Final February 2023

UPPER GUNNISON

Watershed Wildfire Hazard Assessment

Prepared for the Upper Gunnison River Watershed Conservancy District

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Photo - Beaver Creek Fire 2016 - Credit US Forest Service

Introduction

This watershed/wildfire assessment is designed to identify and prioritize 6th level (HUC12) watersheds (approximately 20,000-25,000 acres) based upon the hazards that could impact water supplies following wildfires, such as generating flooding, debris flows and increased sediment yields . The assessment area is bounded by the Upper Gunnison River Water Conservancy District's (UGRWCD) watershed areas.

The National Hydrography Dataset (NHD) was used for watershed delineations. It identifies watersheds by Hydrologic Unit Code (HUC) which is a numeric identification of specific watersheds and their relationship to other watersheds. Watersheds nationwide are constructed in a nested system of smaller-scale watersheds adding up to larger-scale watersheds. For example, the six HUC10 watersheds in Tomichi Creek (Table 1) combine to make up the single HUC8 Tomichi Creek watershed. HUC numbers contain 2 digits that uniquely identify each watershed level, so a 5th level watershed is a HUC10 because it contains 10 digits (2 digits x 5 levels). All the Upper Gunnison watersheds are part of the Gunnison River Watershed which is a 3rd Level or HUC6 watershed with the code 140200. The Gunnison River Watershed is part of the Colorado River Watershed which is a 1st Level or HUC2 watershed with the code 14. Watershed levels are generally easier to understand than HUC codes and are used throughout this assessment.

All 6th level watersheds that are part of UGRWCD's water collection system or upstream of it were included in the analysis. These 6th level watersheds are used for the prioritization of specific hazards. The total study area covers 2,274,239 acres and includes three 4th level sub-basins (Table 1) and 102 6th level watersheds (Table 1, Figure 1 and Appendix A).

Table 1. Watersheds in the Upper Gunnison River Watershed Analysis

Sub-Basin (4th Level Watershed)	5th Level Watershed	10 Code HUC	Area (acres)	Number of 6th Level Watersheds
Upper Gunnison	Taylor River	1402000101	305,501	13
Upper Gunnison	East River	1402000102	185,188	10
	Upper Gunnison Sub-basin totals		**490,689**	**23**
Middle Gunnison	Ohio Creek	1402000201	131,970	7
Middle Gunnison	South Beaver Creek - Gunnison River	1402000202	83,104	4
Middle Gunnison	Willow Creek	1402000203	46,600	2
Middle Gunnison	Beaver Creek - Blue Mesa Reservoir	1402000204	81,977	3
Middle Gunnison	Cebolla Creek	1402000205	250,167	11
Middle Gunnison	Lake Fork	1402000206	276,913	11
Middle Gunnison	Soap Creek - Blue Mesa Reservoir	1402000207	127,409	6
Middle Gunnison	Blue Creek	1402000208	49,214	2
Middle Gunnison	Crystal Creek.- Gunnison River	1402000210	30,692	2
	Middle Gunnison Sub-basin Totals		**1,078,047**	**48**
Tomichi Creek	Headwaters Tomichi Creek	1402000301	110,429	5
Tomichi Creek	Razor Creek	1402000302	43,525	2
Tomichi Creek	Quartz Creek	1402000303	89,331	5
Tomichi Creek	Middle Tomichi Creek	1402000304	119,095	5
Tomichi Creek	Cochetopa Creek	1402000305	250,541	9
Tomichi Creek	Lower Tomichi Creek	1402000306	92,581	5
	Tomichi Creek Sub-basin Totals		**705,503**	**31**
Totals			**2,274,239**	**102**

Assessment Framework

The analysis presented in this report will help the UGRWCD to prioritize sub-watersheds when developing projects to enhance watershed resilience and mitigate potential wildfire impacts. The watershed analysis assesses and ranks watershed hazards to provide a basis for prioritizing specific areas for targeted and appropriate management actions within the Upper Gunnison Watershed. The 6th level watersheds are comparatively ranked against each other and the ranks do not apply outside of this assessment area. Comparatively ranking the watersheds and overlaying these rankings onto the water system allows for watershed managers and stakeholders to focus on areas that are most at risk and most critical for their system to maintain a high quality and reliable water supply. The watershed analysis ranking also provides insight into other aspects of watershed resilience that should be considered for management, even if not currently critical to the water supply system, such as vegetation diversity, that are important to the long-term health of the watersheds.

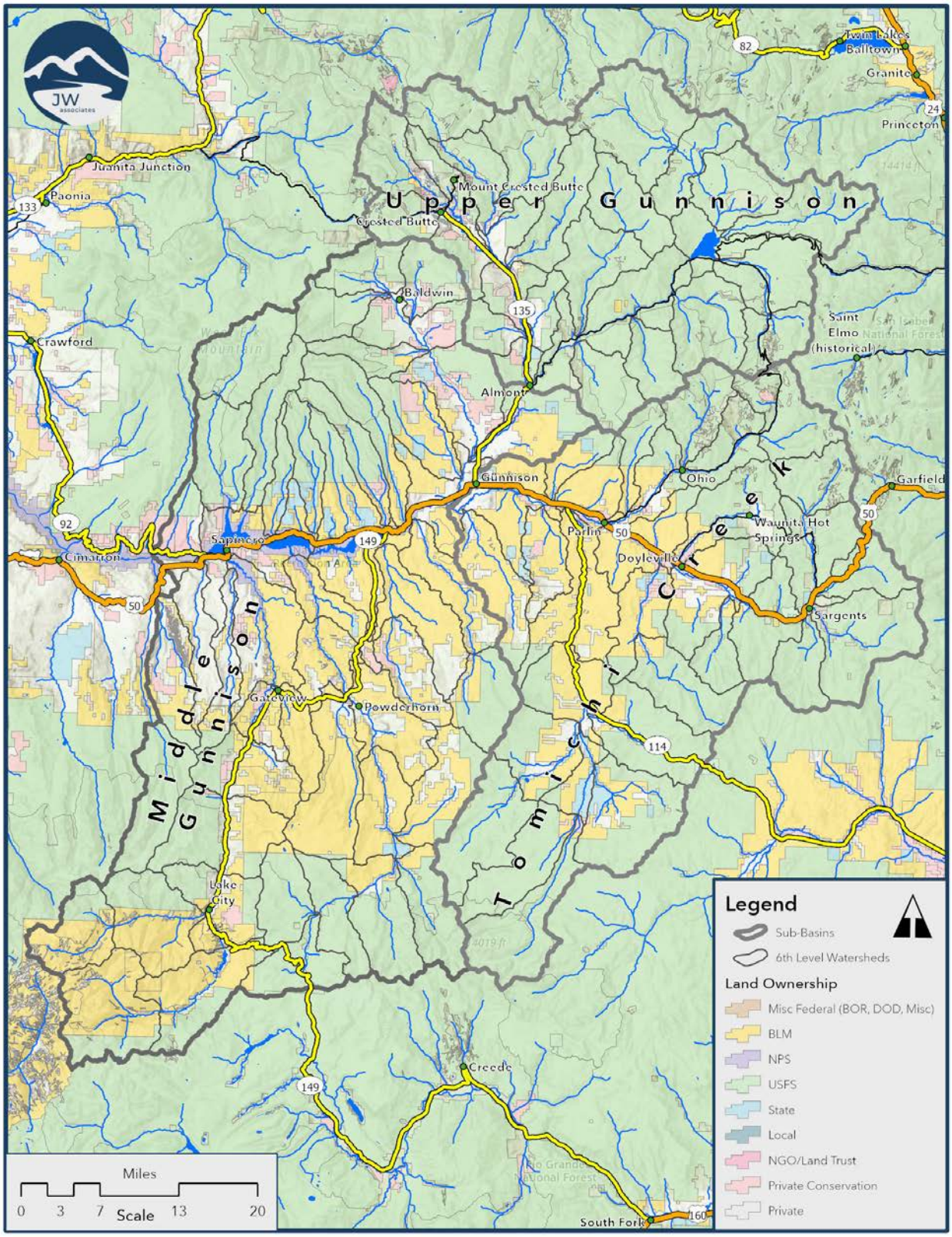

Figure 1. Upper Gunnison River Watershed Analysis Area

The availability and quality of the water supply are at risk from watershed disturbances. Of particular concern are the potential conditions of the watersheds following wildfire and subsequent hydrologic changes. Depending on the severity of burn and the watersheds' characteristics, there is the potential for increased sediment yields, flooding, and debris flows. More details on these changes are described below in the discussion of each of the technical factors in the analysis. The analysis in this report focuses on the impacts of wildfire and post-fire hazards on watershed health and function by analyzing indicators or predictors of watershed response to wildfire. It also examines the longer-term watershed hazards that are posed by changes in climate. The watershed assessment follows a procedure prescribed by the Front Range Watershed Protection Data Refinement Work Group (2009), which is now called the Watershed Wildfire Protection Group.

There is an additional assessment that identifies Zones of Concern, which are watersheds above important water sources, and provides an identification of opportunities and constraints for each Zone of Concern using the analysis and priorities in this document.

Stakeholder Involvement

The Upper Gunnison River Watershed/Wildfire Assessment methods, progress and technical details were presented at a number of meetings during this project (Table 2). These meetings provided a forum for educating stakeholders on what the Watershed/Wildfire Assessment was doing technically, as well as progress on the project and a chance to provide comments and discussion about the assessment's approach and results. A number of people from various groups, agencies and organizations participated in these meetings (Table 3).

Table 2. Upper Gunnison Stakeholder Meetings

Date	Meeting	Subject
Sep 20, 2021	Upper Gunnison Watershed Management Planning Committee	Kickoff Meeting
Oct 20, 2021	Forest and Watershed Health Technical Committee	Focus Areas for Watershed Wildfire Assessment
Nov 5, 2021	Upper Gunnison Shared Stewardship	Watershed/Wildfire Assessment Update
Nov 8, 2021	Growing Water Smart meeting	Outreach Meeting
Nov 15, 2021	Gunnison Basin Roundtable	Outreach Meeting
Dec 3, 2021	Upper Gunnison Shared Stewardship	Presented technical details of wildfire modeling & suggestions for revisions
Mar 9, 2022	Forest and Watershed Health Technical Group	Watershed/Wildfire Assessment Update
Apr 1, 2022	Special Meeting	Discussion of ongoing and future assessments in the Upper Gunnison Basin
Jun 27, 2022	UGRWCD Board Meeting	Watershed/Wildfire Assessment Update
Jul 14, 2022	Upper Gunnison Watershed Management Planning Committee	Watershed/Wildfire Assessment Update
Nov 15, 2022	Upper Gunnison Shared Stewardship	Draft Assessment Overview

Table 3. Upper Gunnison Stakeholder List[1]

Name	Organization
Andrew Breibart	Bureau of Land Management
Art Haines	US Forest Service
Ashley Bembenek	Alpine Environmental Consultants LLC
Ashley Hom	US Forest Service
Beverly Richards	Upper Gunnison River Water Conservancy District
Bryan Stevens	US Forest Service
Casey Cooley	Colorado Parks & Wildlife
Dan Brauch	Colorado Parks & Wildlife
Dan Olson	Natural Resources Conservation Service
Dave Carr	US Forest Service
Dylan Eimer	Colorado State Forest Service
Jamie Gomez	West Region Wildfire Council
Jesse Kruthaupt	Trout Unlimited
Jonathon Coop	Western Colorado University
Julie Nania	High Country Conservation Advocates
Katie Jagt	Water Science & Design
Leigh Robertson	West Region Wildfire Council
Lisa Clay	Gunnison County
Liz Smith	Gunnison County Commissioner
Michael Blazewicz	Round River Design
Mike Tarantino	Colorado State Forest Service
Nancy Johnston	Trout Unlimited
Pat Medina	US Forest Service
Paul Jones	The Nature Conservancy
Rob McCann	West Region Wildfire Council
Sam Pankratz	Colorado State Forest Service
Sonja Chavez	Upper Gunnison River Water Conservancy District
Stacy McPhail	Gunnison Legacy
Stewart Robertson	US Forest Service

[1] Note - Not all the people listed in this table actually attended meetings but all were invited and only a few did not attend any meetings.

Watershed Hazard Analysis Methods

The 6th level (HUC12) watersheds were used with the goal of identifying hazards that may be targets of pre-fire or post-fire actions or other watershed protection measures. These watersheds were analyzed and ranked based upon the hazard components shown in Figures 2 and 3.

The methodology allows for all the 6th level watersheds to be compared and ranked against each other for each of the hazard components. The results of each hazard component analysis are scaled to fall within categories ranging from lowest hazard to highest hazard based upon the comparison to other watersheds in the total project area. This provides a ranking of watersheds by hazard. The calculation of this ranking was completed as follows.

The results of the analysis for each component are computed by 6th level watershed and then compared to other watersheds within the Watershed Analysis Area.

1. Calculate the hazard based on the percentage or average value of each watershed (or other metrics, depending on hazard component).
2. Scale the numerical results so that they fall within five hazard rank categories, with a reasonable distribution that spans the range of hazards.
3. Round the scaled result to the nearest whole number, between 1 and 5. (Retain the original number for Composite Hazard Ranking calculations).
4. Create a map of the results using the following scheme:

Category 1	Lowest Rank
Category 2	Low Rank
Category 3	Moderate Rank
Category 4	High Rank
Category 5	Highest Rank

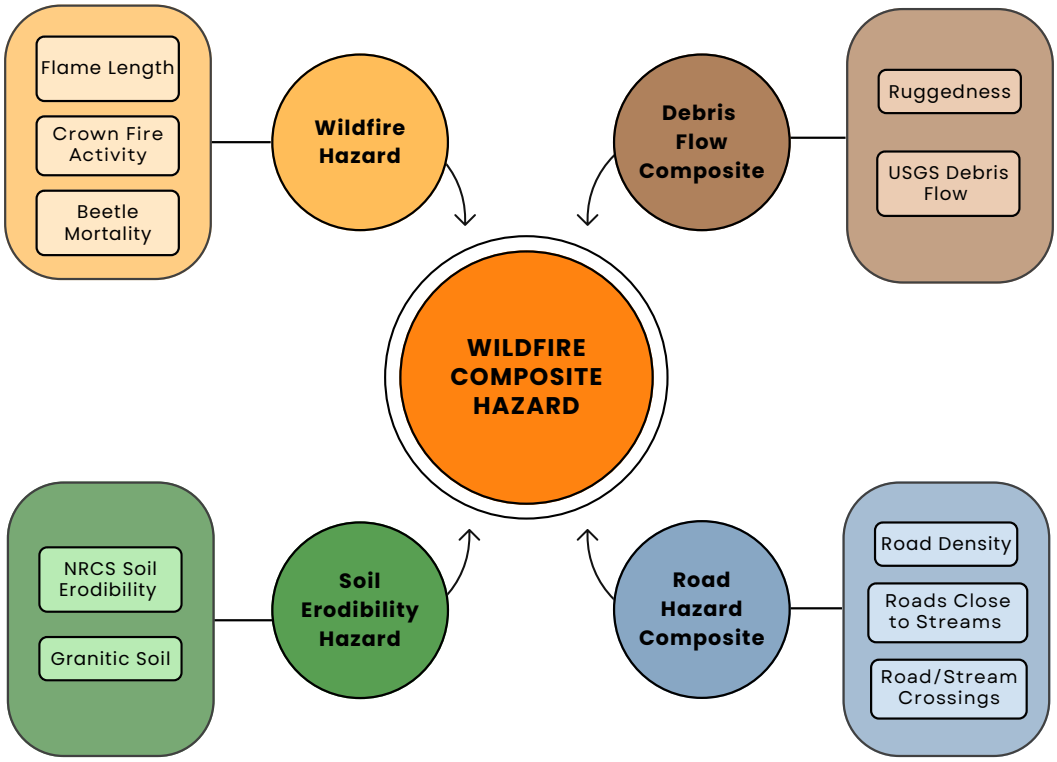

Figure 2. Wildfire Composite Hazard Components

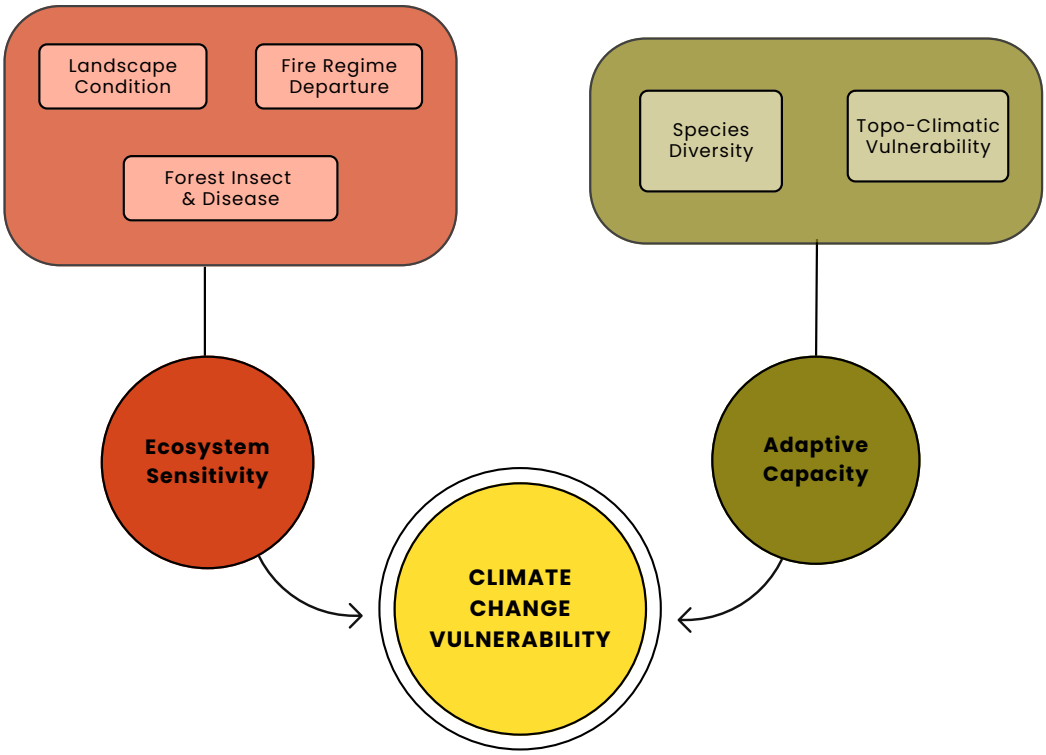

Figure 3. Climate Change Vulnerability Hazard Components

Wildfire Composite Hazard Analysis

Wildfire Hazard

The Interagency Fuel Treatment Decision Support System (IFTDSS), an online implementation (www.iftdss.firenet.gov) of the FlamMap fire mapping and analysis system (Finney 2006, Stratton 2006), was used to assess wildfire hazard. The FlamMap analysis describes potential fire behavior, such as spread rate, flame length, crown fire activity and fireline intensity, for constant environmental conditions (weather and fuel moisture). It does not calculate fire spread across a landscape. FlamMap outputs and comparisons can be used to identify combinations of hazardous fuel and topography, aiding in prioritizing fuel treatments. FlamMap is widely used by the U.S. Forest Service, National Park Service, and other federal and state land management agencies in support of fire management activities. LANDFIRE (https://landfire.gov) is the source for the basic data used in the vegetation and wildfire modeling. The benefit of LANDFIRE is that it covers all ownerships and is updated frequently. The latest update (as of the project kickoff meeting in 2021) for LANDFIRE data was completed in June 2019 and includes updates through 2016. A number of assumptions were used in the modeling and are presented in Appendix B.

Several fire behavior outputs of the FlamMap model were evaluated for this analysis. Flame length and crown fire activity were the two outputs selected as the basis for this wildfire hazard analysis. All the model outputs were mapped and reviewed. The selection process involved reviewing comparisons to past modeling efforts and consultation with local experts. For this analysis the post-fire hydrologic changes are of most concern so it is focused on fire intensity and severity and not fire behavior. Crown fire activity is being used as a surrogate for burn severity by researchers (Gannon et al. 2020). Flame length is also a good indication of relative fire intensity. Flame length and crown fire activity have been used in many similar watershed/wildfire assessments in Colorado and were determined to be the most appropriate components for the analysis of wildfire hazard. The FlamMap modeling results in all watersheds burning in extreme conditions. Wildfires are driven by weather and moisture/fuel conditions during the fire, so the actual burn severity in watersheds may differ from the model results.

Flame Length

Flame length is the distance measured from the flame tip to the middle of the flaming zone at the base of the fire. It is measured on a slant when the flames are tilted due to effects of wind and slope. Flame length is an indicator of fire intensity. A combination of many factors are used in the modeling to determine flame length including slope, aspect, wind speed and direction, fuel model, surface fuels, canopy fuels, canopy base height, vegetation types, and more. The flame length results were divided into six categories of wildfire hazard ranging from lowest (Category 0) to highest (Category 5). The flame length categories that were used are:

Flame Length Category 0: 0 feet

Flame Length Category 1: 1 to 4 feet

Flame Length Category 2: >4 to 8 feet

Flame Length Category 3: >8 to 12 feet

Flame Length Category 4: >12 to 25 feet

Flame Length Category 5: >25 feet

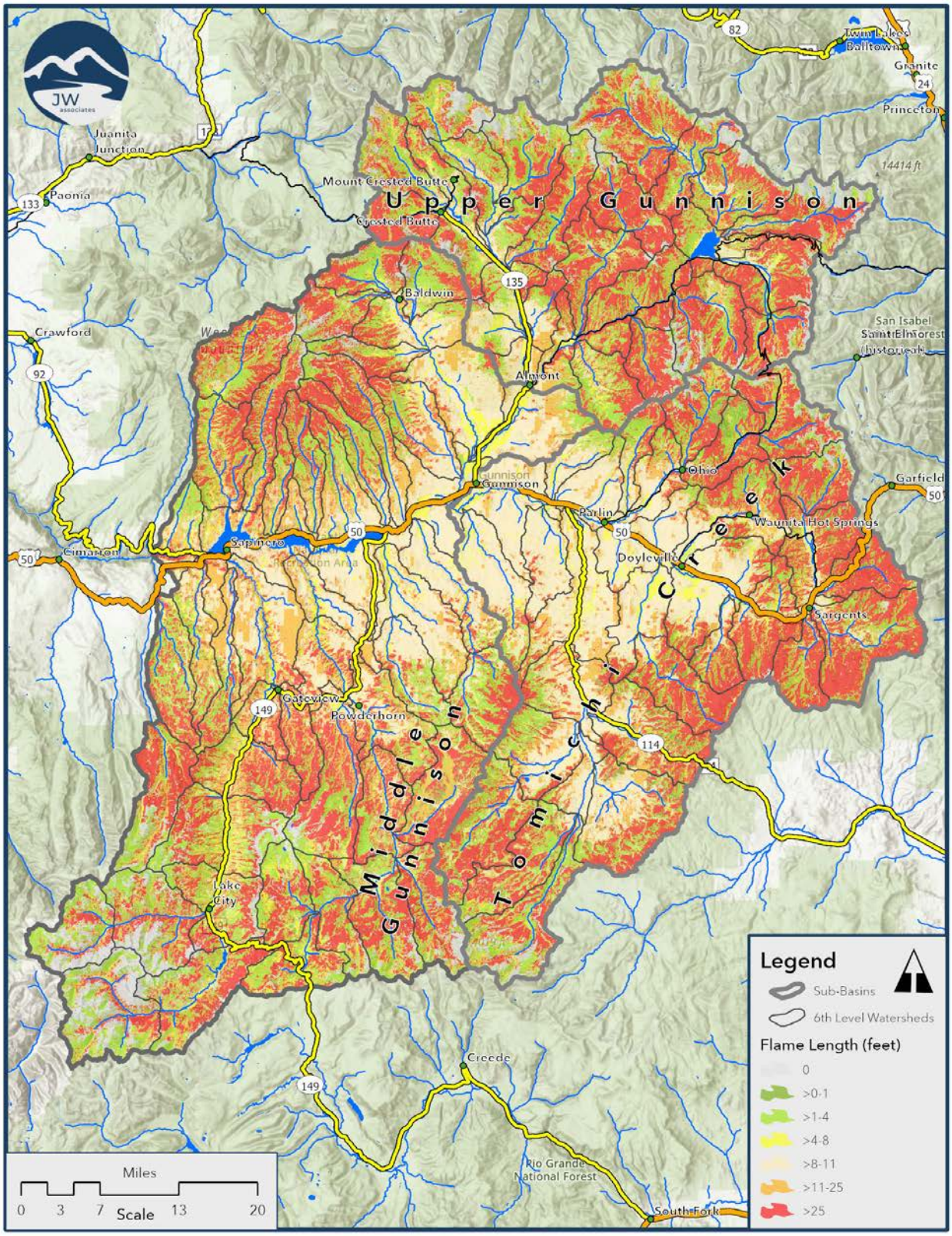

Figure 4. Upper Gunnison Modeled Flame Length

Flame length categories were mapped throughout the project area and are shown in Figure 4. Within each 6th level watershed, the areas in Flame Length Categories 3, 4 and 5 were weighted by severity to determine an overall score as follows (where WA = Watershed Area):

Flame Length Metric = [Area in Category 3 + 2*(Area in Category 4) + 3*(Area in Category 5)]/WA

All 6th level watersheds were then ranked by the Flame Length Metric.

Crown Fire Activity

Crown fire is when the canopy of a tree burns. For this analysis crown fire is modeled as either passive or active. These are defined by the National Wildfire Coordinating Group as:

Passive Crown Fire occurs where surface fire intensity is sufficient to ignite tree crowns, individually or in groups, but winds are not sufficient to support propagation from tree to tree.

Active Crown Fire occurs where surface and crown fire energy are linked. Surface intensity is sufficient to ignite tree crowns, and fire spread and intensity in the tree crowns encourages fire spread and intensity.

A combination of many factors are used in the modeling to determine crown fire activity including slope, aspect, wind speed and direction, fuel model, surface fuels, canopy fuels, canopy base height, vegetation types, and more. The crown fire activity modeling output presents results in the following four classifications:

Non-burnable: Category 0

Surface Fire: Category 1

Passive Crown Fire: Category 2

Active Crown Fire: Category 3

The crown fire activity categories were mapped throughout the project area and are shown on Figure 5. As was done for the flame length metric, within each 6th level watershed, the areas in Category 2 (Passive Crown Fire) and Category 3 (Active Crown Fire) were weighted by severity to determine an overall score as follows (where WA = Watershed Area):

Crown Fire Activity Metric = [Area in Category 2 + 2*(Area in Category 3)]/WA

All 6th level watersheds were then comparatively ranked by the crown fire activity metric.

Insect Mortality

In the last two decades, Colorado has experienced epidemics of Mountain pine beetles and spruce beetles. These epidemics have caused high tree mortality across large swaths of forested landscapes. Colorado has also experienced many small to very large wildfires that have burned areas of those beetle-killed forests. Early research on the impacts of beetle mortality to wildfire behavior proposed that once trees lose their needles, fire behavior would be less intense compared to green trees. However, Hoffman et al. (2013) argued that the reduction in canopy biomass can result in greater wind penetration into the canopy which can increase wildfire rate of spread. The consensus of the fire fighting community and technical post-fire restoration experts is that wildfires in beetle-killed forests have shown much more extreme wildfire behavior and resulted in some very large fires that have areas of high burn severity within areas of past beetle mortality.

