SIX RIVERS NATIONAL FOREST
BURNED AREA EMERGENCY RESPONSE

GASQUET COMPLEX
HYDROLOGY RESOURCE ASSESSMENT

September 25, 2015

OBJECTIVES

The purpose of this report is to provide hydrology input for planning and implementation of burn area emergency response (BAER) activities for the Gasquet Complex on the Six Rivers National Forest. A rapid assessment approach was used for the collection of information and preparation of the BAER report. This hydrology report focuses on the following topics:

- ☐ Calculation of hydrologic design factors for Burned-Area Report (FS-2500-8) and pre-fire and post-fire modeling.
- ☐ Summary of burn severity as it relates to hydrology resources at areas related to specific values at risk that have potential to be affected by the post fire condition. Potential treatments and the rationale for no treatments are discussed where applicable.

BURNED AREA CHARACTERIZATION

Resource Setting

The Gasquet Complex consists of four fires (Bear, Peak, Feeder, and Coon) which burned mostly in the Smith River Watershed located in Del Norte County of Northern California south of the town of Gasquet. These lands are administered by the Six Rivers National Forest and are within the Smith River National Recreation Area with small amounts in the Klamath National Forest. The complex area is characterized by the steep mountainous terrain of the Siskiyou Mountains with elevations ranging from around 300 feet where the Coon Creek meets the South Fork Smith River (Coon Fire) to nearly 6,000 feet at top of Bear Mountain (Bear Fire). The area includes deep rugged river canyons cut by the Smith River and its tributaries, most of which are designated Wild and Scenic River corridors for recreation under the Wild and Scenic Rivers Act of 1968. Vegetation types are predominantly mixed evergreen forests of the Klamath-Siskyou mountains and include a diverse array of species. The climate of the area is controlled by the close proximity to the Pacific Ocean. The area receives an average of 90-100 inches of precipitation per year with most rain and snow falling in winter months. The combination of sheared rocks, steep slopes, and high precipitation amounts make landslides a common hazard (Rantz 1964). The Smith River is free flowing along its entire length and is a very popular recreation river for fishing and boating. Stream gradients are high and there are numerous rapids and bedrock canyons along the Middle and South Forks. Average annual discharges are high owing to the high annual precipitation amounts. The highly variable annual flow is approximately 3,746 cu ft/s (106.1 m^3/s), with an average monthly high of 8,432 cu ft/s (238.8 m^3/s) in January, and

an average low of 336 cu ft/s (9.5 m^3/s) in September. The all-time highest flow was 228,000 cubic feet per second (6,500 m^3/s) on December 22, 1964 during the Christmas flood of 1964.[3]

The fires are located in three different areas within the Middle and South Fork watersheds (Figure 1) with Peak and Feeder being directly adjacent to each other, henceforth just referred to as the Peak Fire. The Bear Fire is drained by the Siskiyou Fork of the Middle Fork Smith River east of Gasquet. The Coon fire is drained by Coon Creek, which is a tributary of the South Fork Smith River, directly south of Gasquet. The Peak fire is drained by Williams and Eightmile Creeks, which is a tributary of the South Fork Smith River south-east of Gasquet. 6th Field hydrologic units or subwatersheds affected by the fire are listed in Table 1.

Soil Burn Severity

The burned area was visited for a field reconnaissance during September 18-21, 2015. Pixel values from BARC imagery were compared with field observations of soil burn severity to create a soil burn severity map for the entire complex (Figure 1). The burn severities encountered throughout the complex range from very-low/unburned to high. Table 2 includes detail about the acres and percentages of burn severity throughout each the fires. Overall, areas of moderate and high soil burn severity are of limited extent and are not continuous throughout any of the fires. The fire burned in a patchwork pattern with the majority of the area being classified as low and unburned. High and moderate severity patches are predominantly located on upper slopes near ridges where the fire made short runs consuming the entire forest canopy. The fire resulted in low to very-low soil burn severity within and directly adjacent to most stream channels and riparian areas. The burned area includes and is surrounded by numerous historic fire scars of varying ages. It was noted in the field that areas with evidence of recent fire occurrence included a large shrub component that burned more completely and was more readily captured by the BARC imagery. Much of these areas were classified as moderate and high soil burn severity though variability in these conditions was observed throughout the fire.

