Planning with Fire:
Exploring the Barriers & Opportunities Surrounding Wildfire Fuel Reduction at the Wildland Urban Interface

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Abstract

Planning with Fire: Exploring the Barriers and Opportunities to Wildfire Fuel Reduction at the Wildland Urban Interface

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With unprecedented climate change and rapidly shifting wildfire regimes heightening wildfire risk across the Pacific Northwest, our research explores fuel reduction as a holistic wildfire mitigation strategy. Using the Methow Valley in Washington State as a case study, we examine the barriers and opportunities surrounding fuel reduction practices at the wildland urban interface (WUI). Development has expanded into the WUI across the country and rural communities are increasingly vulnerable to serious wildfire impacts. Through qualitative stakeholder interviews, case studies, and spatial analysis, we highlight the need for change, emphasize key linkages to perceived barriers, and offer multi-scale recommendations for strengthening fuel reduction programming at the WUI. By revealing the barriers and opportunities associated with wildfire fuel reduction, we hope that this document can be used to formulate site specific best practices in holistic wildfire mitigation.


PLANNING
WITH FIRE

ACKNOWLEDGEMENTS

First and foremost, we acknowledge that the land that encompasses the Methow Valley is the ancestral homeland of the Methow People. They stewarded this region of Washington State since time immemorial, up until colonization when violence and government-orchestrated relocation forcibly removed them from their lands.

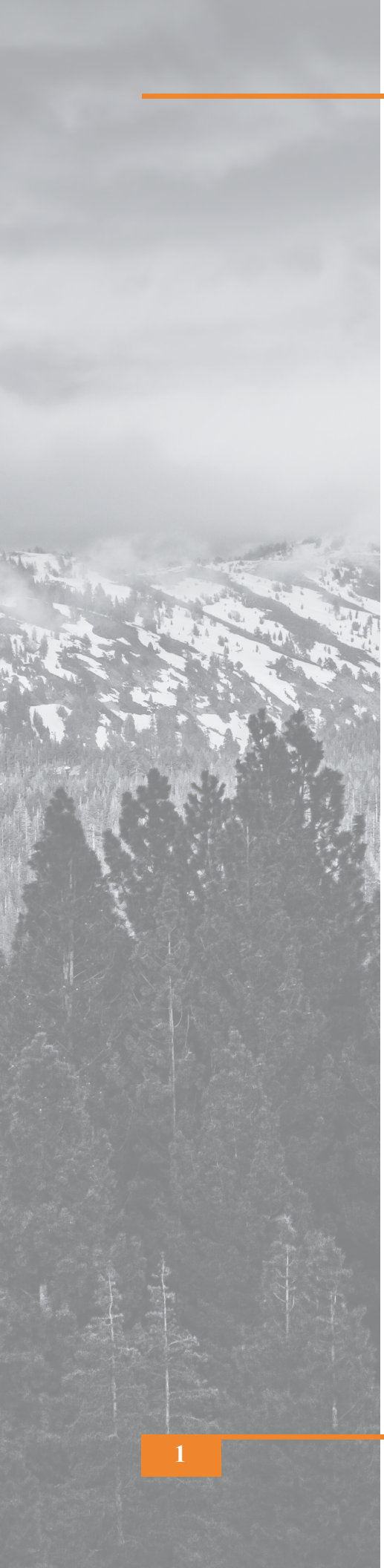
Thank you to our committee members, Bob Freitag and Ken Yocom, for their ongoing support and guidance. Arriving at our final research scope was no easy task, and we are deeply grateful for the insight of our committee. Many thanks to all of the stakeholders that we have met with over the course of this exploration, especially Eli Loftus from the Okanogan Conservation District and William Knowlton and Jake Hardt from Washington Department of Natural Resources, who have been incredibly generous with their time and knowledge. Thank you to fire ecologists Paul Hessburg and Susan Pritchard for their groundbreaking work on wildfire, and for paving the pathway for fire novices like us.

Finally, thank you to our friends, family, and academic community for propping us up and listening to our rants about fire and fuels for months on end.

This thesis is the result of a collaborative effort between Jude Brown and Max Fuangaromya by the authority of the graduate school. All work was done under the direction of Bob Freitag and Ken Yocom. Research and outreach was shared, Jude produced supporting graphics, and Max produced all maps. The writing was allocated evenly, with Jude managing sections 1 and 2, and Max managing sections 3 and 4.

TABLE OF CONTENTS

LIST OF FIGURES



I. FRAMEWORK

APPROACH

Wildfire is an integral part of the fire adapted ecologies across the Pacific Northwest, yet it has become increasingly destructive in recent decades. According to the U.S. Department of the Interior, wildfires have exhibited more extreme and unpredictable behaviors since the turn of the 21st century (US Dept of the Interior, 2021). In Washington State, the three most widespread and destructive wildfires on record have happened since 2014 (WA Dept of Natural Resources, 2021). This spike in extreme wildfire occurrence can be attributed to climate change, the accumulation of excess fuels, and the increase of human development at the WUI (FEMA, 2022). We were drawn to research wildfire mitigation because it has reached crisis level; smoke-filled summer skies and stories of decimated rural communities are commonplace during the fire season in the Pacific Northwest. As future planners and avid outdoor enthusiasts, we seized the opportunity to dive deeper into the complexities of wildfire mitigation in our state, and particularly at the WUI, where fire threats are elevated.

We began our exploration with a broad question: What are the ecologically resilient approaches to wildfire mitigation at the WUI? While there is a great deal of discussion around the topic of resilience in hazard mitigation planning, in this context, we define resilience as the ability for an ecosystem to recover after an impact event. For this research project, the ecosystem is the dry, mountainous landscape of the Methow Valley and the impact event is wildfire. Only 3.5 residents per square mile live within the 1,710

square mile region of the Methow Valley (U.S. Census, 2021). It is a sparsely populated, wilderness rich area of Okanogan County that receives approximately one million visitors annually. We chose the Methow Valley as a case study because of its rural characteristics and the extreme fire threat that it experiences every year; all three of the most devastating wildfires in Washington State history took place in Okanogan County.

Initially, we considered riparian buffers as possible mitigation tools. Several recent studies have found that healthy, robust riparian buffers can serve as fire breaks (Pettit & Naiman, 2007). We mapped riparian zones in the Methow Valley and compared them to fire impacts in the last fifty years. While there was spatial correlation between fire edges and riparian zones, there is limited data on the functionality of the riparian zones throughout the Methow, as much of it is federally managed wildlands on rugged and remote terrain. Furthermore, after reviewing various wildfire mitigation plans, it became apparent that fuels reduction is the leading strategy for agencies and governments that are currently managing the wildfire crisis. Fuels reduction, or the removal of excess woody debris, vegetation, and trees below 8 inches in diameter in forested landscapes, ensures that wildfires burn at lower temperatures and stay below the tree canopy. High temperature fires that reach into and engulf the tree canopy spread faster, are harder to manage, and exhibit behavior that is more difficult to predict for evacuation and public safety purposes (FEMA, 2022).

Through stakeholder interviews, we noticed a pattern of critical barriers to fuels reduction across our study area, both perceived and actual, and a plethora of correlated opportunities. It was then that we narrowed our focus to explore fuels reduction as a holistic wildfire mitigation strategy and highlight the barriers and opportunities associated with it.

METHODOLOGY

Our methodology for this research endeavor was distinctly nonlinear. We began by identifying key stakeholders; fire ecologists working in the Pacific Northwest, wildfire mitigation specialists at Washington Department of Natural Resources and Okanogan Conservation District, and key foresters in the U.S. Forest Service were contacted early on for guidance. Through qualitative interviews with these stakeholders, we were directed to pertinent wildfire mitigation and resilience plans that applied to the Methow Valley. With this information, we began an extensive plan review, focusing on wildfire mitigation strategies at the national, state, and county levels. We supplemented the plan review with a literature review, analyzing wildfire and fuels reduction research that has already been conducted. As we revealed facets of fuels reduction programming within the various mitigation plans and literature, we referred back to the stakeholders we had interviewed previously for further information and guidance.