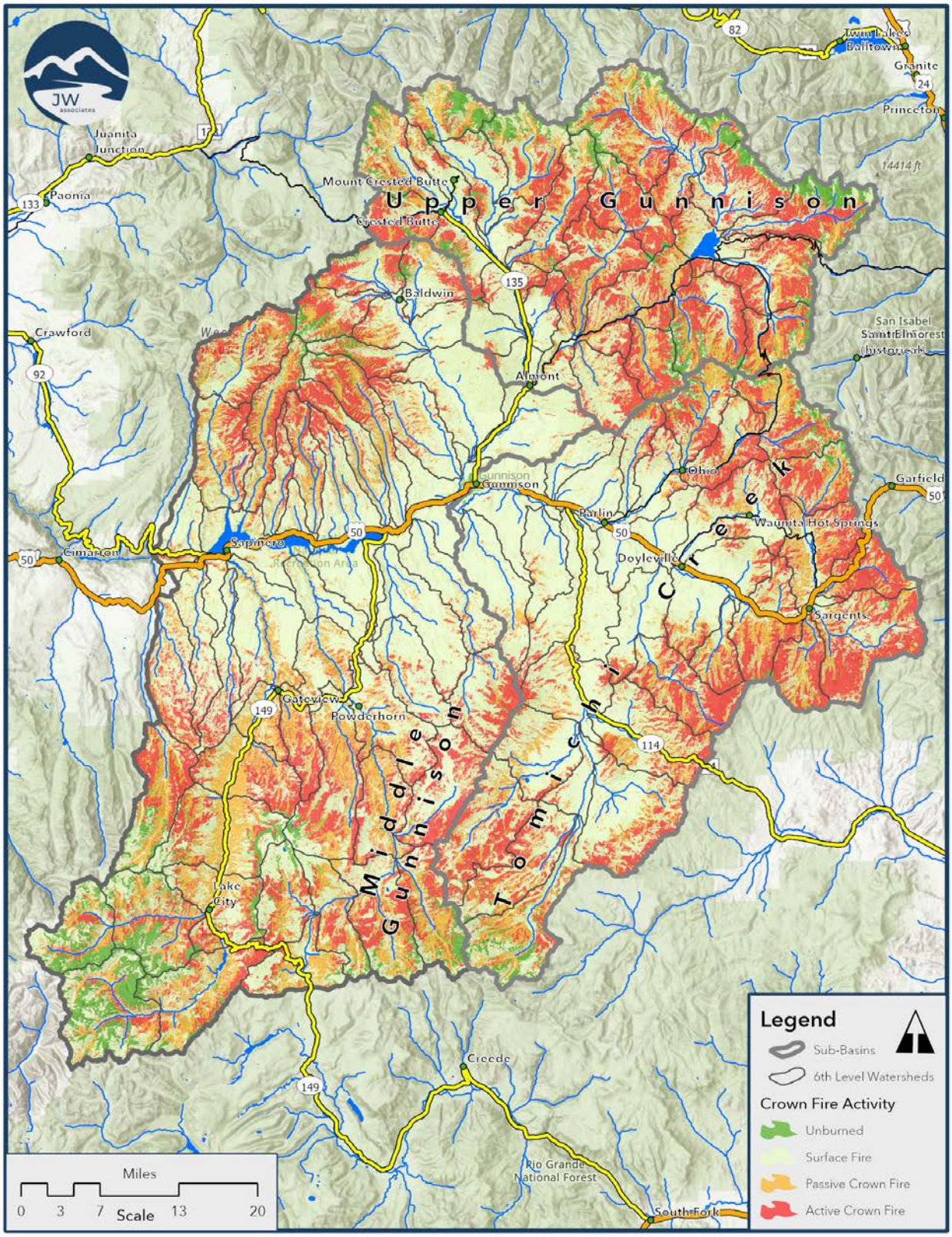

Figure 5. Upper Gunnison Modeled Crown Fire Activity

The insect mortality area and severity mapping created by Rodman et al. (2021) was used to calculate the average insect mortality severity in each 6th level watershed. This research utilized Landsat time series products, as well as field data and Random Forest models to develop 30-m resolution maps of the presence and severity (cumulative percent basal area mortality) of beetle-caused tree mortality between 1997-2019 in subalpine forests across the Southern Rocky Mountains. For each 6th level watershed, the mean pixel severity from 0-100 was calculated to create an insect mortality metric, accounting for both presence and severity across the entire watershed.

The insect mortality severity was mapped throughout the project area and is shown on Figure 6. All 6th level watersheds were then comparatively ranked by the insect mortality metric.

Overall Wildfire Hazard

Once the watersheds were ranked by flame length, crown fire activity, and insect mortality, the three ranking numbers were combined. Using the combined score, watersheds were ranked into five roughly equal categories from 1 (lowest overall wildfire hazard) to 5 (highest overall wildfire hazard). Figure 7 presents the result of this analysis for all 102 6th level watersheds. A total of 20 watersheds were ranked as Highest Hazard and are identified in Table 4. The complete categorization listing can be found in Appendix C.

Table 4. Highest Ranked Watersheds for Wildfire Hazard.

Sub-basin Name	6th Level Watershed Name
Upper Gunnison	Outlet Willow Creek
	Crystal Creek
	Rocky Brook-Spring Creek
	Bear Creek-Spring Creek
	Coal Creek
Middle Gunnison	Upper Ohio Creek
	Spring Creek
	Powderhorn Creek
	Indian Creek
	West Soap Creek-Soap Creek
Tomichi Creek	Headwaters Tomichi Creek
	Agate Creek
	Marshall Creek
	Long Branch Creek
	Porphyry Creek-Tomichi Creek
	Headwaters Razor Creek
	Upper Quartz Creek
	Gold Creek
	Owens Creek-Tomichi Creek
	Headwaters Los Pinos Creek

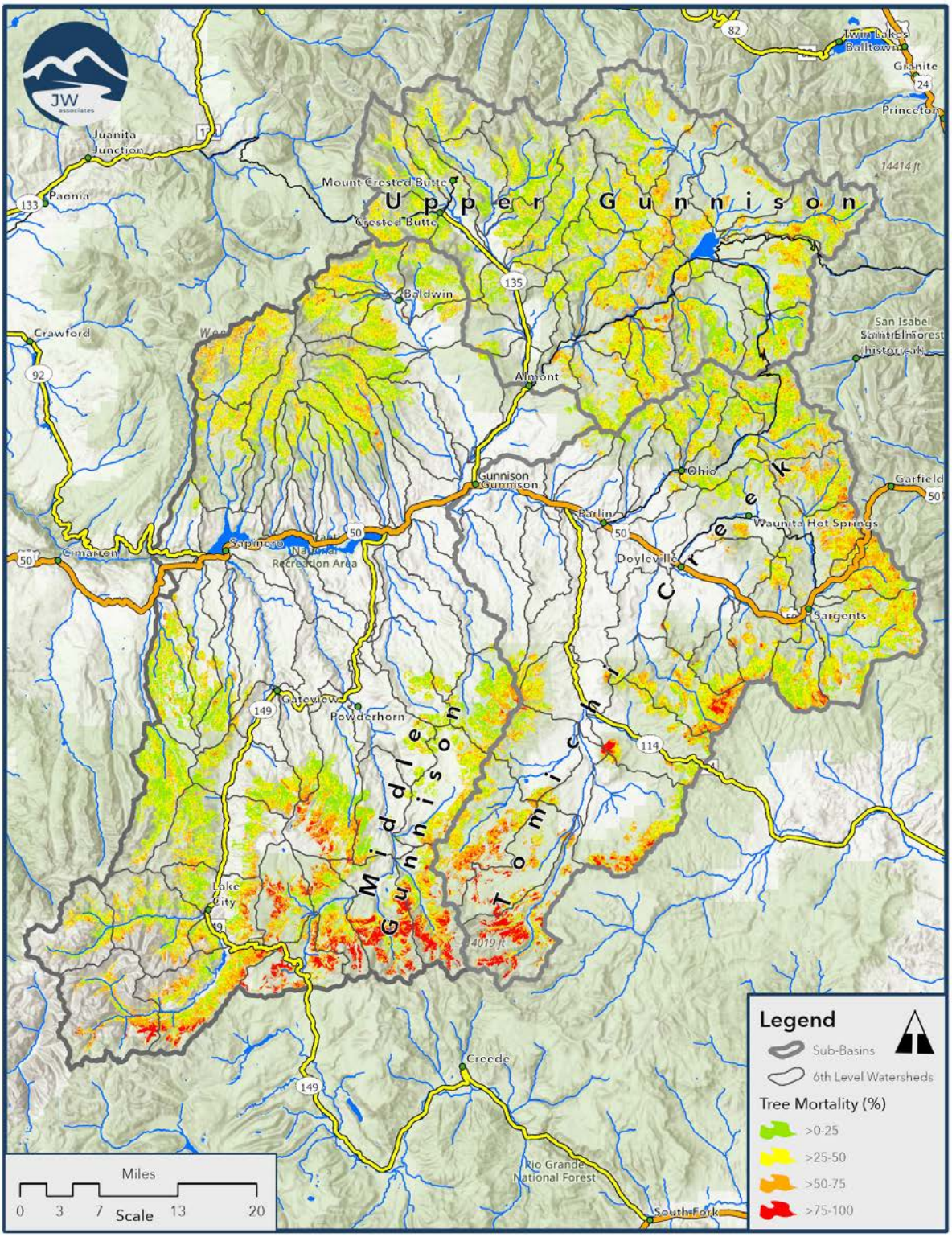

Figure 6. Upper Gunnison Existing Insect Caused Tree Mortality[2]

[2] based on Rodman et al., 2021

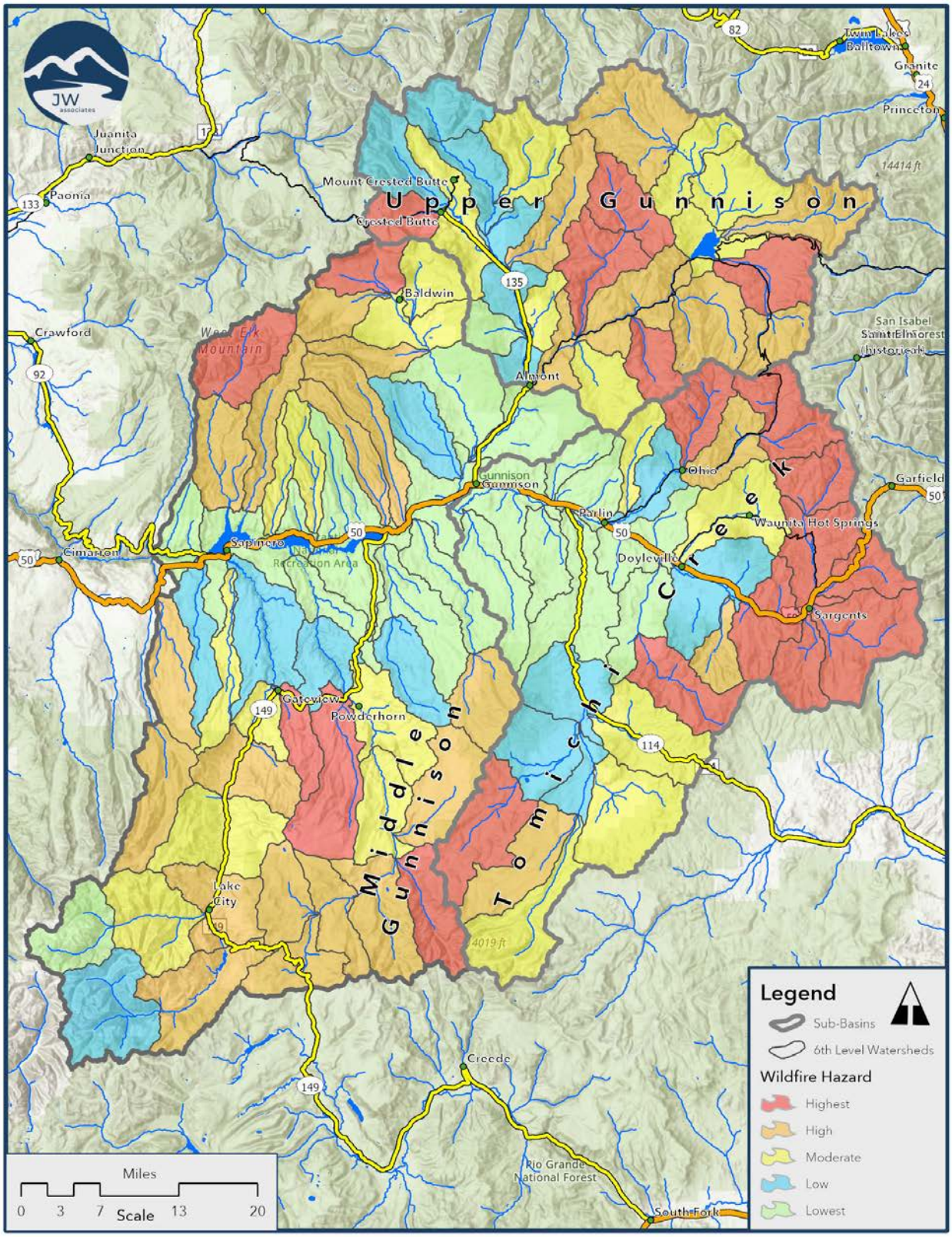

Figure 7. Upper Gunnison Wildfire Hazard Ranking

Debris Flow Composite Hazard

Rapid runoff from burned areas can result in high peak flows that can overwhelm the stream bank armoring. These events can result in rapid destabilization of the stream channel which can initiate a debris flow. Debris flows contain water but also can carry sediment, rocks, boulders, woody debris and whole trees. A recent example of a destructive debris flow is the Black Hollow debris flow that occurred in 2021 after the Cameron Peak Fire. This debris flow had major water quality impacts on the Cache La Poudre River, killed fish for miles downstream, and also impacted the stream channel itself. The debris flow shown also created major life and safety hazards to the homes and people living at the base of the watershed. The unstable stream channels that produce debris flows generally are sources of increased stream bank sediment yield for years following the event.

Black Hollow Debris Flow 2021 - Cameron Peak Fire

The rapid movement of water, sediments and debris from flooding and debris flows can overwhelm or damage water supply infrastructure in the short term. The material deposited in-stream during the debris flow event can also cause longer term problems as the sediments and larger materials may continue to move downstream for months to years after the event occurs. Debris flow likelihood is influenced predominantly by the steepness or ruggedness of the watershed and the rainfall intensity of a storm event, combined with the amount of moderate or high burn severity following wildfire.

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 of upslope catchment height and the catchment area. Studies have shown that the Melton ruggedness number is a valuable tool to identify basins with topographic indicators of high debris flow potential (Marchi and Fontana, 2005). Melton (1957) defines ruggedness, R, as;

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

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

The Ruggedness Number (R) in some watersheds was adjusted because the value did not accurately reflect the steepness of some of the contributing tributaries. This most commonly occurs in composite watersheds that are disconnected from their headwaters. These watersheds can have a higher hazard for debris flows than is indicated by the ruggedness calculation because they contain a main stem of a creek or river which does not reflect the steepness of the first order streams that enter the main stem as tributaries, as discussed in Marchi and Fontana, 2005. In those situations, the ruggedness calculation was adjusted up by reducing the watershed area. Headwaters and Composite watersheds are shown on Figure 8.

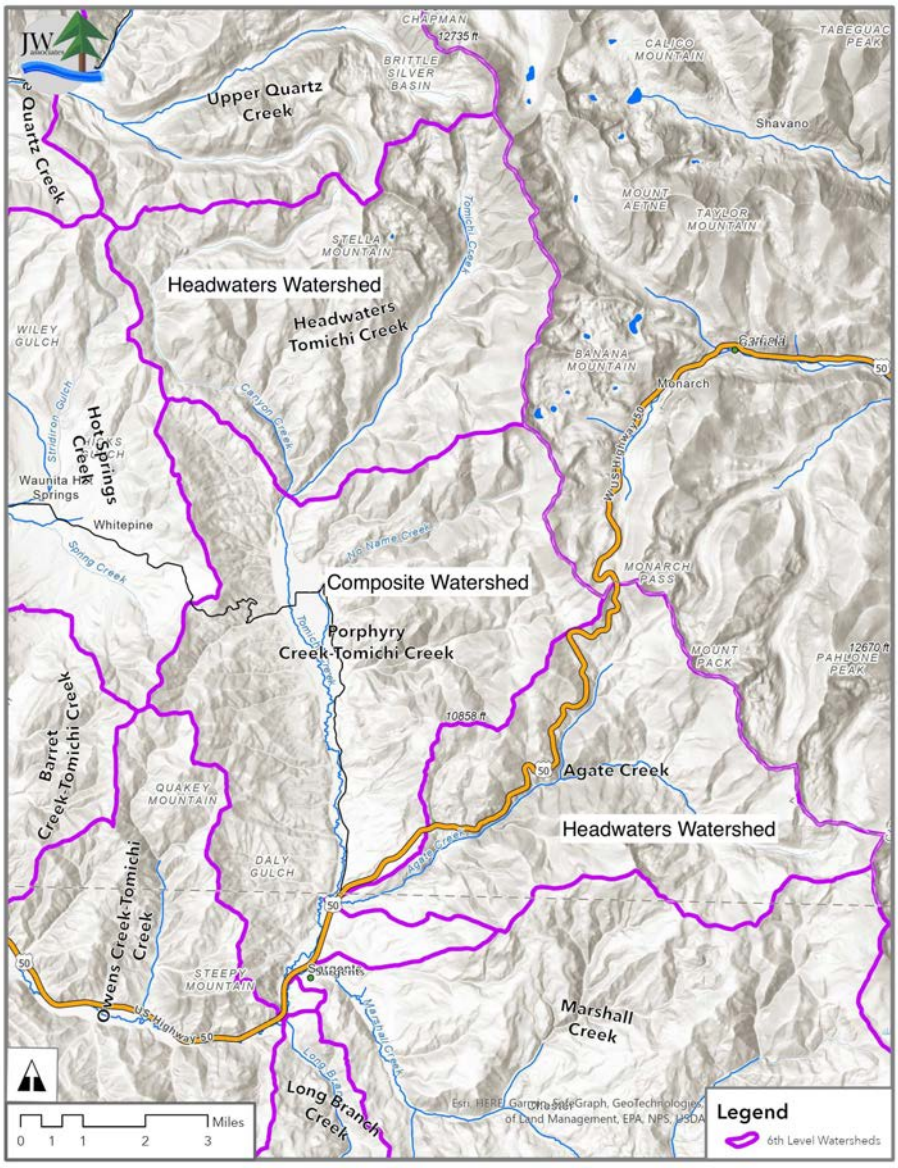

Figure 8. Headwaters and Composite Watersheds

Once Ruggedness was calculated for all 6th level watersheds, the watersheds were grouped into roughly equal categories from lowest to highest ruggedness. Figure 9 and Appendix D present the results of this categorization.

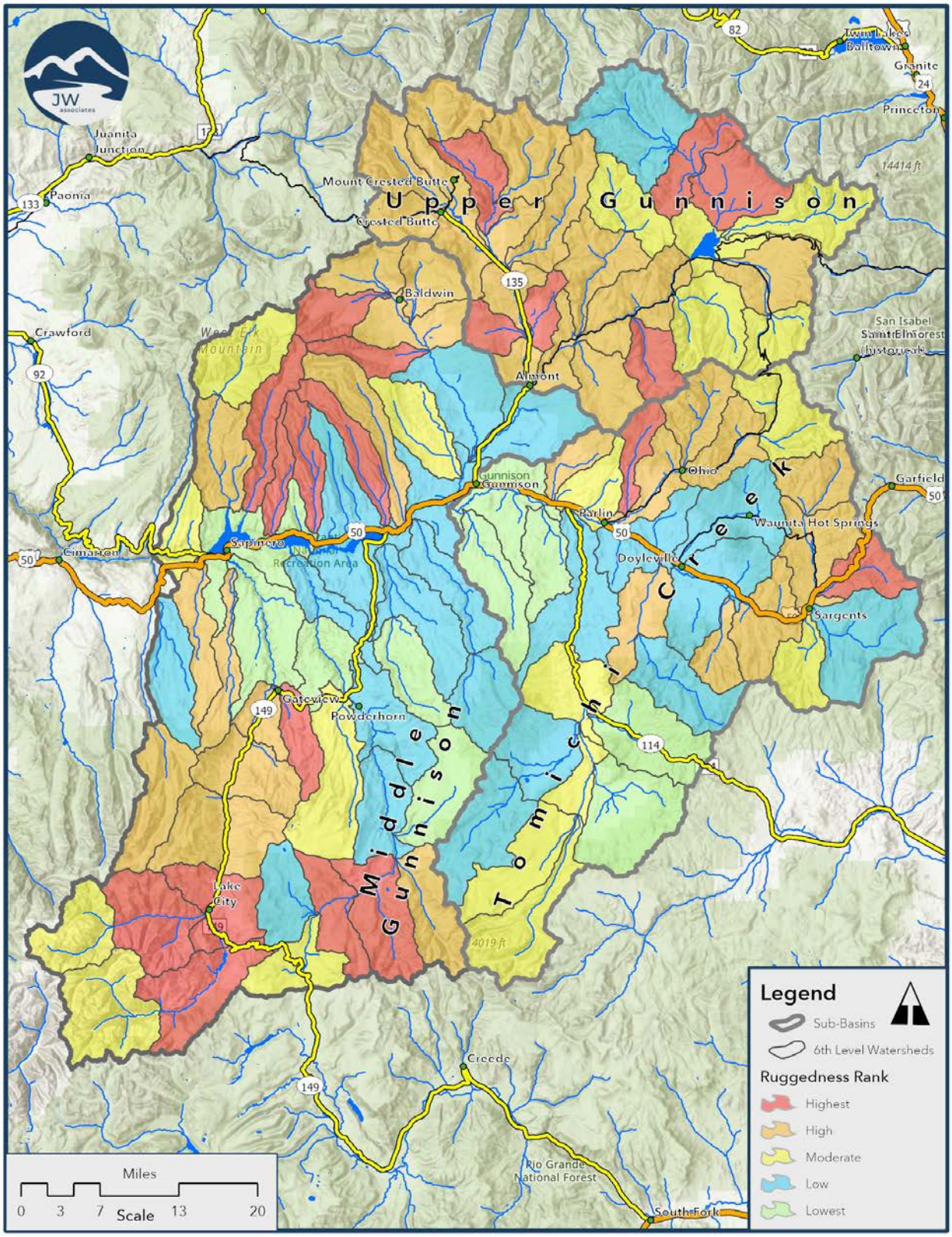

Figure 9. Upper Gunnison Ruggedness Hazard Ranking

Post-Wildfire Debris Flow Hazard

The United States Geological Survey (USGS) created a method for estimating the post-fire debris flow hazards for watersheds before wildfire occurs (Staley et. al., 2018). This is a prediction technique that combines wildfire modeling with other debris-flow indicators including slope and soil erodibility in order to predict the post-fire debris flow hazards in response to a triggering rainfall event.

The variables included in the model are described below. The model was run for a triggering rainfall event intensity of 6mm in 15-min. This is nearly a 1-year storm across the study area. The likelihood (probability) of this type of rain event causing a debris flow was calculated for each 6th level watershed.

The watersheds were then grouped into roughly equal categories from lowest to highest hazard. Figure 10 and Appendix E present the results of this categorization. The following discussion describes the variables used in the debris flow estimation model.

Soil Burn Severity and Slope

Modeled crown fire activity as described above was used to estimate soil burn severity. Results are presented in the following four classifications:

Non-burnable: Unburned

Surface Fire: Low Burn Severity

Passive Crown Fire: Moderate Burn Severity

Active Crown Fire: High Burn Severity

Slope is calculated in degrees from a 30-meter digital elevation model (DEM). The proportion of watershed area burned at high or moderate burn severity with gradient in excess of 23 degrees is used in the model equation.

difference Normalized Burn Ratio (dNBR)

The USGS completes an Emergency Assessment of Post-Fire Debris-Flow Hazards following western US wildfires. This assessment uses the difference Normalized Burn Ratio (dNBR) image from remote sensing and field validated soil burn severity. The Normalized Burn Ratio (NBR) is an index designed to highlight burned areas in large fire zones by calculating a ratio from two different infrared satellite images. The difference between the pre-fire and post-fire NBR obtained from the images is used to calculate the dNBR, which then can be used to estimate the burn severity.

In lieu of this data for pre-fire estimation of post-fire debris flow hazard, the USGS defined a range of potential fire severities for a given area based on the historical statistical distribution of burn severity metrics in each vegetation class. Therefore, using the LANDFIRE vegetation type, we were able to estimate the dNBR values across the study area, which is used in the debris-flow hazard model.

Actual burn severity depends on a number of variables in addition to vegetation type, including soil moisture deficit, fuels, wind direction, etc. In order to narrow the range of possible dNBR values calculated, a simple scaling variable (Pdsim, between 0-1) is used to control the severity of the fire simulated (Staley et al., 2018). In our modeling, we use a value of Pdsim = 0.75. The severity of a wildfire can be quite variable depending on conditions, but the intensity and severity of wildfires across the western United States have been increasing since the mid-1980's (Westerling, 2016). A value of 75% on the intensity spectrum produces dNBR values that predict a fire on the more severe end of the spectrum, while maintaining a burn character across the entire area that is similar to what Colorado has experienced in recent years. After simulating dNBR values for the 2020 fires in Colorado, and comparing the values to the actual post-fire

remote sensing images, this value for Pdsim produced a dNBR image in line with those large fires.

Soil Erodibility

The inherent susceptibility of soil to erosion for just the fine fraction of soils (KF-factor), from the STATSGO and SSURGO databases (see description below with the Soil Erodibility Hazard Ranking).

15-min rainfall intensity in mm/hr

This is based on a design storm of 24mm/hour, which translates to a peak intensity of 6 mm of precipitation in 15 minutes.

Debris Flow Composite Hazard Ranking

The Debris Flow Composite Hazard combines the Ruggedness and Post-Wildfire Debris Flow Hazards. This ranking was calculated for all 6th level watersheds, and the watersheds were grouped into five roughly equal categories from lowest to highest Debris Flow Composite Hazard. Figure 11 and Appendix F present the results of this categorization. Based upon this analysis, there are 21 watersheds that received a Debris Flow Composite Hazard metric of Highest in the UGRWCD watershed analysis area (Table 5).

Table 5. Highest Ranked Watersheds for Debris Flow Composite Hazard.

