Recommendations for Chelan County, WA

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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.

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 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 their 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 wildland-urban interface 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.

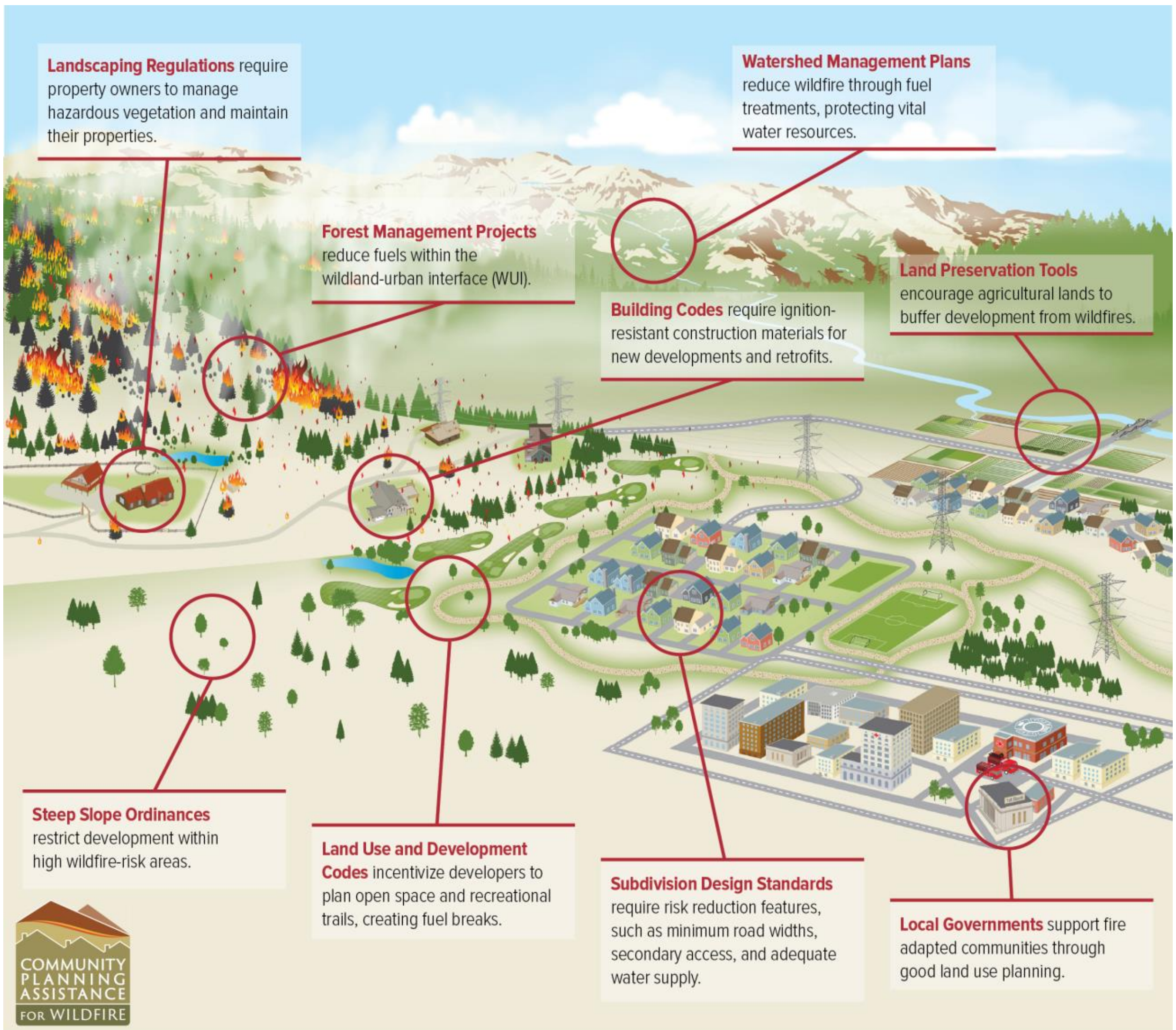

Figure 1. Illustration of Community Planning Tools for Wildfire

This report provides Chelan County with three 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, and any tips or additional resources. 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.

❖ Chelan County Planning Context

Chelan 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

Located in eastern Washington, Chelan County is the third largest county in the state in terms of land area. The county is shaped by grasslands to the east and a number of mountain ranges to the west, including the Cascade Mountains, Chiwaukum Mountains, Stuart Range, The Enchantments, Bonanza Peak (9,516 feet).[1] Two and a half percent of Chelan County is water,[2] including the Columbia and Wenatchee Rivers, and Lake Chelan—the largest natural lake in Washington.

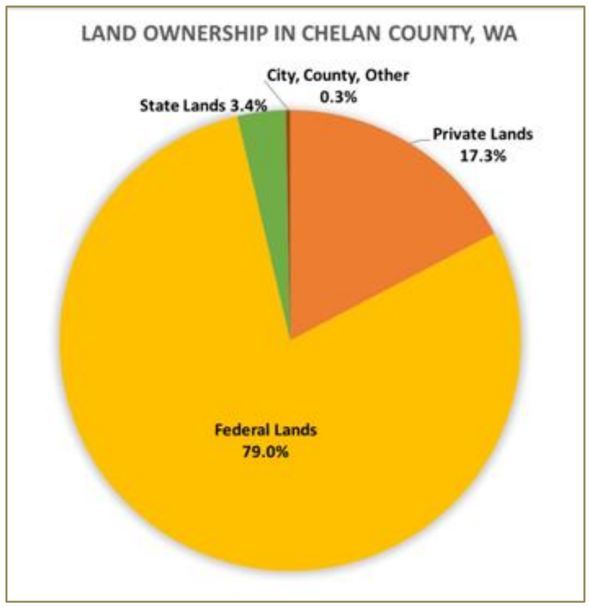

Figure 2. Land ownership in Chelan County (by percentage).

Land Area and Ownership

Chelan County has a total land area of 2,994 square miles,[3] the majority of which is federally managed and protected (77.9%). This includes the Lake Chelan National Recreation Area, North Cascades National Park, and the Wenatchee National Forest.[4] Private lands consist of 17.9%, and state land consists of 3.9% of land. Less than one percent (.3%) of land is owned by Chelan County and the municipalities within.[5]

[1] Chelan County, Washington. 2015. “Chelan County Comprehensive Plan.” January. 18p.
[2] County of Chelan, Chelan County IT - Jessie Laya - http://www.co.chelan.wa.us/
[3] U.S. Census Bureau. 2010.
[4] Chelan County, Washington. 2017. “Chelan County Comprehensive Plan 2017.” January. 4p.
[5] U.S. Geological Survey, Gap Analysis Program. 2012. Protected Areas Database of the United States (PADUS) version 1.3; Rasker, R. 2006. "An Exploration Into the Economic Impact of Industrial Development Versus Conservation on Western Public Lands." Society and Natural Resources. 19(3): 191-207

Key Demographics and Economic Trends

There are five incorporated cities in the county: Cashmere, Chelan, Entiat, Leavenworth, and Wenatchee (county seat). The remainder of the county is mostly rural, and includes the unincorporated communities of Chelan Falls, Manson, Plain, South Wenatchee, Peshastin, Monitor, and Malaga.

Chelan County is one of the fastest growing counties on the east side of the Cascade Mountain range. The county has approximately 436 square miles (279,000 acres) of land available for development.[6] Previous development has primarily occurred along the hills and valleys near river and lake basins. The majority of new development is predicted to occur on the outskirts of existing communities, in areas adjacent to existing infrastructure and other easily accessible services. The county also anticipates continued growth of second homes and vacation homes.

Table 1: Overview of Demographics in Chelan County, Washington

Topic	Key Statistic	Notes
Current population (residents)	74,267 residents	This is a 2.5% increase in population since 2000. [b]
Population density (people per sq. mile)	24.8 people/sq. mile	Compared to the state average of 101.2 people per sq. mile. [a]
Median age (years)	39.3 years	State median age is 37.4 years. [b]
Total number of housing units	35,934	514 of these housing units have been built since 2010. [b]
Housing units for seasonal, recreational or occasional use	5,454 homes	This accounts for 15.4% of all housing units. [a]
Median home price	$246,300	Compared to the state’s median home price of $259,50. [b]
Median household income	$51,837	Compared to state average of $61,062. [b]
Workforce employment	35,862	Largest employments industries are Educational services, health care, and social assistance (20.9%). [b]
Poverty rate	14.3%	State poverty rate: 13.3%. [b]

a. U.S. Census Bureau. 2010.
b. U.S. Census Bureau 2011-2015 American Community Survey 5-Year Estimates.

[6] Chelan County, Washington. 2015. “Chelan County Comprehensive Plan.” January. 2p.

Fire Environment and Wildfire History

Chelan County encompasses a large land area with varying vegetation capable of large fire growth. The Chelan County landscape is a fire dependent ecosystem (Figure 5). Historically, the vegetative landscape was shaped by a range of fire disturbance from frequent, low intensity fires typical of the low elevation grasslands and sage step fuels to less frequent large stand replacing events typical of the higher elevation forests. According to the Chelan County Fire Plan, most of the planning area (80%) is dominated by dense Ponderosa Pine stands with large amounts of Douglas Fir regeneration and intrusions of Grand Fir at higher elevations. Deciduous species consisting of Cottonwood, Willow, and Aspen are concentrated by streams and lakes. Non-forested areas at lower elevations consist of sage brush along with various species of grass.

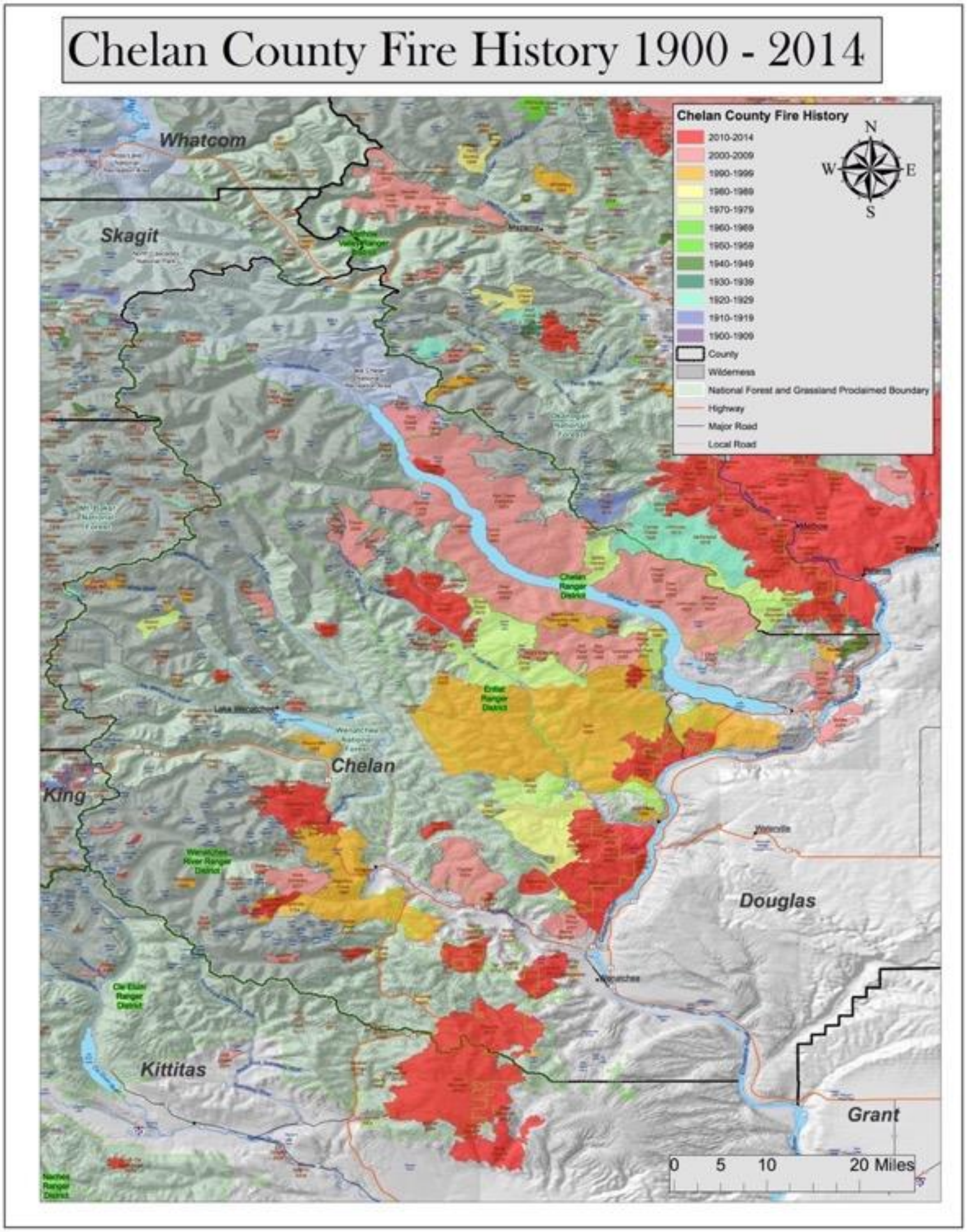

Figure 5: Cannon, Jamie. "Chelan County Fire History Map 1900-2014." Map. Wolverine Fire-Chelan Washington. Accessed August 8, 2017. https://wolverinefireinfo.wordpress.com/page/18/.

Recent fire history (Table 2) reveals several notable fires in which county residents, structures and infrastructure have been adversely affected with increasing frequency. The most recent notable fires include:

- The **2015 Chelan Complex Fires** burned over 95,000 acres and destroyed over 50 homes in the First Creek Neighborhood and the City of Chelan. The entire Lake Chelan area lost power for three days, which affected their communications network and their ability to pump water from the city fire hydrants.
- The **2015 Wolverine Fire** ignited earlier than the Chelan Complex fire, but burned through the summer. The fire destroyed 4 structures and threatened numerous others including in the Chiwawa Valley and the Ponderosa Neighborhood.
- The **2015 Sleepy Hollow Fire** burned 3,000 acres and destroyed 30 residences in the Broadview neighborhood located in the western foothills of Wenatchee. The city also experienced fire starts in the center of town at several warehouses due to embers from the burning homes.

Table 2: History of Significant Fires in Chelan County Since 1970

Fire Name	Year	Size	Complex	County	Structures Lost
Blue Ribbon Fire [a]	2016	25		Chelan	0
Horse Lake Road Fire [d]	2016	20		Chelan	3
Suncrest Fire [d]	2016	390		Chelan	0
Chelan Complex [c]	2015	88,985	Chelan Complex	Chelan	44
First Creek Fire [c]	2015	7,490		Chelan	19
Sleepy Hollow Fire [c]	2015	2,950		Chelan	33
Wolverine Fire [c]	2015	65,512		Chelan	4
Chiwaukum Creek Fire [c]	2014	13,895	Chiwaukum Complex	Chelan	0
Duncan Fire [c]	2014	12,695		Chelan	0
Mills Canyon Fire [c]	2014	22,571		Chelan	0
Colockum Tarps Fire [c]	2013	80,184		Chelan / Kittitas	5
Antoine 2 Fire [c]	2012	6,837		Chelan / Okanogan	0
Byrd Fire [c]	2012	14,119	Wenatchee Complex	Chelan	0
Canyon Fire [c]	2012	7,557	Wenatchee Complex	Chelan	0

Table 2: History of Significant Fires in Chelan County Since 1970					
Fire Name	**Year**	**Size**	**Complex**	**County**	**Structures Lost**
Peavine Canyon Fire [c]	2012	19,467	Wenatchee Complex	Chelan / Kittitas	0
Poison Canyon Fire [c]	2012	5,910	Wenatchee Complex	Chelan	0
Swakane Fire [c]	2010	19,291		Chelan	0
Badger Mountain Fire [c]	2008	15,023		Chelan / Douglas	0
Easy Street Fire [b]	2007	5,209		Chelan	1
Flick Creek Fire [b]	2006	7,889		Chelan	0
Tinpan Fire [c]	2006	9,252		Chelan	0
Deep Harbor Fire [b]	2004	28,500	Pot Peak/Sisi Ridge Complex	Chelan	3
Pot Peak Fire [b]	2004	17,190	Pot Peak/Sisi Ridge Complex	Chelan	0
Deer Point Fire [c]	2002	43,375		Chelan / Okanogan	5
Rex Creek Fire [b]	2001	50,000	Rex Creek Complex	Chelan / Okanogan	n/a
Rat Creek / Hatchery Creek Fire [b]	1994	43,000		Chelan	n/a
Tyee Creek Fire [b]	1994	135,000		Chelan	37
Dinkelman Fire [b]	1988	50,000		Chelan	n/a
Lightning Bust [b]	1970	188,000		Chelan / Okanogan	n/a

a: Arac, Adem. "Evacuations Lifted from Entiat Fire." *K5news*, May 9, 2016. Accessed February 15, 2017. http://www.king5.com/article/news/local/evacuations-lifted-from-entiat-fire/281-181157761?scroll=1441.;
b: Chelan County Multi-Jurisdictional Natural Hazard Mitigation Plan (2011);
c: City of Chelan Community Briefing Report;
d: InciWeb developed and maintained by USDA Forest Service, Fire and Aviation Management, helpdesk@dms.nwcg.gov - https://inciweb.nwcg.gov/

❖ Chelan County Community Analysis

In addition to understanding the local planning context, CPAW team members gather information through facilitated conversations and meetings with stakeholders, field tours, and internal research. CPAW team members also review and analyze community plans, policies and regulations to determine their level of effectiveness for community wildfire mitigation. This information is internally compiled into a WUI Planning Audit and reviewed with the local steering group. The following section highlights planning challenges and opportunities that emerged in Chelan County during that process.