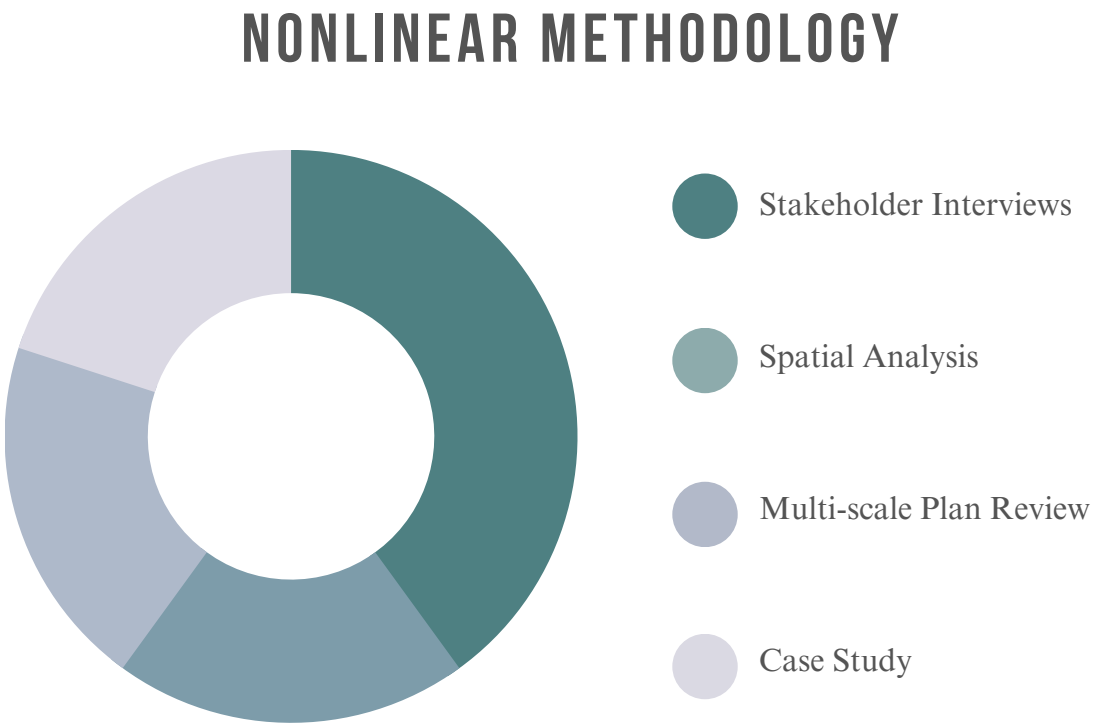


Figure 1: Methodological Framework

In tandem with qualitative stakeholder engagement and plan review, we began quantitative spatial analysis by mapping a variety of data sets, including wildfire impacts, fuels behavior, treatment areas, geomorphology, land use, and property ownership. Spatial analysis allowed us to visually examine where fuels reduction treatment had occurred throughout the Methow Valley, and how the treated parcels fared during various wildfire events. We were also able to identify how different types of fuels engage with wildfire. These maps are included as supplemental data visualizations throughout this document.

Our contacts at Washington Department of Natural Resources and Okanogan Conservation District graciously invited us to attend two community outreach meetings in the Methow Valley that revolved around wildfire mitigation. The meetings took place at the end of February and were attended by approximately 75 Methow Valley residents, ranging in age and occupation. It was there that we were able to observe and collect data from a critical stakeholder, the community itself. Community members were knowledgeable and engaged as they passed the microphone around to share their concerns and suggestions. Many of the barriers that we had already identified were confirmed during the meetings, and opportunities began to take shape. Our decision to create a public facing resource as part of this research project was driven, primarily, by the feedback that we received directly from the Methow Valley community.

II. BACKGROUND OF THE METHOW VALLEY

SPATIAL CONTEXT

The Methow Valley spans roughly 1,650 square miles in north-central Washington State, from the Cascade Crest east to the Okanogan Range, and down a lateral 12 mile line running south from the Canadian border. It lies between the Methow River and Lake Chelan at its southern boundary, and includes drainage systems of the Methow, Twisp, and Chewack Rivers. Except for the section of the Methow River between Carlton on the south and Mazama in the north, the terrain is primarily composed of steep ridges and canyons. The valley bottom is more than a mile broad throughout this 32-mile stretch. Suitable for irrigation, the numerous glaciofluvial terraces attracted homesteaders to the valley in the late 19th century.

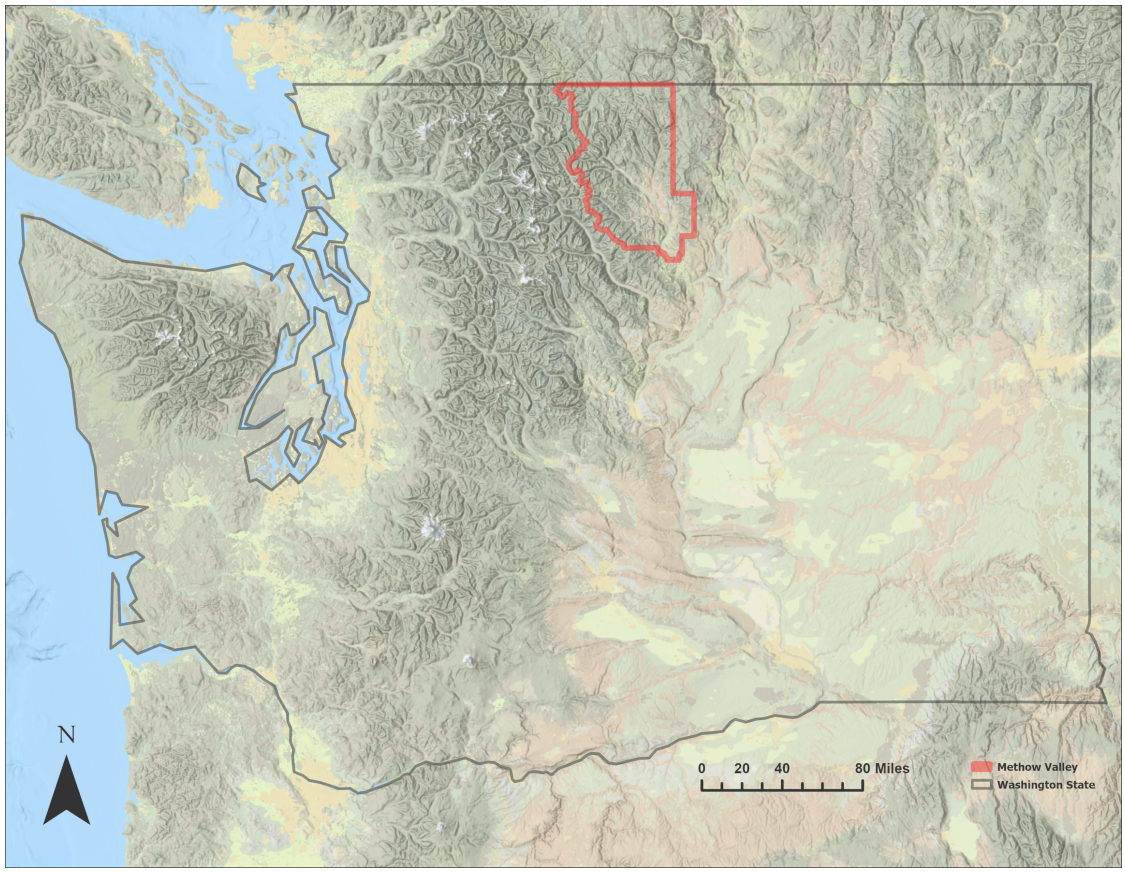


Figure 2: Context Map of the Methow Valley

There is a 4,200 foot difference in elevation between the wide valley and the mountainous terrain in the area. Ridges climb above 7,000 feet in elevation, and several jagged peaks that are not near the main drainages have summits that are nearly 9,000 feet above sea level. The highest point in the Methow Valley, Gardner Mountain, rises over the Twisp River at 8,956 feet. U shaped canyons, the majority of which were significantly eroded by glaciers, are the largest canyons. The Methow Valley above Mazama is particularly impressive due to the high cliff walls that rise 2,000 feet or more above the vast, flat floor of the canyon, where the undersized Methow River has carved out a well-defined meander pattern in the glaciofluvial fill.

Similar traits are present in the valleys of the Twisp River and Eightmile Creek, albeit on a smaller scale. The area above the junction of the Twisp River and Eightmile Creek is highly forested, with a mix of ponderosa pine (Pinus ponderosa), grand fir (Abies grandis), interior Douglas fir (Pseudotsuga menzies), and sporadic red cedar (Thuja plicata). Above 3,200 feet in elevation, ponderosa pine and cedar are rarely encountered. True alpine fir (Abies lasiocarpo), which predominates above 4,000 feet, overlaps with grand and douglas firs. Between Mazama and Twisp, the lower slopes of the Methow Valley are mostly unforested or covered by a sparse mosaic of ponderosa pine and steppe plants, primarily bitterbrush (Purshia tridentata) and beardless bluebunch wheatgrass (Agropyron inermi, a variety of A. spicatum). In the richer soil areas south of Twisp, giant sagebrush (Artemisia tridentata) coexists with bitterbrush; however, on the slopes east of the Methow River, bunchgrass predominates amongst the rugged rock outcrops.

With an average annual precipitation of 15 inches in the Twisp-Winthrop area (primarily in the form of snow), the climate of the valley below Winthrop can be categorized as semiarid. At

6,109 feet above sea level on the Cascade crest, Harts Pass has an average annual precipitation of 60 inches during the past 27 years. Most years, the heavy snow drifts make it impossible to traverse along the crest pathways from late October until late May. In some years, patches of snow on the north slopes fail to completely melt until late July. Numerous springs and some streams continue to flow year round as a result of this delayed melting at the higher elevations.

The Methow Valley Highway, State Highway 153, intersects with U.S. Highway 97 at the Columbia River, just west of the town of Pateros. In the town of Twisp, Highway 153 intersects with Highway 20, which winds through the Methow and its tributary Early Winters Creek, up the Cascade crest at Washington Pass, and down westward-flowing Granite Creek and the Skagit River to the Puget Lowland; this east-west road connects Okanogan with the major Puget Sound artery, Interstate 5, though it is subject to seasonal snow closures. In addition to the numerous main haulage roads built that serve the Methow Valley, the Forest Service maintains a variety of critical access subsidiary roads in all the major drainages.

POPULATION & DEMOGRAPHICS

The Methow Valley is sparsely populated and distinctly rural. We used the school district demarcation as our spatial boundary to collect and analyze data. Based on the 2021 American Community Survey, approximately 5,900 people reside amongst the roughly 1,650 square miles of the region (Census Reporter, 2021). This population resides within approximately 2,600 households, primarily clustered around the small towns of Pateras, Methow, Carlton, Twisp, Winthrop, and Mazama that run north up the valley. The northernmost section of the boundary that we have used for this study is largely wilderness. Notably, of the roughly 4,100 housing units, only 64% were permanently occupied at the time of the 2021 survey; this highlights that many housing units in the Methow Valley are rental properties or vacation homes.

