Blue Cut BAER

San Bernardino National Forest

Soil Resource Assessment Report

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Soil Resource Setting

The Blue Cut Fire started the morning of August 16, 2016 in the Cajon Pass along Old Cajon Blvd. north of Kenwood Avenue, west of Interstate 15. The fire quickly began spotting onto the San Bernardino National Forest and burned a total of 28,980 acres on both the Front Country Ranger District and the Santa Clara/Mojave Rivers Ranger District of the Angeles National Forest. The fire continued to burn for five days before it was declared contained by fire personnel on August 24th and burned a total of 36,240 acres. The Blue Cut Fire impacted the communities of Lytle Creek, Wrightwood, Summit Valley, Baldy Mesa, Phelan, and Oak Hills threatening the lives and property of residents residing within these communities. On national forest lands the fire burned over Joshua trees, chaparral, Pinyon pine, big cone Douglas-fir, and semi- desert riparian vegetation communities. Within the fire perimeter approximately 6,205 acres contained unburned/very low soil burn severity, 12,504 acres of low, 15,678 acres of moderate, and 1,852 acres of high, see Table 1 and Figure 1 in Appendix B.

Table 1: Blue Cut BAER soil burn severity (29/Sept/2015)

Soil Burn Severity	Acres	% Fire Area
Unburned/Very Low	6,205	17%
Low	12,505	35%
Moderate	15,678	43%
High	1,852	5%
Total:	**36,240**	

Soil Inventory

The San Bernardino is made up of four principle mountain ranges of those, the San Gabriel was effected by the Blue Cut fire. The San Gabriel's are separated from the San Bernardino range by the San Andreas Fault Zone creating what is known as the "main divide". The surrounding faults have had tremendous influence on the landforms associated with the San Bernardino National Forest having many landslides, rock falls, and generally unstable areas. The east west trend of the mountain range also drastically influences the precipitation spectrum (2 to 5 inches on the desert side to as high as 40 inches on the mountain crest) which is often bested expressed in the diverse vegetation communities found within this range. This wide range in distribution of rainfall and topography play an intricate role in the development of the soils found within the San Bernardino Mountains. Of the soils analyzed in this report many consist of shallow and moderately deep, weakly consolidated rock material with already naturally erodible tendencies.

Soils surveys are used to analyze various soil characteristics e.g., soil type, texture, and rock content. The San Bernardino National Forest Area Survey (CA777) and the Soil Survey of San Bernardino County (CA671) were used for the soil's assessment. Within the fire perimeter there are a total of 23 soil map units (SMUs), see Table 7 in Appendix A for a complete list of the soil map units and Figure 1 in Appendix B for a map display of these soils occurring within the fire perimeter. For further information regarding the soils found within the fire perimeter, both the CA777 and CA671 are available online, see Reference section of this report.

The top four dominant soils families within the burn area include Typic Xerothents, Soboba, Springdale, Olete, and Trigo see Table 2. A complete list is in Table 8 available in the Appendix A. Soil survey data was compared with data collected within the fire perimeter and site-specific observations to generate interpretations of fire effects upon known (visited) soils, and extrapolate interpretations for unvisited areas. This information provided basic soil characteristics for predicting post fire effects on soil productivity and erosion potential.

Table 2: Blue Cut Fire BAER top five dominant soil families

Soil Family	Acres	% Fire Area
Typic Xerorthents	9,031	25%
Soboba	5,846	16%
Springdale	4,232	12%
Olete	3,623	10%
Trigo	3,348	9%

Soil Erosion Hazard Rating

In order to assess the potential risk of a given soil to erode, the erosion hazard rating (EHR) system was developed within Region-5 of the United States Forest Service, Soil and Water Conservation Handbook (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, 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.

To develop the EHR ratings for the soils on the Blue Cut Fire soil map units were evaluated using information relevant to 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. Table 3 displays the EHR's accessed within the fire perimeter. Appendix B, Figure 3 displays a map of this information.