Local Planning Challenges

Stakeholders discuss local access challenges near Lake Chelan. (CPAW Photo)

- **Ingress and egress constraints.** As a result of its topography, many developed areas throughout the county have access constraints, such as "one-way-in/one-way-out" roads, narrow and steeply graded driveways, unpaved surface conditions, and heavily forested areas with limited visibility. These access constraints hinder safe evacuation and response, and have even prompted some fire protection districts to inform residents they may not be able to respond to wildfires under certain conditions. Many existing subdivisions do not have an option for a secondary emergency access route and are dependent on other means to effectively address this issue, such as education and preparedness programs.
- **Demographic shifts.** The county's population is increasing with new full time residents, second homeowners, and tourists. Some new homeowners and visitors are from less wildfire-prone areas, such as coastal environments, and may have limited understanding of wildfire risk or the wildland-urban interface. This lack of local awareness affects building construction and landscaping decisions, ultimately working at odds with other risk reduction efforts.
- **Changes in land uses.** In addition to a growing population, some land uses that were traditionally considered "fire safe," such as orchards and irrigated farmlands, are being converted to other uses, including large-lot subdivisions. While attractive for development, this contributes to an increased wildland-urban interface by putting more people and structures at risk to wildfires. Unless appropriate development mitigation activities are implemented (such as defensible space and fire safe construction techniques), this will further strain response and suppression capabilities.
- **Large public landownership component.** Although wildfire mitigation science has shown the effectiveness of performing mitigation within the "home ignition zone," there is some local sentiment that the USFS is responsible for private property owner's wildfire risk. Meanwhile, other groups have opposed local efforts by the USFS to perform forest mitigation projects due to social values that prioritize tree preservation. While these discussions are much more nuanced and complex, it has contributed to well-intentioned efforts to address wildfire being limited, costly, or time-consuming.
- **Recent fire history.** The county's recent fire history underscores the need to address wildfire from a multi-pronged approach. While many past and current efforts are effective, there is no single program or one-size-fits-all approach to wildfire prevention and mitigation.

Local Planning Opportunities

- **Increased capacity and local knowledge.** The county recently staffed its fire marshal position, which includes the responsibility of administering codes related to the wildland-urban interface. The county also appointed several advisory groups to offer technical advice and assistance throughout the CPAW process. Increased expertise from stakeholder and the fire marshal has improved the county's ability to identify appropriate land use planning mechanisms to address the WUI.
- **Update of countywide wildfire assessment products.** The USFS Rocky Mountain Research Station is providing the county with a new countywide assessment products that comprehensively assess the wildfire hazard. These products incorporate local stakeholder expertise and will be used to improve decision support for planning policies and regulations countywide. They can also be used to inform the future Community Wildfire Protection Plan.
- **Alignment with other projects.** The county's engagement in CPAW comes at a time when other countywide initiatives are also moving forward. Following CPAW recommendations, the county will be pursuing its first countywide Community Wildfire Protection Plan and will also undertake an update to its Hazard Mitigation Plan. These synergistic opportunities, along with previous communities' participation in CPAW (cities of Chelan and Wenatchee), can help leverage further stakeholder support and implementation funding for planning-based CPAW initiatives.
- **Public education and awareness.** Dedicated local groups have created a culture of awareness and action over the past decades. Non-profits organizations, including the Cascadia Conservation District and Chumstick Coalition, neighborhood Firewise Communities, active fire department community education programs, the Era of Megafires presentation tour, and many other local groups and efforts have helped build a strong foundation of public understanding for wildfire mitigation and necessary action. This is a critical component for the future success of implementing land use plans and codes.
- **Stakeholder engagement and support.** In addition to public education programs, there are many local stakeholders (e.g., fire districts chiefs, county commissioners, land management agencies) who are advocating for increased implementation of policies and regulations in light of recent wildfire activity across the county and state. Due to the high proportion of federally managed lands, federal agencies take an active role in mitigation projects. The county is also fortunate to currently benefit from grants and other funding opportunities from state and federal sources. The combination of stakeholder engagement and resources enables a collaborative approach toward community wildfire protection and mitigation, including the potential implementation of CPAW recommendations.

Summary of Recommendations for Chelan County, WA

Table 3. Overview of Recommendations		
Recommendation	**Summary**	**Key Points**
1. Define the Wildland-Urban Interface (WUI) and Implement a WUI Risk Assessment Program	*Clearly define Chelan County's wildland-urban interface, and integrate a risk assessment map as a component of the decision support tool for land use policies and regulations. Consider the implementation of a spatially delineated risk assessment program 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. Adopt a Wildland-Urban Interface Code	*Adopt the International Code Council International Wildland-Urban Interface Code (IWUIC) with local amendments to establish minimum wildfire safety standards for future development in Chelan County.*	• Current fire protection standards (Title 15 Development Standards, Chapter 15.40) do not adequately address wildfire risk throughout the county's wildland-urban interface. • Adoption of the IWUIC with local amendments provides the county with a resource-efficient and effective risk reduction option. • Implementation guidance includes utilizing the wildfire hazard assessment to spatially define the WUI and determine the standards required in development subject to mitigation. • Additional guidance and resources highlight local examples of WUI codes, and educational materials for engaging stakeholders and the public in the adoption process.
3. Update Comprehensive Plan to Support Wildfire Activities	*Update the Chelan County Comprehensive Plan with goals and policies to increase support for, and consistency with, future wildfire planning and mitigation activities.*	• Comprehensive plans must demonstrate internal consistency and be adopted through a public participatory process. • As the county pursues adoption of a WUI code, stakeholders should ensure current and future policies align with this and similar activities.

RECOMMENDATION 1: **Define the Wildland-Urban Interface (WUI) and Implement a WUI Risk Assessment Program**

Clearly define Chelan County's wildland-urban interface, and integrate a risk assessment map as a component of the decision support tool for land use policies and regulations. Consider the implementation of a spatially delineated risk assessment program by incorporating property specific assessment information.

❖ Why This Recommendation Matters

Overview

Ideally, a complete wildfire risk assessment should be developed, 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 6).[7]

[7] 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 6. 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.

Chelan County Wildfire Risk Assessment History

Historically, wildfire risk assessments have been undertaken to support individual Community Wildfire Protection Plans within the county. Additionally, the County Fire Plan and Chelan County's Title 15 Development Standards reference a Washington Department of Natural Resources (DNR) WUI Hazard Assessment Map, that appears to be based on the National Fire Protection Association (NFPA) 299 Standard. Unfortunately, the DNR WUI Hazard Assessment is of too coarse scale to be useful for planning.

As part of the 2016 CPAW projects in the cities of Chelan and Wenatchee, a wildfire risk assessment map was developed for the entire county by a private contractor. The map is currently only used in the cities of Chelan and Wenatchee.

Chelan County's Title 15 Development Standards also provides a definition for the wildland urban interface as "an area where improved property and wildland fuels meets at a well-defined boundary. All areas shown as having moderate, high, or extreme risk hazard on the current edition of the Chelan County Fire Map, developed by the Washington State Department of Natural Resources, are wildland urban interface areas."

Current WUI research and best practices typically describe the wildland-urban interface as a "set of conditions" in which both vegetation (wildland fuels) and the built environment (built fuels) are influenced by weather and topography to create an environment where fire can ignite and spread through this combined fuel complex (the combination of wildland and built fuels). A comprehensive countywide risk assessment and spatial definition of the WUI is necessary to provide decision support for developing and implementing land use policies and regulations.

USDA Forest Service Risk and Hazard Assessment

A large scale regional risk assessment by the USDA Forest Service (Region 6, Oregon and Washington) was recently undertaken. This project is nearing completion. Due to the large National Forest land base present in the county, the desire of the county stakeholders to integrate this process with the county effort, and a recent collaborative working arrangement between the CPAW program and the USDA Forest Service Rocky Mountain Research Station (RMRS), the RMRS is undertaking a countywide hazard assessment (likelihood and susceptibility) to support this project. As a component of the hazard assessment, the RMRS will also undertake the SILVIS lab's approach to spatially defining the WUI in Chelan County.

Parcel Level Susceptibility 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 Structure Ignition Zone (SIZ). The county should also consider undertaking parcel level assessments to complete the susceptibility component of the risk triangle, by providing ignition potential data for individual structures and infrastructure.

❖ Implementation Guidance

As part of the CPAW process, RMRS staff engaged with local wildfire risk subject matter experts to achieve three main objectives:

1. Validate the RMRS spatial fuels layers through local SME input.
2. Explore RMRS tools that can be used to develop a countywide hazard map to compliment the Region 6 Risk Assessment process and better support land use planning and other wildfire risk reduction efforts.
3. Spatially define the WUI.

This collaborative engagement was undertaken in the form of a workshop 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 spatial hazard assessment to support to the development and implementation of land use planning policy and regulations.

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 (270 m pixels), Local Wildfire Hazard (30 m pixels which includes ember zones) and Mitigation Potential (30 m). A summary of the methodology used to develop these outputs can be found in Appendix A.

Landscape Level Wildfire Hazard

This scale (120 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 (subwatershed) boundaries. The subwatersheds range in size from 13 to 75 mi^2, with an average of 36 mi$^{2.}$ The landscape level hazard assessment is delineated into the following rankings:

- **MODERATE**
- **HIGH**
- **VERY HIGH**

The factors influencing these rankings can be used to determine the potential landscape level exposure that a development will be subject to. 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 very 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 collaborative, multi-agency large-scale fire management planning and mitigation is necessary.

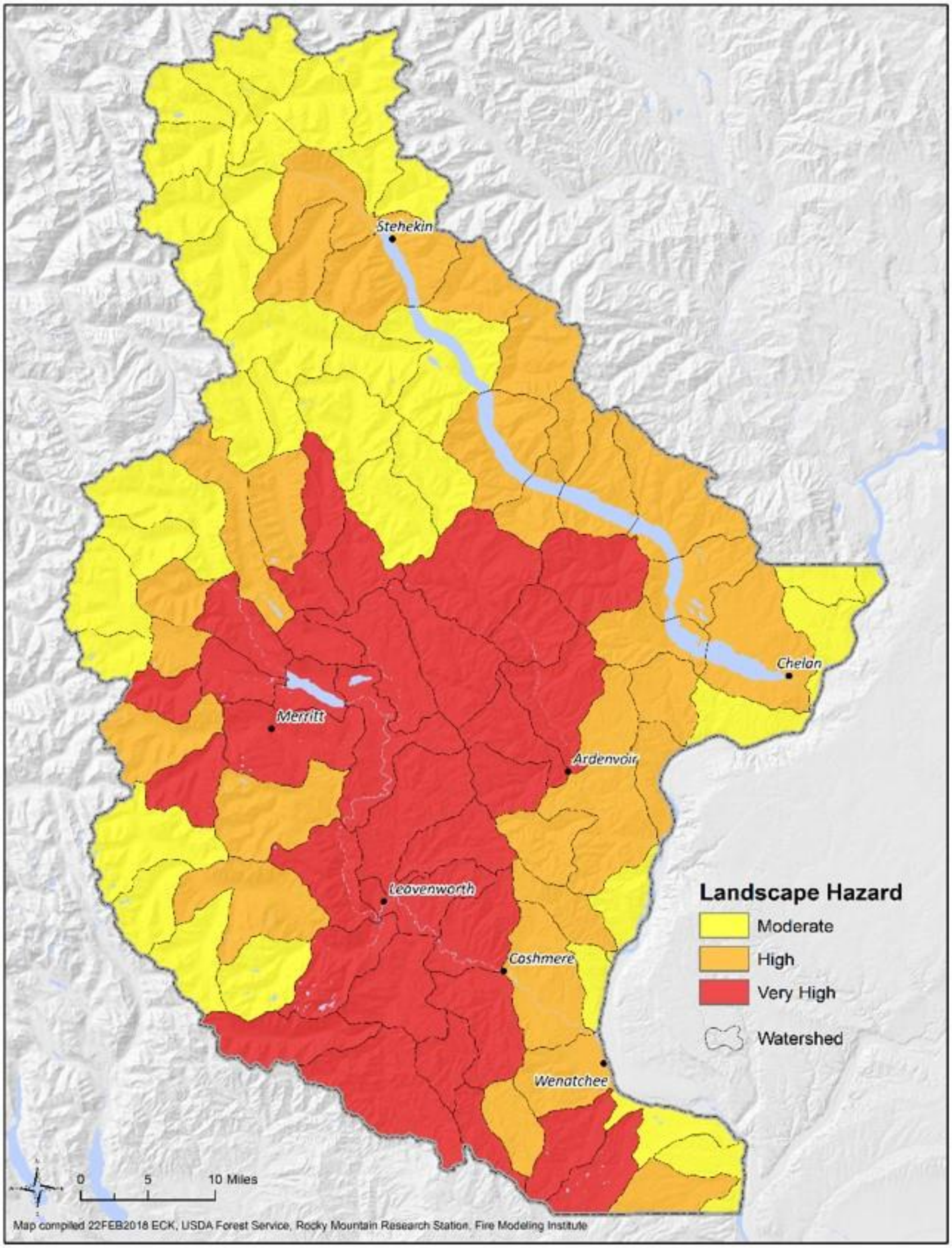

Figure 7. Chelan County Landscape Wildfire Hazard Map

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 with the HUC 12 boundaries. This does not show the likelihood of a fire occurring but does shows where fires are likely to burn at high intensity. 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. The same rankings used at the landscape scale are used at this local scale:

- **MODERATE**
- **HIGH**
- **VERY HIGH**

As part of the wildfire hazard analysis the potential ember transport was assessed using a number of approaches and all outcomes indicated that the entire county is susceptible to ember impingement.

Land Use Planning Application: This informs land use planners on the relative worst-case (hottest, driest, windiest days during a fire season) wildfire exposure (radiant, convective and ember) that can be expected in any given polygon where development exists or is planned for.

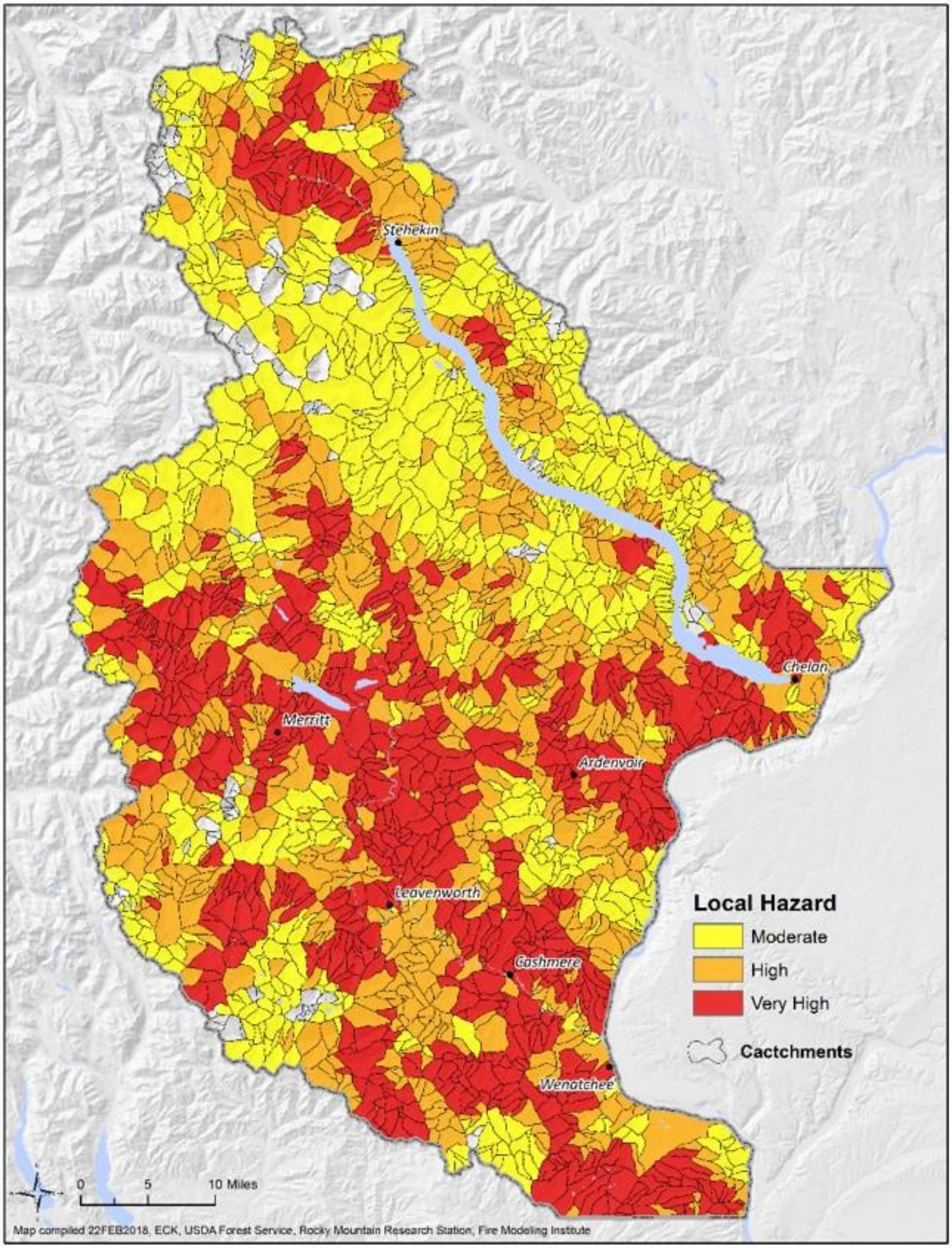

Figure 8. Chelan County Local Wildfire Hazard Map

Mitigation Difficulty

The Mitigation Difficulty component (30-meter 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 is represented by six categories of hazard based on mitigation potential and extreme fire behavior potential.