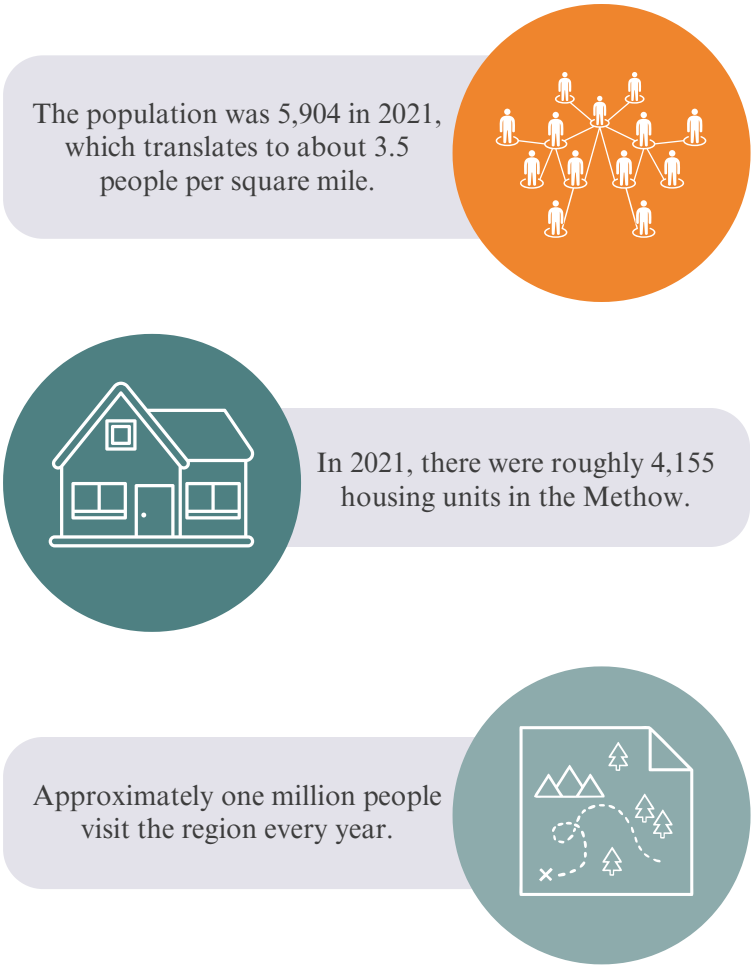


Figure 3: Methow Valley Population & Housing Infographic

The median age in the study region is 53.4, which is considerably higher than the Okanogan County median age of 42.9 and the Washington state median age of 37.9. For further comparison, 27% of Methow Valley residents are aged 65 and older, whereas 15% of the state population falls into this category. Mobility, access to resources, and increased vulnerability to wildfire hazards are all major concerns when considering an elderly population of this scale and relative isolation.

The Methow Valley is considerably less diverse compared to other counties in the state. Race and ethnicity data collected in the 2021 Community Survey reports that 87% of residents are white, 8% hispanic, 3% mixed race, 1% Asian and 1% Native. While the median income of the region is considerably higher than the greater Okanogan County, $37,972 compared to the county median of $26,365, it is lower than the state median income of $43,817. Poverty rates reported also highlight the disparity between the Methow Valley and the rest of the county; 8% of Methow residents live below the poverty line, while over 20% of Okanogan county residents experience poverty. As this paper will highlight, access to financial resources is often a major barrier to fuels reduction on private property.

LAND OWNERSHIP

It is critical to highlight the unusual land ownership distribution in our case study region, as it has presented unique challenges in the context of forest management and fuels reduction. The majority of the Methow Valley is owned by the federal government and managed by the U.S. Forest Service; approximately 85% of the total region falls into this category. The remaining portion is broken down into 10% privately owned land and 5% state owned land, which is managed by

Washington Department of Natural Resources and Department of Fish and Wildlife. As illustrated in the map below, privately owned land is amalgamated along the low lying areas of the valley floor, while the higher elevation terrain is primarily comprised of National Forest lands. The unique challenges that this ownership distribution presents will be expanded upon in the Barriers section of this paper.

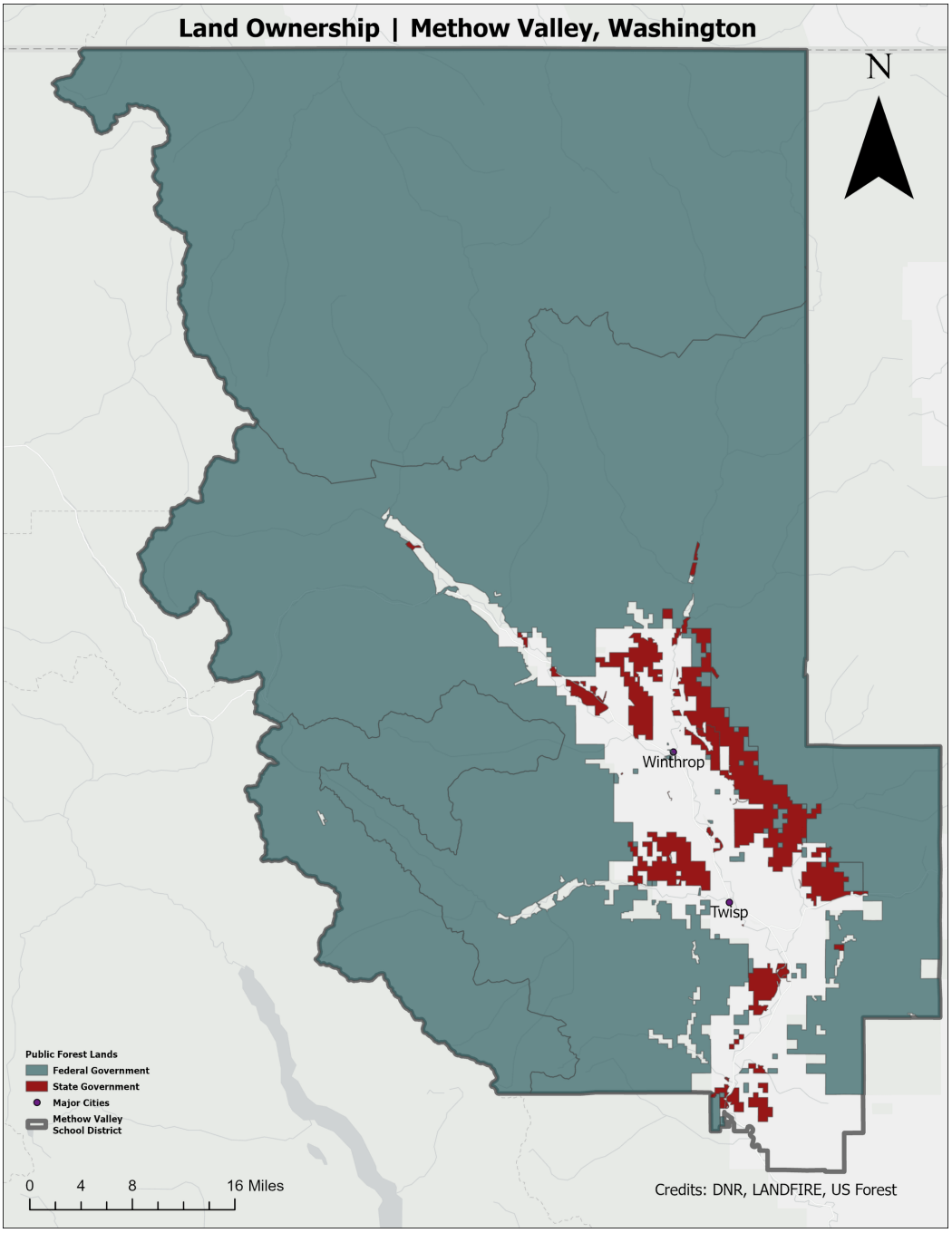


Figure 4: Map of Land Ownership in the Methow Valley

CULTURAL HISTORY

The indigenous people of the Methow Valley, its namesake, stewarded the land for over 13,000 years. The Methow People lived with the land, thriving on the abundance of native edible plants, game, and fish from the various waterways. Fire was an integral part of life for the Methow People, according to Susan Pritchard, fire ecologist and Methow Valley resident (Holtz & Taguchi, 2020). The Methow Valley regularly experienced naturally occurring fires, primarily from lightning, but indigenous peoples also used fire for food cultivation, hunting, and to keep the area clear of biomass buildup. In Robert Boyd's article, Indians, Fire, and The Land in the Pacific Northwest, the Methow People used prescribed burns in the valley every fall to maintain an open park-like setting for their community (Boyd, 1999). Through a series of unethical treaties established in the late 1800s, the Methow People were forcibly removed from their homeland and delineated to the Colville Reservation, which remains today in he southeast region of Okanogan County (Arksey, 2008). They have persevered, however, and are now part of the Confederated Tribes of the Colville Reservation; they continue to advocate for restoration of hunting and fishing rights on their ancestral lands in the Methow Valley.

Following forced removal of indigenous people, the region was opened for colonial settlement. Fur trappers and miners began to settle in the Methow Valley in the mid-1880s near the modern town of Winthrop. Due to its remote nature and the substantial travel barriers formed by the mountainous terrain enveloping the valley, European families were slow to arrive. However, by 1909, a road had been established along the Methow River. After the formation of the Washington State Highway Department, this road became the first highway built by the state (Arksey, 2008). In the early 1900s, extensive

irrigation canals were built to support budding agricultural uses in the often arid valley (Kershner, 2015). Irrigation networks are now a critical piece of infrastructure in the Methow Valley, as over half of the privately owned parcels are currently used for agriculture (Methow Conservancy, 2023).

