Eagle River Phase 1 Watershed Assessment

Prioritization of watershed-based hazards to water supplies

Report Prepared for:

USDA Forest Service

Rocky Mountain Region

Bark Beetle Incident

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This report was prepared by:

PO Box 3759

Breckenridge, Colorado 80424

and

JG Management Systems, Inc.

336 Main Street, Suite 207

Grand Junction, Colorado 81501

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INTRODUCTION

This Phase 1 Watershed Assessment is designed to be the first phase of a process to identify and prioritize sixth-level watersheds based upon their hazards of generating flooding, debris flows and increased sediment yields following wildfires that could have impacts on water supplies. It is intended to expand upon current wildfire hazard reduction efforts by including water supply watersheds as a community value. The watershed assessment follows the ranking procedure for each of the four integral components as prescribed by the Front Range Watershed Protection Data Refinement Work Group (2009).

This Phase 1 Watershed Assessment is one of 15 that are being completed for the Bark Beetle Incident team in the Rocky Mountain Region (Region 2) of the USDA Forest Service (Figure 1). The Bark Beetle Incident team covers the following three National Forests:

1. White River National Forest
2. Medicine Bow-Routt National Forests
3. Arapaho-Roosevelt National Forests

Phase 2 of the Watershed Assessment process would be to gather the key water supply stakeholders to communicate the suggested process, show them the results of Phase 1, listen to any suggested changes, make appropriate changes and build collaborative support for the assessment process. The stakeholder process is critical to local support for the results of the assessment, and the effectiveness of implementing recommendations that would come out of the assessment process.

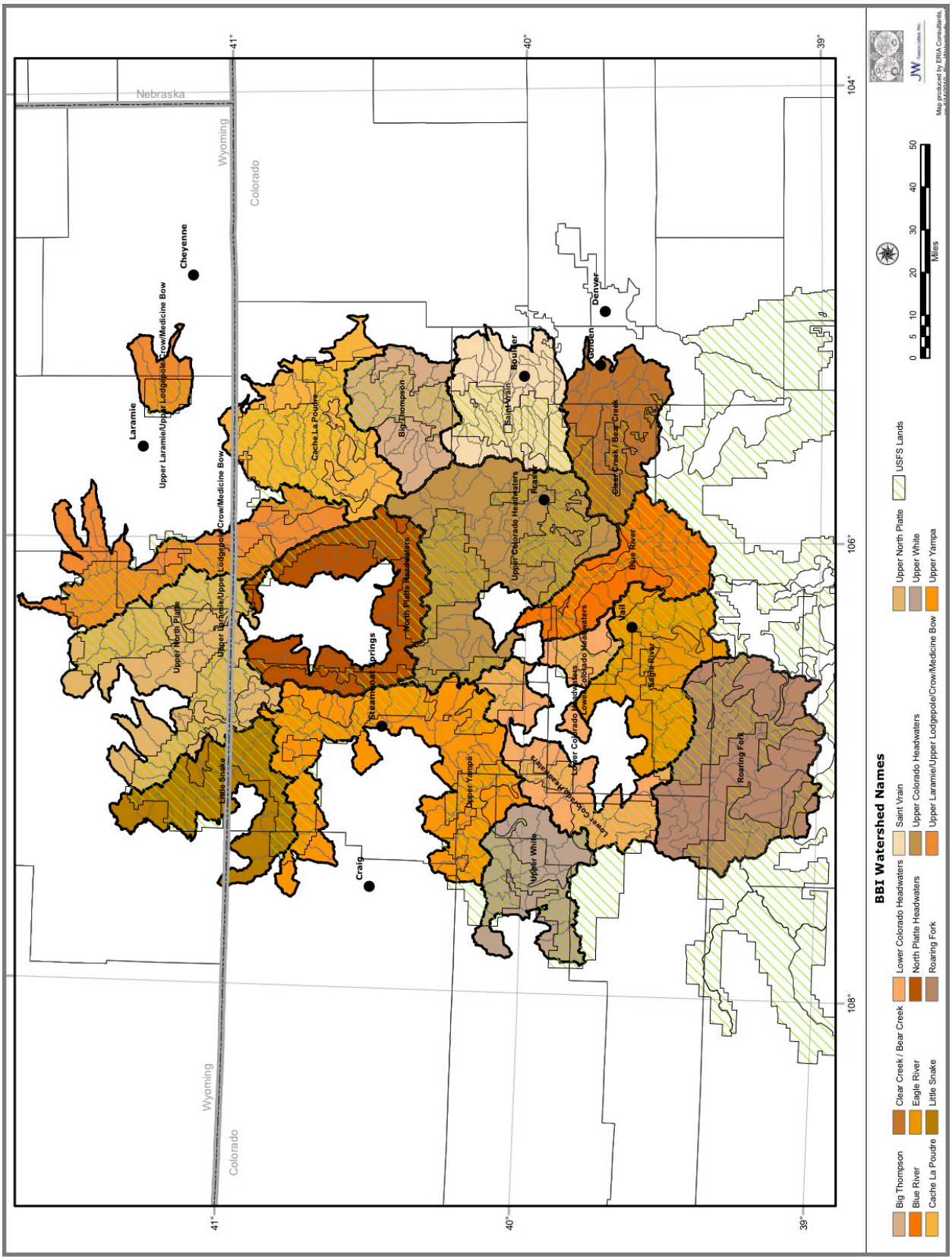

Figure 1. Bark Beetle Incident Phase 1 Watersheds

WATERSHED DESCRIPTION

The Eagle River watershed is a high Rocky Mountain headwaters watershed. The Eagle River flows into the Colorado River when it emerges from this watershed. The Eagle River watershed assessment is designed to assess hazards from forest wildfire to water supply. Therefore, the subwatersheds that are mostly or entirely outside of the forest were examined closely because they can skew the results of the assessment because they are relatively flat, have higher road densities and very different fire regimes.

The Eagle River watershed is one fourth-level[1] (eight-digit) watershed (HUC 14010003) that is 622,151 acres in size and contains 32 sixth-level watersheds. For this watershed assessment, five sixth-level watersheds were eliminated based upon their wildfire hazard, ruggedness, and an examination of how well they fit into this assessment. The Eagle River watershed used in this analysis is 527,429 acres, contains six fifth-level watersheds and 27 sixth-level watersheds, which are the analysis units for this watershed assessment (Front Range Watershed Protection Data Refinement Work Group 2009). The Eagle River watershed and its fifth-level and sixth-level watersheds are shown on Figure 2 and listed in Table 1.

[I] The watersheds that were used are part of the existing national network of delineated watersheds. Hydrologic Unit Codes (HUCs) are nested watersheds and are designated numerically by levels (Federal Geographic Data Committee 2004). Sixth-level HUCs or watersheds, use the 11th and 12th digits in the HUC code. Fifth-level HUCs use the ninth and 10th digits in the HUC code.

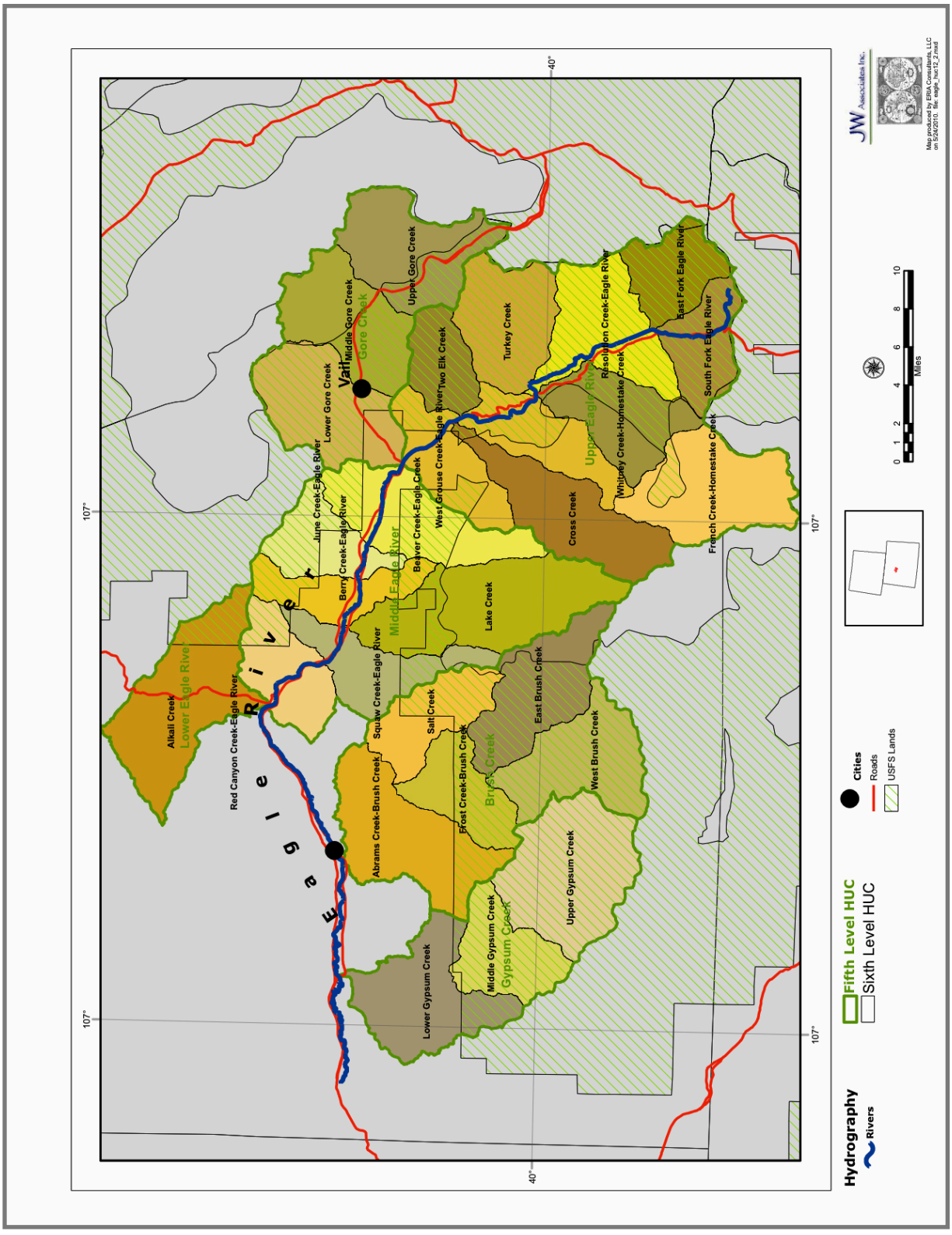

Figure 2. Eagle River Watershed Analysis Area[2]

[2] The fifth-level watersheds are shown in Figure 2.