VALUES AT RISK AND THREATS

High risk is expected to **water quality**. There is a threat to water quality in stream systems adjacent to the burned area from increased sediment delivery. Impacts to watershed process and functions that regulate erosion and sediment delivery are expected in areas adjacent to moderate and high burn severity. Threats to water quality can potentially affect beneficial uses that includes habitat for ESA-listed cold water aquatic species as well as municipal and domestic water supply systems and recreation. The probability of damage or loss was determined to be **likely** and the magnitude of consequences was determined to be **moderate**. No treatments are recommended.

There is a threat to domestic and municipal water supply systems off NFS lands downstream from the burned areas. This threat is from the potential for increased

sediment and turbidity, as well as increased peak flood flows which have the potential damage or clog surface water supply intake systems. It is unclear at the time of the assessment the exact amount and location of these systems adjacent to the fire. One supply system was identified adjacent to the Coon Fire which diverts water from Deer Creek for private residents near boulder Creek and is conveyed in a pipe which spans the South Fork Trinity River near. Other domestic and mouncipal water supply systems are located downstream from the fire area which divert water from the Smith River.

RESOURCE ASSESSMENT

Background

Wildfires can result in increased runoff and sediment yield commensurate with burn severity. These increases in runoff are due to loss of vegetative cover and alteration of soil characteristics. Lack of vegetative cover reduces canopy interception and increases evapotranspiration. Lack of ground cover and, in some cases, hydrophobic soil conditions reduces soil water infiltration rates. These factors combine to increase base flow and overland flow depending on the scale and orientation of the burn severity patterns as well as the timing, intensity, and duration of precipitation events. The potential watershed responses of the Gasquet Complex are: 1) an initial flush of sediment and ash, 2) rill and gully erosion in drainages and on moderate and steep slopes within the burned area, 3) increased peak flows, and 4) sediment deposition in streams within and downstream of the fire. These responses are expected to be greatest during initial storm events. The likelihood and degree of magnitude of these watershed responses will decrease over time as vegetation becomes reestablished (which would provide ground cover and increase surface roughness) and soil hydrophobicity decreases (which would increase the infiltration capacity of the soils).

Methods

For the Gasquet Complex, a pre and post fire peak flow analysis was conducted using the so called “regression method” (Foltz et al. 2009). The regression method relies on using USGS regional regression equations to predict peak flow from ungauged basins based on a given recurrence interval. The Streamstats for California program was used to delineate basins from a point and compute the regression equation peak flows (Gotvald et al. 2012). Estimated peak flows are then adjusted using a modifying factor to account for the proportions of low, moderate, and high burn severity. For this analysis a 10 year recurrence interval peak discharge was used as the pre fire flow. For post fire increases in flow it was assumed that for moderate and high burn severity areas post-fire runoff would be 1.5 times greater than pre-fire conditions and 1.1 times greater for low soil burn severity conditions.

10 yr recurrence interval equation - $Q_{10} = 14.8(\text{Area})^{0.880}(\text{Precip})^{0.696}$

Post-fire peak flow modeling is typically focused on addressing locations with values that may be potentially impacted by increased post-fire stream flows and altered runoff processes. Pre-fire and Post-fire design flows help to better understand if treatments may be appropriate to address the threat and mitigate risk. For the Gasquet Complex,

no location specific values that may be impacted the potential for increased flows were identified in the vicinity of the burned area. Overall, stream channels adjacent to the fire are mostly free from crossings (culverts and bridges) and other USFS and private infrastructure that would warrant a detailed hydrologic design flow analysis. Pre and post fire flow estimates were calculated for several basins that were directly affected by the fire to provide a rough estimate of anticipated effects on hydrology and streamflows. Basins analyzed include: See Figures (2-4)

- South Siskiyou Fork – Bear Fire
- Siskiyou Fork – Bear Fire
- Williams Creek – Peak Fire
- Coon Creek Tributary – Coon Fire