Table 4. Mitigation Difficulty Classes and Descriptions

Class	Characteristics	Mitigation Discussion
1	Non-vegetated, with potential for ember impact	Barren ground/water/sparse vegetation or land that lies within potential spotting distance of a wildfire. Mitigation will involve appropriate structure ignition zone and IR structure construction.
2	Herbaceous on a shallow slope (< 15%)	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 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.
3	Herbaceous on moderate slope (15≤ to <30%)	Harder to construct fuel breaks, increased difficulty in mechanical (mowing) treatment, increased potential for erosion, increased rate of spread and intensity may make frequent burning and other mitigation more difficult. Focus should be on appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.
4	Herbaceous on steep slope (≥ 30%)	Significant challenges in fuel break construction, unlikely option for mechanical (mowing) treatment, significant potential for erosion, high rate of spread and intensity potential may make frequent burning and other mitigation difficult. High winds combined with short-term drying conditions leads to potentially dangerous fast-moving fires with fire fighter access concerns. Mitigation potential may involve a combination of frequent burning, and fuel breaks in conjunction with slope set-back along with appropriate structure ignition zone and IR structure construction.
	Shrub on shallow slope (< 15%)	Fires are typically harder to suppress than grassfires in these areas. High winds combined with dry conditions lead to potentially dangerous fast moving high intensity fires with fire fighter access concerns. Mitigation may involve a combination of frequent burning, and fuel breaks in conjunction with appropriate structure ignition zone and IR structure construction.
5	Shrub on moderate slope (15≤ to <30%)	Harder to construct fuel breaks, increased difficulty in mechanical (mastication) treatment, increased potential for erosion, increased rate of spread and intensity may make burning more difficult. Focus should be on a combination of appropriate mechanical treatment and burning, slope set-backs, structure ignition zone and IR structure construction mitigation.
6	Shrubs on steep (≥30%) slopes	Significant challenges in fuel break construction unlikely option for extensive mechanical (mastication) treatment. Significant potential for erosion or slope instability resulting from treatments is a likely mitigation challenge. Increased rate of spread and significant intensity may make burning more difficult. Focus should be on a combination of appropriate mechanical treatment and burning, slope set-backs, structure ignition zone and IR structure construction mitigation.
	Tree on shallow slope (< 15%)	Open canopy must be maintained to prevent increased crown fire potential. 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.
7	Tree on moderate slope (15≤ to <30%)	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. Increased potential for erosion or slope instability resulting from treatments can be a mitigation challenge. Mitigation should also include appropriate slope set-backs, structure ignition zone and IR structure construction mitigation.

Table 4. Mitigation Difficulty Classes and Descriptions

Class	Characteristics	Mitigation Discussion
7	Tree on shallow slope (< 15%) 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.
8	Tree on moderate slope with potential for crown fire (15≤ to <30%)	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. Increased potential for erosion or slope instability resulting from treatments can be a mitigation challenge. Mitigation should also include appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.
	Tree on steep slope (≥ 30%)	Open canopy must be maintained to prevent increased crown fire potential, which can be significantly difficult due to the slope. Surface fuels must be treated/maintained in a state that reduces the chances of fast moving surface fires. Significant potential for erosion or slope instability resulting from treatments is a likely mitigation challenge. Mitigation should also include appropriate slope set-backs, structure ignition zone and IR structure construction mitigation.
9	Tree on steep slope (≥ 30%) with potential for crown fire	Dense canopy needs to be thinned to reduce crown fire potential, which may be extremely difficult, if not prohibitive due to the slope. Surface fuels must be treated to reduce risk of fast moving surface fires. A very high potential for erosion or slope instability resulting from treatments is a likely mitigation challenge. Mitigation should also include appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.

Land Use Planning Application: This informs land use planners on the general potential success and challenges of mitigation when aligning with the mitigation requirements of the Wildland-Urban Interface regulatory requirements.

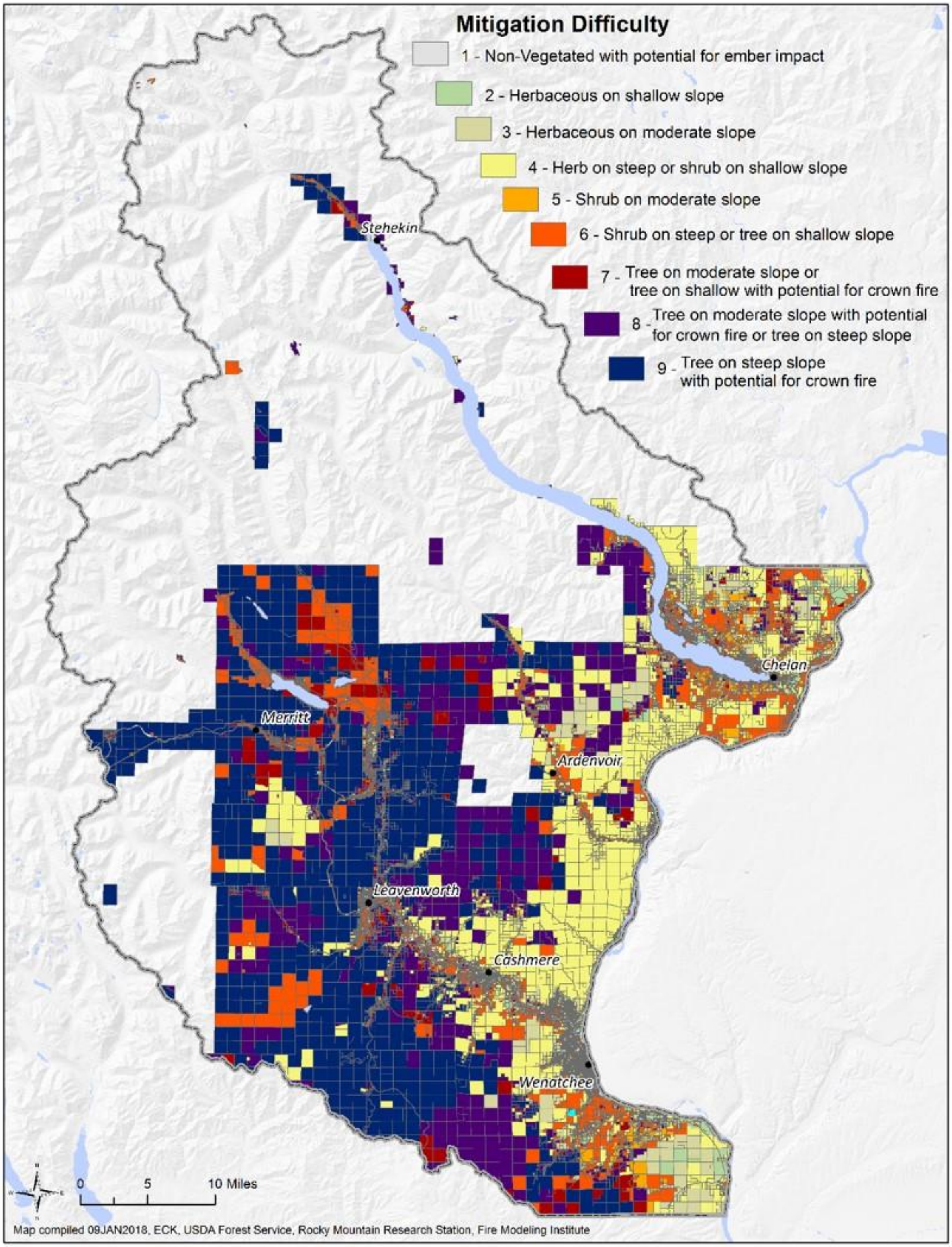

Figure 9. Chelan County Mitigation Difficulty Map

Parcel Level Assessment

Parcel level wildfire assessment requires a "boots on the ground" approach. 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 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 Chelan 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[8] 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[9]
    a) **WUI Intermix**: Areas with ≥16 houses per square mile and ≥50 percent cover of wildland vegetation
    b) **WUI Interface:** Areas with ≥16 houses per square mile and <50 percent cover of vegetation located <1.5 miles of an area ≥2 square miles in size that is ≥75 percent vegetated
    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 <16 houses per square mile (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 <128 houses per square mile (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 ≥128 houses density per square

[8] 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.

[9] Schlosser, W.E. 2012. Defining the Wildland-Urban Interface: A Logic-Graphical Interpretation of Population Density. Kamiak Ridge, LLC

mile (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 < 1.5 mile reference in b) and considering the entire County as an "ember zone". Due to this outcome and for simplicity, the categories have also be modified into the following categories:

g) **WUI Intermix**: Areas with houses present and ≥50 percent cover of wildland vegetation

h) **WUI Interface:** Areas with ≥16 houses per square mile and <50 percent cover of vegetation.

i) **Non-**WUI Vegetated: Areas with ≥50 percent cover of wildland vegetation and no houses (e.g., protected areas, steep slopes, mountain tops)

j) **Non-Vegetated or Agriculture:** Areas with <50 percent cover of wildland vegetation

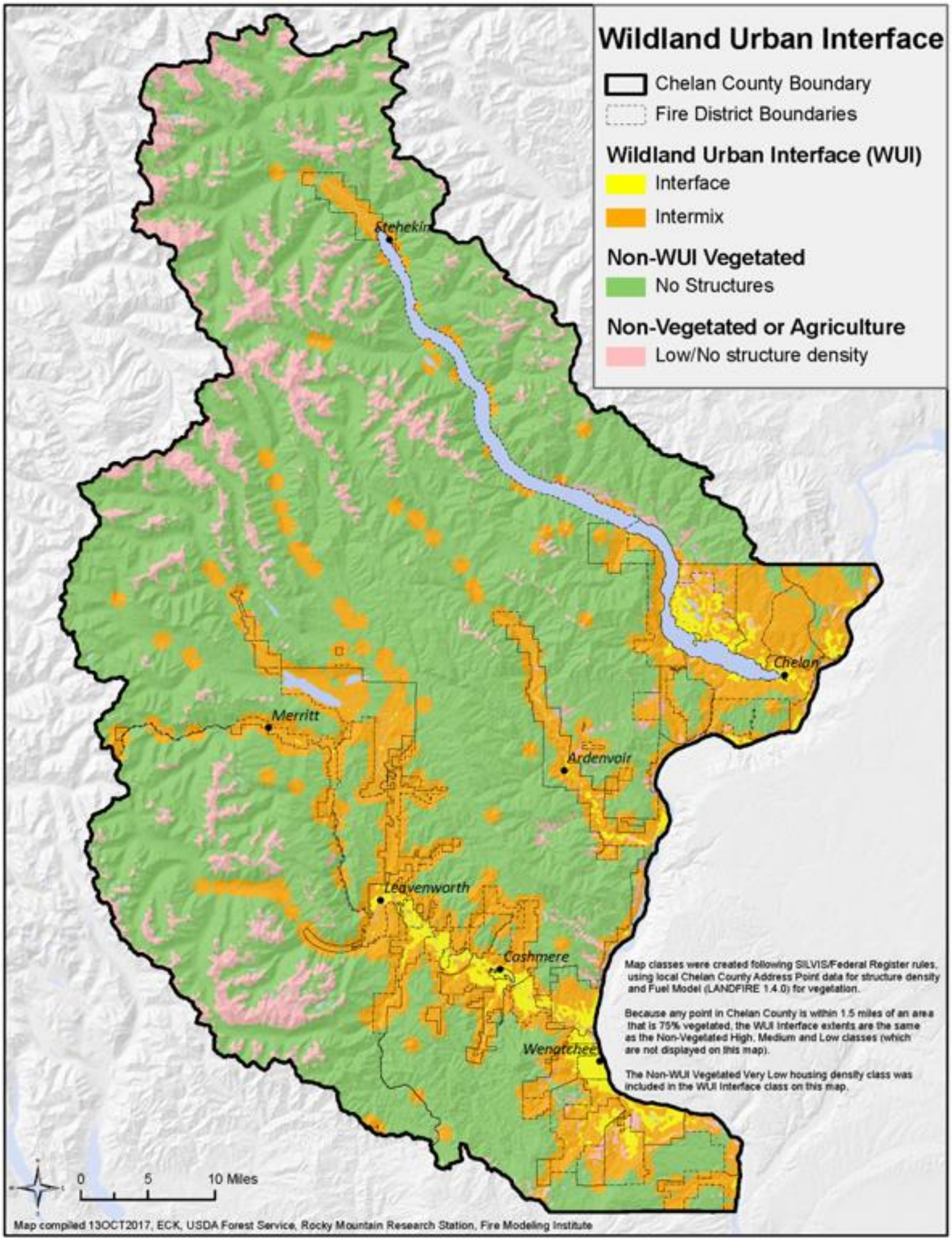

Figure 10. Chelan County map of the Wildland Urban Interface and Wildland Urban Intermix

Using the Risk Assessment to Support Land Use Policy and Regulation

The landscape and local scale maps, as well as the mitigation potential wildfire exposure 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 watershed polygon, or mitigation 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 provide the ability for end-users to examine the spatial variability of factors contributing to hazard and exposure with any watershed. The local scale map and mitigation potential 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 wildland-urban interface 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.

❖ 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 a best practices document (Appendix A) that will provide guidance to the county on the methodology for updating the assessment. The risk assessment outputs should be strongly linked as a decision support tool for implementing the proposed WUI Code and planning policies.

RECOMMENDATION 2: **Adopt a Wildland-Urban Interface Code**

Adopt the International Code Council International Wildland-Urban Interface Code (IWUIC) with local amendments to establish minimum wildfire safety standards for future development in Chelan County.

❖ Why This Recommendation Matters

Overview of Current Wildfire Regulations

Chelan County broadly regulates its wildland-urban interface per Title 15 Development Standards, Chapter 15.40, Fire Protection Standards. Standards address fire department access, water mains and fire hydrants, and fire-flow requirements for buildings. Specific standards for fire protection within the wildland urban interface are addressed in Section 15.40.050.

Other titles may reference fire management as related to specific activities or zones. For example, fire management within fish and wildlife habitat conservation areas where required by a county, state, or federal agency shall be done in consultation with the Chelan County fire marshal (11.78.020(9)). The Icicle Valley design review overlay area also requires a fire prevention specialist to review applications that include wildfire development standards (e.g., noncombustible roofing materials, water supply, vegetation management).

Current requirements under Section 15.40.050 Fire Protection within the Wildland Urban Interface apply to subdivisions, planned developments, binding site plans and other similar permits which are identified as having moderate, high, or extreme risk hazard according to the Chelan County fire map, developed by the Washington State Department of Natural Resources.

Development Standards require Class A roofing/noncombustible roof covering, as defined in the Uniform Building Code, to be used in wildland-urban interface areas. The fire marshal may also reference the current editions of the International Code Council's International Wildland-Urban Interface Code (IWUIC) or the National Fire Protection Association's standards for wildland-urban interface development when reviewing development projects in the wildland-urban interface to determine if additional fire protection requirements are necessary for approval.

Opportunities for Improvement

As part of the CPAW process, team members convened a group of local wildland-urban interface representatives[10] to discuss the current fire protection standards. Stakeholders indicated that

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[10] Representatives were invited based on their recent participation in the selection committee for the county fire marshal position.

wildland-urban interface regulations under Section 15.04.050 are not being implemented or enforced for two primary reasons:

1) until recently, the county fire marshal position had been vacant;
2) more significantly, the referenced Chelan County fire map is not at the appropriate scale to identify WUI risk rating or spatially define the WUI to inform development review decisions.

Stakeholders also acknowledged the limited effect achieved by only regulating roof coverings in certain areas. Stakeholders expressed an interest in pursuing a more comprehensive approach to regulating the wildland-urban interface to accomplish county goals, including:

- **Increase public and first responder safety.** Requiring construction and access standards reduces likelihood of ignitions, increases ability for the public to safely evacuate, and improves response capabilities.
- **Establish a long-term strategy to address rising insurance premiums and reduced coverage.** As recent fires in Washington and other western states have resulted in property losses, some insurance companies have already begun adjusting their rates or terminating policies.
- **Ensure consistency of standards.** Requiring future development be built to a consistent mitigation standard provides a measurable way to address one of the county's most significant hazards.

