Recommendations for Lewis and Clark County, MT



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About the Community Planning Assistance for Wildfire Program

The Community Planning Assistance for Wildfire (CPAW) program works with communities to reduce wildfire risks through improved land use planning. It is supported through grants from the U.S. Forest Service, the LOR Foundation, and other private foundations. It is a program of Headwaters Economics and Wildfire Planning International.

Author Contact Information

CPAW engages consultants with relevant training and expertise in land use planning, forestry, risk modeling, and fire behavior. This report was written by the following CPAW consultants:

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Cover photos provided by CPAW.

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Introduction

Each year, wildfires affect communities across the United States. These wildfires—both human- and lightning-caused—can have a variety of impacts on communities' built and natural environments. Some of these impacts bring positive ecological outcomes, such as improved forest health and habitats. Other wildfires, however, can have devastating social, economic, and environmental consequences to communities' public and first responder safety, homes and businesses, parks, roads, watersheds, forests, hospitals, and more.

Communities have many options to address and reduce their wildfire risk. The Community Planning Assistance for Wildfire (CPAW) program offers a unique approach to help community stakeholders identify what's at risk in the "wildland-urban interface" (WUI, pronounced "WOO-EE") and determine ways to address this risk through improved land use planning strategies.

❖ Community Planning Assistance for Wildfire

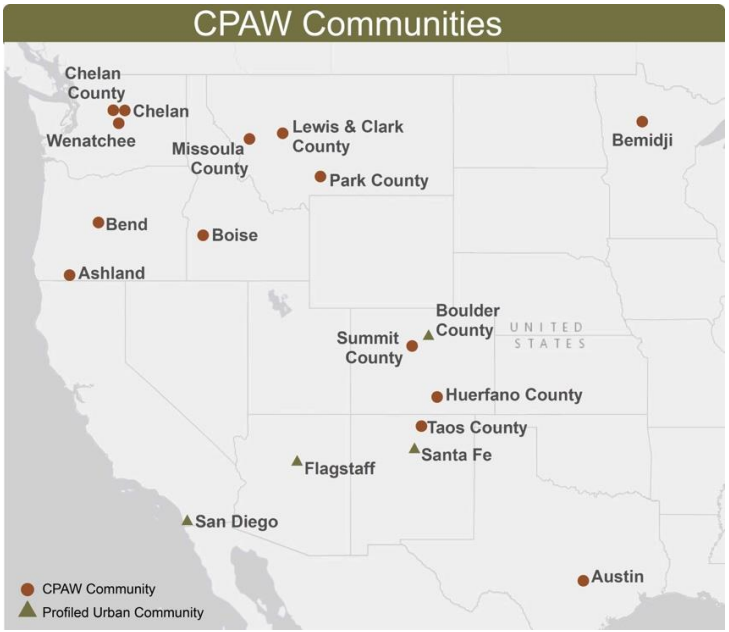


Figure 1. Communities who have been engaged in the Community Planning Assistance for Wildfire program (as of October 2017).

CPAW was established by Headwaters Economics and Wildfire Planning International in 2015 and is funded by the USDA Forest Service, the LOR Foundation, and other private foundations. Since its inception, CPAW has worked with communities of varying sizes, capacities, and geographical locations across the United States (Figure 1).

Community Selection and Services

Communities voluntarily apply and are competitively selected to participate in the program on an annual basis. Communities must show commitment and engagement from both the planning and fire departments to reflect the collaborative nature required for

CPAW success. If selected, communities receive customized technical consulting services from CPAW's team of professional land use planners, foresters, risk modelers, and researchers. Specific services vary based on community needs, and may include capacity-building trainings on WUI planning topics, risk modeling and spatial analysis, guidance on wildfire mitigation plans and policies, and other strategies to address local wildfire risk.

Stakeholder Engagement

Community members engaged in the CPAW process play a critical role to project success. While services are provided at no charge to the community, each community signs a Memorandum of Understanding with CPAW to outline its mutual understanding of roles and responsibilities and project commitments. CPAW teams engage with a variety of local stakeholders who may serve as steering group members, local experts, or interested parties. These stakeholders provide valuable input and feedback, represent diverse wildfire and community development interests, and act as communication channels to other local groups.

CPAW Process

The CPAW community planning process typically occurs over the course of one year (Figure 2). During that time, CPAW team members meet with stakeholders to discuss local issues, conduct several field tours to learn about unique WUI and wildfire mitigation challenges, and provide presentations to help the community understand CPAW's program goals. Team members also thoroughly review community planning documents to analyze gaps and opportunities for strengthening wildfire policies and regulations. At the end of the process, team members provide the community with a set of voluntary recommendations to more effectively address the WUI through appropriate land use planning strategies. Follow-up implementation assistance may also be available to communities depending on their unique needs and CPAW's program funding.

Figure 2. Community Planning Assistance for Wildfire typical planning process.

CPAW Recommendations

CPAW recommendations are customized to each local community based on a combination of important inputs: community observations and stakeholder feedback, science and best practices, and national expertise in planning, forestry, hazard mitigation and wildfire risk reduction. All recommendations are voluntary. Local governments retain sole authority for the decision to implement any recommendations delivered by CPAW.

There are many planning tools available to communities to help address challenges associated with the wildland-urban interface. These tools include plans and policies (e.g., growth management plans, neighborhood plans, open space management plans), and codes and regulations (e.g., subdivision regulations, landscaping ordinances, steep-slope ordinances, zoning codes, building codes, and wildland-urban interface codes). See Figure 3 for more examples.

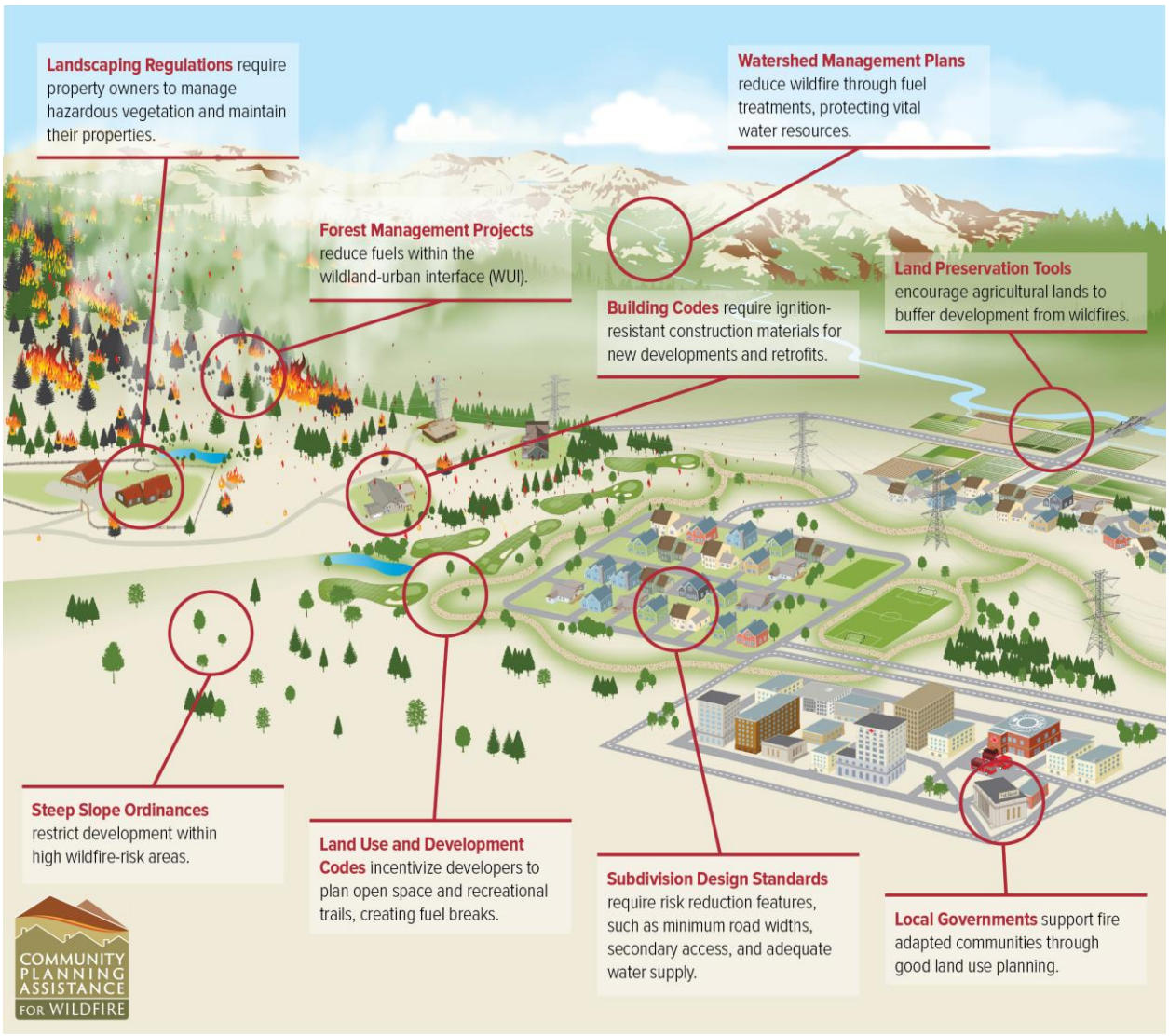


Figure 3. There are many planning tools available to communities to address the wildland-urban interface, as illustrated by examples in the figure above.

This report provides Lewis and Clark County with four recommendations to implement those tools most appropriate for addressing local conditions and opportunities (summarized in Table 3). Each recommendation includes an overview of its importance and relevance. Implementation guidance for staff is also provided. Many aspects of the recommendations are related to one another; where applicable, recommendations are cross-referenced. As staff consider CPAW recommendations, they may further refine the concepts to ensure alignment with county goals and actions.

❖ Lewis and Clark County Planning Context

Lewis and Clark County was accepted into the CPAW program in November 2016 and received assistance over the course of the past year. As an initial step to understand local conditions, team members assembled community information and data, including: geographical information, key demographics, economic trends, fire environment and wildfire history. This section provides a summary of that information.

Geographic Location and Significant Features

Lewis and Clark County is located in west-central Montana and adjacent to seven counties (Teton, Cascade, Meagher, Broadwater, Jefferson, Powell and Flathead). More than 70 percent of the land is mountainous, and elevation ranges from 3,400 in valleys to 8,000 feet along the Continental Divide.[1] Portions of wilderness areas within the county are Helena National Forest, Flathead National Forest, and Lolo National Forest. Other significant land features include the Missouri River, which flows northward out of the county.

Land Area and Ownership

Lewis and Clark County has a total land area of 3,458 square miles.[2] Federal agencies, including the USDA Forest Service, Bureau of Land Management, and U.S. Military, comprise the largest group of land owners in the County. Private land ownership is 43.7%, which includes conservation easements (6%). Remaining lands are owned by the state, county, or other agency.[3]

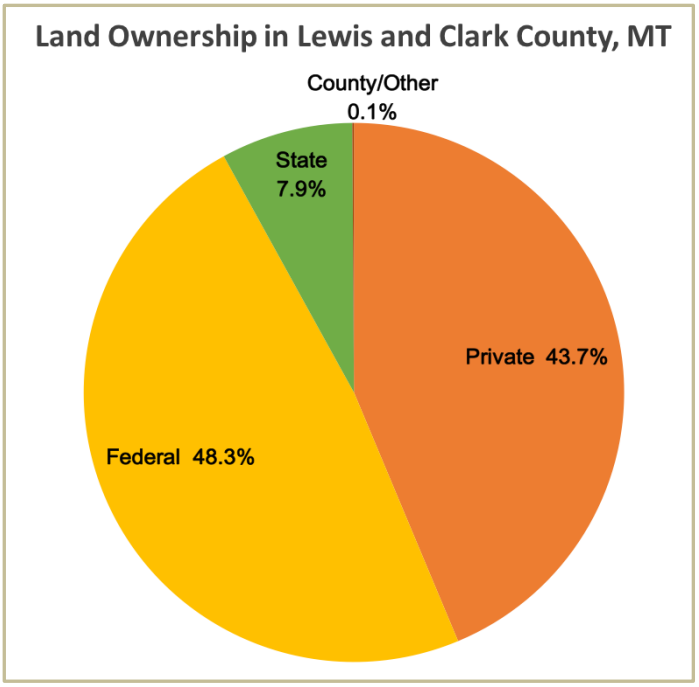


Figure 4. Land ownership in Lewis and Clark County (by percentage).

[1] Lewis and Clark County Pre-Disaster Mitigation Plan. 2017.
[2] U.S. Census Bureau. 2010.
[3] Headwaters Economics Economic Profile System (Land Use): U.S. Geological Survey, Gap Analysis Program. 2016. Protected Areas Database of the United States (PADUS) version 1.4

Key Demographics and Economic Trends

Lewis and Clark County's seat is Helena. Other incorporated and unincorporated communities in the county are Augusta, Baxendale, Canyon Creek, Canyon Ferry, Craig, East Helena, Helena Valley, Lakeside, Lincoln, Marysville, Nelson, Wolf Creek, York and Unionville.

The Lewis and Clark County Growth Policy (2004) identifies six planning areas: Helena Valley, Augusta, Canyon Creek/Marysville, Canyon Ferry/York, Wolf Creek/Craig and Lincoln. The Helena Valley Planning Area, which excludes the city limits of Helena and East Helena, covers 386 square miles.

Despite the Helena Valley Planning Area being less than 10 percent of the county's total land area, it contains 95 percent of the county's population. An even greater percentage (98%) of the county's development activity has occurred in the Helena Valley Planning Area in recent decades as witnessed by changes in land use from agriculture to residential and commercial development.[4]

Table 1: Overview of Demographics in Lewis and Clark County, MT

Topic	Key Statistic	Notes
Current population	65,357 residents	6.0% population increase (2010-2015).[c]
Population density	18.3 people per sq. mile	Population density varies across county; Lewis and Clark County's population density is higher than the state average of 6.2 people per sq. mile.[a]
Median age	41 years	State median age is 39.8 years.[c]
Total number of housing units	30,946	Unit total as of 2016, compared to 30,180 in 2010.[a]
Housing units for seasonal, recreational or occasional use	2,225	U.S. Census Bureau[a]
Median home price	$208,600	American Community Survey Office[b]
Median household income	$55,594	Compared to state average of $46,766.[c]
Workforce employment	33,121	Largest employment industries are education, healthcare and social assistance (21.6%), and public administration (19.3%).[c]
Poverty rate	11.2%	State poverty rate: 15.3%.[c]

a. U.S. Census Bureau. 2010

b. American Community Survey Office 2011-15

c. Headwaters Economics Economic Profile System (Demographics): U.S. Department of Commerce. 2016. Census Bureau, American Community Survey Office, Washington, D.C.

[4] Helena Valley Area Plan, Volume 1. 2015.

Fire Environment and Wildfire History

The vegetation in Lewis and Clark County reflects a mosaic of fire dependent and fire adapted ecosystems. Vegetation ranges from low elevation open grasslands historically experiencing frequent low-intensity fires, to high elevation forests historically experiencing less-frequent, high intensity fires. In addition, significant forest health impacts, such as mountain pine beetle and spruce budworm, have resulted in an increased hazard in many of the conifer forests.

The Tri-County FireSafe Working Group (TCFSWG) has undertaken significant fuels identification and classification work over the past three decades, which has resulted in an excellent spatial representation of the fuels and subsequent fire intensity potential of vegetation across most of the county, including those areas affected by forest health issues.

The county's population, communities, and infrastructure are located primarily in the low elevations and are dispersed throughout the fuel types mentioned above. This is reflected in the county's significant history of large wildfires in the area. Many small fires in Lewis and Clark County have also contributed to structure loss, as listed in Table 2.

Table 2: Notable Lewis and Clark County Fires (1984-2016)

Year	Fire Name	Size	Structures Lost
1984	North Hills	26,950	0
1988	Canyon Creek	46,900	0
1990	Beartooth Complex	32,968	0
1997	Willow Creek	1,940	0
2000	Bucksnort	15,311	0
2000	Cave Gulch	30,000	0
2003	Snowbank	37,405	0
2003	Cottonwood	7	7
2004	Across the River	.25	1
2004	Rocky Road	4	1
2004	Spring Creek	.25	1
2004	Accristo Road	0.01	1
2005	Hazard Lake	5,733	0
2006	Cigarette Rock	2,271	0
2006	Coulter Hill	1.5	2
2006	Smoking John	3	1
2007	Country Club	43	10
2007	Ahorn	52,505	0
2007	Fool Creek	60,042	0
2007	Novak	1,527	0
2007	Meriwether	46,298	0
2007	Conger Creek	24,598	0

Table 2: Notable Lewis and Clark County Fires (1984-2016)			
Year	**Fire Name**	**Size**	**Structures Lost**
2008	Dearborn	9	1
2009	Gates of the Mountains	.1	1
2009	Indian Trail	4,409	0
2010	Davis	1,940	8
2001	Stoos	19	1
2012	Corral	1,851	4
2012	Black Beach	1,450	0
2013	Red Shale	12,534	0
2014	Log Gulch	215	0
2015	RV Ranch	116	0
2015	Bray Gulch-Holter Lake Complex	748	0
2016	Wilson	620	0
2016	Rattlesnake	582	0
Source: Lewis and Clark County Pre-Disaster Mitigation Plan, 2017			

Detailed fire histories are located in the Pre-Disaster Mitigation Plan and the Tri-County 2014-2015 CWPP. In addition to the above historical fires, 2017 has been recorded as the "worst fire season in (Montana) history"[5]. To date, there have been 34 wildfires within Lewis and Clark County during the 2017 fire season; including the Arrasta Creek Fire (6,318 acres), Park Creek Fire (16,403 acres as of September 7) and Alice Creek Fire (22, 417 acres as of September 7)[6].

❖ Lewis and Clark County Community Analysis

CPAW team members gathered information about Lewis and Clark County through conversations and meetings with stakeholders, field tours, and internal research. CPAW team members also reviewed and analyzed community plans, policies, and regulations to determine their level of effectiveness for community wildfire mitigation. This information was internally compiled into a WUI Planning Audit and reviewed with the local steering group. The following is a summary of planning challenges and opportunities that emerged in Lewis and Clark County during the CPAW research phase.