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

EHRs	ACRES	% of the Fire Area
Low	10,882	30%
Moderate	5,576	15%
High	7,236	20%
Very High	12,546	35%

Estimated Erosion Response

Hydrologic soil groups are a standard soil-survey index of potential runoff response and subsequent erosion, this grouping is designated regardless of fire effects of soil characteristic used to classify each group. The associated value is used to determine the associated runoff curve number and is used to make direct estimates of runoff from rainfall (see Hydrology Report for more information). Hydrologic soil Group A 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. Determinations are not made for miscellaneous land types such as riverwash or rock outcrop. Table 4 displays the total number of acres for each group. Appendix B, Figure 4 displays a map of each soil hydrologic group found within the fire perimeter.

Table 4: Blue Cut Fire BAER hydrologic soil groups

Soil Hydrologic Group	Acres	% of Fire Area
A	7,897	22%
B	22,993	63%
C	3,996	11%
D	-	-
Riverwash (N/A)	1.009	3%
Rock Outcrop (N/A)	4,400	1%

Post-Fire Condition Assessment

The need for rapid assessment and mapping of soil burn severity (SBS) is essential to identifying areas of potential hazards caused by flooding or erosion to human and biological resources. Factors such as soil type, slope, and hydrologic characteristics are important components in identifying risk and risk management.

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 are influenced by pre-fire, fire, and post-fire environments. Soil burn severity includes careful consideration of factors such as, 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), and the length of time heat from the fire has been in contact with the soil (residence time). This differs from above-ground vegetation impacts as it is, more related to peak temperatures and fire behavior during the fire.

Understanding these factors that influence soil burn severity is an integral part in 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 long residence times and complete consumption of accumulated surface fuels can have negative consequences to soils and streams. Soil burn severity, used in this context, is a much better index of soil productivity, vegetative recovery, and overall watershed response in the post-fire environment.

Soil Burn Severity

Soil burn severity indicators (Parsons et al 2010) were used to characterize the soil burn severity at field data points. These field points were then used to modify the BARC to better reflect the on-ground conditions and the final soil burn severity map was produced.

A total of 1,852 acres were identified as high soil burn severity (5% of the fire area) common characteristics of both a high and moderate soil burn severities are present, representative of the natural variability on the landscape. Very few areas observed within the fire perimeter were found displaying a "true" high soil burn severity. Ash color varied from gray to white with the ash layer ranging from less than 1" to 3" depending on landscape position and wind exposure. It was not uncommon to see deeper ash layers within low laying areas and flat topography. Soil organic matter consumption was often completely consumed destroying effective soil structure needed for slope stability, vegetative regeneration, and moderation of runoff potential. The remaining ground cover was regularly completely consumed leaving only burned skeletons of the pre-existing vegetation. Soil water repellency (hydrophobicity) was variable down to three inches; included areas of weak (<10 seconds) too strong (>40 seconds) water repellency, see Photo 1 for a visual representation of strong hydrophobicity. Areas identified as high soil burn severity displayed common fire effects associated with dry fuels, deep litter layers, and longer residence times. These cumulative effects will like result in the higher likelihood of hillslope erosion and negative watershed response.

Photo 1: Strong soil water repellency (hydrophobicity)

Photo 2: Moderate soil burn severity

A total of 15,678 acres were identified with a moderate soil burn severity (43% of the area) see Photo 2. Ash color varied from black to white and ash 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 was patchy and included areas of weak (<10 second) too strongly (>40 seconds) hydrophobic soils. Ground cover within the moderate soil burn severity is similar to high soil burn severity with complete consumption of vegetative cover. What distinguish the two classes are often the overall watershed response and the presence of factors that influence the hazardous response. 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.

Low soil burn severity represents 12,504 acres (35 % of the area), see Photo 3 for a visual representation. Little evidence of significant soil heating was observed within these areas. Very little vegetative consumption occurred leaving a charred look in patches. Ground cover was recognizable with little to no effective cover loss. Ash was generally white to black in areas of total consumption. Very little organic matter was consumed resulting in an unaltered soil texture. Water repellency was low to non-existent. It is often common for soils to exhibit natural water repellency however, the coarser texture of many of the soils found within the fire perimeter only slightly displayed this natural condition. 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. Areas of

unburned/very low constituted for the remaining 6,205 acres within the fire (17% of the area). These areas are likely to recovery quickly if left undisturbed with little acceleration of erosion and runoff potential outside of natural variability.