Sub-basin Name	6th Level Watershed Name
Upper Gunnison	Trail Creek-Upper Taylor River
	Crystal Creek
	Bear Creek-Spring Creek
	Brush Creek
	Middle East River
	Roaring Judy Creek
Middle Gunnison	Castle Creek
	Mill Creek
	Beaver Creek
	Steuben Creek
	Rough Creek-Cebolla Creek
	Lake Sanc Cristobal-Lake Fork
	Nellie Creek-Henson Creek
	Larson Creek-Lake Fork
	East Elk Creek
	Red Creek
	West Elk Creek
Tomichi Creek	Agate Creek
	Gold Creek
	Middle Quartz Creek
	Alder Creek

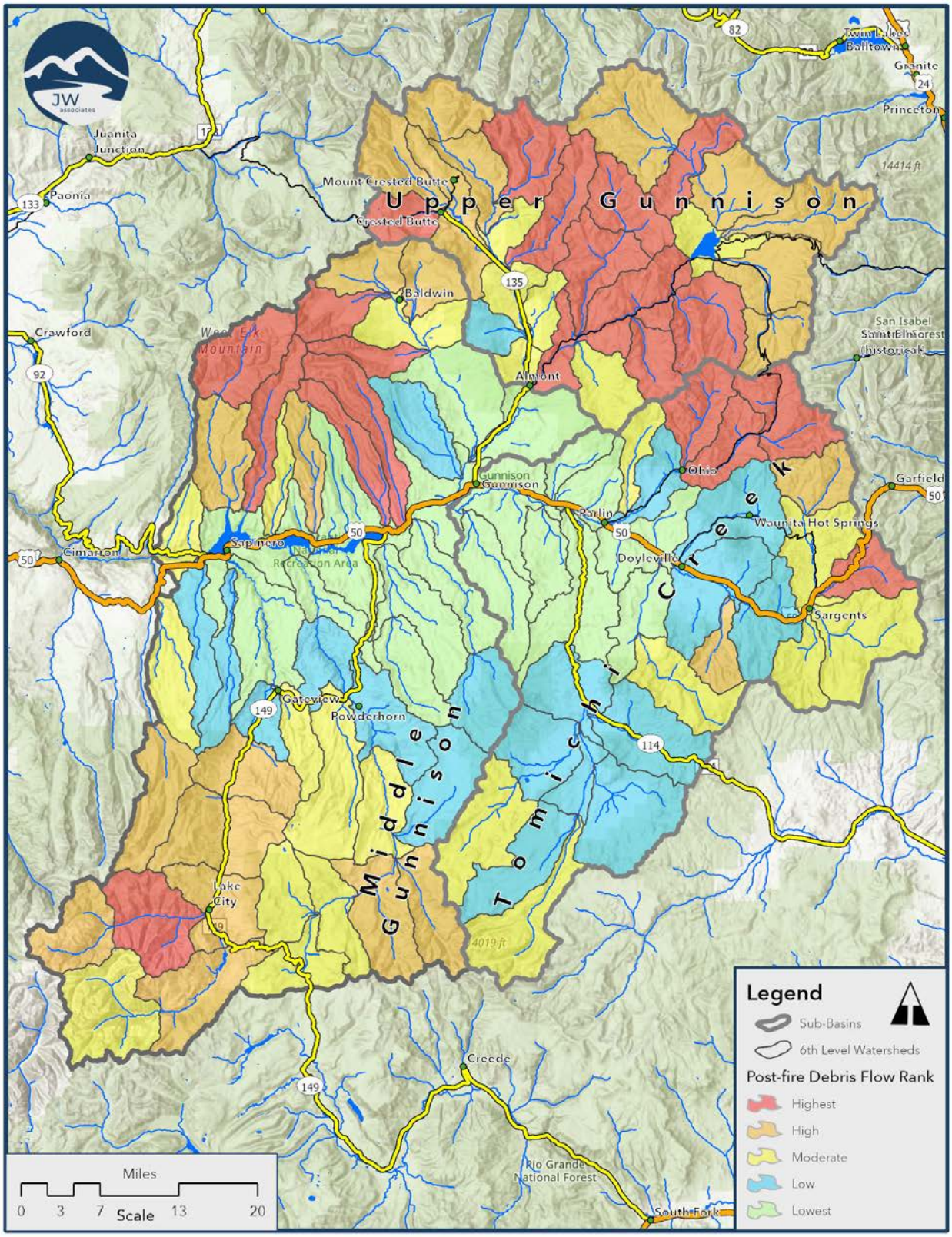

Figure 10. Upper Gunnison Post-Wildfire Debris Flow Hazard Ranking

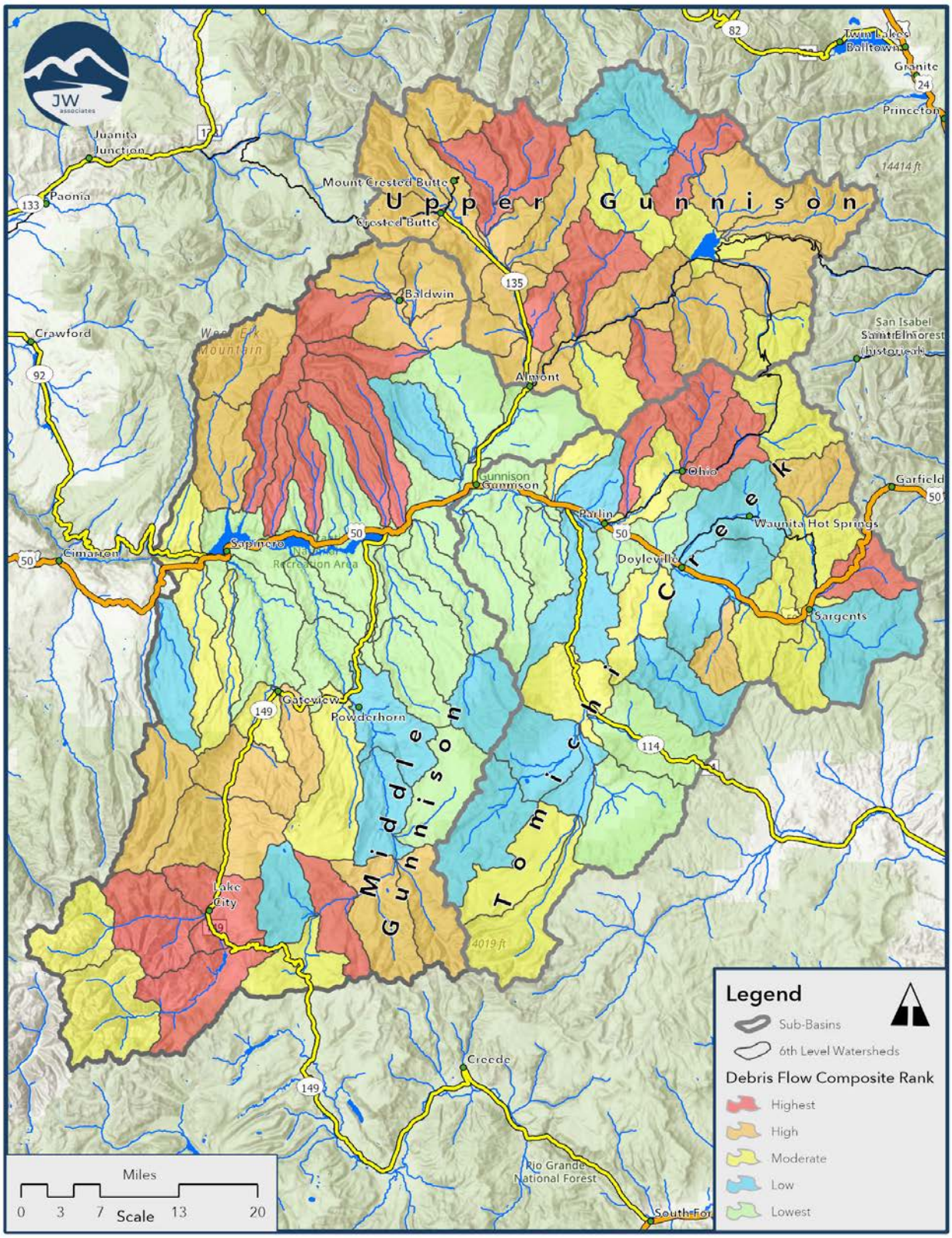

Figure 11. Upper Gunnison Debris Flow Composite Hazard Ranking

Roads Composite Hazard

Roads can pose hazards to healthy watershed function and can amplify post-fire or flooding impacts. Roads can convert subsurface runoff to surface runoff and then route the surface runoff in a ditch or on the road surface to stream channels, increasing both peak flows and suspended sediment in the stream (Megan and Kidd 1972, Ice 1985, and Swanson et al. 1987). Often culverts on forest roads are not adequately sized for the conditions that may occur during peak flows or especially post-fire. This can lead to over-topping of the road, increasing erosion of the road fill, and the risk of debris flows stemming from road failure. Even if culverts are adequately sized, road erosion and the subsequent transport of sediments during high flow events can be a significant contributor to in-stream sediments. Forest roads are usually the largest source of long-term sediment in forested watersheds (Elliott 2000, MacDonald and Stednick 2003).

Road Blowout in Cabin Creek in the East Troublesome Fire Area 2022

The potential hazard posed by roads in these watersheds was evaluated by considering the types of roads and the density of different road features that pose risks for flooding and possible contributions to debris flows in vulnerable watersheds. The densities include:

1. Overall road density,
2. Density of roads in close proximity to streams
3. Density of road/stream crossings

Road Data

The roads data used on National Forest System (NFS) lands was the U.S. Forest Service roads data, which is the most accurate data for those roads. On all other lands Gunnison County and Colorado Department of Transportation roads data were used. Within all watersheds, the roads data was overlaid onto digital images and vegetation mapping to visually check the roads layers against digital imagery data.

Road Densities

Overall Road Density

Watersheds with higher road densities have a higher sensitivity to increases in peak flows, and therefore flooding, following wildfires. Road density in miles of road per square mile of watershed area was used as an indicator of flooding hazard.

The total length of roads in each 6th level watershed was divided by the watershed area. The watersheds were then ranked from lowest to highest overall road density.

Roads Close to Streams

Roads close to streams can become major sources of sediment during flooding or higher post-fire peak flows. In order to quantify this effect, the density of roads near streams was determined by calculating the length of roads located within a 100-meter stream buffer.

The total length of roads within the 100-meter stream buffer in each 6th level watershed was divided by the watershed area. The watersheds were then ranked from lowest to highest density of roads close to streams.

Road/Stream Crossings

Road/stream crossings are locations where overtopping of roads, clogging of culverts and subsequent erosion and possible blow-out can occur. The number of road/stream crossings were manually acquired using the road and stream layers in combination with aerial imagery verification. Note that this analysis does not evaluate the design or adequacy of these road/stream crossings.

The total number of crossings in each 6th level watershed was divided by the watershed area. The watersheds were then ranked from lowest to highest density of road/stream crossings.

Overall Roads Composite Hazard

The results for all three road density rankings were combined and the results were grouped into roughly equal categories ranked from 1 (lowest) to 5 (highest) to create the Roads Composite Hazard Ranking. Figure 12 and Appendix G present the results of this categorization. Based upon this analysis, there are 20 watersheds that received a Composite Roads Hazard metric of Highest in the UGRWCD watershed analysis area (Table 6).

Table 6. Highest Ranked Watersheds for Roads Composite Hazard.

Sub-basin Name	6th Level Watershed Name
Upper Gunnison	Middle Taylor River
	Headwaters Willow Creek
	Outlet Willow Creek
	Rocky Brook-Spring Creek
	Lower Taylor River
	Coal Creek
	Washington Gulch-Slate River
	Cement Creek
	Roaring Judy Creek
Middle Gunnison	Sheep Gulch-Gunnison River
	Steers Gulch-Gunnison River
	Willow Creek
	Red Creek
Tomichi Creek	Headwaters Tomichi Creek
	Upper Quartz Creek
	Gold Creek
	Middle Quartz Creek
	Lower Quartz Creek
	Hot Springs Creek
	West Pass Creek

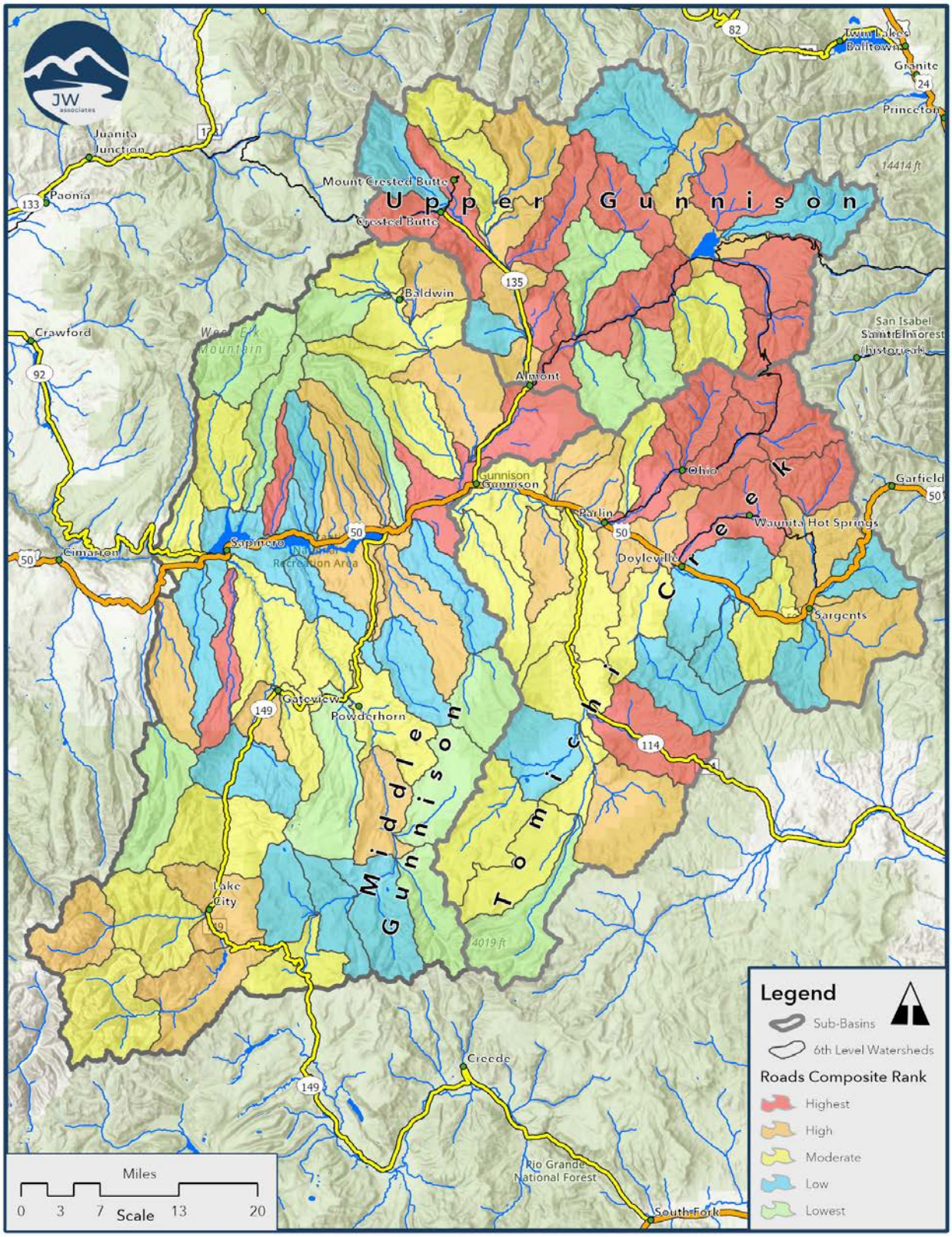

Figure 12. Upper Gunnison Roads Composite Hazard Ranking

Soil Erodibility Hazard

High-severity fires may affect critical watershed function, dramatically altering runoff and erosion processes in watersheds, particularly if followed by high-intensity rainfall events. Soil erosion and subsequent sediment yields from hillslopes that have been burned at a moderate to high severity tend to be an order of magnitude higher than those burned at low severity (Johansen et al. 2001, Gannon et al. 2017). High-severity fires consume more of the forest floor than low severity fires, exposing forest soils and thereby increasing both sediment and water yields (Wells et al. 1979, Robichaud and Waldrop 1994, Soto et al. 1994, Neary et al. 2005, and Moody et al. 2008). Hydrophobic soil layers are also a byproduct of high-severity fires. Water repellant or hydrophobic layers are formed by the heat and fire-induced volatilization of organics, which results in a waxy, water repellent layer on or close to the soil surface. These hydrophobic layers reduce infiltration rates and exacerbate runoff (Hungerford et al. 1991).

The delivery of hillslope sediments to surface waters has numerous ramifications for water supply infrastructure, including both the physical effects of sediment deposition in surface waters as well as chemical changes to water quality. An increase in sediments delivered to the streams or reservoirs can alter and/or increase water treatment requirements. Sediments that are deposited in surface waters bring nutrients that may promote the growth of algae, affecting water taste and odor. Dissolved organic carbons can form potentially carcinogenic by-products during disinfection. An increase in sediments can also mean an increase in metals delivered to water treatment facilities. Increases in any of these types of factors will lead to a subsequent increase in treatment costs (Writer and Murphy 2012). Additionally, drinking water treatment processes are most efficient when source water quality remains constant. The effects of wildfire which vary spatially and temporally, combined with the high variability of precipitation events, can result in unequal system loading and the need for site specific treatment plans (Writer and Murphy 2012). Additionally, the magnitude and duration of post-fire water quality changes is difficult to predict, making it complicated for water providers to evaluate risks and develop management strategies (Writer and Murphy 2012, Bladon et al. 2014, Martin 2016).

Soils vary throughout the Upper Gunnison analysis area and so do characteristics that define their susceptibility to increased post-fire erosion. The soil erodibility analysis uses 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 and STATSGO spatial databases was combined with slope using NRCS (USDA NRCS 1997) slope-soil relationships to create a classification grid divided into Slight, Moderate, Severe and Very Severe erosion hazard ratings (Table 7).

Table 7. 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

Two soils data sets were evaluated for use in this analysis: the USDA - 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 analysis area. SSURGO data does not cover all watersheds but is available at a more detailed scale (generally ranges from 1:12,000 to 1:63,360). Areas that were not covered with SSURGO data were filled in with STATSGO data.

The Soil Erodibility metric was calculated with the following formula.

Soil Erodibility Metric = (% Moderate + 2 x % Severe + 3 x % Very Severe)

The Soil Erodibility Metric was calculated for each 6th level watershed. The watersheds were then grouped by this metric into five roughly equal categories and ranked from 1 (lowest soil erodibility) to 5 (highest soil erodibility) to create the Soil Erodibility Ranking. These results are presented in Appendix H and on Figure 13. Based upon this analysis, there are 21 watersheds that received a Soil Erodibility ranking of Highest in the UGRWCD analysis area (Table 8).

Table 8. Highest Ranked Watersheds for Soil Erodibility Hazard.

Sub-basin Name	6th Level Watershed Name
Upper Gunnison	Bear Creek-Spring Creek
	Upper East River
	Brush Creek
	Middle East River
	Coal Creek
	Cement Creek
Middle Gunnison	Upper Ohio Creek
	Castle Creek
	Carbon Creek
	Mill Creek
	Beaver Creek
	Steuben Creek
	Spring Creek
	Elk Creek-Lake Fork
	Trout Creek-Lake Fork
	East Elk Creek
	Red Creek
	West Elk Creek
	West Soap Creek-Soap Creek
	Cow Creek-Soap Creek
Tomichi Creek	Middle Quartz Creek

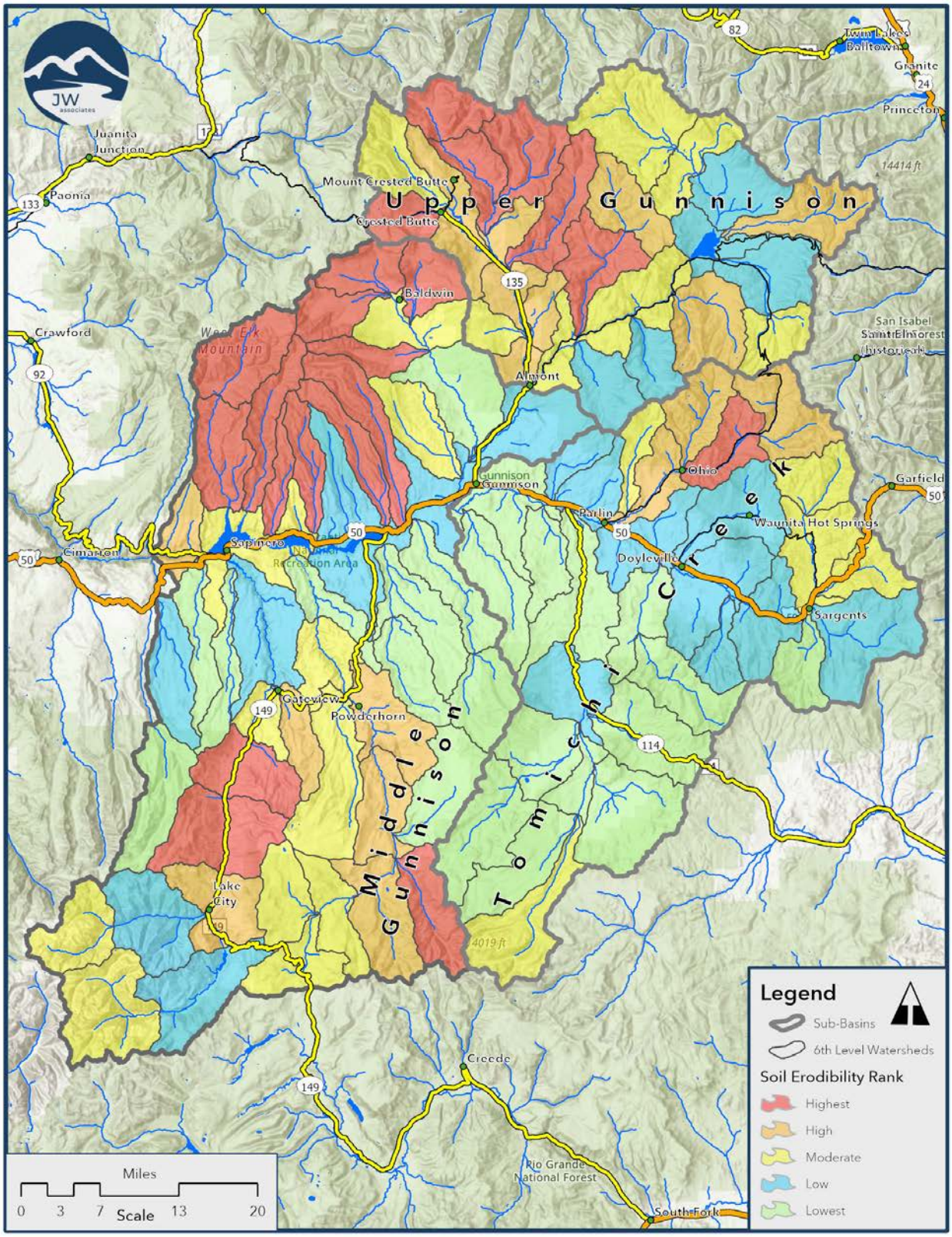

Figure 13. Upper Gunnison Soil Erodibility Hazard Ranking

Wildfire Composite Hazard Rank

The Wildfire Composite Hazard Ranking is a combination of wildfire hazard and post-fire hazards related to flooding, debris flows, roads, and hillslope erosion. The composite ranking is calculated by adding together the following respective rankings for each 6th level watershed and then recategorizing the results.

1. Wildfire Hazard
2. Debris Flow Composite Hazard
3. Roads Composite Hazard
4. Soil Erodibility

The total scores are grouped into 5 categories, as was done for the subcomponents, and assigned a final rank from 1 (lowest Wildfire Composite Hazard) to 5 (highest Wildfire Composite Hazard). The categorized Wildfire Composite Hazard Rank by watershed are displayed in Appendix I and on Figure 14. Based upon this analysis, there are 20 watersheds that received a Wildfire Composite Hazard Rank of Highest in the UGRWCD analysis area (Table 9).

Table 9. Highest Ranked Watersheds for Wildfire Composite Hazard.

Sub-basin Name	6th Level Watershed Name
Upper Gunnison	Headwaters Willow Creek
	Rocky Brook-Spring Creek
	Bear Creek-Spring Creek
	Lower Taylor River
	Brush Creek
	Coal Creek
	Cement Creek
Middle Gunnison	Upper Ohio Creek
	Carbon Creek
	Mill Creek
	Steuben Creek
	Larson Creek-Lake Fork
	Trout Creek-Lake Fork
	Red Creek
	West Elk Creek
	Cow Creek-Soap Creek
Tomichi Creek	Headwaters Tomichi Creek
	Upper Quartz Creek
	Gold Creek
	Middle Quartz Creek

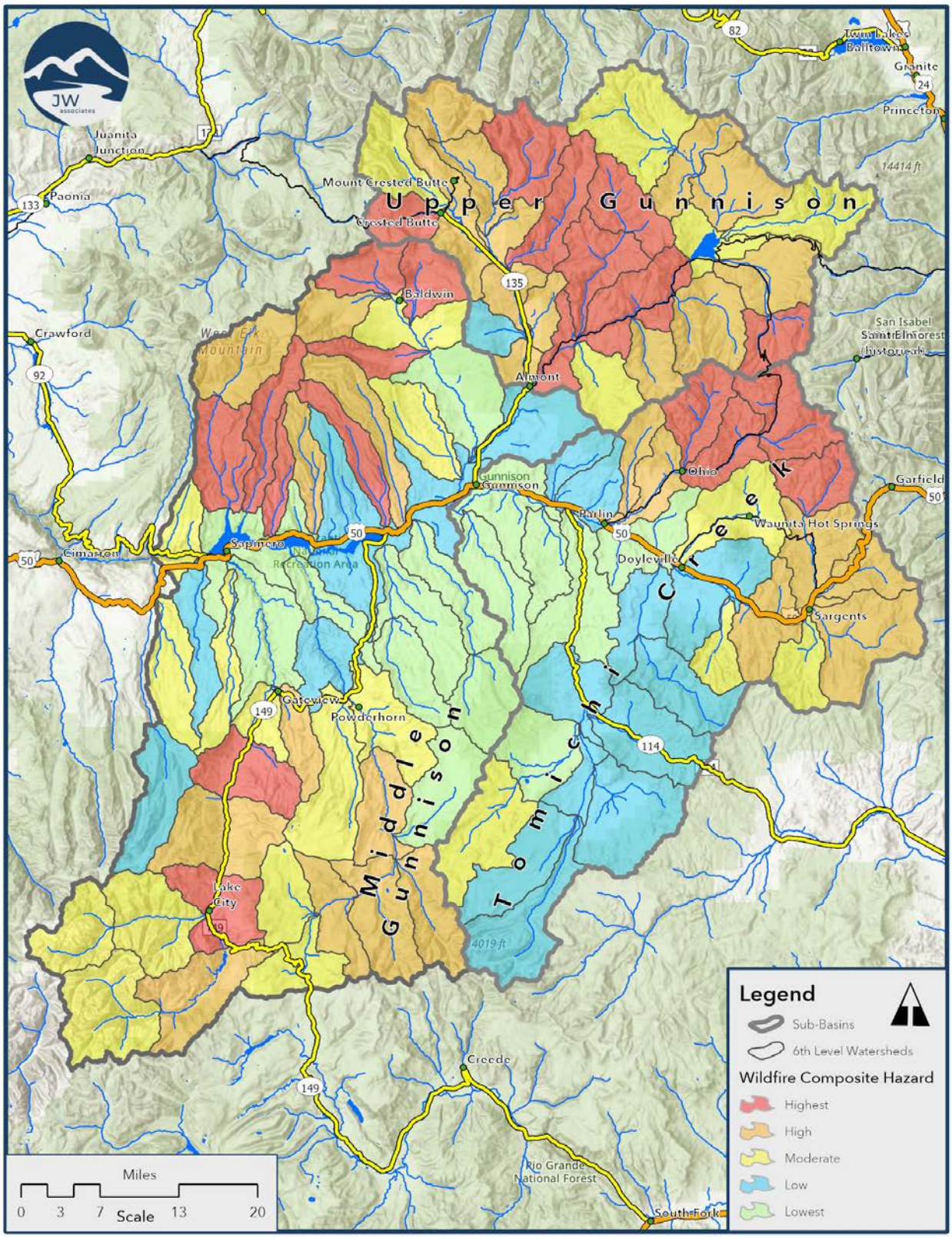

Figure 14. Upper Gunnison Wildfire Composite Hazard Ranking

Climate Change Vulnerability

The stress on ecosystems due to a changing climate can trigger a transformation of natural communities at regional and local scales with varying speed and magnitude (Comer et al, 2019). Alterations in temperature and precipitation patterns can disrupt an ecosystem's natural dynamics and balance by altering a range of factors including but not limited to plant growth and stability within an eco-zone, streamflows and timing of runoff, frequency and intensity of wildfire, and habitat suitability for flora and fauna (Halofsky et al., 2018). These changes can cascade through natural communities and may result in alterations that can lead to species extinctions, ecological degradation or even potential collapse (Comer, et al, 2019).