Table 1. Fifth-level and Sixth-level Watersheds in Eagle River Watershed[3]

Fifth-level Watershed	Sixth-level Watershed	Watershed Area (acres)	Hydrologic Unit Code (HUC)	Map Number
Gore Creek HUC 1401000301	Upper Gore Creek	22,133	140100030101	257
	Middle Gore Creek	20,622	140100030102	258
	Lower Gore Creek	22,451	140100030103	259
Upper Eagle River HUC 1401000302	South Fork Eagle River	12,161	140100030201	260
	East Fork Eagle River	12,223	140100030202	261
	Turkey Creek	18,893	140100030203	262
	French Creek-–-Homestake Creek	23,967	140100030204	263
	Whitney Creek-–-Homestake Creek	16,951	140100030205	264
	Resolution Creek-–-Eagle River	20,771	140100030206	256
	Two Elk Creek	10,092	140100030207	244
	Cross Creek	21,937	140100030208	245
	West Grouse Creek-–-Eagle River	29,443	140100030209	246
Middle Eagle River HUC 1401000303	Beaver Creek-–-Eagle Creek	21,444	140100030301	247
	June Creek-–-Eagle River	12,607	140100030302	248
	Lake Creek	31,389	140100030303	249
	Berry Creek-–-Eagle River	11,662	140100030304	250
	Squaw Creek-–-Eagle River	15,000	140100030305	251
	Red Canyon Creek-–-Eagle River	14,634	140100030306	252
Brush Creek HUC 1401000304	West Brush Creek	20,844	140100030401	253
	East Brush Creek	20,769	140100030402	254
	Salt Creek	13,749	140100030403	255
	Frost Creek-–-Brush Creek	13,213	140100030404	265
	Abrams Creek-–-Brush Creek	25,676	140100030405	266
Gypsum Creek HUC 1401000305	Upper Gypsum Creek	28,403	140100030501	267
	Middle Gypsum Creek	14,620	140100030502	268
	Lower Gypsum Creek	22,737	140100030503	269
Lower Eagle River HUC 1401000306	Alkali Creek	29,039	140100030601	270
	Total Area	**527,429**		

[3] Map numbers are used in Figures 3, 6 and 9

WATERSHED ASSESSMENT

The potential of a watershed to deliver sediments following wildfire depends on forest and soil conditions, the physical configuration of the watersheds, and the sequence and magnitude of rain falling on the burned area. High-severity fires can cause changes in watershed conditions that are capable of dramatically altering runoff and erosion processes in watersheds. Water and sediment yields may increase as more of the forest floor is affected by fire.

This Phase 1 - Eagle River Watershed Assessment provides the analysis for the first three components specified in the Front Range Watershed Protection Data Refinement Work Group (2009) procedure. It provides the analysis for: wildfire hazard, flooding or debris flow hazard, and soil erodibility. This Phase 1 assessment then combines those three components into a composite hazard ranking. This report discusses the technical approach for each component and the process used to assemble the watershed ranking.

The categories used in the prioritization are numbered one though five, with one being the lowest ranking and five being the highest. The numeric ranges for each category are as follows;

Category 1 - 0.5 to 1.49
Category 2 - 1.5 to 2.49
Category 3 - 2.5 to 3.49
Category 4 - 3.5 to 4.49
Category 5 - 4.5 to 5.49

The categories are used in this analysis for the purpose of comparing watersheds to each other within the Eagle River watershed. Comparisons with other watershed assessments are not valid because this approach prioritizes watersheds by comparing them to the other sixth-level watersheds only in this watershed assessment area.

Component 1 - Wildfire Hazard

The forest conditions that are of concern for the assessments are the wildfire hazard based on existing forest conditions. The wildfire hazard (Flame Length) was determined using the Fire Behavior Assessment Tool (FBAT) (http://www.fire.org) which is an interface between ArcMap and FlamMap. The input spatial data were collected from LANDFIRE project (http://www.landfire.gov/).

After a mountain pine beetle outbreak there are substantial increases in the amount of fine dead fuels in the canopy. The majority of these fuels remain in the canopy for 2-3 years post outbreak (Knight 1987, Schmid and Amman 1992). Therefore, certain input spatial data sets were updated based on Mountain Pine Beetle (MPB) mortality conditions using USDA Forest Service, Rocky Mountain Region Aerial Detection Survey (ADS) Data from the years 2002-2007 (http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/). The assumptions used in the FBAT model are presented in Appendix A.

The flame length results were divided into five categories of wildfire hazard ranging from lowest (Category 1) to highest (Category 4). The flame length categories that were used are;

Flame Length Category 0 - 0 meters

Flame Length Category 1 - 1 to 10 meters

Flame Length Category 2 - 11 to 25 meters

Flame Length Category 3 - 26 to 40 meters

Flame Length Category 4 - >40 meters

Figure 3 shows the results of the wildfire hazard modeling. The results were categorized by sixth-level watershed into five categories that are used throughout the analysis (see Table B-1 in Appendix B) using the following formula.

Wildfire Hazard Ranking = (Percentage in Category 3 + Percentage in Category 4 * 2)

The categorized wildfire hazard by sixth-level watershed was mapped (Figure 4). The map shows that the highest hazards are in the following sixth-level watersheds: South Fork Eagle River, Turkey Creek, Resolution Creek-Eagle River and Two Elk Creek. Eight watersheds were ranked as Category 4, which is the next highest category (see Table B-1 in Appendix B). Two watersheds were manually adjusted because they were skewing the results of the categorization because of their low values. Red Canyon Creek-Eagle River and Alkali Creek were given a wildfire hazard value of 10 percent (Table B-1 in Appendix B).

