain on tree. Smaller shrubs may be burned down to main stem, skeletons remain. Litter and duff is burned over most of the area, but is not completely burned to the soil surface at most locations. Hydrophobic layers are discontinuous.

High - Medium and fine branches have been burned from trees and large shrubs. Canopy totally consumed on conifers. Smaller shrubs are usually burned to short stabs. Litter and duff is usually burned to the soil surface over most of the area, leaving only a cover of ash (white/gray) above the mineral soil. There are usually patches where duff is partially or not completely consumed.