Climate Change Vulnerability of the Gunnison Basin

Watershed vulnerability to climate change is considered high in the Gunnison Basin (The Nature Conservancy, 2011). The primary factors contributing to the area's overall vulnerability include a snow-dominated system that has a high sensitivity to increases in drought, heat, and flooding. In this system, climate change will lead to increased evaporation, lower snowpack, and earlier snowmelt. As temperatures rise, more of the precipitation will fall as rain rather than snow.

The Nature Conservancy report on the Gunnison Basin Climate Change Vulnerability Assessment projects the average annual temperature of the Upper Gunnison Basin to increase by approximately 3°C (5.4°F) from the late 20th century to the middle 21st century.

The change in precipitation patterns and increase in heat and evaporation will result in a smaller snowpack and drier soils during the growing season. This will subsequently alter the timing of runoff and reduce streamflows. Climate projections also predict a 10-25% decrease in average annual runoff in the Gunnison Basin (The Nature Conservancy, 2011). Despite reduced streamflows, flooding events are likely to increase due to the increased precipitation as rain and an accompanying increase in rain on snow events. The Gunnison Basin has many high-gradient streams that have high vulnerability to flooding and debris flows. These types of floods can create excessive sediment input through erosion and debris flows, potentially restructuring channels, damaging or destroying infrastructure, and destroying important fish habitat.

The combination of drought, lower streamflows and higher temperatures also poses a risk to riparian vegetation (Halofsky et al., 2018). Stressed vegetation in the riparian zone will be more vulnerable to additional disturbances from cattle grazing, ungulate browsing and expansion of invasive species into the riparian ecosystem. Willows and low-elevation cottonwoods are among the most intolerant of drought. A healthy riparian ecosystem is important for bank stabilization, maintaining cooler in-stream water temperatures, and adding woody debris and nutrients to the streams, which support aquatic insects and fish. Riparian vegetation also acts as a filter for hillslope erosion providing sedimentation in floodplains or riparian areas instead of transport downstream and removes nitrogen and sediment bound phosphorus, improving water quality (Naiman et al., 2010).

Watershed/Ecosystem Resilience

Resiliency is determined by the particular ecosystem's ecological ability to respond to stresses and changes in the natural environment such as those induced by climate change. Holling (1973) defined ecological resiliency as:

> "*The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks*"

The following characteristics create healthy and functional watersheds that are able to experience disturbance and recover relatively quickly:

- Forests that are diverse in terms of both forest types and density
- Areas of high wildfire hazard that are relatively small and separated from other watersheds that have high wildfire hazard
- Intact, functional riparian areas that can respond quickly after disturbances
- Healthy, native riparian vegetation
- Floodplains are connected to streams that flood during larger runoff events
- Upland areas have appropriate ground cover, comprised of mostly native vegetation, that can recover quickly following disturbances
- Roads that have minimal impacts on watershed function
- Where development occurs in watersheds, it has minimal impacts on watershed functions

Comer et al. (2019) has designed an assessment to help determine which communities are at most risk of climate change impacts, providing a warning of elevated risk for affected natural communities. Comer's (2019) Habitat Climate Change Vulnerability Index (HCCVI) integrates variables from previous assessments and provides a framework for assessing vulnerability based on natural community (major vegetation) types. The analysis provided here uses components of this framework to assess relative vulnerability within the studied watersheds.

The HCCVI examines a community's 1) exposure to climate induced stress and 2) resilience to that stress. Areas most at risk from climate change are those that are likely to experience the most severe changes in temperature and precipitation (high exposure) but which have limited capacity to adapt or absorb these changes (low resilience).

Exposure

In Comer et al. (2019), Exposure refers to

> "*the rate, magnitude and nature of climate-induced stress on the community. Exposure encompasses trends in climate, such as changes in temperature and precipitation regimes and any predicted effects on ecosystem-specific processes.*"

The stressors from a change in climate includes temperature and rainfall patterns (both drought and increased precipitation) but also changing disturbance regimes such as wildfire.

The scale of this analysis is relatively small compared with the ecoregion analysis for most climate exposure modeling (Halofsky et al., 2018). Exposure across the study area is consistent and does not provide for differentiations between watersheds to assess relative risk. The Gunnison Basin has been determined to have high exposure to climate change as discussed above. Therefore, exposure is not used as a differentiating component in this assessment of climate change vulnerability. However, it should be assumed that throughout the watersheds being discussed, exposure is consistently high.

Watershed/Ecosystem Resilience

Comer et al. (2019) looked at measuring an ecosystem's resilience to climate change through two subcategories: Ecosystem Sensitivity and Adaptive Capacity.

> Ecosystem Sensitivity - Reflects the numbers, intensity and types of ecosystem stressors that are independent of, but likely to interact with, changes in climate.
>
> Adaptive Capacity - The natural characteristics that allow for an ecosystem to respond and adapt to changes in climate.

These factors are used in this analysis with slight modifications to provide an evaluation tool for the UGRWCD 6th level watersheds in the study area. This analysis will allow decision makers to target management strategies to lessen the impacts of climate change in particularly sensitive watersheds, or to protect water supply systems from changes in the watershed that may be inevitable due to a changing climate.

Ecosystem Sensitivity Hazard

Ecosystem sensitivity includes both intrinsic or natural factors that can place stress on an ecosystem, as well as human alterations to ecosystem function. The impact on natural processes from these stressors may intensify in the presence of climate change. Examples of these types of stressors include landscape fragmentation, invasive species, fire regimes across the landscape, and insects and disease. Landscape fragmentation can inhibit or prevent the migration of flora or fauna in the face of a rapid change in climatic conditions, increasing the vulnerability of communities within the landscape. The introduction of non-native species can intensify competition for increasingly limited niches or habitats as well as altering fire regimes or increasing the landscape's vulnerability to fire. Historic human fire suppression, fragmentation and wildland-urban interface zones, which have already altered historical fire patterns, can exacerbate the effects of increasing temperature and periods of drought. Insects and disease, endemic to forests ecosystems, may increase as a disruptive factor in the face of changing conditions that increase stress on vegetation. With a changing climate, different types of insects and diseases, adapted for warmer areas, may also move into forests that have not previously developed resiliency. All these factors interact with each other and can describe the sensitivity to climate change for a specified area such as a watershed.

Landscape Condition

The amount of existing and potential fragmentation and human-induced stress within a landscape is reflected by the established road network. As discussed by Riitters and Wickham (2003) the ecological impacts of roads extend tens to hundreds of meters from the road itself and include disrupting wildlife movements, modifying habitats, altering water drainage patterns, contributing to debris flow risk during flooding, and introducing non-native species. Roads also follow economic constraints and are designed to create connections, movement and development including further expansion of the road network. They often cross natural boundaries so their influence is not limited by natural constraints.

For this analysis, the NatureServe Landscape Condition Model was used to assess the landscape condition of each watershed (Hak and Comer, 2017). This model is a spatially-based 90 meter resolution assessment of the relative ecological effects of human land uses such as built transportation or urban and industrial infrastructure, including mining, and land cover changes such as for agriculture. The model also uses a decay parameter to account for the effect of each land use as it diminishes with distance away from the site. Each pixel value is scored from 1-100

on this relative landscape condition scale. The watershed mean landscape condition value was used in our ranking.

Invasive Plant Species

Invasive and non-native plants can aggressively compete with native species for limited resources particularly as native species become stressed in the face of rising temperatures and drought. Human activity and fire disturbance may both support further spread. There is also evidence that some non-native invasive species such as cheatgrass are correlated with increased fire risk and spread (Rice et al., 2012). Where cheatgrass occurs in grass and shrubland vegetation types, fire starts in those areas can carry into adjacent forested areas. Comprehensive spatial data describing invasive plant species for this analysis area are not available and therefore the invasive plant species analysis was not completed.

Fire Regime Departure

Vegetation follows patterns of regrowth and change after disturbances such as timber harvesting, wildfire, or insect outbreaks. This process of patterned regrowth and change is called succession. The rate of succession and the vegetation present at different stages depend on the type of disturbance, the characteristics of the site, and the species available to occupy the site.

Fire regime models use estimates of successional rates combined with historical fire frequency to predict the proportion of natural successional stages that would be expected across a landscape in various community types. These predictions can be compared to the existing conditions to indicate the departure of an ecosystem from what would be expected without human alterations such as fire suppression or other modifications to the natural environment. These departures can be an indication of the landscape's stability in the face of wildfire.

To rank watersheds for Fire Regime Departure (FRD), the US Interagency LANDFIRE program was used. This program provides spatial models of wildfire regime departure by comparing existing conditions to predicted successional stages for different vegetation types. LANDFIRE provides an index score called the Fire Regime Condition Class (FRCC) that is an indication of the percent departure from the expected condition. FRCC values range from "1.0 = most favorable" to "0.0 = least favorable." Comer et al. (2019) uses FRCCs to represent the Fire Regime Departure within defined pixels which are then averaged over a larger 100 km^2 area. Since Comer et al. (2019), LANDFIRE has revised its analysis and now uses the term Vegetation Conditions Class (VCC) and reverses the ranking so that a value of 0.0 represents the most favorable condition. This analysis uses the VCCs with weighting factors as follows:

VCC 1 = 0.0 No or little change from expected successional state

VCC 2 = 0.5 Moderate change from expected successional state

VCC 3 = 0.85 Significant change from expected successional state

The total area of each VCC in each 6th level watershed was multiplied by the weighting factor identified above, then the total weighted area of all three classes was divided by the watershed area to provide an average VCC for each watershed. Watersheds are then ranked with the highest average VCCs representing watersheds with the greatest departure from the expected successional state and the greatest FRD.

Forest Insect and Disease Risk

Climate change and human disturbance can affect the risk of damage and stress from insects and disease in multiple ways. Human disturbance can introduce non-native species to the ecosystem. Increasingly mild winters augments the overwintering survival rate of both native and introduced insect species. Drought and temperatures out of the range of normal can stress vegetation that is adapted to a cooler and wetter climate. These compounding factors may increase the impact of insects and disease as a disturbance agent, affecting forest health and ultimately stand structure and vegetative composition. Higher mortality rates from insects and disease over historical conditions may increase fuel loadings and further intensify wildfires.

The National Insect and Disease Risk Map defines forest areas where, "*the expectation* that, *without remediation, at least 25% of standing live basal area greater than one inches in diameter will die over a 15-year timeframe (2013–2027) due to insects and diseases*" (Krist et al. 2013). The mapping was updated in 2018 to account for reductions in hazard due to previous and ongoing tree mortality.

For the UGRWCD watershed assessment area, the insects that apply to forested areas include;

- Aspen decline
- Douglas-fir beetle
- Dwarf mistletoe
- Fir engraver
- Mountain pine beetle
- Spruce beetle
- Western balsam bark beetle
- Western spruce budworm
- White pine blister rust

The 2018 National Insect and Disease Risk Map Update is a 240-meter resolution map that represents areas of remaining risk for predicted future biomass loss. The area of remaining risk for each watershed was divided by the total watershed area. These scores produce an estimated hazard of predicted biomass loss in each 6th level watershed. Watersheds are then ranked to indicate the relative risk of loss due to insects and disease within the wider study area.

Ecosystem Sensitivity Hazard Rank

The Ecosystem Sensitivity Hazard Rank was calculated by summing the Landscape Condition, Fire Regime Departure, and Forest Insect and Disease Risk rankings. The results of this calculation were ranked from 1 (lowest Ecosystem Sensitivity Hazard) to 5 (highest Ecosystem Sensitivity Hazard) to create the Ecosystem Sensitivity Hazard Ranking. The categorized Ecosystem Sensitivity Hazard Rank by watershed are displayed in Appendix J and Figure 15. Based upon this analysis, there are 21 watersheds that received an Ecosystem Sensitivity Hazard Rank of Highest in the UGRWCD analysis area (Table 10).

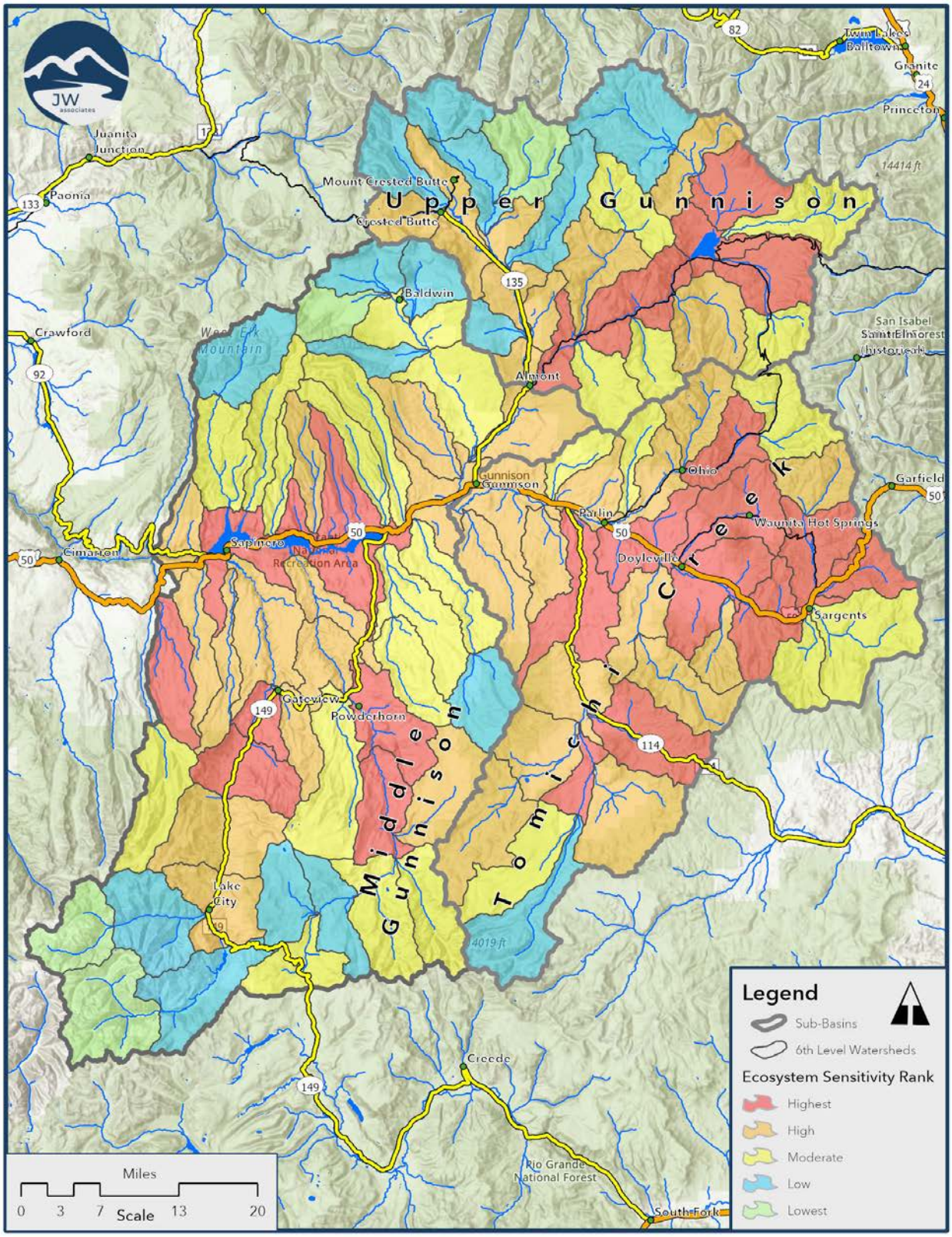

Figure 15. Upper Gunnison Ecosystem Sensitivity Hazard Ranking

Table 10. Highest Ranked Watersheds for Ecosystem Sensitivity Hazard.

Sub-basin Name	6th Level Watershed Name
Upper Gunnison	Middle Taylor River
	Outlet Willow Creek
	Taylor Park Reservoir
	Lower Taylor River
Middle Gunnison	Willow Creek-Blue Mesa Reservoir
	Fish Canyon-Cebolla Creek
	Road Beaver Creek-Cebolla Creek
	Trout Creek-Lake Fork
	Yeager Gulch-Lake Fork
	Pine Creek Mesa-Blue Mesa Reservoir
	Little Blue Creek
Tomichi Creek	Agate Creek
	Porphyry Creek-Tomichi Creek
	Middle Quartz Creek
	Owens Creek-Tomichi Creek
	Barret Creek-Tomichi Creek
	Hot Springs Creek
	Wood Gulch-Tomichi Creek
	Middle Cochetopa Creek
	West Pass Creek
	Outlet Cochetopa Creek

Adaptive Capacity

Adaptive Capacity is the ability of an ecosystem to respond to external stressors such as the effects of climate change. Landscapes that are more diverse provide more opportunities for organisms to find climate refuge than those that are relatively homogenous (Comer et al., 2019). Conversely, an ecosystem that has little variability in microclimates or elevational change lacks buffers for species to move into new areas as the climate shifts. Therefore an indication of a landscape or watershed's Adaptive Capacity can be found in the relative diversity of topography and microclimates. The adaptive capacity of an ecosystem is also dependent on the diversity of the species within it and their sensitivity to shifts in climate or ability to migrate within the landscape to new areas with suitable microclimates (Rice et al., 2017). Therefore, there are several useful measures of the ability of an ecosystem to absorb climate change. Comer et al. (2019) defines three factors, which in combination provide an indicator of the potential for a given landscape to successfully buffer the effects of climate change. These factors include:

- Species Diversity (Simpson's Diversity Index)
- Topo-climate variability
- Climate change vulnerability of "keystone species."

Simpson's Diversity Index

Comer et al. (2019) uses a diversity component called Functional Species Groups (FSGs). Ecosystems or communities with FSGs that have rich internal diversity tend to be more resilient to external stressors (Folke et al. 2004, Walker et al. 2004, Nyström et al. 2008). Within any landscape there may be several functional groups that interact and form a link to external ecosystem processes and structures (Comer et al. 2019). Since individual species respond differently to disturbances, the more diverse the taxonomy of an identified FSG, the more likely it is that a function within the group can be performed by more than one member should individual species be lost as the climate changes. High FSG diversity therefore provides a buffer to insure that the larger FSG community will retain key functions.

However, the data on the FSGs for the area of study are incomplete and the relative difference between the known FSGs in the study area are too small to create a useful ranking scheme. Therefore, Simpson's Diversity Index (Simpson, 1952) was used instead of FSGs. This index is a well-established method to quantify the diversity of plant and/or animal species as well as the abundance of each species. Accounting for diversity in terms of both richness and evenness is important because although two communities may have the same number of species (richness), the community dominated by just one or two of those species is considered less diverse than the one in which many different species have a similar abundance (evenness). Simpson's Index (D) is calculated with the following formula:

$$D = \sum (n/N)^2;$$

where n = total acres of a particular species, and N = total acres of all species.

This index produces a scale from 0 (high diversity) to 1 (low diversity). The value of D was calculated for each watershed and the watersheds were then ranked from 1 (high diversity, low hazard) to 5 (low diversity, high hazard).

Topo-Climatic Variability

The distribution of a natural community is determined by both regional and micro-climatic factors of temperature and precipitation. For example, limited topographical relief may provide a wide area of distribution but only gradual change over distance, while rugged canyons and mountain ranges offer numerous microclimates that provide opportunities for rapid change in vegetation types over short distances. The idea of climate change "velocity" has been proposed as a measure of climate change exposure and the concept reflects the interaction of changing climate with topography (Loarie et al. 2009). Areas with rugged topography and significant elevational gradients will support a greater diversity of microclimates (low velocity) as compared with areas of flat topography (high velocity). Given the same degree of climate change over the same time period, a species in a rugged topographic environment would be required to migrate a shorter distance than a species in an expansive and flat landscape (Comer et al. 2019).

Maps of terrain ruggedness express the influence of topography on microclimate variability (Comer et al. 2018). Riley et al. (1999) provided a terrain ruggedness index (TRI) that an be used to arrive at a measure of this influence. This analysis was completed and then an average TRI calculated for each watershed.

Climate Change Vulnerability of Keystone Species

Adaptive Capacity may also be affected by the vulnerability to climate change for individual species who provide “keystone” functions for the ecosystem. Keystone species are critical for maintaining the healthy functioning and structure of an ecological community and influence the abundance and type of other species in a habitat. Due to their key functional role within a community, a reduction in their abundance or their extirpation, could cause disproportionate effects on the populations of other species within the community.

However, while this concept provides an important insight into the vulnerability of an ecosystem, it is often difficult to identify and assess species for each vegetative category given current knowledge (Comer et al. 2019). Within the Upper Gunnison, the only keystone species is aspen within two of the forest types (Comer et al. 2018). Because of the very limited number of keystone species this component of the analysis was not used.

Lack of Adaptive Capacity Rank

The Lack of Adaptive Capacity Rank was calculated by summing the Simpson’s Diversity and Topo-Climatic Variability rankings. The results of this calculation were ranked from 1 (lowest Lack of Adaptive Capacity or highest Adaptive Capacity) to 5 (highest Lack of Adaptive Capacity or lowest Adaptive Capacity) to create the Lack of Adaptive Capacity Ranking. The categorized Lack of Adaptive Capacity Rank by watershed are displayed in Appendix K and on Figure 16. Based upon this analysis, there are 20 watersheds that received a Lack of Adaptive Capacity Rank of Highest (lowest Adaptive Capacity or Resilience) in the UGRWCD analysis area (Table 11).

Table 11. Highest Ranked Watersheds for Lack of Adaptive Capacity Hazard.

Sub-basin Name	6th Level Watershed Name
Middle Gunnison	Lower Ohio Creek
	Sheep Gulch-Gunnison River
	Long Gulch-South Beaver Creek
	Steers Gulch-Gunnison River
	Sugar Creek-Willow Creek
	Willow Creek-Blue Mesa Reservoir
	Outlet Cebolla Creek
	Outlet Lake Fork
	Pine Creek Mesa-Blue Mesa Reservoir
Tomichi Creek	Outlet Razor Creek
	Barret Creek-Tomichi Creek
	Wood Gulch-Tomichi Creek
	Pauline Creek
	Middle Cochetopa Creek
	Outlet Cochetopa Creek
	Sewell Gulch-Tomichi Creek
	Cabin Creek
	Long Gulch
	Stubbs Gulch
	Chance Gulch-Tomichi Creek

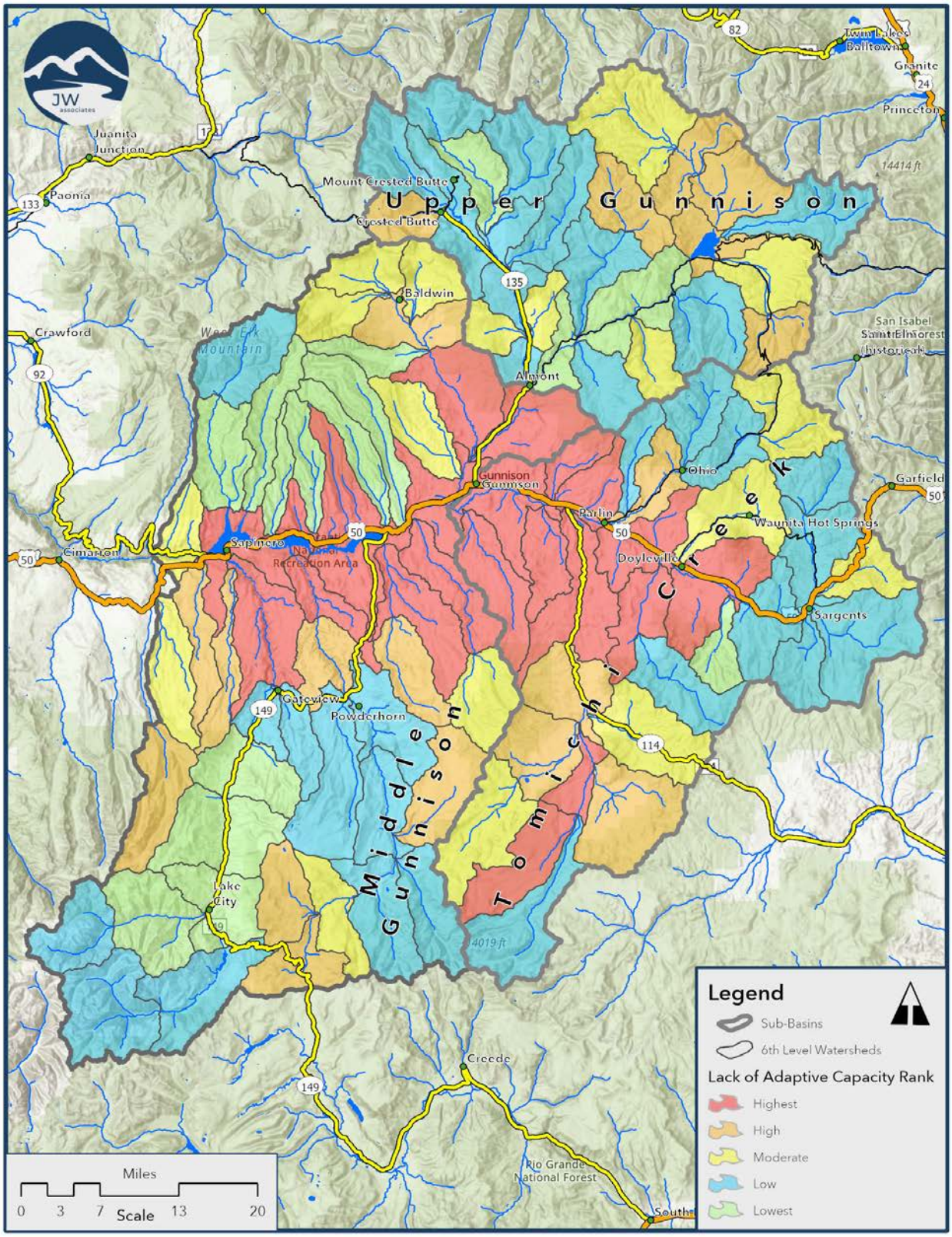

Figure 16. Upper Gunnison Lack of Adaptive Capacity Ranking

Climate Change Vulnerability Rank

The Climate Change Vulnerability Rank was calculated by summing the Adaptive Capacity Hazard and Ecosystem Sensitivity rankings. The results of this calculation were ranked from 1 (lowest Climate Change Vulnerability) to 5 (highest Climate Change Vulnerability). The categorized Climate Change Vulnerability Rank by watershed are displayed in Appendix L and on Figure 17. Based upon this analysis, there are 20 watersheds that received a Climate Change Vulnerability Rank of Highest in the UGRWCD analysis area (Table 12).