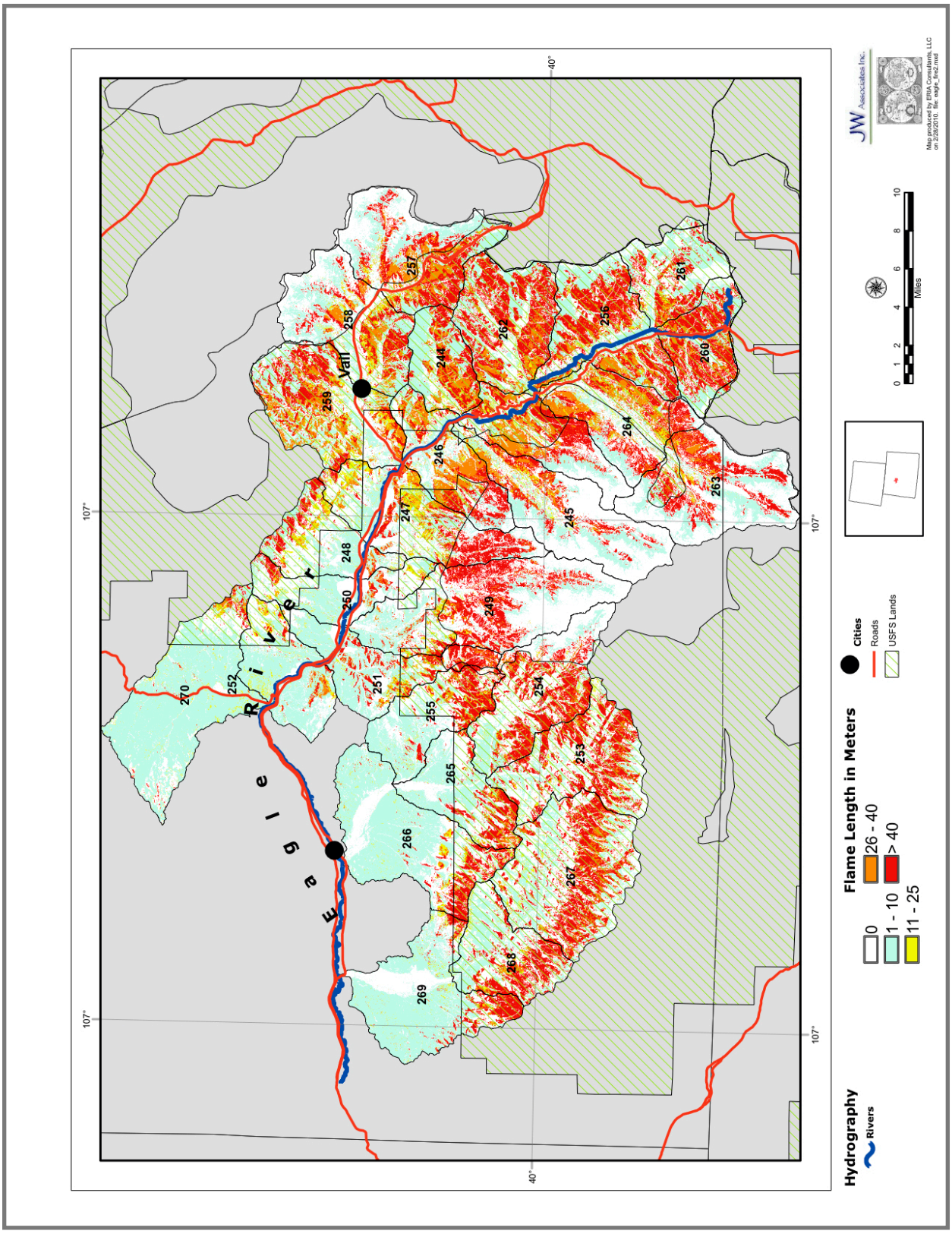

Figure 3. Eagle River Watershed Wildfire Hazard Modeling Results

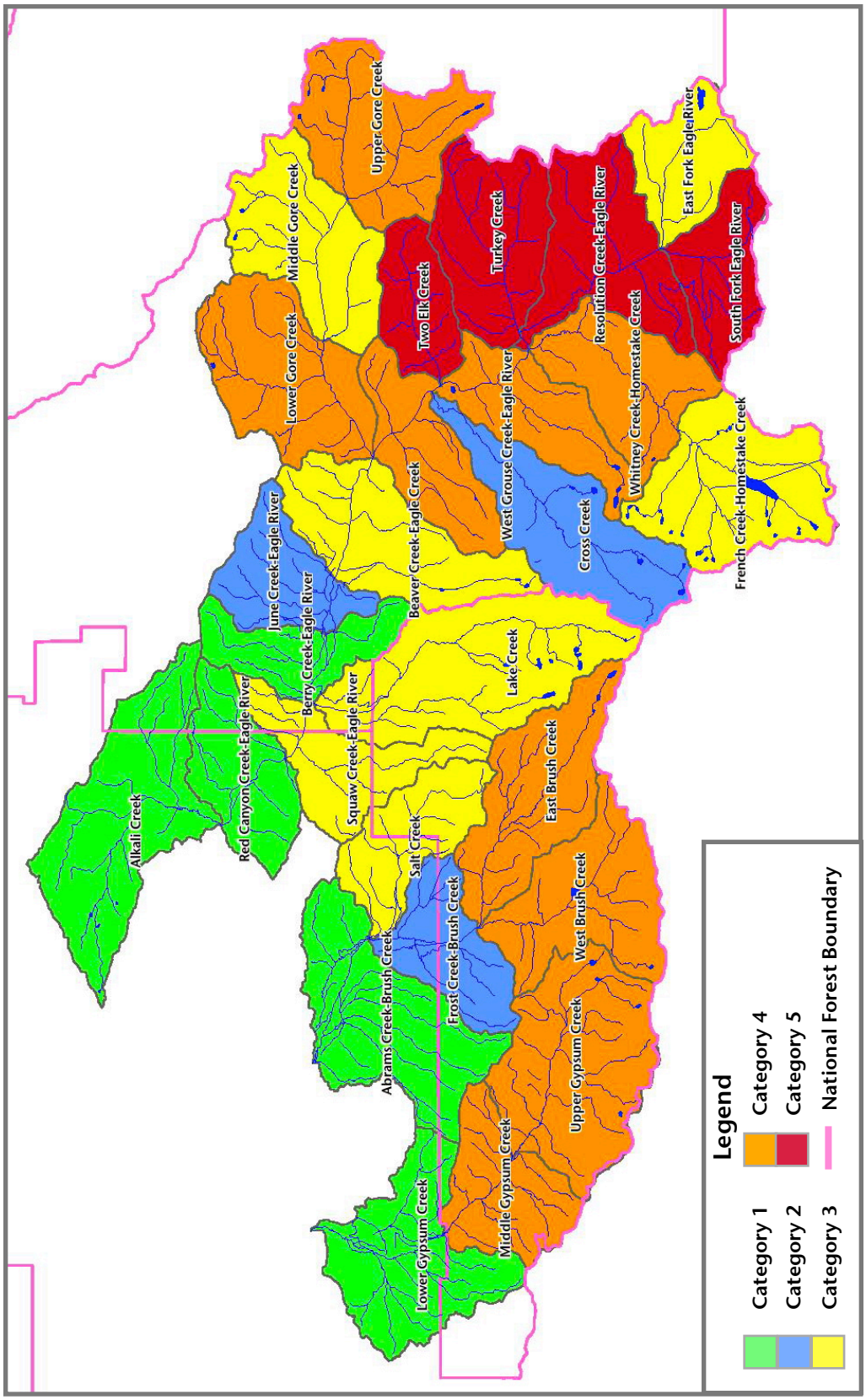

Figure 4. Eagle River Watershed Wildfire Hazard Ranking

Component 2 - Flooding or Debris Flow Hazard

A combination of ruggedness and road density (miles of road per square mile of watershed area) was used to assess the flooding or debris flow hazard portion of the analysis. The two components, ruggedness and road density, are described below.

Ruggedness

Watershed steepness or ruggedness is an indicator of the relative sensitivity to debris flows following wildfires (Cannon and Reneau 2000). The more rugged the watershed, the higher its sensitivity to generating debris flows following wildfire (Melton 1957). The Melton ruggedness factor is basically a slope index.

Melton (1957) defines ruggedness, R, as;

$$R = H_b A_b^{-0.5}$$

Where A_b is basin area (square feet) and H_b is basin height (feet) measured from the point of highest elevation along the watershed divide to the outlet.

The ruggedness result in some watersheds was adjusted because they do not accurately reflect the slope in those watersheds. Those situations are most common in composite watersheds because they are disconnected from their headwaters. These watersheds can have a high hazard for debris flows because they contain a main stem of a creek or river with several steep first order streams as tributaries. In those situations, the ruggedness calculation was adjusted up by reducing the watershed area. These adjustments were completed on the following watersheds; Upper Gore Creek, Middle Gore Creek, Lower Gore Creek, French Creek-–-Homestake Creek, West Grouse Creek-–-Eagle River, Beaver Creek-–-Eagle Creek, Squaw Creek-–-Eagle River, Abrams Creek-–-Brush Creek, Upper Gypsum Creek, Middle Gypsum Creek and Lower Gypsum Creek.

Figure 5 displays the categorized ruggedness for the Eagle River Watershed. The tabular results are presented on Table B-2 in Appendix B. The map (Figure 5) shows that the most rugged sixth-level watersheds are Beaver Creek-Eagle River, Middle Gypsum Creek, Cross Creek, East Brush Creek and West Grouse Creek-Eagle River.

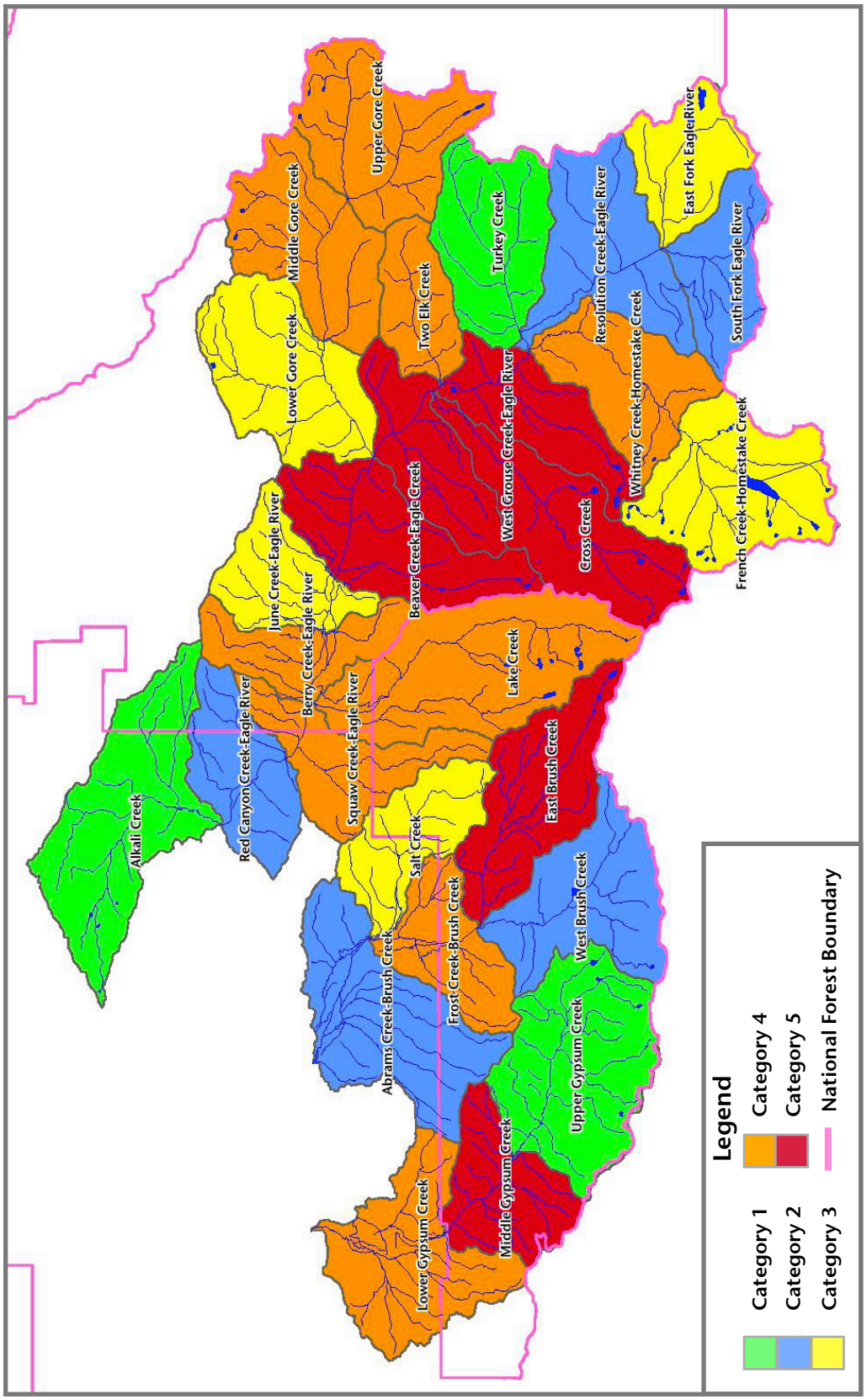

Figure 5. Eagle River Watershed Ruggedness Ranking

Road Density

Roads can convert subsurface runoff to surface runoff and then route the surface runoff to stream channels, increasing peak flows (Megan and Kidd 1972, Ice 1985, and Swanson et al. 1987). Therefore, watersheds with higher road densities have a higher sensitivity to increases in peak flows following wildfires. Road density in miles of road per square mile of watershed area was used as an indicator of flooding hazard. The U.S. Forest Service roads data was used on National Forest System (NFS) lands because it is the most accurate roads data for those roads in the forest. On all other lands the U.S. Census Bureau's Tiger database was used because it is a consistent roads data layer (Figure 6).

Road densities were adjusted in some watersheds for two separate reasons. One reason for adjusting the road density was the situation where a watershed had a much higher road density than the next highest value, so that watershed was skewing the categorization. In that situation, the watershed was manually given a road density slightly higher than the next highest score.

The other situation where road density was adjusted is where some of the roads within a watershed were within towns, developed areas, or outside the forested areas of the watershed. The roads that are of interest in this analysis are those roads that would increase the risk of flooding or debris flows following wildfires in forested areas. The watersheds were all examined by looking at the roads data overlain on digital images and vegetation mapping. If it was found that there were significant lengths of road outside forested areas, the road density in those watersheds was adjusted down based on ocular estimates.

Road density in the Middle Gore Creek, Lower Gore Creek, Beaver Creek-Eagle River, June Creek-Eagle River, Berry Creek-Eagle River and Red Canyon Creek-Eagle River watersheds were all adjusted down. The adjustments are displayed on Table B-3 in Appendix B.

Figure 7 displays the categorized road density for the Eagle River Watershed and tabular results are presented in Appendix B (Table B-3). Figure 7 shows that the highest rankings are in Berry Creek-Eagle River, June Creek-Eagle River, Squaw Creek-Eagle River, Lower Gore Creek and Turkey Creek.

