Rough Fire South Zone BAER

Sequoia National Forest

Soil Resource Assessment Report

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Figure 1: King River looking towards the Cedar Grove area

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Soil Resource Setting

On July 31, 2015, a lightning strike started a wildfire on the steep northern side of the Kings River Canyon. The Rough fire burned for two and a half weeks within the Sierra National Forest (NF) and grew to 30,000 acres. On August 18, it jumped the south fork of the Kings River and onto the Sequoia NF. The fire burned for an additional six weeks and expanded to over 151,000 acres, with 89% containment. The Rough fire consumed a wide variety of vegetation across both sides of the Kings Canyon Gorge. It burned from blue oak savanna ecosystem type at 1,000 feet elevation to sub-alpine forest at over 10,000 feet elevation, with chaparral, live oak forest, black oak forest, ponderosa pine forest, mixed conifer forest, giant sequoia groves, montane meadows, and red fir forest, in between. Various riparian plant communities are also found along rivers, streams, and within meadows. In the fire area, approximately two-thirds (68%) of the Rough Fire is either very low/unburned to low soil burn severity, while 28% sustained a moderate soil burn severity and 4% burned at high severity, see Table 1.

Table 1: Rough Fire BAER soil burn severity (29/Sept/2015)

Soil Burn Severity	Acres	%
Unburned/Very Low	36,631	24.2%
Low	66,497	44.0%
Moderate	41,943	27.8%
High	6,031	4.0%
Total:	**151,102**	

The Sequoia National Forest (CA760), Sierra National Forest (CA750), and the High Sierra (CA740) Soil Resource Inventories were used for assessment purposes. There are ninety-five soil map units (SMUs) present within the fire area, see Table 8 for the complete list of the SMUs and Figure 6 for a map of the SMUs present within the fire area. Corresponding map unit data and interpretations were obtained for further analyses. This provided the basic soil information for making interpretations of fire effects upon the various soils, particularly as many areas were not field visited due to access and time constraints.

The top five dominant soil families within the burned area excluding rock outcrop and soils located within the park without soils data include Coarsegold, Chaix, Entic Xerumbrepts, Holland, and Auberry, see Table 2. For the complete list of soil families present within the fire area see Appendix B Table 7 and for a complete list of soil map units see Table 8. Soil map unit data was combined with field data and site-specific observations to generate interpretations of fire effects upon known (visited) soils, and extrapolate interpretations for unvisited areas. Subsequent erosion hazard ratings and erosion modeling estimates were based in part upon soil survey information and modified using field-calibrated data where appropriate.

Table 2: Rough Fire BAER top five dominant soil families

Soil Family	Acres	% of Fire Area
Coarsegold	17,940	11.9%
Chaix	15,579	10.3%
Entic Xerumbrepts	13,133	8.7%
Holland	10,058	6.7%
Auberry	8,052	5.3%

In order to assess the potential risk of a given soil to erode, an erosion hazard rating (EHR) system was developed in R-5 (FSH 2505.22). The EHR system is designed to assess the relative risk of accelerated sheet and rill erosion processes only, and was developed primarily for land use activities such as agriculture or logging. The rating system is based on soil texture, depth, clay content, infiltration, amount of rock fragments, effective surface cover, slope gradient, and climate (USDA Forest Service 1990). Risk ratings range from low to very high, with low ratings meaning low probability of surface erosion occurring. Moderate ratings mean that accelerated erosion is likely to occur in most years and water quality impacts may occur for the upper part of the moderate numerical range. High to very high EHR ratings mean that accelerated erosion is likely to occur in most years and that erosion control measures should be evaluated. For BAER purposes, fire induced changes to soil infiltration, ground cover, and runoff from adjacent areas can be factored in to determine changes in erosion hazard by soil burn severity classes, to produce a customized "post-fire EHR" map displaying erosion hazards on a relative basis.

For EHR purposes, soil map units were evaluated using information for texture, rock content, slope gradient, and characteristics relating to infiltration, permeability, and depth of the soil. EHR ratings were calculated for each soil with soil burn severity characteristics also factored in. Ratings thus represent a summary of soil physical characteristics, slope gradient, soil cover present, and level of hydrophobicity (water repellency) as observed in the field. Fire has altered the erosion hazard rating of the soils and the altered EHR ratings were 27,530 acres of none (rock outcrop and National Park), 23,147 acres of low, 66,031 acres of moderate, 34,048 acres of high, and 346 acres of very high. See Table 3 for the EHR ratings and Figure 7for a map of the EHRs present within the fire area.

Table 3: Rough Fire BAER soil erosion hazard ratings (EHRs)

EHRs	ACRES	% of the Fire Area
None	27,530	18.2%
Low	23,147	15.3%
Moderate	66,031	43.7%
High	34,048	22.5%
Very High	346	0.2%

Hydrologic soil groups are a standard soil-survey index of potential for runoff generation and subsequent erosion, regardless of fire effects of soil burn severity or water repellency. Group A soils have high infiltration rates even when thoroughly wetted, consisting chiefly of deep, well to excessively drained sands and/or gravel. Group B soils have moderate infiltration rates when thoroughly wetted, consisting chiefly of moderately deep to deep, moderately well to well drained soils, with moderately fine to moderately coarse textures. Group C soils have slow infiltration rates when thoroughly wetted, consisting chiefly of soils with a layer that impedes the downward movement of water or soils with moderately fine to fine textures a slow infiltration rate. Group D soils have very slow infiltrations rates when thoroughly wetted, consisting chiefly of shallow soils over nearly impervious materials. Soil hydrologic groups include 34,309 acres of A, 47,019 acres of B, 28,671 acres of C, 27,431 acres of D, and 13,671 acres of no ratings. See Table 4 for the hydrologic soil groups and Figure 8 for a map of the soil hydrologic groups within the fire area. Additional effects of the fire will cause more runoff, accelerated sheet and rill erosion throughout the fire areas.