❖ Options for Adopting a Wildland-Urban Interface Code

To more comprehensively address the wildland-urban interface, CPAW recommends that Chelan County adopt a wildland-urban interface code. The county has several options to consider:

Option 1: Adopt the 2018 IWUIC Code with Local Amendments

The International Code Council's International Wildland-Urban Interface Code (IWUIC) is a model code that is intended to supplement other building and fire codes adopted by a jurisdiction. The IWUIC 2018 edition is organized into seven chapters and eight appendices, as follows:

Chapter 1: Scope and Administration
Chapter 2: Definitions
Chapter 3: Wildland-Urban Interface Areas
Chapter 4: Wildland-Urban Interface Area Requirements
Chapter 5: Special Building Construction Regulations
Chapter 6: Fire Protection Requirements
Chapter 7: Referenced Standards
Appendix A: General Requirements
Appendix B: Vegetation Management Plan
Appendix C: Fire Hazard Severity Form
Appendix D: Fire Danger Rating System
Appendix E: Findings of Fact

Appendix F: Characteristics of Fire-Resistive Vegetation
Appendix G: Self-Defense Mechanism
Appendix H: International Wildland-Urban Interface Code Flowchart

When adopted in full, the IWUIC provides jurisdictions with a *minimum* set of special regulations for the "safeguarding of life and property from the intrusion of fire from wildland fire exposures and fire exposures from adjacent structures and to prevent structure fires from spreading to wildland fuels, even in the absence of fire department intervention." In other words, the IWUIC serves as a tool to strengthen the likelihood of a structure's survival and reduce reliance on suppression and response resources.

Many communities adopt the IWUIC with local amendments to better reflect their needs, such as creating a local definition of the wildland-urban interface and referencing a locally appropriate wildfire risk or hazard assessment.

Option 2: Adopt the WA State Pre-Approved IWUIC (State Building Code Appendix N)

In 2007, the Washington State Legislature created the Forest Fire Prevention and Protection Work Group to examine strategies and practices for the prevention and suppression of forest fires in the state. The Forest Fire Prevention and Protection Work Group recommended that the IWUIC (with amendments) be proposed for adoption through the State Building Code Council code adoption process.[11] Subsequently, the State Building Code Council Council adopted the IWUIC with amendments as an appendix to the International Fire Code.[12]

The 2015 IWUIC (Appendix N) is available to local governments for voluntary adoption and is considered a pre-approved local amendment when adopted with the specified amendments and Appendices B (Vegetation Management Plan) and C (Fire Hazard Severity Form).

Option 3: Create Customized Approach to WUI Code

As an alternative to adopting the state or IWUIC with amendments, the county may choose to draft a customized set of wildfire regulations and adopt these as a standalone code or integrate them into existing codes, such as the development, zoning, and subdivision codes. This approach is conceptually attractive because it maximizes flexibility of regulations, such as creating performance-based mitigation measures. However, it requires significant initial effort and a regular program to update these regulations in response to changes in industry best-practices or other guidance.

Options Analysis

Advantages and disadvantages are associated with each option, as summarized in Table 5 below:

[11] Washington State. Department of Natural Resources. *Recommendations of the Forest Fire Prevention and Protection Work Group*. 2p

[12] Committee on Local Government and Housing. Washington House Bill Report HB2383. February 1st, 2010.

Table 5: Analysis of WUI Code Adoption Options

Option	Advantages	Disadvantages
1. Adopt IWUIC with local amendments	• Relies on tested, current, coordinated set of regulations and best practices, • Efficient process for addressing updates when future IWUIC versions are released • Allows for more local flexibility than the WA IWUIC Appendix N • Common approach for many communities nationwide	• Requires gap analysis with existing regulations • Limitations may exist on risk reduction if not adopted in full, including applicable appendices (e.g., Vegetation Management Plan) • Requires approval from State Building Code Council
2. Adopt WA IWUIC (Appendix N)	• Pre-approved code designed to work efficiently within the state building code system • Potentially simple, fast, and inexpensive	• Adoption of Appendix N would not allow utilization of countywide hazard assessment (as described in Recommendation 1), unless amendments were made; therefore changes are strongly recommended to Appendix N but this would require approval from State Building Code Council • Requires gap analysis with existing regulations • Limitations may exist on risk reduction depending on local amendments made
3. Create Customized Approach to WUI Regulations	• Can draw from multiple sources to tailor regulations and review process • Full range of wildfire issues can be addressed in self-contained set of WUI regulations or integrated across different codes (e.g., landscaping, development standards, access, fire protection) • Land use regulations can remain separate from building code regulations	• Requires approval from State Building Code Council • Requires significant capacity and specialized skill sets to research and draft language • Requires detailed legal review on specific language • May require funding for professional consulting services if staff cannot develop internally • Requires time and resources to coordinate with other regulations, and resolve conflicts between different regulations • Frequent code amendments may be needed if changes to wildfire best practices occur

❖ Implementation Guidance

To adequately plan for and address wildfire in the built environment, the CPAW team recommends Chelan County pursue **Option 1** (adopt the current edition of the IWUIC with local amendments). This is based on stakeholder feedback which balances capacity concerns, local flexibility, and best practices. To fully realize the potential benefits of the IWUIC through a successful adoption process, the CPAW team has provided the following implementation guidance:

1. Define the Wildland-Urban Interface

Chapter 3 of the IWUIC, Wildland-Urban Interface Areas, provides a methodology to establish and record wildland-urban interface areas based on the findings of fact. Some jurisdictions choose to use this standard language, while others amend this section with their own WUI definition. The county will have a new wildfire hazard assessment (see Recommendation #1), which will include the spatial delineation of the WUI. **CPAW recommends that the County amend Chapter 3 to spatially define their own WUI areas, using the information available in the wildfire hazard assessment.** This information will provide for a more accurate reflection of the local WUI.

2. Apply the IWUIC Standards Based on the Wildfire Hazard Assessment

Chapter 5, Section 502 of the IWUIC, 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; however, the county will have a new wildfire hazard assessment (see Recommendation #1). **CPAW recommends that the County amend Chapter 5, Section 502, to instead use the newly developed wildfire hazard assessment to inform the IWUIC standards using the following process:**

A. Determine the Local Level Wildfire Hazard summarized ranking in which the proposed development is located to understand the likelihood of the buildings exposure to high intensity fire.
B. Determine the Mitigation ranking (0 to 9) of the parcel in which the proposed development is located and immediately adjacent to.
C. Use the following table (Table 6, below) to determine the appropriate IWUIC mitigation standards to apply:

Table 6: Chelan County RMRS Mitigation Potential/ IWUIC Hazard Crosswalk							
Local Wildfire Hazard	**Table 603.2 Minimum Required Defensible Space (site/slope adjustment required)[1]**	**RMRS Mitigation Difficulty and Slope % category**			**24.301.181(21) Minimum IR Construction**		
		< 15	**15≤ to <30**	**> 30**	**Non-Conform[2]**	**Conform**	**1.5x Conform**
Moderate	30 ft.	1, 2, 4	1, 2, 3, 5	4	IR1	IR2	IR3
High[3]	50 ft.	6	7	6	IR1 (N.C.)	IR2	IR2
Very High	100 ft.	7	8	8, 9	IR1 (N.C.)	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) **Non-conforming** indicates that the minimum slope-adjusted defensible space distances with appropriate mitigation cannot be achieved from the structure to vegetative fuels; as opposed to **conforming** in which the defensible space defensible space distances with appropriate mitigation can be achieved.
(3) High hazard is also used where non-conforming structures are present within 50 ft of the primary structure.
N.C = Non-Combustible materials; including tempered glass.

3. Designate Administration and Enforcement through County Fire Marshal

The IWUIC requires the designation of a code official (Section 104), which may be the same or separate from the designated enforcement agency (Section 103). **CPAW recommends that the county Fire Marshal be responsible for the administration and enforcement of the IWUIC.**

4. Align Existing Regulations With IWUIC

Upon adoption of the IWUIC, the county should review existing regulations to reconcile any potential conflicts with the IWUIC and/or add appropriate references. For example:

- Chapter 15.50 Landscape Standards lists evergreen trees and shrubs as a landscape screening option (15.50.040). Section 15.50.055 Alternative landscaping should be amended to provide for safety considerations, *including mitigation of wildland-urban interface as required by the IWUIC.*
- Chapter 11.78 Fish and Wildlife Habitat Conservation Areas Overlay District (FWOD) provides an exemption for fire management where required by a county, state or federal agency in consultation with the Chelan County fire marshal (11.78.020(9). This section should reference the IWUIC.
- Wetland reports (Section 11.80.100) and mitigation plan should include a reference to required wildfire mitigation.
- Chapter 11.86 Geologically Hazardous Areas Overlay District (GHOD) provisions for erosion control through vegetation will require reconciliation with any development also subject to the requirements of the IWUIC.

To avoid unforeseen conflicts and inconsistencies between IWUIC standards and other regulations, CPAW also recommends that the county include conflict resolution language to clearly state the relationship between regulations. This language is currently provided in the IWUIC Section 102 Applicability.

5. Coordinate with Local Communities and Industry Professionals

Current county zoning regulations apply to unincorporated areas under Chelan County's land use regulatory authority and are consistent with the provisions adopted by the county for the unincorporated urban growth area boundaries of the cities of Leavenworth, Cashmere, Wenatchee, Entiat, and Chelan. Several cities have already adopted, or are in the process of adopting, a local WUI code (see Local Community Examples below). Adoption of the IWUIC by the county will require collaborative discussions and working sessions with cities to align WUI regulatory objectives and implementation. To the extent feasible, coordination should establish uniformity across building and construction requirements to minimize the burden on developers.

❖ Tips and Additional Resources

Local Community Examples

Below are local and state examples of communities who have adopted a WUI code within their jurisdictions.

Kittitas County

Kittitas County adopted its first WUI code for all areas outside of fire districts in 2006 due to "lack of on-site water supplies, extended response times, and past wildland fires."[13] Following the Taylor Bridge Fire in 2012, the county adopted the most current adoption edition of the IWUIC code with local amendments, including appendix B. (Title 20: Fire and Life Safety, Chapter 20.10). The code is also referenced in Title 16: Subdivision Standards and Title 14: Building and Construction Code.

The Kittitas County WUI Code applies to all areas designated as the Wildland Urban Interface areas within the county. The Kittitas County Wildland-Urban Interface map identifies three zones that apply varying levels of regulation. For example: IR 1A and 1B require a sprinkler system along with non-combustible materials and defensible space. In the IR 1A designation, sprinklers can be substituted with 2.5 times the required defensible space. IR 2 requires non-combustible materials and defensible space according to the adopted WUI Code. IR 3 includes one identified urban area that does not apply the WUI Code. Designated zones IR 1A and IR 2 can have a site assessment conducted at the request of the property owner for $130. IR1B is identified as extreme risk and does not allow requested assessments to alter requirements.

The County has a determination of non-significance letter for an environmental impact statement required under RCW 43.21C.030 and WAC 197-11. Kittitas County also has a Building Permit Submittal-WUIC Requirements document for public reference.

[13] Agenda Staff Report, Kittitas County Fire Marshal's Office, December 18, 2012

Yakima County

Initially adopted in 2001, the Yakima County WUI code was based on the International Fire Code Institute model ordinance found in Urban-Wildland Interface Code 2000 Handbook.[14] More recently, Yakima County adopted the 2015 IWUIC (Title 13. Building and Construction, Chapter 13.12) with local amendments, and including Appendices A and C. Appendix A (General Requirements) applies to all new and existing properties within WUI areas except for R-3 and U occupancies, and Appendix C is used to determine the fire hazard severity and applicability of the code. Both the Building Official and Fire Marshal enforce the code throughout the county.

Exemptions to the code include buildings that are less than 200 sq./ft. in area and 50 ft. from habitable structures, including agricultural structures. Communication towers, utility substations, and wind power generation machines are also exempt if spaced 50 feet from habitable structures.[15]

City of Chelan

The City of Chelan is currently revising their code to include the 2015 IWUIC. The adoption of the WUI code was a recommendation from the 2015-16 City of Chelan CPAW report. The City of Chelan applied to the CPAW program after the 2015 Chelan Complex fires that significantly impacted homes, commercial buildings, and the city's economy.

The City of Chelan Planning and Building Department will be the enforcement agency and the building code official will be the code official who will consult with the appropriate fire marshal or fire districts serving the subject property. A code enforcement officer has also been hired to increase the enforcement capacity of the city.

Amendments made to the 2015 IWUIC include an exemption from a mandated permit for "one-story detached accessory structures used as tool and storage sheds, playhouses and similar uses, provided the floor area does not exceed 200 square feet and the structure is located more than 50 feet from the nearest adjacent structure" and fencing not over six feet high.[16]

City of Wenatchee

The City administers Wildland-Urban Interface Standards (Chapter 3.36) as part of its Fire Code. These standards delineate the City into two distinct WUI zones but do not fully capture the set of conditions that promotes the ignition and spread of fire through the WUI fuel complex (wildland and built fuels). This was observed in 2015 when the city experienced the Sleepy Hollow fire, which burned 30 homes on the outskirts of town (due to direct flame impingement and embers) and multiple commercial warehouses in the urban downtown core (due to the transportation of embers from the burning structures).

Taking previous fire experiences and risk information into account, the CPAW team worked with Wenatchee in 2015-16 to provide recommendations to improve its WUI approach. Included in the final recommendations was a priority recommendation for the City to redefine the WUI

[14] Yakima County 2015 Community Wildfire Protection Plan
[15] 13.12.070 Amendments to Chapter 5, Section 501, Yakima County International Wildland Urban Interface Code
[16] NOTE: City Council vote scheduled for Sept 26, 2017 and section will be updated.

and implement a WUI risk assessment program (currently in the implementation stages) to better prepare for potential wildfire impacts in Wenatchee. As part of this, the CPAW team recommended that the entire City be identified as the WUI, with a redefined Primary and Secondary Zone. The most stringent WUI Standards are recommended to apply to the Primary Zone, where structures will be potential exposed to radiant and convective heat transfer, as well as burning airborne embers. Less stringent standards are recommended to apply to the Secondary Zone, where structures are potentially exposed to localized radiant and convective heat, as well as short, medium and long range burning embers.

Within its WUI Standards, Wenatchee also provides the definition of defensible space, outlines the responsibilities of the land owner, and references the ICC International WUI Code and the NFPA 1144, Standard for Reducing Structure Ignition Hazards from Wildland Fire.

Additional Policy Guidance

The Municipal Research and Services Center (MRSC) helps local governments across Washington by providing legal and policy guidance. The MRSC has a webpage dedicated to Wildfire Prevention: The Wildland/Urban Interface, which includes resources and examples of local wildfire building codes.

RECOMMENDATION 3: **Update Comprehensive Plan to Support Wildfire Activities**

Update the Chelan County Comprehensive Plan with goals and policies to increase support for, and consistency with, future wildfire planning and mitigation activities.

❖ Why This Recommendation Matters

Comprehensive Plan Overview

In 1990, the Washington State Legislature passed the Growth Management Act, which specifies that any counties or cities who are required or choose to adopt comprehensive plans must adhere to a mandatory set of plan elements. These elements address the topics of land use, housing, capital facilities plan, utilities, aspects of rural development and growth management (including protection of critical areas and natural resources), transportation, economic development, park and recreation. Plans must also demonstrate internal consistency and be adopted through a public participatory process.[17]

Counties and cities who develop a comprehensive plan, as required by the state, must also implement development regulations that are consistent with the comprehensive plan within a designated timeframe. This activity ensures that intention of the plan is executed through regulatory mechanisms.

Although Chelan County's first Comprehensive Plan dates back to 1958[18], the Growth Management Act required the county to update its plan to comply with the newly mandated framework. The county adopted its first compliant Comprehensive Plan in 2000; the last mandated review and update to the Comprehensive Plan occurred in 2007, and amendments occur annually. Because the 2007 plan was based on a 20 year planning cycle, many elements of the plan are now undergoing a public review and update to incorporate new data and information, including population and employment projections.

The county's current Comprehensive Plan is divided into the following elements: Land Use, Rural, Housing, Capital Facilities, Utilities, Park and Recreation, Economic Development, Transportation, Resource. Appendices include: Countywide Planning Policies, a Residential Land Capacity Analysis, Land Use Inventory, Sub Area Comp Plans, and Transportation.