It is important to note that while an estimate of pre and post fire flows are presented here, they should be interpreted with caution. No detailed information exists about many of the dominant processes controlling post fire runoff conditions such as continuity of burned patches and proximity of burned areas to the channel. Precipitation location, duration, and intensity, soil conditions and hillslope and channel routing all play an important role in determining peak flow conditions and this information is stochastic and dynamic throughout the burned area. This analysis is best views as a relative change comparison based on the extent of soil burn severity classes and the size and orientation of the drainage basins in relationship to areas impacted by the fire. Modifying factors used here are lower than modifying factors used in previous BAER reports in the same vicinity (see Route Complex BAER Hydrology Report and South Complex BAER Hydrology Report). The rationale for using conservative modifying factors is based on qualitative observations collected during field reconnaissance as well as consideration of soil burn severity patterns and identified downstream values at risk (discussed in more detail in the following section). As was stated previously, areas of moderate and high soil burn severity were predominantly limited to upper headwater areas and ridgelines and did not fully consume large contiguous areas within individual basins.

Post-wildfire changes in hydrologic processes are expected at the point and hillslope scales for reasons outlined above. There is less certainty, however, that broader watershed scale increases in streamflow will be realized due to large downslope areas of intact vegetation and relatively low burn severity lower in the watersheds. Additionally, consideration for the dominant climate patterns found in the region suggest that typical storm systems affecting the fire area are that of long duration with moderate intensity as is found in Pacific coastal mountain ranges. This is in contrast to the short duration, high intensity summer thunderstorms that dominate runoff generation in more arid climates (e.g. Southern California, Front Range of Colorado) and can result in large relative increases in flow and damaging debris flow events when combined with burned watershed conditions.

Results

Overall, it is likely that the modeled basin outlets presented in this analysis will see an immeasurable to small increase in streamflows from typical rainfall patterns resulting in moderate consequences to water quality from increased sediment and turbidity. There is the potential that, if a short duration high intensity storm directly affects a localized area of high and moderate burn severity, runoff and erosion from that area will increase measurably and could result in more dramatic effects realized downstream in the form of debris flows, debris dams, and large increases in sediment and discharge to stream networks.

Regression flow analysis was completed over several representative basins within the fire area. Pre to post fire flow ratios varied from 1.16 to 1.31 (Table 3). These ratios represent the proportions of basins affected by moderate and high burn severity based on the increase in runoff factor.

Discussion

Increases in streamflows combined with erosion, riling, gully initiation, and sediment deposition are expected in areas immediately downstream from moderate and high burn severity. Larger basins, such as those analyzed with regression analysis are expected to see small to moderate changes in peak flows and associated debris and sediment. Low overall amounts and limited continuity of moderate and high soil burn severity suggests that large increases in peak flows at larger drainage basin scales should not be expected from typical local climate scenarios. Should a storm event with higher than normal precipitation intensity affect the fire area, increases in peak flow beyond what is presented here is possible.

ASSESSMENT OF VALUES AT RISK

Water quality was the only hydrology specific BAER critical value at risk identified during the assessment. Other BAER critical values, such as property (road and trail infrastructure), have an important linkage with water quality due to the threat of additional water quality effects (sedimentation) associated with loss of those structures. Post-fire increases in runoff and erosion have the potential to overwhelm drainage structures and road and trail prisms causing additional erosion and potential degradation of water quality. See Engineering and Recreation resources reports for additional information about risks to these values and associated treatments.

Water quality concerns are linked to other BAER critical values considered during the assessment such as domestic water supplies and federally designated or occupied ESA fisheries habitat.

A high risk to water quality from post-fire conditions was determined for the Gasquet Complex Fires using exhibit 2 of ID-2520-2014-1. This risk was determined based on the resource assessment discussed in the previous sections.

RESPONSE ACTIONS RECOMMENDED TO MITIGATE THE RISK

Treatments proposed for road and trail system drainage function will increase the likelihood that those pieces of infrastructure will continue to function appropriately with anticipated increases in runoff and sedimentation. These treatments also provide assurance that trail and road prism failures will not affect water quality.