Table 4: Rough Fire BAER hydrologic soil groups

Soil Hydrologic Group	Acres	% of Fire Area
A	34,309	23%
B	47,019	31%
C	28,671	19%
D	27,431	18%
National Park (N/A)	9,271	6%
Rock Outcrop (N/A)	4,400	3%

Post-Fire Condition Assessment

Rapid assessment and mapping of areas in soil burn severity (SBS) classes is necessary for incorporation with other site factors such as soil type, slope, hydrologic characteristics, and biological or human resource issues to identify source areas of potential flooding and erosion, and areas where critical ecosystem values may be degraded.

Figure 2: Strong soil water repellency

It should be understood that **soil burn severity is NOT vegetative burn severity or mortality**. Vegetative burn severity is but one component taken into consideration – soil burn severity goes beyond aboveground vegetation impacts to belowground soil heating effects and associated impacts to soil hydrologic function, runoff and erosion potential, and vegetative recovery. Such additional factors include amount and condition of residual ground cover, viability of native seed banks, condition of residual fine roots, degree of fire-induced water-repellency, soil physical factors (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 more related to peak temperatures and fire behavior during the fire, below-ground soil burn severity is related strongly to the length of time that heat is in contact with the soil (residence time).

Understanding these differences is crucial to meeting the objectives of the BAER assessment. A high intensity fire (high flame lengths, rapid rate of spread, crown fire, etc.) in a stand-replacement event can result in a moderate (or even low) soil burn severity, if the residence time is short and soil characteristics are not altered significantly. Conversely, a slow-moving fire with complete consumption of accumulated surface fuels can leave trees alive, but heat the soil severely with predictable negative consequences to soils and streams. Soil burn severity, used in this context, is a much better index of soil damage, watershed response, and potential for natural vegetative recovery after the fire. Residual soil cover post-fire is the most crucial aspect of aboveground fire effects for potential erosion, but there is a tendency for some to consider only cover at the expense of belowground soil conditions.

Soil Burn Severity Indicators (Parsons et al 2010) used to characterize the soil burn severity at field data points:

- **Low soil burn severity**: Surface organic layers are not completely consumed and are still recognizable. Structural aggregate stability is not changed from its unburned condition, and roots are generally unchanged

because the heat pulse below the soil surface was not great enough to consume or char any underlying organics. The ground surface, including any exposed mineral soil, may appear brown or black (lightly charred), and the canopy and understory vegetation will likely appear "green."

- **Moderate soil burn severity:** Up to 80 percent of the pre-fire ground cover (litter and ground fuels) may be consumed but generally not all of it. Fine roots (~0.1 inch or 0.25 cm diameter) may be scorched but are rarely completely consumed over much of the area. The color of the ash on the surface is generally blackened with possible gray patches. There may be potential for recruitment of effective ground cover from scorched needles or leaves remaining in the canopy that will soon fall to the ground. The prevailing color of the site is often "brown" due to canopy needle and other vegetation scorch. Soil structure is generally unchanged.

- **High soil burn severity**: All or nearly all of the pre-fire ground cover and surface organic matter (litter, duff, and fine roots) is generally consumed, and charring may be visible on larger roots. The prevailing color of the site is often "black" due to extensive charring. Bare soil or ash is exposed and susceptible to erosion, and aggregate structure may be less stable. White or gray ash (up to several centimeters in depth) indicates that considerable ground cover or fuels were consumed. Sometimes very large tree roots (> 3 inches or 8 cm diameter) are entirely burned extending from a charred stump hole. Soil is often gray, orange, or reddish at the ground surface where large fuels were concentrated and consumed.

Field sites were used to finalize the soil burn severity map from the Burn Are Reflectance Classification (BARC) map and to determine the degree of water repellency present within the top soil. Within the areas identified with a high soil burn severity (4% of the fire area) characteristics of both a high and moderate soil burn severities. Ash color varied from gray to red and the layer depth, where still present, ranged from less than 1" of ash to up 3" of ash. The depth of soil charring varied from only at the surface to one to two inches deep. Within this same zone partial to complete consumption of the soil organic matter had occurred (consumption of smaller roots and charring of coarser roots) and soil structure ranged from partial to complete consumption. Very few areas were observed within the fire area that showed a "true" high soil burn severity, see Figure 3. Varying degrees of non-consumed organic matter within the surface soil has caused the soil structure to be slightly altered to completely destroyed in some circumstances, as the soil structure became more altered as the soil aggregates became weaker and weaker. Increased fuel loads within certain areas have increased the fire residence times increasing the duration and intensity of soil heating causing higher soil burn severities to occur. Soil water repellency (hydrophobicity) was variable down to three inches; included were areas of weak (<10 seconds) too strongly (>40 seconds) hydrophobic soils, see Figure 2 for a visual representation of strong hydrophobicity. Remaining ground cover varied from partially (50 to 80% consumed) to completely consumed. The canopy was typically completely consumed and minimal recruitment of additional soil cover will occur in these areas. The cumulative effects of having minimal remaining ground cover and insignificant additional needle cast will result in a higher likelihood of hillslope erosion potentially causing a negative watershed response.

Figure 3: High soil burn severity

Figure 5: Moderate soil burn severity

Within the areas identified with a moderate soil burn severity (27.8% of the area) the ground conditions were representative of moderate soil burn severity, see Figure 4 for a visual representation. Ash color varied from black to white and the thickness was commonly less than 1". Minimal consumption of the soil organic matter had occurred and commonly only occurred to ¼ of an inch. Fine roots were frequently present but charred within this same depth range and soil structure varied from slightly too highly altered. Soil water repellency (hydrophobicity) was very patchy and included areas of weak (<10 second) too strongly (>40 seconds) hydrophobic soils. Ground cover varied between 50 to 80% consumption to complete consumption and the canopy varied from partially too completely consumed. With some areas still containing an intact brown canopy and able to provide an influx of ground cover in addition to non-consumed ground cover still present, a less intense watershed response is expected. Infiltration of storm precipitation will vary depending on storm intensity and duration, possibly resembling a high watershed response similar to high SBS areas in the event of a severe storm. In general areas with a moderate SBS will have higher infiltration capacity and greater soil cover retention when compared to areas with a high soil burn severity, resulting in a lesser erosion risk.