CHANGING LAND USE

In the last two decades, population in the Methow Valley has increased by 31% (Methow Conservancy, 2023). The WUI is rapidly growing across the country and homes built at the WUI have increased by nearly 41% in the last thirty years (FEMA, 2021). Changes in land use patterns in the Methow Valley further illustrate this trend in rural development expansion; since 2005, agricultural land in the valley has decreased by 13%, undeveloped land has decreased by 12%, and development on private residential land has increased by 33%. As of 2020, 26% of the valley is undeveloped, 25% is residential, 47% is agricultural, and the remainder is categorized as "other" (Methow Conservancy, 2023). An average of 66 building permits are granted in the Methow Valley every year, which is substantial in comparison to the total housing unit count of 4,155 in 2021 (Census Reporter, 2021). As development continues to encroach into the WUI, more people and property are at serious risk of wildfire impacts.

III. PROFILE OF FIRE HAZARD

HISTORICAL FIRE IMPACTS

Wildfires have increased their spread and mitigation costs across the West. While wildfires have decreased since 1990, their magnitude has impacted more acres as a result. The intensity of recent fire seasons has been significantly impacted by the trend of warmer and drier summers over the past few decades, especially in locations where decades of fire suppression have led to an abundance of fuel loads and tree stock density. However, other contributions lead to the inverse association between total fires and total acres burned.

Post-fire debris movements also known as the "fire-flood cycle", can pose a high risk of death, resulting in numerous fatalities. Burned forest soils frequently repel water, resulting in fire-induced reductions in infiltration that increase the likelihood of inundation and detritus flows caused by runoff (Rengers, K., et al., 2020).

Because more people are aware of the effects of wildfire and are consequently more cautious when working or playing in high-risk regions, fire awareness programs have decreased the number of fire starts per season. The rise in annual acreage burned can be partly ascribed to modifications in wildland firefighting strategies and a focus on safety, in addition to recent climatic trends. In some circumstances, fire management teams have chosen holistic fire management allowing wildfires to burn their course allowing wildfire technicians a great degree of control.

Future fire seasons are anticipated to increase in their behavior and magnitude. In particular, conditions grow more erratic

during the hottest and driest parts of the year and fire seasons extend earlier and later into the year. More people, buildings, and infrastructure will be exposed to wildfire dangers as the population grows and the WUI spreads, which raises the importance of fire planning and fire mitigation operations. The Okanogan County fire suppression organizations respond to

wildland fires every year, but only a small number of those flames escalate. Only 1-2% of all wildland fires, according to national statistics, escape the initial onslaught. However, that 1-2% is responsible for the majority of fire suppression costs and poses a risk to people's lives, property, and natural resources (DOI, 2015). These large fire inventories are distinguished by their magnitude and complexity, which necessitate specific management groups that assemble resources for suppression from across the country. These flames pose particular difficulties to the surrounding populations because of their rapid growth and size.

FIRE IN THE VALLEY

Like most citizens, residents of the Methow Valley experience four seasons; spring, summer, fall and winter, however over the past decade residents have become witness to a fifth season in smoke season. When grasses and shrubs become tinder-dry, they become prime fuel for the next wildfire which now threatens the valley beginning in July and ending in September when rains return to the state. This time frame has fluctuated, with seasons beginning in May and ending in as late as early November. Last fall, The Bolt Creek Fire erupted in September lasting until late October. The fire had a burn area of 14,978 acres along state route highway 2 and the town of Skykomish, blanketing Seattle the state's queen city with smoke, ranking the city's air quality index above all international cities during a two day period.

In 2018, the Methow Valley saw harmful to dangerous air quality over a 40 day period. Last year, wildfire season was below normal, a reprieve for firefighters and smoke-exhausted residents, especially those living in cities. The year prior in 2021, the valley experienced 38 straight days of harmful smoke resulting from the total fire inventory of the Cedar Creek, Cub Creek 2 and Delancy fires which scorched about 125,700 acres.

In 2014, the Methow Valley experienced a flashpoint when the four consecutive lightning strikes ignited the Carlton Complex, which eventually spread to cover 256,108 acres becoming the largest fire in Washington state history. Although one homeowner died of a heart attack while defending his property, the fire did not directly result in any fatalities or significant injuries. On July 14th, 2014, lightning ignited fire in four locations near the communities of Winthrop, Twisp and Carlton in Okanogan County. On July 17th, high winds caused the fires to merge into a firestorm speeding 25 miles South. Firefighters had largely halted the advance by July 22nd, suppressing 71 percent of the fire inventory by the end of July. On August 21, intense rainstorms triggered disastrous mudslides over the barren, desolate region, and by August 24th authorities proclaimed the containment of the Carlton Complex.

Using a temporal scale, we cataloged wildfire inventory in the Methow Valley over a 50 year time period. Our analysis provides correlation between decades as the general consensus of fire has shifted. [Figures 1-6] provide visual representation of wildfire inventory, during years of suppression, followed by intense fires over the past 20 years. While holistic approaches to fire mitigation have largely been understood as the preeminent strategy, current forest density and fuel surplus have shown to determine the severity of fire inventory.

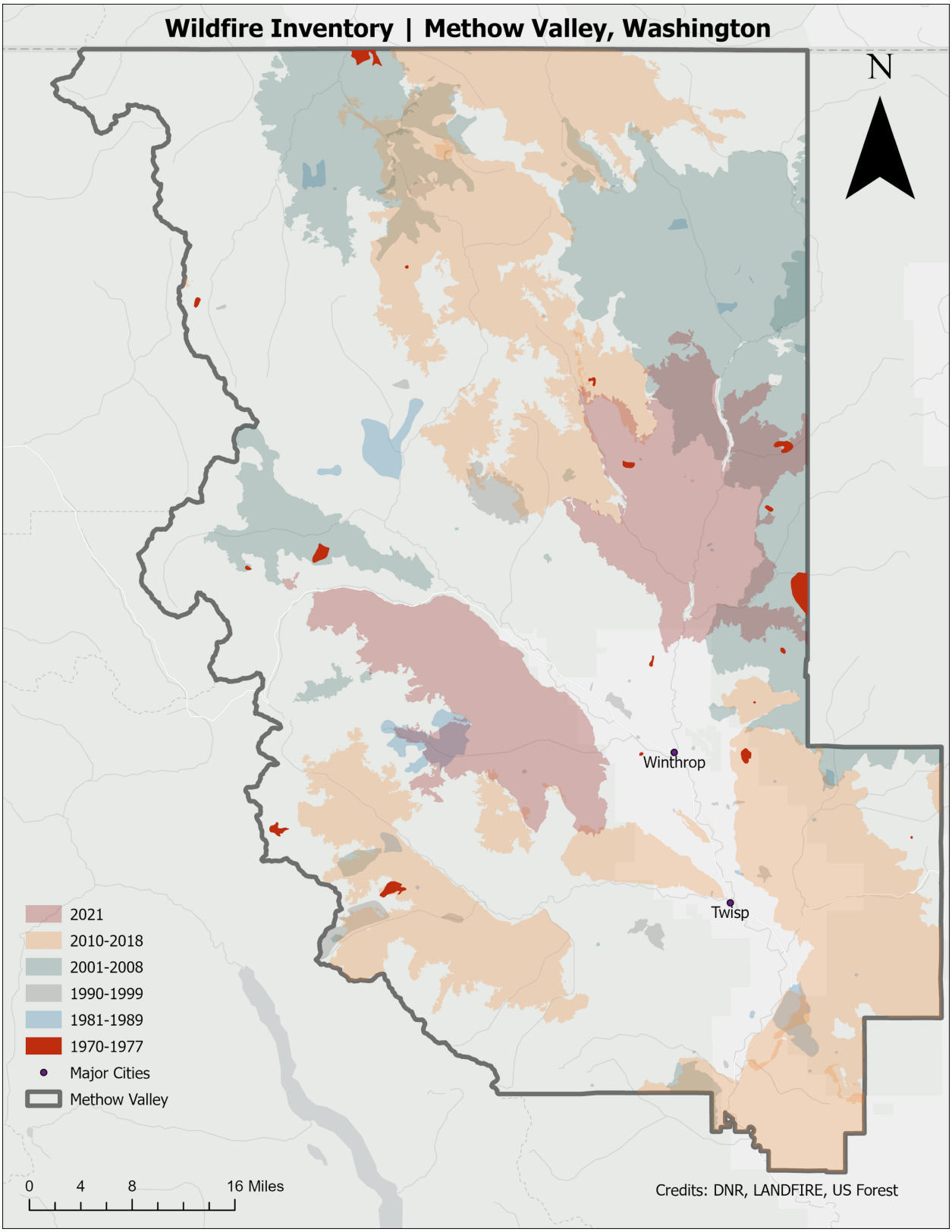


Figure 5: Map of Wildfire Inventory during the 1970s; wildfires are relatively small-scale.