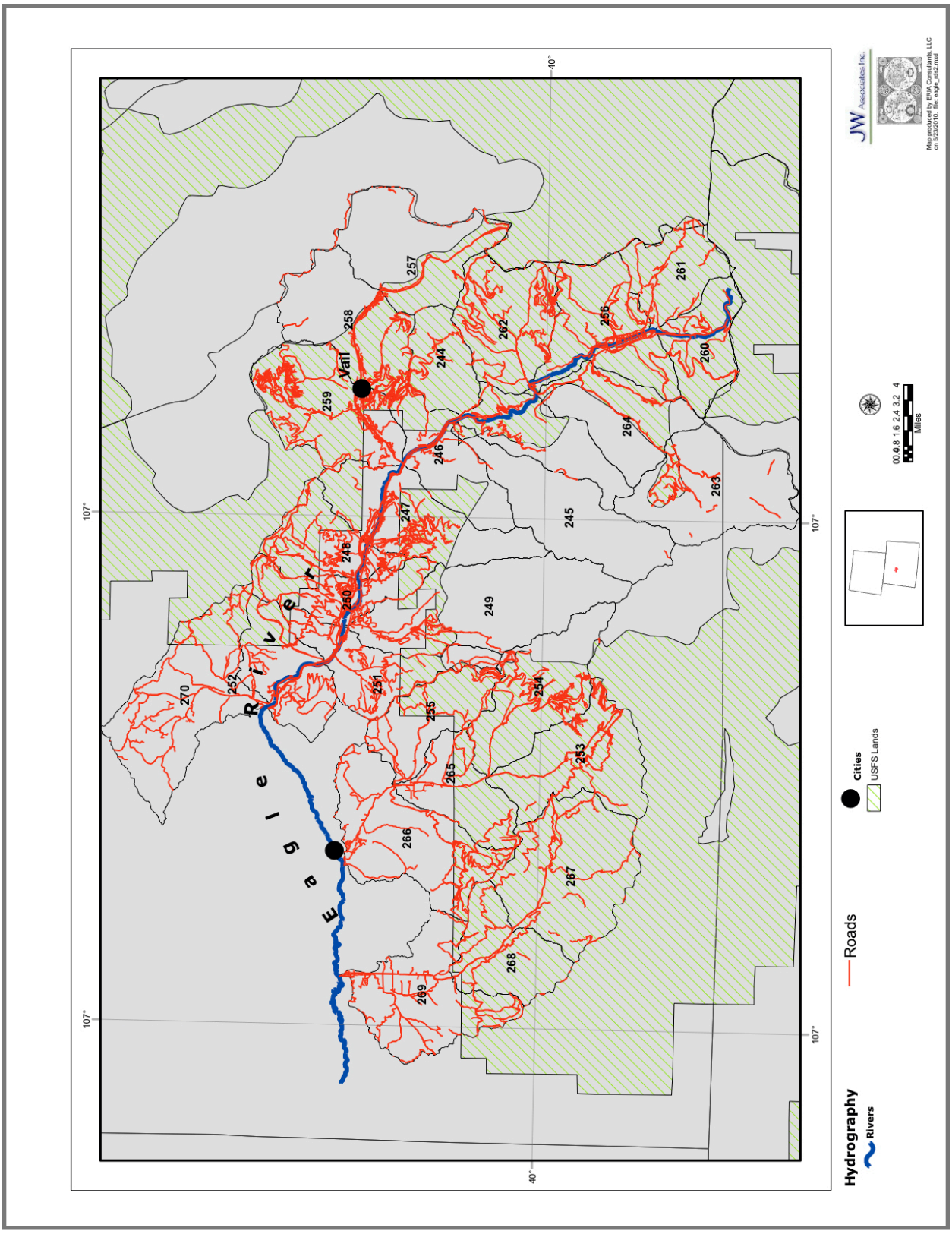

Figure 6. Eagle River Watershed Roads Map

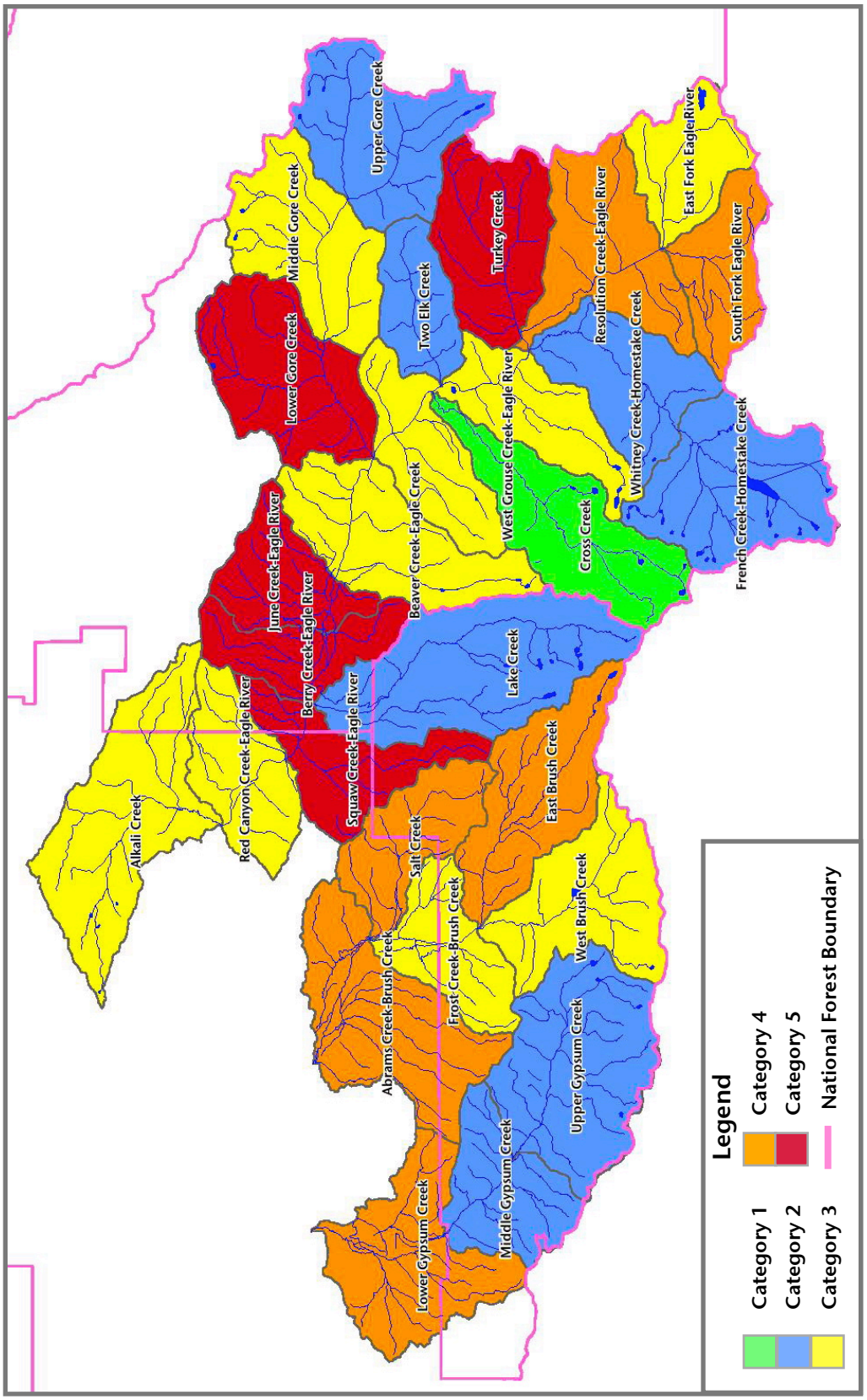

Figure 7. Eagle River Watershed Road Density Ranking

Flooding or Debris Flow Hazard Ranking

The Flooding or Debris Flow Hazard is the combination of ruggedness and road density. The procedure from the Front Range Watershed Work Group (2009) assigned ruggedness a higher value than road density in this ranking. While ruggedness is the most important factor, an increase in road density will magnify the effects of ruggedness on the flooding/debris flow hazard. Accordingly, the analysis for flooding or debris flow hazard for the Eagle River Watershed used the following formula. The results of this calculation were then re-categorized into five hazard rankings.

Flooding or Debris Flow Hazard Ranking = (Road Density Ranking + Ruggedness Ranking * 2)

Figure 8 shows that areas of the watershed with high road densities and high ruggedness rank high in this combined factor. The best way to look at this map is to look at a single watershed on the ruggedness and road density maps, noting the rankings on each. Then look at this map and see how they result in the final ranking for this component. The tabular results are presented in Table B-4 in Appendix B.

The highest ranked sixth-level watersheds are Beaver Creek-Eagle River, Squaw Creek-Eagle River, East Brush Creek, and Berry Creek-Eagle River. Alkali Creek was skewing the categorization because of it low combined numeric score for Flooding or Debris Flow Hazard Ranking. The combined numeric score for Alakli Creek was manually given a score slightly less than the next lowest score (Table B-4 in Appendix B).

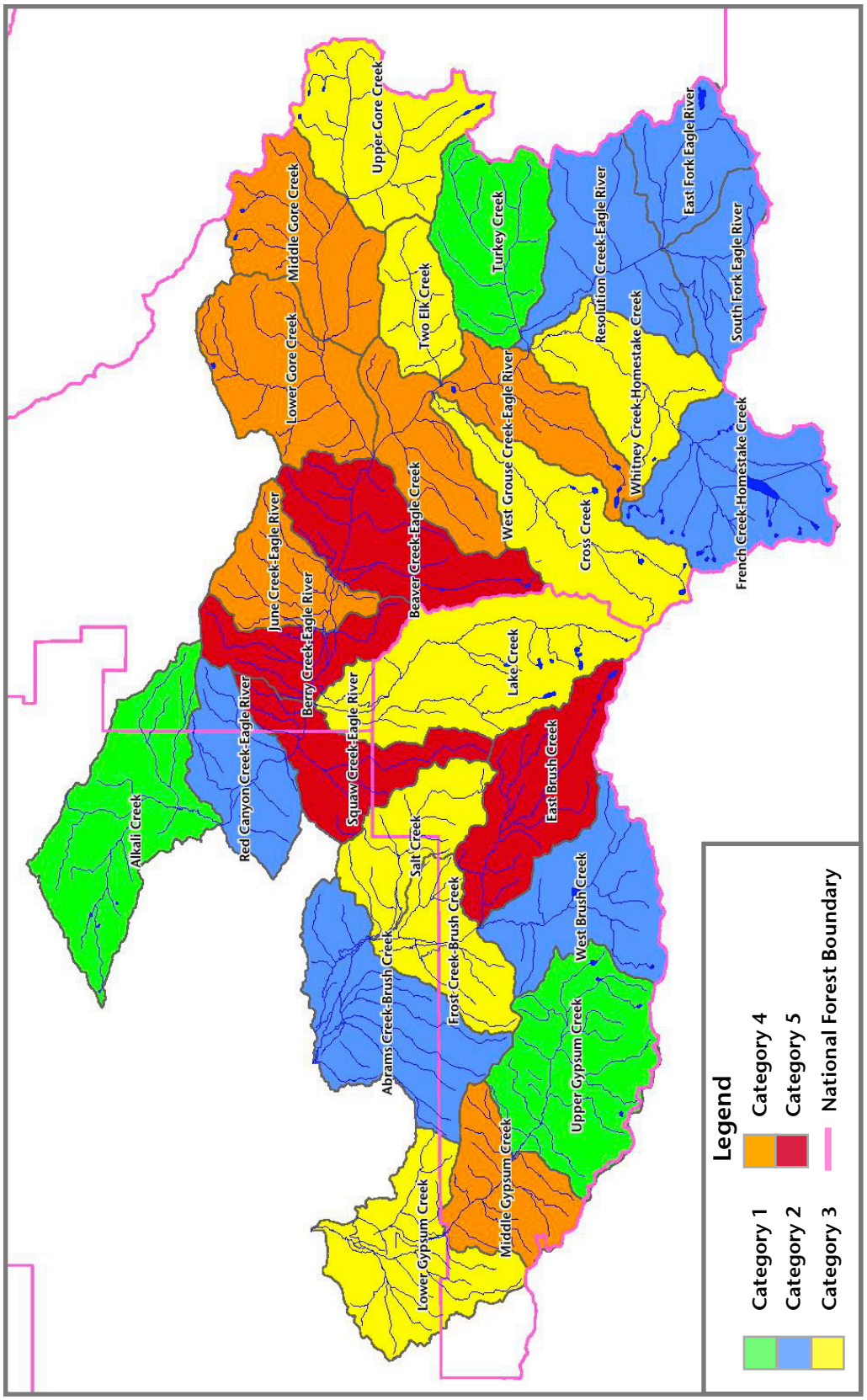

Figure 8. Eagle River Watershed Flooding/Debris Flow Hazard Ranking

Component 3 - Soil Erodibility

High-severity fires can cause changes in watershed components that can dramatically change runoff and erosion processes in watersheds. Water and sediment yields may increase as more of the forest floor is consumed (Wells et al. 1979, Robichaud and Waldrop 1994, Soto et al. 1994, Neary et al. 2005, and Moody et al. 2008) and soil properties are altered by soil heating (Hungerford et al. 1991).