Photo 3: Low soil burn severity

Estimated Erosion Response

Quantitative erosion figures were estimated using the Erosion Risk Management Tool (ERMiT) batch model. ERMiT is a Water Erosion Prediction Project (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 landslides 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. 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. ERMiT uses the PRISM module to generate climatic input parameters; a customized climate interpolated for San Bernardino, CA was generated for the fire area to account for the variations in precipitation across the fire perimeter.

Results of soil erosion modeling are reported by watershed name and only references watersheds within the fire perimeter both as burned and unburned (Table 5 and Table 6). The reported values are in total tons and tons per acre for the entire fire as a whole and each individual watershed within the fire. To help picture what a 1,000 tons of sediment might look like consider roughly 120 standard 10 cubic yard dump trucks filled up.

A 2-year storm event was modeled in ERMiT to determine if the estimated soil erosion for the fire area would affect soil productivity. The modeled 2-year event (50% probability) produced 192,805 tons of sediment equivalent to 4.7 tons per acre or 2,522 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. This increase in erosion is expect to be exasperated throughout the high and moderate soil burn severity areas, as soils within the fire perimeter are naturally erodible; which is reflected in the geomorphology of the area. The unburned, pre-fire conditions 2 year storm modeled a total of 2,090 tons of sediment equivalent to 0.06 tons per acre or 27 cubic yards per square mile. The stated accuracy of the model is +/- 50%.

Table 5: Blue Cut ERMiT batch unburned results

Area	50% (2 Year)		20% (5 Year)		10% (10 Year)	
	Tons/Acre	Tons	Tons/Acre	Tons	Tons/Acre	Tons
Blue Cut Fire	0.06	2,098	0.16	7,006	5.25	192,402
180902080502	0.02	9	0.10	41	1.76	70

Area	50% (2 Year)		20% (5 Year)		10% (10 Year)	
	Tons/Acre	Tons	Tons/Acre	Tons	Tons/Acre	Tons
Cajon Wash-Lytle Creek	0.10	3	0.21	6	8.10	245
Grass Valley Creek-West Fork Mojave River	0.03	47	0.14	138	1.16	1,625
Horse Canyon-Fremont Wash	0.02	53	0.12	242	2.32	5,935
Lower Cajon Wash	0.10	1,209	0.21	2,549	9.69	109,854
Manzanita Wash	0.02	10	0.09	111	1.32	821
North Fork Lytle Creek	0.06	85	0.13	169	4.55	6,461
Oro Grande Wash	0.02	22	0.10	171	1.13	1,801
Sheep Creek	0.04	19	0.14	74	3.86	1,893
Upper Cajon Wash	0.03	487	0.14	3,144	2.89	48,636

Table 6: Blue Cut Fire ERMiT batch burned results

Area	50% (2 Year)		20% (5 Year)		10% (10 Year)	
	Tons/Acre	Tons	Tons/Acre	Tons	Tons/Acre	Tons
Blue Cut Fire	4.7	192,805	11.9	537419.	19.2	862,442
180902080502	1.3	542	4.2	1,933	8.1	3,433
Cajon Wash-Lytle Creek	12.7	183	28.4	535	40.9	824
Grass Valley Creek-West Fork Mojave River	1.8	1,503	5.4	4,256	9.2	7,503
Horse Canyon-Fremont Wash	2.6	5,706	6.7	16,009	11.7	27,251
Lower Cajon Wash	8.3	93,784	20	252,477	30.6	379,260
Manzanita Wash	1.4	2,018	4.3	6,450	7.7	11,793
North Fork Lytle Creek	9.1	17,156	21.3	47,517	31.8	70,829
Oro Grande Wash	1.5	1,670	4.4	5,094	7.7	10,052
Sheep Creek	4.6	3,920	11.7	9,380	19.3	14,325
Upper Cajon Wash	3.5	67,834	9.3	197,157	16	339,616

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

Based on the analysis done in this assessment the probability of damage or loss is considered to be likely, occurrence >50% to < 90%**.** The magnitude of consequence is considered moderate; injury or illness to humans, moderate property damage, and damage to critical natural or cultural resources resulting in considerable or long term effects. The combined probability of damage or loss and magnitude of consequence, results in a high risk for soil productivity. See the BAER Risk Assessment matrix within Appendix C.