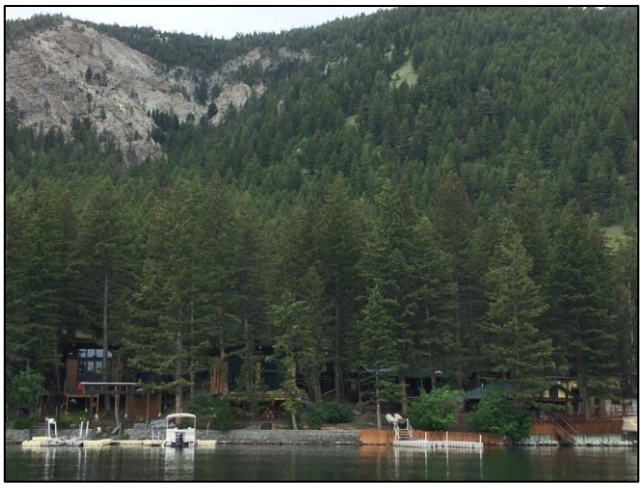
Local Planning Challenges

- **More homes in the WUI.** The county can continue to anticipate population growth in wildfire-prone areas, particularly in the Helena Valley which projects between 7,000 and

[5]State of Montana Executive Order Declaring a Disaster to Exist in the State of Montana. Office of the Governor. September 1, 2017

[6] National Wildfire Coordinating Group. Inciweb. https://inciweb.nwcg.gov/unit/12680/. Accessed September 7, 2017

18,000 new residents could move to this area in the next twenty years. This could require between 2,800 and 7,300 new housing units to be built.[7]



Homes at Holter Lake are surrounded by dense vegetation with no road access. (Photo by CPAW)

- **Private lands adjacent to national forests**. Many areas in the county are adjacent to federally-managed lands, creating a situation where private property mitigation is also dependent on mitigation from neighboring public land managers. This can create a challenge when aligning the timing and funding priorities for mitigation and planning projects.
- **Difficult access and substandard roads.** In addition to response capacity challenges, constraints in the built environment include homes, driveways and streets which lack proper signage, poor road surface conditions and single-entry neighborhoods. These conditions hinder response times throughout the county and pose a safety risk for the public and first responders during response and evacuation.
- **Limited response capacity**. The county relies on volunteer fire departments to serve many of its rural areas. Locally and nationally, however, trends show that recruitment is becoming increasingly difficult and the population of volunteer firefighters is aging. As population in the WUI increases, more pressure will be placed on response capacity.
- **Inconsistent water supply standards.** Both rural and suburban fire districts face challenges related to water supply, including a lack of installation standards for water systems and a lack of dependable centralized systems to serve populated areas. Historically, the lack of enforceable development agreements to address water supply maintenance has been a concern, although water supplies in newer subdivisions are maintained via county-administered rural improvement districts. These issues, in addition to broader regional water availability challenges in the Helena Valley, are creating unpredictable response scenarios and can have costly impacts to fire districts.
- **Changing climates and wildfire seasons.** As noted in both the recently updated Tri-County Regional Community Wildfire Protection Plan (CWPP) and the county's Pre-Disaster Mitigation Plan, climate change in the Northern Rockies is predicted to result in increased annual temperatures and longer summers. These changes will extend periods of drought, increase insect attacks, reduce fuel moisture content and exacerbate fire behavior activity.
- **Social and cultural challenges.** Like many communities in the West, citizens in Lewis and Clark County can be suspicious of government involvement in private property matters. This sentiment can result in resistance to building and zoning regulations as well as resistance to taxes or fees necessary to support fire protection measures. Some homeowners also want to preserve trees around their homes to protect privacy and the

[7] Helena Valley Area Plan, Volume 1. 2015.

forested environment. Seasonal homeowners may also see fire protection as a relatively low priority. Finally, when the smoke clears after fire season, homeowners may prioritize other day-to-day issues, leaving fire protection as an item to be addressed during the next fire season.

Local Planning Opportunities

- **Proactive planning approaches for the WUI**. The county has taken significant strides recently to implement plans and regulations which address the WUI, including the adoption of the Helena Valley Area Plan, which contains a chapter on the WUI, and the inclusion of fire protection standards in the recently updated Subdivision Regulations. These documents help create a solid foundation for future implementation of WUI planning and regulatory strategies.
- **New data can enhance existing hazard maps.** The USFS recently completely an updated risk assessment for portions of the county. This information could be used to further inform and update the Wildland Fuels Hazard Rating Map developed by the Tri-County FireSafe Working Group and published in the Tri-County Regional CWPP (2015 update). Enhancements from these newly developed products can improve decision support for planning policies and regulations countywide. Hazard and risk maps can also serve as an effective public engagement tool to help residents learn about wildfire and take personal action.
- **State-level legal infrastructure for local WUI regulations.** As part of its Building Code Chapter,[8] the Montana Department of Labor and Industry adopted and incorporated by reference the International Wildland-Urban Interface Code, 2012 edition, published by the International Code Council.[9] Although amendments were made, the adoption includes Appendix B (Vegetation Management) and Appendix C (Fire Hazard Severity Form). This provides local governments with a mechanism to adopt and regulate aspects of their WUI through this tool.
- **Creative funding mechanisms.** The county is increasingly using rural improvement districts (RIDs) to fund the maintenance of water sources for fire protection. The scope of RIDs can be expanded to include funding for long-term vegetation management along roads and subdivisions.
- **Track record of collaboration and partnerships.** Lewis and Clark County has a strong track record of collaboration and partnerships when it comes to addressing the challenges of wildfire. This includes working with building and real estate industry professionals, city, state and federal agencies, and convening the Lewis and Clark Rural Fire Council and Tri-County FireSafe Working Group. Local fire districts also regularly work with homeowners and groups to reduce fire risk on private property.

[8] Administrative Rules of Montana. Rule Chapter 24.301: Building Codes
[9] Administrative Rules of Montana. Rule 24.301.181 Incorporation By Reference of International Wildland-Urban Interface Code (IWUIC)

Montana Legislative Context

Montana law provides communities with several options to address WUI development. These options include:

- **Plans**, such as growth policies and neighborhood plans;
- **Regulations**, including subdivision, zoning, and building codes;
- **Revenue-generating strategies,** such as impact fees and rural improvement districts; and
- **Voluntary measures**, including education, outreach, and incentives to reduce hazardous fuels on private property.

While all of the options have advantages and disadvantages, the ideal approach is for local governments and communities to use some or all of the options simultaneously to address WUI development.[10] In fact, Lewis and Clark County has incorporated several of the options listed above into its long-term approach.

However, within Montana's legislative framework there are also several challenges for local governments including unnecessarily complex and confusing issues in statute and administrative rule. For example, there are artificial distinctions and overlap between what subdivision regulations, zoning regulations, and building codes can contain that create challenges for local governments in developing and administering legally defensible wildfire protection measures. A full description of these issues is beyond the scope of this report, but still must be accounted for when considering the recommendations below.

[10] Haines, Terry K.; Renner, Cheryl R.; Reams, Margaret A. 2008. A review of state and local regulation for wildfire mitigation. The Economics of Forest Disturbances; Wildfires, Storms, and Invasive Species, 273-293

Summary of Recommendations for Lewis and Clark County, MT

Table 3. Overview of Recommendations		
Recommendation	Summary	Key Points
1. Update Wildfire Hazard Assessment	*Enhance the existing Tri-County FireSafe Working Group Fuel Hazard Map with updated interactive spatial tools to provide decision support for land use planning and regulations. Consider the implementation of a complete spatially delineated risk assessment by incorporating property-specific assessment information.*	• A wildfire assessment provided by the USFS can be used to enhance previous efforts; the updated assessment identifies the county's risk at landscape and local scales. • The county can use the mitigation potential map to inform future development mitigation requirements. • The hazard assessment can be further supported through the inclusion of parcel-level hazard assessment data to produce a complete wildfire risk assessment.
2. Strengthen Subdivision Regulations	*Strengthen the Lewis and Clark County Subdivision Regulations by clarifying fire safety standards, linking requirements to updated risk assessment information, and aligning implementation with future adoption of a wildland-urban interface code.*	• Subdivision regulations are the primary means of regulating development in the county. • Current fire protection standards lack clarity or pose conflicts with other regulations, making it difficult to ensure appropriate risk reduction. • Steps to strengthen regulations include using the updated hazard assessment, creating one set of definitions for the wildland-urban interface, and resolving conflicts with design review criteria.
3. Adopt a Wildland-Urban Interface Code	*Adopt the 2012 International Wildland-Urban Interface Code (as amended by the State of Montana) to increase property resilience to wildfire.*	• Subdivision regulations do not address building construction and materials, which are well-documented structure ignition vulnerabilities. • Adoption of the Montana WUI code would address significant gaps in the mitigation process. • Administration and enforcement can be undertaken in coordination with the Montana Department of Labor and Industry, eliminating the need for additional county staff.

4. Update Growth Policies to Comprehensively Address Wildfire	*Update county plans to comply with state growth policy requirements for the wildland-urban interface and address long-term planning for post-disaster recovery.*	• The county's Growth Policy (2004) does not meet all current legal requirements associated with the identification and evaluation of fire. • The Helena Valley Area Plan provides a replicable model for growth policy updates in other planning areas of the county. • Post-disaster recovery planning should also be included as topic to ensure the county is prepared for future wildfire disasters.

RECOMMENDATION 1: **Update Wildfire Hazard Assessment**

Enhance the existing Tri-County FireSafe Working Group Fuel Hazard Map with updated interactive spatial tools to provide decision support for land use planning and regulations. Consider the implementation of a complete spatially delineated risk assessment by incorporating property specific assessment information.

❖ Why This Recommendation Matters

Overview

Ideally, a complete wildfire risk assessment should be developed to enhance the previous efforts of the TCFSWG, including a map of spatially delineated risk classes across the county. This map should be provided at an appropriate resolution and scale to support land use and regulatory decisions.

What is Wildfire Risk?

Wildfire risk can be visualized as a triangle, consisting of three components:

1. Likelihood of a wildfire occurring based on topography, weather, and ignition patterns; this can also include ignition sources from hazardous land uses (e.g., sawmills or propane storage facilities);
2. Predicted intensity of a wildfire (usually measured in flame length) based on vegetation type and weather conditions;
3. Susceptibility of values (for land use planning purposes, values consist of communities, structures and infrastructure).

Together, these components complete the wildfire risk triangle (Figure 5).[11]

[11] Scott, J. H.; Thompson, M. P.; Calkin, D. E., 2013. A wildfire risk assessment framework for land and resource management. Gen. Tech. Rep. RMRS-GTR-315. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 83 p.

Figure 5. **Components of the wildfire risk triangle.**

Land use planning largely focuses on mitigating the susceptibility portion of the wildfire risk triangle. There are two important susceptibility inputs that should be evaluated to appropriately determine wildfire risk in the context of land use planning:

- The location and density of structures and infrastructure;
- The ignition potential of individual structures and infrastructure.

Lewis and Clark County Wildfire Risk Assessment History

The Tri-County FireSafe Working Group (TCFSWG) has undertaken considerable effort in developing a Fuel Hazard Map. This map provides spatial reference for the five general fuel classifications listed in Table 4.[12]

[12] Tri-County Fire Safe Working Group. 2015. Tri-County Regional Community Wildfire Protection Plan (CWPP) 2015 Update. http://www.lccountymt.gov/fileadmin/user_upload/Safety/DES/TriCounty/Documents/2014-15_CWPP.pdf

Table 4. Tri-County FireSafe Working Group Fuel Hazard Classifications	
Fuel Group	**Description**
Group A	Includes the grass fuel type with shrubs under 2 feet in height
Group B	Consists of "medium density Conifer Stands with primarily a grass and brush understory"
Group C	Includes "dense conifer stands"
Group X	Includes "dense, flammable vegetation over two feet high consistent with tall sagebrush and Conifer regeneration stands"
Group CX	A combination group created to reflect the infestation of Mountain Pine Beetle and Spruce Budworm. This fuel type includes "dead trees with a receptive fuel bed of dead needles primed for easy ignition with unusually rapid rates of spread and burning intensity."

Additionally, the TCFSWG also developed a local WUI definition.[11] This definition is based on the Healthy Forest Restoration Act[13], which defines the WUI as:

A. An area within or adjacent to an at-risk community that is identified in recommendations to the Secretary of Agriculture in a community wildfire protection plan; or

B. In the case of any area for which a community wildfire protection plan is not in effect:

   i) An area extending 0.5 miles from the boundary of an at-risk community;

   ii) An area within 1.5 miles of the boundary of an at-risk community including any land that:

   - Has a sustained steep slope that creates the potential for wildfire behavior endangering the at-risk community;
   - Has a geographic feature that aids in creating an effective fire break, such as a road or ridge top; or
   - Is in condition class 3 as documented by the Secretary in the project specific environmental analysis; and
   - An area that is adjacent to an evacuation route for an at-risk community that the Secretary determines, in cooperation with the at-risk community, requires hazardous fuel reduction to provide safer evacuation from the at-risk community.

Based on local conditions, the TCFSWG further modified this definition by expanding the 0.5 and 1.5-mile distances to 4 miles.

[13] U.S. Congress. 2003. Healthy Forest Restoration of 2003. https://www.fs.fed.us/emc/applit/includes/hfr2003.pdf

To date, the fuel hazard map has served as an accurate representation of local fuel conditions and an excellent resource for fuel treatment and mitigation funding justification. However, county planning staff and local subject matter experts recognized some challenges in using the map as a decision support tool for land use planning and regulation. The TCFSWG definition of the WUI remains a reasonable definition, but a spatial representation (i.e., a map) of ember impacts on developed areas is a recommended addition.

Parcel Level Assessments

Individual Parcel Level Assessments complete the risk triangle by providing the susceptibility component. This focuses on assessing each structure and the immediate surroundings, or Home Ignition Zone (HIZ).

❖ Implementation Guidance

As part of the CPAW process, USDA Forest Service Rocky Mountain Research Station (RMRS) staff engaged with local wildfire risk subject matter experts to achieve two main objectives:

1. Validate the RMRS spatial fuels layers through local subject matter expert input based on the TCFSWG Fuel Hazard Map.
2. Explore RMRS tools that can be used to enhance the TCFSWG Fuel Hazard Map to better support land use planning and other wildfire risk reduction efforts.

This collaborative engagement was undertaken in the form of three separate workshops in which local subject matter experts worked with RMRS staff and CPAW team members to determine the appropriate parameters and tools that would be useful in supporting local risk reduction efforts.

As a result of this collaborative work, the RMRS has calibrated the spatial fuel layer and developed a methodology to provide enhanced hazard assessment tools to the TCFSWG Fuel Hazard mapping while providing decision support for land use planning policy and regulations.

Enhanced Wildfire Hazard Assessments and Mapping

To provide an effective decision support tool for the county and its partners, RMRS staff developed the following wildfire hazard mapping outputs. Three maps are provided at two scales; the Landscape Level Wildfire Hazard (180 m resolution) (Figure 6), Local Wildfire Hazard (30 m resolution) (Figure 7), and Mitigation Potential (30 m resolution) (Figure 8). A summary of the methodology used to develop these outputs can be found in Appendix A.

Landscape Level Wildfire Hazard

This scale (180 m pixel resolution) represents the likelihood (probability) of a fire occurring and intensity of the fire at the landscape level based on the inherent landscape characteristics including broad existing vegetation, biophysical settings, fire regimes and fire histories. The polygon boundaries are based on the U.S. Geological Survey Hydrological Unit Code (HUC) 12 (sub-watershed) boundaries. The landscape hazard is the product of the burn probability times the intensity. This index was classified into four rankings based on the following quantiles for the Tri-Counties area: The following landscape level hazard index is delineated into the following rankings:

- **LOW**: 0 – 25th percentile of hazard index
- **MODERATE**: 25 – 50th percentile
- **HIGH**: 50 – 75th percentile
- **EXTREME**: 75 – 100th percentile

The factors influencing these rankings can be used to determine the potential landscape level exposure of a development. The ranking at this scale is difficult to change at the local/parcel level. Mitigation affecting change at this scale is typically done by large scale disturbances such as insect mortality, fires or landscape level mitigation. Many of the high ranked polygons are present on federal lands and would require mitigation by federal land management agencies

Land Use Planning Application: This informs land use planners on the general areas where fires are most likely to occur, and with what intensity. It is a quick way to compare sub-watersheds across a large landscape to get a relative picture of hazard.

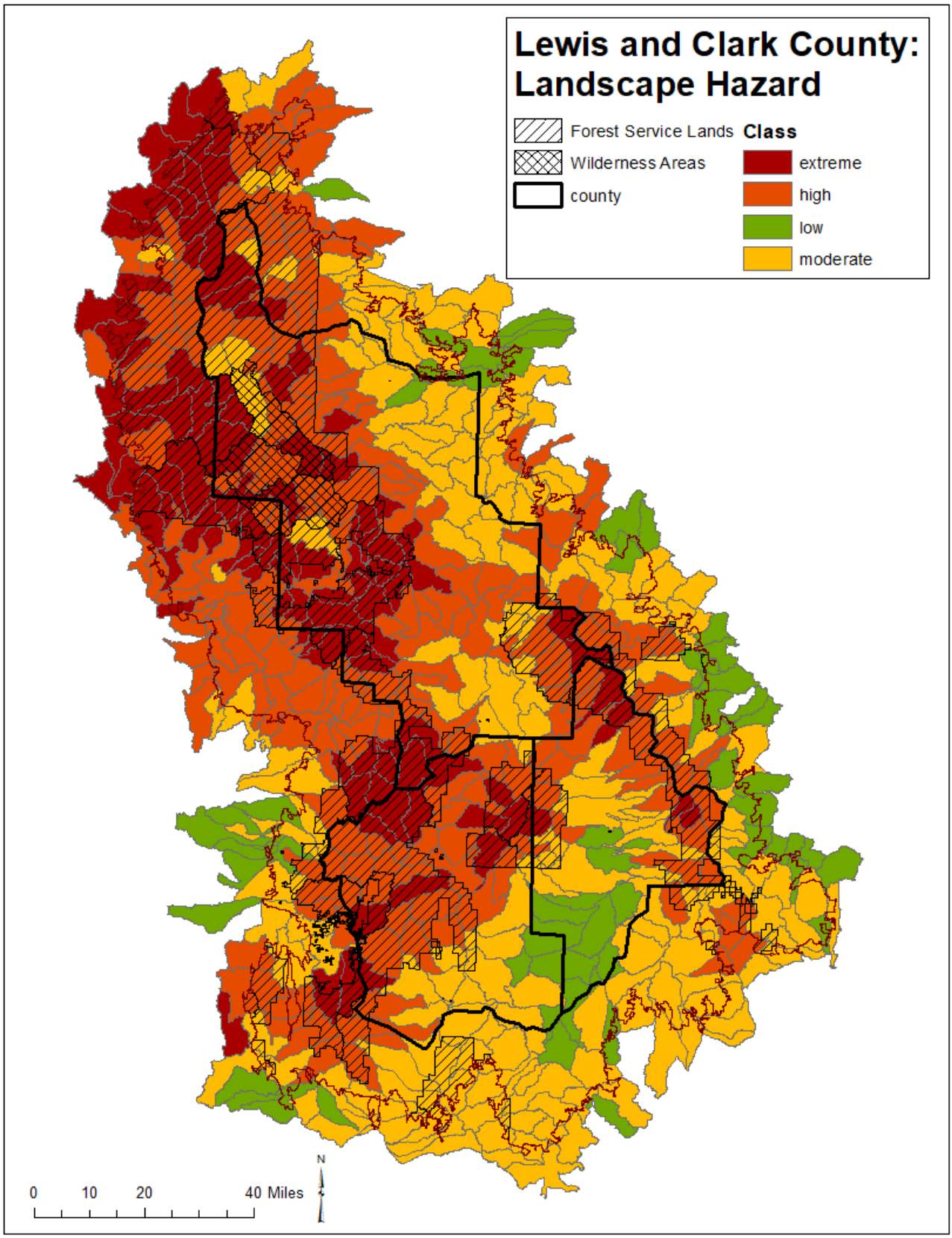


Figure 6. Lewis and Clark County Landscape Level Hazard Assessment Map.