The remaining 68.2% of the burned area contained an unburned/very low too low soil burn severity, see Figure 5 for a visual representation. Very little evidence of significant soil heating was observed. No to partial consumption of the canopy had occurred. Ground cover was recognizable with commonly less than 50% ground cover consumption throughout. Ash was generally white with a few occurrences of gray and white ash observed. Very little organic matter was consumed resulting in an unaltered soil texture. Water repellency is hit-or-miss, from slight to severe, and is attributed as natural, not fire-exacerbated. The seed source within these areas would still be present in most of the topsoil and natural understory revegetation is expected to progress without delay. Ground cover was recognizable and less than 20% consumption was commonly observed. Areas within the unburned/very low to low soil burn severities currently have 50 to 100% soil cover and should produce little accelerated runoff or erosion above natural "background" rates.

Figure 4: Low soil burn severity

Quantitative erosion figures were estimated using the ERMiT batch model. ERMiT (Erosion Risk Management Tool) 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. 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 landsliding or gullying, stream-bank erosion, road effects, or fire-line erosion and gullying, which could present large additional sources of sediment entering the fluvial systems.

ERMiT models erosion potential based on single hillslopes, single-storm "runoff events," and post-fire soil burn severity. Hillslopes include soil and topography inputs. Soil inputs include texture and matrix rock content, which was based upon soil map unit information and field verified in many areas of the fire as part of the assessment. Generalized hillslope gradients and profiles were developed in GIS by soil map unit, and soil burn severity class to account for fairly site specific differences in topography. One thousand and thirty-five hillslopes were modeled within the fire area. One batch run was completed for the entire fire area and seventeen individual runs for each of the HUC12 watersheds within proximity to the fire area. See Table 5 and Table 6 for the burned and unburned ERMiT batch results. See Figure 9 for a fire wide erosion potential map per the HUC12 level. As input for storm events, ERMiT uses the PRISM module to generate climatic input parameters; a customized climate interpolated from Grant Grove, CA was generated for the fire area and each individual HUC12 subwatershed. Various storm runoff-event magnitudes may be chosen in ERMiT for erosion response estimates; 2-year, 5-year, and 10-year events were run for this analysis.

Soil erosion estimates are based upon watershed areas within the fire perimeter only; unburned watershed areas outside the fire area were not modeled. As an interpretive visual, tons/ac is roughly equivalent to that many sheets of paper stacked being removed from the soil surface, and 1000 tons of sediment would fill about 120 standard 10-yard dump trucks. A 2-Year storm was modeled in ERMiT to determine if the estimated soil erosion for the fire area would affect soil productivity. For the 2-year event (50% probability); an estimated average 1,031,070 tons of sediment may be produced (6.48 tons/acre), equivalent to 3,235 cubic yards per square mile (using a conversion factor of 1.35 tons per cubic yard). Increased hillslope erosion is expected to occur throughout the fire area, especially within those areas in the high soil burn severity. Unburned, pre-fire conditions estimated an average 14,256 tons of sediment could be produced (0.13 tons/acre) for a 2-year event (50% probability). Stated model accuracy is +/- 50%.

Table 5: Rough Fire ERMiT batch unburned results

Area	50% (2 Year)		20% (5 Year)		10% (10 Year)	
	Tons/Acre	Tons	**Tons/Acre**	**Tons**	**Tons/Acre**	**Tons**
Rough Fire	0.13	14,256	0.48	44,512	1.42	99,396
Big Meadows Creek-Boulder Creek	0.03	4	0.17	23	0.79	107
Boulder Creek-South Fork Kings River	0.09	759	0.30	2,830	0.75	8,523
Converse Creek-Kings River	0.06	363	0.29	4,842	0.86	11,188
Crown Creek	0.02	4	0.14	14	0.96	143
Granite Creek-South Fork Kings River	0.03	0	0.16	0	0.42	2
Lewis Creek-South Fork Kings River	0.09	489	0.27	1,144	2.61	12,270
Lightning Creek-South Fork Kings River	0.03	148	0.14	754	0.96	5,461
Lower Middle Fork Kings River	0.07	787	0.26	2,930	2.11	24,897
Middle Mill Creek	0.04	0	0.16	0	1.41	1
Mill Flat Creek	0.19	3,563	0.55	9,426	1.46	16,377
Patterson Creek-North Fork Kings River	0.17	528	0.71	1,954	2.31	5,832

Rancheria Creek-North Fork Kings River	0.06	121	0.24	742	1.76	4,052
Tenmile Creek	0.08	191	0.30	1,045	0.82	2,541
Upper Mill Creek	0.02	0	0.11	2	0.50	6
Upper Pine Flat Reservoir	0.41	1	1.34	2	2.36	4
Verplank Creek-Kings River	0.13	1,788	0.68	10,928	2.41	27,422
White Deer Creek	0.09	1	0.87	4	2.22	16

Table 6: Rough Fire ERMiT batch burned results

Area	50% (2 Year)		20% (5 Year)		10% (10 Year)	
	Tons/Acre	Tons	Tons/Acre	Tons	Tons/Acre	Tons
Rough Fire	6.48	1,031,070	19.46	3,096,146	33.01	5,503,267
Big Meadows Creek-Boulder Creek	4.13	1,671	13.32	4,895	24.60	8,688
Boulder Creek-South Fork Kings River	6.75	110,106	18.18	342,294	26.51	479,526
Converse Creek-Kings River	5.89	194,526	18.39	600,063	32.39	1,100,002
Crown Creek	0.39	4	1.20	14	2.70	144
Granite Creek-South Fork Kings River	2.93	7	9.20	269	19.41	623
Lewis Creek-South Fork Kings River	3.77	24,038	10.16	77,149	17.95	132,786
Lightning Creek-South Fork Kings River	5.41	40,005	15.38	111,431	22.44	165,156
Lower Middle Fork Kings River	5.53	67,463	15.53	204,349	22.83	343,454
Middle Mill Creek	3.97	60	14.16	238	25.95	518
Mill Flat Creek	5.48	178,384	14.87	456,595	27.60	918,625
Patterson Creek-North Fork Kings River	7.28	32,912	20.75	114,388	44.49	240,176
Rancheria Creek-North Fork Kings River	5.58	36,171	15.64	119,561	25.16	177,060
Tenmile Creek	6.07	42,505	16.17	139,461	26.35	229,551
Upper Mill Creek	4.02	58	14.86	187	30.64	455
Upper Pine Flat Reservoir	3.96	3	10.66	8	20.64	16
Verplank Creek-Kings River	4.56	79,965	16.10	293,403	27.14	538,182
White Deer Creek	4.84	33	12.15	139	17.20	194