Soil quality and hydrologic function throughout the fire was assessed by determining soil burn severity, soil erosion hazard, and evaluating the potential of on- and off-site effects to soil productivity, soil loss, and sedimentation. The combined effects of soil type, steep slopes, and lack of vegetative soil cover will create a watershed response with elevated erosion, sedimentation, and the potential for debris flows. Risks downstream of the fire will be elevated considering the close proximity of homes, roads, and utility infrastructure.

The degree of threat to the soil resource will be determined over the coming winter months and throughout the next 3-5 years as soils and vegetation recovery stabilize. Potential impacts can be categorized into both on-site and off-site

effects. Unauthorized Off Highway Vehicle (OHV) use can increase soil loss and recovery times as well as damage or destroy cultural heritage and other natural resources such as threatened and endangered species. Natural re-establishment of cover can take many years to reach natural pre-burn cover conditions resulting in excess runoff and erosion until adequate cover is achieved. If extreme rainfall events occur within a five year period, high runoff and erosional events could occur resulting in a further loss of soil productivity, affects to water quality, or an increase in the potential for damage or loss of resource values downstream on and off Forest Service lands.

Natural hillslope erosion rates are rather low (< .5 tons/acre) when vegetated and covered with liter/duff; vegetation mortality and lack of cover in moderate and high SBS areas will certainly accelerate runoff and erosion processes in the post-fire environment, to what degree depends on the magnitude and intensity of coming storm events.

Emergency Determination and Treatments to Mitigate the Emergency

Specific to soil productivity for a 2-Year (50% probability storm), fire wide average erosion rates of 4.7tons/acre were predicted. There is a threat of sedimentation and potential debris flows affecting downstream values at risk considering the close proximity this fire had to homes, roads, and utility infrastructure. Risks to roads exist throughout the fire area which are necessary to the transportation system (see Engineering Report) and represent valuable infrastructure investments; these are generally more effectively protected by road "hardening" treatments than land treatments. Regardless of the risk level or emergency determination, topography significantly limits the possibility for land treatments that would effectively reduce this risk (considered 'untreatable' with land treatments on slopes >60%), Thus the places where treatments would not effectively reduce the risks. For the life and safety Values At Risk (VARs), communicating and coordinating with Natural Resource Conservation Service (NRCS) is the only feasible option, to develop point-protection treatments in lieu of upslope treatments on private lands.

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Appendix A

Table 7: Blue Cut Fire soil map units

Soil Map Unit	Soil Map Unit Name	Acres	% Fire Area
102	Avawatz-Oak Glen Association, Gently Sloping*	170	0.47%
111	Bull Trail-Typic Xerorthents Association, Moderately Steep*	676	1.86%
121	Crafton-Sheephead-Rock Outcrop Association, Steep*	1	0.00%
126	Gullied Land-Haploxeralfs Association	790	2.18%
175	Wrightwood-Bull Trail Association, Sloping*	4	0.01%
175	Wrightwood-Bull Trail Association, Sloping*	505	1.39%
AbD	Soboba-Hanford Families Association, 2 To 15 Percent Slopes	5846	16.13%
BeDE	Wrightwood-Morical, Dry Families, Association 2 To 30 Percent Slopes	2180	6.02%
BgEF	Morical Family, Dry-Badland Association, 15 To 50 Percent Slopes	1953	5.39%
ChFG	Typic Xerorthents, Warm-Typic Haploxeralfs-Badland Complex, 30 To 100 Percent Slopes	7518	20.74%
CmE	Modesto-Osito Families Association, 15 To 30 Percent Slopes	68	0.19%
CmF	Osito-Modesto Families Association, 30 To 50 Percent Slopes	579	1.60%
DnF	Trigo Family-Lithic Xerorthents, Warm Complex, 30 To 50 Percent Slopes	485	1.34%
DnG	Trigo Family-Lithic Xerorthents, Warm Complex, 50 To 75 Percent Slopes	2863	7.90%
EsD	Riverwash-Soboba Families Association, 2 To 15 Percent Slopes	997	2.75%
FLG	Springdale Family-Lithic Xerorthents Association, Dry, 50 To 75 Percent Slopes	4049	11.17%
FsD	Wilshire-Oak Glen, Dry Families Association, 2 To 15 Percent Slopes	1568	4.33%
JoG	Springdale, Dry-Olete Families Complex, 50 To 75 Percent Slopes	183	0.50%
MoFG	Typic Xerorthents-Morical Family, Dry Association, 30 To 75 Percent Slopes	1514	4.18%
PsD	Avawatz-Oak Glen, Dry Families Association, 2 To 15 Percent Slopes	314	0.87%
Rs	Rock Outcrop, 30 To 100 Percent Slopes	345	0.95%
Rw	Riverwash	12	0.03%
SgF	Olete-Kilburn-Goulding Families Complex, 30 To 50 Percent Slopes	1	0.00%
SgG	Olete-Goulding Families-Rubble Land Association, 50 To 100 Percent Slopes	3622	10.00%