Local Level Wildfire Hazard

This scale (30 m pixel resolution) is based on an extreme event (worst fire days). The polygon boundaries are based on the catchment boundaries within the HUC 12 boundaries. This does not show the annual likelihood of a fire occurring, rather it presents the likelihood and intensity of a short term (8 hours or less), fast moving fire, given an ignition during an extreme fire danger day. For example, a fire that starts in an area where the local hazard is high can spread fast and burn at high intensity creating significant wildfire exposure to any structures in the area, and requiring rapid evacuation. The same rankings used at the landscape scale are used at this local scale:

- **LOW**: 0 – 25th percentile of hazard index
- **MODERATE**: 25 – 50th percentile
- **HIGH**: 50 – 75th percentile
- **EXTREME**: 75 – 100th percentile

Land Use Planning Application: This informs land use planners on the worst-case wildfire exposure (i.e., radiant, convective and ember) that can be expected in any given polygon.

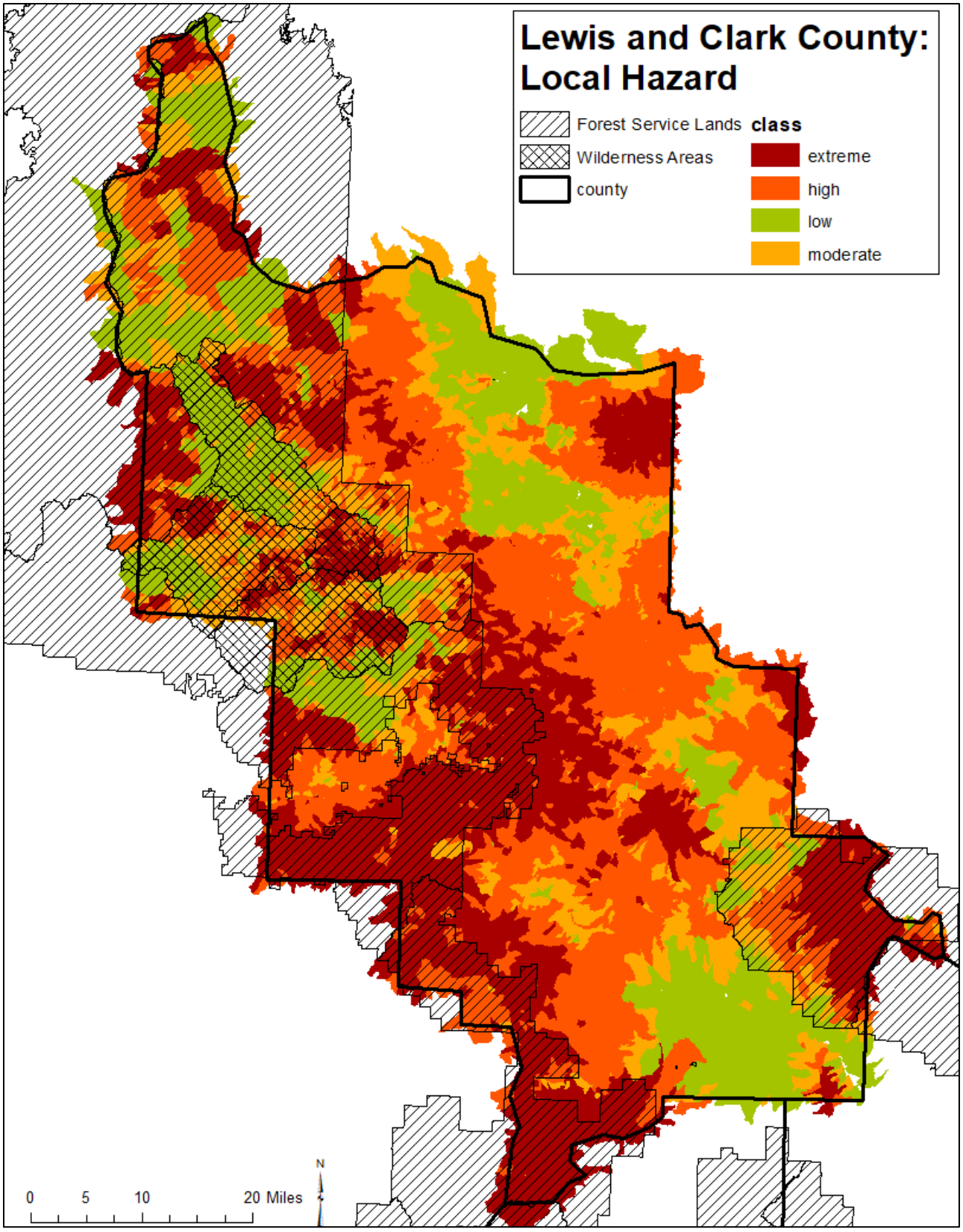


Figure 7. Lewis and Clark County Local Level Hazard Assessment Map.

Vegetation Mitigation Potential

The Vegetation Mitigation Potential component (30meter resolution) uses the life form (grass, shrubs, trees), slope and crown fire potential to classify the potential mitigation success of any given 30-meter pixel on the map. The mitigation potential ranking is represented by eight classes of hazard based on mitigation potential and extreme fire behavior potential (see Appendix A).

Table 5. Mitigation Potential Classes and Descriptions

Class	Characteristics	Mitigation Discussion
0	Ember impact mitigation only	Barren ground/water/sparse vegetation or land. Mitigation potential should involve appropriate home ignition zone and IR structure construction to mitigate ember impacts.
1	Grass life forms and agricultural areas on flat ground	Fires are typically easier to suppress in these areas. However high winds combined with dry conditions leads to potentially dangerous fast moving high intensity fires. Mitigation potential may involve a combination of irrigation, mechanical (mowing) treatment, frequent burning, and fuel breaks in conjunction with appropriate home ignition zone and IR structure construction.
2	Grass life forms on steep (≥30%) slopes	Harder to construct fuel breaks, difficulty in mechanical (mowing) treatment, increased potential for erosion, increased rate of spread and intensity may make frequent prescribed burning more difficult. Focus should be on appropriate slope setbacks, home ignition zone and IR structure construction mitigation.
	Shrubs on flat slopes	Fires are typically harder to suppress than grassfires in these areas. High winds combined with dry conditions leads to potentially dangerous fast moving high intensity fires with fire fighter access concerns. Mitigation potential may involve a combination of mechanical (mastication) treatment, moderately frequent burning, and fuel breaks in conjunction with appropriate home ignition zone and IR structure construction.
3	Shrubs on steep (≥30%) slopes	Harder to construct fuel breaks, difficulty in mechanical (mastication) treatment, increased potential for erosion, increased rate of spread and intensity may make frequent prescribed burning more difficult. Focus should be on a combination of appropriate mechanical treatment or burning, slope setbacks, home ignition zone and IR structure construction mitigation.
	Trees on flat slopes with open canopy	Open canopy must be maintained to prevent increase crown fire potential. Surface fuels must be treated/maintained in a state that reduces the chances of fast moving surface fires in conjunction with appropriate home ignition zone and IR structure construction mitigation.
4	Trees on steep slopes (≥30%) with open canopy	Open canopy must be maintained to prevent increased crown fire potential, which may be more difficult due to the slope. Surface fuels must be treated/maintained in a state that reduces the chances of fast moving surface fires. Mitigation should also include appropriate slope setbacks, home ignition zone and IR structure construction mitigation.
	Trees on flat slopes with dense canopy	Dense canopy needs to be thinned to reduce crown fire potential. Surface fuels must be treated to reduce risk of fast moving surface fires. Mitigation should also include appropriate home ignition zone and IR structure construction mitigation.
5	Trees on steep slopes (≥30%) with dense canopy	Dense canopy needs to be thinned to reduce crown fire potential, which may be more difficult due to the slope. Surface fuels must be treated/maintained in a state that reduces the chances of fast moving surface fires. Mitigation should also include appropriate slope setbacks, home ignition zone and IR structure construction mitigation.
6	Complex ecosystems	Due to the ecological system of these areas mitigation is extremely difficult and/or dangerous. Advanced vegetation management / mitigation plans will be necessary and highly skilled personnel will need to determine if any mitigation can be achieved. Avoiding new development in these areas should be considered. At a minimum, the most stringent standards should be applied to slope setbacks, the structure ignition zone and IR structure construction mitigation
7	Extremely dangerous areas to mitigate	Due to the current state of these lands mitigation is extremely dangerous. Advanced vegetation management / mitigation plans will be necessary and highly skilled personnel will need to determine if any mitigation can be achieved safely. Avoiding new development in these areas should be considered. At a minimum, the most stringent standards should be applied to slope setbacks, the structure ignition zone and IR structure construction mitigation.

Land Use Planning Application: This informs land use planners about the general potential for successful mitigation when aligning with the mitigation requirements of the subdivision regulations or a WUI Code (see Recommendations 2 and 3).

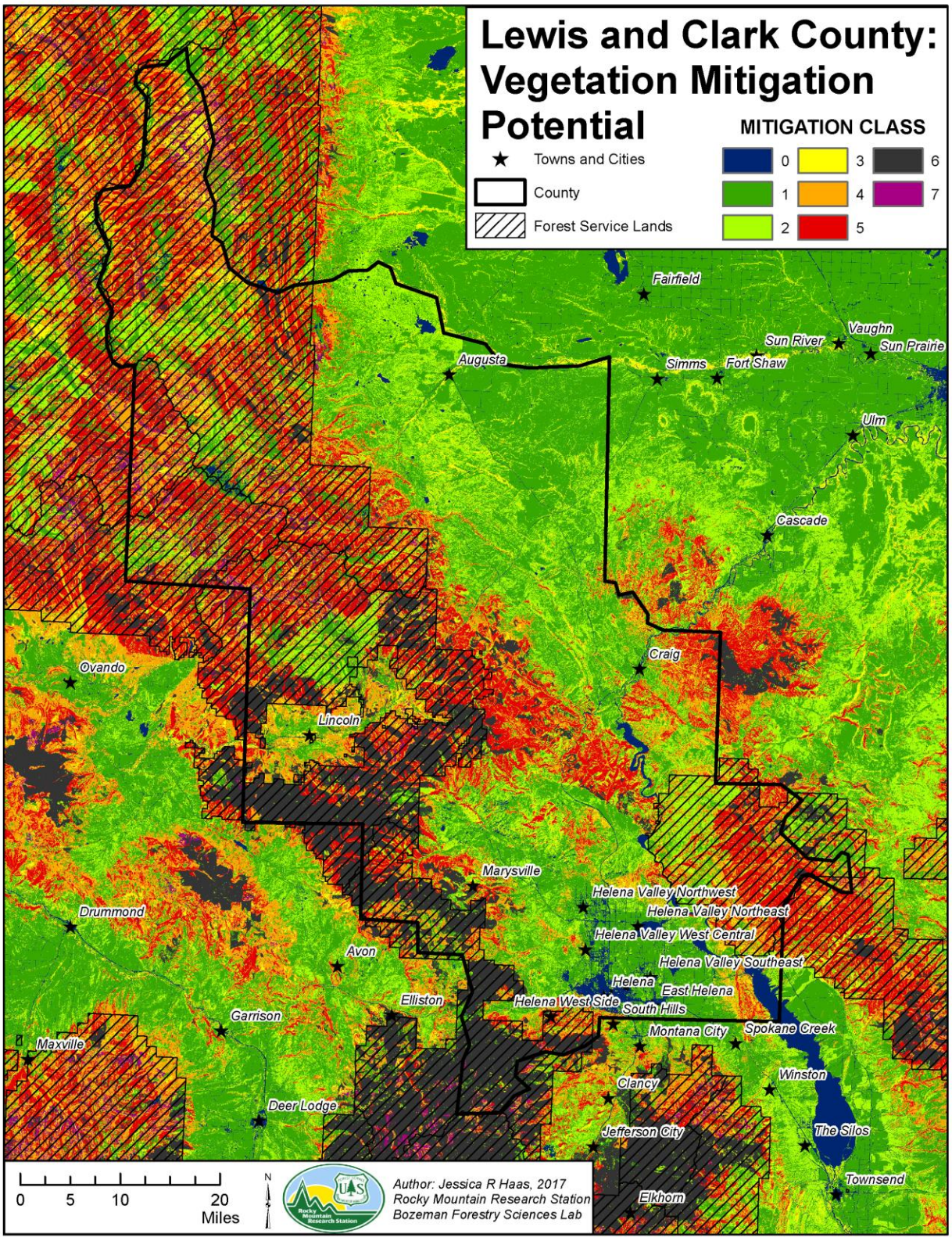


Figure 8. Lewis and Clark County Mitigation Potential Map.

Using the Hazard Assessment to Support Land Use Policy and Regulation

The landscape and local scale wildfire hazard maps will be supplied as a geodatabase to the county. This will allow the user to explore a hierarchy of hazard/exposure metrics including all of the elements described above. For example, if a user clicks on a particular watershed polygon, or local scale pixel, they will see the elements that contribute to the calculation of the final hazard rating. The display of pixel-level model outputs at finer display scales will also give end-users the ability to examine the spatial variability of factors contributing to hazard and exposure with any watershed. The local scale map will provide the opportunity for planners to appropriately assess a future or existing development area for wildfire exposure and require the appropriate mitigation. It will also provide a ranked scale to guide implementation of a WUI Code with regards to the degree of standards that must apply based on exposure and mitigation and if the area is within the branding zone.

Parcel Level Susceptibility Assessment

Parcel level wildfire assessment requires a "boots on the ground" approach. The TCFSWG and some fire districts within the county are already engaging in parcel level assessments using a variety of assessment tools.

CPAW Recommends the county engage with the TCFSWG and fire districts to gain a better understanding of the current data available and the gaps where a collaborative approach can facilitate the coordinated collection of countywide parcel level assessment information.

Defining the WUI

A general WUI definition used across all policies, plans and regulations should account for the "set of conditions" where vegetation (wildland fuels) and structures or infrastructure (built fuels) are influenced by weather and topography to allow fire to ignite and spread through the WUI environment. To provide the basis for a true understanding of the risk that Lewis and Clark county faces, the WUI should be more accurately defined as:

Any developed area where conditions affecting the combustibility of both wildland and built fuels allow for the ignition and spread of fire through the combined fuel complex.

In order to provide a spatial reference in defining the WUI, the SILVIS labs approach should be used. The SILVIS lab approach originated in the Federal Register[14] report on WUI communities at risk from fire, and Tie and Weatherford's 2000 report to the Council of Western State Foresters on WUI fire risk. This approach focuses on the following inputs:

1. Housing density
2. Landcover[15]
    a) WUI Intermix: Areas with ≥6.18 houses per km2 and ≥50 percent cover of wildland vegetation
    b) WUI Interface: Areas with ≥6.18 houses per km2 and <50 percent cover of vegetation located <2.4 km of an area ≥5 km^2 in size that is ≥75 percent vegetated

[14] USDA and USDI. 2001. Urban wildland interface communities within vicinity of Federal lands that are at high risk from wildfire. Federal Register 66:751–777.
[15] Schlosser, W.E. 2012. Defining the Wildland-Urban Interface: A Logic-Graphical Interpretation of Population Density. Kamiak Ridge, LLC

c) Non- WUI Vegetated (no housing): Areas with ≥50 percent cover of wildland vegetation and no houses (e.g., protected areas, steep slopes, mountain tops)
d) Non-WUI (very low housing density): Areas with ≥50 percent cover of wildland vegetation and <6.18 houses per km2 (e.g., dispersed rural housing outside neighborhoods)
e) Non-Vegetated or Agriculture (low and very low housing density): Areas with <50 percent cover of wildland vegetation and <49.42 houses per km2 (e.g., agricultural lands and pasturelands)
f) Non-Vegetated or Agriculture (medium and high housing density): Areas with <50 percent cover of wildland vegetation and ≥49.42 houses density per km2 (e.g., urban and suburban areas, which may have vegetation, but not dense vegetation**)**

CPAW and the RMRS have modified the above approach by removing the < 2.4 km reference in b) and considering the entire county as an "Ember Zone". Due to this outcome and for simplicity, the categories have also been modified into the following categories:

a) **WUI Intermix (including "Low Density Intermix")**: Areas with houses present and ≥50 percent cover of wildland vegetation
b) **WUI Interface:** Areas with ≥6.18 houses per km2 and <50 percent cover of vegetation
c) **Non-WUI Vegetated:** Areas with ≥50 percent cover of wildland vegetation and no houses (e.g., protected areas, steep slopes, mountain tops)
d) **Non-Vegetated or Agriculture:** Areas with <50 percent cover of wildland vegetation

Finally, the WUI interface and intermix classes were buffered out to 4 miles to capture the wildland fuels most likely to generate embers that could reach a structure. This area is identified as the **Ember Generation Zone** and represents vegetated lands where fuel reduction efforts may be a priority.