[17] Washington Code §RCW 36.70A.040

[18] Chelan County Community Development - 2017 Comprehensive Plan Update

Policy References to Wildfire

The county's currently adopted Comprehensive Plan (last amended in December 2016) contains multiple policies that address wildfire. These policies include:

- The county should encourage forest management activities that minimize the potential for catastrophic wildfires. (LU 11.7)
- Encourage all commercial, industrial and residential development to be located within fire districts. (LU 12.4)
- Fire protection standards should be developed and implemented for commercial, industrial and residential development within rural areas. (RE 3.12)
- Require the use of fire retardant building materials for structures within forested areas, where appropriate (RE 3.13)
- The fire districts and the county Fire Marshal should provide input for design standards for adequate ingress and egress to new development to address fire safety issues (RE 3.14)
- Provision should be made for reasonable access to any on-site water bodies such as lakes, streams, ponds, public fire department cisterns and swimming pools (RE 3.15)
- Encourage the use of fire prevention measures which may include: perimeter fire breaks, appropriate placement of structures, natural vegetative thinning; road right of way; or other measures. (RE 3.16)

Additional information related to fire protection facilities, equipment, and stations is provided in the Critical Facilities Element.

It is important to note that both the Land Use and Rural Elements are undergoing revisions as part of the county's Comprehensive Plan update. At the time of this CPAW report, many of the county's policies related to wildfire (referenced above) reflect changes. Although the overall policy intent appears to remain unchanged, current revisions have reduced the number of relevant policies. Due to the current process of revisions, the following guidance is limited to suggestions which can strengthen long-term success of policy implementation.

❖ Implementation Guidance

Establish link to Community Wildfire Protection Plan and other hazard plans.

Establishing strong links between the Comprehensive Plan and other hazard plans reinforces a community's commitment to implementing hazard mitigation activities. It can also decrease redundancies and ensure consistency. Specific recommendations include:

- Include a reference to the countywide Community Wildfire Protection Plan in the Comprehensive Plan to direct readers to further learn about the role of wildfire, local wildfire history and specific wildfire actions. This eliminates the need to update two documents with background information on wildfires and helps residents understand the implementation process.

- Reference relevant wildfire exposure assessment maps and other spatial assessment tools housed in hazard plans in the Comprehensive Plan. These tools are critical to guiding development decisions and should be appropriately consulted during the land use planning process.
- Evaluate whether some information currently in the Comprehensive Plan, such as fire protection equipment and fire station information, will be duplicated in the future Community Wildfire Protection Plan.
- Establish a regular update cycle to crosswalk the Comprehensive Plan with the Community Wildfire Protection Plan to ensure appropriate land use planning activities are integrated into wildfire mitigation actions and vice versa.

Develop Consistent Set of Key Wildfire Definitions

The current Chelan County Comprehensive Plan does not define wildfire, wildland-urban interface or other key terms related to wildfire mitigation. Given the anticipated timing of developing a countywide Community Wildfire Protection Plan and updating the Multi-Jurisdiction Natural Hazard Mitigation Plan, CPAW recommends that the county adopt a single set of definitions for terms including wildfire, wildland-urban interface, and wildfire mitigation. These terms should be used consistently across all planning, regulatory, and policy documents, including the Comprehensive Plan (where applicable). For reference, CPAW provides a list of relevant definitions in this report.

Expand Scope of Future Wildfire Policies

Current and draft policies related to wildfire in the Comprehensive Plan focus primarily on developing fire protection standards for commercial, industrial and residential development in rural areas, managing forest resources, and coordinating with rural fire districts and the county Fire Marshal to address fire safety issues. The county is encouraged to think more broadly about wildfire and how it may shape or affect local communities and ecosystems. For example, policies can also address:

- the role of wildfire on the landscape and its ecological benefits;
- potential impacts to local economies dependent on tourism;
- post-disaster recovery plans for wildfire-prone areas;
- increasing social resilience of vulnerable populations affected by disaster;
- educating local residents on their role and responsibility in wildfire preparedness.

While the Community Wildfire Protection Plan, local community groups, and other efforts play a significant role in implementing these activities, Comprehensive Plan policies provide support by acknowledging the far-reaching effects of wildfire.

Coordinate Wildfire Planning Across Urban Growth Areas by Utilizing Wildfire Hazard Assessment

The county contains two urban growth areas surrounding the unincorporated communities of Manson and Peshastin. Other urban growth area boundaries are associated with the incorporated cities of Chelan, Cashmere, Entiat, Leavenworth, and Wenatchee. The county's Comprehensive Plan policies related to development and growth apply only to areas outside of city urban growth area boundaries (unincorporated areas of the county *within* urban growth area boundaries are addressed in each city's respective comprehensive plan, as adopted by the county).

Planning for the wildland-urban interface ideally results in consistent policies and regulations across jurisdictional boundaries, including urban growth areas. This offers residents and the development community a predictable set of regulations and a consistent approach to wildfire safety. The county should therefore work with cities to ensure wildfire policies and development regulations meet county and city objectives. This process can be further facilitated by utilizing the wildfire hazard assessment and other decision making support tools from CPAW and the future Community Wildfire Protection Plan.

❖ Tips and Additional Support

- The State of Colorado recently released a new guide "Planning for Hazards – Land Use Solutions for Colorado." This online resource provides land use planners with hazard planning community examples, draft policy language, and appropriate planning tools to address different hazards, many of which are focused on wildfire.
- Headwaters Economics profiled five urban areas across the western U.S. to illustrate how planning tools can be used to address the WUI.
- The Fire Adapted Communities (FAC) Learning Network offers a series of FAC Quick Guides on Using Plans and Regulations to Increase Community Fire Adaptation.

Conclusion

This report identifies three primary areas where Chelan County can strengthen its approach to wildfire risk reduction through improved policy and regulation. 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 structural ignitions for builders, can also improve internal stakeholder understanding of long-term risk reduction goals.
- **Public Outreach and Engagement.** Underlying any successful effort to adopt regulations is a concerted approach to engage the public. This component typically includes public meetings and presentations on wildfire, information brochures that illustrate mitigation standards, and one-on-one interactions between fire department and planning staff with residents.

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

- **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 county's resilient future.

COMMUNITY PLANNING ASSISTANCE FOR WILDFIRE

CPAW Definitions

The following list of definitions is intended to aid understanding of terms associated with CPAW recommendations.

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 Hazard and Exposure Mapping for Chelan County, Washington**

Eva Karau, USDA Forest Service, Rocky Mountain Research Station
Kelly Johnston, Wildland Professional Solutions Inc.

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 (CPAW) effort for Chelan County, WA to perform assessments of spatial wildfire hazard to support CPAW's recommendations for wildfire planning codes and regulations. In this analysis and report we accomplish two objectives: 1) provide a realistic, localized representation of wildfire behavior in the county, including finely-tuned model parameters and landscape modifications that reflect stakeholder input; 2) use methods that are transparent, based on the best available science, and appropriate for use with federal 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 Chelan 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.

For the purposes of this analysis, we focus 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 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, similar to those that occurred during the 2015 Sleepy Hollow fire.

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 Chelan County.

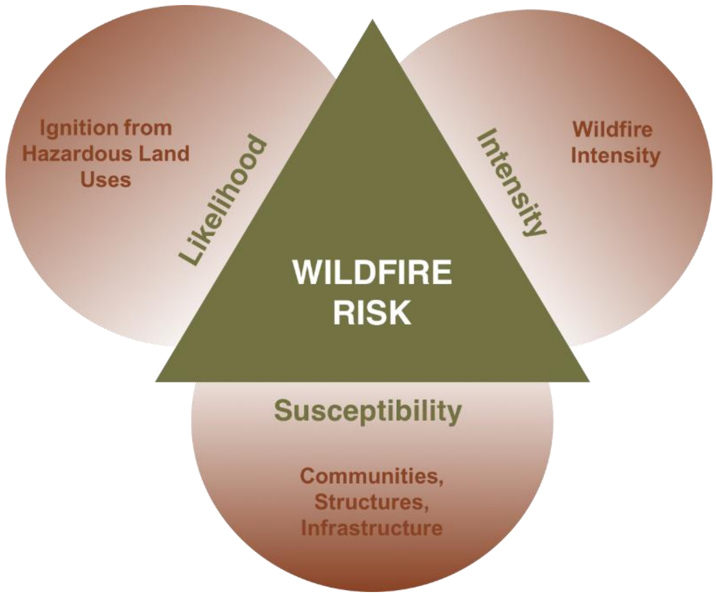

Figure A-1. The three components of the wildfire risk triangle include the likelihood of a wildfire, the intensity of a wildfire and the effect of a wildfire on something we care about (susceptibility). Figure is based on Scott et al. (2013).

❖ 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 Chelan 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 created firesheds for both the landscape and local scale fire modeling assessments conducted for Chelan County (Figure A-2). Both FSim and FlamMap modeling systems produce outputs of modeled fire perimeters and the ignition points associated with those perimeters. To construct the fireshed polygons, we first selected all simulated fire ignition points that fall within fire perimeters which intersect with the county boundary. Then, we used the selected ignition points as input to the Kernel Density tool (ESRI ArcGIS) to create a density surface which represents the density of fire ignition points for each cell in a raster layer. To create the final fireshed footprints, we chose a threshold of the ignition density raster that forms a boundary enclosing all of the ignition points that grew fire perimeters which reached the county boundary. The landscape fireshed boundary is much larger than the local fireshed; this is an expected outcome and it is due to the differences in the FSim and FlamMap modeling systems and the way that the models were parameterized for each assessment. In summary, we can interpret the final firesheds as boundaries that represent the area where wildfires could originate and spread into and out of

Chelan County, whose size and shape depend upon the objective of the fire behavior analysis.

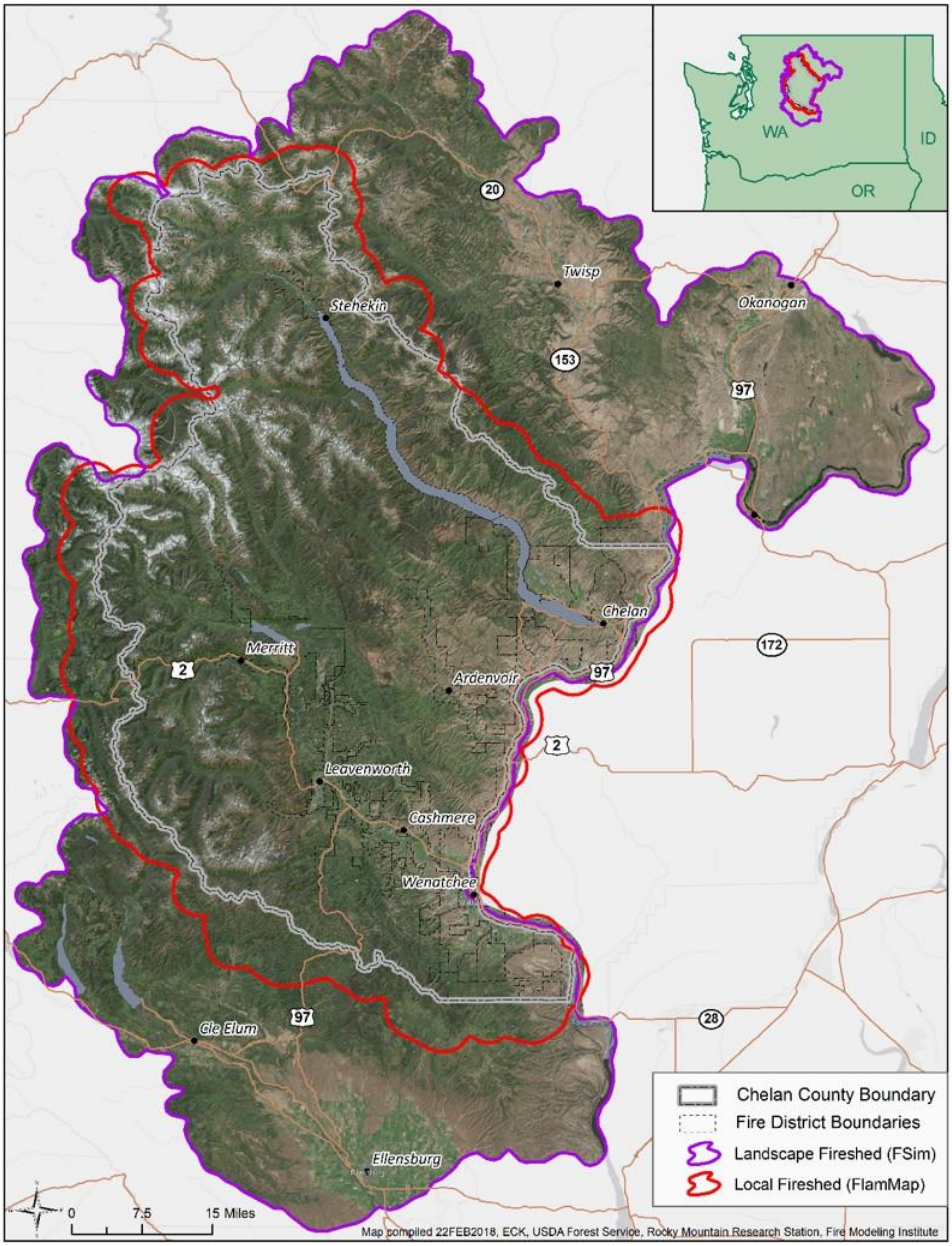

Figure A-2. Chelan County and modeling "firesheds" (landscape and local).

Wildfire Hazard Characterization for Chelan 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 Chelan 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 (Quantitative Wildfire Risk Assessment for OR and WA, In Prep) for the purpose of evaluating wildfire likelihood and intensity for landscape level analysis. We acquired the 120m-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 Quantitative Wildfire Risk Assessment for OR and WA report.

Landscape Level Summary Zone

To summarize the spatial metrics of likelihood, intensity, and hazard for the "landscape level" analysis, we chose subwatersheds from the national USGS Watershed Boundary Dataset (https://nhd.usgs.gov/wbd.html) as the polygon summary unit. Subwatersheds 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 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 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 99 subwatersheds that intersect the Chelan County boundary. Because the landscape characteristics and fire behavior on the east side of the Columbia River in Douglas County differ so greatly from those in Chelan County, we clipped the subwatershed boundaries to the extent of the county. This resulted in 11 smaller sections of subwatersheds on the eastern and southern edges of the county with artificially low acreages. For example, the total acreage of the Whitson Canyon-Columbia River subwatershed is 22,724 acres, but only 2,873 of those acres are in Chelan County. The resulting subwatershed and partial subwatershed summary unit polygons range in size from 2,873 to 40,653 acres, and average 19,357 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 120-m pixel values within each subwatershed, classified into three classes of moderate, high and very high (Figure A-3a). The classes are relative to the distribution of watershed averages only within the analysis area, and are based on quantile thresholds. "Moderate" represents values below the 33rd percentile, high represents values between the 33rd and 66th percentile, and very high moderate represents values above the 66th percentile. The average BPs for subwatersheds range from 0.0006888 to 0.03351, with a mean of 0.01256. This means, on average, any watershed has about a 1 in 80 chance of experiencing a large fire in any given fire season. (For an explanation of this math, see Scott et al. 2013).

In our Chelan County assessment, average landscape burn probability values are low in the western part of the county through the Cascade Mountains, high in a North-South band through mid-elevation timbered foothills, and grade to moderate in the grass/shrublands on the eastern edge of the county (Figure 3a). Much of the landscape surrounding Lake Chelan and in the southeastern part of the county has experienced wildfire within the past 15 years (Figure A-4). Most of those fires were represented in the FSim fuel model input file, and result in lower burn probability values for those areas.

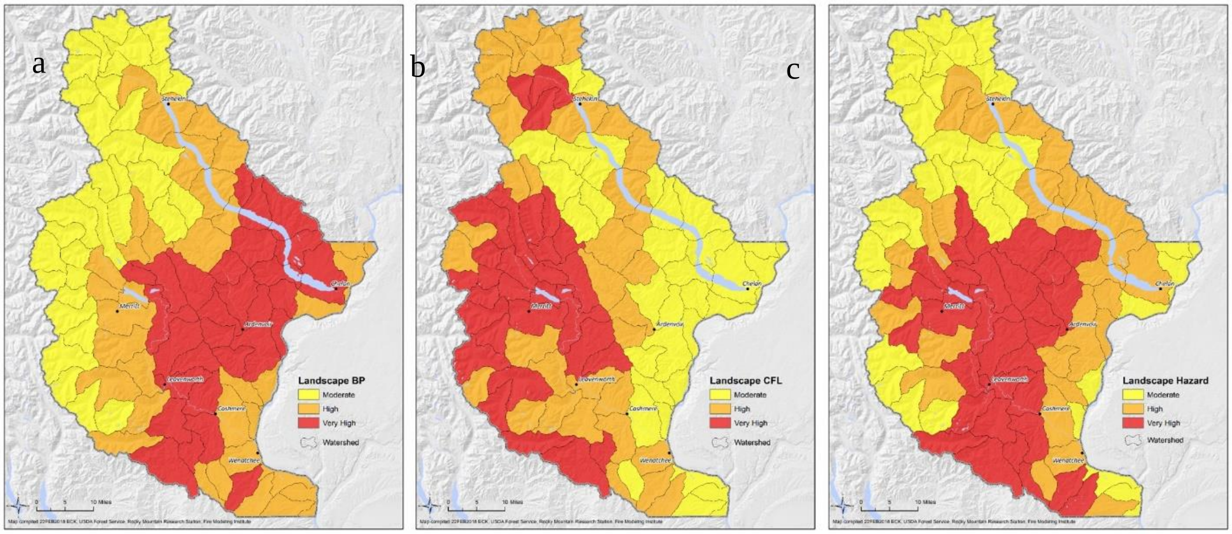

Figure A-3. Landscape level burn probability, fire intensity and wildfire hazard

Landscape Fire Intensity

FSim can apportion burn probability into wildfire intensity levels and produce estimates of the probability of a certain flame length level, given a fire burns a pixel. Conditional flame length (CFL) is the average of all flame length probabilities that FSim simulated for each 120-m pixel.