Values at Risk – Threats to Life, Property, and Cultural & Natural Resources

In one sense, fire and post-fire erosion are integral parts of the local disturbance regime; however many of the BAER critical values we are concerned with did not naturally occur in the fire area prior to historic times. Soil quality and hydrologic function throughout the fire was assessed by determining soil burn severity, soil erosion hazard, 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 elevated erosion and sedimentation, the degree depending upon the severity of the coming winters over the next 3-5 years at least. Potential impacts can be categorized into both on-site and off-site effects. On-site effects include the physical, chemical, and biological response of the soils to the fires, and likely recovery rates. Off-site effects due to sedimentation and stream bulking are downstream; these in a general sense include potential adverse effects to life and facilities (roads, buildings, reservoirs), water quality deterioration for sensitive aquatics species and human use, and risk to human life and property from potential flooding, mudslides, and debris flows, both on and off of Forest Service lands.

Erosion and sedimentation would contribute to debris flows and mudflows IF they were to occur, which would have a high potential to threaten life and property, as well as water quality for beneficial uses. Natural hillslope erosion rates are rather low (< 1 ton/acre) when vegetated and covered with duff; vegetation mortality and lack of cover in moderate SBS areas will certainly accelerate runoff and erosion processes in the post-fire environment, the degree depending on the magnitude and intensity of coming storm events. While this may or may not pose an unacceptable risk to on-site soil resources, it would contribute to downstream hazards, particularly if larger storm events occur in the first several winters.

Emergency Determination

Specific to soil productivity for a 2-Year (50% probability storm), modeled fire wide average erosion rates (6.48 tons/acre) are low and are not likely impact to soil productivity. Soil families within the fire area consisted of moderately deep to deep soil profiles within the more developed, older soils and shallower profiles within the young soils. Water repellency was observed in all of the soil burn severities. Risk rating for soils varies according to the likelihood of major soil loss: there is a **likely/possible** probability of damage or loss from a 50% probability storm with a **minor** magnitude of consequences based off an average erosion rate of 6.48 tons/acre, resulting in a **low** risk to soil productivity, see the BAER Risk Assessment matrix within Appendix A. While soil erosion is always irreversible (major magnitude of consequences), the damage to soil productivity is considered recoverable in most cases, as forest soils are generally resilient and post-fire pulse erosion is a very natural geomorphic process.

References

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USDA Forest Service. 1990. Soil erosion hazard rating. Soil and Water Conservation Handbook

Appendix A

BAER Risk Assessment

Probability of Damage or Loss	Magnitude of Consequences		
	Major	Moderate	Minor
	Risk		
Very Likely	Very High	High	Low
Likely	Very High	High	Low
Possible	High	Intermediate	Low
Unlikely	Intermediate	Low	Very Low

Probability of Damage or Loss

The following descriptions provide a framework to estimate the relative probability that damage or loss would occur within one to three years (depending on the resource):

- Very likely- nearly certain occurrence (>90%)
- Likely- likely occurrence (>50% to < 90%)
- Possible- possible occurrence (>10% to <50%)
- Unlikely- unlikely occurrence (<10%)

Magnitude of Consequences

- Major- Loss of life or injury to humans; substantial property damage; irreversible damage to critical natural or cultural resources.
- Moderate- Injury or illness to humans; moderate property damage; damage to critical natural or cultural resources resulting in considerable or long term effects.
- Minor- Property damage is limited in economic value and/or to few investments; damage to natural or cultural resources resulting in minimal, recoverable or localized effects.

Appendix B

Table 7: Rough Fire soil families in order of dominance

Soil Families	Acres	%
Rock Outcrop	18,248	12%
Coarsegold	17,940	12%
Chaix	15,579	10%
Entic Xerumbrepts	13,133	9%
Holland	10,058	7%
National Park Soils	9,269	6%
Auberry	8,052	5%
Dystric Xerorthents	6,626	4%
Typic Xerorthents	5,644	4%
Chawanakee	5,159	3%
Cieneba	4,120	3%
Shaver	3,855	3%
Cagwin	3,682	2%
Cannell	3,571	2%
Dome	3,321	2%
Brownlee	3,044	2%
Bohna	2,848	2%
Stecum	2,341	2%
Sirretta	2,297	2%
Hotaw	1,782	1%
Ahwahnee	1,739	1%
Gerle	1,698	1%
Chualar	1,260	1%
Umpa	1,256	1%
Tollhouse	1,104	1%
Typic Xerumbrepts	945	1%
Boomer	790	1%
Typic Cryorthents	771	1%
Dystric Xerochrepts	428	0%
Ultic Haploxeralfs	392	0%
Kriest	60	0%
Typic Argixerolls	56	0%
Xerofluvents	21	0%
Water	13	0%
Total:	151,102	