Table 12. Highest Ranked Watersheds for Climate Change Vulnerability Hazard.

Sub-basin Name	6th Level Watershed Name
Upper Gunnison	Middle Taylor River
	Outlet Willow Creek
	Taylor Park Reservoir
Middle Gunnison	Lower Ohio Creek
	Sheep Gulch-Gunnison River
	Steers Gulch-Gunnison River
	Sugar Creek-Willow Creek
	Willow Creek-Blue Mesa Reservoir
	Outlet Cebolla Creek
	Outlet Lake Fork
	Pine Creek Mesa-Blue Mesa Reservoir
Tomichi Creek	Outlet Razor Creek
	Barret Creek-Tomichi Creek
	Wood Gulch-Tomichi Creek
	Middle Cochetopa Creek
	Outlet Cochetopa Creek
	Sewell Gulch-Tomichi Creek
	Long Gulch
	Stubbs Gulch
	Chance Gulch-Tomichi Creek

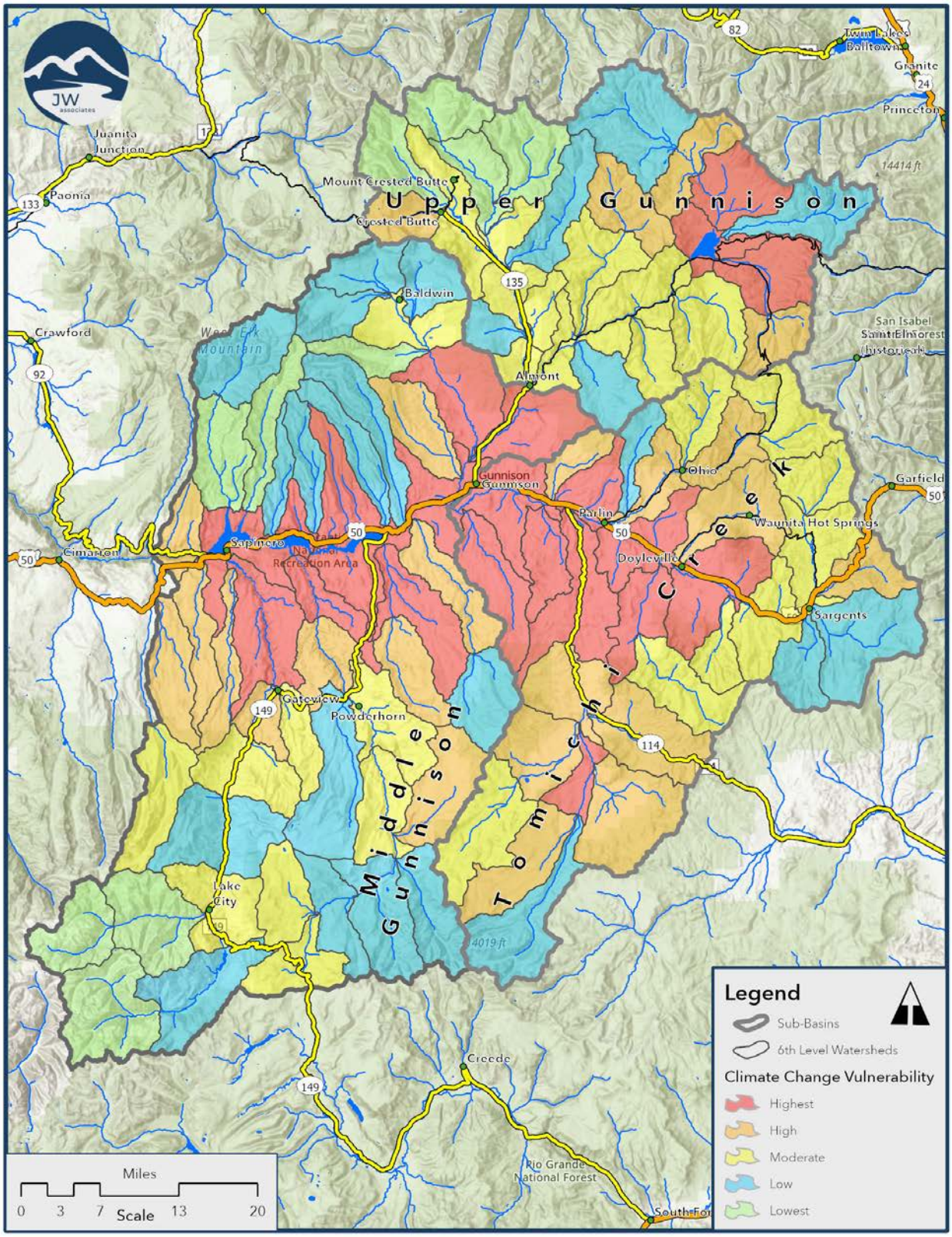

Figure 17. Upper Gunnison Climate Change Vulnerability Hazard Ranking

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Appendix A
6th Level Watersheds

Upper Gunnison River Water Conservancy District Watersheds

12 code HUC	Sixth-level Watershed Name	Area (acres)	Lakes (acres)	Area w/o lakes	Sub-Basin	Fifth-level Watershed Name
140200010101	Upper Taylor River	39,858	7	39,851	Upper Gunnison	Taylor River
140200010102	Trail Creek-Upper Taylor River	18,441	3	18,437	Upper Gunnison	Taylor River
140200010103	Middle Taylor River	23,744	1	23,743	Upper Gunnison	Taylor River
140200010104	Texas Creek	25,911	2	25,909	Upper Gunnison	Taylor River
140200010105	Headwaters Willow Creek	16,093	35	16,059	Upper Gunnison	Taylor River
140200010106	Outlet Willow Creek	24,511	1	24,511	Upper Gunnison	Taylor River
140200010107	Taylor Park Reservoir	14,030	2,016	12,014	Upper Gunnison	Taylor River
140200010108	Lottis Creek	26,945	13	26,932	Upper Gunnison	Taylor River
140200010109	Crystal Creek	14,385	3	14,381	Upper Gunnison	Taylor River
140200010110	Rocky Brook-Spring Creek	20,885	51	20,834	Upper Gunnison	Taylor River
140200010111	Bear Creek-Spring Creek	23,114		23,114	Upper Gunnison	Taylor River
140200010112	Beaver Creek	18,306		18,306	Upper Gunnison	Taylor River
140200010113	Lower Taylor River	39,280		39,280	Upper Gunnison	Taylor River
140200010201	Upper East River	17,206	13	17,193	Upper Gunnison	East River
140200010202	Brush Creek	24,472	6	24,466	Upper Gunnison	East River
140200010203	Middle East River	16,674	3	16,671	Upper Gunnison	East River
140200010204	Coal Creek	13,146	5	13,141	Upper Gunnison	East River
140200010205	Oh-be-Joyful Creek-Slate River	21,472	4	21,468	Upper Gunnison	East River
140200010206	Washington Gulch-Slate River	22,976	3	22,972	Upper Gunnison	East River
140200010207	Cement Creek	22,846		22,846	Upper Gunnison	East River
140200010208	Alkali Creek	9,457		9,457	Upper Gunnison	East River
140200010209	Roaring Judy Creek	9,197		9,197	Upper Gunnison	East River
140200010210	Lower East River	27,742	4	27,739	Upper Gunnison	East River
140200020101	Upper Ohio Creek	15,506		15,506	Middle Gunnison	Ohio Creek
140200020102	Castle Creek	14,595	7	14,589	Middle Gunnison	Ohio Creek
140200020103	Carbon Creek	16,052	0	16,051	Middle Gunnison	Ohio Creek
140200020104	Mill Creek	10,667		10,667	Middle Gunnison	Ohio Creek
140200020105	Middle Ohio Creek	19,521		19,521	Middle Gunnison	Ohio Creek
140200020106	Lower Ohio Creek	29,379		29,379	Middle Gunnison	Ohio Creek
140200020107	Sheep Gulch-Gunnison River	26,250		26,250	Middle Gunnison	Ohio Creek
140200020201	Antelope Creek	21,029	33	20,996	Middle Gunnison	South Beaver Creek-Gunnison River
140200020202	Headwaters South Beaver Creek	21,431		21,431	Middle Gunnison	South Beaver Creek-Gunnison River
140200020203	Long Gulch-South Beaver Creek	21,809		21,809	Middle Gunnison	South Beaver Creek-Gunnison River
140200020204	Steers Gulch-Gunnison River	18,835	49	18,786	Middle Gunnison	South Beaver Creek-Gunnison River
140200020301	Headwaters Willow Creek	20,026	19	20,007	Middle Gunnison	Willow Creek
140200020302	Sugar Creek-Willow Creek	26,574	0	26,574	Middle Gunnison	Willow Creek
140200020401	Beaver Creek	23,115		23,115	Middle Gunnison	Beaver Creek-Blue Mesa Reservoir
140200020402	Steuben Creek	16,499	0	16,499	Middle Gunnison	Beaver Creek-Blue Mesa Reservoir
140200020403	Willow Creek-Blue Mesa Reservoir	42,362	2,701	39,661	Middle Gunnison	Beaver Creek-Blue Mesa Reservoir
140200020501	Mill Creek-Brush Creek	19,125	45	19,080	Middle Gunnison	Cebolla Creek
140200020502	Headwaters Cebolla Creek	19,312		19,312	Middle Gunnison	Cebolla Creek
140200020503	Rough Creek-Cebolla Creek	18,631		18,631	Middle Gunnison	Cebolla Creek

12 code HUC	Sixth-level Watershed Name	Area (acres)	Lakes (acres)	Area w/o lakes	Sub-Basin	Fifth-level Watershed Name
140200020504	Spring Creek	23,224		23,224	Middle Gunnison	Cebolla Creek
140200020505	Mineral Creek-Cebolla Creek	29,143	46	29,097	Middle Gunnison	Cebolla Creek
140200020506	Rock Creek	26,266		26,266	Middle Gunnison	Cebolla Creek
140200020507	Fish Canyon-Cebolla Creek	21,226		21,226	Middle Gunnison	Cebolla Creek
140200020508	Powderhorn Creek	35,267	7	35,260	Middle Gunnison	Cebolla Creek
140200020509	Road Beaver Creek-Cebolla Creek	25,434		25,434	Middle Gunnison	Cebolla Creek
140200020510	Goose Creek-Cebolla Creek	17,753		17,753	Middle Gunnison	Cebolla Creek
140200020511	Outlet Cebolla Creek	14,785	132	14,653	Middle Gunnison	Cebolla Creek
140200020601	Headwaters Lake Fork	36,698	4	36,694	Middle Gunnison	Lake Fork
140200020602	Lake Sanc Cristobal-Lake Fork	31,446	6	31,440	Middle Gunnison	Lake Fork
140200020603	North Fork Henson Creek-Henson Creek	22,723		22,723	Middle Gunnison	Lake Fork
140200020604	Nellie Creek-Henson Creek	30,791		30,791	Middle Gunnison	Lake Fork
140200020605	Larson Creek-Lake Fork	24,785		24,785	Middle Gunnison	Lake Fork
140200020606	Elk Creek-Lake Fork	35,604		35,604	Middle Gunnison	Lake Fork
140200020607	Trout Creek-Lake Fork	24,601		24,601	Middle Gunnison	Lake Fork
140200020608	Yeager Gulch-Lake Fork	10,512		10,512	Middle Gunnison	Lake Fork
140200020609	Indian Creek	13,354		13,354	Middle Gunnison	Lake Fork
140200020610	Willow Creek	14,787		14,787	Middle Gunnison	Lake Fork
140200020611	Outlet Lake Fork	31,612	455	31,157	Middle Gunnison	Lake Fork
140200020701	East Elk Creek	14,155	0	14,155	Middle Gunnison	Soap Creek-Blue Mesa Reservoir
140200020702	Red Creek	9,095		9,095	Middle Gunnison	Soap Creek-Blue Mesa Reservoir
140200020703	West Elk Creek	19,607		19,607	Middle Gunnison	Soap Creek-Blue Mesa Reservoir
140200020704	West Soap Creek-Soap Creek	28,360		28,360	Middle Gunnison	Soap Creek-Blue Mesa Reservoir
140200020705	Cow Creek-Soap Creek	24,271	125	24,147	Middle Gunnison	Soap Creek-Blue Mesa Reservoir
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	31,921	5,640	26,281	Middle Gunnison	Soap Creek-Blue Mesa Reservoir
140200020801	Headwaters Blue Creek	26,881		26,881	Middle Gunnison	Blue Creek
140200020802	Little Blue Creek	22,333		22,333	Middle Gunnison	Blue Creek
140200021001	Pine Creek	17,288		17,288	Middle Gunnison	Crystal Creek-Gunnison River
140200021003	Corral Creek-Gunnison River	13,404	170	13,234	Middle Gunnison	Crystal Creek-Gunnison River
140200030101	Headwaters Tomichi Creek	17,982	2	17,979	Tomichi Creek	Headwaters Tomichi Creek
140200030102	Agate Creek	15,132		15,132	Tomichi Creek	Headwaters Tomichi Creek
140200030103	Marshall Creek	36,725		36,725	Tomichi Creek	Headwaters Tomichi Creek
140200030104	Long Branch Creek	15,497	6	15,492	Tomichi Creek	Headwaters Tomichi Creek
140200030105	Porphyry Creek-Tomichi Creek	25,094		25,094	Tomichi Creek	Headwaters Tomichi Creek
140200030201	Headwaters Razor Creek	24,678	23	24,655	Tomichi Creek	Razor Creek
140200030202	Outlet Razor Creek	18,847		18,847	Tomichi Creek	Razor Creek
140200030301	Upper Quartz Creek	25,878	2	25,876	Tomichi Creek	Quartz Creek
140200030302	Gold Creek	19,350	4	19,345	Tomichi Creek	Quartz Creek
140200030303	Middle Quartz Creek	17,863	1	17,863	Tomichi Creek	Quartz Creek
140200030304	Alder Creek	10,988		10,988	Tomichi Creek	Quartz Creek
140200030305	Lower Quartz Creek	15,252		15,252	Tomichi Creek	Quartz Creek
140200030401	Owens Creek-Tomichi Creek	23,254		23,254	Tomichi Creek	Middle Tomichi Creek
140200030402	Needle Creek	11,487	40	11,447	Tomichi Creek	Middle Tomichi Creek

12 code HUC	Sixth-level Watershed Name	Area (acres)	Lakes (acres)	Area w/o lakes	Sub-Basin	Fifth-level Watershed Name
140200030403	Barret Creek-Tomichi Creek	32,588		32,588	Tomichi Creek	Middle Tomichi Creek
140200030404	Hot Springs Creek	28,893	28	28,865	Tomichi Creek	Middle Tomichi Creek
140200030405	Wood Gulch-Tomichi Creek	22,873		22,873	Tomichi Creek	Middle Tomichi Creek
140200030501	Headwaters Cochetopa Creek	31,708		31,708	Tomichi Creek	Cochetopa Creek
140200030502	Pauline Creek	26,477		26,477	Tomichi Creek	Cochetopa Creek
140200030503	Archuleta Creek	37,542	18	37,524	Tomichi Creek	Cochetopa Creek
140200030504	Headwaters Los Pinos Creek	32,081	34	32,047	Tomichi Creek	Cochetopa Creek
140200030505	Trail Creek-Cochetopa Creek	24,041	5	24,036	Tomichi Creek	Cochetopa Creek
140200030506	Middle Cochetopa Creek	9,910		9,910	Tomichi Creek	Cochetopa Creek
140200030507	West Pass Creek	31,850		31,850	Tomichi Creek	Cochetopa Creek
140200030508	Rock Creek-Cochetopa Creek	23,757	12	23,744	Tomichi Creek	Cochetopa Creek
140200030509	Outlet Cochetopa Creek	33,176		33,176	Tomichi Creek	Cochetopa Creek
140200030601	Sewell Gulch-Tomichi Creek	15,161		15,161	Tomichi Creek	Lower Tomichi Creek
140200030602	Cabin Creek	10,105		10,105	Tomichi Creek	Lower Tomichi Creek
140200030603	Long Gulch	16,198		16,198	Tomichi Creek	Lower Tomichi Creek
140200030604	Stubbs Gulch	25,287	0	25,287	Tomichi Creek	Lower Tomichi Creek
140200030605	Chance Gulch-Tomichi Creek	25,830	3	25,827	Tomichi Creek	Lower Tomichi Creek
	Total	**2,274,239**	**11,787**	**2,262,452**		

Appendix B
Wildfire Modeling Assumptions

Upper Gunnison Wildfire Modeling Assumptions

We are using two models for wildfire hazard - FlamMap model and the Interagency Fuel Treatment Decision Support System (IFTDSS). FlamMap is a Windows only based model. IFTDSS is an online implementation of FlamMap and other tools (www.iftdss.firenet.gov). LANDFIRE (https://landfire.gov) is the source for data for all the basic data. LANDFIRE is also the source of data for vegetation, topographic and other GIS data. The benefit of LANDFIRE is that it covers all ownerships and is updated as frequently as most other data sources. The negative of LANDFIRE is that it is intended for large-scale projects, so looking at the accuracy of the data a small scales (30-meter pixel scale) may show some inaccuracies. The latest update for LANDFIRE data for the Southwest was competed in June 2019 and includes updates through 2016.

Landscape Files and Adjustments

FlamMap needs data from LANDFIRE or other sources to run. The basic input data is called a Landscape (.LCP) file, a multi-band raster format commonly used by wildland fire behavior and fire effects models such as FARSITE and FlamMap. The bands of an .LCP file store data describing terrain, tree canopy, and surface fuel. This .LCP file utilizes LANDFIRE (LF) data, such as the optional crown fuel bands (canopy height, canopy base height, canopy bulk density), but currently does not include the optional surface fuel bands. LCP files are listed as LANDFIRE products in the Data Distribution Site (DDS) Download Data panel.

A number of recent wildfires in Colorado have involved beetle-killed Lodgepole pine. These fires did not burn exclusively in Lodgepole pine, but the extreme fire behavior of these fires in Lodgepole pine is not reflected in current FlamMap modeling fuel models. Therefore, some fuel models in Lodgepole pine were adjusted to more accurately represent potential fire behavior in those stands. The following change was made in the modeling runs.

Lodgepole pine with Fuel Model (FBFM) for moderate load conifer litter (TL3) was changed to high load conifer litter (TL5).

Basic Modeling Assumptions

There are a number of basic assumptions that need to be input into either FlamMap or IFTDSS. The following assumptions were used for the modeling;

Fire Behavior Fuel Models - Scott and Burgan (40)

Wind Type: Gridded Winds

Wind Speed and Wind Direction: Wind Speed 25 mph, Wind Direction = 240 degrees

Crown Fire Method: Scott/Reinhardt

Foliar Moisture: 75%

Fuel Moisture Conditioning: On - Extreme - Southern Rockies (Upper Colorado Basin)

Initial Fuel Moistures:

1hr FM: 3
10hr FM: 4
100hr FM: 7
Herbaceous FM: 40
Woody FM: 60

Appendix C
Wildfire Hazard

Wildfire Hazard Analysis Calculations

12 code HUC	Sixth-Level Watershed	Watershed Area (acres)	Flame Length Rank	Crown Fire Activity Rank	Mortality Rank	Wildfire Hazard Rank
140200010101	Upper Taylor River	39,851	High	High	Moderate	High
140200010102	Trail Creek-Upper Taylor River	18,437	Moderate	High	Low	Moderate
140200010103	Middle Taylor River	23,743	High	High	Low	Moderate
140200010104	Texas Creek	25,909	Moderate	High	High	High
140200010105	Headwaters Willow Creek	16,059	High	Highest	High	High
140200010106	Outlet Willow Creek	24,511	Highest	Highest	High	Highest
140200010107	Taylor Park Reservoir	12,014	Moderate	Moderate	Moderate	Moderate
140200010108	Lottis Creek	26,932	High	Highest	Moderate	High
140200010109	Crystal Creek	14,381	Highest	Highest	Highest	Highest
140200010110	Rocky Brook-Spring Creek	20,834	Highest	Highest	Highest	Highest
140200010111	Bear Creek-Spring Creek	23,114	Highest	Highest	High	Highest
140200010112	Beaver Creek	18,306	Moderate	High	High	Moderate
140200010113	Lower Taylor River	39,280	High	High	High	High
140200010201	Upper East River	17,193	Lowest	Low	Moderate	Low
140200010202	Brush Creek	24,466	Low	Moderate	Moderate	Moderate
140200010203	Middle East River	16,671	Low	Low	Low	Low
140200010204	Coal Creek	13,141	Highest	Highest	Highest	Highest
140200010205	Oh-be-Joyful Creek-Slate River	21,468	Low	Moderate	Low	Low
140200010206	Washington Gulch-Slate River	22,972	Moderate	Moderate	Low	Moderate
140200010207	Cement Creek	22,846	High	High	High	High
140200010208	Alkali Creek	9,457	Low	Lowest	Lowest	Lowest
140200010209	Roaring Judy Creek	9,197	High	Moderate	Lowest	Moderate
140200010210	Lower East River	27,739	Moderate	Low	Low	Low
140200020101	Upper Ohio Creek	15,506	High	High	Highest	Highest
140200020102	Castle Creek	14,589	High	High	High	High
140200020103	Carbon Creek	16,051	Low	Moderate	Moderate	Moderate
140200020104	Mill Creek	10,667	Moderate	High	High	High
140200020105	Middle Ohio Creek	19,521	Moderate	Low	Moderate	Moderate
140200020106	Lower Ohio Creek	29,379	Low	Lowest	Lowest	Lowest
140200020107	Sheep Gulch-Gunnison River	26,250	Low	Lowest	Lowest	Lowest
140200020201	Antelope Creek	20,996	Moderate	Low	Lowest	Low
140200020202	Headwaters South Beaver Creek	21,431	High	High	Highest	High
140200020203	Long Gulch-South Beaver Creek	21,809	Low	Lowest	Lowest	Lowest
140200020204	Steers Gulch-Gunnison River	18,786	Lowest	Lowest	Lowest	Lowest
140200020301	Headwaters Willow Creek	20,007	Low	Low	Low	Low
140200020302	Sugar Creek-Willow Creek	26,574	Low	Lowest	Lowest	Lowest
140200020401	Beaver Creek	23,115	High	High	High	High
140200020402	Steuben Creek	16,499	High	High	Moderate	High
140200020403	Willow Creek-Blue Mesa Reservoir	39,661	Low	Lowest	Lowest	Lowest
140200020501	Mill Creek-Brush Creek	19,080	Moderate	Moderate	Highest	High
140200020502	Headwaters Cebolla Creek	19,312	Moderate	Moderate	Highest	High
140200020503	Rough Creek-Cebolla Creek	18,631	Moderate	Moderate	Highest	High
140200020504	Spring Creek	23,224	High	High	Highest	Highest

12 code HUC	Sixth-Level Watershed	Watershed Area (acres)	Flame Length Rank	Crown Fire Activity Rank	Mortality Rank	Wildfire Hazard Rank
140200020505	Mineral Creek-Cebolla Creek	29,097	High	High	Highest	High
140200020506	Rock Creek	26,266	Highest	High	High	High
140200020507	Fish Canyon-Cebolla Creek	21,226	High	High	Low	Moderate
140200020508	Powderhorn Creek	35,260	Highest	High	High	Highest
140200020509	Road Beaver Creek-Cebolla Creek	25,434	High	Moderate	Lowest	Moderate
140200020510	Goose Creek-Cebolla Creek	17,753	High	Low	Lowest	Low
140200020511	Outlet Cebolla Creek	14,653	Moderate	Lowest	Lowest	Lowest
140200020601	Headwaters Lake Fork	36,694	Lowest	Low	Moderate	Low
140200020602	Lake Sanc Cristobal-Lake Fork	31,440	Moderate	High	Highest	High
140200020603	North Fork Henson Creek-Henson Creek	22,723	Lowest	Low	Low	Lowest
140200020604	Nellie Creek-Henson Creek	30,791	Low	Moderate	Moderate	Moderate
140200020605	Larson Creek-Lake Fork	24,785	Moderate	High	High	High
140200020606	Elk Creek-Lake Fork	35,604	Low	Moderate	Moderate	Moderate
140200020607	Trout Creek-Lake Fork	24,601	High	Highest	Moderate	High
140200020608	Yeager Gulch-Lake Fork	10,512	Highest	High	Lowest	Moderate
140200020609	Indian Creek	13,354	Highest	Highest	Low	Highest
140200020610	Willow Creek	14,787	High	Moderate	Moderate	Moderate
140200020611	Outlet Lake Fork	31,157	High	Low	Lowest	Low
140200020701	East Elk Creek	14,155	High	High	Low	Moderate
140200020702	Red Creek	9,095	High	Moderate	Lowest	Moderate
140200020703	West Elk Creek	19,607	Highest	Highest	High	High
140200020704	West Soap Creek-Soap Creek	28,360	High	High	Highest	Highest
140200020705	Cow Creek-Soap Creek	24,147	High	High	Moderate	High
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	26,281	Low	Lowest	Lowest	Lowest
140200020801	Headwaters Blue Creek	26,881	High	High	High	High
140200020802	Little Blue Creek	22,333	High	High	High	High
140200021001	Pine Creek	17,288	Moderate	Low	Moderate	Low
140200021003	Corral Creek-Gunnison River	13,234	Low	Lowest	Lowest	Lowest
140200030101	Headwaters Tomichi Creek	17,979	Highest	Highest	Highest	Highest
140200030102	Agate Creek	15,132	Highest	Highest	Highest	Highest
140200030103	Marshall Creek	36,725	Highest	Highest	Highest	Highest
140200030104	Long Branch Creek	15,492	Highest	Highest	Highest	Highest
140200030105	Porphyry Creek-Tomichi Creek	25,094	Highest	Highest	High	Highest
140200030201	Headwaters Razor Creek	24,655	Highest	Highest	Highest	Highest
140200030202	Outlet Razor Creek	18,847	Low	Lowest	Lowest	Lowest
140200030301	Upper Quartz Creek	25,876	High	High	Highest	Highest
140200030302	Gold Creek	19,345	High	High	Highest	Highest
140200030303	Middle Quartz Creek	17,863	Highest	Highest	High	High
140200030304	Alder Creek	10,988	Moderate	Moderate	Low	Moderate
140200030305	Lower Quartz Creek	15,252	Moderate	Low	Lowest	Low
140200030401	Owens Creek-Tomichi Creek	23,254	Highest	Highest	Moderate	Highest
140200030402	Needle Creek	11,447	Highest	Highest	Moderate	High
140200030403	Barret Creek-Tomichi Creek	32,588	Moderate	Low	Lowest	Low
140200030404	Hot Springs Creek	28,865	High	Moderate	Low	Moderate