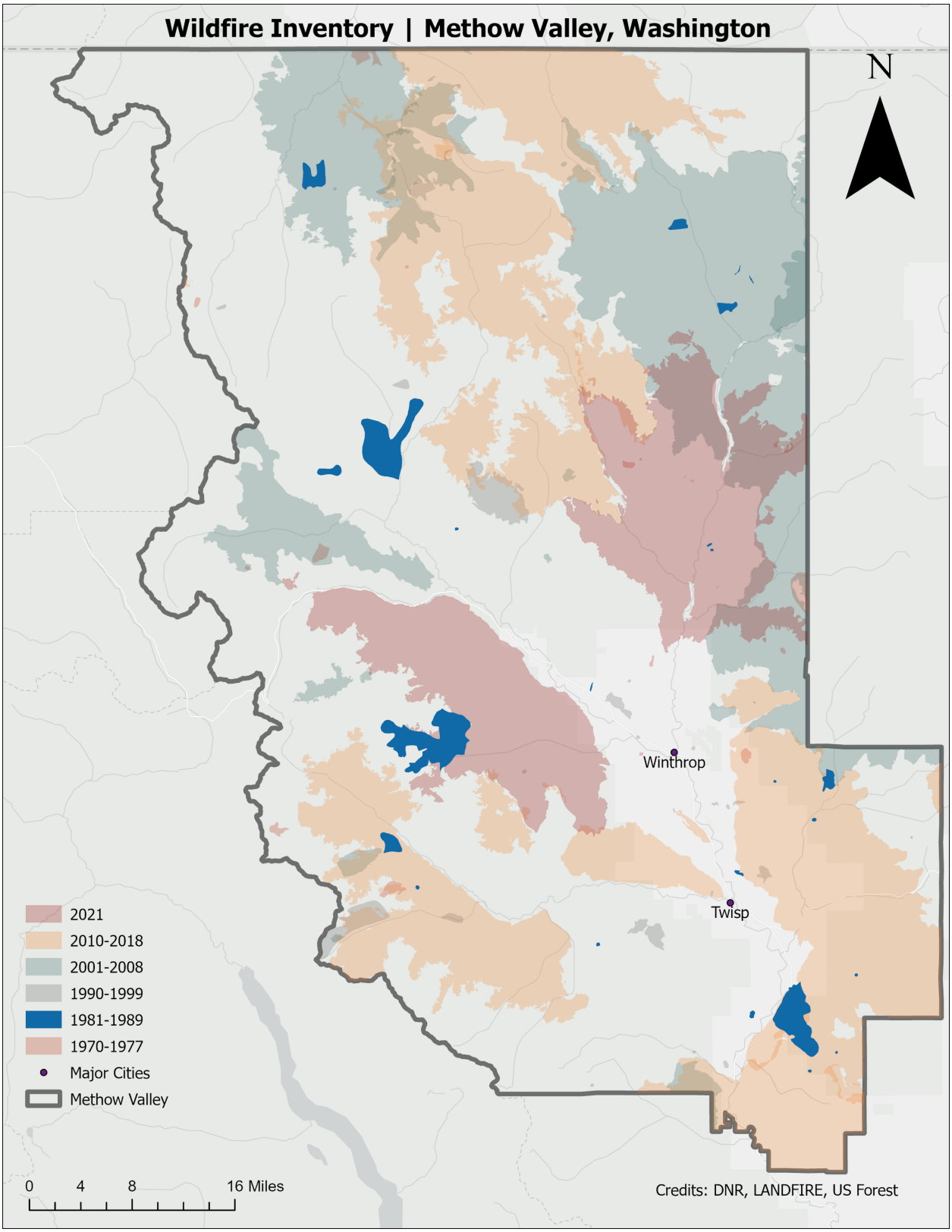


Figure 6: Map of Wildfire Inventory during the 1980s; there are slightly larger scale impacts.

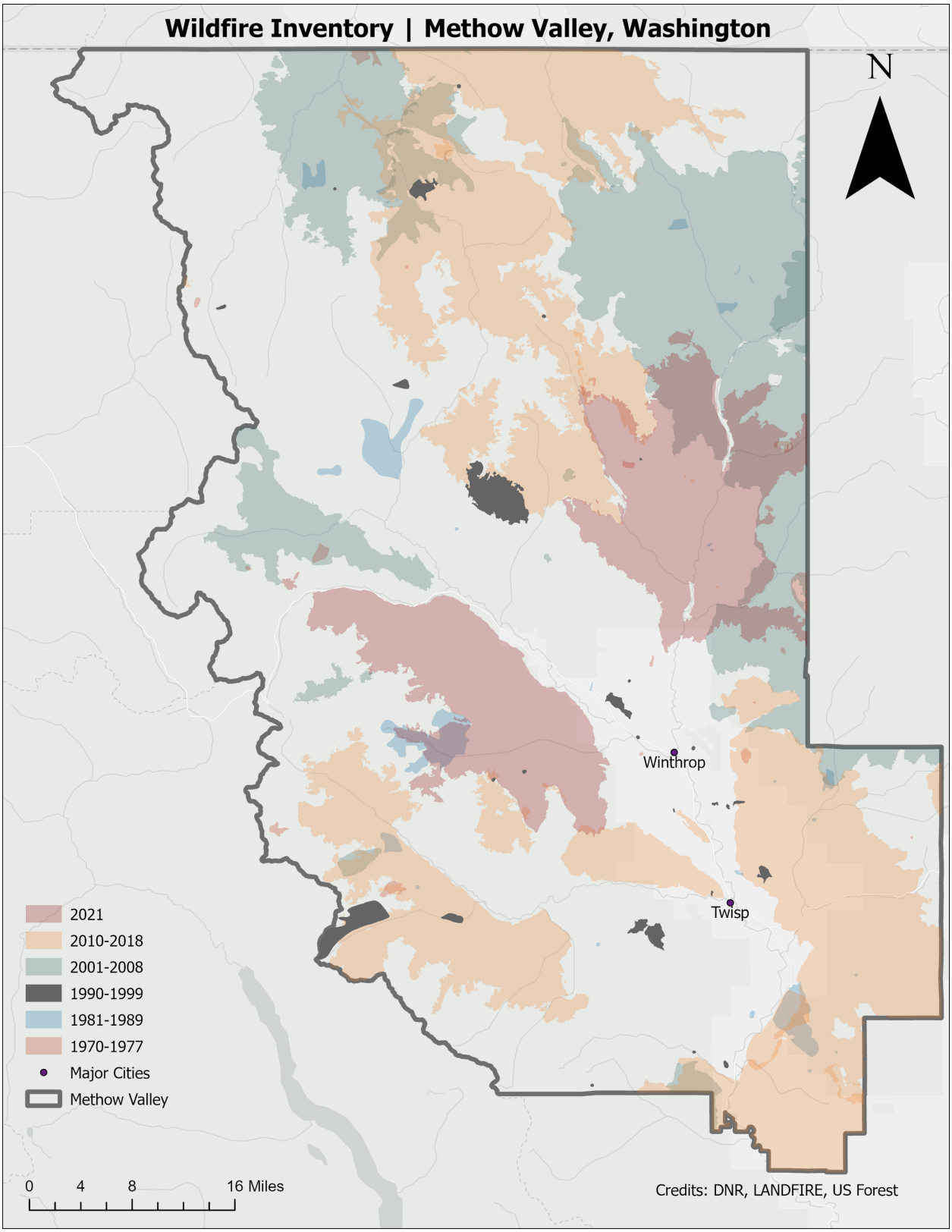


Figure 7: Map of Wildfire Inventory during the 1990s; impacts are similar to previous decades.