Table 8: Rough Fire soil map units

Soil Survey & Soil Map Unit	SMUN	ACRES
CA740 - 103	Ahwahnee family-Rock outcrop complex, 35 to 75 percent slopes	1,739
CA740 - 111	Cagwin family, 25 to 60 percent slopes	1,255
CA740 - 113	Cagwin family-Lithic Xeropsamments-Rock outcrop complex, 15 to 45 percent slopes	405
CA740 - 115	Typic Cryorthents-Rock outcrop complex, 40 to 85 percent slopes	771
CA740 - 124	Dystric Xerorthents-Dystric Xerochrepts-Rock outcrop complex, 40 to 85 percent slopes	3,724
CA740 - 125	Dystric Xerorthents-Typic Xerumbrepts-Rock outcrop complex, 15 to 45 percent slopes	2,902
CA740 - 126	Chawanakee family-Rock outcrop complex, 35 to 65 percent slopes	2,992
CA740 - 128	Typic Xerorthents-Entic Haploxerolls-Typic Xerochrepts complex, 35 to 75 percent slopes	5,644
CA740 - 135	Gerle-Cagwin families association, 35 to 55 percent slopes	1,698
CA740 - 139	Holland-Chaix families complex, 35 to 65 percent slopes	1,680
CA740 - 142	Entic Xerumbrepts-Dystric Xerorthents-Rock outcrop association, 40 to 85 percent slopes	13,133
CA740 - 147	Rock outcrop	695
CA740 - 147	Rock outcrop-Typic Cryorthents complex, 0 to 45 percent slopes	172
CA740 - 148	Rock outcrop-Typic Cryorthents complex, 40 to 85 percent slopes	600
CA740 - 148	Rock outcrop-Chawanakee family association, 35 to 65 percent slopes	1,190
CA740 - 149	Rock outcrop-Cryorthents complex, 5 to 50 percent slopes	874
CA740 - 152	Rock outcrop-Lithic Xeropsamments complex, 15 to 45 percent slopes	327
CA740 - 153	Rock outcrop-Lithic Xeropsamments complex, 45 to 85 percent slopes	510
CA750 - 106	Auberry family, 35 to 65 percent slopes	521
CA750 - 108	Auberry-Ahwahnee families association, 35 to 65 percent slopes	67
CA750 - 109	Auberry family-Rock outcrop complex, 35 to 75 percent slopes	373
CA750 - 110	Auberry-Tollhouse families-Rock outcrop association, 25 to 65 percent slopes	1,221
CA750 - 112	Cagwin-Cannell families complex, 2 to 25 percent slopes	292
CA750 - 116	Cagwin family-Rock outcrop complex, 35 to 65 percent slopes	565
CA750 - 127	Coarsegold-Auberry families association, 35 to 65 percent slopes	5,669
CA750 - 128	Coarsegold-Auberry families-Rock outcrop association, 35 to 85 percent slopes	3,213
CA750 - 131	Dystric Xerochrepts and Typic Xerumbrepts, 20 to 50 percent slopes	428
CA750 - 137	Holland family, 35 to 65 percent slopes	2,248
CA750 - 140	Holland-Chawanakee families complex, 35 to 65 percent slopes	498
CA750 - 158	Sirretta family, 25 to 50 percent slopes	643
CA750 - 159	Sirretta family-Rock outcrop complex, 15 to 45 percent slopes	272
CA750 - 160	Sirretta family-Rock outcrop complex, 45 to 65 percent slopes	741
CA750 - 161	Sirretta family and Umpa family, wet, 2 to 25 percent slopes	640
CA750 - 162	Stecum family, 3 to 35 percent slopes	1,466
CA750 - 163	Stecum family-Aquic Cryumbrepts association, 1 to 25 percent slopes	81
CA750 - 164	Stecum family-Rock outcrop complex, 5 to 45 percent slopes	794
CA750 - 166	Tollhouse family-Rock outcrop complex, 30 to 60 percent slopes	593
CA750 - 167	Tollhouse family-Rock outcrop association, 60 to 85 percent slopes	512

CA750 - 168	Typic Argixerolls, 15 to 50 percent slopes	6
CA750 - 169	Typic Argixerolls-Coarsegold family association, 35 to 65 percent slopes	50
CA750 - 170	Typic Xerumbrepts, 5 to 20 percent slopes	945
CA750 - 171	Ultic Haploxeralfs, deep, 15 to 50 percent slopes	392
CA750 - 174	Umpa family, 5 to 35 percent slopes	982
CA750 - 175	Umpa family, 35 to 55 percent slopes	274
CA750 - W	Water	8
CA760 - 105	Auberry sandy loam, 50 to 75 percent slopes	1,248
CA760 - 107	Bohna loam, 30 to 50 percent slopes	2,848
CA760 - 114	Auberry-Holland association, very steep	804
CA760 - 201	Cieneba-Rock outcrop complex, 15 to 50	165
CA760 - 202	Cieneba-rock outcrop complex, 50 to 75 percent slopes	3,955
CA760 - 205	Chualar family-Rock outcrop complex, 50 to 75 percent slopes	1,260
CA760 - 212	Auberry-cieneba-rock outcrop complex, 10 to 30 percent slopes	448
CA760 - 213	Auberry-Cieneba-Rock outcrop complex, 30 to 50 percent slopes	3,369
CA760 - 300	Xerofluvents-Xerorthents-Riverwash association, sloping	21
CA760 - 400	Rock outcrop	5,488
CA760 - 404	Rock outcrop-Xerorthents association, steep	37
CA760 - 409	Rock outcrop-Toem-Sirretta complex, 10 to 30 percent slopes	292
CA760 - 410	Rock outcrop-Toem complex, 30 to 50 percent slopes	142
CA760 - 411	Rock outcrop-Toem complex, 50 to 75 percent slopes	335
CA760 - 414	Rock outcrop-Chualar family complex, 50 to 75 percent slopes	3,219
CA760 - 420	Rock outcrop-Cieneba complex, 50 to 75 percent slopes	2,641
CA760 - 429	Rock outcrop-Cieneba-Chawanakee complex, 30 to 75 percent slopes	385
CA760 - 432	Rock outcrop-Chawanakee-Chaix complex, 50 to 75 percent slopes	1,343
CA760 - 601	Brownlee family-Hotaw variant complex, 30 to 50 percent slopes	3,044
CA760 - 609	Cagwin-Toem-Rock outcrop complex, 5 to 30 percent slopes	618
CA760 - 610	Cagwin-Toem rock outcrop complex, 30 to 50 percent slopes	548
CA760 - 618	Chaix-Chawanakee-Rock outcrop complex, 5 to 30 percent slopes	1,711
CA760 - 635	Hotaw variant-Brownlee family-Rock outcrop complex, 40 to 75 percent slopes	1,782
CA760 - 645	Cannell-Kriest family,-Rock outcrop complex, 5 to 30 percent slopes	1,668
CA760 - 646	Cannell-Kriest family,-Rock outcrop complex, 30 to 50 percent slopes	1,671
CA760 - 647	Cannell-Kriest family,-Rock outcrop complex, 50 to 75 percent slopes	231
CA760 - 648	Kriest family,-Cannell-Rock outcrop complex, 5 to 30 percent slopes	60
CA760 - 657	Chaix-Dome-Holland association, moderately steep	1,126
CA760 - 658	Chaix-Dome-Holland association, steep	926
CA760 - 660	Shaver-Chaix association, moderately steep	1,904
CA760 - 661	Shaver-Chaix association, steep	1,431
CA760 - 662	Shaver-Chaix association, very steep	519
CA760 - 663	Chawanakee-Rock outcrop-Chaix complex, 5 to 30 percent slopes	410
CA760 - 664	Chawanakee-Rock outcrop complex, 30 to 50 percent slopes	1,351