Table 8: Blue Cut Fire soil families

Soil Family	Acres	% Fire Area
Typic Xerorthents	9,031	25%
Soboba	5,846	16%
Springdale	4,232	12%
Olete	3,623	10%
Trigo	3,348	9%
Wrightwood	2,689	7%
Morical	1,953	5%
Wilshire	1,568	4%
Riverwash	1,009	3%
Gullied Land	790	2%
Bull Trail	676	2%
Osito	579	2%
Avawatz	484	1%
Rock Outcrop	345	1%
Modesto	68	<1%
Crafton	1	<1%

Appendix B

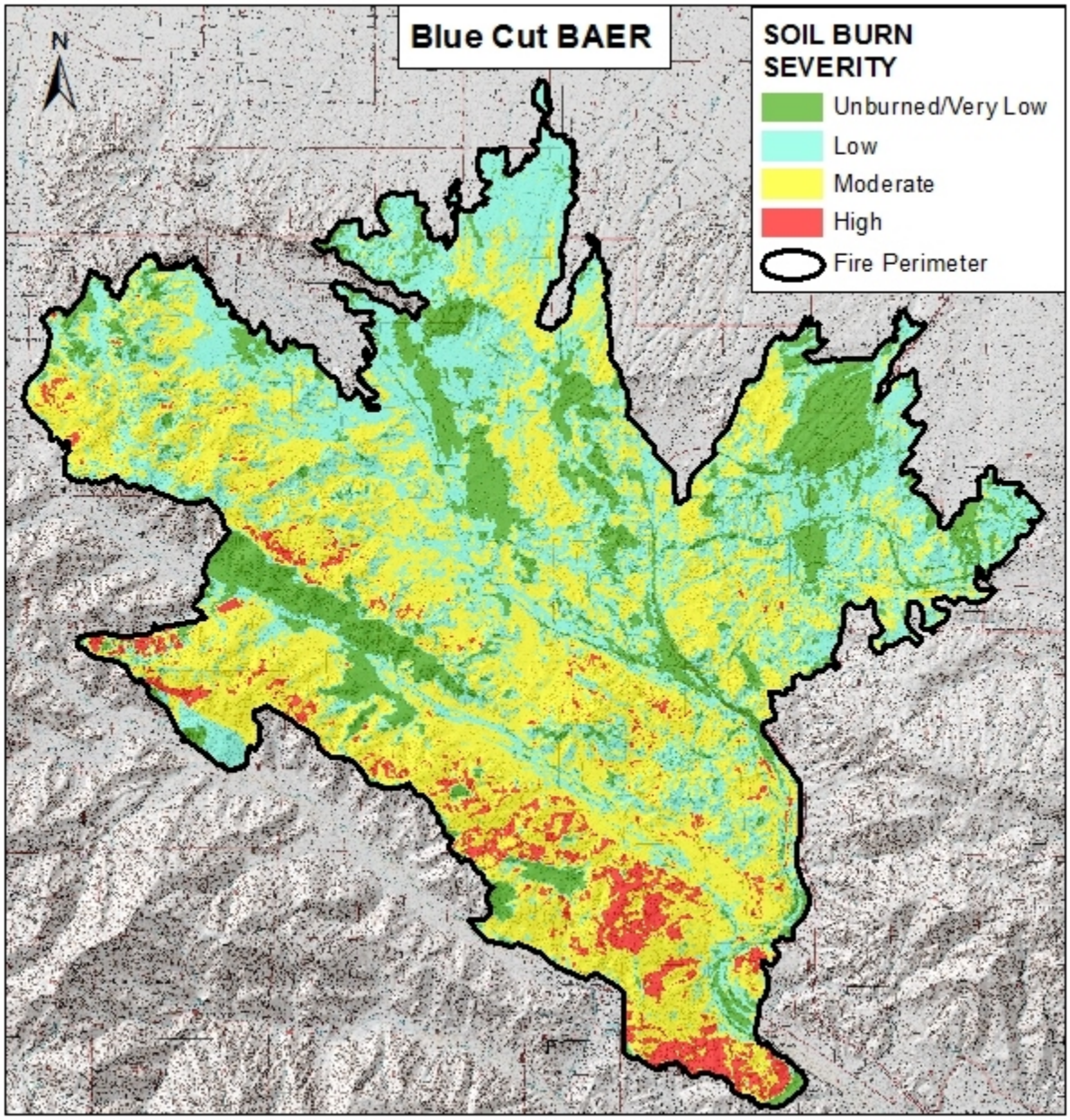