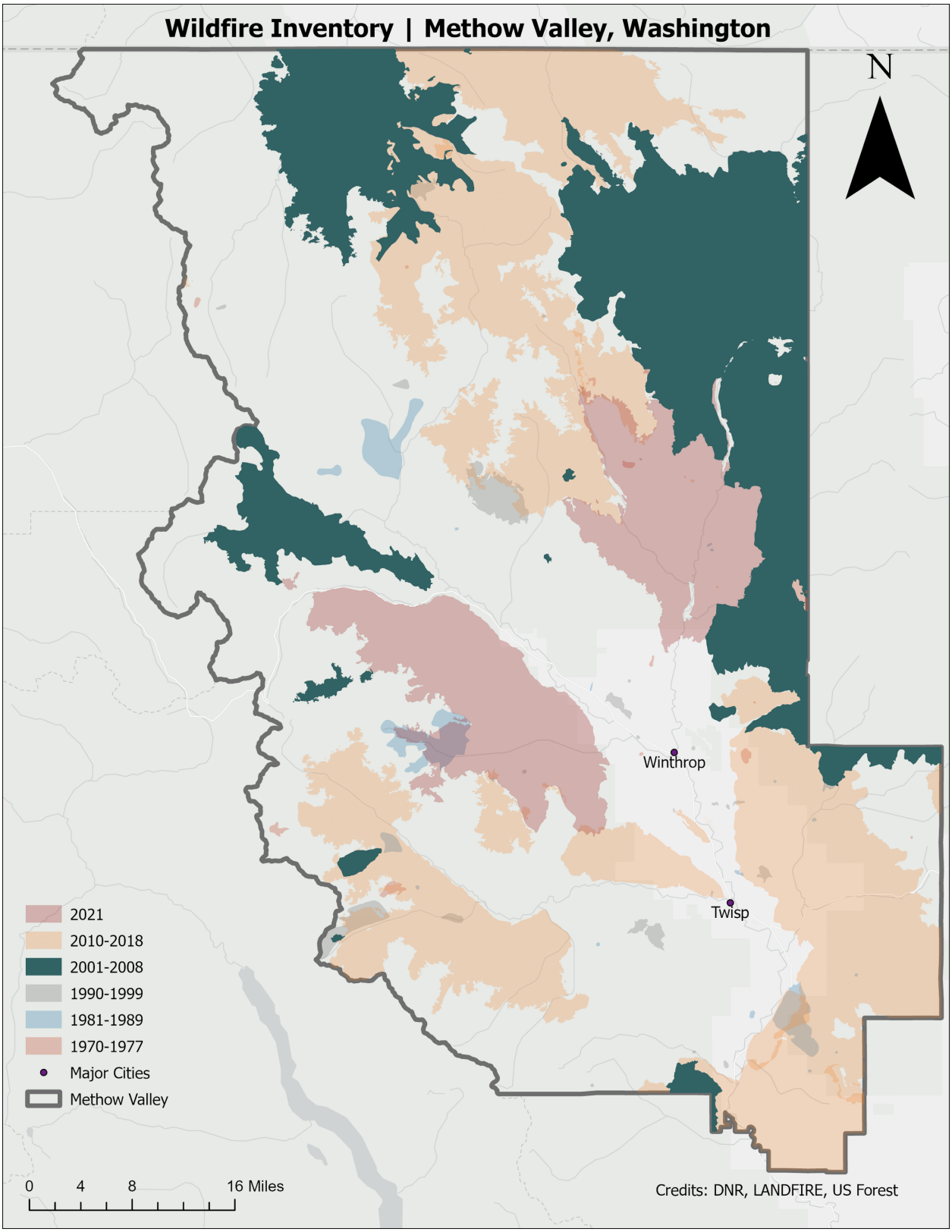


Figure 8: Map of Wildfire Inventory during the 2000s, showing substantially larger impacts.

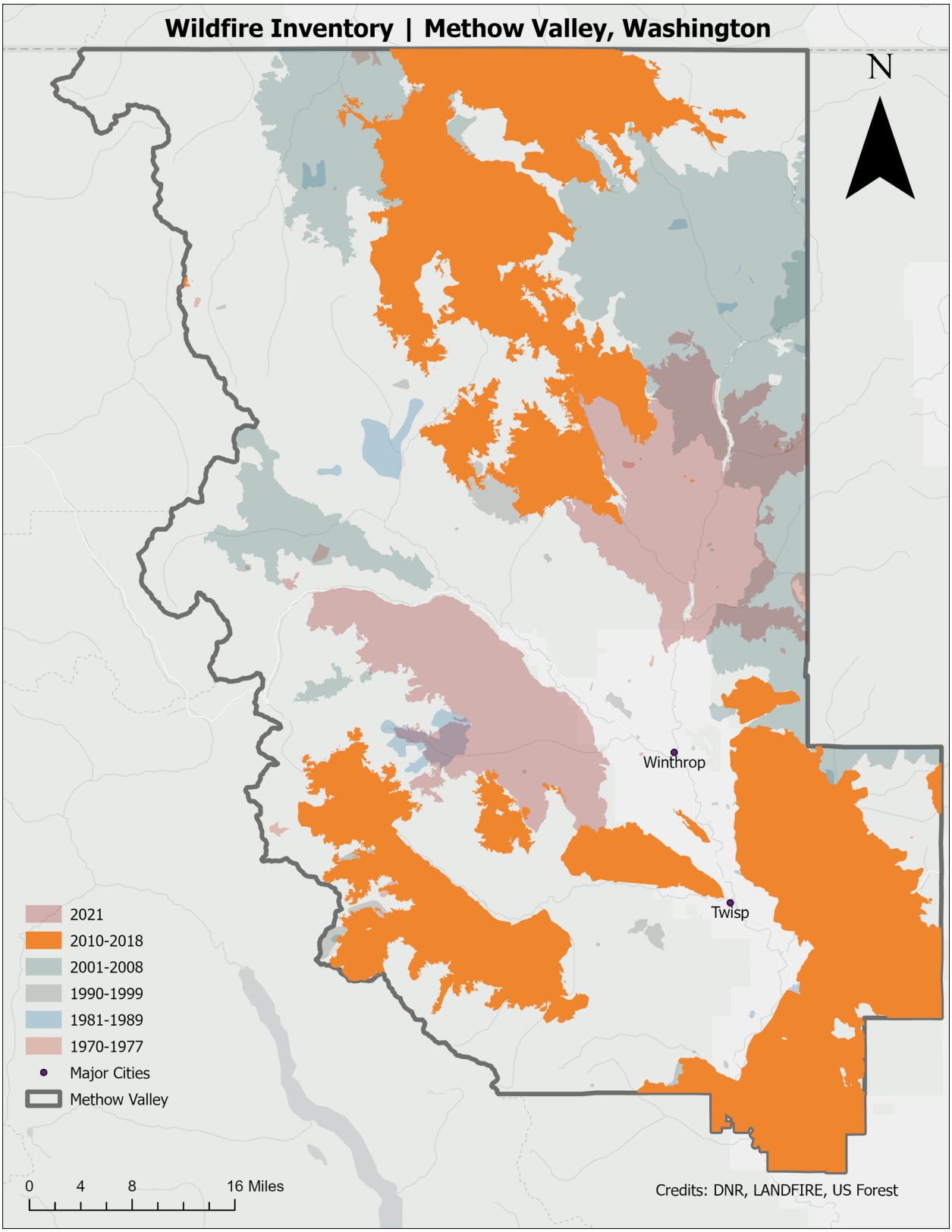


Figure 9: Map of Wildfire Inventory during the 2010s, the most extreme fire decade on record.

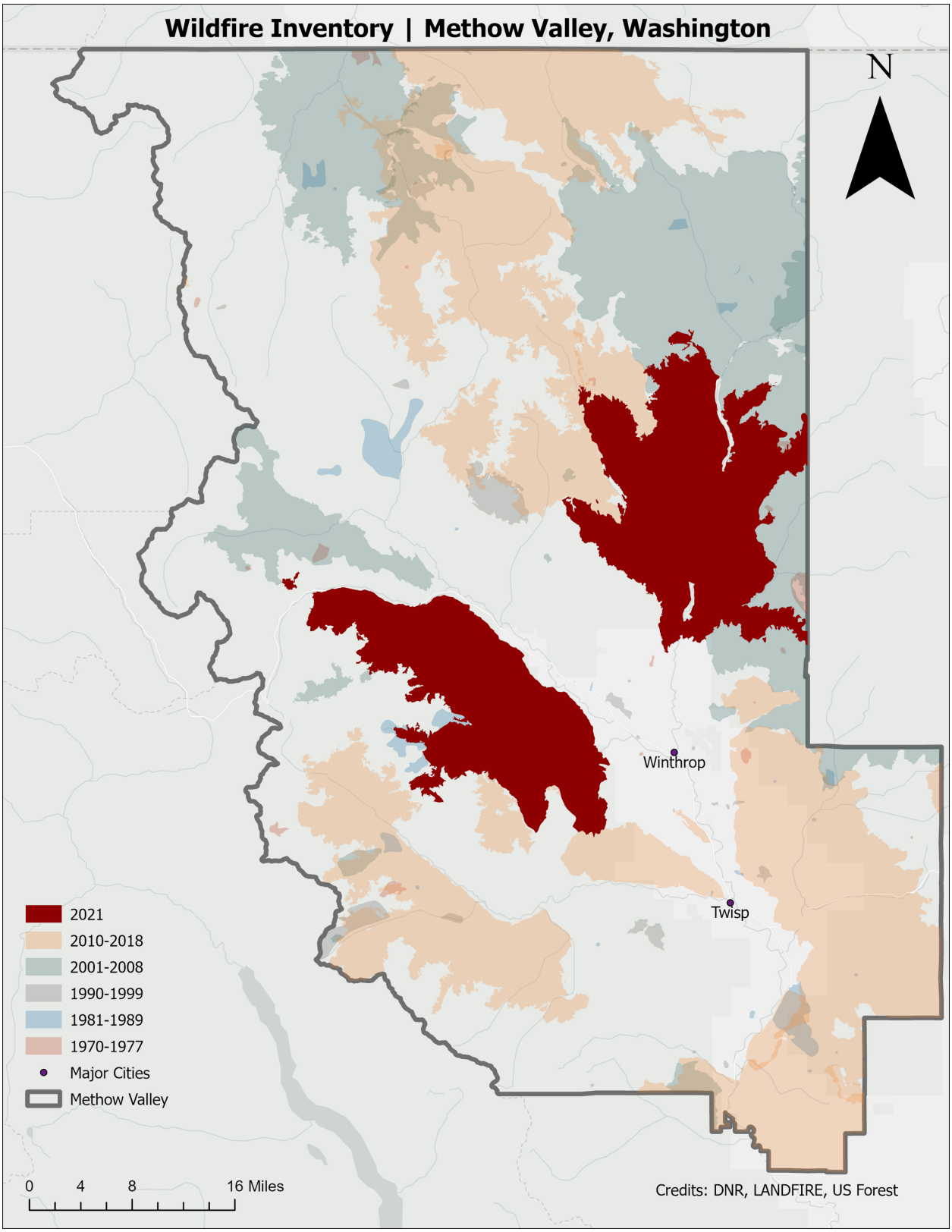


Figure 10: Map of Wildfire Inventory during 2021, starting the decade with large-scale fires.