CA760 - 665	Chawanakee-Rock outcrop-Chaix complex, 50 to 75 percent slopes	407
CA760 - 670	Chaix-Dome-Rock outcrop complex, 30 to 50 percent slopes	3,456
CA760 - 671	Chaix-Dome-Rock outcrop complex, 50 to 75 percent slopes	1,361
CA760 - 672	Dome-Chaix association, moderately steep	2,211
CA760 - 673	Dome-Chaix association, steep	1,110
CA760 - 681	Boomer-Crozier-Rock outcrop complex, 5 to 40 percent slopes	790
CA760 - 685	Holland-Shaver association, steep	470
CA760 - 693	Holland-Hotaw association, moderately steep	2,949
CA760 - 694	Holland-Hotaw association, steep	2,214
CA760 - 696	Chaix-Rock outcrop-Dome complex, 10 to 30 percent slopes	1,293
CA760 - 697	Chaix-Rock outcrop-Dome complex, 30 to 50 percent slopes	3,763
CA760 - 698	Chaix-Rock outcrop-Dome complex, 50 to 75 percent slopes	1,944
CA760 - CxEef	Coarsegold fine sandy loam, 30 to 45 percent slopes	9,002
CA760 - CxFef	Coarsegold fine sandy loam, 45 to 70 percent slopes	56
CA760 - W	Water	5
Park		9,269