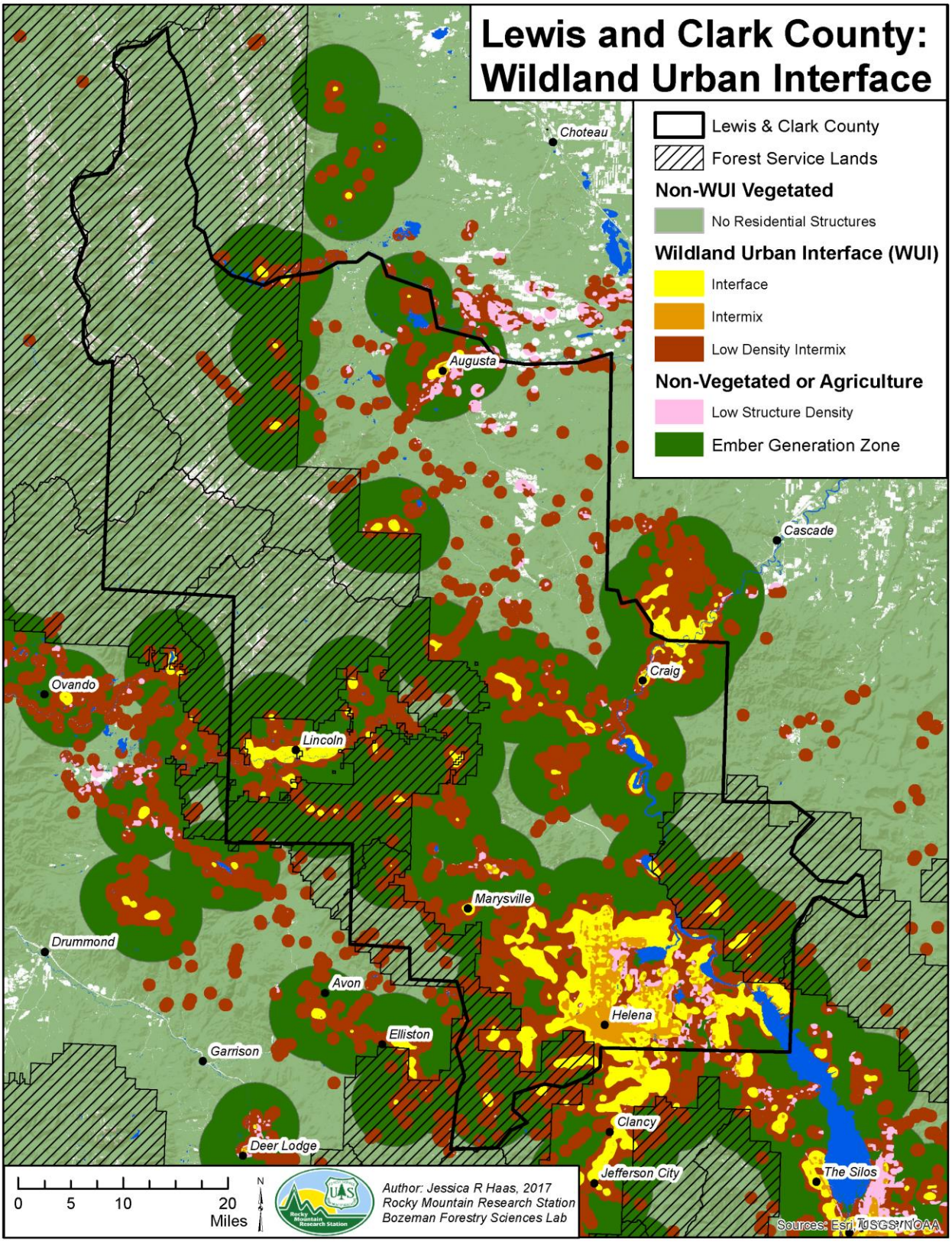


Figure 9. Lewis and Clark County WUI areas map.

❖ Tips and Additional Resources

The resulting risk assessment tool will be provided in the form of a geodatabase for addition to the county's geomatics servers for use as an ESRI ARC GIS layer. For the data to be made available to land use planners and the development community, the expertise of a GIS specialist will be required to ensure it is in the appropriate format for access and consumption by these groups.

The risk assessment tools must be kept up to date to be relevant. A minimum default 5-year update schedule is recommended, with recommended updates to occur based on the following:

- Significant wildland fire activity;
- Significant fuel management activity;
- Significant forest health impacts, or other disturbances that alter large scale vegetation structure;
- Significant urban growth.

The RMRS has provided the county with a best practices document (Appendix A)which outlines guidance on the methodology for updating the assessment.

The risk assessment outputs should be strongly linked as a decision support tool for implementing the proposed subdivision regulation updates, WUI code adoption, and growth policies (outlined in subsequent recommendations).

RECOMMENDATION 2: **Strengthen Subdivision Regulations**

Strengthen the Lewis and Clark County Subdivision Regulations by clarifying fire safety standards, linking requirements to updated risk assessment information, and aligning implementation with future adoption of a wildland-urban interface code.

❖ Why This Recommendation Matters

Overview

The Lewis and Clark County Subdivision Regulations (updated in 2016) are the primary means of regulating development in the unincorporated areas of the county. The regulations govern the creation of new lots, as well as roads, utilities and subdivision water supplies. Subdivision regulations are intended to ensure new development can occur in a safe manner.

There are two main subdivision phases: preliminary plat review and final plat review. Preliminary plat review occurs when a subdivider submits a subdivision plat and application, which typically includes a fire protection plan. County staff, public safety personnel, the planning board and county commissioners review the application for compliance with adopted standards. This review typically results in preliminary approval subject to several conditions. After preliminary approval, the subdivider must comply with all conditions, which may include clearing vegetation, building roads, installing water supplies, and entering into a Rural Improvement District (RID) for road and water system maintenance. Final plat review occurs when the subdivider submits a final subdivision plat and application that demonstrate all conditions have been met. After staff and the commissioners determine the subdivision is in compliance with all requirements, the subdivider may file the final plat and sell lots.

The Helena Valley Area Plan projects between 2,800 and 7,300 new housing units will be built in the Helena Valley alone over the next 20 years. Many of the new homes will be built on newly subdivided lots. Ensuring the subdivision regulations include comprehensive and clear fire safety requirements, and ensuring the review processes can be effectively administered, is critical to ensuring new homes and neighborhoods can be developed safely.

Current Fire Protection Standards

The General Design and Improvement Standards (Chapter XI, Subdivision Regulations), in conjunction with the design specifications in the Lewis and Clark County Public Works Manual, currently include general standards to address fire safety concerns for building sites and lots, road construction and maintenance, and bridges. These standards are summarized as follows:

- Building sites are not allowed on slopes greater than 30 percent and in high and severe fire hazard areas;
- Building envelopes may be required and minimum lot sizes may be increased for development in areas of steep slopes greater than 30 percent;
- Roads and bridges must be built to adopted standards for width, surfacing, grade, materials, compaction, weight bearing capacity, etc.;
- The maximum length of road ending in a cul-de-sac or hammerhead turnaround is typically 700 feet (depending on topography, fuels, and future development potential adjacent to the site);
- Each major subdivision (six or more lots) and subsequent minor subdivision must have at least two access routes unless the road is 700 feet or less and is not determined to be a safety threat;
- Subdivision roads are maintained through a public rural improvement district;
- Road names and street signs are required, and all lots are addressed;
- Utilities must generally be placed underground; and
- All subdivisions must be designed to avoid or mitigate any significant adverse impacts on fire protection and structures, and are prohibited in high fire hazard areas, or in severe fire hazard areas identified in the Growth Policy.

In addition, Fire Protection Standards (Appendix K, Subdivision Regulations) requires that all subdivisions must be planned, designed, constructed, and maintained in compliance with specific fire protection standards, including:

- Water supply for fire protection (volume dependent on lot sizes, setbacks and number of homes) with a perpetual access easement. The water supply must be certified by an engineer and approved by the Fire Protection Authority Having Jurisdiction (FPAHJ);
- The subdivider to establish or join a rural improvement district that ensures continual operation, annual testing, and maintenance of water supply and fire protection features, and annual maintenance assessments;
- Two accesses for all major and subsequent minor subdivisions;
- Minimum lot sizes may be increased to four acres depending on slope and vegetation;
- A vegetation management plan and potential fuels modifications;
- A detailed map of the subdivision provided to the FPAJH; and
- Possible fire protection covenants to be filed with the final subdivision plat.

Analysis of Fire Protection Standards

The county has taken a proactive approach to address many aspects of fire safety in its subdivision regulations. However, an in-depth analysis by the CPAW team revealed several instances where fire protection standards in the county's Subdivision Regulations lacked clarity and therefore may be difficult to enforce, or may pose a conflict with other regulations. Table 6 summarizes these potential conflicts and limitations.

Table 6. Fire Protection Standards: Potential Conflicts or Limitations		
Reference	**Overview**	**Analysis**
Definitions in Appendix A, Appendix K Sec. 18-2, and the DNRC Guidelines Introduction Sec. D.	Definitions related to fire protection and the WUI are provided in several locations throughout county documents. WUI terms include: • fire resistant landscaping • fire resistive or fire resistive construction • survivable space • wildland fire • wildland/urban interface	Some of the fire related definitions in Appendix A differ from those in Appendix K. For example, "accessory building or use" is defined in Appendix A while "accessory building or structure" is defined in Appendix K, and they are different. Other examples are "defensible space," "mitigate/ mitigation" and "wildland urban interface." Several definitions in the subdivision regulations also do not align with the referenced DNRC guidelines, such as: • Accessory building or structure • Defensible space • Dwelling • Hammerhead T (turn around) • Survivable space • Water supply • Wildland-Urban Interface
18-7.2 WUI Areas - Additional Requirements	Subdivisions proposed in areas classified as B, C or X wildland fuel hazard (as defined in 18-7.1) and where the fuels are not modified to a lower hazard rating in accordance with 18-7 must adhere to additional standards for roof coverings.	There is no objective measure stated in the regulations for what constitutes an acceptable lower hazard rating in accordance with Section 18-7 (Wildland/Urban Interface).
18-7.2.1 WUI Areas - Additional Requirements, Roof Coverings	WUI areas may be subject to a roof covering standard. This provision references Guideline 205 Roof Construction (Appendix B of Fire Protection Guidelines for Wildland Residential Interface Development).	Because this is referred to as a guideline, it is unclear if this is a required standard. It is also unclear where this guideline is located in the referenced text.
18-7.4 WUI Areas – Building Density Requirements	Densities in areas of steep slopes and/or dense forest growth shall be reduced through minimum lot standards. Minimum lot sizes range from one to four acres in size.	Densities of lots should be based on developable conditions per the hazard assessment. This regulation also conflicts with design standards for Ridgeline and Hillside Development (AA.2.) which requires building envelopes to be sited in a manner that utilizes existing vegetation to minimize building visibility from public roads.
18-8.1 Fire Protection Covenants	Covenants may be included as a requirement of the Fire Protection Plan to mitigate potential fire threats.	It is unclear under what conditions these covenants are required and who makes this determination.
18-10.2 Vegetation Management Plan	Subdividers in the WUI must prepare a vegetation management plan, which shall include: • A copy of the site plan for development • Methods and timetables for vegetation management • Defensible space • Fuel breaks and greenbelts • Maintenance plan	Requirements for defensible space, fuel breaks and greenbelts reference Fire Protection Guidelines for Wildland Residential Interface Development 201.1 and 201.2 (Vegetation Reduction and Clearance) and 204 (Fuel Breaks and Greenbelts). Although the guidelines can be found online, they are not accurately referenced in the subdivision regulations. It is also unclear how specific information in these plans will be evaluated for approval.

In addition, relying on subdivision regulations for fire safe development *over time* has significant limitations. For example, there is no effective mechanism to ensure emergency responder access to structures will be sufficiently developed or maintained without obstruction (Section 18-5 and 18-5.2); address numbers will be appropriately posted (Public Works Manual Sec. 4.13.2), lot vegetation will be maintained over time (Sec. 18-10.2.e), or maintenance of fire protection water supply and other features will be enforced (Sec. 18-8.1). Although fire protection covenants may be used to inform lot owners of these responsibilities, these standards have varied in their effectiveness of ensuring appropriate parties are held accountable for long term maintenance.

❖ Implementation Guidance

In order to resolve inconsistencies and potential conflicts, and strengthen the county's ability to objectively administer and enforce fire protection standards for subdivisions, the CPAW team recommends implementing the following measures:

1. Define Applicability of Subdivision Regulations

CPAW recommends that the county initially applies updated fire protection standards to future subdivisions only, not development of existing (approved) lots.

2. Use Updated Hazard Assessments During Subdivision Review and Approval

Revise Wildland/Urban Interface (Section 18-7.1) to reference the updated Wildfire Hazard and Mitigation Potential Assessment. Subdivisions located in areas with either a landscape level wildfire ranking greater than low and/or a local wildfire ranking greater than low will be subject to submission of required fire protection plan. The fire protection plan should be developed by a qualified professional and outline mitigation requirement, including a vegetation management plan.

3. Align Vegetation Management with Mitigation Potential Assessment

When evaluating and approving vegetation management plans (Section 18-10.2), county staff should reference the mitigation potential assessment to obtain general guidance of the appropriate type of mitigation to expect fuel breaks, greenbelts, roadsides, drives and defensible space.

4. Ensure Implementation of Mitigation Prior to Final Approval

Currently, there is no process to ensure fire protection features (fuel breaks, driveway routes, defensible space) have been properly implemented. The county must require a follow up on-site inspection to ensure mitigation measures have been implemented in accordance with approved fire protection plans (including vegetation management plans) prior to final subdivision approval.

5. Create One Set of WUI Definitions for Countywide Consistency

All definitions for fire protection should align to prevent confusion during subdivision review, including those in Appendix A and Appendix K (Subdivision Regulations), and those in the DNRC Guidelines for Development Within the Wildland-Urban Interface. This alignment will

also include definitions used in the future Wildland-Urban Interface Code and other planning documents, including CWPPs and growth policies. (See recommendations 3 and 4). CPAW recommends that the county work with a local advisory group, such as the TCFSWG, to create one set of WUI definitions that align across all regulatory and policy implementation documents. CPAW definitions are also provided at the end of this document.

6. Resolve Current and Potential Regulatory Conflicts

The county should ensure that required mitigation (i.e., lot siting and vegetation management) for approved developments does not create a conflict with other subdivision standards. For example, Ridgeline and Hillside Development design review criteria requires that building envelopes be sited in a manner that reduces roadside visibility. The county can resolve this through an exemption for fire protection standards or providing conflict resolution language that states which provision shall be controlling.

5. Align Subdivision Regulations with WUI Code

CPAW recommends that the county adopt the Montana WUI code with local amendments (see Recommendation 3). Adoption of the Montana WUI code will require revisions to Subdivision Regulations to ensure alignment. For example, Section 18-7.2.1 (Roof Covering Requirement) would be deleted if required through the WUI code.

In addition, new subdivisions should not be approved if they result in nonconforming lots under an adopted WUI code. In other words, subdivided lots should be approved only if they allow for future mitigation to occur through vegetation management and IR building construction that meets the WUI code standards. This approval process will determine the number of developable lots that can be properly mitigated in the WUI. As a result, Section 18-7.4 (Building Density Requirements) will no longer apply and should be deleted.

6. Strengthen Approaches to Maintenance

Maintenance of subdivision roads, water supplies, and vegetation is a major fire safety issue over the long-term. The county has relied on fire protection covenants for maintenance of fire protection water supply, features, and vegetation management plans. Current language in Section 18-8.1, however, does not specify when fire protection covenants are required as part of a Fire Protection Plan. CPAW recommends that any subdivisions in areas rated above a low wildfire hazard ranking be required to include the current provisions under Section 18-8 in a covenant.

❖ Tips and Additional Resources

Rural Improvement Districts

The scope of RIDs can be expanded to fund the maintenance of vegetation management along roadways and within subdivisions (e.g., greenbelts, other community features requiring mitigation). This exemplary approach is not seen in other Montana counties, but county staff has confirmed this approach is feasible.

Compliance with State Adoption Procedures

All amendments to the subdivision regulations must follow the procedures provided in Montana Code Annotated Section 76-3-503, which require the governing body to hold a properly noticed public hearing on the regulations and its intent to adopt the regulations.

Alignment with Growth Policies

Revisions to subdivision regulations should ensure they continue to implement the *intent* of current and future growth policies for consistency among county documents. For example, the Helena Valley Area Plan originally called for minimum lot sizes as a policy option to address growth in the wildland-urban interface. This CPAW report instead recommends that the county use a science-based approach informed by the hazard assessment (see Recommendation 1) to determine the acceptable number of lots and required mitigation in hazard areas. This approach is a more defensible process and still achieves the same goal of community wildfire risk reduction.

RECOMMENDATION 3: **Adopt a Wildland-Urban Interface Code**

Adopt the 2012 International Wildland-Urban Interface Code (as amended by the State of Montana) to increase property resilience to wildfire.

❖ Why This Recommendation Matters

Overview

Subdivision regulations only address the initial subdivision of land, not development of the subdivided lots. While subdivision regulations can be used to address access, water supply and subdivision-scale fuels reduction, they do not typically address critical items such as vents, decks, roofing materials, fire resistant windows, defensible space around homes and other items. Although subdivision regulations may contain these items, Montana subdivision law does not provide counties the authority to adopt a permit process to ensure these items are addressed during home construction.

To address these shortcomings, the Montana Department of Labor and Industry (DLI) adopted the International Code Council's International Wildland-Urban Interface Code (IWUIC) with amendments to provide construction standards, defensible space requirements around homes, and a permit process. The code applies to the construction, alteration, movement, repair, addition, change-of-use or remodeling of any building, structure or premises within the designated WUI. This means the requirements would apply to construction on all lots, not only in new subdivisions.

Montana amended the IWUIC through rule making authority to meld with local subdivision regulations, giving deference to the local access, water supply, building site, road signage and related requirements (referred to here as the "Montana WUI code").

The Montana Department of Labor and Industry currently administers the Montana WUI code in Lewis and Clark County on all commercial structures and residential structures of five or more living units. However, the vast majority of development in the county's WUI is single-family residential, which is currently exempt from Montana Department of Labor and Industry review. To complement its Subdivision Regulations Fire Protection Standards, CPAW recommends that Lewis and Clark County adopt the Montana WUI code to ensure wildfire mitigation is comprehensively implemented by applying standards to single-family and multi-family construction with fewer than five units.

❖ Implementation Guidance

1. Define the WUI Area

Adoption of the Montana WUI code requires the authority having jurisdiction to declare or designate a WUI area based on findings of fact or some other process, such as mapping, boundary designations, or identification of the WUI in applicable wildland fire plans. The WUI must be shown on official WUI maps available for public inspection.

The TCFSWG has previously defined the WUI as an area extending four miles from the boundary of an at-risk development. The WUI area mapping (developed by the RMRS) can supplement the TCFSWG designation by further delineating the WUI using the SILVIS Labs approach. (See Recommendation 1).

2. Create a WUI Code Local User Reference Document

Amendments to the 2012 IWUIC have been made to the Montana WUI code through rule making authority at the state level (ARM 24.301.181). Due to these changes, staff should produce a single, comprehensive document for planners, fire professionals, developers, and residents to understand the Montana WUI code. Appendix F of the IWUIC provides model findings of fact supporting adoption. See tips and Additional Resources for further support.