No hydrology specific land treatments were proposed to mitigate the general risk to water quality. Treatments to stabilize hillslopes and reduce the potential for erosion and sedimentation downstream from the burned area were not considered for several reasons. Hillslope treatments are costly and time consuming to implement and do not mitigate the threat to water quality with complete certainty. Such treatments would typically require accumulations of multiple critical values, focused on specific basin areas that are at risk, which would benefit from reduced potential for increased flows and increased sediment volumes.

Coordination with local water system operators is recommended to notify operators of the potential for increased sedimentation and turbidity, as well as the potential for debris flows and dams in surface waters downstream from the burned areas. Increased sediment and turbidity and debris flows could damage water systems to leave local residents without access to potable water. It is recommended to provide water system operators information about the location and extent of burned areas in drainages above these areas so they may determine the level of risk associated with these systems. In particular, the water system in Deer Creek was identified as being potentially at risk.

Prepared by:

Brian Anderson, Hydrologist, USFS Boise National Forest

REFERENCES

Foltz, R. B. Robichaud, P.R. Hakjun, R. 2009. A Synthesis of Post Fire Road Treatments for BAER Teams: Methods, Treatments Effectiveness, and Decision Making Tools for Rehabilitation. Gen. Tech. Rep. RMRS-GTR-228. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 152 p.

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles, 2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl., available online only at http://pubs.usgs.gov/sir/2012/5113/.

Moody, J.A., 2012. An analytical method for predicting postwildfire peak discharges. U.S. Geological Survey Scientific Investigations Report 2011–5236. (36 pp.).

Rantz S. E.. 1964. Surface Water Hydrology of Coastal Basins of Northern California. Geological Survey Water Supply Paper 1758.

State of California. 2012. California Integrated Report (Clean Water Act Section 303(d) List / 305(b) Report).

Appendix A – Hydrologic Design Factors

PART IV - HYDROLOGIC DESIGN FACTORS

A. Estimated Vegetative Recovery Period (years): 5-7

B. Design Chance of Success (percent): 65

C. Equivalent Design Recurrence Interval (years): 10 yr

D. Design Storm Duration (hours): 12 hr
- estimated potentially 1st damaging storm

E. Design Storm Magnitude (inches): 5.6 (NOAA Atlas 14)

F. Design Flow (cubic feet / second/ square mile): 356.3 (average of 4 basins)

G. Estimated Reduction in Infiltration (percent): 26% (extent of moderate/high soil burn severity)

H. Adjusted Design Flow (cfs per square mile): 419.6 (average of 4 basins)

Appendix B – Tables

Table 1. 6th Field Hydrologic Units affected by the fire

Subwatershed name	Subwatershed number	acres	percent of fire acres
Copper Creek-Dillon Creek	180102090502	149.2	0.5%
Craigs Creek	180101010308	9.3	0.0%
Crescent City Fork	180102090903	536.1	1.8%
Eightmile Creek	180101010302	9711.9	32.0%
Goose Creek	180101010306	1.8	0.0%
Hurdygurdy Creek	180101010305	24.9	0.1%
Lower South Fork Smith River	180101010309	5669.7	18.7%
Middle South Fork Smith River	180101010304	2240.8	7.4%
Siskiyou Fork Smith River	180101010201	10224.0	33.7%
Upper Blue Creek	180102090902	412.8	1.4%
Upper Clear Creek	180102090402	447.2	1.5%
Upper Middle Fork Smith River	180101010202	11.1	0.0%
Upper South Fork Smith River	180101010301	902.3	3.0%
Grand Total		**30340.9**	**100.0%**

Table 2 Soil Burn Severity acres by Fire and percentages

Soil Burn Severity (SBS) - Acres				
Fire	**High**	**Moderate**	**Low**	**Very Low/Unburned**
Bear	799	1,803	5,485	3,564
Coon	121	1,101	2,779	1,677
Feeder	11	120	250	517
Peak	686	3,307	3,934	4,255
Total	1,617	6,331	12,448	10,013
Soil Burn Severity (SBS) - Percent				
Fire	**High**	**Moderate**	**Low**	**Very Low/Unburned**
Bear	7%	15%	47%	31%
Coon	2%	19%	49%	30%
Feeder	1%	13%	28%	58%
Peak	6%	27%	32%	35%