We summarize the pixel level CFL values within subwatersheds by calculating the average CFL for each subwatershed polygon. To create the Landscape Fire Intensity map (Figure A-3b), we classified the summarized CFL values into three classes by quantile, as described above for burn probability summaries.

Much of the forested western half of Chelan County have moderate to high mean CFL values, reflecting a pervasive forested fuel model with a moderate shrub/grass component and a high potential for passive and active crown fires, facilitating high flame lengths. There are several subwatersheds with low or moderate landscape mean wildfire intensity, where the impacts of previous fires were reflected in the FSim fuel input files, resulting in simulation of lower flame lengths.

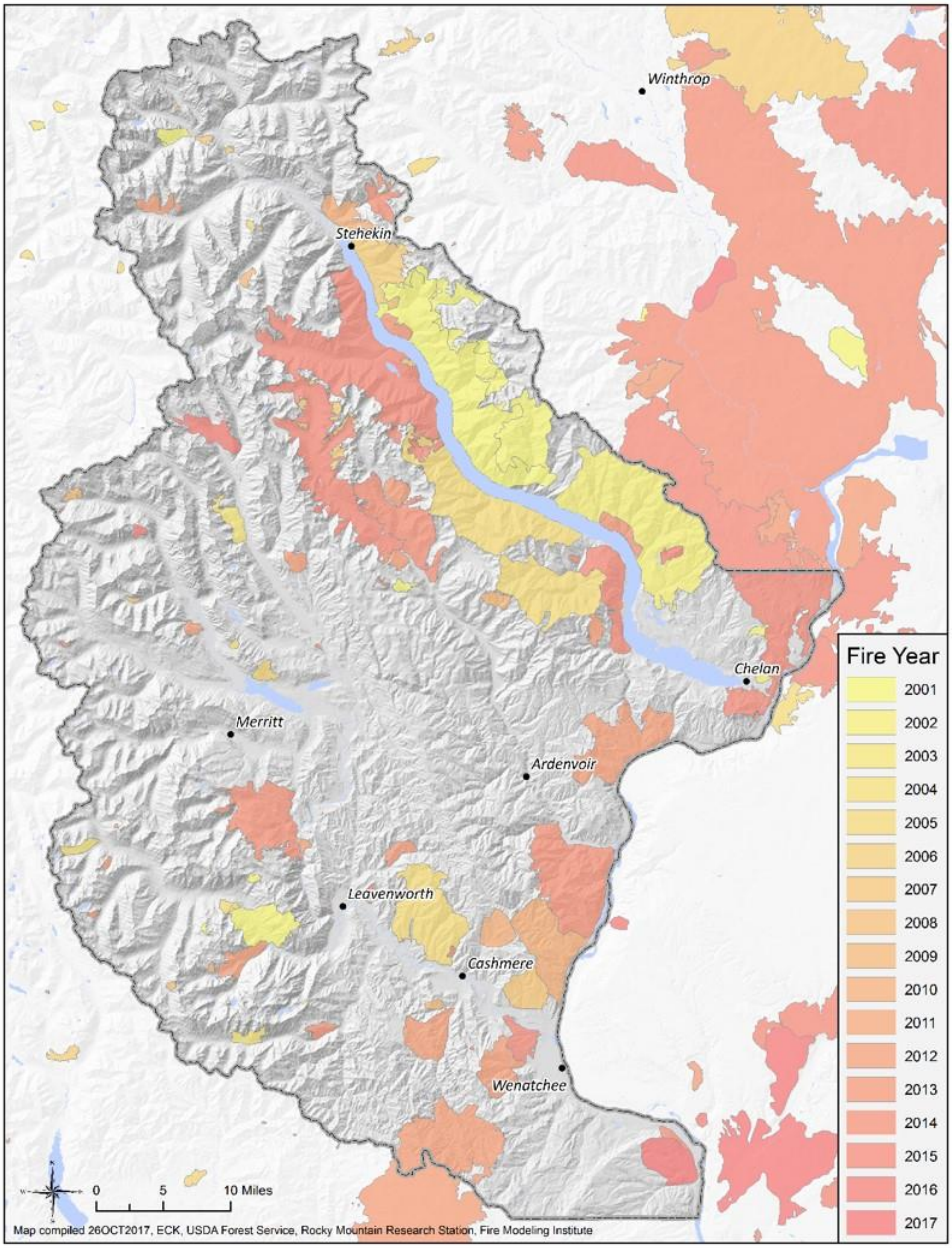

Figure A-4. Fire history (2001 – 2017) in and around Chelan County. Fire Perimeters were gathered from WFDSS (July, 2017) and may not include all fires.

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 subwatershed scale by calculating the mean CFL in each watershed polygon. We then classified the values into three classes (Moderate, High, and Very High) based on quantiles 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. Very high landscape wildfire hazard values generally cluster in the center of the county (Figure A-3c). 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 subwatershed as the intersection of average BP and average CFL (Figure A-5). By doing this, we can see the degree to which each input contributes to the overall wildfire hazard.

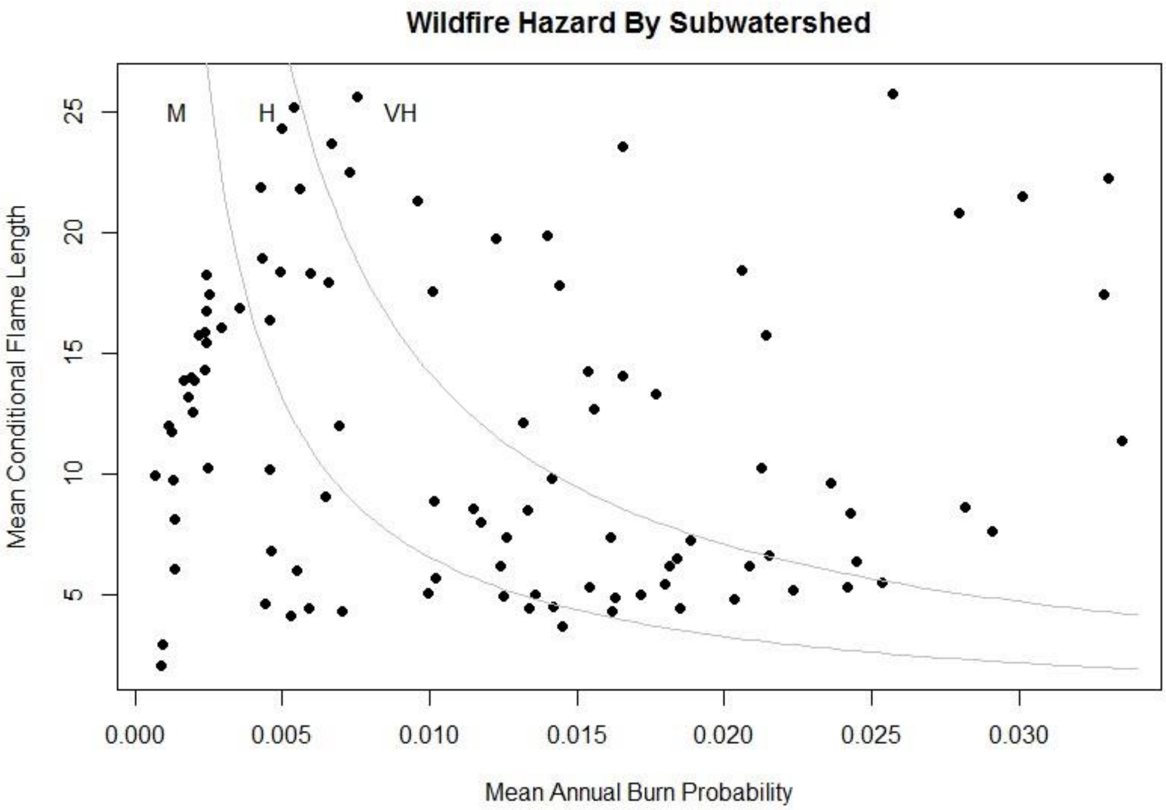

Figure A-5. Landscape level hazard by subwatershed. Curves represent lines of constant hazard and stratify the plot into hazard zones that correspond to map categories; M = Moderate, H = High, VH = Very High.

❖ 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 Chelan County. Camp 4, Dry Creek, and Entiat RAWS were evaluated from June 1 – Sept 15, 2002 – 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 (2.5, 3, and 5% for the 1-hr, 10-hr, and 100-hr dead fuel moistures) with almost completely cured live fuel moistures (40%, 70%). We used the Live Fuel Index (LFI) (synonymous with Growing Season index) which characterizes moistures that are closely related to live fuel moisture trends and also represents the range of moistures from higher to lower elevations. This is important because live fuel moisture values stay constant throughout the duration of the simulation in FlamMap. 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.

Realistically, dead fuel moisture values vary due to changes in aspect, slope, elevation, canopy cover, cloud cover, temperature and relative humidity, and precipitation amount and duration. In order to model these changes, a conditioning period is applied using those attributes from a wind and weather file and the elevation, slope, aspect and canopy cover GIS data (Nelson 2000). Because time is held constant during FlamMap simulations, hourly weather (temperature, relative humidity, precipitation and the time of day the minimum and maximum values occurred) are only used to “condition” dead fuel moisture. Hourly values for percent cloud cover (from the wind file) is also used for dead fuel moisture conditioning. We evaluated 97th percentile conditions for relative humidity and temperature but recognized that these variables did not occur simultaneously as measured by RAWS stations. Instead, we used the wind and weather scenario selected from the days preceding the Twisp fire event in 2015, which had exceptionally low RH coupled with high temperature. The thresholds as determined in the Okanogan – Wenatchee pocket card (RH < 25%, Temp > 80, 10-hr fuel moisture < 7% and 1000-hr fuel moisture < 11%) was evaluated for the 3 RAWS stations that composed a SIG in Fire Family Plus (Entiat, Camp4, and Dry Creek); August 9 – 14, 2015 was chosen to represent hot and dry conditions that would condition dead fuel moistures for a severe fire event.

The FlamMap simulation holds time constant through the duration of the simulation. Subsequently, wind speed is held constant as well. However, unlike FSim, FlamMap uses a sub module called Wind Ninja (Forthofer et al. 2014) to compute spatially varying wind fields for complex terrain. Ideally, spatially explicit winds will better represent simulated fire behavior impacted by the dissected terrain of Chelan County that strongly influences wind speed and direction (Figure A-6). Historically, higher wind speeds from the west are shown to occur in the summer months when conditions are dry (Figure A-7), so we chose an 18 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. For example, the Entiat RAWS had measured a summer-time maximum wind gust of 60 mph (with an hourly wind speed of 40 mph). We chose to initialize the FlamMap simulation with 18 mph from the west, which resulted in range of wind speeds 0 – 53 mph after being adjusted for terrain and vegetation effects (Figure A-6). Wind Ninja simulates higher wind speed at the tops of prominent ridges like Angle Peak and East Point (Devil’s Backbone) and adjusts wind vectors to the terrain

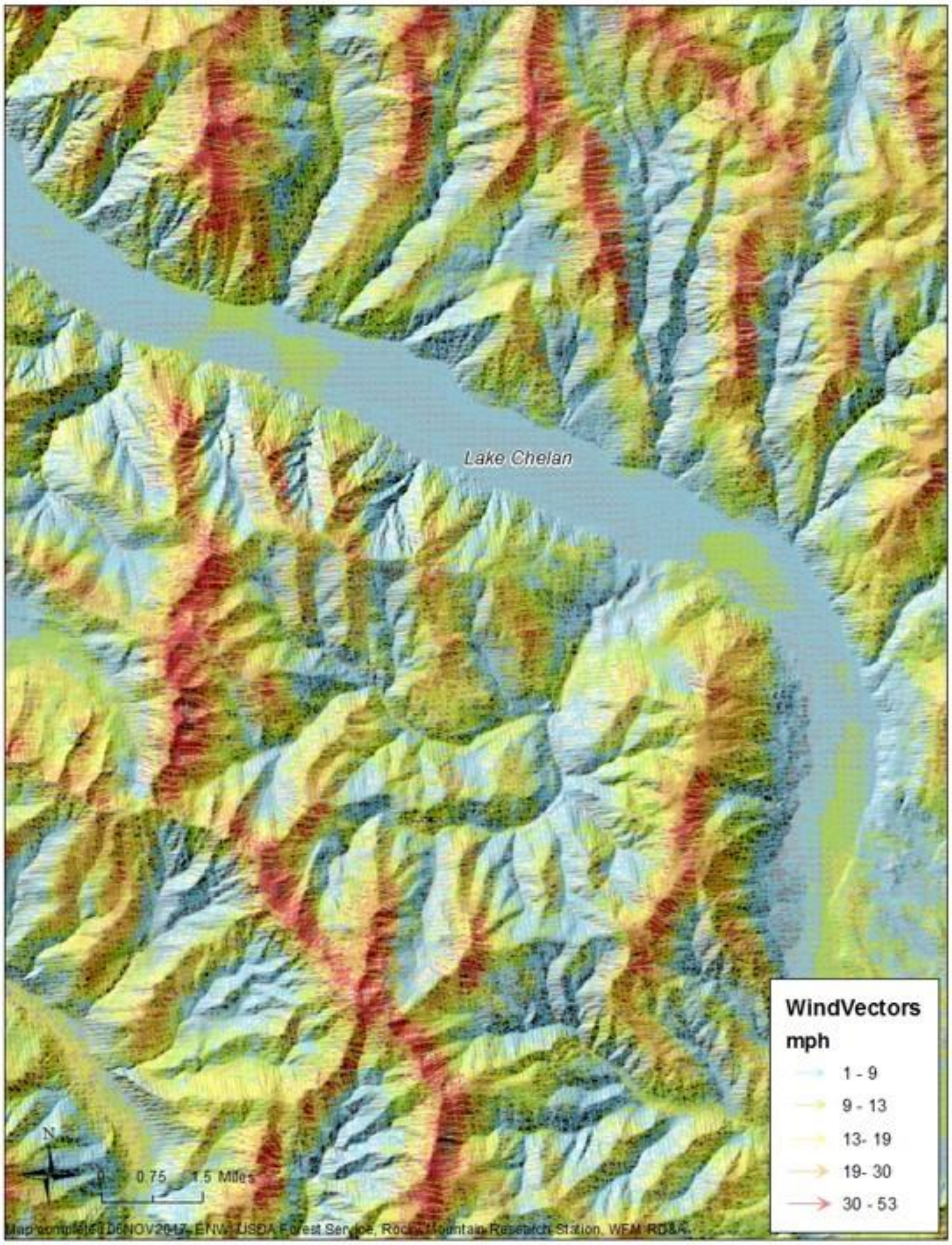

Figure A-6. FlamMap wind vector map.

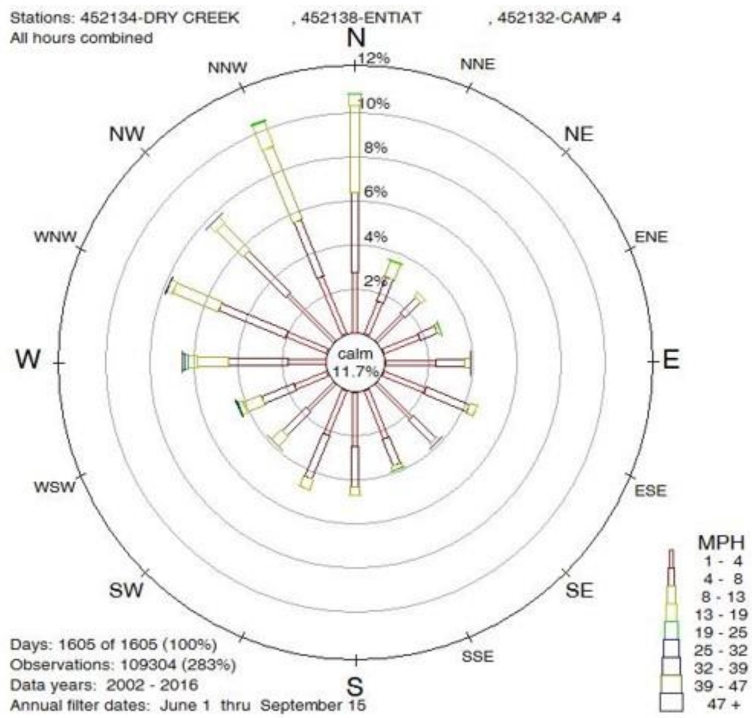

Figure A-7: Historical 20 ft wind speed and direction during summer months

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 to initialize their FSim modeling for Washington and Oregon, and we modified some of the layers, as described in the following sections.