Two soils data sets were evaluated for use in this analysis. They were the U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) STATSGO and SSURGO soils data. STATSGO data are relatively coarse soils data, created at a scale of 1:250,000 and are available for the entire watershed assessment area. SSURGO soils data do not cover all the watershed assessment area, though efforts by the NRCS are currently under way to produce an updated soils data layer.

The data used in this analysis is the U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) SSURGO soils data combined with the U.S. Forest Service soils data. SSURGO data does not cover all the watershed but is available at a preferable scale (generally ranges from 1:12,000 to 1:63,360) than STATSGO data. The U.S. Forest Service soils data is comparable with the SSURGO data in scale and quality. Areas without SSURGO data were filled in with U.S. Forest Service soils data (Figure 9).

The soil erodibility analysis used a combination of two standard erodibility indicators: the inherent susceptibility of soil to erosion (K factor) and land slope derived from Unites States Geological Survey (USGS) 30-meter digital elevation models. The K factor data from the SSURGO spatial database was combined with a slope grid using NRCS (USDA NRCS 1997) slope-soil relationships (Table 2) to create a classification grid divided into slight, moderate, severe and very severe erosion hazard ratings.

Table 2. NRCS Criteria for Determining Potential Soil Erodibility

Percent Slope	K Factor <0.1	K Factor 0.1 to 0.19	K Factor 0.2 to 0.32	K Factor >0.32
0-14	Slight	Slight	Slight	Moderate
15-34	Slight	Slight	Moderate	Severe
35-50	Slight	Moderate	Severe	Very Severe
>50	Moderate	Severe	Very Severe	Very Severe

The potential soil erodibility hazard rankings are shown on Figure 10 and the tabular results are presented in Table B-5 in Appendix B. The map shows areas of high soil erodibility in the assessment area. The highest ranked sixth-level watersheds based on soil erodibility are Squaw Creek-Eagle River, Middle Gore Creek, and Berry Creek-Eagle River. The soil erodibility value for Upper Gore and Middle Gore Creeks were adjusted up due to the presence of large quantities of highway sand that increase the concern for soil erosion. South Fork Eagle River was skewing the categorization because of it low soil erodibility value and was manually given a score slightly less than the next lowest score (Table B-5 in Appendix B).

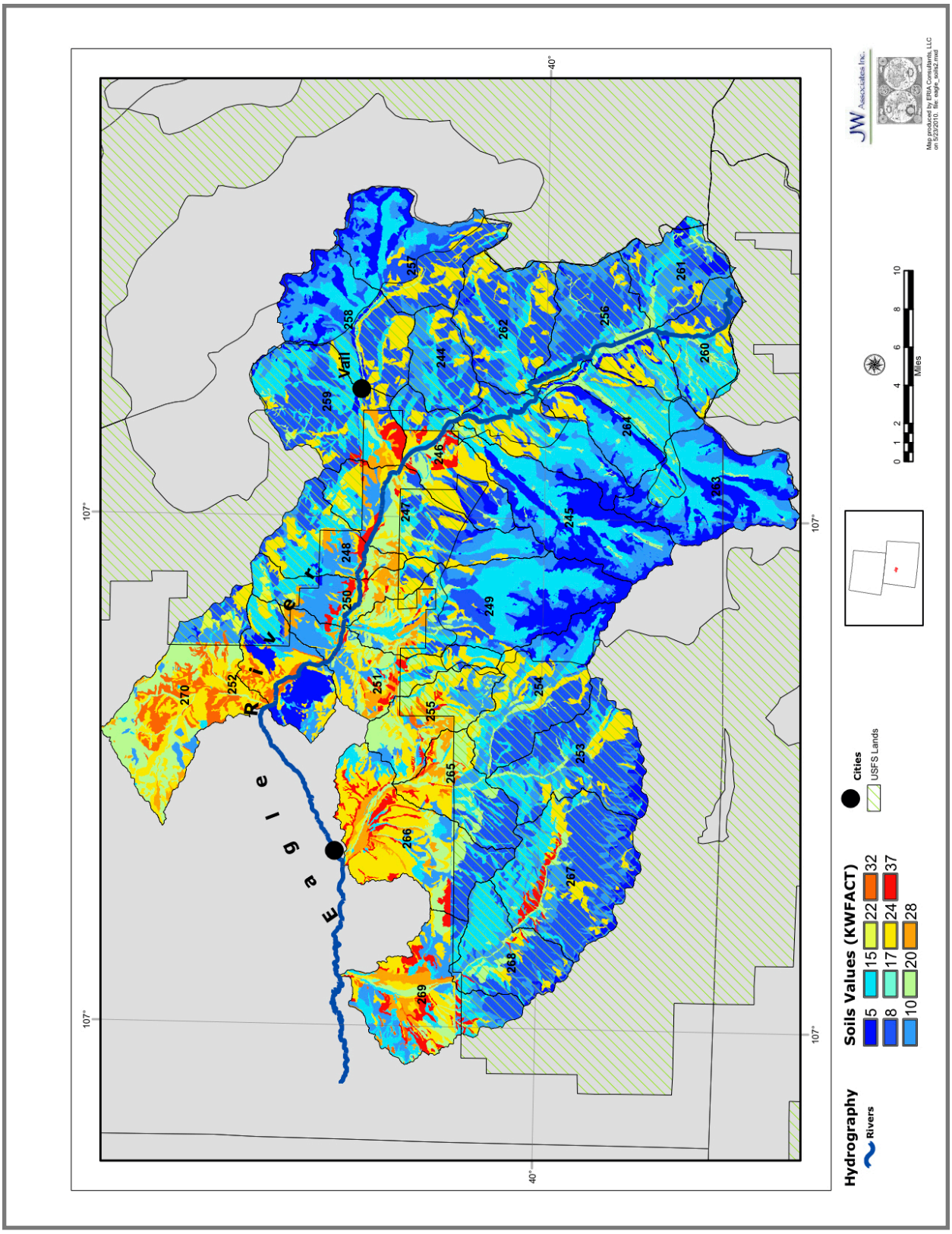

Figure 9. Eagle River Watershed Soils K-Factor Map

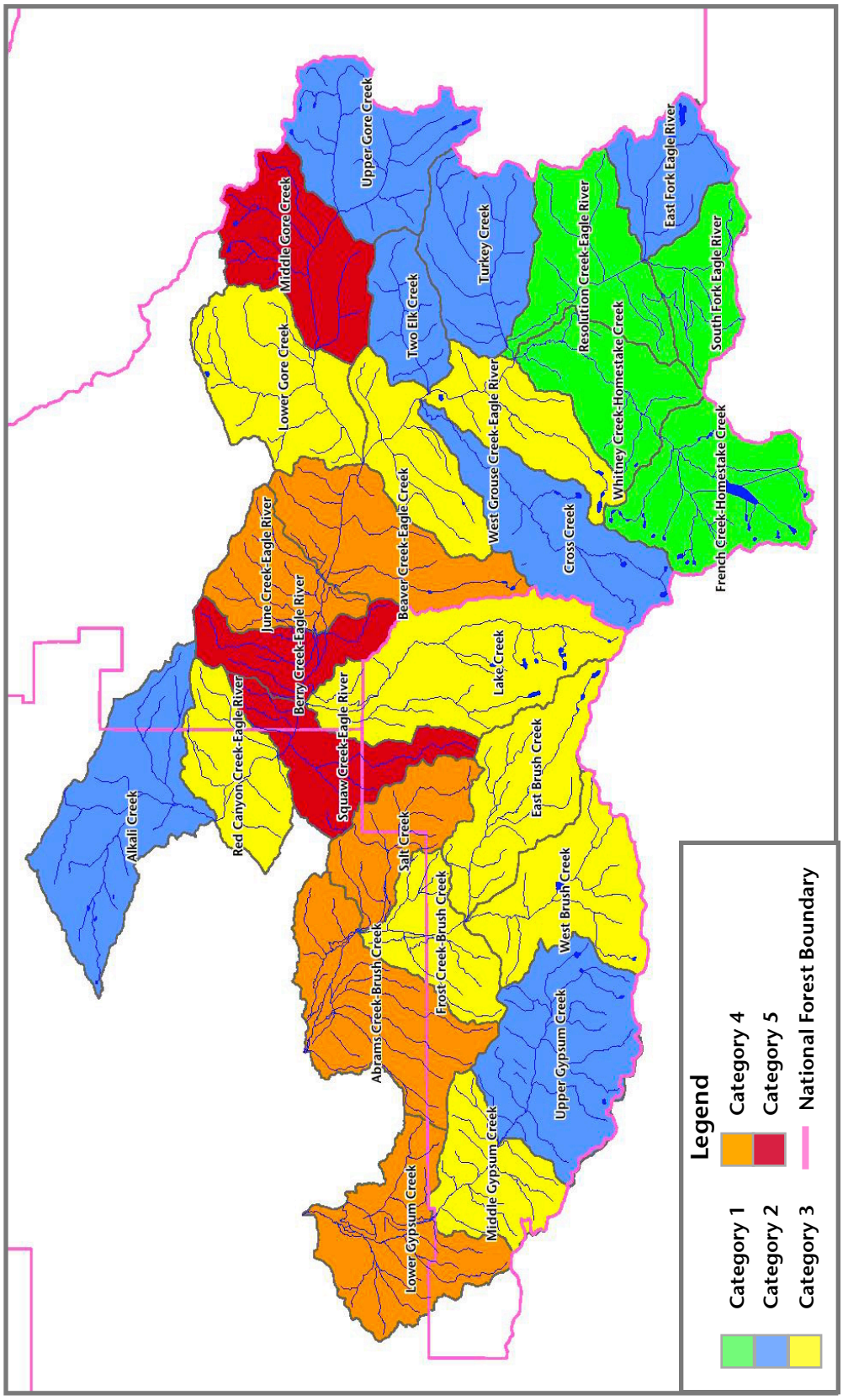

Figure 10. Eagle River Watershed Potential Soil Erodibility Hazard Ranking

Composite Hazard Ranking

The Composite Hazard Ranking combines the first three components (Wildfire Hazard, Flooding/Debris Flow Hazard and Soil Erodibility) by numerically combining their rankings for each sixth-level watershed and then re-categorizing the results. The Composite Hazard Ranking map is useful in comparing relative watershed hazards based solely on environmental factors. Figure 11 shows the Composite Hazard Ranking for the Eagle River Watershed. The tabular results that display the rankings for Wildfire Hazard, Flooding/ Debris Flow Hazard and Soil Erodibility, as well as the composite rankings are presented in Table B-6 in Appendix B. The highest ranked sixth-level watersheds are Squaw Creek-Eagle River, Beaver Creek-Eagle River, East Brush Creek, and Lower Gore Creek. Additionally, there are five watersheds in Category 4.