Table 3. Regression flow analysis results in various basins for pre and post fire runoff estimates

Basin	Area (acres)	Pre-fire 10 yr Peak Q (ft^3/s)	Post-fire 10 yr Peak Q (ft^3/s)	Ratio
Coon Creek Tributary	585	383	501	1.31
Siskiyou Fork	4,708	2,980	3,497	1.17
South Siskiyou Fork	5,341	2,680	3,096	1.16
Williams Creek	6,183	3,320	3,932	1.18

Appendix B – Maps

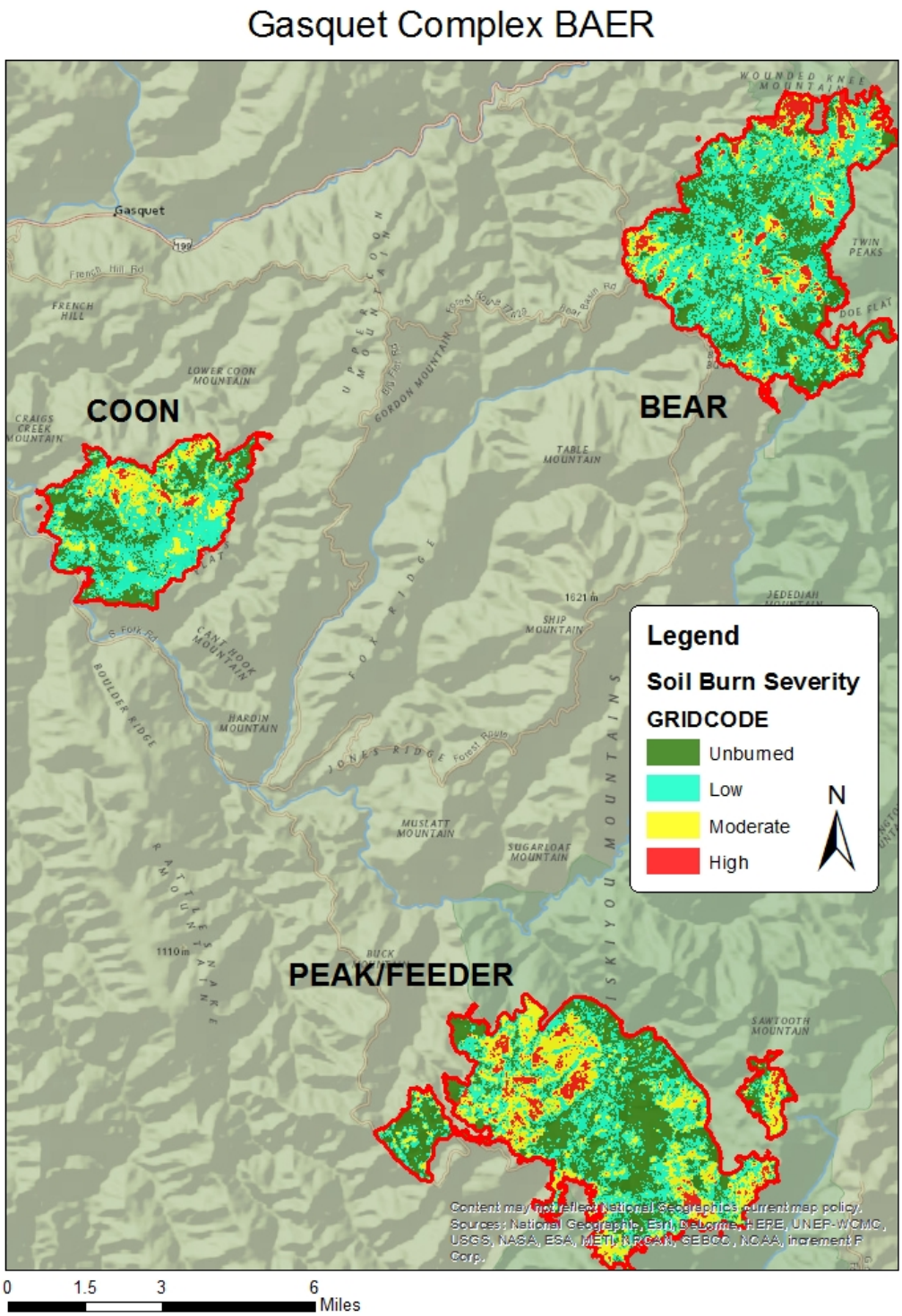

Figure 1 Gasquet Complex Overview with Soil Burn Severity

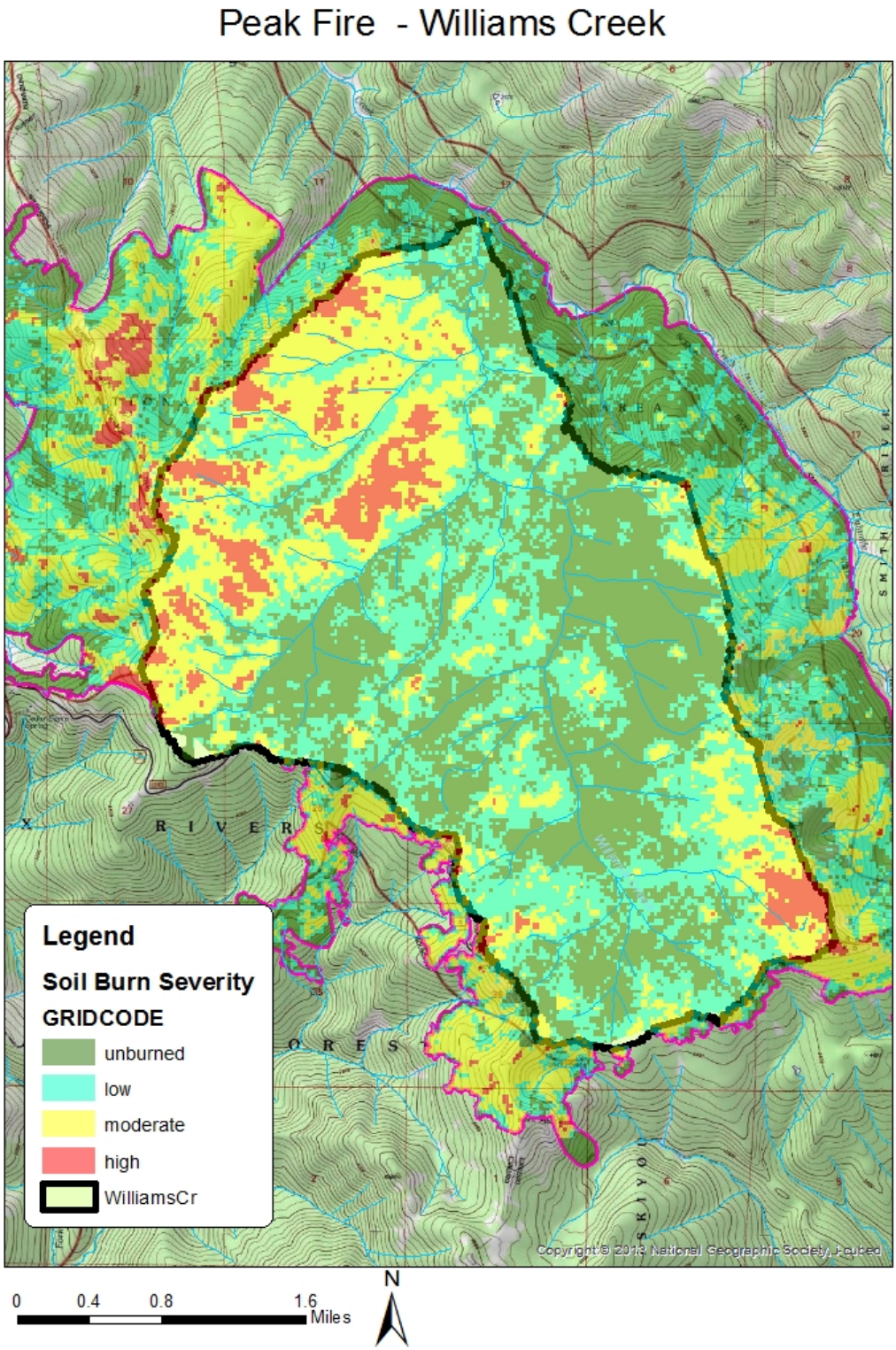

Figure 2 Williams Creek modeled basin