12 code HUC	Sixth-Level Watershed	Watershed Area (acres)	Flame Length Rank	Crown Fire Activity Rank	Mortality Rank	Wildfire Hazard Rank
140200030405	Wood Gulch-Tomichi Creek	22,873	Low	Lowest	Lowest	Lowest
140200030501	Headwaters Cochetopa Creek	31,708	Low	Moderate	Highest	Moderate
140200030502	Pauline Creek	26,477	High	High	Moderate	High
140200030503	Archuleta Creek	37,524	High	Moderate	Moderate	Moderate
140200030504	Headwaters Los Pinos Creek	32,047	Highest	Highest	Highest	Highest
140200030505	Trail Creek-Cochetopa Creek	24,036	Moderate	Low	Low	Low
140200030506	Middle Cochetopa Creek	9,910	Moderate	Lowest	Low	Low
140200030507	West Pass Creek	31,850	High	Moderate	Moderate	Moderate
140200030508	Rock Creek-Cochetopa Creek	23,744	Moderate	Low	Low	Low
140200030509	Outlet Cochetopa Creek	33,176	Low	Lowest	Lowest	Lowest
140200030601	Sewell Gulch-Tomichi Creek	15,161	Low	Lowest	Lowest	Lowest
140200030602	Cabin Creek	10,105	Lowest	Lowest	Lowest	Lowest
140200030603	Long Gulch	16,198	Low	Lowest	Lowest	Lowest
140200030604	Stubbs Gulch	25,287	Low	Lowest	Lowest	Lowest
140200030605	Chance Gulch-Tomichi Creek	25,827	Lowest	Lowest	Lowest	Lowest

Appendix D
Ruggedness

Ruggedness Calculations

12 code HUC	Sixth-Level Watershed	Minimum Elevation	Maximum Elevation	Difference Elevation	Ruggedness	Ruggedness Rank	Adjustments
140200010101	Upper Taylor River	9,770	13,625	3,855	0.0925	Low	1
140200010102	Trail Creek-Upper Taylor River	9,678	13,428	3,750	0.1739	Highest	1.2
140200010103	Middle Taylor River	9,334	13,533	4,199	0.1717	Highest	1.2
140200010104	Texas Creek	9,334	13,937	4,603	0.1370	Moderate	1
140200010105	Headwaters Willow Creek	10,112	13,537	3,425	0.1295	Moderate	1
140200010106	Outlet Willow Creek	9,334	13,061	3,727	0.1499	High	1.2
140200010107	Taylor Park Reservoir	9,331	12,096	2,766	0.1395	Moderate	1.1
140200010108	Lottis Creek	9,039	13,264	4,226	0.1234	Moderate	1
140200010109	Crystal Creek	8,720	13,264	4,544	0.1815	Highest	1
140200010110	Rocky Brook-Spring Creek	9,777	13,320	3,543	0.1176	Moderate	1
140200010111	Bear Creek-Spring Creek	8,320	12,221	3,901	0.1616	High	1.2
140200010112	Beaver Creek	8,287	12,411	4,124	0.1460	High	1
140200010113	Lower Taylor River	8,005	12,654	4,649	0.1477	High	1.2
140200010201	Upper East River	9,409	13,510	4,101	0.1499	High	1
140200010202	Brush Creek	8,924	14,252	5,328	0.1632	High	1
140200010203	Middle East River	8,799	12,894	4,094	0.1753	Highest	1.1
140200010204	Coal Creek	8,878	12,379	3,501	0.1463	High	1
140200010205	Oh-be-Joyful Creek-Slate River	8,865	13,255	4,390	0.1435	High	1
140200010206	Washington Gulch-Slate River	8,583	12,618	4,035	0.1472	High	1.1
140200010207	Cement Creek	8,507	13,356	4,849	0.1537	High	1
140200010208	Alkali Creek	8,192	11,657	3,465	0.1707	Highest	1
140200010209	Roaring Judy Creek	8,159	12,172	4,012	0.1950	Highest	1
140200010210	Lower East River	8,005	12,178	4,173	0.1578	High	1.2
140200020101	Upper Ohio Creek	8,671	12,385	3,714	0.1429	High	1
140200020102	Castle Creek	8,629	13,041	4,413	0.1750	Highest	1
140200020103	Carbon Creek	8,383	12,507	4,124	0.1560	High	1
140200020104	Mill Creek	8,228	12,963	4,734	0.1950	Highest	1
140200020105	Middle Ohio Creek	8,228	12,087	3,858	0.1526	High	1.1
140200020106	Lower Ohio Creek	7,736	10,577	2,841	0.0916	Low	1.1
140200020107	Sheep Gulch-Gunnison River	7,733	10,659	2,927	0.0998	Low	1.1
140200020201	Antelope Creek	7,684	11,224	3,540	0.1171	Moderate	1
140200020202	Headwaters South Beaver Creek	9,003	12,152	3,150	0.1031	Low	1
140200020203	Long Gulch-South Beaver Creek	7,523	9,911	2,388	0.0894	Low	1.1
140200020204	Steers Gulch-Gunnison River	7,523	10,033	2,510	0.1012	Low	1.1
140200020301	Headwaters Willow Creek	8,130	10,607	2,477	0.0839	Lowest	1
140200020302	Sugar Creek-Willow Creek	7,523	10,505	2,982	0.1011	Low	1.1
140200020401	Beaver Creek	7,523	12,851	5,328	0.1679	High	1
140200020402	Steuben Creek	7,523	12,385	4,862	0.1814	Highest	1
140200020403	Willow Creek-Blue Mesa Reservoir	7,520	11,132	3,612	0.1003	Low	1.1
140200020501	Mill Creek-Brush Creek	9,810	12,792	2,982	0.1034	Low	1
140200020502	Headwaters Cebolla Creek	9,810	13,379	3,570	0.1231	Moderate	1
140200020503	Rough Creek-Cebolla Creek	9,170	13,497	4,327	0.1950	Highest	1.2
140200020504	Spring Creek	8,878	14,009	5,131	0.1613	High	1
140200020505	Mineral Creek-Cebolla Creek	8,878	13,497	4,619	0.1706	Highest	1.2
140200020506	Rock Creek	8,720	11,132	2,411	0.0713	Lowest	1
140200020507	Fish Canyon-Cebolla Creek	8,291	11,168	2,877	0.1092	Low	1.1

12 code HUC	Sixth-Level Watershed	Minimum Elevation	Maximum Elevation	Difference Elevation	Ruggedness	Ruggedness Rank	Adjustments
140200020508	Powderhorn Creek	8,015	12,667	4,652	0.1187	Moderate	1
140200020509	Road Beaver Creek-Cebolla Creek	8,015	10,607	2,592	0.0898	Low	1.1
140200020510	Goose Creek-Cebolla Creek	7,680	9,485	1,804	0.0749	Lowest	1.1
140200020511	Outlet Cebolla Creek	7,520	9,823	2,303	0.1052	Low	1.1
140200020601	Headwaters Lake Fork	9,409	14,045	4,636	0.1160	Moderate	1
140200020602	Lake Sanc Cristobal-Lake Fork	8,996	14,035	5,039	0.1790	Highest	1.2
140200020603	North Fork Henson Creek-Henson Creek	9,659	13,983	4,324	0.1374	Moderate	1
140200020604	Nellie Creek-Henson Creek	8,661	14,304	5,643	0.1950	Highest	1.2
140200020605	Larson Creek-Lake Fork	8,501	13,114	4,613	0.1845	Highest	1.2
140200020606	Elk Creek-Lake Fork	8,235	13,114	4,879	0.1628	High	1.2
140200020607	Trout Creek-Lake Fork	8,012	12,530	4,518	0.1592	High	1.1
140200020608	Yeager Gulch-Lake Fork	7,822	10,541	2,720	0.1466	High	1.1
140200020609	Indian Creek	7,831	11,890	4,058	0.1683	Highest	1
140200020610	Willow Creek	7,530	11,506	3,976	0.1567	High	1
140200020611	Outlet Lake Fork	7,516	9,849	2,333	0.0731	Lowest	1.1
140200020701	East Elk Creek	7,523	11,778	4,255	0.1714	Highest	1
140200020702	Red Creek	7,523	11,660	4,137	0.1950	Highest	1
140200020703	West Elk Creek	7,523	13,041	5,518	0.1888	Highest	1
140200020704	West Soap Creek-Soap Creek	8,310	12,923	4,613	0.1312	Moderate	1
140200020705	Cow Creek-Soap Creek	7,520	11,467	3,947	0.1600	High	1.2
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	7,339	9,852	2,513	0.0743	Lowest	1
140200020801	Headwaters Blue Creek	9,442	14,314	4,872	0.1424	High	1
140200020802	Little Blue Creek	8,179	11,506	3,327	0.1067	Low	1
140200021001	Pine Creek	7,169	11,115	3,947	0.1438	High	1
140200021003	Corral Creek-Gunnison River	7,149	10,049	2,900	0.1208	Moderate	1
140200030101	Headwaters Tomichi Creek	9,140	13,369	4,229	0.1511	High	1
140200030102	Agate Creek	8,510	12,851	4,341	0.1691	Highest	1
140200030103	Marshall Creek	8,442	12,690	4,249	0.1062	Low	1
140200030104	Long Branch Creek	8,409	11,982	3,573	0.1375	Moderate	1
140200030105	Porphyry Creek-Tomichi Creek	8,409	12,133	3,724	0.1481	High	1.2
140200030201	Headwaters Razor Creek	8,419	11,686	3,268	0.0997	Low	1
140200030202	Outlet Razor Creek	8,002	11,532	3,530	0.1421	High	1.1
140200030301	Upper Quartz Creek	9,360	13,215	3,855	0.1148	Moderate	1
140200030302	Gold Creek	8,556	13,215	4,659	0.1605	High	1
140200030303	Middle Quartz Creek	8,556	12,008	3,451	0.1627	High	1.2
140200030304	Alder Creek	8,048	12,411	4,364	0.1950	Highest	1
140200030305	Lower Quartz Creek	7,920	11,312	3,392	0.1518	High	1.1
140200030401	Owens Creek-Tomichi Creek	8,205	11,978	3,773	0.1558	High	1.2
140200030402	Needle Creek	8,173	11,450	3,278	0.1468	High	1
140200030403	Barret Creek-Tomichi Creek	8,031	11,476	3,445	0.1055	Low	1.1
140200030404	Hot Springs Creek	8,031	11,476	3,445	0.0972	Low	1
140200030405	Wood Gulch-Tomichi Creek	7,920	10,486	2,566	0.0938	Low	1.1
140200030501	Headwaters Cochetopa Creek	9,364	14,009	4,646	0.1250	Moderate	1
140200030502	Pauline Creek	9,364	13,983	4,619	0.1360	Moderate	1
140200030503	Archuleta Creek	9,055	11,512	2,457	0.0608	Lowest	1
140200030504	Headwaters Los Pinos Creek	9,180	13,409	4,229	0.1132	Low	1
140200030505	Trail Creek-Cochetopa Creek	8,868	11,969	3,100	0.1105	Low	1.1

12 code HUC	Sixth-Level Watershed	Minimum Elevation	Maximum Elevation	Difference Elevation	Ruggedness	Ruggedness Rank	Adjustments
140200030506	Middle Cochetopa Creek	8,868	11,132	2,264	0.1257	Moderate	1.1
140200030507	West Pass Creek	8,842	11,391	2,549	0.0684	Lowest	1
140200030508	Rock Creek-Cochetopa Creek	8,291	11,995	3,704	0.1329	Moderate	1.1
140200030509	Outlet Cochetopa Creek	7,818	11,450	3,632	0.1102	Low	1.1
140200030601	Sewell Gulch-Tomichi Creek	7,802	10,568	2,766	0.1242	Moderate	1.1
140200030602	Cabin Creek	7,789	10,791	3,002	0.1431	High	1
140200030603	Long Gulch	7,779	9,741	1,962	0.0739	Lowest	1
140200030604	Stubbs Gulch	7,625	10,482	2,858	0.0861	Lowest	1
140200030605	Chance Gulch-Tomichi Creek	7,602	9,669	2,067	0.0711	Lowest	1.1

Appendix E
Post-Fire Debris Flow Hazard

Post-Fire Debris Flow Calculations

12 code HUC	Sixth-level Watershed Name	Debris Flow Likelihood (HL)	Rainfall needed for 50% Debris Flow Likelihood (Ht15)	Debris Flow Likelihood Metric	Debris Flow Likelihood Rank
140200010101	Upper Taylor River	0.461	6.27	0.46	High
140200010102	Trail Creek-Upper Taylor River	0.481	6.13	0.48	Highest
140200010103	Middle Taylor River	0.437	6.45	0.44	High
140200010104	Texas Creek	0.440	6.42	0.44	High
140200010105	Headwaters Willow Creek	0.474	6.18	0.47	High
140200010106	Outlet Willow Creek	0.442	6.41	0.44	High
140200010107	Taylor Park Reservoir	0.385	6.89	0.39	Moderate
140200010108	Lottis Creek	0.544	5.72	0.54	Highest
140200010109	Crystal Creek	0.491	6.06	0.49	Highest
140200010110	Rocky Brook-Spring Creek	0.510	5.93	0.51	Highest
140200010111	Bear Creek-Spring Creek	0.577	5.53	0.55	Highest
140200010112	Beaver Creek	0.346	7.27	0.35	Moderate
140200010113	Lower Taylor River	0.495	6.03	0.50	Highest
140200010201	Upper East River	0.471	6.20	0.47	High
140200010202	Brush Creek	0.519	5.88	0.52	Highest
140200010203	Middle East River	0.437	6.45	0.44	High
140200010204	Coal Creek	0.509	5.94	0.51	Highest
140200010205	Oh-be-Joyful Creek-Slate River	0.437	6.45	0.44	High
140200010206	Washington Gulch-Slate River	0.436	6.46	0.44	High
140200010207	Cement Creek	0.541	5.74	0.54	Highest
140200010208	Alkali Creek	0.321	7.56	0.32	Low
140200010209	Roaring Judy Creek	0.343	7.30	0.34	Moderate
140200010210	Lower East River	0.378	6.95	0.38	Moderate
140200020101	Upper Ohio Creek	0.444	6.40	0.44	High
140200020102	Castle Creek	0.544	5.72	0.54	Highest
140200020103	Carbon Creek	0.408	6.68	0.41	High
140200020104	Mill Creek	0.518	5.88	0.52	Highest
140200020105	Middle Ohio Creek	0.365	7.08	0.36	Moderate
140200020106	Lower Ohio Creek	0.232	8.94	0.23	Lowest
140200020107	Sheep Gulch-Gunnison River	0.225	9.10	0.23	Lowest
140200020201	Antelope Creek	0.278	8.13	0.28	Low
140200020202	Headwaters South Beaver Creek	0.275	8.18	0.28	Low
140200020203	Long Gulch-South Beaver Creek	0.191	9.95	0.19	Lowest
140200020204	Steers Gulch-Gunnison River	0.210	9.45	0.21	Lowest
140200020301	Headwaters Willow Creek	0.226	9.08	0.23	Lowest
140200020302	Sugar Creek-Willow Creek	0.182	10.22	0.18	Lowest
140200020401	Beaver Creek	0.536	5.77	0.54	Highest
140200020402	Steuben Creek	0.474	6.18	0.47	Highest
140200020403	Willow Creek-Blue Mesa Reservoir	0.219	9.23	0.22	Lowest
140200020501	Mill Creek-Brush Creek	0.361	7.12	0.36	Moderate
140200020502	Headwaters Cebolla Creek	0.364	7.09	0.36	Moderate
140200020503	Rough Creek-Cebolla Creek	0.386	6.88	0.39	Moderate
140200020504	Spring Creek	0.465	6.24	0.47	High
140200020505	Mineral Creek-Cebolla Creek	0.413	6.65	0.41	High

12 code HUC	Sixth-level Watershed Name	Debris Flow Likelihood (HL)	Rainfall needed for 50% Debris Flow Likelihood (Ht15)	Debris Flow Likelihood Metric	Debris Flow Likelihood Rank
140200020506	Rock Creek	0.292	7.94	0.29	Low
140200020507	Fish Canyon-Cebolla Creek	0.355	7.18	0.36	Moderate
140200020508	Powderhorn Creek	0.378	6.95	0.38	Moderate
140200020509	Road Beaver Creek-Cebolla Creek	0.304	7.78	0.30	Low
140200020510	Goose Creek-Cebolla Creek	0.247	8.65	0.25	Low
140200020511	Outlet Cebolla Creek	0.180	10.32	0.18	Lowest
140200020601	Headwaters Lake Fork	0.387	6.87	0.39	Moderate
140200020602	Lake Sanc Cristobal-Lake Fork	0.445	6.39	0.45	High
140200020603	North Fork Henson Creek-Henson Creek	0.414	6.64	0.41	High
140200020604	Nellie Creek-Henson Creek	0.499	6.01	0.50	Highest
140200020605	Larson Creek-Lake Fork	0.443	6.40	0.44	High
140200020606	Elk Creek-Lake Fork	0.423	6.56	0.42	High
140200020607	Trout Creek-Lake Fork	0.434	6.48	0.43	High
140200020608	Yeager Gulch-Lake Fork	0.296	7.88	0.30	Low
140200020609	Indian Creek	0.385	6.89	0.39	Moderate
140200020610	Willow Creek	0.300	7.82	0.30	Low
140200020611	Outlet Lake Fork	0.235	8.89	0.23	Lowest
140200020701	East Elk Creek	0.467	6.23	0.47	High
140200020702	Red Creek	0.371	7.03	0.37	Moderate
140200020703	West Elk Creek	0.582	5.50	0.55	Highest
140200020704	West Soap Creek-Soap Creek	0.604	5.38	0.55	Highest
140200020705	Cow Creek-Soap Creek	0.458	6.29	0.46	High
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	0.225	9.11	0.22	Lowest
140200020801	Headwaters Blue Creek	0.473	6.18	0.47	High
140200020802	Little Blue Creek	0.361	7.12	0.36	Moderate
140200021001	Pine Creek	0.294	7.90	0.29	Low
140200021003	Corral Creek-Gunnison River	0.384	6.90	0.38	Moderate
140200030101	Headwaters Tomichi Creek	0.462	6.26	0.46	High
140200030102	Agate Creek	0.475	6.17	0.47	Highest
140200030103	Marshall Creek	0.385	6.89	0.38	Moderate
140200030104	Long Branch Creek	0.385	6.89	0.38	Moderate
140200030105	Porphyry Creek-Tomichi Creek	0.344	7.30	0.34	Moderate
140200030201	Headwaters Razor Creek	0.381	6.93	0.38	Moderate
140200030202	Outlet Razor Creek	0.233	8.93	0.23	Lowest
140200030301	Upper Quartz Creek	0.498	6.01	0.50	Highest
140200030302	Gold Creek	0.531	5.80	0.53	Highest
140200030303	Middle Quartz Creek	0.578	5.52	0.55	Highest
140200030304	Alder Creek	0.325	7.51	0.33	Moderate
140200030305	Lower Quartz Creek	0.273	8.22	0.27	Low
140200030401	Owens Creek-Tomichi Creek	0.312	7.67	0.31	Low
140200030402	Needle Creek	0.399	6.77	0.40	High
140200030403	Barret Creek-Tomichi Creek	0.263	8.37	0.26	Low
140200030404	Hot Springs Creek	0.283	8.06	0.28	Low
140200030405	Wood Gulch-Tomichi Creek	0.203	9.62	0.20	Lowest
140200030501	Headwaters Cochetopa Creek	0.359	7.14	0.36	Moderate
140200030502	Pauline Creek	0.311	7.68	0.31	Low

12 code HUC	Sixth-level Watershed Name	Debris Flow Likelihood (HL)	Rainfall needed for 50% Debris Flow Likelihood (Ht15)	Debris Flow Likelihood Metric	Debris Flow Likelihood Rank
140200030503	Archuleta Creek	0.248	8.64	0.25	Low
140200030504	Headwaters Los Pinos Creek	0.333	7.42	0.33	Moderate
140200030505	Trail Creek-Cochetopa Creek	0.260	8.43	0.26	Low
140200030506	Middle Cochetopa Creek	0.265	8.35	0.26	Low
140200030507	West Pass Creek	0.258	8.46	0.26	Low
140200030508	Rock Creek-Cochetopa Creek	0.256	8.50	0.26	Low
140200030509	Outlet Cochetopa Creek	0.200	9.71	0.20	Lowest
140200030601	Sewell Gulch-Tomichi Creek	0.221	9.19	0.22	Lowest
140200030602	Cabin Creek	0.230	9.00	0.23	Lowest
140200030603	Long Gulch	0.171	10.61	0.17	Lowest
140200030604	Stubbs Gulch	0.188	10.05	0.19	Lowest
140200030605	Chance Gulch-Tomichi Creek	0.193	9.89	0.19	Lowest

Appendix F
Debris Flow Composite Hazard

Debris Flow Composite Calculations

12 code HUC	Sixth-level Watershed Name	Ruggedness	Post-Fire Debris Flow	Debris Flow Composite
140200010101	Upper Taylor River	Low	High	Low
140200010102	Trail Creek-Upper Taylor River	Highest	Highest	Highest
140200010103	Middle Taylor River	Highest	High	High
140200010104	Texas Creek	Moderate	High	High
140200010105	Headwaters Willow Creek	Moderate	High	Moderate
140200010106	Outlet Willow Creek	High	High	High
140200010107	Taylor Park Reservoir	Moderate	Moderate	Moderate
140200010108	Lottis Creek	Moderate	Highest	High
140200010109	Crystal Creek	Highest	Highest	Highest
140200010110	Rocky Brook-Spring Creek	Moderate	Highest	Moderate
140200010111	Bear Creek-Spring Creek	High	Highest	Highest
140200010112	Beaver Creek	High	Moderate	Moderate
140200010113	Lower Taylor River	High	Highest	High
140200010201	Upper East River	High	High	High
140200010202	Brush Creek	High	Highest	Highest
140200010203	Middle East River	Highest	High	Highest
140200010204	Coal Creek	High	Highest	High
140200010205	Oh-be-Joyful Creek-Slate River	High	High	High
140200010206	Washington Gulch-Slate River	High	High	High
140200010207	Cement Creek	High	Highest	High
140200010208	Alkali Creek	Highest	Low	High
140200010209	Roaring Judy Creek	Highest	Moderate	Highest
140200010210	Lower East River	High	Moderate	High
140200020101	Upper Ohio Creek	High	High	High
140200020102	Castle Creek	Highest	Highest	Highest
140200020103	Carbon Creek	High	High	High
140200020104	Mill Creek	Highest	Highest	Highest
140200020105	Middle Ohio Creek	High	Moderate	High
140200020106	Lower Ohio Creek	Low	Lowest	Lowest
140200020107	Sheep Gulch-Gunnison River	Low	Lowest	Lowest
140200020201	Antelope Creek	Moderate	Low	Low
140200020202	Headwaters South Beaver Creek	Low	Low	Low
140200020203	Long Gulch-South Beaver Creek	Low	Lowest	Lowest
140200020204	Steers Gulch-Gunnison River	Low	Lowest	Lowest
140200020301	Headwaters Willow Creek	Lowest	Lowest	Lowest
140200020302	Sugar Creek-Willow Creek	Low	Lowest	Lowest

12 code HUC	Sixth-level Watershed Name	Ruggedness	Post-Fire Debris Flow	Debris Flow Composite
140200020401	Beaver Creek	High	Highest	Highest
140200020402	Steuben Creek	Highest	Highest	Highest
140200020403	Willow Creek-Blue Mesa Reservoir	Low	Lowest	Lowest
140200020501	Mill Creek-Brush Creek	Low	Moderate	Low
140200020502	Headwaters Cebolla Creek	Moderate	Moderate	Moderate
140200020503	Rough Creek-Cebolla Creek	Highest	Moderate	Highest
140200020504	Spring Creek	High	High	High
140200020505	Mineral Creek-Cebolla Creek	Highest	High	High
140200020506	Rock Creek	Lowest	Low	Lowest
140200020507	Fish Canyon-Cebolla Creek	Low	Moderate	Low
140200020508	Powderhorn Creek	Moderate	Moderate	Moderate
140200020509	Road Beaver Creek-Cebolla Creek	Low	Low	Low
140200020510	Goose Creek-Cebolla Creek	Lowest	Low	Lowest
140200020511	Outlet Cebolla Creek	Low	Lowest	Lowest
140200020601	Headwaters Lake Fork	Moderate	Moderate	Moderate
140200020602	Lake Sanc Cristobal-Lake Fork	Highest	High	Highest
140200020603	North Fork Henson Creek-Henson Creek	Moderate	High	Moderate
140200020604	Nellie Creek-Henson Creek	Highest	Highest	Highest
140200020605	Larson Creek-Lake Fork	Highest	High	Highest
140200020606	Elk Creek-Lake Fork	High	High	High
140200020607	Trout Creek-Lake Fork	High	High	High
140200020608	Yeager Gulch-Lake Fork	High	Low	Moderate
140200020609	Indian Creek	Highest	Moderate	High
140200020610	Willow Creek	High	Low	Moderate
140200020611	Outlet Lake Fork	Lowest	Lowest	Lowest
140200020701	East Elk Creek	Highest	High	Highest
140200020702	Red Creek	Highest	Moderate	Highest
140200020703	West Elk Creek	Highest	Highest	Highest
140200020704	West Soap Creek-Soap Creek	Moderate	Highest	High
140200020705	Cow Creek-Soap Creek	High	High	High
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	Lowest	Lowest	Lowest
140200020801	Headwaters Blue Creek	High	High	High
140200020802	Little Blue Creek	Low	Moderate	Low
140200021001	Pine Creek	High	Low	Moderate
140200021003	Corral Creek-Gunnison River	Moderate	Moderate	Moderate
140200030101	Headwaters Tomichi Creek	High	High	High
140200030102	Agate Creek	Highest	Highest	Highest
140200030103	Marshall Creek	Low	Moderate	Low

12 code HUC	Sixth-level Watershed Name	Ruggedness	Post-Fire Debris Flow	Debris Flow Composite
140200030104	Long Branch Creek	Moderate	Moderate	Moderate
140200030105	Porphyry Creek-Tomichi Creek	High	Moderate	Moderate
140200030201	Headwaters Razor Creek	Low	Moderate	Low
140200030202	Outlet Razor Creek	High	Lowest	Moderate
140200030301	Upper Quartz Creek	Moderate	Highest	Moderate
140200030302	Gold Creek	High	Highest	Highest
140200030303	Middle Quartz Creek	High	Highest	Highest
140200030304	Alder Creek	Highest	Moderate	Highest
140200030305	Lower Quartz Creek	High	Low	Moderate
140200030401	Owens Creek-Tomichi Creek	High	Low	Moderate
140200030402	Needle Creek	High	High	High
140200030403	Barret Creek-Tomichi Creek	Low	Low	Low
140200030404	Hot Springs Creek	Low	Low	Low
140200030405	Wood Gulch-Tomichi Creek	Low	Lowest	Lowest
140200030501	Headwaters Cochetopa Creek	Moderate	Moderate	Moderate
140200030502	Pauline Creek	Moderate	Low	Moderate
140200030503	Archuleta Creek	Lowest	Low	Lowest
140200030504	Headwaters Los Pinos Creek	Low	Moderate	Low
140200030505	Trail Creek-Cochetopa Creek	Low	Low	Low
140200030506	Middle Cochetopa Creek	Moderate	Low	Low
140200030507	West Pass Creek	Lowest	Low	Lowest
140200030508	Rock Creek-Cochetopa Creek	Moderate	Low	Moderate
140200030509	Outlet Cochetopa Creek	Low	Lowest	Low
140200030601	Sewell Gulch-Tomichi Creek	Moderate	Lowest	Low
140200030602	Cabin Creek	High	Lowest	Moderate
140200030603	Long Gulch	Lowest	Lowest	Lowest
140200030604	Stubbs Gulch	Lowest	Lowest	Lowest
140200030605	Chance Gulch-Tomichi Creek	Lowest	Lowest	Lowest