Alkali Creek was skewing the categorization because of it low score for the Composite Numeric Rank. The Composite Numeric Rank for Alakli Creek was manually given a score less than the next lowest score (Table B-6 in Appendix B).

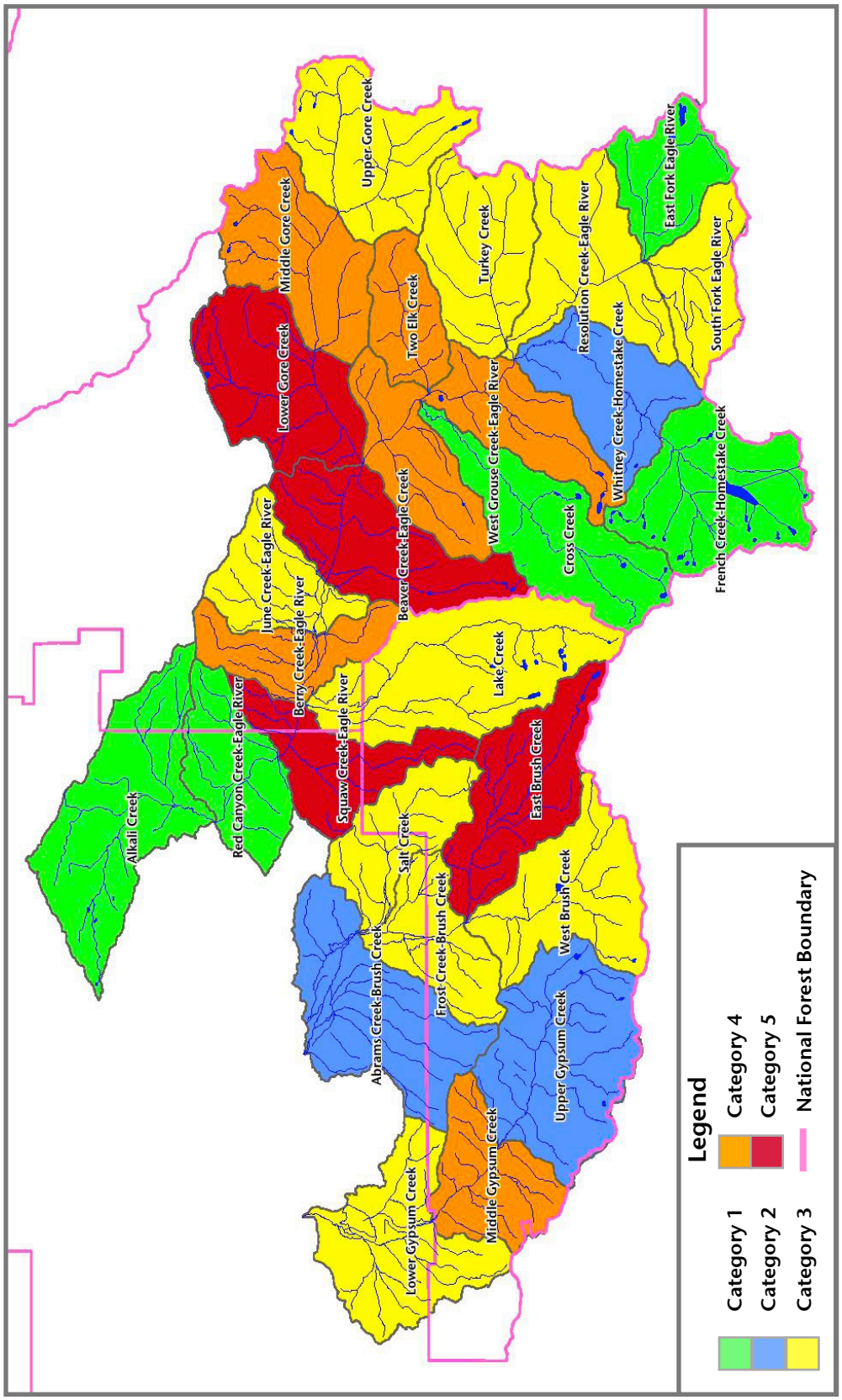

Figure 11. Eagle River Watershed Composite Hazard Ranking

Component 4 - Water Supply Ranking

Surface water intakes, diversions, conveyance structures, storage reservoirs and streams are all susceptible to the effects of wildfires. The suggested approach from the procedure prescribed by the Front Range Watershed Protection Data Refinement Work Group (2009) is to first rank watersheds based upon the presence of water nodes.

Surface drinking water supply collection points from the Source Water Assessment and Protection (SWAP) Program (see http://www.cdphe.state.co.us/wq/sw/swaphom.html for basic information on the SWAP Program) were used to identify which sixth-level watersheds contain critical components of the public water supply infrastructure in Colorado. For this assessment, water nodes were defined as coordinate points corresponding to surface water intakes, upstream diversion points and classified drinking water reservoirs.

Water supply locations may not be identified in the state's database for some drinking water supply reservoirs that do not have associated direct surface water intakes. Also, some water supply reservoirs may not be identified in the SWAP database. The Water Supply map was modified to include these features by including all named reservoirs.

Figure 12 shows the sixth-level watersheds that have water supply locations in blue and those without water supply locations in green.

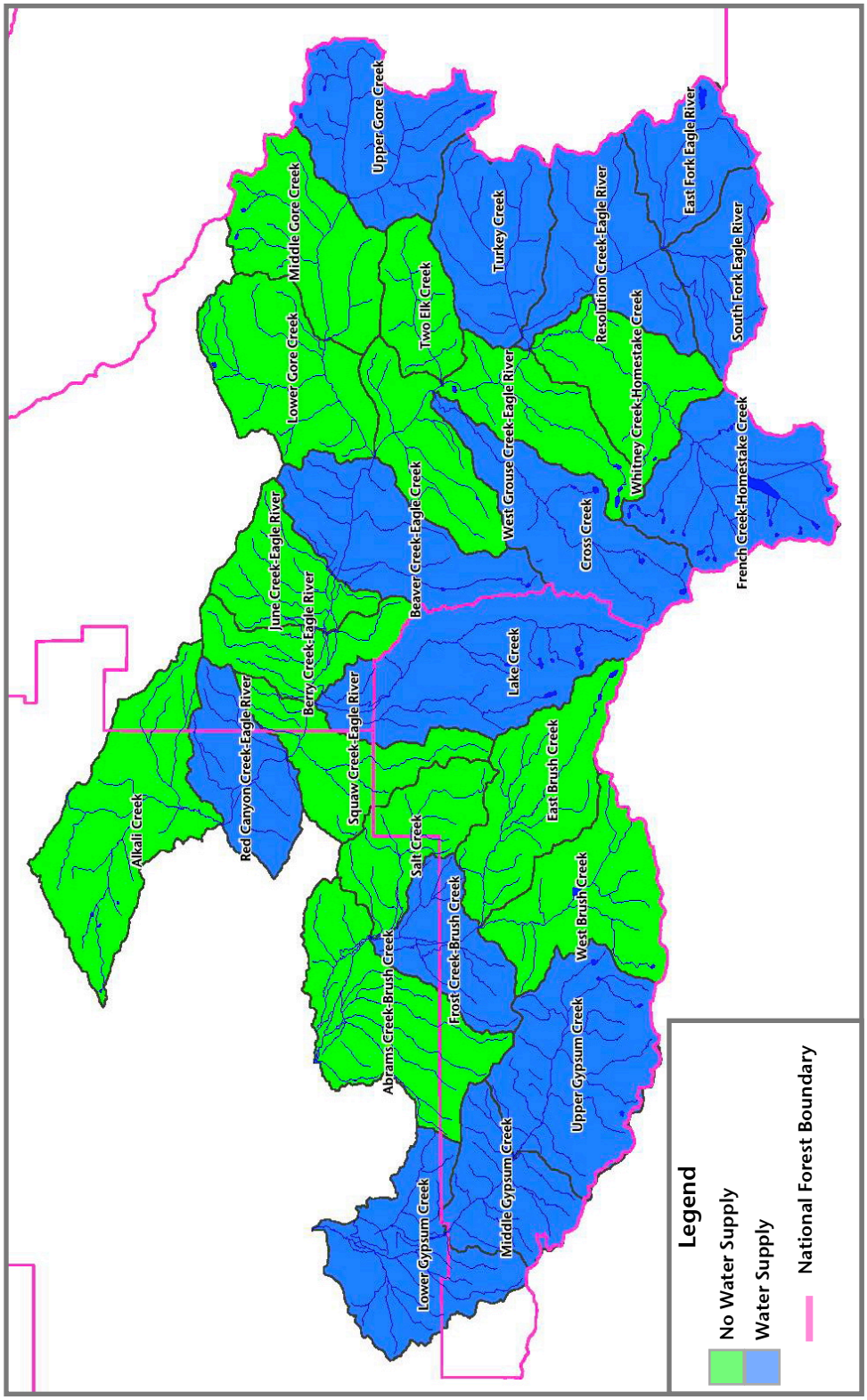

Figure 12. Eagle River Watershed Water Supply Map

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APPENDIX A

EAGLE RIVER WILDFIRE HAZARD MODELING METHODOLOGY

The forest conditions that are of concern for the assessments are the wildfire hazard based on existing forest conditions. The wildfire hazard (Flame Length) was determined using the Fire Behavior Assessment Tool (FBAT) (http://www.fire.org) which is an interface between ArcMap and FlamMap. The input spatial data were collected from LANDFIRE project (http://www.landfire.gov/).