Figure 1: Blue Cut Fire soil burn severity map

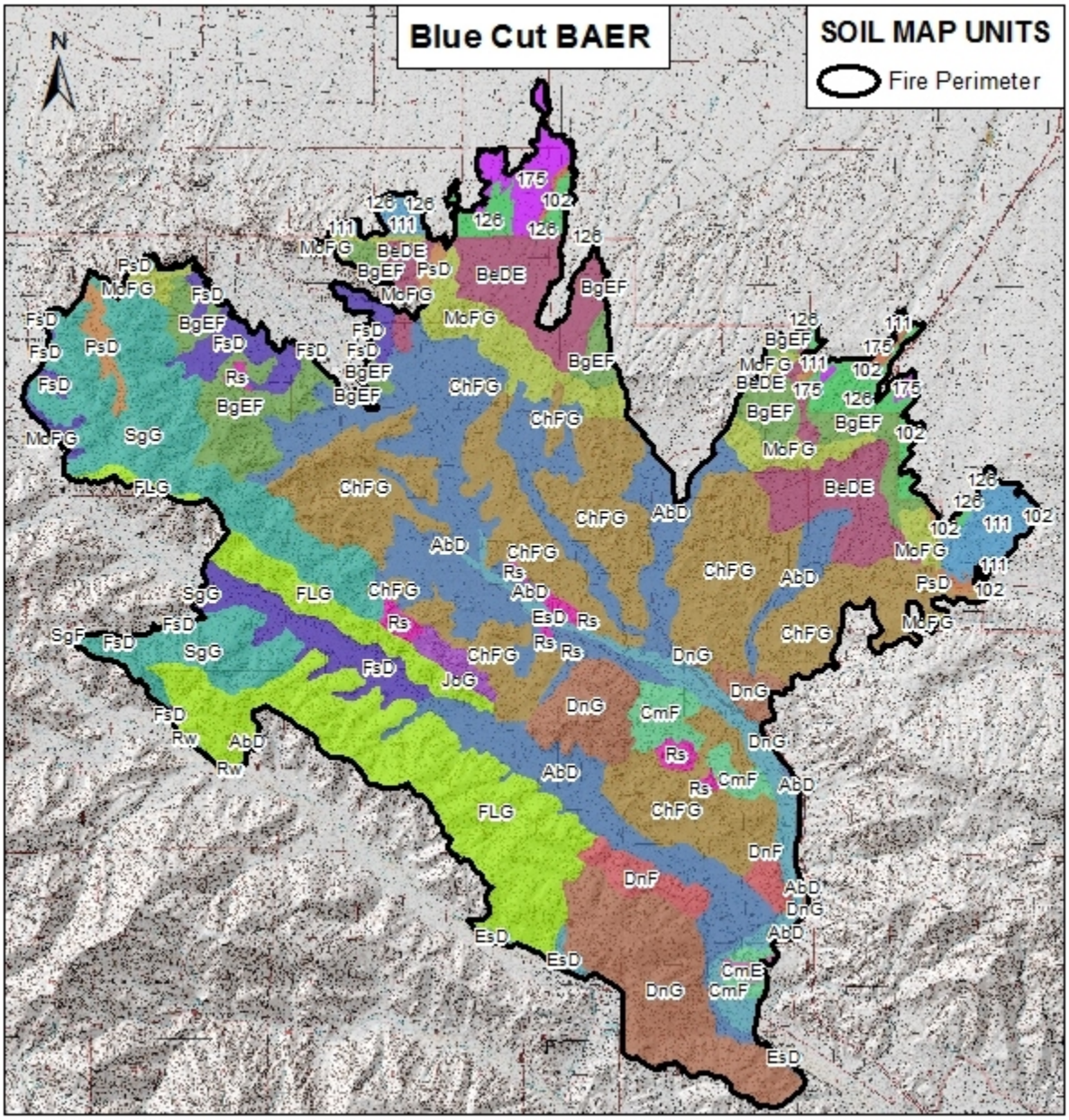

Figure 2: Blue Cut Fire soil map units

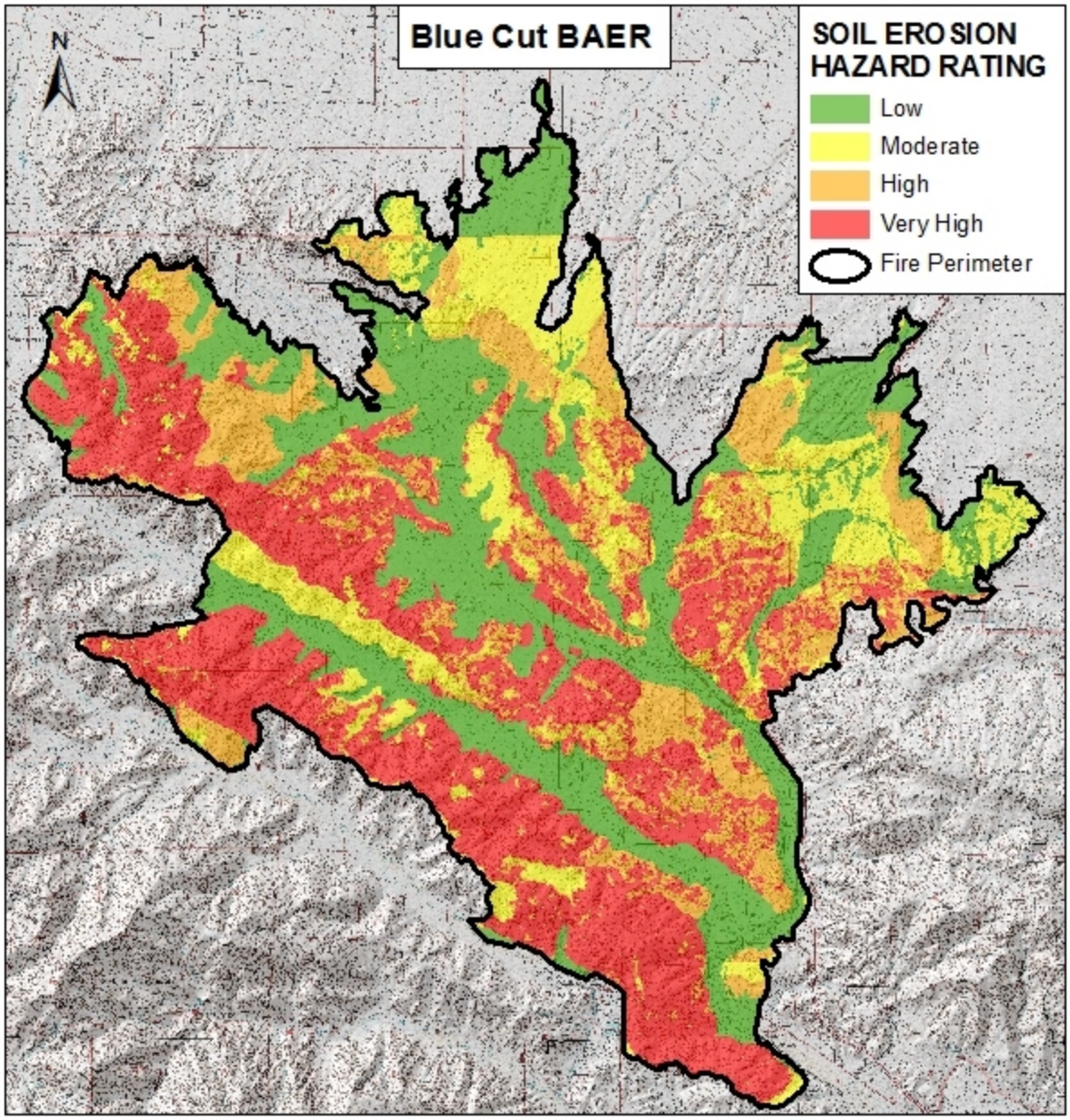