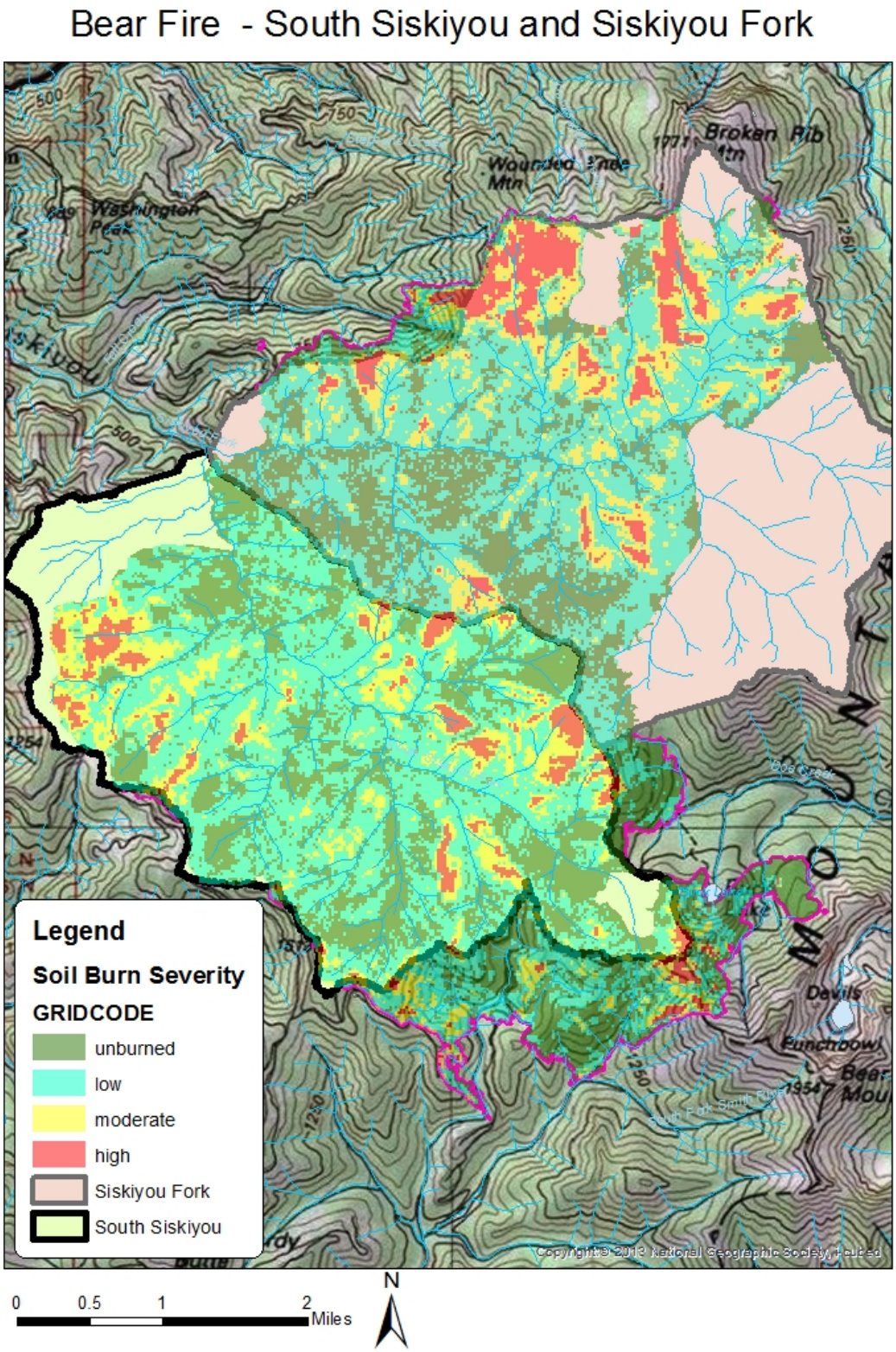

Figure 3 South Siskiyou and Siskiyou Fork modeled basins

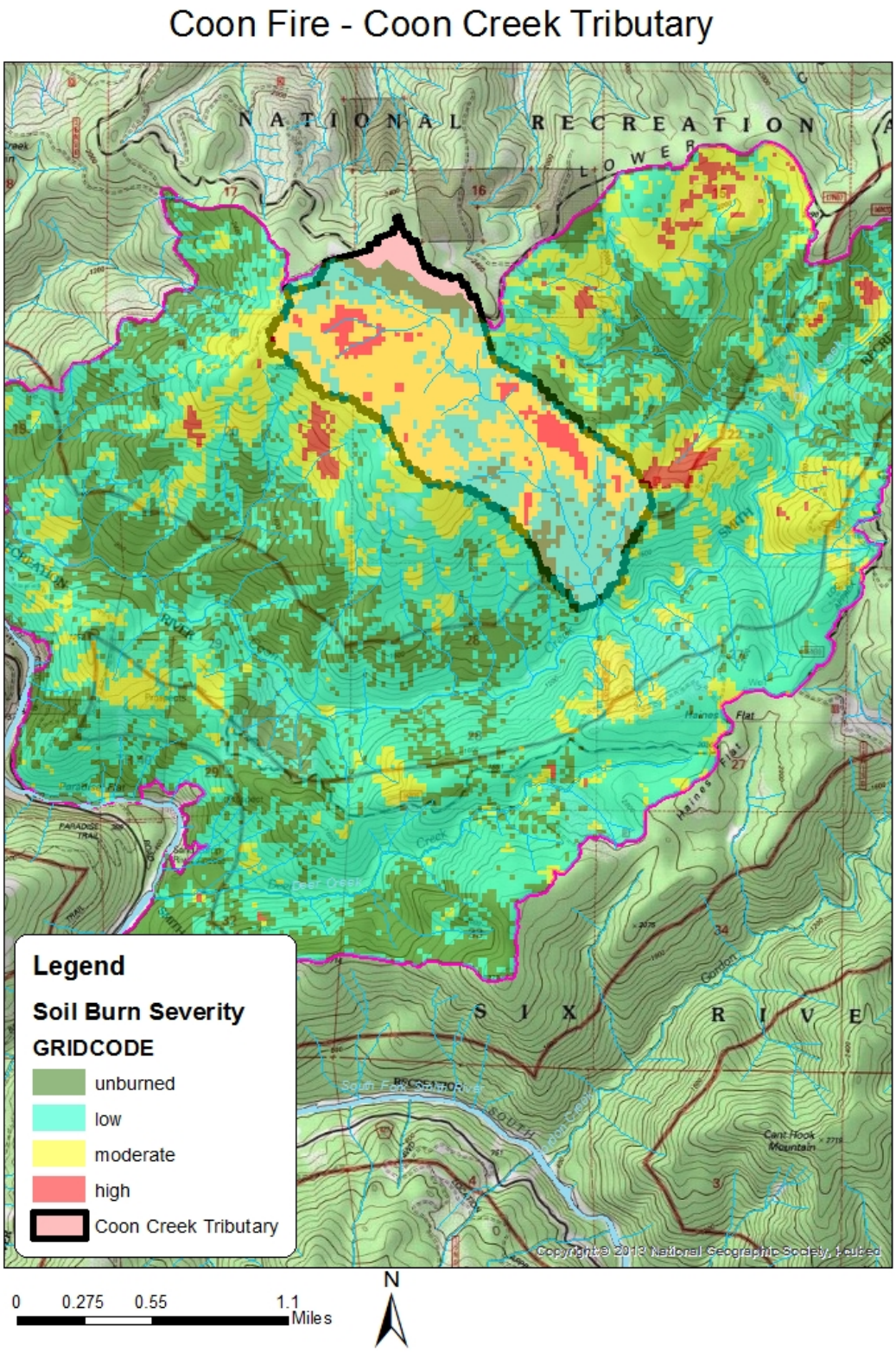

Figure 4 Coon Creek Tributary modeled basin