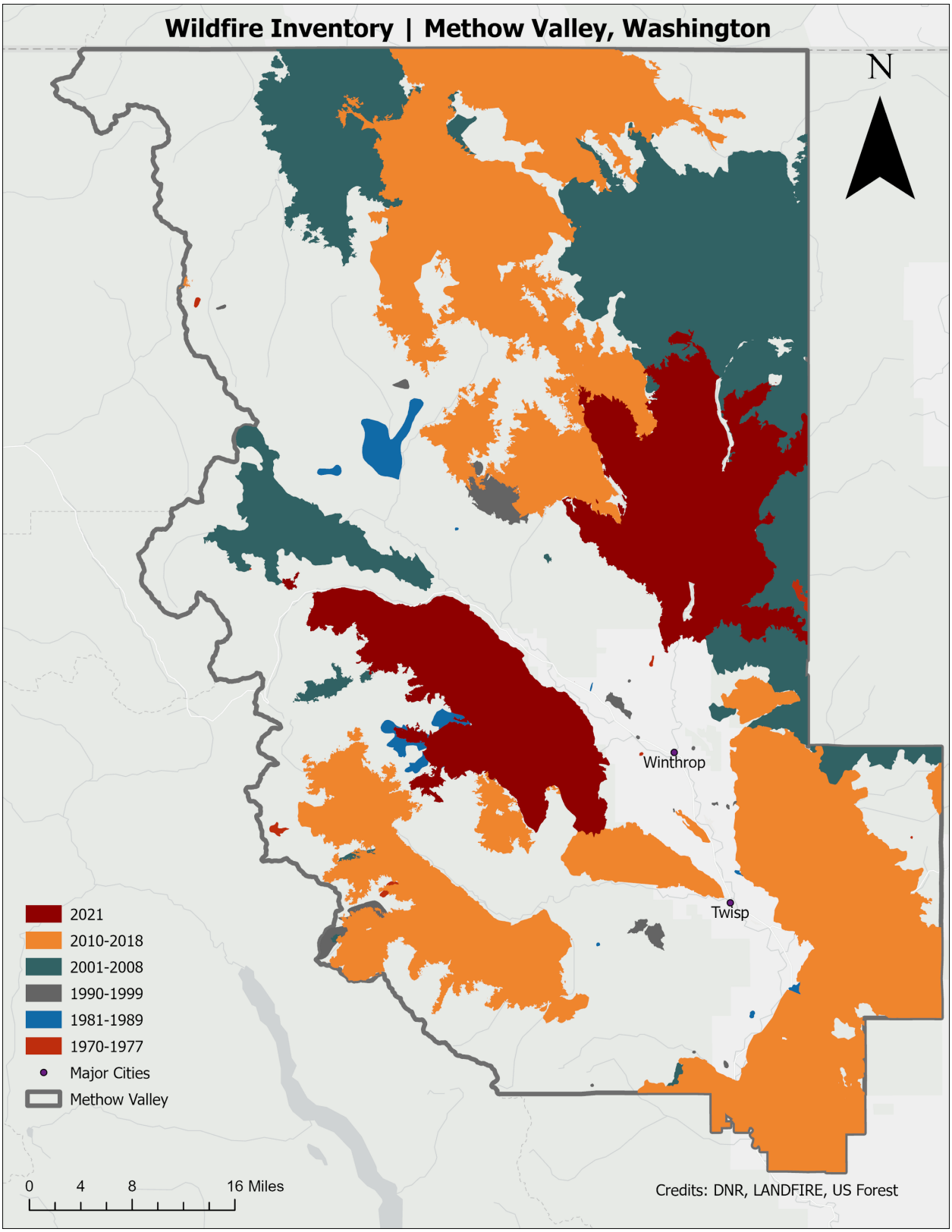


Figure 11: Map of the total Wildfire Inventory between 1970 and 2021.

FIRE MITIGATION STRATEGIES

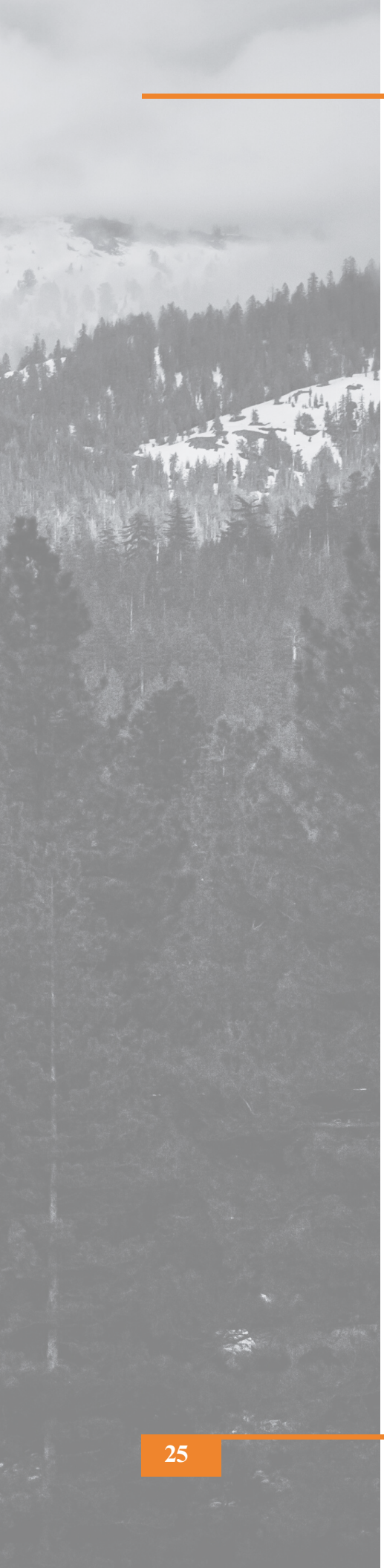
In 2003, President George W. Bush made forest land management a priority by signing the Healthy Forest Restoration Act (HFRA) into law. HFRA's goals included lowering the risk of devastating wildfires, generating employment in rural areas and enhancing air quality. The act was intended to provide land managers with a framework for navigating layers of legal bureaucracy, placing an end to agency turf wars, and streamlining the permitting and public engagement process. Unfortunately, preservationists criticized the plan, dismissing it as yet another pretext to log on public property. Instead of paving the way for improved forest management, HFRA became weighed down by agency inaction, appeals, and litigation. Lack of funding for ground debris removal, forest thinning, prescribed burns, and the logging of mature, diseased, and dead trees also factored into the large inventory of wildfire fuels. While sales of timber decreased, the price of putting out forest fires increased. In context, U.S. Forest Service allocated 16% of its 1995 budget on battling fires, by 2018, firefighting accounted for well over half of agency spending and actual costs were much higher.

During pre-colonial settlement during the 19th century, wildfire was the primary disturbance that shaped Washington State's forest structure. In the past, fires were an integral component of many eastern Washington forests, though not nearly as prevalent as they are now. In pre-colonial forests, fire-return intervals were brief, in the area of 12-15 fires per century. The low fire frequency is characterized by low fuel loads, typically consisting of branch timber, needle debris, grasses and small shrubs. Under these conditions, fires would frequently move across the forest floor and burn the relatively small quantity of available fuel. Thick-barked trees, such as ponderosa pine or western larch, are typically unaffected by

low-intensity fire since the flames cannot penetrate their bark. During this time, lightning and Native Americans were the primary causes of forest fires in the Pacific Northwest. Lightning ensured that periodic, low-intensity fires spread through forests and prairies. Indigenous Americans used fire for hunting, clearing land for harvest, and even strategic warfare.

As forestry and milling became the backbone of the economy in the Pacific Northwest, the impact of fire on business was evaluated, as time was a valuable commodity. The Washington Forest Fire Association (WFFA) was founded in 1908 by timber companies to suppress fires on private lands. The WFFA and Washington State collaborated on fire prevention, suppression, and fire patrols. Legal authority greenlit rangers ability to apprehend offenders of fire prevention laws. In 1910 the Big Burn, burned over 3 million acres of trees and killed an estimated 86 people in Idaho and Montana. In Gary Ferguson's book, *Land on Fire*, the author intensely describes the forces of the burn, "the upward draft of the smoke was so fierce that flaming pine trees were literally plucked from the ground by the roots and sent spinning across the landscape. A forester named Edward Stahl called the fire 'a veritable red demon from hell.'" (Ferguson, 2027., pg. 43) Congress appropriated funds to the U.S. Forest Service for fire suppression in national forests. This initiated a 80 year fire suppression national policy.

Following the release of Walt Disney's 1942 film Bambi depicting the fawn and his companions narrowly escaping a forest fire initiated by hunters, the country's opposition to forest fires would intensify. In 1944, the forest service enlisted the help of Smokey Bear, campaigning fire suppression and prevention through the end of the century. By 1963, the Department of the Interior, accountable for National Parks,



acknowledged the importance of fires to park ecosystems. In 1968 the park service began selective manual burns, and allowed natural fire to occur in certain areas. In the 1970s, Northwest parks progressively adopted the practice of prescribed burning.

Private and public forestlands were administered to produce timber through a series of growth cycles. These forests were subjugated to routine thinning, in which underbrush is removed to reduce fire risk and promote tree growth. However, since fire did not recognize ownership boundaries, forests with high fuel burdens posed a threat to neighboring fire-resistant forests. After World War II, suburbanization attracted millions to settle in the WUI, which presented firefighters with new challenges. Both urban fire departments and forest fire personnel attempted to protect structures from wildfires. Between 1995 and 2000, federal land managers torched nearly 1.4 million acres of wildlands across the United States, compared to an estimated 70 million acres in dire need of fuel reduction. By the end of the century tree density in the national forests had become six to ten times greater compared to a century earlier. This enabled fires to grow hotter, quicker, and became more destructive in nature than in the past.