After a mountain pine beetle outbreak there are substantial increases in the amount of fine dead fuels in the canopy. The majority of these fuels remain in the canopy for 2-3 years post outbreak (Knight 1987, Schmid and Amman 1992). Therefore, certain input spatial data sets were updated reflecting Mountain Pine Beetle (MPB) mortality conditions using USDA Forest Service, Rocky Mountain Region Aerial Detection Survey (ADS) Data from the years 2002 - 2007 (http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/). The following modeling settings and spatial data modification were used:

Modeling Setting

1. Scott and Burgan (2005) Fire Behavior Model (Fuel Moisture is shown in Table A-1)
2. Uphill wind direction
3. Scott & Reinhardt (2001) crown fire calculation
4. Foliar Moisture at 100%

Spatial Data Modifications

1. Canopy Cover was assigned a value of 10% when coincident with MPB mortality from ADS for years 2002-2007.
2. Canopy Base Height (CBH) was reduced by 25% for MPB mortality derived from ADS for the years 2002-2006.
3. CBH was reassigned a value of 0 for MPB mortality from ADS for the year 2007.
4. Canopy Bulk Density (CBD) was reduced by 50% for MPB mortality derived from ADS for the years 2002-2006

Table A-1. Fuel Moisture (percent) used in FBAT Model Runs

Scott and Burgan (2005) fuel model	1-Hour Fuel	10-Hour Fuel	100-Hour Fuel	Live Herbaceous	Live Woody
1	4	5	8	200	95
2	4	5	8	150	95
3	4	5	8	85	95
4	4	5	8	85	95
5	4	5	8	85	150
6	4	5	8	85	95
7	4	5	8	85	95
8	4	5	8	85	95
9	4	5	8	85	95
10	4	5	8	85	95
11	4	5	8	85	95
12	4	5	8	85	95
13	4	5	8	85	95
14	3	4	8	85	95
15	3	4	8	85	95
16	3	4	8	85	95
17	3	4	8	85	95
18	3	4	8	85	95
19	3	4	8	85	95
20	3	4	8	85	95
21	3	4	8	85	95
22	3	4	8	85	95
23	3	4	8	85	95
24	3	4	8	85	95
25	3	4	8	85	95
26	3	4	8	85	95
27	3	4	8	85	95
28	3	4	8	85	95
29	3	4	8	85	95
30	3	4	8	85	95
31	3	4	8	85	95
32	3	4	8	85	95
33	3	4	8	85	95
34	3	4	8	85	95
35	3	4	8	85	95
36	3	4	8	85	95
37	3	4	8	85	95
38	3	4	8	85	95
39	3	4	8	85	95
40	3	4	8	85	95
41	3	4	8	85	95
42	3	4	8	85	95
43	3	4	8	85	95
44	3	4	8	85	95
45	3	4	8	85	95
46	3	4	8	85	95
47	3	4	8	85	95
48	3	4	8	85	95
49	3	4	8	85	95
50	3	4	8	85	95

Weather Data

The weather data used comes from the Colorado Wildfire Risk Assessment Statewide (CRA) dataset prepared by Sandborn under contract to the Colorado State Forest Service. For the Colorado Fire Risk Assessment nine weather influence zones (WIZ) were developed for analysis purposes. A WIZ is an area where for analysis purposes the weather on any given day is uniform. Within each WIZ, daily weather data was gathered for the years 1980-2006. Where not available, the weather data was gathered from the earliest year through 2006. Several weather stations were analyzed within each WIZ. From this analysis, one representative weather station was selected for each WIZ. From this data set, percentile weather was developed for each WIZ using the Fire Family Plus software package.

For this watershed assessment the percentile weather for WIZ CO 02 (Dowd 1986-2006) was used for all watersheds on the west side of the continental divide and WIZ CO 03 (Coral Creek 1980-2006) was used for all watersheds on the east side of the continental divide. The 20-foot wind speeds for the "High" case was used in the modeling runs (Table A-2).

In addition the wind direction was assumed to be uphill (parallel with slope) in all instances. This setting encourages crown fire initiation and establishes a common baseline for the evaluation of areas within the landscape based upon the fuels hazard represented by vegetation conditions.

Table A-2. Wind Speed (Miles per Hour) used in FBAT Model Runs

Watershed Name	Wind Speed (mph)	Probable Momentary Gust Speed (mph)
North Platte	15	29
Upper North Platte	15	29
Crow/Medicine Bow/Upper Laramie/Upper Lodgepole	12	25
Clear/Bear Creek	12	25
Big Thompson	12	25
Cache la Poudre	12	25
Blue River	15	29
Eagle River	15	29
Upper Yampa	15	29
Little Snake	15	29
Upper White	15	29
Lower Colorado	15	29
Upper Colorado	15	29
Saint Vrain	12	25
Roaring Fork	15	29

Categorization of Results

The FBAT model results were divided into five categories of flame length. These values range from lowest (Category 0) to highest (Category 4) based upon flame length. The flame length categories that were used are:

Flame Length Category 0 - 0 meters

Flame Length Category 1 - 1 to 10 meters

Flame Length Category 2 - 11 to 25 meters

Flame Length Category 3 - 26 to 40 meters

Flame Length Category 4 - >40 meters

APPENDIX B

DETAILED EAGLE RIVER WATERSHED ASSESSMENT RESULTS

Table B-1. Eagle River Watershed Wildfire Hazard Ranking[1]

Sixth-level Watershed Name	Watershed Area (acres)	Wildfire Hazard Calculation	Wildfire Hazard Rank
South Fork Eagle River	12,161	80.0%	*5.5*
Turkey Creek	18,893	80.0%	*5.5*
Resolution Creek-–-Eagle River	20,771	78.4%	*5.4*
Two Elk Creek	10,092	66.5%	*4.5*
West Brush Creek	20,844	65.1%	*4.4*
West Grouse Creek-–-Eagle River	29,443	62.8%	*4.3*
Whitney Creek-–-Homestake Creek	16,951	62.1%	*4.2*
East Brush Creek	20,769	61.3%	*4.2*
Lower Gore Creek	22,451	59.1%	*4.0*
Upper Gypsum Creek	28,403	58.8%	*4.0*
Upper Gore Creek	22,133	53.2%	*3.6*
Middle Gypsum Creek	14,620	52.2%	*3.5*
East Fork Eagle River	12,223	44.7%	*3.0*
Beaver Creek-–-Eagle Creek	21,444	44.1%	*2.9*
Lake Creek	31,389	44.0%	*2.9*
French Creek-–-Homestake Creek	23,967	42.6%	*2.8*
Salt Creek	13,749	42.1%	*2.8*
Middle Gore Creek	20,622	38.9%	*2.6*
Squaw Creek-–-Eagle River	15,000	37.9%	*2.5*
Frost Creek-–-Brush Creek	13,213	36.7%	*2.4*
Cross Creek	21,937	28.4%	*1.8*
June Creek-–-Eagle River	12,607	27.9%	*1.8*
Abrams Creek-–-Brush Creek	25,676	21.0%	*1.3*
Lower Gypsum Creek	22,737	20.2%	*1.2*
Berry Creek-–-Eagle River	11,662	15.3%	*0.9*
Red Canyon Creek-–-Eagle River	14,634	10.0%	*0.5*
Alkali Creek	29,039	10.0%	*0.5*
Totals	527,429		

[1] Two watersheds were manually adjusted because they were skewing the results of the categorization because of their low values. The wildfire hazard calculation for Red Canyon Creek-–-Eagle River and Alkali Creek were originally 8.77 and 4.45 respectively.

Table B-2. Eagle River Watershed Ruggedness Ranking[2]

Sixth-level Watershed Name	Maximum Elevation	Minimum Elevation	Difference Elevation	Ruggedness[3]	Ruggedness Rank
Beaver Creek-–-Eagle Creek	13,156	7,396	5,760	0.2107	*5.5*
Middle Gypsum Creek	11,493	6,940	4,553	0.2017	*5.1*
Cross Creek	13,983	7,980	6,003	0.1942	*4.7*
East Brush Creek	13,369	7,583	5,786	0.1924	*4.6*
West Grouse Creek-–-Eagle River	13,815	7,708	6,107	0.1907	*4.5*
Squaw Creek-–-Eagle River	11,224	7,065	4,159	0.1819	*4.1*
Two Elk Creek	11,805	8,003	3,802	0.1813	*4.1*
Middle Gore Creek	12,989	8,161	4,828	0.1801	*4.0*
Lake Creek	13,546	7,114	6,432	0.1739	*3.7*
Frost Creek-–-Brush Creek	11,162	6,993	4,169	0.1738	*3.7*
Berry Creek-–-Eagle River	11,004	7,111	3,893	0.1727	*3.7*
Upper Gore Creek	13,320	8,561	4,759	0.1714	*3.6*
Whitney Creek-–-Homestake Creek	13,238	8,584	4,654	0.1713	*3.6*
Lower Gypsum Creek	11,054	6,262	4,792	0.1702	*3.5*
June Creek-–-Eagle River	11,178	7,288	3,890	0.1660	*3.3*
Lower Gore Creek	12,310	7,731	4,579	0.1637	*3.2*
French Creek-–-Homestake Creek	13,733	9,191	4,542	0.1572	*2.9*
Salt Creek	10,785	6,993	3,792	0.1549	*2.8*
East Fork Eagle River	12,707	9,282	3,425	0.1484	*2.5*
South Fork Eagle River	12,697	9,286	3,411	0.1482	*2.5*
Red Canyon Creek-–-Eagle River	10,650	6,911	3,739	0.1481	*2.5*
West Brush Creek	11,979	7,606	4,373	0.1451	*2.3*
Abrams Creek-–-Brush Creek	10,755	6,501	4,254	0.1422	*2.2*
Resolution Creek-–-Eagle River	12,644	8,551	4,093	0.1361	*1.9*
Upper Gypsum Creek	11,762	7,754	4,008	0.1274	*1.5*
Turkey Creek	12,021	8,666	3,355	0.1170	*1.0*
Alkali Creek	10,726	6,914	3,812	0.1072	*0.5*

[2] Ruggedness is based on Melton (1957)

[3] These watersheds were manually adjusted because they do not accurately reflect the ruggedness in those watersheds. The original values were; Upper Gore Creek (0.1533), Middle Gore Creek (0.1611), Lower Gore Creek (0.1464), French Creek-Homestake Creek (0.1406), West Grouse Creek-Eagle River (0.1705), Beaver Creek-Eagle River (0.1885), Squaw Creek-Eagle River (0.1627), Abrams Creek-Brush Creek (0.1272), Upper Gypsum Creek (0.1139), Middle Gypsum Creek (0.1804), and Lower Gypsum Creek (0.1523).