Figure 3: Blue Cut Fire soil erosion hazard rating (EHR) map

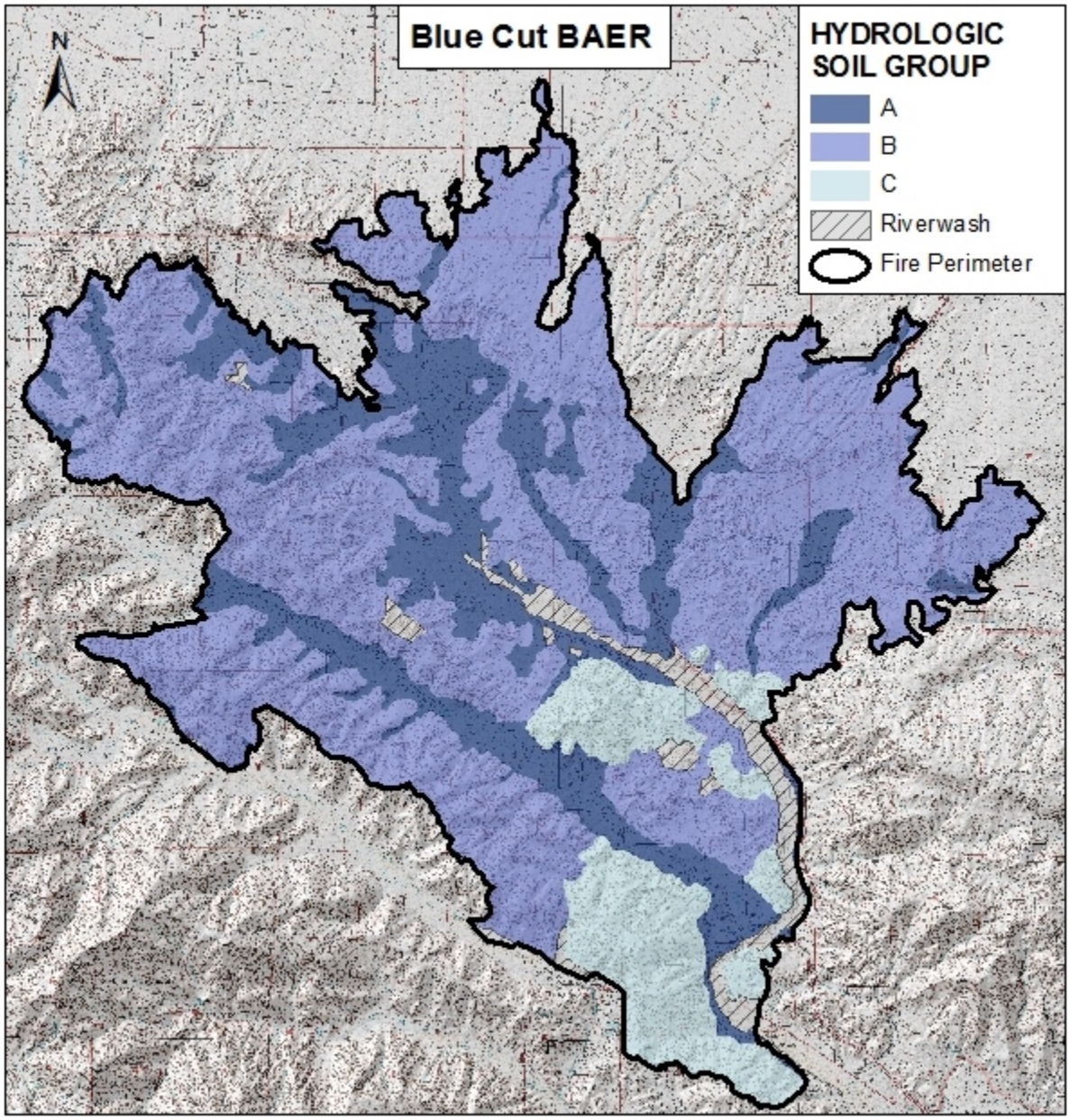

Figure 4: Blue Cut Fire hydrologic soil group

Appendix C

Table 9: 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.