Appendix G
Roads Composite Hazard

Roads Composite Calculations

12 code HUC	Sixth-level Watershed Name	Road Density Rank	Roads by Streams Rank	Road/Stream Crossing Rank	Roads Composite Rank
140200010101	Upper Taylor River	Moderate	Low	Lowest	Low
140200010102	Trail Creek-Upper Taylor River	High	Moderate	Highest	High
140200010103	Middle Taylor River	Highest	Moderate	Highest	Highest
140200010104	Texas Creek	Low	Moderate	Lowest	Low
140200010105	Headwaters Willow Creek	Highest	Highest	Highest	Highest
140200010106	Outlet Willow Creek	Highest	Moderate	Highest	Highest
140200010107	Taylor Park Reservoir	Highest	Lowest	Highest	High
140200010108	Lottis Creek	Low	Lowest	High	Moderate
140200010109	Crystal Creek	Lowest	Lowest	Lowest	Lowest
140200010110	Rocky Brook-Spring Creek	Highest	Moderate	High	Highest
140200010111	Bear Creek-Spring Creek	Lowest	Lowest	Lowest	Lowest
140200010112	Beaver Creek	Low	Lowest	Lowest	Lowest
140200010113	Lower Taylor River	Moderate	Highest	Highest	Highest
140200010201	Upper East River	Low	Low	Highest	Moderate
140200010202	Brush Creek	Low	Moderate	Highest	High
140200010203	Middle East River	Moderate	Lowest	High	Moderate
140200010204	Coal Creek	Highest	Highest	Highest	Highest
140200010205	Oh-be-Joyful Creek-Slate River	Moderate	Low	Lowest	Low
140200010206	Washington Gulch-Slate River	Highest	Moderate	Highest	Highest
140200010207	Cement Creek	Moderate	Highest	Highest	Highest
140200010208	Alkali Creek	Lowest	Low	Low	Low
140200010209	Roaring Judy Creek	Highest	Low	Highest	Highest
140200010210	Lower East River	Highest	Moderate	Moderate	High
140200020101	Upper Ohio Creek	Low	Low	High	Moderate
140200020102	Castle Creek	Lowest	Lowest	Lowest	Lowest
140200020103	Carbon Creek	Moderate	Highest	High	High
140200020104	Mill Creek	Low	Moderate	High	Moderate
140200020105	Middle Ohio Creek	Low	Low	Moderate	Moderate
140200020106	Lower Ohio Creek	High	Moderate	High	High
140200020107	Sheep Gulch-Gunnison River	Highest	High	High	Highest
140200020201	Antelope Creek	Moderate	Moderate	Moderate	Moderate
140200020202	Headwaters South Beaver Creek	Lowest	Lowest	Lowest	Lowest
140200020203	Long Gulch-South Beaver Creek	Low	Lowest	Lowest	Low
140200020204	Steers Gulch-Gunnison River	Highest	Highest	High	Highest
140200020301	Headwaters Willow Creek	Low	Low	Lowest	Low
140200020302	Sugar Creek-Willow Creek	Moderate	Highest	Low	High
140200020401	Beaver Creek	Lowest	Lowest	Lowest	Lowest
140200020402	Steuben Creek	Low	Highest	High	High

12 code HUC	Sixth-level Watershed Name	Road Density Rank	Roads by Streams Rank	Road/Stream Crossing Rank	Roads Composite Rank
140200020403	Willow Creek-Blue Mesa Reservoir	High	Moderate	Moderate	High
140200020501	Mill Creek-Brush Creek	Low	Low	Moderate	Low
140200020502	Headwaters Cebolla Creek	Moderate	Lowest	High	Moderate
140200020503	Rough Creek-Cebolla Creek	Lowest	High	Lowest	Low
140200020504	Spring Creek	Low	Lowest	Lowest	Lowest
140200020505	Mineral Creek-Cebolla Creek	Lowest	Low	Moderate	Low
140200020506	Rock Creek	Lowest	Lowest	Lowest	Lowest
140200020507	Fish Canyon-Cebolla Creek	Low	Highest	Highest	High
140200020508	Powderhorn Creek	Low	Lowest	Lowest	Lowest
140200020509	Road Beaver Creek-Cebolla Creek	Moderate	High	Low	Moderate
140200020510	Goose Creek-Cebolla Creek	High	Moderate	Low	Moderate
140200020511	Outlet Cebolla Creek	Low	Low	Low	Low
140200020601	Headwaters Lake Fork	Low	Moderate	High	Moderate
140200020602	Lake Sanc Cristobal-Lake Fork	Moderate	Moderate	Highest	High
140200020603	North Fork Henson Creek-Henson Creek	Low	Highest	Moderate	High
140200020604	Nellie Creek-Henson Creek	Lowest	Highest	Low	Moderate
140200020605	Larson Creek-Lake Fork	High	High	Moderate	High
140200020606	Elk Creek-Lake Fork	Low	High	Low	Moderate
140200020607	Trout Creek-Lake Fork	Low	Low	Low	Low
140200020608	Yeager Gulch-Lake Fork	Moderate	Low	Highest	High
140200020609	Indian Creek	Moderate	Low	Moderate	Moderate
140200020610	Willow Creek	Highest	Moderate	Highest	Highest
140200020611	Outlet Lake Fork	High	Moderate	Lowest	Moderate
140200020701	East Elk Creek	Moderate	Lowest	Low	Low
140200020702	Red Creek	High	Highest	Moderate	Highest
140200020703	West Elk Creek	Lowest	Lowest	Lowest	Lowest
140200020704	West Soap Creek-Soap Creek	Lowest	Lowest	Lowest	Lowest
140200020705	Cow Creek-Soap Creek	Low	High	Lowest	Moderate
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	High	Low	Lowest	Low
140200020801	Headwaters Blue Creek	Lowest	Lowest	Lowest	Lowest
140200020802	Little Blue Creek	Highest	Moderate	Low	High
140200021001	Pine Creek	Low	Lowest	Lowest	Low
140200021003	Corral Creek-Gunnison River	Moderate	Moderate	Moderate	Moderate
140200030101	Headwaters Tomichi Creek	High	Highest	Highest	Highest
140200030102	Agate Creek	Moderate	Lowest	Lowest	Low
140200030103	Marshall Creek	High	High	Low	High
140200030104	Long Branch Creek	Lowest	Highest	Lowest	Low
140200030105	Porphyry Creek-Tomichi Creek	High	High	Moderate	High
140200030201	Headwaters Razor Creek	Moderate	Lowest	Lowest	Low

12 code HUC	Sixth-level Watershed Name	Road Density Rank	Roads by Streams Rank	Road/Stream Crossing Rank	Roads Composite Rank
140200030202	Outlet Razor Creek	Highest	Low	Low	Moderate
140200030301	Upper Quartz Creek	Highest	Highest	High	Highest
140200030302	Gold Creek	Highest	Highest	Highest	Highest
140200030303	Middle Quartz Creek	Highest	Highest	Highest	Highest
140200030304	Alder Creek	Moderate	Low	Low	Moderate
140200030305	Lower Quartz Creek	High	Highest	Highest	Highest
140200030401	Owens Creek-Tomichi Creek	Low	High	Low	Moderate
140200030402	Needle Creek	Lowest	Low	Lowest	Low
140200030403	Barret Creek-Tomichi Creek	High	Lowest	Low	Low
140200030404	Hot Springs Creek	Highest	Highest	High	Highest
140200030405	Wood Gulch-Tomichi Creek	High	High	Moderate	High
140200030501	Headwaters Cochetopa Creek	Lowest	Lowest	Lowest	Lowest
140200030502	Pauline Creek	High	Lowest	Moderate	Moderate
140200030503	Archuleta Creek	High	Moderate	Moderate	High
140200030504	Headwaters Los Pinos Creek	High	Low	Moderate	Moderate
140200030505	Trail Creek-Cochetopa Creek	Low	Low	Low	Low
140200030506	Middle Cochetopa Creek	Moderate	Moderate	Low	Moderate
140200030507	West Pass Creek	Highest	Moderate	High	Highest
140200030508	Rock Creek-Cochetopa Creek	Moderate	High	Lowest	Moderate
140200030509	Outlet Cochetopa Creek	High	High	Lowest	Moderate
140200030601	Sewell Gulch-Tomichi Creek	High	Moderate	Moderate	High
140200030602	Cabin Creek	Moderate	Highest	High	High
140200030603	Long Gulch	High	High	High	High
140200030604	Stubbs Gulch	High	Moderate	Lowest	Moderate
140200030605	Chance Gulch-Tomichi Creek	Highest	Low	Low	Moderate

Appendix H
Soil Erodibility Hazard

Soil Erodibility Calculations

12 code HUC	Sixth-level Watershed Name	Moderate (acres)	Moderate (%)	Severe (acres)	Severe (%)	Very Severe (acres)	Very Severe (%)	Soil Erodibility Rank
140200010101	Upper Taylor River	8,834.1	22.2%	3,705.2	9.3%	120.2	0.3%	Low
140200010102	Trail Creek-Upper Taylor River	4,884.4	26.5%	1,294.1	7.0%	20.3	0.1%	Low
140200010103	Middle Taylor River	4,426.6	18.6%	607.3	2.6%	56.9	0.2%	Lowest
140200010104	Texas Creek	7,133.1	27.5%	2,849.8	11.0%	64.0	0.2%	Moderate
140200010105	Headwaters Willow Creek	4,596.5	28.6%	959.7	6.0%	84.7	0.5%	Low
140200010106	Outlet Willow Creek	4,611.7	18.8%	746.7	3.0%	17.0	0.1%	Lowest
140200010107	Taylor Park Reservoir	1,512.2	12.6%	234.6	2.0%	0.0	0.0%	Lowest
140200010108	Lottis Creek	6,872.4	25.5%	3,527.8	13.1%	0.2	0.0%	Moderate
140200010109	Crystal Creek	1,896.7	13.2%	635.9	4.4%	0.0	0.0%	Lowest
140200010110	Rocky Brook-Spring Creek	7,565.3	36.3%	2,135.6	10.3%	481.8	2.3%	High
140200010111	Bear Creek-Spring Creek	9,311.3	40.3%	4,412.3	19.1%	1,948.0	8.4%	Highest
140200010112	Beaver Creek	3,432.5	18.8%	514.3	2.8%	0.0	0.0%	Lowest
140200010113	Lower Taylor River	6,257.7	15.9%	3,450.4	8.8%	521.0	1.3%	Low
140200010201	Upper East River	7,439.6	43.3%	2,242.4	13.0%	2,784.2	16.2%	Highest
140200010202	Brush Creek	8,700.2	35.6%	5,057.7	20.7%	6,061.2	24.8%	Highest
140200010203	Middle East River	5,603.3	33.6%	2,828.6	17.0%	1,713.5	10.3%	Highest
140200010204	Coal Creek	5,191.7	39.5%	2,562.4	19.5%	766.8	5.8%	Highest
140200010205	Oh-be-Joyful Creek-Slate River	7,144.9	33.3%	1,817.0	8.5%	563.4	2.6%	Moderate
140200010206	Washington Gulch-Slate River	6,244.7	27.2%	4,343.7	18.9%	1,089.5	4.7%	High
140200010207	Cement Creek	6,704.3	29.3%	4,382.6	19.2%	1,562.1	6.8%	Highest
140200010208	Alkali Creek	3,356.1	35.5%	623.0	6.6%	205.0	2.2%	Moderate
140200010209	Roaring Judy Creek	3,376.6	36.7%	724.6	7.9%	44.7	0.5%	Moderate
140200010210	Lower East River	10,940.4	39.4%	2,724.0	9.8%	1,100.3	4.0%	High
140200020101	Upper Ohio Creek	5,468.9	35.3%	3,454.1	22.3%	237.8	1.5%	Highest
140200020102	Castle Creek	4,709.5	32.3%	5,058.8	34.7%	892.2	6.1%	Highest
140200020103	Carbon Creek	4,717.0	29.4%	4,405.8	27.4%	431.5	2.7%	Highest
140200020104	Mill Creek	2,596.6	24.3%	3,314.2	31.1%	1,094.6	10.3%	Highest
140200020105	Middle Ohio Creek	5,928.4	30.4%	2,188.0	11.2%	695.7	3.6%	High
140200020106	Lower Ohio Creek	5,066.0	17.2%	640.8	2.2%	210.1	0.7%	Lowest
140200020107	Sheep Gulch-Gunnison River	6,143.7	23.4%	812.3	3.1%	214.3	0.8%	Low
140200020201	Antelope Creek	5,401.1	25.7%	2,187.0	10.4%	581.9	2.8%	Moderate
140200020202	Headwaters South Beaver Creek	1,444.7	6.7%	286.9	1.3%	31.0	0.1%	Lowest
140200020203	Long Gulch-South Beaver Creek	2,896.1	13.3%	482.1	2.2%	101.8	0.5%	Lowest
140200020204	Steers Gulch-Gunnison River	4,776.5	25.4%	338.3	1.8%	137.5	0.7%	Low
140200020301	Headwaters Willow Creek	1,663.1	8.3%	217.3	1.1%	2.6	0.0%	Lowest
140200020302	Sugar Creek-Willow Creek	1,650.5	6.2%	150.3	0.6%	44.6	0.2%	Lowest
140200020401	Beaver Creek	3,708.6	16.0%	5,118.0	22.1%	5,137.1	22.2%	Highest
140200020402	Steuben Creek	3,841.9	23.3%	4,077.5	24.7%	2,570.0	15.6%	Highest
140200020403	Willow Creek-Blue Mesa Reservoir	6,060.0	15.3%	2,876.9	7.3%	684.2	1.7%	Low
140200020501	Mill Creek-Brush Creek	5,917.9	31.0%	1,338.1	7.0%	339.2	1.8%	Moderate
140200020502	Headwaters Cebolla Creek	5,846.7	30.3%	1,186.6	6.1%	199.6	1.0%	Moderate
140200020503	Rough Creek-Cebolla Creek	6,971.4	37.4%	1,570.8	8.4%	403.9	2.2%	Moderate
140200020504	Spring Creek	7,638.7	32.9%	2,592.8	11.2%	2,712.3	11.7%	Highest

12 code HUC	Sixth-level Watershed Name	Moderate (acres)	Moderate (%)	Severe (acres)	Severe (%)	Very Severe (acres)	Very Severe (%)	Soil Erodibility Rank
140200020505	Mineral Creek-Cebolla Creek	9,829.5	33.8%	2,947.0	10.1%	1,526.2	5.2%	High
140200020506	Rock Creek	1,513.9	5.8%	960.4	3.7%	438.1	1.7%	Lowest
140200020507	Fish Canyon-Cebolla Creek	6,851.3	32.3%	3,128.2	14.7%	686.3	3.2%	High
140200020508	Powderhorn Creek	8,942.6	25.4%	4,549.7	12.9%	1,305.8	3.7%	Moderate
140200020509	Road Beaver Creek-Cebolla Creek	7,666.8	30.1%	2,650.9	10.4%	236.2	0.9%	Moderate
140200020510	Goose Creek-Cebolla Creek	2,336.6	13.2%	2,272.2	12.8%	462.8	2.6%	Moderate
140200020511	Outlet Cebolla Creek	1,306.3	8.9%	497.9	3.4%	355.7	2.4%	Lowest
140200020601	Headwaters Lake Fork	5,212.6	14.2%	3,441.5	9.4%	1,480.1	4.0%	Moderate
140200020602	Lake Sanc Cristobal-Lake Fork	4,027.9	12.8%	2,033.3	6.5%	655.1	2.1%	Low
140200020603	North Fork Henson Creek-Henson Creek	3,979.2	17.5%	1,907.8	8.4%	1,230.7	5.4%	Moderate
140200020604	Nellie Creek-Henson Creek	3,773.5	12.3%	1,859.3	6.0%	1,208.3	3.9%	Low
140200020605	Larson Creek-Lake Fork	7,647.0	30.9%	4,236.2	17.1%	1,327.7	5.4%	High
140200020606	Elk Creek-Lake Fork	9,271.2	26.0%	5,554.3	15.6%	3,348.7	9.4%	Highest
140200020607	Trout Creek-Lake Fork	7,954.4	32.3%	5,547.2	22.5%	1,744.3	7.1%	Highest
140200020608	Yeager Gulch-Lake Fork	2,480.1	23.6%	1,228.2	11.7%	93.0	0.9%	Moderate
140200020609	Indian Creek	5,662.1	42.4%	2,123.6	15.9%	184.0	1.4%	High
140200020610	Willow Creek	1,885.3	12.7%	494.5	3.3%	175.1	1.2%	Lowest
140200020611	Outlet Lake Fork	4,244.9	13.6%	2,485.4	8.0%	784.4	2.5%	Low
140200020701	East Elk Creek	2,830.5	20.0%	1,632.6	11.5%	1,931.9	13.6%	Highest
140200020702	Red Creek	1,116.4	12.3%	1,408.4	15.5%	1,330.0	14.6%	Highest
140200020703	West Elk Creek	7,040.8	35.9%	3,779.6	19.3%	3,565.9	18.2%	Highest
140200020704	West Soap Creek-Soap Creek	6,289.1	22.2%	10,696.5	37.7%	5,497.7	19.4%	Highest
140200020705	Cow Creek-Soap Creek	5,942.2	24.6%	3,150.1	13.0%	4,618.5	19.1%	Highest
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	5,804.0	22.1%	1,563.3	5.9%	1,045.7	4.0%	Moderate
140200020801	Headwaters Blue Creek	2,797.0	10.4%	624.1	2.3%	259.2	1.0%	Lowest
140200020802	Little Blue Creek	3,930.2	17.6%	1,183.5	5.3%	195.2	0.9%	Low
140200021001	Pine Creek	2,415.8	14.0%	489.5	2.8%	148.0	0.9%	Lowest
140200021003	Corral Creek-Gunnison River	4,910.6	37.1%	2,012.8	15.2%	521.3	3.9%	High
140200030101	Headwaters Tomichi Creek	4,968.2	27.6%	998.3	5.6%	71.8	0.4%	Low
140200030102	Agate Creek	3,422.6	22.6%	734.2	4.9%	22.5	0.1%	Low
140200030103	Marshall Creek	6,124.9	16.7%	2,840.9	7.7%	657.6	1.8%	Low
140200030104	Long Branch Creek	1,263.9	8.2%	21.2	0.1%	45.6	0.3%	Lowest
140200030105	Porphyry Creek-Tomichi Creek	4,976.9	19.8%	889.3	3.5%	49.4	0.2%	Low
140200030201	Headwaters Razor Creek	3,266.1	13.2%	364.4	1.5%	144.3	0.6%	Lowest
140200030202	Outlet Razor Creek	3,612.1	19.2%	330.7	1.8%	71.9	0.4%	Lowest
140200030301	Upper Quartz Creek	8,973.7	34.7%	4,241.5	16.4%	264.3	1.0%	High
140200030302	Gold Creek	5,973.3	30.9%	3,483.8	18.0%	452.7	2.3%	High
140200030303	Middle Quartz Creek	6,930.9	38.8%	3,971.4	22.2%	2,625.4	14.7%	Highest
140200030304	Alder Creek	2,659.5	24.2%	923.9	8.4%	206.9	1.9%	Moderate
140200030305	Lower Quartz Creek	5,076.4	33.3%	1,454.8	9.5%	375.5	2.5%	Moderate
140200030401	Owens Creek-Tomichi Creek	3,602.4	15.5%	895.8	3.9%	86.5	0.4%	Lowest
140200030402	Needle Creek	2,656.6	23.2%	437.4	3.8%	132.3	1.2%	Low
140200030403	Barret Creek-Tomichi Creek	8,629.4	26.5%	760.6	2.3%	66.8	0.2%	Low
140200030404	Hot Springs Creek	5,756.0	19.9%	653.0	2.3%	71.9	0.2%	Lowest
140200030405	Wood Gulch-Tomichi Creek	4,197.3	18.4%	498.9	2.2%	61.6	0.3%	Lowest

12 code HUC	Sixth-level Watershed Name	Moderate (acres)	Moderate (%)	Severe (acres)	Severe (%)	Very Severe (acres)	Very Severe (%)	Soil Erodibility Rank
140200030501	Headwaters Cochetopa Creek	8,728.4	27.5%	2,231.7	7.0%	1,629.7	5.1%	Moderate
140200030502	Pauline Creek	1,315.3	5.0%	258.6	1.0%	94.6	0.4%	Lowest
140200030503	Archuleta Creek	1,909.9	5.1%	557.5	1.5%	140.7	0.4%	Lowest
140200030504	Headwaters Los Pinos Creek	4,971.1	15.5%	1,026.8	3.2%	143.3	0.4%	Lowest
140200030505	Trail Creek-Cochetopa Creek	4,280.7	17.8%	770.1	3.2%	35.0	0.1%	Lowest
140200030506	Middle Cochetopa Creek	1,309.7	13.2%	106.4	1.1%	17.6	0.2%	Lowest
140200030507	West Pass Creek	2,234.3	7.0%	591.4	1.9%	65.1	0.2%	Lowest
140200030508	Rock Creek-Cochetopa Creek	4,289.4	18.1%	607.0	2.6%	366.9	1.5%	Low
140200030509	Outlet Cochetopa Creek	5,302.0	16.0%	808.7	2.4%	193.8	0.6%	Lowest
140200030601	Sewell Gulch-Tomichi Creek	4,049.1	26.7%	746.4	4.9%	74.3	0.5%	Low
140200030602	Cabin Creek	2,468.8	24.4%	272.0	2.7%	9.4	0.1%	Low
140200030603	Long Gulch	1,142.7	7.1%	116.6	0.7%	4.4	0.0%	Lowest
140200030604	Stubbs Gulch	3,093.4	12.2%	494.2	2.0%	81.5	0.3%	Lowest
140200030605	Chance Gulch-Tomichi Creek	4,720.3	18.3%	296.7	1.1%	92.2	0.4%	Lowest

Appendix I
Wildfire Composite Hazard

Wildfire Composite Hazard Calculations

12 code HUC	Sixth-level Watershed Name	Wildfire Hazard	Roads Composite	Debris Flow Composite	Soils/Geology	Composite Hazard Rank
140200010101	Upper Taylor River	High	Low	Low	Moderate	Moderate
140200010102	Trail Creek-Upper Taylor River	Moderate	Highest	High	Moderate	High
140200010103	Middle Taylor River	Moderate	High	Highest	Low	High
140200010104	Texas Creek	High	High	Low	High	Moderate
140200010105	Headwaters Willow Creek	High	Moderate	Highest	Moderate	Highest
140200010106	Outlet Willow Creek	Highest	High	Highest	Low	High
140200010107	Taylor Park Reservoir	Moderate	Moderate	High	Low	Moderate
140200010108	Lottis Creek	High	High	Moderate	High	High
140200010109	Crystal Creek	Highest	Highest	Lowest	Low	High
140200010110	Rocky Brook-Spring Creek	Highest	Moderate	Highest	High	Highest
140200010111	Bear Creek-Spring Creek	Highest	Highest	Lowest	Highest	Highest
140200010112	Beaver Creek	Moderate	Moderate	Lowest	Low	Moderate
140200010113	Lower Taylor River	High	High	Highest	Moderate	Highest
140200010201	Upper East River	Low	High	Moderate	Highest	High
140200010202	Brush Creek	Moderate	Highest	High	Highest	Highest
140200010203	Middle East River	Low	Highest	Moderate	Highest	High
140200010204	Coal Creek	Highest	High	Highest	Highest	Highest
140200010205	Oh-be-Joyful Creek-Slate River	Low	High	Low	Moderate	Moderate
140200010206	Washington Gulch-Slate River	Moderate	High	Highest	High	High
140200010207	Cement Creek	High	High	Highest	Highest	Highest
140200010208	Alkali Creek	Lowest	High	Low	Moderate	Low
140200010209	Roaring Judy Creek	Moderate	Highest	Highest	High	High
140200010210	Lower East River	Low	High	High	High	High
140200020101	Upper Ohio Creek	Highest	High	Moderate	Highest	Highest
140200020102	Castle Creek	High	Highest	Lowest	Highest	High
140200020103	Carbon Creek	Moderate	High	High	Highest	Highest
140200020104	Mill Creek	High	Highest	Moderate	Highest	Highest
140200020105	Middle Ohio Creek	Moderate	High	Moderate	Moderate	Moderate
140200020106	Lower Ohio Creek	Lowest	Lowest	High	Lowest	Lowest
140200020107	Sheep Gulch-Gunnison River	Lowest	Lowest	Highest	Low	Low
140200020201	Antelope Creek	Low	Low	Moderate	Moderate	Moderate
140200020202	Headwaters South Beaver Creek	High	Low	Lowest	Lowest	Lowest
140200020203	Long Gulch-South Beaver Creek	Lowest	Lowest	Low	Lowest	Lowest
140200020204	Steers Gulch-Gunnison River	Lowest	Lowest	Highest	Low	Low
140200020301	Headwaters Willow Creek	Low	Lowest	Low	Lowest	Lowest
140200020302	Sugar Creek-Willow Creek	Lowest	Lowest	High	Lowest	Lowest
140200020401	Beaver Creek	High	Highest	Lowest	Highest	High
140200020402	Steuben Creek	High	Highest	High	Highest	Highest
140200020403	Willow Creek-Blue Mesa Reservoir	Lowest	Lowest	High	Low	Low
140200020501	Mill Creek-Brush Creek	High	Low	Low	Moderate	Moderate
140200020502	Headwaters Cebolla Creek	High	Moderate	Moderate	Moderate	Moderate