3. Apply the WUI Code Standards Based on the Wildfire Hazard Assessment

Chapter 5, Section 502 of the Montana WUI code, Fire Hazard Severity, provides guidance for determining the fire hazard severity rankings which will in turn become the criteria for determining the appropriate fuel modification (Chapter 6, Section 603) and ignition resistant construction (Chapter 5, Section 503) standards to apply. This is general guidance only; because the county will have a new wildfire hazard assessment (Recommendation 1), **CPAW recommends that the county amend Chapter 3, Section 302, to a) declare the wildland urban interface area using the newly developed Lewis and Clark County Wildfire Hazard Assessment and Wildland Urban Interface Maps, and b) use these maps to inform the Montana WUI code standards based on the following process:**

A. Determine if the proposed development is currently in the WUI; or if the proposed will result in the creation of a new WUI Interface or Intermix Zone.

B. Determine the Landscape Level Wildfire Hazard ranking in which the proposed development is located to understand the general likelihood of fire occurring.

C. Determine the Local Level Wildfire Hazard ranking in which the proposed development is located to understand the likelihood of the buildings exposure to high intensity fire.

D. Determine the Mitigation ranking (0 to 7) of the parcel in which the proposed development is located and immediately adjacent to (within 50 ft for ranks 1to 3 and with 100 ft. for ranks 4 to 7).

E. Use the following crosswalk (Table 7) to determine the appropriate Montana WUI code mitigation standards to apply:

Table 7: Lewis and Clark County RMRS Mitigation Potential/ IWUIC Hazard Crosswalk							
Table 603.2 WUI Area (2012 IWUIC)	**Table 603.2 Minimum Required Defensible Space (site/slope adjustment required)[1]**	**RMRS Mitigation Potential equivalent with IWUIC Slope % category[2] Table 502.1 (2012 IWUIC)**			**24.301.181(21) Minimum IR Construction**		
Fuel Model[3]		**≤ 40**	**41-60**	**≥ 61**	**Non-Conform[4]**	**Conform**	**1.5x Conform**
Moderate hazard	30 ft.	1, 2, 3	1, 2, 3		IR2	IR3	Not required
High hazard	50 ft.			1, 2, 3	IR1	IR2	IR3
Extreme hazard	100 ft.	4, 5,6, 7	4, 5,6, 7	4, 5,6, 7	IR1	IR1	IR2

Table Notes:

(1) "Distances are allowed to be increased due to site-specific analysis based on local conditions and the fire protection plan" (Figure 603.2- 2012 IWUIC)

(2) "When required by the code official, fuel classification shall be based on the historical fuel type for the area" (Table 502.1- IWUIC)

(3) **Non-conforming** indicates that the minimum slope-adjusted defensible space distances with appropriate mitigation cannot be achieved; as opposed to **conforming** in which the defensible space defensible space distances with appropriate mitigation can be achieved.

4. Align with Growth Policies and Subdivision Regulations

The Montana WUI code as amended does not include standards for access and water supply. The access and water supply standards in the subdivision regulations and Public Works Manual would continue to be used for new subdivisions. Adopting a regional water supply plan, as called for in the Helena Valley Area Plan, would be the best way to address water supplies on the county scale.

The county should also determine where potential conflicts may arise with the adoption of the Montana WUI code. For example, subdivision design standards under Ridgeline and Hillside Development (Section AA.) allows decks, fences, and other attachments to be considered outside of the building envelope. Unless properly mitigated, these features can be highly combustible and contribute to the likelihood of structure ignitions.

Finally, the county should require conforming defensible space and not allow non-conforming defensible space (as defined in the IWUIC) in all new subdivisions, as well as require the prescribed IR construction in existing subdivisions where conforming defensible space cannot be achieved.

5. Coordinate with State on Future Montana WUI Code Updates

Local stakeholders should take an active role in future Montana WUI Code amendments. This will ensure local regulatory needs are considered as part of the state code, such as vents and slope adjustments, and integrate the latest available science from the IWUIC 2018 version (and future versions).

❖ Tips and Additional Resources

The IWUIC can be viewed online for no charge by visiting the International Code Council website. The latest version available is the 2018 IWUIC. Specific amendments made to the Montana WUI Code based on the 2012 IWUIC are currently available through a third party website (UpCodes).

Additional public outreach materials, such as an informational brochure, website, FAQs, and similar materials would provide information to industry professionals and the public. Working with industry professionals prior to adoption is a critical step to help address any concerns. The county can also use the Wildfire Hazard Assessment Mapping as a WUI delineation and communication tool to help residents and industry professionals understand the WUI and the need for these regulations.

RECOMMENDATION 4: **Update Growth Policies to Comprehensively Address Wildfire**

Update county plans to comply with state growth policy requirements for the wildland-urban interface and address long-term planning for post-disaster recovery.

❖ Why This Recommendation Matters

Overview

The Lewis and Clark County Growth Policy is a long-range, non-regulatory planning document that establishes a broad framework for how to proceed with shorter-term, area-specific planning. The county's Growth Policy was last updated in 2004 and addresses countywide issues, including land use, housing, natural environment, demographics and economics, transportation, utilities, safety services and capital facilities planning. The Growth Policy's implementation strategy identifies different mechanisms to engage the community and implement appropriate planning actions.

The Growth Policy also recognizes six different planning areas in the county: Helena Valley, Augusta, Canyon Creek/Marysville, Canyon Ferry/York, Wolf Creek/Craig and Lincoln. Many planning area priorities reflect unique local conditions and needs. The Lincoln Planning Area also created its own Growth Policy, which was adopted as an addendum to the county's Growth Policy in 2004.

All of the planning areas share similar challenges related to wildfire. These challenges include providing adequate fire protection services through expansion of fire districts, minimizing wildfire hazards through outreach, prevention and code enforcement, recognizing wildfire as part of the ecosystem, increasing response capacity and funding, and coordinating resources. The Growth Policy acknowledges that development in environmentally critical areas, particularly in places identified at high risk for flooding or wildfires, has proven costly. While policies discourage development in high risk areas and encourage mitigation measures, public education, and modernization of fire protection systems, many of these policies have not been implemented.[16][17]

[16] Letter from Land Solutions, LLC to Community Development and Planning Director George Thebarge reviewing the 2004 Growth Policy for compliance with Section 76-1-601 through 76-1-607, MCA, May 27, 2014.
[17] Growth Policy Evaluation Table evaluating implementation of policies relevant to the 4 key issues for the Helena Valley Planning Area, Land Solutions, LLC, June 2014.

Lewis & Clark County Growth Policy Update

Since the adoption of the 2004 Growth Policy, the Helena Valley Planning Area has seen rapid population growth and continues to experience development pressure. This growth has also lead to increased local economic activity. As a result, the county updated its Growth Policy to focus on the issues specifically facing the Helena Valley Planning Area. This plan, referred to as the Helena Valley Area Plan, was adopted in 2016.

Compliance with State Requirements for WUI Planning

Montana state law[18] requires that a growth policy must include an evaluation of the potential for fire and wildland fire in the jurisdictional area, including whether or not there is a need to:

- Delineate the wildland-urban interface; and
- Adopt regulations requiring:
    - Defensible space around structures;
    - Adequate ingress and egress to and from structures and developments to facilitate fire suppression activities; and
    - Adequate water supply for fire protection.

The 2015 Helena Valley Area Plan addresses MCA Growth Policy WUI and fire protection requirements in Volume I Chapter Five – Fire Protection. This chapter discusses constraints to development associated with fire protection and the WUI, including continuing development pressures, high and high-to-extreme fuel hazards, substandard roads, limited water supplies, and reliance on volunteer rural fire departments. This analysis is limited to the Helena Valley Planning Area and does not include other jurisdictions.

The county's 2004 Growth Policy, excluding the updated portion for the Helena Valley Planning Area, does not meet current legal requirements for including an evaluation of fire and wildland fire and whether there is a need to delineate the WUI, nor does it address whether there is a need to adopt regulations requiring defensible spaces around structures, providing adequate ingress and egress, and adequate water supply for fire protection. While Lincoln's Growth Policy contains a section on fire protection, and states the entire Lincoln Rural Fire District is part of the WUI, clear policy direction is also lacking on whether local regulations are required to address defensible space, water supply and access.

Because wildfire is an issue that spans the county, there is a need to bring *all* of the county's planning areas into compliance to adequately plan for WUI development and fire protection services. Further, there are other planning topics, such as post-disaster recovery and redevelopment, that would benefit wildfire-prone areas. These topics should be considered during growth policy updates to provide a comprehensive community planning approach for wildfire.

[18] Montana Code Annotated 2015. Section 76-1-601. Growth policy – contents.

❖ Implementation Guidance

1. Adopt Local Scale Wildfire Assessment

To comply with the state requirement for WUI identification, the county should amend their growth policies to include the updated countywide wildfire assessments as provided by this CPAW process. This information will also serve as a guide for local planning areas to determine unique considerations for mitigation requirements.

2. Use the Helena Valley Area Plan Development Process as a Replicable Model

The Helena Valley Area Plan uses a constraints-based approach to planning, eliminating certain areas from consideration for intensive development due to natural or human-caused limitations. The constraints are water availability, wastewater management, roads, fire protection and flooding. Constraints associated with fire protection include:

- Areas of high and high-to-extreme fuel hazards, which represent a constraint to development in the WUI;
- Volunteer rural fire departments who are tasked with protecting a growing population over a large coverage area with limited fire hydrants and water pumping sources;
- Poorly designed, high density subdivisions with narrow streets and small lots which exacerbates access by fire response personnel.

To address fire protection and WUI constraints, the Helena Valley Area Plan calls for specific regulatory and planning approaches. While many of these constraints and policy options are unique to the Helena Valley Planning Area, other planning areas in the county could follow a similar community-based process to identify fire protection and WUI constraints and potential solutions. Volume I Chapter Seven – Public Input describes the process undertaken to engage community members in the Growth Policy update.

It is important to note that the Helena Valley Area Plan included a policy option to adopt new zoning to limit development density as a strategy to address the wildland-urban interface. This CPAW report does not advocate for the use of density development restrictions unless they are specifically informed by a hazard or risk assessment, as recommended in Recommendation 1, to ensure a sound and scientific basis for this type of regulatory approach.

Although the Helena Valley Area Plan was time intensive, it has proven to be a successful model that could be replicated in other planning areas. Replicating this model also aligns with the county's Pre-Disaster Mitigation Plan recommendations, which call for integrating rural growth management with fire protection efforts, expanding the county's Growth Policy to address WUI hazard planning, and adopting rural fire protection standards. Finally, recommendations in this CPAW report support this effort by providing baseline WUI information for discussions and public participation.

3. Integrate Post-Disaster Recovery into Wildfire Planning Activities

In addition to updating the Growth Policy to include WUI information for all planning areas, the county should consider incorporating post-disaster recovery policies into Growth Policy updates and other relevant planning efforts. Post-disaster recovery planning can help identify issues and challenges associated with wildfire disasters, such as post-fire flooding, soil stability and erosion,

vegetation removal options, damaged or burned infrastructure, service interruptions and delays, rebuilding, and debris removal. Identifying these potential issues prior to a wildfire can help prioritize mitigation efforts and reduce community impacts during and after an event.

Other benefits to planning for post-disaster situations include increasing access to funding sources. Many communities wait until losses occur before considering post-disaster mitigation grant funding options. Through post-disaster recovery plans, communities have the opportunity to identify potential funding sources in advance of an event.

The American Planning Association recommends planners gain support from political leadership for hazard mitigation and post-disaster recovery planning by framing it within broader resiliency program efforts.[19] In addition, aligning mitigation and recovery planning across planning documents – in this case the Growth Policy, Pre-Disaster Mitigation Plan, and Community Wildfire Protection Plans – strengthens opportunities for multi-stakeholder support.

❖ Tips and Additional Resources

- The American Planning Association provides post-disaster recovery information through its website – much of which is also accessible to non-members. Resources include briefing papers, case studies, and a model pre-event recovery ordinance. Some of this information was developed in partnership with FEMA, which also has a webpage dedicated to Recovery Planning. Resources include a wildfire case study on local recovery efforts from the Hayman Fire.
- Larimer County, CO has adopted a Disaster Re-Build Program as part of the county's Land Use Code. (See Chapter 11.0 Disaster Re-Build Program in the Larimer County Land Use Code.) The purpose of the program is to assist disaster survivors in their rebuilding efforts by offering additional flexibility with regulatory requirements.
- Florida created a Post-Disaster Development Planning Guide for Florida Communities (2010). While the guide covers a variety of coastal and inland hazards, many of its core planning concepts are transferable to jurisdictions outside of Florida, such as integrating post-disaster redevelopment issues into the Comprehensive Plan and other key planning documents.
- New Mexico State Forestry and other project partners developed an online After Wildfire Guide for New Mexico Communities. Topics and resources include financial tips and funding options for affected communities, post-fire treatments, and other safety information.

[19] American Planning Association. Planning for Post-Disaster Recovery: Next Generation. PAS Report 576. 2014.

Conclusion

This report identifies four key areas where Lewis and Clark County can strengthen its approach to wildfire risk reduction through improved policy and regulation. Many of these CPAW recommendations support one another, and the county should determine its implementation priorities based on timing, capacity, resources, and other local factors. Tips and resources have been offered throughout this report as a helpful starting point. Follow-up implementation assistance may also be available to communities depending on their unique needs and CPAW's program funding.

In addition, general guidance can be offered to improve the overall success of any future implementation effort. This guidance includes:

- **Trainings and Capacity Building.** Many of the recommendations rely on additional education of staff related to technical topics. Future trainings, such as in-depth courses on the Home Ignition Zone, can also improve internal capacity and reduce reliance on outsourcing. Training and capacity building efforts can be coordinated with existing local resources already focused on these activities and other departments mentioned throughout this report.

Facilitating opportunities for training and collaboration has been an essential ingredient to local wildfire successes in the county. (Photo by CPAW)

- **Public Outreach and Engagement.** Underlying any successful effort to update community plans, policies and regulations is a concerted approach to engage the public. This component will be essential to moving CPAW recommendations forward, and may include public meetings and presentations on wildfire, information brochures in development applications that illustrate mitigation standards, and one-on-one interactions between fire department and planning staff with residents. To date, the county and its partners have been extremely active in public outreach and engagement, as illustrated through the efforts of the Tri-County FireSafe Working Group.

- **Stakeholder Collaboration.** As mentioned throughout the report, collaborating with a number of stakeholders is critical throughout the implementation process. Stakeholders will vary—where applicable, suggestions to individual agencies and departments have been provided. These suggestions serve as a starting point only and are not intended to limit the participants throughout the collaborative process.

Thoughtful execution of wildland-urban interface policies and regulations takes time. While these recommendations are purposefully ambitious in nature, it's important to acknowledge that change does not occur overnight. These recommendations serve as a long-term roadmap for the community's resilient future. As wildfires continue to affect communities across the United States and Montana, CPAW encourages Lewis and Clark County to pursue implementation of these recommendations.

CPAW Definitions

Built Fuels- Man-made structures (buildings and infrastructure).

Burn Probability- The probability or effect of a wildland fire event or incident, usually evaluated with respect to objectives.

Burn Severity- A qualitative assessment of the heat pulse directed toward the ground during a fire. Burn severity relates to soil heating, large fuel and duff consumption, consumption of the litter and organic layer beneath trees and isolated shrubs, and mortality of buried plant parts.

Community Based Ecosystem Management- With an emphasis on local stakeholder participation, allowing the local community to manage their ecosystem based on the unique characteristics of an area.

Community Wildfire Protection Plan (CWPP)-Established by the 2002 Healthy Forest and Restoration Act, A CWPP is a plan that identifies and prioritizes areas for hazardous fuel reduction treatments on Federal and non-Federal land that will protect one or more at-risk communities and essential infrastructure and recommends measures to reduce structural ignitability throughout the at-risk community. A CWPP may address issues such as wildfire response, hazard mitigation, community preparedness, and structure protection.

Convection Heat- The movement caused through the rising of a heated gas or liquid.

Conduction Heat- Transfer of heat through direct contact of material.

Critical Facilities- FEMA defines critical facilities as "facilities/infrastructure that are critical to the health and welfare of the population and that are especially important following hazard events. Critical facilities include, but are not limited to, shelters, police, fire stations, and hospitals". In addition, CPAW recognizes emergency water pumping stations, egress routes, communication facilities, and backup power supplies as critical facilities.

Ecosystem Based Fire Management- The incorporation of the natural or desired ecological role of fire into the management and regulation of community's natural areas.

Effects- The anticipated benefits and losses associated with exposure to a hazard or event, in this case fire.

Embers- A small piece of burning material that can be thrown into the air due to the convective heating forces of a wildfire. Larger embers and flammable materials have the ability to sustain ignition through transport.

Exposure- The contact of an entity, asset, resource, system, or geographic area with a potential hazard. Note: In incident response, fire responder exposure can be characterized by the type of activity.

Fire Adapted Communities -A group of partners committed to helping people and communities in the wildland urban interface adapt to living with wildfire and reduce their risk for damage, without compromising firefighter or civilian safety.

Fire Effects - The physical, biological, and ecological impacts of fire on the environment.

Fire Intensity- Commonly referred to as fire line intensity, this is the amount of heat energy that is generated by burning materials.

Firewise– Program administered by the National Fire Protection Association which teaches people how to adapt to living with wildfire and encourages neighbors to work together and take action to prevent losses. The program encourages local solutions for wildfire safety by involving homeowners and others in reducing wildfire risks by fostering defensible space and resilient structures for homes and communities.

Frequency- The number of occurrences of an event per a specified period of time.

Hazard - Any real or potential condition that can cause damage, loss, or harm to people, infrastructure, equipment, natural resources, or property.

Hazard Reduction- Coordinated activities and methods directed to reduce or eliminate conditions that can cause damage, loss, or harm from real or potential hazards.

Home Ignition Zone- The characteristics of a home and immediate surrounding area when referring to ignition potential during a fire event.

Infrastructure- the basic physical structures and facilities (e.g., buildings, roads, and power supplies) needed for the operation of a community.

Prescribed Fire- A planned controlled wildland fire that is used to meet a variety of objectives for land managers.

Radiation Heat- Transmission of heat through waves or particles.

Residual Risk – Risk that remains after risk control measures have been implemented.

Resilience- The ability to recover from undesirable outcomes, both individually and organizationally.

Risk- A measure of the probability and consequence of uncertain future events.

Risk Acceptance- A strategy that involves an explicit or implicit decision not to take an action that would affect all or part of a particular risk.

Risk Assessment- A product or process that collects information and assigns values (relative, qualitative, quantitative) to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision making.

Risk Avoidance- A strategy that uses actions or measures to effectively remove exposure to a risk.