Table B-3. Eagle River Watershed Road Density Ranking[4]

Sixth-level Watershed Name	Roads (miles)	Roads Adjusted (miles)	Watershed Area (sq. mi.)	Road density (miles per sq. mi.)	Road Density Rank
Berry Creek-–-Eagle River	91.9	68.9	18.22	3.78	*5.5*
June Creek-–-Eagle River	94.1	70.6	19.70	3.58	*5.2*
Squaw Creek-–-Eagle River	83.3	83.3	23.44	3.55	*5.2*
Lower Gore Creek	165.7	124.3	35.08	3.54	*5.2*
Turkey Creek	96.5	96.5	29.52	3.27	*4.8*
Resolution Creek-–-Eagle River	97.3	97.3	32.45	3.00	*4.4*
East Brush Creek	83.6	83.6	32.45	2.58	*3.9*
South Fork Eagle River	45.3	45.3	19.00	2.39	*3.6*
Lower Gypsum Creek	84.4	84.4	35.53	2.38	*3.6*
Salt Creek	50.7	50.7	21.48	2.36	*3.6*
Abrams Creek-–-Brush Creek	94.2	94.2	40.12	2.35	*3.5*
Beaver Creek-–-Eagle Creek	102.3	76.7	33.51	2.29	*3.5*
Red Canyon Creek-–-Eagle River	69.4	52.0	22.86	2.28	*3.4*
West Brush Creek	73.2	73.2	32.57	2.25	*3.4*
Middle Gore Creek	84.1	71.5	32.22	2.22	*3.4*
Frost Creek-–-Brush Creek	38.3	38.3	20.65	1.86	*2.9*
East Fork Eagle River	34.3	34.3	19.10	1.79	*2.8*
Alkali Creek	77.7	77.7	45.37	1.71	*2.7*
West Grouse Creek-–-Eagle River	77.2	77.2	46.00	1.68	*2.6*
Two Elk Creek	23.8	23.8	15.77	1.51	*2.4*
Middle Gypsum Creek	34.2	34.2	22.84	1.50	*2.4*
Whitney Creek-–-Homestake Creek	35.7	35.7	26.49	1.35	*2.2*
Upper Gypsum Creek	58.3	58.3	44.38	1.31	*2.1*
Upper Gore Creek	39.1	39.1	34.58	1.13	*1.9*
French Creek-–-Homestake Creek	37.4	37.4	37.45	1.00	*1.7*
Lake Creek	46.3	46.3	49.05	0.94	*1.6*
Cross Creek	4.0	4.0	34.28	0.12	*0.5*
Totals	1822.2	1678.7	824.11	2.04	

[4] The road density was adjusted based upon the procedure discussed in the report (p. 12). The original road density values were; Middle Gore Creek (2.61), Lower Gore Creek (4.72), Beaver Creek-Eagle River (3.05), June Creek-Eagle River (4.78), Berry Creek-Eagle River (5.04), and Red Canyon Creek-Eagle River (3.03).

Table B-4. Eagle River Watershed Flooding/Debris Flow Hazard Ranking[5, 6]

Sixth-level Watershed Name	Ruggedness Ranking	Road Density Ranking	Combined Numeric Rank	Combined Ranking
Beaver Creek-–-Eagle Creek	5.5	3.5	14.46	5.5
Squaw Creek-–-Eagle River	4.1	5.2	13.40	4.9
East Brush Creek	4.6	3.9	13.08	4.8
Berry Creek-–-Eagle River	3.7	5.5	12.83	4.6
Middle Gypsum Creek	5.1	2.4	12.51	4.5
June Creek-–-Eagle River	3.3	5.2	11.91	4.1
West Grouse Creek-–-Eagle River	4.5	2.6	11.69	4.0
Lower Gore Creek	3.2	5.2	11.63	4.0
Middle Gore Creek	4.0	3.4	11.41	3.9
Lower Gypsum Creek	3.5	3.6	10.67	3.5
Two Elk Creek	4.1	2.4	10.56	3.4
Frost Creek-–-Brush Creek	3.7	2.9	10.30	3.3
Cross Creek	4.7	0.5	9.91	3.1
Whitney Creek-–-Homestake Creek	3.6	2.2	9.37	2.8
Salt Creek	2.8	3.6	9.18	2.7
Upper Gore Creek	3.6	1.9	9.08	2.7
Lake Creek	3.7	1.6	9.08	2.7
South Fork Eagle River	2.5	3.6	8.56	2.4
Red Canyon Creek-–-Eagle River	2.5	3.4	8.39	2.3
Resolution Creek-–-Eagle River	1.9	4.4	8.22	2.2
West Brush Creek	2.3	3.4	8.07	2.1
Abrams Creek-–-Brush Creek	2.2	3.5	7.93	2.0
East Fork Eagle River	2.5	2.8	7.77	2.0
French Creek-–-Homestake Creek	2.9	1.7	7.53	1.8
Turkey Creek	1.0	4.8	6.74	1.4
Upper Gypsum Creek	1.5	2.1	5.09	0.5
Alkali Creek	0.5	2.7	5.00	0.5

[5] Combined Ranking is Ruggedness Ranking times 2 plus the Road Density Ranking

[6] The Alkali Creek watershed was manually adjusted because it was skewing the results of the categorization because of its low value. The Combined Numeric Rank for Alkali Creek was originally 3.12.

Table B-5. Eagle River Watershed Soil Erodibility Ranking[7, 8, 9]

Sixth-level Watershed Name	Severe (%)	Very Severe (%)	Soil Erodibility Value	Soil Erodibility Rank
Squaw Creek-–-Eagle River	21.3%	7.3%	0.358	*5.5*
Middle Gore Creek	23.6%	1.4%	0.319	*4.8*
Berry Creek-–-Eagle River	19.5%	5.9%	0.312	*4.6*
Lower Gypsum Creek	15.5%	5.8%	0.272	*3.9*
June Creek-–-Eagle River	18.6%	3.8%	0.261	*3.7*
Salt Creek	14.6%	5.7%	0.259	*3.7*
Abrams Creek-–-Brush Creek	15.0%	5.4%	0.259	*3.7*
Beaver Creek-–-Eagle Creek	15.7%	4.9%	0.254	*3.6*
Lower Gore Creek	14.9%	4.8%	0.245	*3.4*
Frost Creek-–-Brush Creek	15.2%	4.2%	0.237	*3.2*
Lake Creek	20.2%	1.4%	0.230	*3.1*
Middle Gypsum Creek	19.2%	1.4%	0.220	*2.9*
West Brush Creek	17.0%	2.5%	0.219	*2.9*
West Grouse Creek-–-Eagle River	15.4%	3.1%	0.216	*2.9*
Red Canyon Creek-–-Eagle River	13.1%	4.0%	0.211	*2.8*
East Brush Creek	15.0%	2.4%	0.198	*2.5*
Upper Gore Creek	12.2%	1.0%	0.196	*2.5*
Alkali Creek	11.2%	3.6%	0.183	*2.2*
Two Elk Creek	16.6%	0.5%	0.176	*2.1*
Upper Gypsum Creek	11.1%	3.2%	0.175	*2.1*
Turkey Creek	13.5%	0.6%	0.148	*1.6*
East Fork Eagle River	13.6%	0.4%	0.145	*1.5*
Cross Creek	14.0%	0.2%	0.145	*1.5*
French Creek-–-Homestake Creek	13.7%	0.1%	0.138	*1.4*
Whitney Creek-–-Homestake Creek	9.7%	0.9%	0.115	*1.0*
Resolution Creek-–-Eagle River	9.2%	0.7%	0.105	*0.8*
South Fork Eagle River	4.2%	0.9%	0.090	*0.5*

[7] Soil Erodibility Value is percentage of Severe plus 2 times the percentage of Very Severe.

[8] The soil erodibility values for Upper Gore and Middle Gore Creeks were adjusted up by 0.100 due to the presence of large quantities of highway sand that increase the concern for soil erosion.

[9] The South Fork Eagle River watershed was manually adjusted because it was skewing the results of the categorization because of its low value. The Soil Erodibility Value was originally 0.059.

Table B-6. Eagle River Watershed Composite Hazard Ranking[10, 11]

Sixth-level Watershed Name	Wildfire Hazard Rank	Flooding/ Debris Flow Rank	Soil Erodibility Rank	Composite Numeric Rank	Composite Hazard Rank
Squaw Creek-–-Eagle River	2.5	4.9	5.5	12.9	5.5
Beaver Creek-–-Eagle Creek	2.9	5.5	3.6	12.0	4.9
East Brush Creek	4.2	4.8	2.5	11.5	4.6
Lower Gore Creek	4.0	4.0	3.4	11.4	4.5
Middle Gore Creek	2.6	3.9	4.8	11.2	4.4
West Grouse Creek-–-Eagle River	4.3	4.0	2.9	11.2	4.4
Middle Gypsum Creek	3.5	4.5	2.9	10.9	4.2
Berry Creek-–-Eagle River	0.9	4.6	4.6	10.1	3.7
Two Elk Creek	4.5	3.4	2.1	10.1	3.7
June Creek-–-Eagle River	1.8	4.1	3.7	9.6	3.4
West Brush Creek	4.4	2.1	2.9	9.5	3.3
Salt Creek	2.8	2.7	3.7	9.2	3.1
Frost Creek-–-Brush Creek	2.4	3.3	3.2	9.0	3.0
Upper Gore Creek	3.6	2.7	2.5	8.7	2.8
Lake Creek	2.9	2.7	3.1	8.7	2.8
Lower Gypsum Creek	1.2	3.5	3.9	8.6	2.8
Turkey Creek	5.5	1.4	1.6	8.5	2.7
South Fork Eagle River	5.5	2.4	0.5	8.4	2.6
Resolution Creek-–-Eagle River	5.4	2.2	0.8	8.4	2.6
Whitney Creek-–-Homestake Creek	4.2	2.8	1.0	8.0	2.4
Abrams Creek-–-Brush Creek	1.3	2.0	3.7	7.0	1.8
Upper Gypsum Creek	4.0	0.5	2.1	6.6	1.5
East Fork Eagle River	3.0	2.0	1.5	6.5	1.4
Cross Creek	1.8	3.1	1.5	6.4	1.4
French Creek-–-Homestake Creek	2.8	1.8	1.4	6.1	1.2
Red Canyon Creek-–-Eagle River	0.5	2.3	2.8	5.5	0.8
Alkali Creek	0.5	0.5	2.2	5.0	0.5

[10] The Composite Hazard Rank is the average of the Wildfire Hazard Rank, Flooding/Debris Flow Rank, and Soil Erodibility Rank that is re-categorized into 5 categories using the procedure described in Front Range Watershed Protection Data Refinement Work Group (2009).

[11] The Alkali Creek watershed was manually adjusted because it was skewing the results of the categorization because of its low value. The Composite Numeric Rank was originally 3.5.