Appendix C

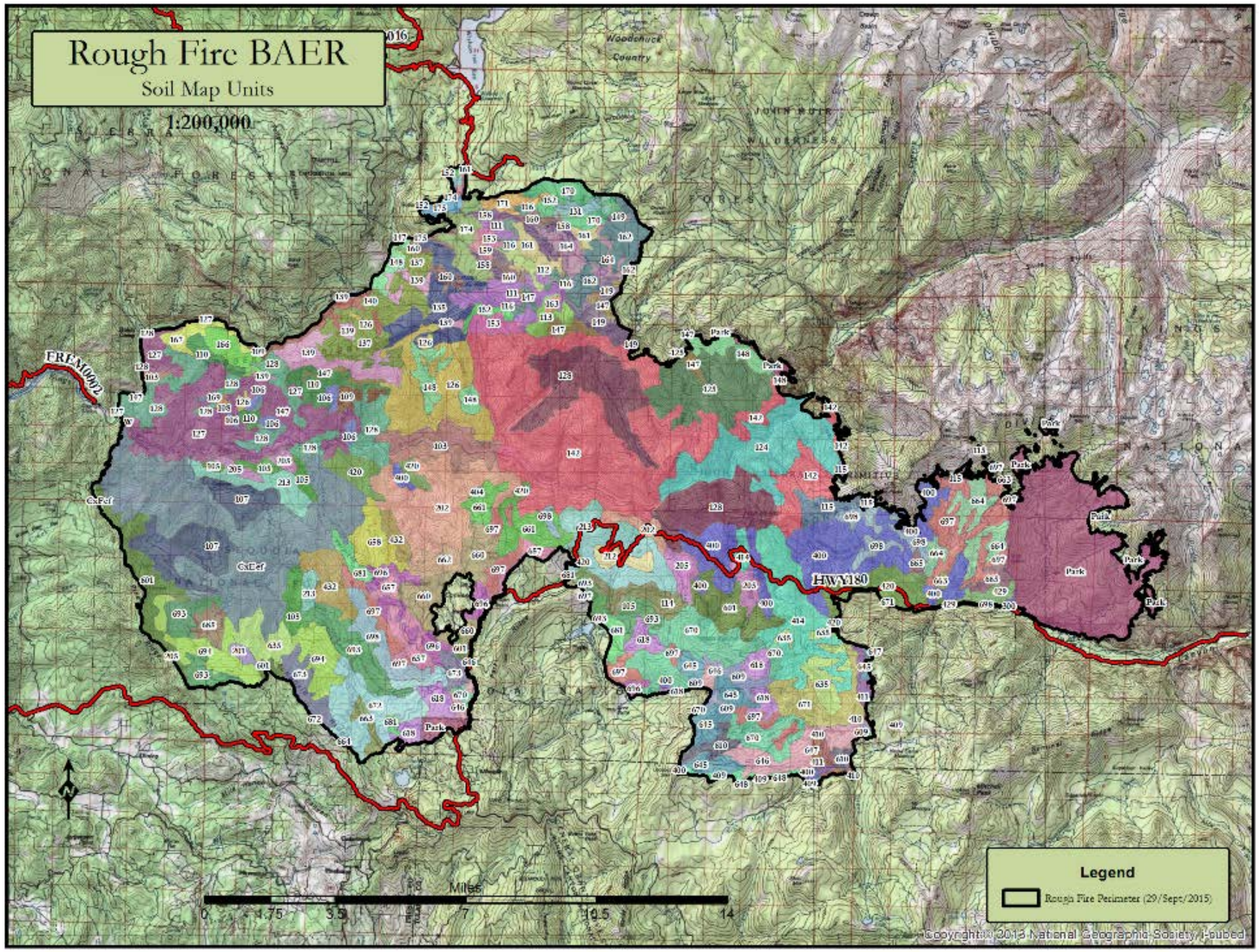

Figure 6: Rough Fire BAER soil map units

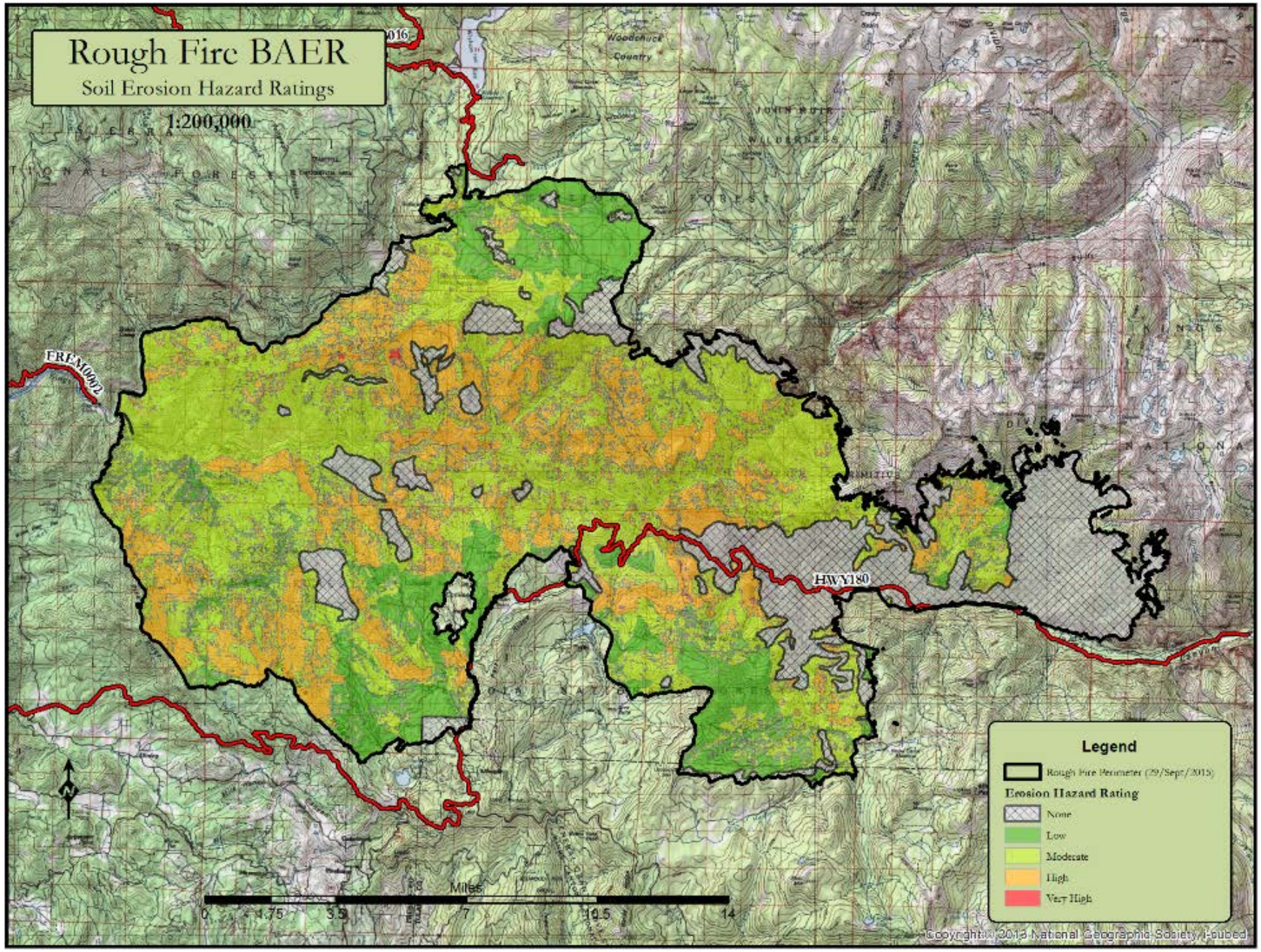

Figure 7: Rough Fire BAER soil erosion hazard ratings