12 code HUC	Sixth-level Watershed Name	Wildfire Hazard	Roads Composite	Debris Flow Composite	Soils/Geology	Composite Hazard Rank
140200020503	Rough Creek-Cebolla Creek	High	Highest	Low	Moderate	High
140200020504	Spring Creek	Highest	High	Lowest	Highest	High
140200020505	Mineral Creek-Cebolla Creek	High	High	Low	High	High
140200020506	Rock Creek	High	Lowest	Lowest	Lowest	Lowest
140200020507	Fish Canyon-Cebolla Creek	Moderate	Low	High	High	High
140200020508	Powderhorn Creek	Highest	Moderate	Lowest	Moderate	Moderate
140200020509	Road Beaver Creek-Cebolla Creek	Moderate	Low	Moderate	High	Moderate
140200020510	Goose Creek-Cebolla Creek	Low	Lowest	Moderate	Moderate	Low
140200020511	Outlet Cebolla Creek	Lowest	Lowest	Low	Lowest	Lowest
140200020601	Headwaters Lake Fork	Low	Moderate	Moderate	Moderate	Moderate
140200020602	Lake Sanc Cristobal-Lake Fork	High	Highest	High	Low	High
140200020603	North Fork Henson Creek-Henson Creek	Lowest	Moderate	High	Moderate	Moderate
140200020604	Nellie Creek-Henson Creek	Moderate	Highest	Moderate	Low	Moderate
140200020605	Larson Creek-Lake Fork	High	Highest	High	High	Highest
140200020606	Elk Creek-Lake Fork	Moderate	High	Moderate	Highest	High
140200020607	Trout Creek-Lake Fork	High	High	Low	Highest	Highest
140200020608	Yeager Gulch-Lake Fork	Moderate	Moderate	High	Moderate	Moderate
140200020609	Indian Creek	Highest	High	Moderate	High	High
140200020610	Willow Creek	Moderate	Moderate	Highest	Lowest	Moderate
140200020611	Outlet Lake Fork	Low	Lowest	Moderate	Low	Lowest
140200020701	East Elk Creek	Moderate	Highest	Low	Highest	High
140200020702	Red Creek	Moderate	Highest	Highest	Highest	Highest
140200020703	West Elk Creek	High	Highest	Lowest	Highest	Highest
140200020704	West Soap Creek-Soap Creek	Highest	High	Lowest	Highest	High
140200020705	Cow Creek-Soap Creek	High	High	Moderate	Highest	Highest
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	Lowest	Lowest	Low	Moderate	Lowest
140200020801	Headwaters Blue Creek	High	High	Lowest	Lowest	Low
140200020802	Little Blue Creek	High	Low	High	Low	Moderate
140200021001	Pine Creek	Low	Moderate	Low	Lowest	Low
140200021003	Corral Creek-Gunnison River	Lowest	Moderate	Moderate	High	Moderate
140200030101	Headwaters Tomichi Creek	Highest	High	Highest	Moderate	Highest
140200030102	Agate Creek	Highest	Highest	Low	Moderate	High
140200030103	Marshall Creek	Highest	Low	High	Low	High
140200030104	Long Branch Creek	Highest	Moderate	Low	Lowest	Moderate
140200030105	Porphyry Creek-Tomichi Creek	Highest	Moderate	High	Moderate	High
140200030201	Headwaters Razor Creek	Highest	Low	Low	Lowest	Low
140200030202	Outlet Razor Creek	Lowest	Moderate	Moderate	Lowest	Low
140200030301	Upper Quartz Creek	Highest	Moderate	Highest	High	Highest
140200030302	Gold Creek	Highest	Highest	Highest	High	Highest
140200030303	Middle Quartz Creek	High	Highest	Highest	Highest	Highest
140200030304	Alder Creek	Moderate	Highest	Moderate	Moderate	High
140200030305	Lower Quartz Creek	Low	Moderate	Highest	High	High

12 code HUC	Sixth-level Watershed Name	Wildfire Hazard	Roads Composite	Debris Flow Composite	Soils/Geology	Composite Hazard Rank
140200030401	Owens Creek-Tomichi Creek	Highest	Moderate	Moderate	Low	High
140200030402	Needle Creek	High	High	Low	Low	Moderate
140200030403	Barret Creek-Tomichi Creek	Low	Low	Low	Low	Low
140200030404	Hot Springs Creek	Moderate	Low	Highest	Low	Moderate
140200030405	Wood Gulch-Tomichi Creek	Lowest	Lowest	High	Low	Lowest
140200030501	Headwaters Cochetopa Creek	Moderate	Moderate	Lowest	Moderate	Low
140200030502	Pauline Creek	High	Moderate	Moderate	Lowest	Low
140200030503	Archuleta Creek	Moderate	Lowest	High	Lowest	Low
140200030504	Headwaters Los Pinos Creek	Highest	Low	Moderate	Lowest	Moderate
140200030505	Trail Creek-Cochetopa Creek	Low	Low	Low	Lowest	Lowest
140200030506	Middle Cochetopa Creek	Low	Low	Moderate	Lowest	Low
140200030507	West Pass Creek	Moderate	Lowest	Highest	Lowest	Low
140200030508	Rock Creek-Cochetopa Creek	Low	Moderate	Moderate	Low	Low
140200030509	Outlet Cochetopa Creek	Lowest	Low	Moderate	Lowest	Lowest
140200030601	Sewell Gulch-Tomichi Creek	Lowest	Low	High	Low	Low
140200030602	Cabin Creek	Lowest	Moderate	High	Low	Low
140200030603	Long Gulch	Lowest	Lowest	High	Lowest	Lowest
140200030604	Stubbs Gulch	Lowest	Lowest	Moderate	Lowest	Lowest
140200030605	Chance Gulch-Tomichi Creek	Lowest	Lowest	Moderate	Lowest	Lowest

Appendix J
Ecosystem Sensitivity

Ecosystem Sensitivity Calculations

12 code HUC	Sixth-level Watershed Name	Landscape Condition	Fire Regime Departure	Insect & Disease	Ecosystem Sensitivity Rank
140200010101	Upper Taylor River	Lowest	Lowest	High	Low
140200010102	Trail Creek-Upper Taylor River	Low	Moderate	Highest	High
140200010103	Middle Taylor River	Low	High	Highest	Highest
140200010104	Texas Creek	Lowest	Low	Highest	Moderate
140200010105	Headwaters Willow Creek	Low	Lowest	Highest	Moderate
140200010106	Outlet Willow Creek	Moderate	High	Highest	Highest
140200010107	Taylor Park Reservoir	Highest	Highest	Highest	Highest
140200010108	Lottis Creek	Lowest	Moderate	Highest	High
140200010109	Crystal Creek	Lowest	Low	Highest	Moderate
140200010110	Rocky Brook-Spring Creek	Low	Lowest	Highest	Moderate
140200010111	Bear Creek-Spring Creek	Lowest	Moderate	Highest	High
140200010112	Beaver Creek	Lowest	High	Moderate	Moderate
140200010113	Lower Taylor River	High	High	Highest	Highest
140200010201	Upper East River	Moderate	Lowest	Lowest	Low
140200010202	Brush Creek	Lowest	Lowest	Low	Lowest
140200010203	Middle East River	Moderate	Low	Lowest	Low
140200010204	Coal Creek	Highest	Low	Low	High
140200010205	Oh-be-Joyful Creek-Slate River	Low	Low	Lowest	Low
140200010206	Washington Gulch-Slate River	Highest	Low	Low	High
140200010207	Cement Creek	Low	Low	Low	Low
140200010208	Alkali Creek	Low	Highest	Lowest	Low
140200010209	Roaring Judy Creek	High	High	Moderate	High
140200010210	Lower East River	Highest	High	Low	High
140200020101	Upper Ohio Creek	Lowest	Low	Moderate	Low
140200020102	Castle Creek	Lowest	Lowest	Moderate	Lowest
140200020103	Carbon Creek	Lowest	Moderate	Low	Low
140200020104	Mill Creek	Low	Low	Moderate	Low
140200020105	Middle Ohio Creek	Moderate	High	Lowest	Moderate
140200020106	Lower Ohio Creek	Highest	Moderate	Lowest	Moderate
140200020107	Sheep Gulch-Gunnison River	Highest	High	Lowest	High
140200020201	Antelope Creek	Moderate	Highest	Low	High
140200020202	Headwaters South Beaver Creek	Lowest	Moderate	Moderate	Low
140200020203	Long Gulch-South Beaver Creek	Low	Highest	Lowest	Moderate
140200020204	Steers Gulch-Gunnison River	Highest	High	Lowest	High
140200020301	Headwaters Willow Creek	Low	Highest	Lowest	Moderate
140200020302	Sugar Creek-Willow Creek	Moderate	Highest	Lowest	Moderate

12 code HUC	Sixth-level Watershed Name	Landscape Condition	Fire Regime Departure	Insect & Disease	Ecosystem Sensitivity Rank
140200020401	Beaver Creek	Lowest	Moderate	High	Moderate
140200020402	Steuben Creek	Low	Moderate	Moderate	Moderate
140200020403	Willow Creek-Blue Mesa Reservoir	Highest	Highest	Lowest	Highest
140200020501	Mill Creek-Brush Creek	Low	Lowest	High	Low
140200020502	Headwaters Cebolla Creek	Moderate	Lowest	High	Moderate
140200020503	Rough Creek-Cebolla Creek	Lowest	Low	Moderate	Low
140200020504	Spring Creek	Lowest	Low	Highest	Moderate
140200020505	Mineral Creek-Cebolla Creek	Lowest	Low	High	Moderate
140200020506	Rock Creek	Low	Highest	Low	High
140200020507	Fish Canyon-Cebolla Creek	High	High	Moderate	Highest
140200020508	Powderhorn Creek	Low	Moderate	Moderate	Moderate
140200020509	Road Beaver Creek-Cebolla Creek	Highest	High	Low	Highest
140200020510	Goose Creek-Cebolla Creek	Highest	Highest	Lowest	High
140200020511	Outlet Cebolla Creek	Highest	High	Lowest	High
140200020601	Headwaters Lake Fork	Lowest	Lowest	Low	Lowest
140200020602	Lake Sanc Cristobal-Lake Fork	Low	Lowest	Moderate	Low
140200020603	North Fork Henson Creek-Henson Creek	Lowest	Lowest	Low	Lowest
140200020604	Nellie Creek-Henson Creek	Lowest	Lowest	High	Low
140200020605	Larson Creek-Lake Fork	High	Moderate	High	High
140200020606	Elk Creek-Lake Fork	Low	Low	High	High
140200020607	Trout Creek-Lake Fork	Moderate	High	Highest	Highest
140200020608	Yeager Gulch-Lake Fork	Highest	Highest	Lowest	Highest
140200020609	Indian Creek	High	High	Moderate	High
140200020610	Willow Creek	Moderate	High	Moderate	High
140200020611	Outlet Lake Fork	High	Highest	Lowest	High
140200020701	East Elk Creek	Low	High	High	High
140200020702	Red Creek	Moderate	High	Low	Moderate
140200020703	West Elk Creek	Lowest	Moderate	High	Moderate
140200020704	West Soap Creek-Soap Creek	Lowest	Low	High	Low
140200020705	Cow Creek-Soap Creek	Low	High	Low	Moderate
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	Highest	Highest	Lowest	Highest
140200020801	Headwaters Blue Creek	Lowest	Lowest	Highest	Moderate
140200020802	Little Blue Creek	Highest	Moderate	Moderate	Highest
140200021001	Pine Creek	High	High	Low	High
140200021003	Corral Creek-Gunnison River	Highest	High	Lowest	High
140200030101	Headwaters Tomichi Creek	Lowest	Low	Highest	High
140200030102	Agate Creek	High	Moderate	Highest	Highest

12 code HUC	Sixth-level Watershed Name	Landscape Condition	Fire Regime Departure	Insect & Disease	Ecosystem Sensitivity Rank
140200030103	Marshall Creek	Low	Moderate	Moderate	Moderate
140200030104	Long Branch Creek	Lowest	High	High	Moderate
140200030105	Porphyry Creek-Tomichi Creek	Moderate	High	Highest	Highest
140200030201	Headwaters Razor Creek	Lowest	High	Highest	High
140200030202	Outlet Razor Creek	High	High	Lowest	High
140200030301	Upper Quartz Creek	Low	Lowest	Highest	Moderate
140200030302	Gold Creek	Low	Low	Highest	High
140200030303	Middle Quartz Creek	Moderate	High	Highest	Highest
140200030304	Alder Creek	Low	High	Moderate	Moderate
140200030305	Lower Quartz Creek	High	High	Low	High
140200030401	Owens Creek-Tomichi Creek	Low	Highest	High	Highest
140200030402	Needle Creek	Lowest	High	High	High
140200030403	Barret Creek-Tomichi Creek	Highest	High	Low	Highest
140200030404	Hot Springs Creek	Moderate	Highest	Moderate	Highest
140200030405	Wood Gulch-Tomichi Creek	Highest	Highest	Lowest	Highest
140200030501	Headwaters Cochetopa Creek	Lowest	Low	High	Low
140200030502	Pauline Creek	Moderate	Moderate	High	Moderate
140200030503	Archuleta Creek	Low	Highest	Low	High
140200030504	Headwaters Los Pinos Creek	Low	Moderate	Highest	High
140200030505	Trail Creek-Cochetopa Creek	Low	High	Low	High
140200030506	Middle Cochetopa Creek	Highest	High	Lowest	Highest
140200030507	West Pass Creek	High	Highest	Moderate	Highest
140200030508	Rock Creek-Cochetopa Creek	High	High	Low	High
140200030509	Outlet Cochetopa Creek	Highest	Highest	Lowest	Highest
140200030601	Sewell Gulch-Tomichi Creek	Highest	Highest	Lowest	High
140200030602	Cabin Creek	Low	Highest	Lowest	Moderate
140200030603	Long Gulch	Moderate	Highest	Lowest	High
140200030604	Stubbs Gulch	Moderate	Highest	Lowest	High
140200030605	Chance Gulch-Tomichi Creek	Highest	High	Lowest	High

Appendix K
Resilience Adaptive Capacity

Resilience/Adaptive Capacity Calculations

12 code HUC	Sixth-level Watershed Name	Simpson Diversity	Topo-Climatic Variability	Resilience Rank
140200010101	Upper Taylor River	Moderate	Low	Moderate
140200010102	Trail Creek-Upper Taylor River	High	Low	High
140200010103	Middle Taylor River	High	Moderate	High
140200010104	Texas Creek	Moderate	Lowest	Low
140200010105	Headwaters Willow Creek	Highest	Low	High
140200010106	Outlet Willow Creek	Moderate	Moderate	Moderate
140200010107	Taylor Park Reservoir	Moderate	High	High
140200010108	Lottis Creek	Moderate	Low	Low
140200010109	Crystal Creek	Highest	Lowest	Moderate
140200010110	Rocky Brook-Spring Creek	Highest	Low	High
140200010111	Bear Creek-Spring Creek	Moderate	Lowest	Low
140200010112	Beaver Creek	Lowest	Low	Low
140200010113	Lower Taylor River	Lowest	Low	Lowest
140200010201	Upper East River	High	Lowest	Low
140200010202	Brush Creek	Moderate	Lowest	Low
140200010203	Middle East River	Lowest	Low	Lowest
140200010204	Coal Creek	Highest	Low	High
140200010205	Oh-be-Joyful Creek-Slate River	Moderate	Lowest	Low
140200010206	Washington Gulch-Slate River	Low	Low	Low
140200010207	Cement Creek	Moderate	Lowest	Low
140200010208	Alkali Creek	Low	Moderate	Moderate
140200010209	Roaring Judy Creek	Low	Moderate	Moderate
140200010210	Lower East River	Lowest	Moderate	Low
140200020101	Upper Ohio Creek	Moderate	Low	Moderate
140200020102	Castle Creek	High	Low	Moderate
140200020103	Carbon Creek	Low	Moderate	Moderate
140200020104	Mill Creek	Low	Lowest	Lowest
140200020105	Middle Ohio Creek	Lowest	Highest	High
140200020106	Lower Ohio Creek	Highest	Highest	Highest
140200020107	Sheep Gulch-Gunnison River	Highest	Highest	Highest
140200020201	Antelope Creek	Low	Moderate	Moderate
140200020202	Headwaters South Beaver Creek	Low	High	Moderate
140200020203	Long Gulch-South Beaver Creek	Highest	High	Highest
140200020204	Steers Gulch-Gunnison River	Highest	Highest	Highest

12 code HUC	Sixth-level Watershed Name	Simpson Diversity	Topo-Climatic Variability	Resilience Rank
140200020301	Headwaters Willow Creek	Moderate	High	High
140200020302	Sugar Creek-Willow Creek	Highest	Highest	Highest
140200020401	Beaver Creek	Lowest	Lowest	Lowest
140200020402	Steuben Creek	Lowest	Low	Lowest
140200020403	Willow Creek-Blue Mesa Reservoir	Highest	Moderate	Highest
140200020501	Mill Creek-Brush Creek	Moderate	High	High
140200020502	Headwaters Cebolla Creek	Moderate	High	High
140200020503	Rough Creek-Cebolla Creek	Low	Moderate	Moderate
140200020504	Spring Creek	Moderate	Lowest	Low
140200020505	Mineral Creek-Cebolla Creek	Low	Low	Low
140200020506	Rock Creek	Lowest	Highest	High
140200020507	Fish Canyon-Cebolla Creek	Low	Low	Low
140200020508	Powderhorn Creek	Lowest	Moderate	Low
140200020509	Road Beaver Creek-Cebolla Creek	Low	Moderate	Low
140200020510	Goose Creek-Cebolla Creek	High	Low	High
140200020511	Outlet Cebolla Creek	Highest	Moderate	Highest
140200020601	Headwaters Lake Fork	Moderate	Lowest	Low
140200020602	Lake Sanc Cristobal-Lake Fork	Moderate	Lowest	Low
140200020603	North Fork Henson Creek-Henson Creek	Moderate	Lowest	Low
140200020604	Nellie Creek-Henson Creek	Low	Lowest	Lowest
140200020605	Larson Creek-Lake Fork	Low	Low	Lowest
140200020606	Elk Creek-Lake Fork	Lowest	Lowest	Lowest
140200020607	Trout Creek-Lake Fork	Lowest	Low	Lowest
140200020608	Yeager Gulch-Lake Fork	Low	Moderate	Low
140200020609	Indian Creek	Lowest	Low	Low
140200020610	Willow Creek	Lowest	Highest	High
140200020611	Outlet Lake Fork	High	High	Highest
140200020701	East Elk Creek	Lowest	Lowest	Lowest
140200020702	Red Creek	Lowest	Low	Lowest
140200020703	West Elk Creek	Lowest	Lowest	Lowest
140200020704	West Soap Creek-Soap Creek	Moderate	Lowest	Low
140200020705	Cow Creek-Soap Creek	Lowest	Lowest	Lowest
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	Highest	Moderate	Highest
140200020801	Headwaters Blue Creek	Highest	Lowest	High
140200020802	Little Blue Creek	Low	High	Moderate

12 code HUC	Sixth-level Watershed Name	Simpson Diversity	Topo-Climatic Variability	Resilience Rank
140200021001	Pine Creek	Low	Highest	High
140200021003	Corral Creek-Gunnison River	Low	Moderate	Moderate
140200030101	Headwaters Tomichi Creek	Moderate	Lowest	Low
140200030102	Agate Creek	Moderate	Low	Moderate
140200030103	Marshall Creek	Low	Moderate	Low
140200030104	Long Branch Creek	Low	Low	Low
140200030105	Porphyry Creek-Tomichi Creek	Low	Low	Low
140200030201	Headwaters Razor Creek	Low	Low	Low
140200030202	Outlet Razor Creek	Highest	Highest	Highest
140200030301	Upper Quartz Creek	High	Lowest	Moderate
140200030302	Gold Creek	Moderate	Lowest	Low
140200030303	Middle Quartz Creek	Moderate	Lowest	Low
140200030304	Alder Creek	Lowest	Low	Low
140200030305	Lower Quartz Creek	Moderate	Moderate	High
140200030401	Owens Creek-Tomichi Creek	Lowest	Low	Low
140200030402	Needle Creek	Lowest	Low	Lowest
140200030403	Barret Creek-Tomichi Creek	High	Highest	Highest
140200030404	Hot Springs Creek	Lowest	High	Moderate
140200030405	Wood Gulch-Tomichi Creek	Highest	Highest	Highest
140200030501	Headwaters Cochetopa Creek	Moderate	Low	Low
140200030502	Pauline Creek	Low	Highest	Highest
140200030503	Archuleta Creek	Lowest	Highest	High
140200030504	Headwaters Los Pinos Creek	Low	High	Moderate
140200030505	Trail Creek-Cochetopa Creek	Lowest	Highest	High
140200030506	Middle Cochetopa Creek	Low	Highest	Highest
140200030507	West Pass Creek	Lowest	High	Moderate
140200030508	Rock Creek-Cochetopa Creek	Low	High	High
140200030509	Outlet Cochetopa Creek	Highest	Highest	Highest
140200030601	Sewell Gulch-Tomichi Creek	Highest	Highest	Highest
140200030602	Cabin Creek	High	High	Highest
140200030603	Long Gulch	Highest	Highest	Highest
140200030604	Stubbs Gulch	Highest	Highest	Highest
140200030605	Chance Gulch-Tomichi Creek	Highest	Highest	Highest

Appendix L
Climate Change Vulnerability

Climate Change Vulnerability Index Calculations

12 code HUC	Sixth-level Watershed Name	Ecosystem Sensitivity	Resilience	CCVI Rank
140200010101	Upper Taylor River	Low	Moderate	Low
140200010102	Trail Creek-Upper Taylor River	High	High	High
140200010103	Middle Taylor River	Highest	High	Highest
140200010104	Texas Creek	Moderate	Low	Low
140200010105	Headwaters Willow Creek	Moderate	High	High
140200010106	Outlet Willow Creek	Highest	Moderate	Highest
140200010107	Taylor Park Reservoir	Highest	High	Highest
140200010108	Lottis Creek	High	Low	Moderate
140200010109	Crystal Creek	Moderate	Moderate	Moderate
140200010110	Rocky Brook-Spring Creek	Moderate	High	High
140200010111	Bear Creek-Spring Creek	High	Low	Moderate
140200010112	Beaver Creek	Moderate	Low	Low
140200010113	Lower Taylor River	Highest	Lowest	Moderate
140200010201	Upper East River	Low	Low	Lowest
140200010202	Brush Creek	Lowest	Low	Lowest
140200010203	Middle East River	Low	Lowest	Lowest
140200010204	Coal Creek	High	High	High
140200010205	Oh-be-Joyful Creek-Slate River	Low	Low	Lowest
140200010206	Washington Gulch-Slate River	High	Low	Moderate
140200010207	Cement Creek	Low	Low	Low
140200010208	Alkali Creek	Low	Moderate	Low
140200010209	Roaring Judy Creek	High	Moderate	Moderate
140200010210	Lower East River	High	Low	Moderate
140200020101	Upper Ohio Creek	Low	Moderate	Low
140200020102	Castle Creek	Lowest	Moderate	Low
140200020103	Carbon Creek	Low	Moderate	Low
140200020104	Mill Creek	Low	Lowest	Lowest
140200020105	Middle Ohio Creek	Moderate	High	Moderate
140200020106	Lower Ohio Creek	Moderate	Highest	Highest
140200020107	Sheep Gulch-Gunnison River	High	Highest	Highest
140200020201	Antelope Creek	High	Moderate	High
140200020202	Headwaters South Beaver Creek	Low	Moderate	Low
140200020203	Long Gulch-South Beaver Creek	Moderate	Highest	High
140200020204	Steers Gulch-Gunnison River	High	Highest	Highest

12 code HUC	Sixth-level Watershed Name	Ecosystem Sensitivity	Resilience	CCVI Rank
140200020301	Headwaters Willow Creek	Moderate	High	High
140200020302	Sugar Creek-Willow Creek	Moderate	Highest	Highest
140200020401	Beaver Creek	Moderate	Lowest	Low
140200020402	Steuben Creek	Moderate	Lowest	Low
140200020403	Willow Creek-Blue Mesa Reservoir	Highest	Highest	Highest
140200020501	Mill Creek-Brush Creek	Low	High	Moderate
140200020502	Headwaters Cebolla Creek	Moderate	High	Moderate
140200020503	Rough Creek-Cebolla Creek	Low	Moderate	Low
140200020504	Spring Creek	Moderate	Low	Low
140200020505	Mineral Creek-Cebolla Creek	Moderate	Low	Low
140200020506	Rock Creek	High	High	High
140200020507	Fish Canyon-Cebolla Creek	Highest	Low	Moderate
140200020508	Powderhorn Creek	Moderate	Low	Low
140200020509	Road Beaver Creek-Cebolla Creek	Highest	Low	Moderate
140200020510	Goose Creek-Cebolla Creek	High	High	High
140200020511	Outlet Cebolla Creek	High	Highest	Highest
140200020601	Headwaters Lake Fork	Lowest	Low	Lowest
140200020602	Lake Sanc Cristobal-Lake Fork	Low	Low	Low
140200020603	North Fork Henson Creek-Henson Creek	Lowest	Low	Lowest
140200020604	Nellie Creek-Henson Creek	Low	Lowest	Lowest
140200020605	Larson Creek-Lake Fork	High	Lowest	Moderate
140200020606	Elk Creek-Lake Fork	High	Lowest	Low
140200020607	Trout Creek-Lake Fork	Highest	Lowest	Moderate
140200020608	Yeager Gulch-Lake Fork	Highest	Low	High
140200020609	Indian Creek	High	Low	Moderate
140200020610	Willow Creek	High	High	High
140200020611	Outlet Lake Fork	High	Highest	Highest
140200020701	East Elk Creek	High	Lowest	Low
140200020702	Red Creek	Moderate	Lowest	Low
140200020703	West Elk Creek	Moderate	Lowest	Lowest
140200020704	West Soap Creek-Soap Creek	Low	Low	Low
140200020705	Cow Creek-Soap Creek	Moderate	Lowest	Lowest
140200020706	Pine Creek Mesa-Blue Mesa Reservoir	Highest	Highest	Highest
140200020801	Headwaters Blue Creek	Moderate	High	Moderate
140200020802	Little Blue Creek	Highest	Moderate	High

12 code HUC	Sixth-level Watershed Name	Ecosystem Sensitivity	Resilience	CCVI Rank
140200021001	Pine Creek	High	High	High
140200021003	Corral Creek-Gunnison River	High	Moderate	High
140200030101	Headwaters Tomichi Creek	High	Low	Moderate
140200030102	Agate Creek	Highest	Moderate	High
140200030103	Marshall Creek	Moderate	Low	Low
140200030104	Long Branch Creek	Moderate	Low	Low
140200030105	Porphyry Creek-Tomichi Creek	Highest	Low	Moderate
140200030201	Headwaters Razor Creek	High	Low	Moderate
140200030202	Outlet Razor Creek	High	Highest	Highest
140200030301	Upper Quartz Creek	Moderate	Moderate	Moderate
140200030302	Gold Creek	High	Low	Moderate
140200030303	Middle Quartz Creek	Highest	Low	High
140200030304	Alder Creek	Moderate	Low	Low
140200030305	Lower Quartz Creek	High	High	High
140200030401	Owens Creek-Tomichi Creek	Highest	Low	Moderate
140200030402	Needle Creek	High	Lowest	Moderate
140200030403	Barret Creek-Tomichi Creek	Highest	Highest	Highest
140200030404	Hot Springs Creek	Highest	Moderate	High
140200030405	Wood Gulch-Tomichi Creek	Highest	Highest	Highest
140200030501	Headwaters Cochetopa Creek	Low	Low	Low
140200030502	Pauline Creek	Moderate	Highest	High
140200030503	Archuleta Creek	High	High	High
140200030504	Headwaters Los Pinos Creek	High	Moderate	Moderate
140200030505	Trail Creek-Cochetopa Creek	High	High	High
140200030506	Middle Cochetopa Creek	Highest	Highest	Highest
140200030507	West Pass Creek	Highest	Moderate	High
140200030508	Rock Creek-Cochetopa Creek	High	High	High
140200030509	Outlet Cochetopa Creek	Highest	Highest	Highest
140200030601	Sewell Gulch-Tomichi Creek	High	Highest	Highest
140200030602	Cabin Creek	Moderate	Highest	High
140200030603	Long Gulch	High	Highest	Highest
140200030604	Stubbs Gulch	High	Highest	Highest
140200030605	Chance Gulch-Tomichi Creek	High	Highest	Highest