Risk Based Decision Making- A decision making process that relies on the identification, analysis, assessment, and communication of wildland fire risk as the principal factors in determining a course of action to improve the likelihood of achieving objectives.

Risk Communication- An exchange of information with the goal of improving the understanding of risk, affecting risk perception, or equipping people or groups to act appropriately in response to an identified risk.

Risk Management- A comprehensive set of coordinated processes and activities that identify, monitor, assess, prioritize, and control risks that an organization faces.

Risk Mitigation- The application of measure to alter the likelihood of an event or its consequences.

Risk Perception- Subjective judgment about the characteristics and magnitude of consequences associated with a risk.

Risk Reduction- A decrease in risk through risk avoidance, risk control, or risk transfer.

Risk Transfer- A strategy that uses actions to manage risk by shifting some or all of the risk to another entity, asset, resources, system, or geographic area.

Values-At- Risk- Those ecological, social, and economic assets and resources that could be impacted by fire or fire management actions.

Vulnerability- The physical feature or attribute that renders values susceptible to a given hazard.

Wildfires- Unplanned wildland fires resulting in a negative impact.

Wildland Fire- Any non-structure fire that occurs in vegetation or natural fuels. Wildland fire includes prescribed fire and wildfire.

Wildland Fuels- All vegetation (natural and cultivated).

Wildland Urban Interface (WUI)- Any developed area where conditions affecting the combustibility of both wildland and built fuels allow for the ignition and spread of fire through the combined fuel complex.

Wildland Urban Interface Hazard- Combustibility of the wildland or built fuels, fuel type or fuel complex.

Wildland Urban Interface Risk- The WUI hazard accounting for factors that contribute to the probability and consequences of a WUI fire.

APPENDIX A: Rocky Mountain Research Station Wildfire Hazard Mapping For Lewis And Clark Co, Montana

***Jessica Haas**, USDA Forest Service, Rocky Mountain Research Station*

Assessment Overview

The U.S. Forest Service's Rocky Mountain Research Station was engaged by the group of planners and analysts leading the Community Planning Assistance for Wildfire analysis (hereafter, the CPAW team) for Lewis and Clark County, MT to perform an assessment of spatial wildfire hazard to support CPAW's recommendations for wildfire planning codes and regulations. This analysis and report accomplishes two objectives: 1) provide an assessment to realistically represent wildfire hazard in the county; 2) provide methods that are transparent, based on the best available science, and can be used with various partners when planning for wildland fires. In this document we provide a brief background outlining wildfire hazard and risk terminology, a detailed explanation of our modeling and mapping methods, and descriptions of final Lewis and Clark County wildfire hazard maps.

❖ Background – Wildfire Hazard and Risk

How likely is it that a place will burn? How hot is it likely to burn? And, at different fire intensity levels, what would the effects be on something we care about? These questions describe the three fundamental components needed to assess wildfire risk: likelihood, intensity, and effects (sometimes termed "susceptibility"). Scott et al. (2013) conceptualize this as the wildfire risk triangle (Figure A-1). If we can gather quantitative information on all three legs of this triangle, then we can quantify the risk to the thing we care about.

Figure A-1. The three components of the wildfire risk triangle include the likelihood of a wildfire, the intensity of a wildfire and the effect of a wildfire on something we care about (susceptibility). Figure is from Scott et al. (2013)

For the purposes of this analysis, we are focusing on two sides of the wildfire risk triangle: *likelihood* and *intensity*. Together, those two pieces of information represent wildfire *hazard*. To map likelihood and intensity across a landscape, we use outputs from two different, but related, fire behavior models. The fire modeling application most often used for large-scale landscapes is called the Large Fire Simulator, or FSim (Finney et al. 2011). FSim draws upon weather and fire occurrence data from recent decades to generate statistically possible weather for 10,000 or more simulated fire seasons. Within each of these simulated years, ignitions are placed on the landscape informed by observed large fire occurrence patterns, fires are spread using spatial data for fuels, topography, and simulated weather, and a set of many thousand possible fire perimeters are generated.

Whereas FSim provides a synoptic, "landscape scale" assessment of fire behavior and estimates annualized probabilities of the occurrence and intensity of large fires, another model, FlamMap (Finney 2006), computes a localized, and specialized view of potential fire behavior under a specific set of environmental conditions. If a user parameterizes FlamMap for environmental conditions representative of when problem wildfires have occurred, fire behavior outputs represent a "problem fire" scenario at a "local scale". Including characterizations of wildfire hazard at both landscape and local scales affords a two-pronged assessment of potential fire behavior; we see what kind of fire behavior we could experience under a range of conditions that have occurred in recent history, and we also get a picture of fire behavior that could occur under extreme conditions.

While we don't specifically address the susceptibility side of the triangle in this analysis, we combine fire behavior probability and intensity estimates to assess and map wildfire hazard at multiple spatial scales in Lewis and Clark County.

❖ The Concept of the "Fireshed"

Wildfire is inherently a process that operates on the landscape independently of ownership, jurisdictional, or other municipal boundaries. For that reason, we began with a jurisdictional boundary (the extent of Lewis and Clark County) for this analysis, but expanded outward to capture the contributing area from which wildfires might impact those boundaries. Just like a watershed is the land area from which water may drain to a specific point, line, or area, a "fireshed" is a potential source area for wildfires that could impact a particular location (Scott and Thompson 2015).

We delineated a fireshed for the landscape scale fire modeling assessments conducted for Lewis and Clark County (Figure A-2). Lewis and Clark County performs most of their fire response within a collaborative called the Tri-County FireSafe Working Group. Therefore the fireshed was created for the entire Tri-County planning area, which includes Lewis and Clark, Broadwater and Jefferson Counties. FSim produces outputs of modeled fire perimeters and the ignition points associated with those perimeters. To construct the fireshed polygons, we first selected all simulated fire perimeters which intersect with the county boundary so we can interpret the final firesheds as boundaries that represent the area where wildfires could spread into and out of the Tri-County area.

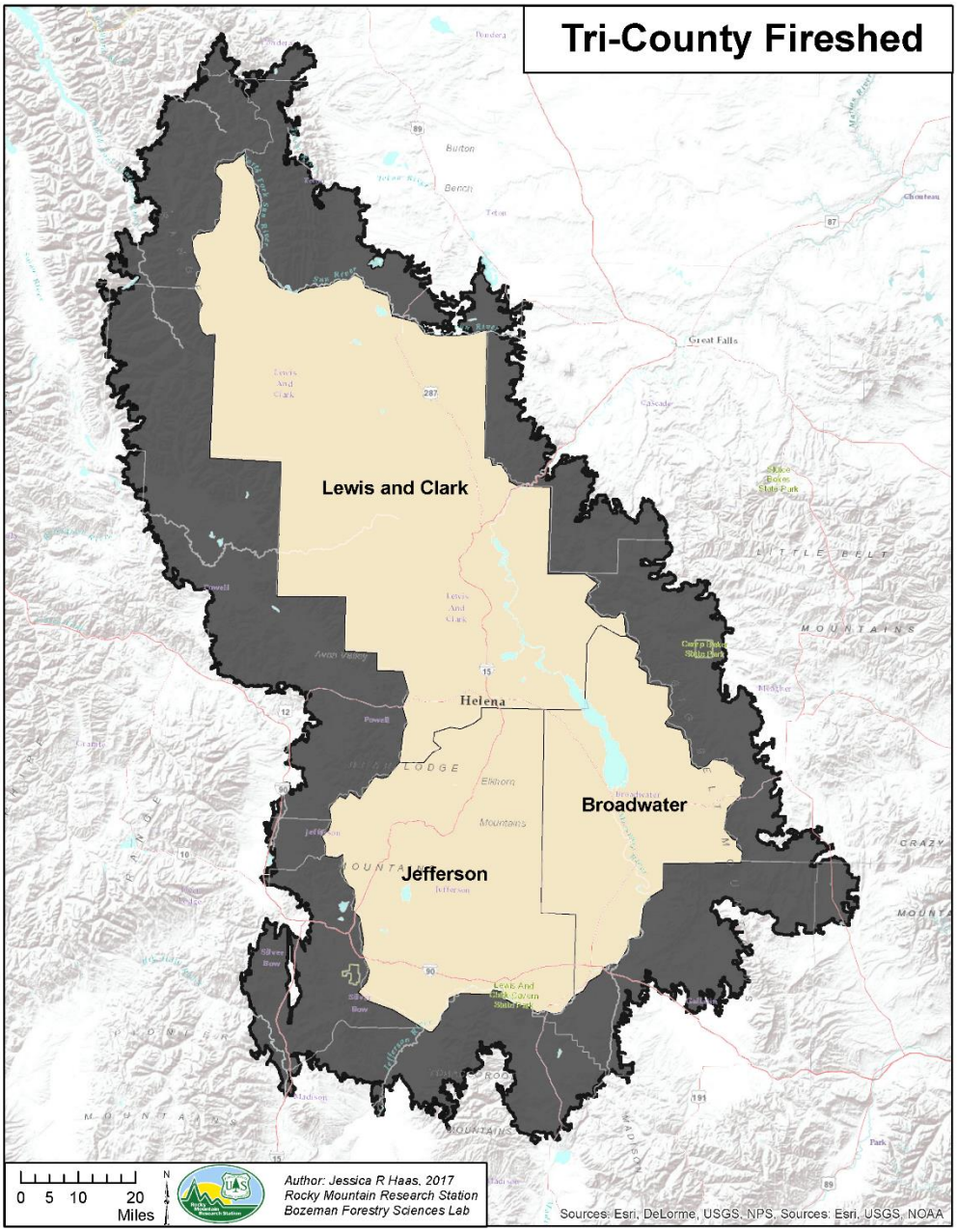


Figure A-2. delineated fireshed for the landscape scale fire modeling assessments conducted for Lewis and Clark County

Wildfire Hazard Characterization for Lewis and Clark County

Wildfire hazard is a measure of the likelihood that an area will burn and the likely intensity of the burn, given that a fire occurs. For Lewis and Clark County, we present two evaluations of wildfire hazard: landscape level and local level.

❖ Landscape Level Wildfire Hazard - Modeling, Maps, and Figures

As noted previously, we used FSim modeling work completed for a regional risk assessment (Gilbertson-Day, J., et al (2017)) for the purpose of evaluating wildfire likelihood and intensity for landscape level analysis. We acquired the 180m-resolution raster geospatial outputs along with the spatial point and polygon datasets for the simulated ignition points and fire perimeters. For a thorough description of the modeling fuelscape, inputs, and parameters, see the Northern Rockies Risk Assessment report.

Landscape Level Summary Zone

To summarize the spatial metrics of likelihood, intensity, and hazard for the "landscape level" analysis, we chose sub-watersheds from the national USGS Watershed Boundary Dataset (https://nhd.usgs.gov/wbd.html) as the polygon summary unit. Sub-watersheds are designated by 12-digit hydrologic unit codes, and are often referred to as "HUC12" watersheds. The HUC12 summary unit is commonly used to summarize landscape attributes; is devoid of administrative boundaries; and is based on the areal extent of surface water draining to a point (Bureau of Land Management, Watershed Boundaries Washington, available at (https://nhd.usgs.gov/wbd.html, accessed 10-30-2017.) Using a summary unit is important, because while an individual spot on the landscape will have an individual value, that one spot is inevitably impacted by the values of its neighbors; summarizing the raster FSim outputs and the derived hazard index to these polygons allows for broad-scale patterns to emerge that may not be immediately visible in the raw pixel datasets.

There are 532 sub-watersheds that intersect the Tri-County boundary, with 127 of them contained within Lewis and Clark County. The resulting sub-watersheds summary unit polygons range in size from 196.15 km^2 (48,470 acres) to 17.78 km^2 (4,394 acres), and average 79.22 km^2 (19,576 acres).

Landscape Fire Likelihood

Landscape Fire Likelihood, or burn probability (BP), is the FSim-modeled annual likelihood that a wildfire will burn a given point or area. It is calculated as the number of times a pixel burns during a simulation, divided by the total number of iterations.

The landscape level burn probability map represents the average of all 180-m pixel values within each sub-watershed, classified into four classes of very low, low, moderate and high (Figure 3a). The classes are relative to the distribution of sub-watershed averages only within the analysis area, and are based on quartiles. Low represents values below the 25^{th} percentile, moderate represents values between the 25^{th} and 75^{th} percentile, and high represents values above the 75^{th} percentile. The average BPs for sub-watersheds range from 0.0011 to 0.0148, with a mean of 0.005. This means, on average, any *watershed*) has about a 1 in 200 chance of experiencing a large fire in any given fire season. (For an explanation of this math, see Scott et al. 2013).

In our Lewis and Clark County assessment, average landscape burn probability values are low in the eastern part of the county through the lower elevation plains and highest in the Northwestern portion of the county, which primarily consists of the Scapegoat and Bob Marshall wilderness (Figure A-3a). Table 1a summarizes the 10 watersheds with the highest mean burn probability. The inverse of burn probability is the odds ratio. The highest burn probability watershed is Basin Creek in the northwestern portion of Lewis and Clark County. This watershed has a mean burn probability of 0.0148, resulting in an odds ratio of 1:67, meaning this watershed has a 1 in 67 chance of experiencing a fire on any year, given the current fuels on the landscape. Only large, landscape-scale changes in fuel composition, such as a large fire, would change these odds for a given watershed.

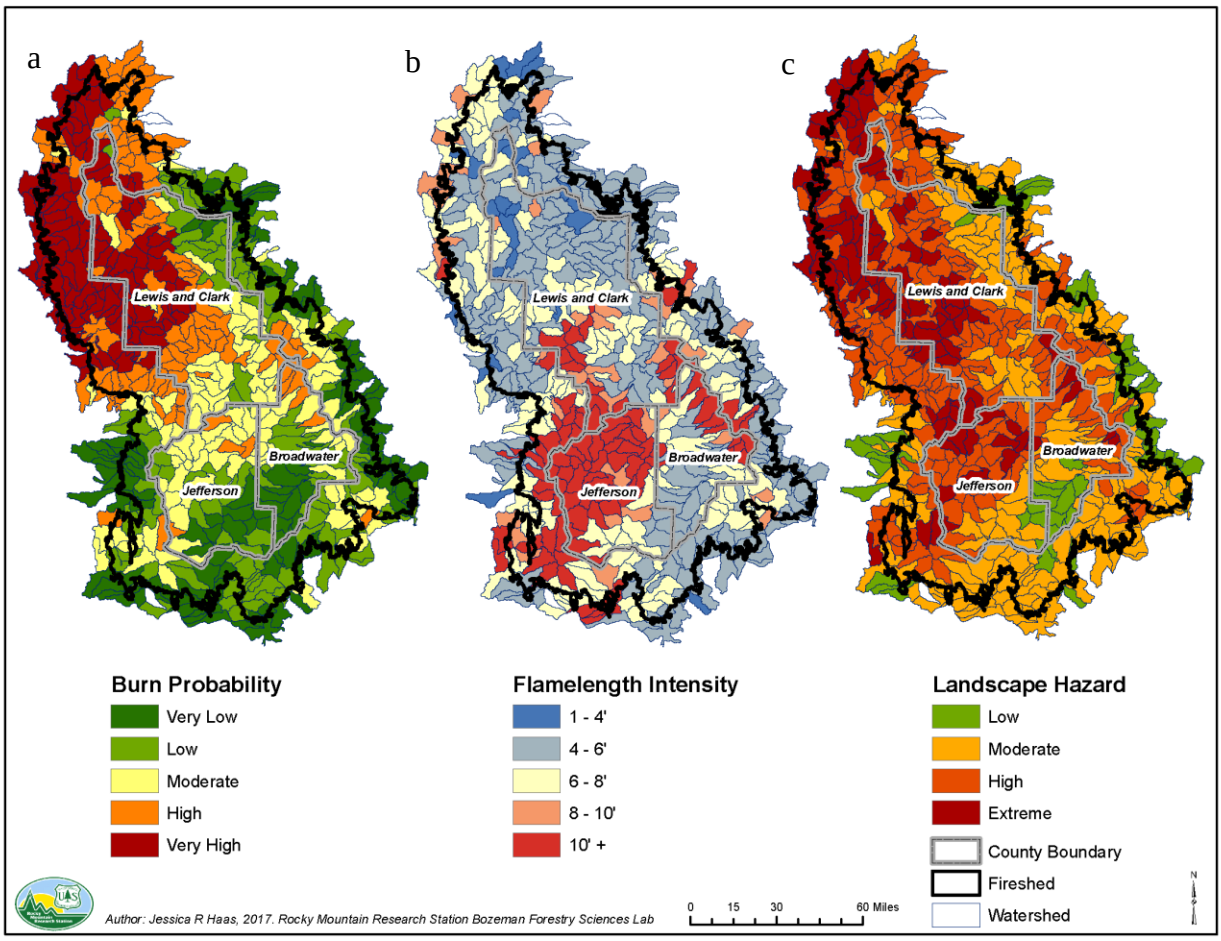


Figure A-3. Landscape level burn probability, fire intensity and wildfire hazard

Landscape Fire Intensity

FSim can apportion burn probability into wildfire intensity levels and produce estimates of the probability of a certain flame length class, given a fire burns a pixel. Conditional flame length (CFL) is the average of all flame length probabilities that FSim simulated for each 180-m pixel. We summarize the pixel level CFL values within sub-watersheds by calculating the average CFL for each sub-watershed polygon. To create the Landscape Fire Intensity map (Figure 3b), we classified the summarized CFL values into five classes by flame lengths.

Starting approximately around the year 2010, the Tri-Counties area experienced broad-scale tree die off due to mountain pine beetle infestation of the lodge pole forested ecosystem. These trees are currently still standing, although many are starting to fall. This increased fuel load has the effect of increasing wildfire intensity. This is very evident in the FSIM outputs where the forests around Southern Lewis and Clark County, northeastern Broadwater County and much of Jefferson County have very high CFL values. The highest mean intensity watershed is the Upper Tenmile Creek watershed west of Helena (Table A-1B).

Landscape Wildfire Hazard

Wildfire hazard is an integration of likelihood and intensity, quantified as the product of burn probability (BP) and conditional flame length (CFL). We calculated hazard at the pixel scale and then summarized values to the HUC12 sub-watershed scale by calculating the mean hazard value for each watershed polygon. We then classified the values into four classes (Low, Moderate, High and Extreme) based on

quartiles in the distribution of values in the Tri-County analysis area. The actual numeric values of hazard are less directly interpretable than BP or CFL. Instead, they provide a relative depiction of hazard across a landscape.