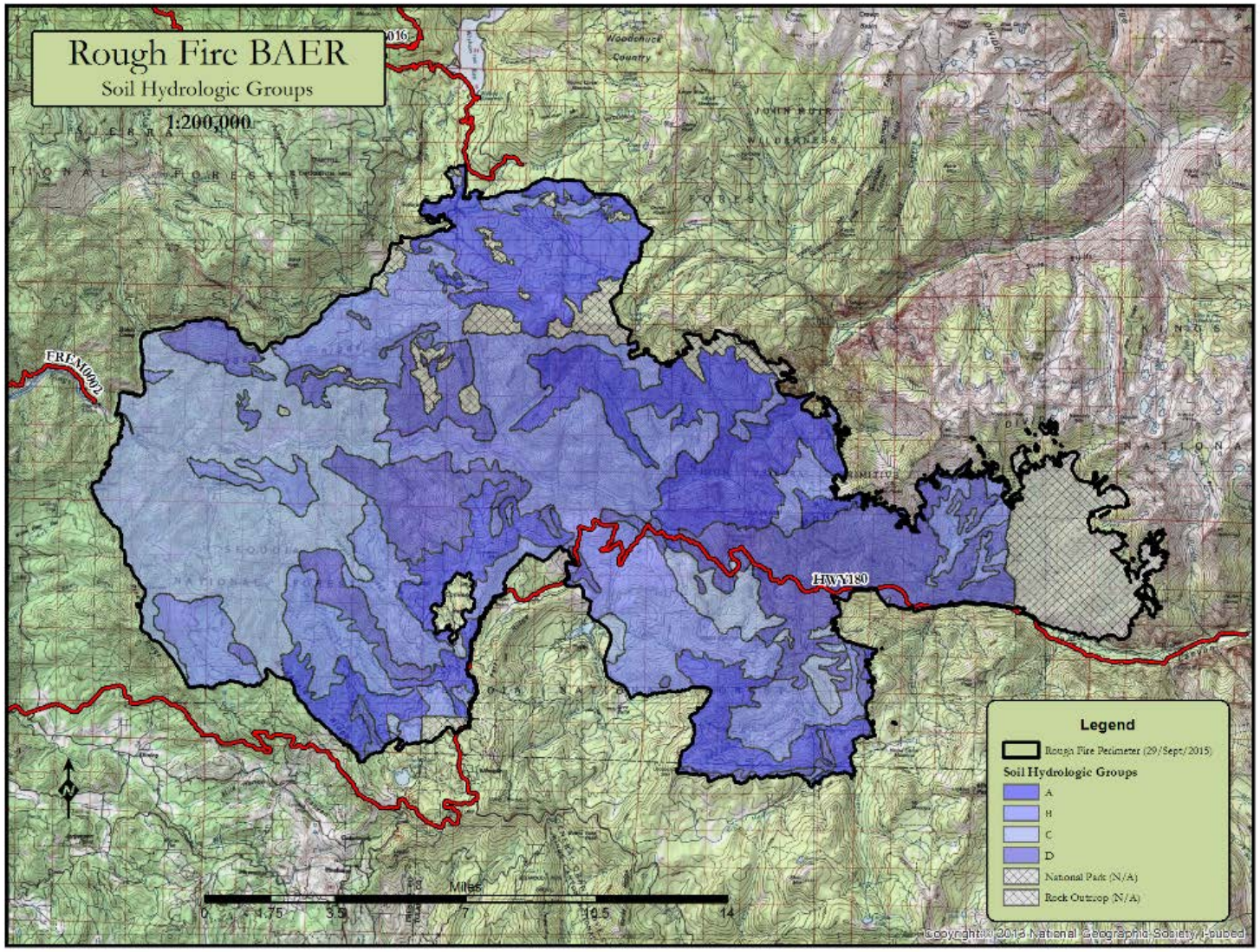

Figure 8: Rough Fire BAER soil hydrologic groups

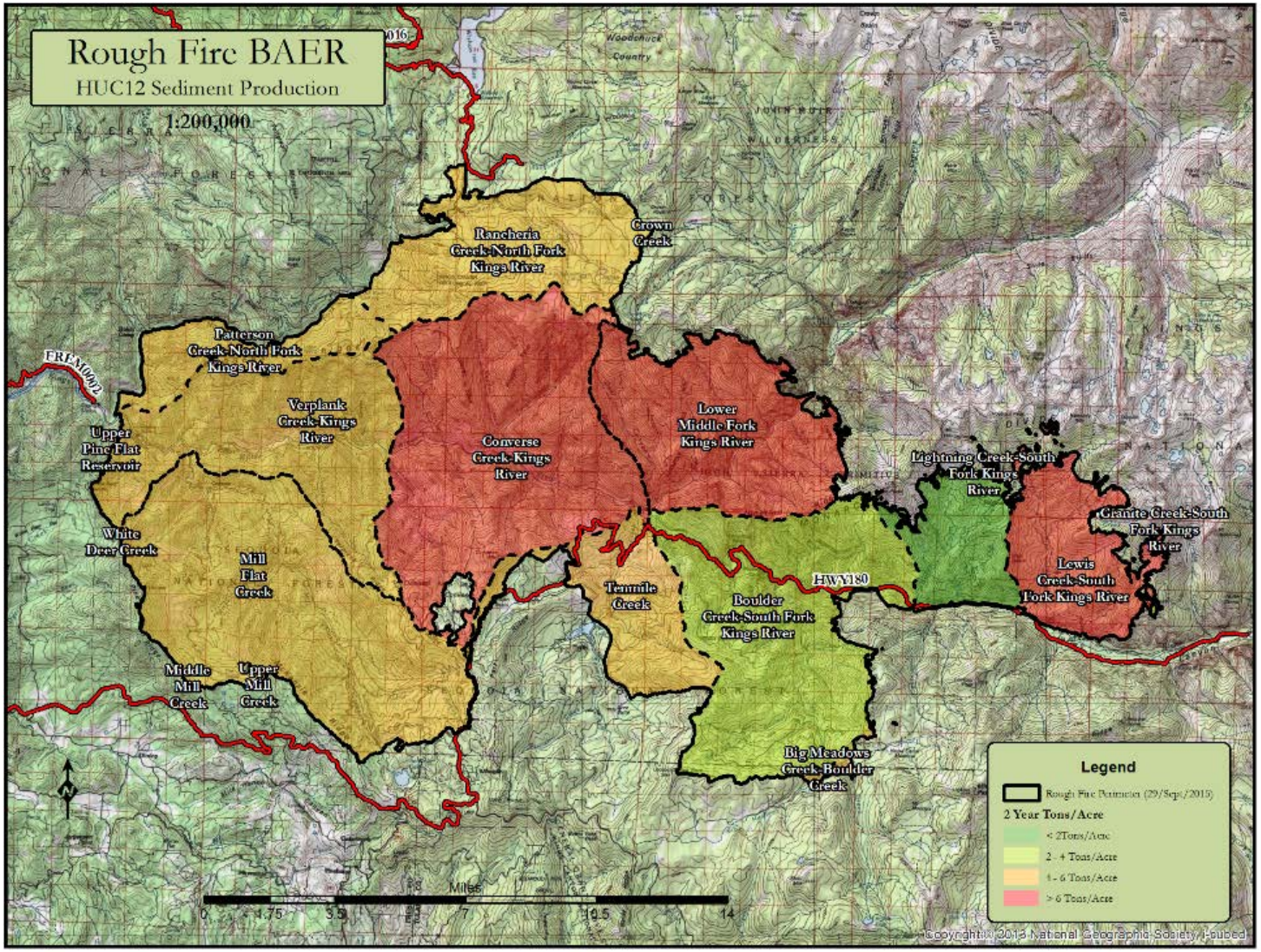

Figure 9: Rough Fire BAER HUC12 sediment production potential