Past Wildfires

Approximately 23% of Chelan County has been impacted by wildland fires since 2000 (~442,000 acres). We used the existing rule set from LANDFIRE and modifications made by Pyrologix LLC as a starting point for the fuel modifications that reflect past wildfires (Quantitative Wildfire Risk Assessment for OR and WA, *In Prep*). We obtained past wildfire perimeters for time span of 2000 through July, 2017 from the Wildland fire Decision Support System disturbance history data archive of. Adjustments to the landscape for wildfires were based on stakeholder feedback gathered at a Subject Matter Expert Workshop in Wenatchee in July 2017, and addressed in 3 ways:

1) The time since the fire occurred and the elevational gradient influence how quickly these disturbed areas recover post-fire. County subject matter experts reported that lower elevation areas (below 600 m or 2000 feet) that are within 1-3 years of experiencing a fire do not recover to a fast moving, high load pre-fire grass vegetation type; rate of spread and fire intensity in those areas will be moderated within grass and grass-shrub fuel models. To reflect this, for areas where fires have burned within the last 1-3 years, we changed grass and grass-shrub fuel models below 2000 feet to a lower rate of spread grass model (GR1).

2) Subject matter exports reported that high elevation timber fires moderate rates of spread for 15-20 years post-fire. To reflect this, we changed fuel models for fires that occurred from 2000 to 2014 in areas above 600m: All grass models were changed to a lower rate of spread GR1; all grass-shrub fuel models were changed to a GS1; and the high load timber understory was changed to a light load timber understory (TU1).
3) Recent, high elevation fires (above 600m and between 1-3 years (2014-2017) were reported to result in lower post-fire rates of spread. We converted the grass and grass-shrub fuel models in these areas to a low rate of spread fuel model; the timber and slash blowdown fuel models were converted to a low rate of spread timber understory fuel model.

Fuel Treatments

We had a discussion at a Subject Matter Expert Workshop in Wenatchee in July 2017 about how the landscape changes due to fuel treatments by private, state, and federal entities. Generally, county experts reported that fuel treatments change both the surface and crown fuels affecting numerous aspects of wildland fire behavior. Intensity, time since the treatment, type, and ownership all affected how different fuels were either re-organized (changed from a vertical to horizontal distribution), decreased, or increased post-treatment. The post-treatment fuel model rules (Table A-1) strive to represent the resultant fire behavior post-treatment, given the discussion at the workshop.

We obtained spatial data describing fuel treatments on state and federal lands from Washington Department of Natural Resources Forest Practices data (http://data-wadnr.opendata.arcgis.com/, accessed July 2017) and the Forest Service Activity Tracking System (https://data.fs.usda.gov/geodata/edw/datasets.php). Fuel treatment polygons ranged in size from 0.3 to 1,083 acres, averaging about 50 acres. While they are generally small in size, some treatments were implemented in the vicinity of important values (like communities) and thus should be represented and tracked over time to evaluate how well they actually do provide a buffer to wildland fire. There continues to be debate on how long different fuel treatments last (Vaillant, Noonan-Wright, Reiner and others 2015; Stephens et al. 2009; Cochrane et al. 2012) and how effective they really are (North et al. 2015, Cochrane et al. 2012). The rule set we developed to represent completed fuel treatments were summarized by a number of factors: 1) the owner of the activity (Private vs Federal); 2) time since treatment; and 3) the treatment itself (thinning of trees, prescribed fire, salvage logging etc.) The combination of the three factors were used to adjust the surface fuel model and/or canopy fuels (canopy base height, canopy bulk density, canopy cover, and stand height).

The canopy fuels information is important for the both fire behavior modeling systems to determine if crown fire occurs and the subsequent rate of spread and flame length. Canopy cover affects dead fuel moisture conditioning and wind speed (less canopy cover means drier fuels and faster wind speed). These are important factors to adjust and reflect the impact of the fuels treatment given the modeling limitations and assumptions. Modifications of canopy fuels were guided by Scott and Reinhardt 2005 and Vaillant et al. 2015. Modifications to surface fuel models were made using the guide from Scott and Burgan 2005, along with suggestions from stakeholders.

Table A-1. Modifications made to FlamMap input fuel layers for fuel treatment units.

Owner	Activity Type	Time Period (TST)	Description (Surface Fuels)	Description (Canopy Fuels)
State & Private	Salvage	1 - 6 years (2011-2017)	Surface fuels changed to light slash fuel model (SB1) when canopy cover > 10%;	Canopy fuels assumed from wildfire effects
State & Private	Uneven Age Harvest	1 - 6 years (2011-2017	Modifications to surface fuels reflect leaving some trees onsite and converting the existing timber litter and timber understory fuel models to a moderate slash fuel model (SB 3).	Modifications to canopy fuels reflect leaving some trees onsite but a general decrease of canopy fuels: canopy cover decreased by 40%; Canopy Base Height increased by 50%; Canopy Bulk Density decreased by 40%
State & Private	Even Age (clear cut)	1 - 6 years (2011-2017	A moderate slash blowdown fuel model (SB2) is used to represent post-harvest Timber Litter(TL) and Timber Understory(TU) fuel models	These polygons generally have only a few trees left onsite post-harvest: cCnopy Cover decreased to 25%; Canopy Base Height is raised to 90% of the canopy height; Canopy Bulk Density is decreased significantly to 0.05 kg/m3.
Federal	Mechanical Add	2 - 5 years (2012-2016)	Surface fuels are mowed or chipped into small pieces and the fuel is re-arranged to be more horizontally configured but remains on site; If Canopy Cover is greater than 25%, then convert the TL and TU fuel models to SB 3 (moderate slash)	No modifications
Federal	Mechanical Remove	2 - 5 years (2012-2016	This includes biomass removal; small diameter fuels will be left on site with low rate of spread fuel models. For areas with canopy cover greater than 25%, TL fuel models were converted to a TL 3, the TU fuel models were converted to TU 1 ; and the SB fuel models were converted to TL 4	No modifications
Owner	Activity Type	Time Period (TST)	Description (Surface Fuels)	Description (Canopy Fuels)
Federal	Prescribed Fire	2 - 5 years (2012-2016	This includes broadcast and jackpot burns and machine pile burn; assumed a moderate intensity burn. Surface fuel models stayed within the same group and a lower rate of spread fuel model was selected; TL to TL8; TU to TU1; GR2 to GR1; GS2 to GS1	Canopy Base Height was increased by 50%; Canopy Bulk Density was decreased by 20%; no change to canopy cover or stand height
Federal	Thin from below	2 - 5 years (2012-2016)	No modifications	Pruning, pre-commerical thin, thinning for hazardous fuels reduction, & site prep for planting/other: assumed treatments select understory tree species and therefore will raise the CBH on a stand level; slightly decrease CBD, maintain stand height, and decrease canopy cover.
Federal	Thin from above	2 - 5 years (2012-2016)	If the polygon did not have a surface fuel treatment, then it was converted to SB 1 (light slash).	Includes commercial thinning and overstory trees were selected for removal. Modifications to canopy fuels reflect leaving some trees onsite but a general decrease of canopy fuels: canopy cover decreased by 40%; Canopy Base Height increased by 50%; Canopy Bulk Density decreased by 40%; Stand Height reduced by 10%.

Agriculture

In a Subject Matter Expert Workshop in Wenatchee in July 2017, experts reported that orchards are typically irrigated and thus do not contribute to fire spread. We obtained an agriculture GIS layer from the county and represented orchards as non-burnable fuels.

Ravines

Ravines where slash and fuels are deposited can contribute to greater fire flame lengths and spotting from wildland fires. When they are located near homes adjacent to the wildland urban interface, the fuels and subsequent fire behavior can facilitate structure loss from fire. County experts suggested that during the Sleepy Hollow fire, slash and debris deposited in ravines near homes contributed to greater intensity and spotting. Slash is commonly deposited in ravines near orchards as well. We represented these areas as a surface fuel model SB4 (heavy slash) to reflect the contribution of these fuels to increased fire behavior and effects.

❖ Local Level Maps and Figures

We initialized the Minimum Travel Time (MTT) module within FlamMap 5.0 with 54,044 fire ignitions whose locations were random, but informed by locations where wildfires have occurred during the period of 1992 through 2015 (Short 2017). We used 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, flame length probabilities classed into 6 bins, and a fire size list. FlamMap generates a raster layer for burn probability, but we needed to convert the flame length probability file into a set of 6 rasters to enable calculation of the conditional flame length raster, which we created using the Convert Fire Size List Tool in ArcFuels, a custom tool bar available for ESRI ArcGIS. 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 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 3,027 catchments that intersect the Chelan County boundary. Because the landscape characteristics and fire behavior on the east side of the Columbia River in Douglas County differ so greatly from those in Chelan County, we clipped the catchment boundaries to the extent of Chelan County, as we did with HUC12 watersheds for the landscape level assessment. This resulted in smaller sections of catchments on the edges of the county with artificially low acreages. The resulting catchment and partial catchment summary unit polygons range in size from 15 to 8,889 acres, and average 633 acres.

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. 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 three classes of moderate, high and very high (Figure A-8a). The classes are relative to the distribution of catchment averages only within the analysis area, and are based on quantile thresholds. “Moderate” represents values below the 33rd percentile, high represents values between the 33rd and 66th percentile, and very high moderate represents values above the 66th percentile. The average BPs for catchments range from 0 to 0.005228, with a mean of 0.000407. Burn probability is a function of rate of spread and duration of fires; these local level probabilities are low as compared to the values produced in the landscape analysis. This is due, in part, to the fact that we used an 8-hr burn period, which is representative of fire behavior observed by local experts, but it also limits the time that a fire has to grow in size as compared to FSim where fires can continue to spread as long as they remain above the 80th percentile Energy Release Component (ERC), a metric used to characterize fire danger. We suggest that burn probability output from the local FlamMap simulation are more useful as relative values as opposed to actual values.

In our Chelan County assessment, FlamMap burn probability values reflect fuel model patterns and our parameterization of environmental conditions. Burn probabilities are moderate and high where fuel models represent high fuel loads and moderate to high rates of spread (GR2, GS2, TU5 and TL5 – see Scoot and Burgan 2005 for a detailed description of fuel models). Similar to the landscape level BP patterns, the FlamMap BPs are moderate in much of the landscape surrounding Lake Chelan and in the southeastern part of the county, in areas that have experienced wildfire within the past 15 years (Figure 4). Most of those fires were represented with fuel models that have lower rates of spread and lower fuel loadings and result in lower burn probability values for those areas. Compared with landscape level BP patterns, the western part of the county has catchments with higher mean BP values; FSim BP outputs reflect calibration efforts that moderate BP on the west side based on the historical fire record, whereas we parameterized our FlamMap run to represent conditions under which fires could spread through the crowns of high elevation forests.

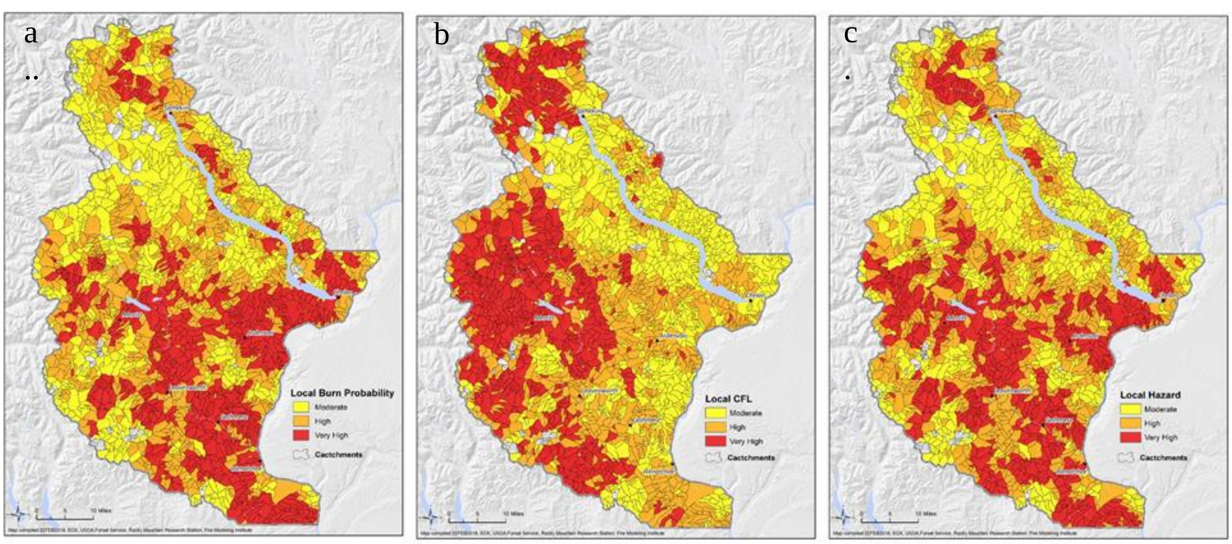

Figure A-8. Local level wildfire maps: burn probability (a), Conditional flame length (b), and Hazard (c). Pixel values are summarized to catchment boundaries.

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-8b), we classified the summarized CFL values into three classes, based on quantiles, as described in the landscape summary discussion.

Much of the forested western half of Chelan County has very high CFL values, reflecting a high potential for passive and active crown fires, and the accompanying high flame lengths. There are several subwatersheds with moderate or high landscape wildfire intensity, where the impacts of previous fires were reflected in the FSim fuel input files, resulting in simulation of relatively lower flame lengths.

Similar to the FSim results, we see very high mean CFL on the western part of the county, again, due to the presence of very high load timber fuel models (TU5 and TL5) in this area leading to higher potential for passive and active crown fire.

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 CFL in each catchment polygon. We then classified the values into three categories (Moderate, High, and Very High) based on quantiles 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.

Very high local wildfire hazard values are speckled throughout the county, but also cluster in the northern tip of the county, the center and west side of the county and in a few areas in the southwest portion of the county (Figure A-8c). There are some clusters of moderate local hazard that reflect the imprint of previous fires, where the fuel model was modified to reflect the disturbance. To examine how BP and CFL combine to influence the overall hazard estimates, we plotted the average hazard value for each catchment as the intersection of average BP and average CFL (Figure A-9). By doing this, we can see the degree to which each input contributes to the overall wildfire hazard. The variability of local hazard values increases as CFL and BP increase; this means that at a catchment with a moderate hazard score is more likely to have moderate values for both BP and CFL, whereas a catchment with a very high hazard score may have a moderate BP and very high CFL, or vice versa.

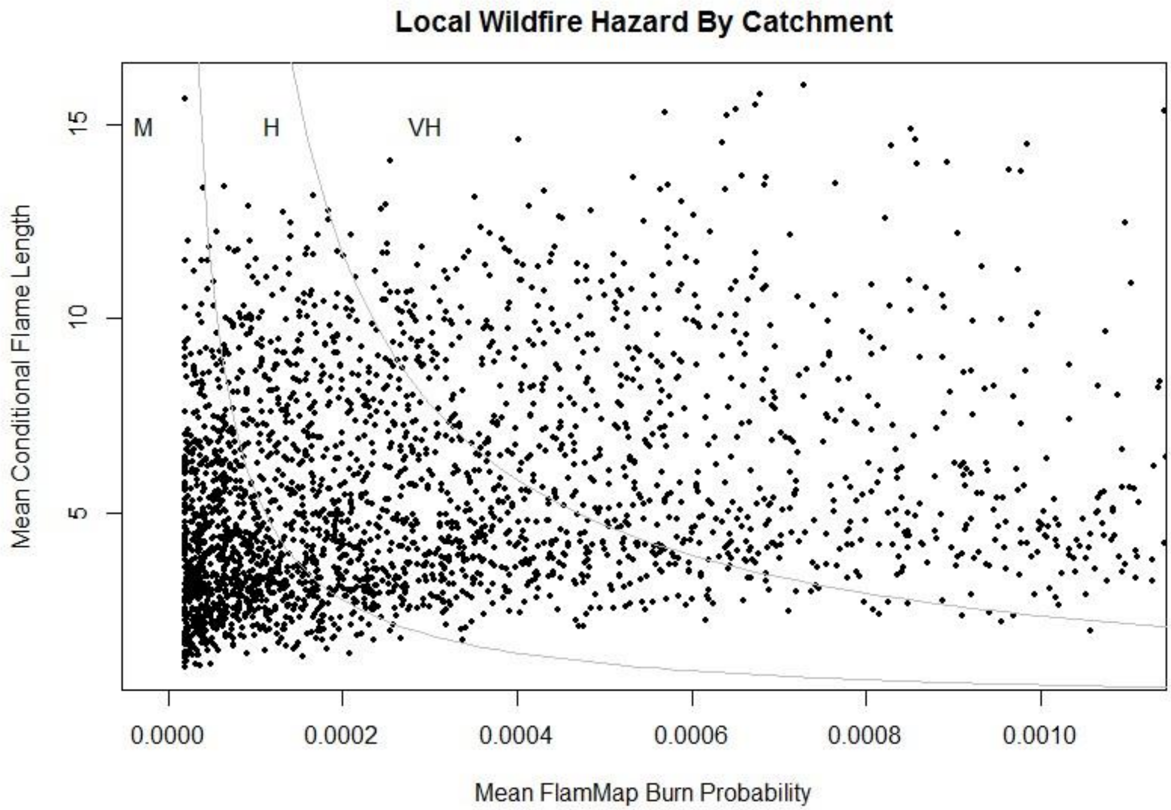

Figure A-9. Local level hazard by catchment. Curves represent lines of constant hazard and stratify the plot into hazard zones that correspond to map categories; M = Moderate, H = High, VH = Very High.