Of the 532 watersheds in the Tri-County area, 127 of them are within or intersect Lewis and Clark County. Since the hazard classes are based on quantiles, 133 watersheds fall within each hazard class across the Tri-Counties area (Figure A-3c). For just Lewis and Clark County, 21 are in the low class, 44 are in moderate, 45 are in high and 66 are in the extreme class. If the hazards were distributed evenly among the three counties, each class would contain 44 watersheds. Given that Lewis and Clark County has 66 in the extreme class, this county holds an above average extreme wildfire hazard for the area.

For further insight into how mean BP and mean CFL combine to influence the overall mean hazard estimates, we plotted the average hazard value for each sub-watershed as the intersection of average BP and average CFL (Figure A-4). By doing this, we can see the degree to which each input contributes to the overall wildfire hazard (numbers on the scatterplot in Figure 4 correspond to labeled sub-watersheds in Figure A-3c and represent the ranked highest (1) to lowest (176) hazard watershed). Twenty-four of the extreme hazard watersheds are within wilderness areas, and are primarily extreme hazard due to high burn probability. The remaining are in the center of the southern half of the county, and the extreme hazard is due primarily to high expected intensities. Table A-1C summarizes the 10 highest hazard watersheds.

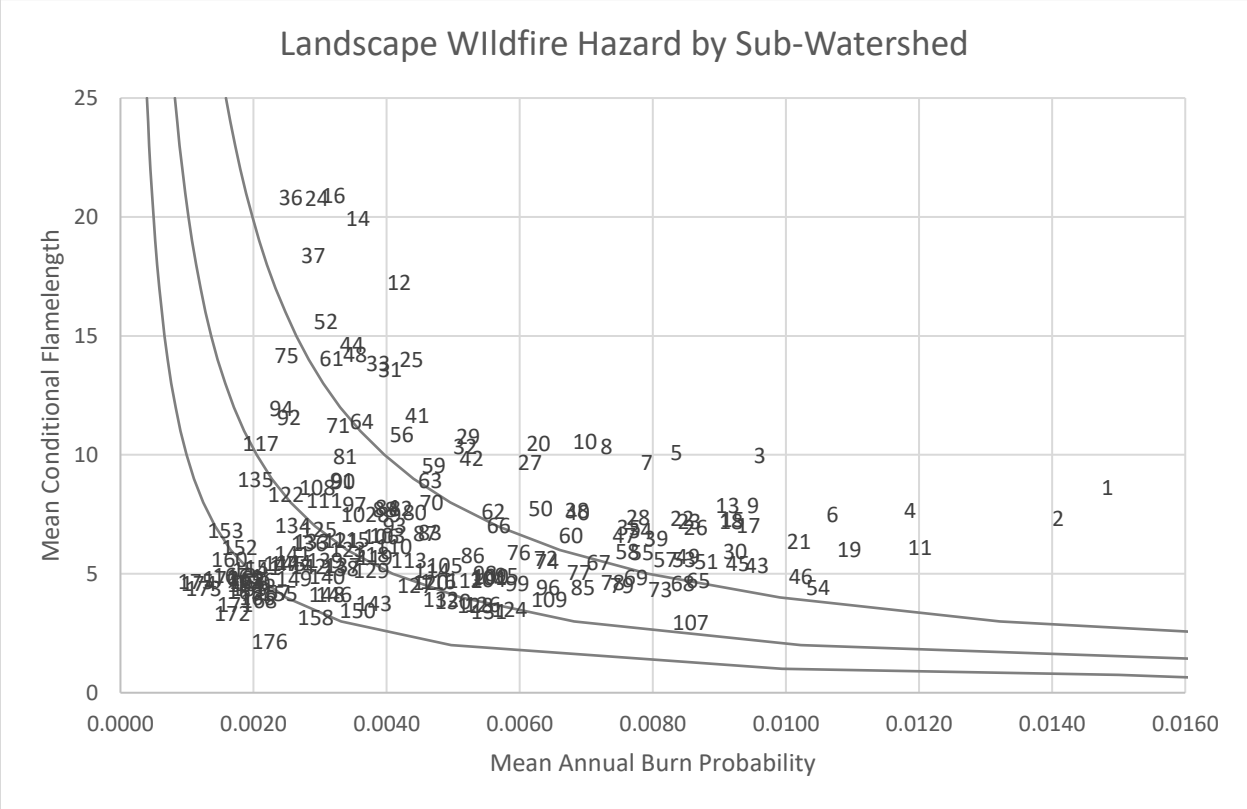


Figure A-4. Landscape level hazard by sub-watershed. Curves represent lines of constant hazard and stratify the plot into hazard zones that correspond to map categories from left to right: low, moderate, high and extreme. The numbers represent the ranked individual sub-watersheds.

Table A-1: Summary of the top 10 watersheds by (A) Burn Probability, (B) Intensity and (C) Hazard.

A: Highest Burn Probability Sub-Watersheds

Sub-Watershed Name	Mean Annual Burn Probability	Mean Intensity	Hazard Index	Hazard Class	Hazard Rank	Odds (1:xx)
Basin Creek	0.0148	8.7	0.1284	extreme	1	67
Lower Danaher Creek	0.0141	7.4	0.1037	extreme	2	71
Upper Danaher Creek	0.0120	6.1	0.0736	extreme	11	83
Middle Spotted Bear	0.0119	7.7	0.0912	extreme	4	84
Rapic Creek	0.0110	6.1	0.0665	extreme	19	91
Lower N. Fork Sun River	0.0107	7.5	0.0806	extreme	6	93
Lake Creek	0.0105	4.5	0.0470	extreme	54	95
N Fork Blackfoot River-Jakey Creek	0.0102	4.9	0.0503	extreme	46	98
Upper Monture Creek	0.0102	6.4	0.0652	extreme	21	98
Beaver Creek	0.0096	10.0	0.0960	extreme	3	104

B: Highest Intensity Sub-Watersheds

Sub-Watershed Name	Mean Burn Probability	Mean Intensity	Hazard Index	Hazard Class	Hazard Rank	Odds (1:xx)
Upper Tenmile Creek	0.0032	20.9	0.0671	extreme	16	312
Basin Creek	0.0026	20.9	0.0534	extreme	36	391
Ontario Creek	0.0029	20.8	0.0614	extreme	24	339
Telegraph Creek	0.0036	20.0	0.0712	extreme	14	280
Cataract Creek	0.0029	18.4	0.0534	extreme	37	345
Iron Horse Creek	0.0042	17.3	0.0723	extreme	12	238
Middle Tenmile Creek	0.0031	15.6	0.0483	extreme	52	323
Lump Gulch	0.0035	14.7	0.0510	extreme	44	287
Mike Renig Gulch	0.0035	14.3	0.0503	extreme	48	283
Last Chance Gulch	0.0025	14.2	0.0355	high	75	400

C: Highest Hazard Sub-Watersheds						
Sub-Watershed Name	**Mean Burn Probability**	**Mean Intensity**	**Hazard Index**	**Hazard Class**	**Hazard Rank**	**Odds (1:xx)**
Basin Creek	0.0148	8.7	0.1284	extreme	1	67
Lower Danaher Creek	0.0141	7.4	0.1037	extreme	2	70
Beaver Creek	0.0096	10.0	0.0960	extreme	3	104
Middle Spotted Bear	0.0119	7.7	0.0912	extreme	4	84
Hogum Creek	0.0084	10.1	0.0845	extreme	5	119
Lower N Fork Sun River	0.0107	7.5	0.0806	extreme	6	93
Blackfoot River-Willow	0.0079	9.7	0.0769	extreme	7	126
Poorman Creek	0.0073	10.4	0.0757	extreme	8	136
Blackfoot River-Anaconda Creek	0.0095	7.9	0.0753	extreme	9	105
Upper S Fork Dearborn	0.0070	10.6	0.0739	extreme	10	143

❖ Local Level Wildfire Hazard - Modeling, Maps, and Figures

For the local level hazard and exposure assessment, we used a command line version of FlamMap 5.0 to model wildfire behavior.

Wind, Weather and Fuel Moisture Parameters

FlamMap needs information regarding fuel moisture and wind for the simulation. To evaluate these parameters for our simulation, we used three Remote Automated Weather Stations (RAWS) stations in the vicinity of Lewis and Clark County. Helena, Lincoln, and Browning RAWS were evaluated from July 1 – October 31, 1977 – 2016 to determine 97th percentile conditions using Fire Family Plus v4.1.

Fuel Moistures were analyzed for percentile values equal to or less than the 97th percentile with almost completely cured live fuel moistures (60%, 90%). We used 97th percentile dead fuel moistures (rounded to the nearest integer) for the initial dead fuel moistures for all fuels (fuel models) during the simulation (3%, 3%, and 5% for the 1-hr, 10-hr and 100-hr dead fuel moistures, respectively. Historically, higher wind speeds from the west are shown to occur in the summer months when conditions are dry (Figure A-5), so we chose a 15-mph west wind to initialize the 20-ft wind speed in FlamMap. Testing showed that this choice of wind speed and direction produced reasonable values for ridgetop wind speeds, as processed by Wind Ninja.

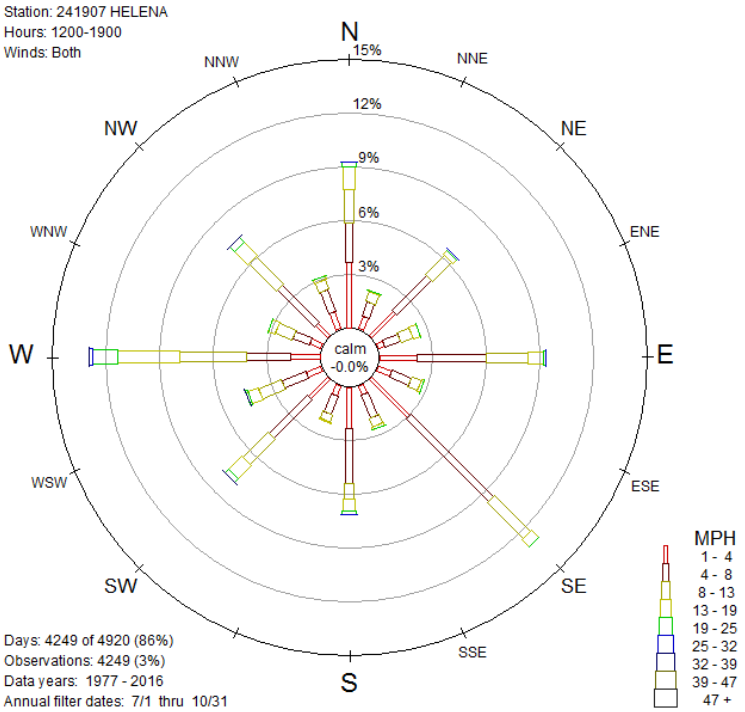


Figure A-5: Historical 20 ft. wind speed and direction during summer months

Landscape File Layers and Modifications

Most fire modeling systems (including FSim and FlamMap) require a set of raster geospatial layers that characterize landscape topography (elevation, slope and aspect) and fuels attributes (fuel model, canopy cover, canopy height, crown base height, and crown bulk density). A local level analysis allows for fine-scale modifications of the landscape file (surface and canopy fuel attributes) to reflect the current existing landscape as best as possible given the modeling assumptions of FlamMap. We obtained the 30-meter resolution geospatial layer set (or landscape file) that Pyrologix LLC had used initialize their FSim modeling for Montana. Pyrologix conducted a landscape file calibration workshop with various fire behavior specialists throughout the study area. They primarily modified lodge pole fuel types that were dead due to the mountain pine beetle outbreak (see the NoRRA assessment report for further details.)

Local Level Maps and Figures

We initialized the Minimum Travel Time (MTT) module within FlamMap 5.0 with 50,000 random fire ignitions with a maximum simulation time of 480 minutes per ignition, a calculation resolution of 60-meters, and an interval for Minimum Travel Paths of 500-meters. We chose to output burn probabilities, fire perimeters, and flame length probabilities classed into 6 bins. Though the input modeling landscape rasters have a cell resolution of 30-meters, the output burn probability and conditional flame length rasters have a 60-m cell resolution, reflecting our decision to use an MTT calculation resolution of 60-meters to drastically reduce simulation duration.

Local Level Summary Zone

To summarize the spatial metrics of likelihood, intensity, and hazard for the "local level" analysis, we chose to use catchments from the USEPA and USGS National Hydrography Dataset Plus V2 (https://www.epa.gov/waterdata/nhdplus-national-hydrography-dataset-plus). Catchments are local level drainage areas and typically subdivide HUC12 watersheds into smaller polygon units. Using a summary unit is important, because an individual spot on the landscape will have an individual value, but that one spot is inevitably impacted by the values of its neighbors; summarizing the raster FlamMap outputs and

the derived hazard index to these polygons allows for broad-scale patterns to emerge that may not be immediately visible in the raw pixel datasets. There are 7,393 catchments that intersect the Lewis and Clark County boundary. The resulting catchment and partial catchment summary unit polygons range in size from 0.0009 to 47.9 km^2, and average 1.39 km^2.

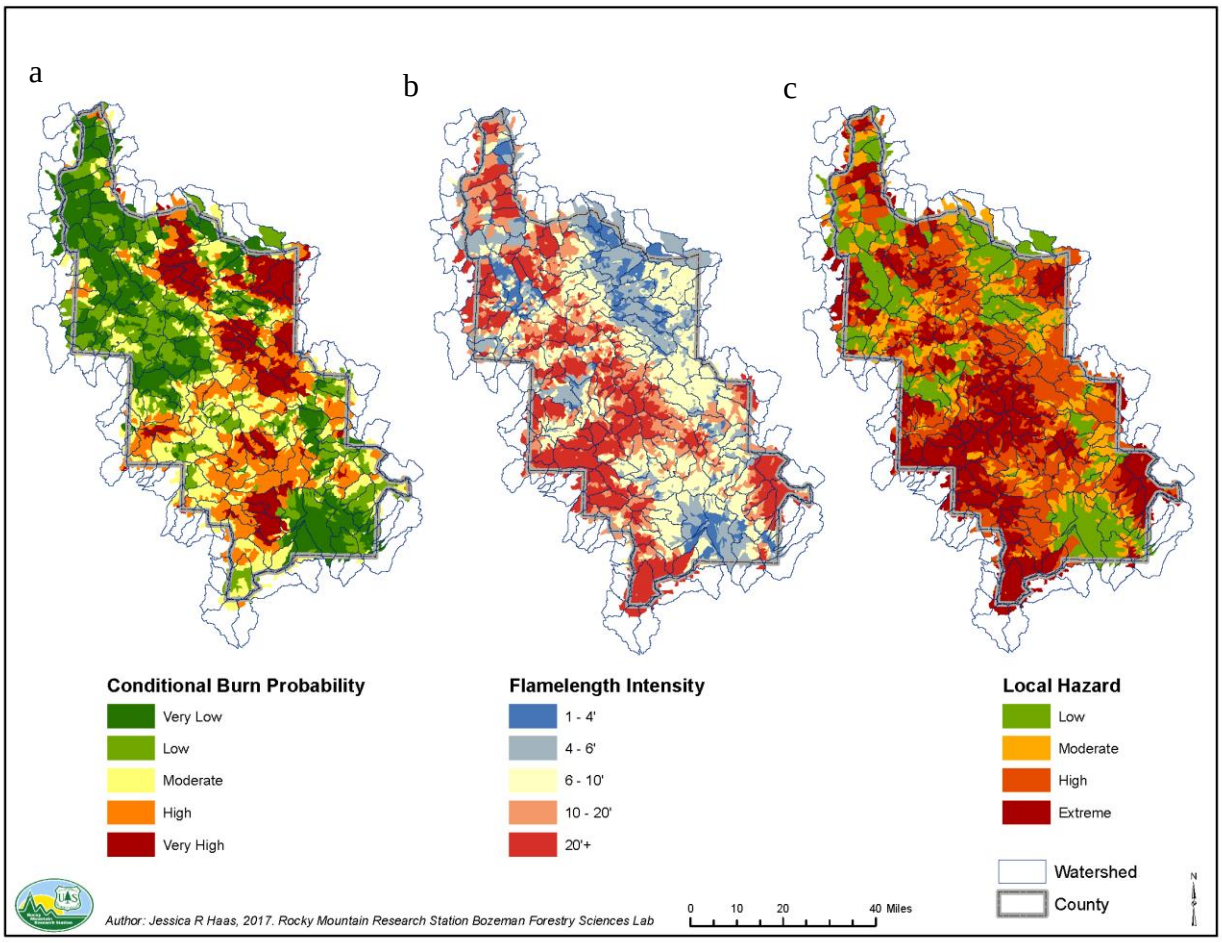


Figure A-6. Local level burn probability, fire intensity and wildfire hazard

Local Fire Likelihood

Local Fire Likelihood, or burn probability (BP), is the FlamMap-modeled likelihood that a wildfire will burn a given point or area, given fixed weather conditions and a random ignition. It is calculated as the number of times a pixel burns during a simulation, divided by the total number of iterations. Because we parameterized FlamMap with a "problem fire" scenario as describe above, BP from our FlamMap run represents those specific conditions.

The local level burn probability map represents the average of all 60-m pixel values within each catchment, classified into five classes of very low, low, moderate, high, and very high (Figure A-6a). The classes are relative to the distribution of catchment averages only within the analysis area, and are based on quartiles. The average BPs for catchments range from 0 to 0.0174, with a mean of 0.0044. Burn probability is a function of rate of spread and duration of fires for an extreme event. We suggest that burn probability output from the local FlamMap simulation are conditional and are more useful as *relative* values as opposed to *actual* annual values from FSim.

Local Burn Probability is quite different spatially than the landscape level burn probability. Where the landscape level BP was low for the eastern portion of the county, the local BP is high. This can be

explained by the presence of more grass/shrub vegetation types. These fuels don't necessarily contribute much to the annual burn probability, but they tend to move quickly and spread rapidly when they ignite under extreme fire conditions. They can be particularly dangerous due to this rapid rate of spread.

Local Fire Intensity

Like FSim, FlamMap can apportion burn probability into wildfire intensity levels and produce estimates of the probability of a certain flame length level, given a fire burns a pixel. Local Conditional Flame Length (CFL) is the average of all flame length probabilities that FlamMap simulated for each 60-m pixel.

We summarize the pixel level CFL values within catchments by calculating the average CFL for each catchment polygon. To create the Local Fire Intensity map (Figure A-6b), we classified the summarized CFL values into five classes, based on flame length, as described in the landscape summary discussion.

Similar to the FSim results, the forests around Southern Lewis and Clark County, northeastern Broadwater County and much of Jefferson County have very high CFL values.

Local Wildfire Hazard

Wildfire hazard is an integration of likelihood and intensity, and we calculated it as the product of BP and CFL. We calculated local hazard at the pixel scale and then summarized values to the catchment scale by calculating the mean hazard in each catchment polygon. We then classified the values into four categories (Low, Moderate, High and Extreme) based on quartiles in the distribution of values in the analysis area (county). The actual numeric values of hazard are less directly interpretable than BP or CFL. Instead, they provide a relative depiction of hazard across a landscape.