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 Chelan 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 Chelan County, the size of Census blocks range from less than an acre to over 265,000 acres 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 (accessed from RiverCom, July 2017), instead of Census data, to represent structures for our mapping efforts (Figure A-10). 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.

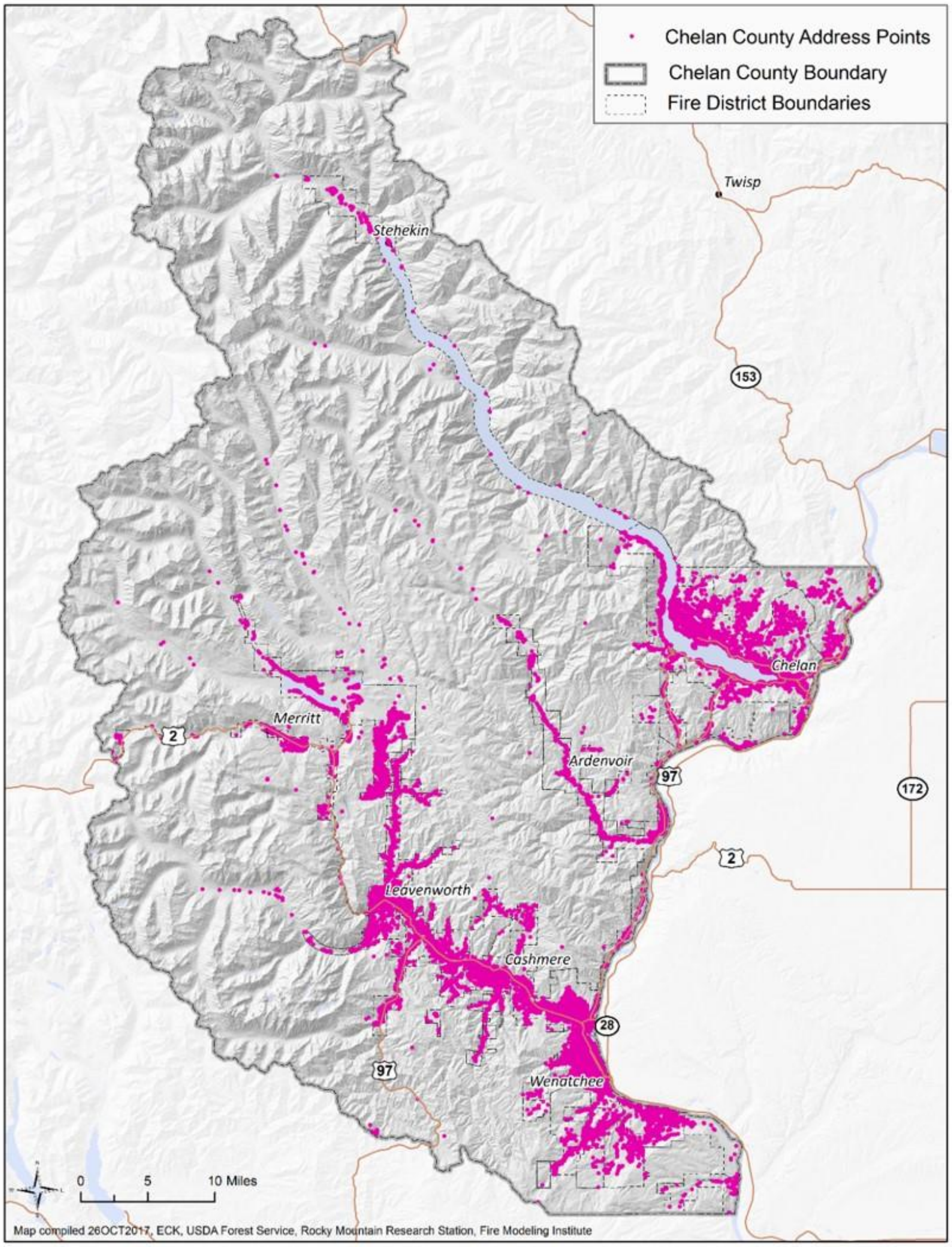

Figure A-10. Chelan County address points

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. We also included orchards, as delineated in an agriculture GIS layer that we obtained from the county, as non-burnable. 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 11), with the map categories described in Table 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.

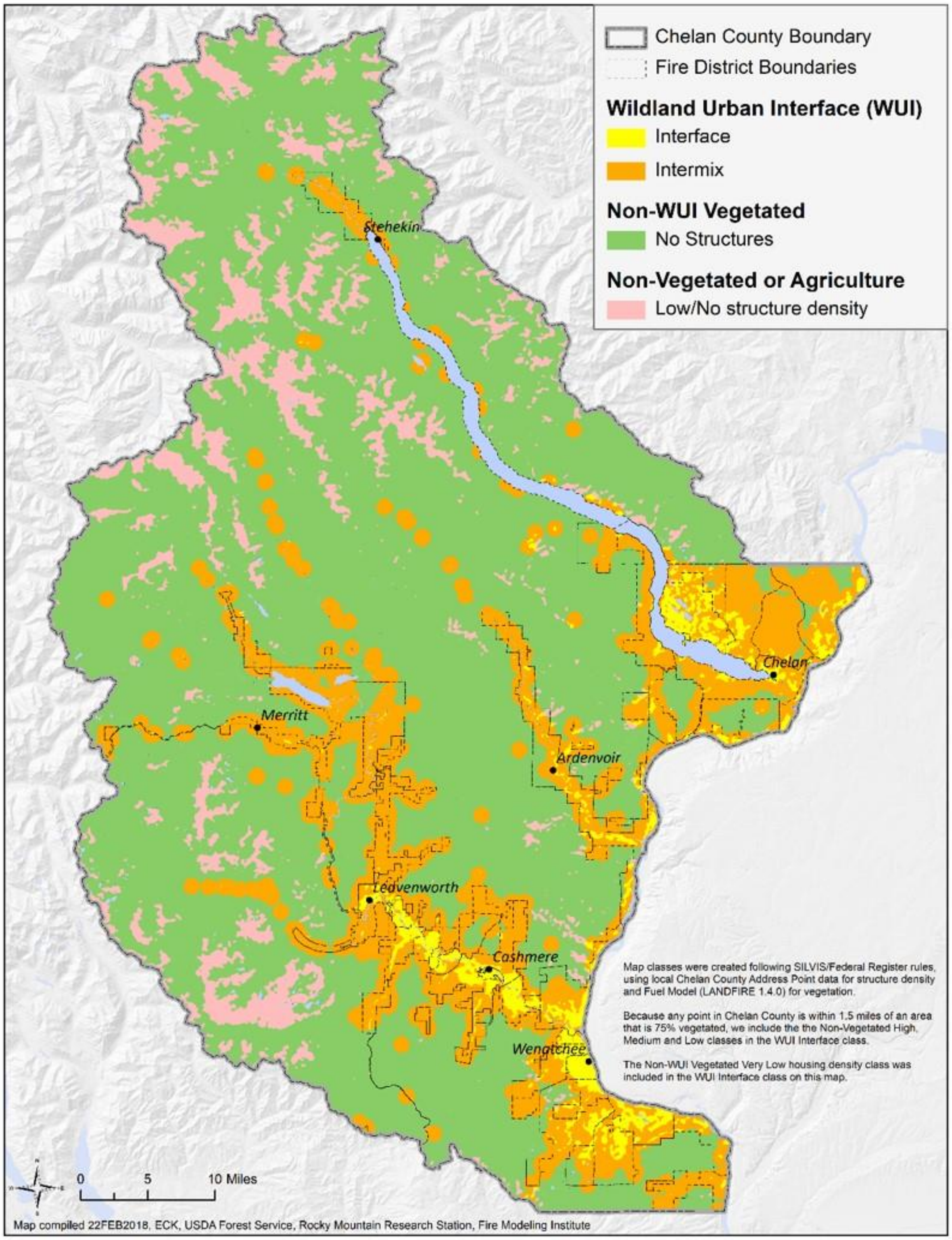

Figure A-11. Categories of wildland vegetation integrated with population

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

WUI Category	Structure Density Description	Structure Density Range (structures/km^2)	Vegetation Description	Notes
Interface	High Density	GE 741.3162	Wildland vegetation LE 50% and within 2.414 km of area with GE 75% wildland vegetation	Every address point in Chelan county is within 2.414 km of an area with GE 75% wildland vegetation, so this was criteria was moot.
	Medium Density	GE 49.42108 and LT 741.3162		
	Low Density	GE 6.177635 and LT 49.42108		
Intermix	High Density	GE 741.3162	Wildland vegetation GT 50%	
	Medium Density	GE 49.42108 and LT 741.3162		
	Low Density	GE 6.177635 and LT 49.42108		
Non-Vegetated	High Density	GE 741.3162	Wildland vegetation LE 50%	Same extent as WUI Interface Hi
	Medium Density	GE 49.42108 and LT 741.3162		Same extent as WUI Interface Med
	Low Density	GE 6.177635 and LT 49.42108		Same extent as WUI Interface Low
	Very Low Density	LT 6.177635		
	Uninhabited	EQ 0		
Vegetated	Very Low Density	LT 6.177635	Wildland vegetation GT 50%	Included with Intermix
	Uninhabited	EQ 0		

In an effort to characterize the potential impact of wildfire spotting from wildland vegetation to structures in Chelan 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 Chelan 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 Chelan 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.

Mitigation Difficulty

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 difficulty, 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 three classes: 1. Steep slopes - Slopes greater than or equal to 30%, 2. Moderate slopes – slopes greater than or equal to 15% and less than 30%, and 3. Shallow slopes – slopes less than 15%.

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 map categories representing the difficulty to mitigate wildfire hazard and summarized by majority rating within Chelan County parcels (Figure A-12). Map classes range from 0 to 9, increasing with difficulty to mitigate wildfire hazard:

1 – Non-vegetated, with potential for ember impact:

Barren ground/water/sparse vegetation or land that lies within potential spotting distance of a wildfire. Mitigation will involve appropriate structure ignition zone and IR structure construction.

2 – Herbaceous on a shallow slope (< 15%):

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 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.

3 – Herbaceous on moderate slope (15≤ to <30%):

Harder to construct fuel breaks, increased difficulty in mechanical (mowing) treatment, increased potential for erosion, increased rate of spread and intensity may make frequent burning and other mitigation more difficult. Focus should be on appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.

4 – Herbaceous on steep slope (≥ 30%):

Significant challenges in fuel break construction, unlikely option for mechanical (mowing) treatment, significant potential for erosion, high rate of spread and intensity potential may make frequent burning difficult. High winds combined with short-term drying conditions leads to potentially dangerous fast-moving fires with fire fighter access concerns. Mitigation potential may involve a combination of frequent burning, and fuel breaks in conjunction with slope set-back along with appropriate structure ignition zone and IR structure construction.

4 – Shrub on shallow slope (<15%):

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 may involve a combination of frequent burning, and fuel breaks in conjunction with appropriate structure ignition zone and IR structure construction.

5 – Shrub on moderate slope (15≤ to <30%):

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

6 – Shrub on steep slope (≥ 30%):

Significant challenges in fuel break construction unlikely option for extensive mechanical (mastication) treatment. Significant potential for erosion or slope instability resulting from treatments is a likely mitigation challenge. Increased rate of spread and significant intensity may make burning more difficult. Focus should be on a combination of appropriate mechanical treatment and burning, slope set-backs, structure ignition zone and IR structure construction mitigation.

6 – Tree on shallow slope (< 15%):

Open canopy must be maintained to prevent increased crown fire potential. 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.

7 – Tree on moderate slope (15≤ to <30%):

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. Increased potential for erosion or slope instability resulting from treatments can be a mitigation challenge. Mitigation should also include appropriate slope set-backs, structure ignition zone and IR structure construction mitigation.

7 – Tree on shallow slope (< 15%) 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.

8 – Tree on moderate slope (15≤ to <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. Increased potential for erosion or slope instability resulting from treatments can be a mitigation challenge. Mitigation should also include appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.

8 – Tree on steep slope (≥ 30%):

Open canopy must be maintained to prevent increased crown fire potential, which can be significantly difficult due to the slope. Surface fuels must be treated/maintained in a state that reduces the chances of fast moving surface fires. Significant potential for erosion or slope instability resulting from treatments is a likely mitigation challenge. Mitigation should also include appropriate slope set-backs, structure ignition zone and IR structure construction mitigation.

9 – Tree on steep slope (≥ 30%) with potential for crown fire:

Dense canopy needs to be thinned to reduce crown fire potential, which may be extremely difficult, if not prohibitive due to the slope. Surface fuels must be treated to reduce risk of fast moving surface fires. A very high potential for erosion or slope instability resulting from treatments is a likely mitigation challenge. Mitigation should also include appropriate slope setbacks, structure ignition zone and IR structure construction mitigation.

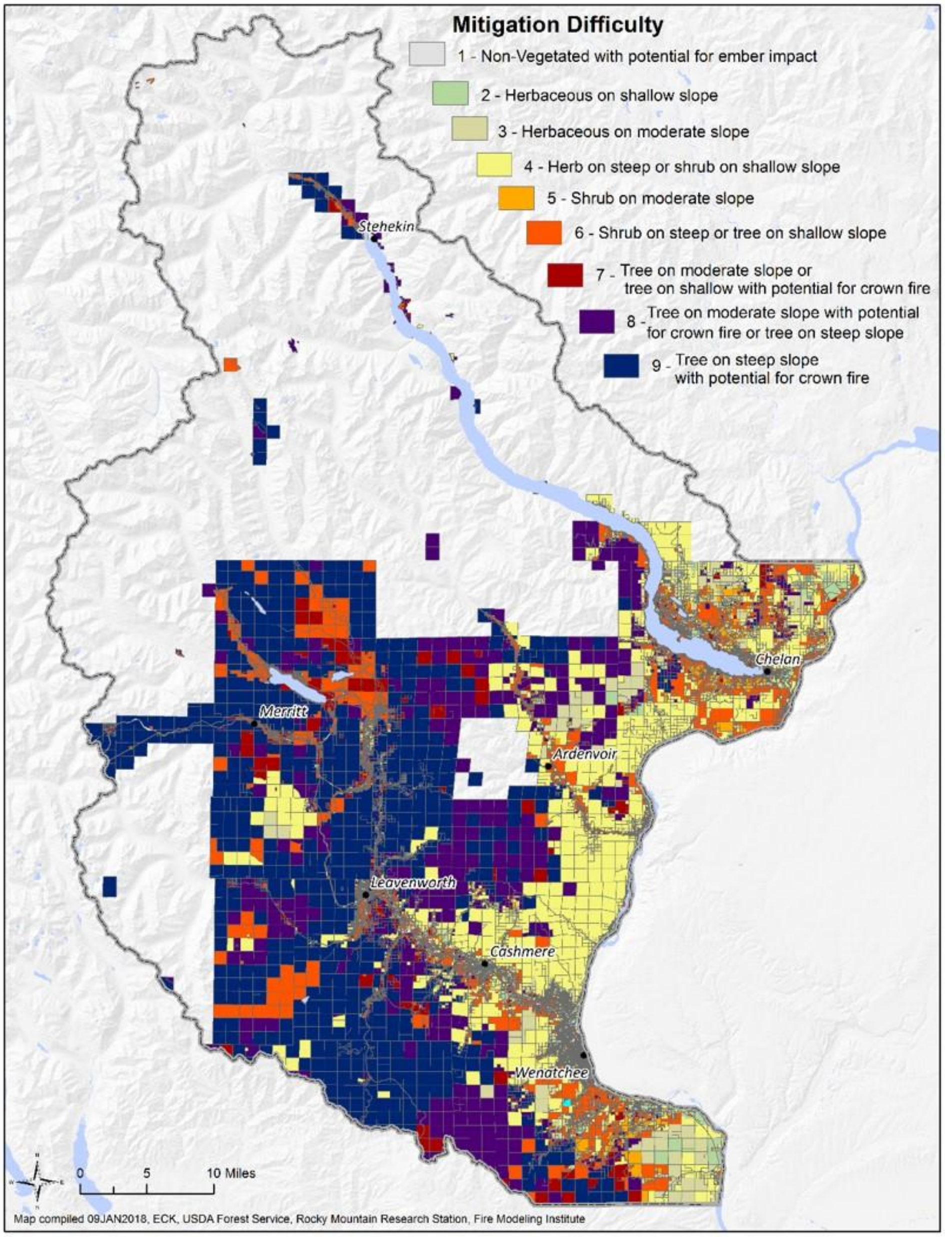

Figure A-12. Vegetation mitigation difficulty map

Analysis Summary and Recommendations for use

In this report, we presented two complementary representations of wildfire hazard for Chelan County. We are fortunate that the FSim modeling results from the Quantitative Wildfire Risk Assessment for OR and WA 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 54,044 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 Chelan 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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