High local wildfire hazard values are speckled throughout the county, but also cluster in the northeastern portion of the county, and in the central and southwest portions of the county (Figure A-6c). There are some clusters of low local hazard that reflect the imprint of previous fires, where the fuel model was modified to reflect the disturbance.

Wildland Urban Interface Zones

We mapped categories of structure density integrated with wildland vegetation to characterize where structures are in or near burnable vegetation in Lewis and Clark County.

Though we generally followed methods that mimic Federal Register Wildland Urban Interface (WUI) definitions as adapted by Radeloff et al. 2005, we customized our WUI mapping to appropriately represent rural developed areas in the county. Conventionally, WUI is mapped using Census data for population density information and Census blocks as the summary unit. In Lewis and Clark County, the size of Census blocks can be quite large, and though structures may exist in the larger blocks, the value attributed to the entire block will be a "low structure density-vegetated" class, with no spatial delineation as to where the structures exist within the large summary unit. Since the county has accurate and up-to-date address point data for all structures in the county, we used these points, instead of Census data, to represent structures for our mapping efforts. We did not filter the address point layer to include only residences; we instead chose a conservative approach and included all records in the address point layer, reasoning that all structures are important to county residents. We used the point data as input into the Kernel Density tool (ESRI ArcGIS) to create a raster surface of structure density, which we then sliced into the ranges of values needed to combine with vegetation categories to create WUI classes (Table 2). We caution that the address point data is accurate for a "snapshot in time"; users should consider periodic remapping WUI zones using a current address point layer to adequately represent new development in the county.

We defined wildland vegetation as anything that is classed with a "burnable" fuel model in the same fuel model raster data that we used in our fire behavior modeling. Non-burnable fuel model categories include urban, snow/ice, agriculture, water, and barren. To quantify the percentage of vegetation within an area, we used the Focal Statistics tool (ESRI ArcGIS) to calculate the percentage of burnable fuel within a 40 acre moving window around each pixel, and assign that value to the center pixel.

Structure density and vegetation raster layers were combined to map the WUI (Figure A-7), with the map categories described in Table A-2. One modification that we made to rules outlined in Radeloff 2005 was to include the "Vegetated Very Low Density" category with the WUI Intermix category. This decision reflects the Federal Register statement that "intermix exists where structures are scattered throughout a wildland area" (USDA and USDOI 2001) and our intent to spatially delineate isolated structures in rural areas.

Table A-2. Description of mapping ruleset for Wildland Interface zones.

WUI Category	Structure Density Description	Structure Density Range (structures/km^2)	Vegetation Description
Interface	High Density	6.17 - 741.31	Wildland vegetation < 50% and within 2.414 km of area with > 75% wildland vegetation
Intermix	High Density	6.17 - 741.31	Wildland vegetation > 50%
Non-Vegetated	High Density	6.17 - 741.31	Wildland vegetation < 50%
	Very Low Density	< 6.17	
Vegetated	Very Low Density	< 6.17	Wildland vegetation > 50%
	Uninhabited	0	

In an effort to characterize the potential impact of wildfire spotting from wildland vegetation to structures in Lewis and Clark County, we explored several different ways of modeling and characterizing spotting distances and we used those methods to assess the estimated spotting distances spatially. Though the scientific community has not yet developed a way to quantify the *probability* of wildfire ember impact to structures, what we found from in our preliminary testing was that virtually every piece of land in Lewis and Clark County is within a distance from wildland fuels that *could* produce embers. This aligns with what we found during our WUI mapping efforts: because any address point in Lewis and Clark County is within 1.5 miles of an area that is 75% vegetated, the mapped extents for WUI Interface classes are identical to the Non-Vegetated High, Medium and Low structure density classes. This means that any area within a high, medium or low density class in the county is mapped as either Interface or Intermix. The 1.5 mile distance was adopted by Radeloff 2005 from a publication of the California Fire Alliance 2001, where it was said to represent the distance that a firebrand (ember) could fly ahead of a fire front. What we found in our preliminary testing is that the 1.5 mile distance may underestimate or overestimate spotting distances depending on fuel type, but since we found that all of the county could possibly be impacted by embers, we feel that it is as appropriate a distance criteria as any for the purpose of this analysis.

We buffered the WUI interface and intermix classes out 4 miles to capture the wildland fuels most likely to generate embers that could reach a structure. This area represents vegetated lands where fuel reduction efforts may be a priority.

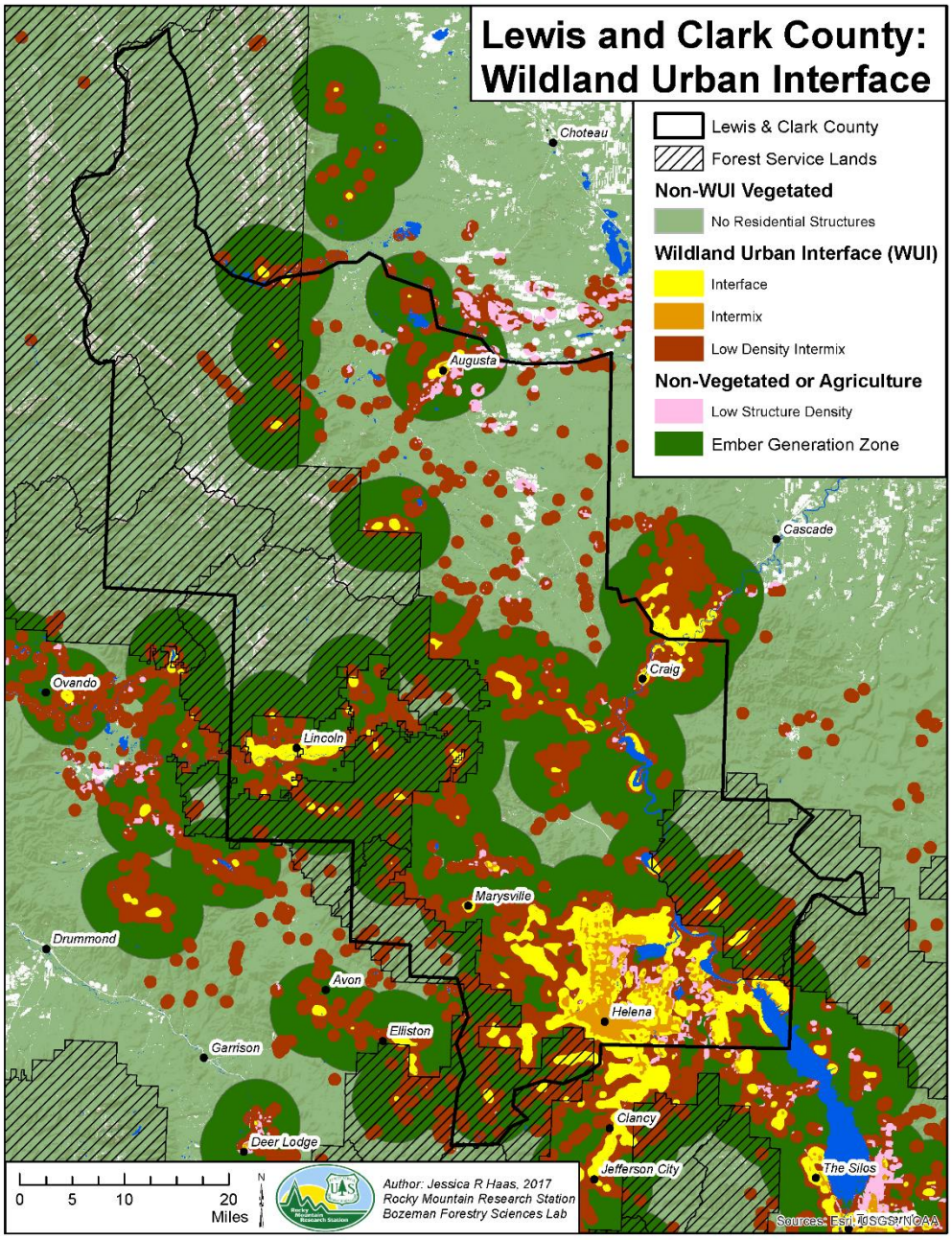


Figure A-7. Lewis and Clark County WUI areas map.

Mitigation Potential

As a complement to the landscape and local wildfire hazard assessments, we calculated an index that characterizes the difficulty and effort involved in modifying landscape characteristics in a way that could reduce wildfire hazard. To create the components necessary to map mitigation potential, we developed three 30-meter resolution spatial datasets, as follows:

Vegetation Life Form – We classified the Existing Vegetation Type (LANDFIRE 1.4.0) data set into four life form classes: 1. Barren/Developed/Sparsely Vegetated/ Irrigated Agriculture, 2. Grass, 3. Shrub, 4. Tree.

Slope – We classified the same slope dataset that was used to parameterize our fire behavior modeling landscape (LANDFIRE 1.4.0) into two classes: 1. Steep slopes - Slopes greater than or equal to 30%, 2. Shallow slopes – slopes less than 30%.

Crown Fire Activity – We used the Crown Fire Activity (CFA) raster output layer from our Basic FlamMap modeling to represent potential for crown fire. The logic used in calculating CFA within FlamMap takes into account the potential for fires burning in surface fuels to transition into tree crowns, and then it uses mapped tree crown characteristics and modeled wind speeds to determine whether that pixel could experience passive (fire is limited to individual tree torching) or active (fire spreads through crowns from tree to tree) crown fire. For the mitigation index, we collapsed the CFA raster into two categories: 1. No crown fire potential, 2. Potential for either passive or active crown fire.

We integrated the spatial layers described above to create the map of mitigation potential (Figure A-8) based on categories ranging from 0 to 5, increasing with difficulty to mitigate wildfire hazard:

0 – ember impact mitigation only:
Barren ground/water/sparse vegetation or land. Mitigation potential should involve appropriate home ignition zone and IR structure construction to mitigate ember impacts.

1 – grass life forms and agricultural areas on flat ground:
Fires are typically easier to suppress in these areas. However high winds combined with dry conditions leads to potentially dangerous fast moving high intensity fires. Mitigation potential may involve a combination of irrigation, mechanical (mowing) treatment, frequent burning, and fuel breaks in conjunction with appropriate structure ignition zone and IR structure construction.

2 – grass life forms on steep (≥30%) slopes:
Harder to construct fuel breaks, difficulty in mechanical (mowing) treatment, increased potential for erosion, increased rate of spread and intensity may make frequent burning more difficult. Focus should be on appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.

2 – shrubs on flat slopes:
Fires are typically harder to suppress than grassfires in these areas. High winds combined with dry conditions leads to potentially dangerous fast moving high intensity fires with fire fighter access concerns. Mitigation potential may involve a combination of mechanical (mastication) treatment, moderately frequent burning, and fuel breaks in conjunction with appropriate structure ignition zone and IR structure construction.

3 – shrubs on steep (≥30%) slopes:
Harder to construct fuel breaks, difficulty in mechanical (mastication) treatment, increased potential for erosion, increased rate of spread and intensity may make frequent burning more difficult. Focus should be on a combination of appropriate mechanical treatment or burning, slope set-backs, structure ignition zone and IR structure construction mitigation.

3 – trees on flat slopes with open canopy (no modeled crown fire potential):

Open canopy must be maintained to prevent increase crown fire potential. Surface fuels must be treated/maintained in a state that reduces the chances of fast moving surface fires in conjunction with appropriate structure ignition zone and IR structure construction mitigation.

4 – trees on steep slopes (≥30%) with open canopy (no modeled crown fire potential):

Open canopy must be maintained to prevent increased crown fire potential, which may be more difficult due to the slope. Surface fuels must be treated/maintained in a state that reduces the chances of fast moving surface fires. Mitigation should also include appropriate slope set-backs, structure ignition zone and IR structure construction mitigation.

4 – trees on flat slopes with potential for crown fire:

Dense canopy needs to be thinned to reduce crown fire potential. Surface fuels must be treated to reduce risk of fast moving surface fires. Mitigation should also include appropriate structure ignition zone and IR structure construction mitigation.

5 – trees on steep slopes (≥30%) with potential for crown fire:

Dense canopy needs to be thinned to reduce crown fire potential, which may be more difficult due to the slope. Surface fuels must be treated to reduce risk of fast moving surface fires. Mitigation should also include appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.

6 – complex ecosystems:

Due to the ecological system of these areas mitigation is extremely difficult and/or dangerous. Advanced vegetation management / mitigation plans will be necessary and highly skilled personnel will need to determine if any mitigation can be achieved. Avoiding new development in these areas should be considered. At a minimum, the most stringent standards should be applied to slope setbacks, the structure ignition zone and IR structure construction mitigation

7 – extremely dangerous areas to mitigate:

Due to the current state of these lands mitigation is extremely dangerous. Advanced vegetation management / mitigation plans will be necessary and highly skilled personnel will need to determine if any mitigation can be achieved safely. Avoiding new development in these areas should be considered. At a minimum, the most stringent standards should be applied to slope setbacks, the structure ignition zone and IR structure construction mitigation.

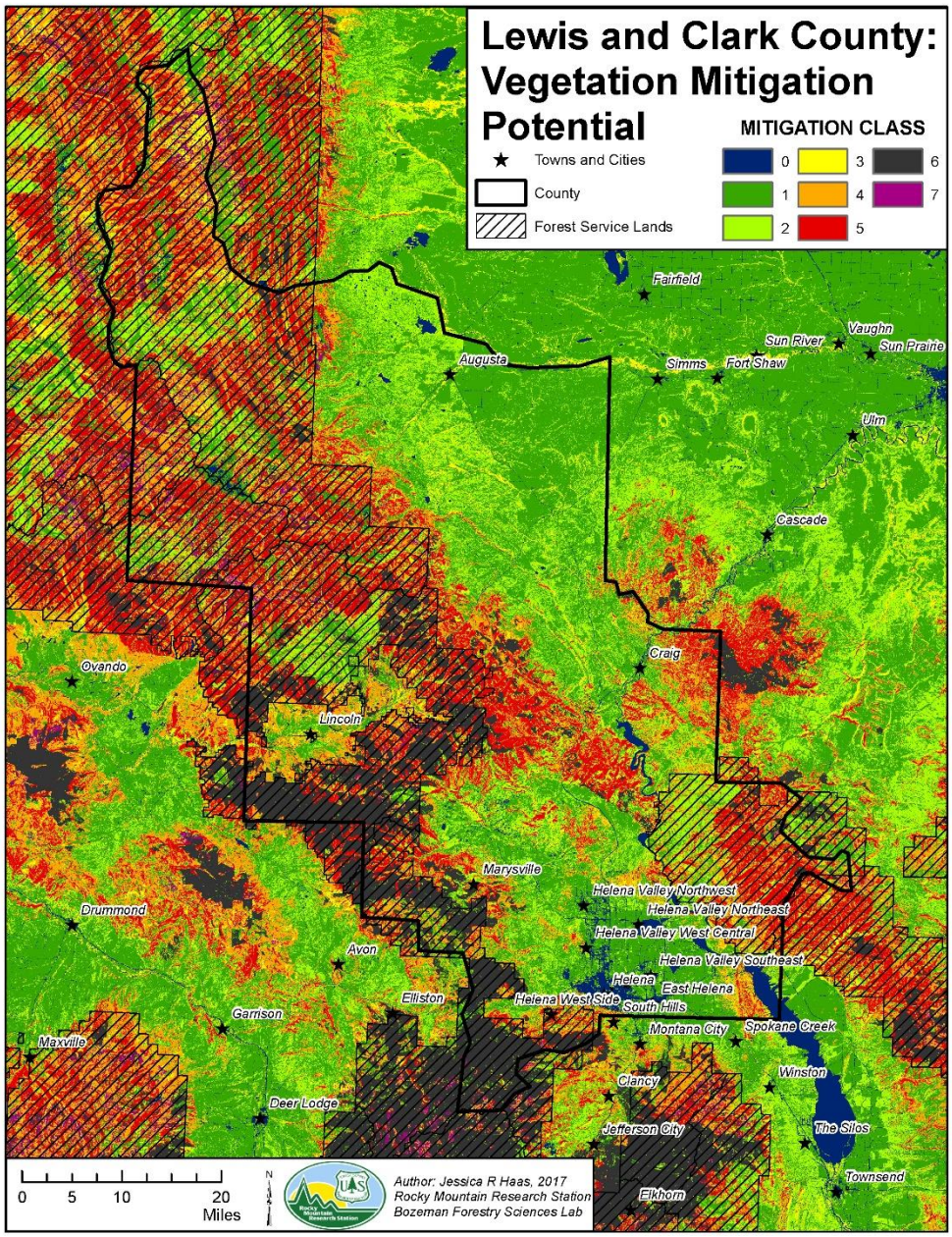


Figure A-8. Vegetation mitigation potential map

Analysis Summary and Recommendations for Use

In this report, we have presented two complementary representations of wildfire hazard for Lewis and Clark County. We are fortunate that the FSim modeling results from the Northern Rockies Quantitative Wildfire Risk Assessment were available in time for us to incorporate them into the landscape scale analysis. FSIM models thousands of fires that may last the entire fire season using tens of thousands of weather and wind scenarios. FSIM burn probability and conditional flame length can be annualized or evaluated on a yearly basis. A user can also answer the question, "what is the annual chance of a fire occurring?" anywhere on a landscape. As such, this part of the assessment sets the context for a broad picture of wildfire hazard, and dovetails with efforts of federal land owners to map wildfire risk on nearby federal lands.

The local level assessment used a more basic approach to model fire under a problem fire scenario. In FlamMap, we modeled 50,000 random fire ignitions with one wind and weather scenario that remained constant throughout the 8-hour simulation. Using a west wind, burn probability was modeled based on a dry and windy fire day and answers the question, "given a fire has already occurred, what is the chance this area could burn?" The local assessment benefits from adjustments made to fine-tune the fuels based on stakeholder feedback. It also benefits from the utilization of a sub-model called Wind Ninja that spatially modifies wind speed and direction based on terrain and vegetation influences (a common occurrence in Lewis and Clark County). However, the output must be used in the context of understanding that the problem fire scenario only represents one wind direction (west). Now that we have established the methodology for mapping the local wildfire hazard, there is opportunity for analysts to implement them on updated or modified datasets, either to refine the current picture of hazard or to compare current vs. past assessments to assess progress toward landscape changes that decrease hazard in the county.

Finally, the WUI mapping and Mitigation maps were included as ancillary datasets that could be used to further focus attention on where codes and regulations may best impact wildfire hazard reduction in the county.

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