Today, Washington State confronts a forest health crisis, each summer's smoke serves as a reminder of the growing severity. There are 2.7 million acres of inadequately maintained, flammable forestland in Central and Eastern Washington. In 2022, legislators unanimously passed House Bill 1168, which committed $125 million per year to fire prevention and preparation. These funds are required not only to pay for firefighters and their equipment, but also to thin and treat failing forests. According to a report by the U.S. Forest Service (Parks, S. A., et al., 2018), with an average relative influence of 53.1%, live fuel was the most influential factor propelling high-severity fires across

ecoregions. Fire weather was the second most influential factor with an average relative influence of 22.9% across ecoregions. Climate (13.7%) and topography (10.3%) were found to be the least impactful. To combat fuel loading the Washington Department of Natural Resources partnered with the U.S. Forest Service on the Central Washington Initiative. This joint effort will seek to remove 124,000 acres of wildfire fuel loads as part of the federal government's 10-Year Wildfire Crisis Strategy (USFS, 2022, p. 4).

The diagram below illustrates the correlations between changes in forest density, climate change driven temperature increase, and historical fire impacts since 1895.

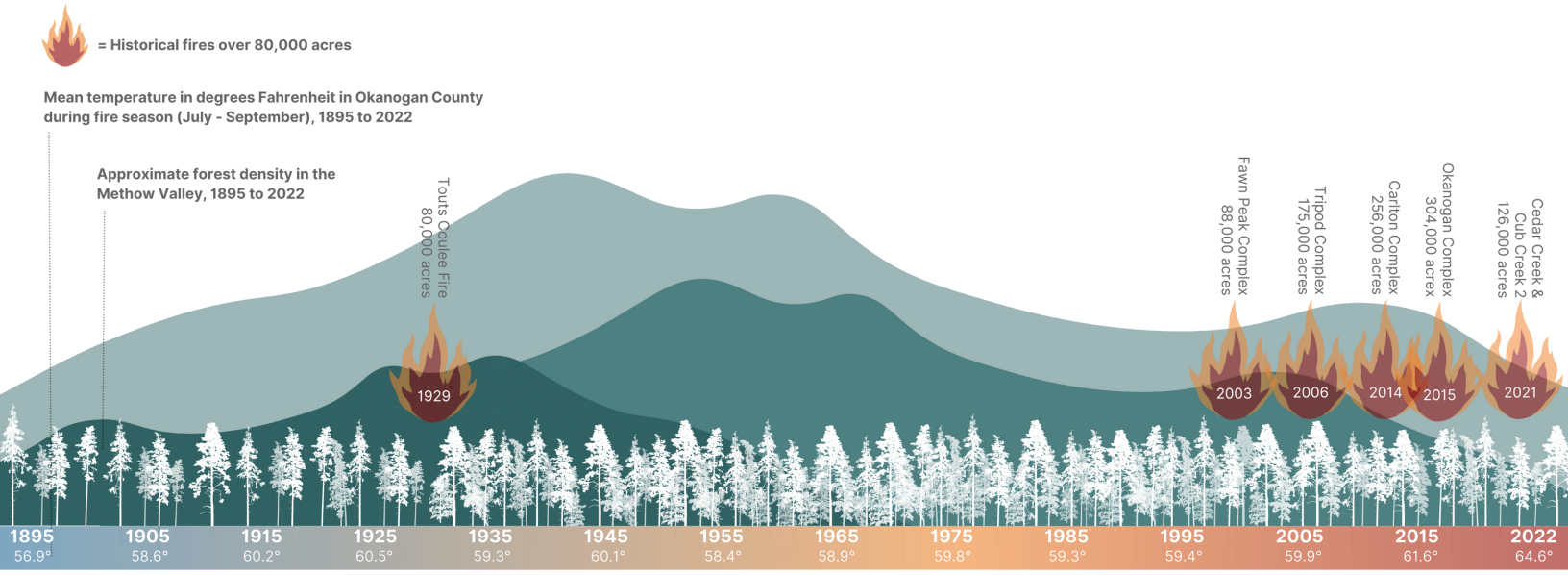


Figure 12: Visualization of Forest Density, Temperature Change, and Major Fire Impacts

PLAN EVALUATION

In the last two decades, agencies that manage forests and wildfire impacts have established a clear direction towards "forest health" restoration. According to the U.S. Forest Service's 2022 Wildfire Crisis Strategy, forest health is defined as "the resiliency of a forest and its ability to self-renew following drought, wildfire, beetle outbreaks, and other forest stresses and disturbances" (USFS, 2022, p. 3). This has been part of a greater paradigm shift away from wildfire suppression to fuels reduction and forest management strategies that allow low-temperature fires to run their course. Across all agencies, climate change, fuels accumulation, and increasing development at the WUI are highlighted as the key drivers to our current wildfire crisis.

In this section, we will evaluate four key wildfire mitigation plans that pertain to the Methow Valley at the county, state, and federal levels. The evaluation protocol is simple, as the primary facet that we are focusing on is fuels reduction. We pose the following questions: Does the plan address fuel reduction as a strategy? Does the plan consider fuel reduction on both public and private lands? Does the plan identify barriers to fuel reduction programming? Does the plan offer funding mechanisms for fuel reduction? Lastly, does the plan offer a clear timeline for carrying out fuel reduction? The table on the following page displays a brief summary of our findings; it is followed by more details and a deeper discussion of how fuels reduction is approached in each of the four mitigation plans.

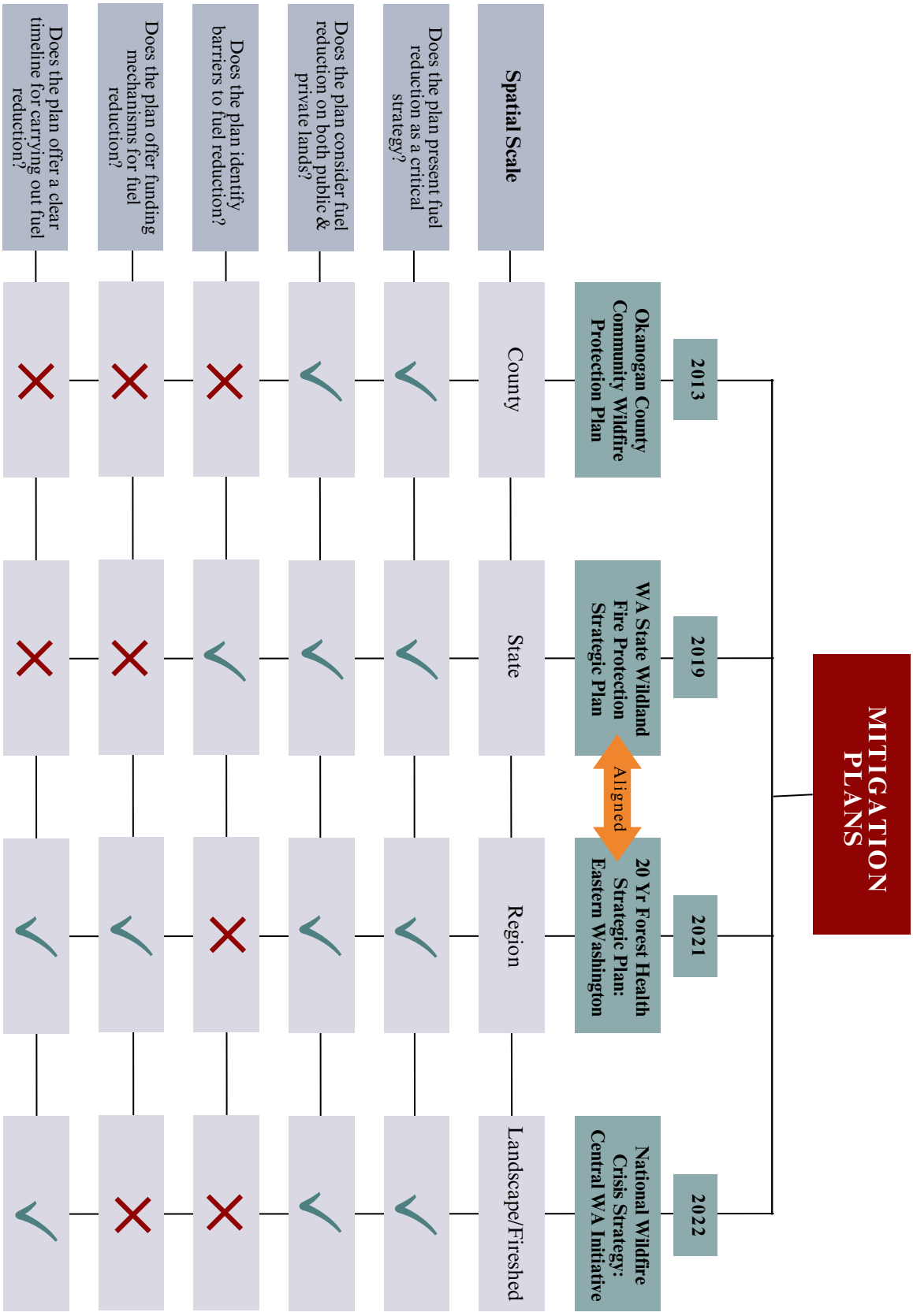


Figure 13: Comparison and Evaluation of Four Fire Mitigation Plans

OKANOGAN COUNTY COMMUNITY WILDFIRE PROTECTION PLAN

The Okanogan County Community Wildfire Protection Plan (OCCWPP) is the smallest spatial scale plan that we are covering. It was developed by the Okanogan County Community Wildfire Protection Plan committee in cooperation with the Okanogan County Department of Emergency Management, Washington Department of Natural Resources, and Northwest Management, Inc, a private forest and environmental management firm based in Everett, Washington. Collaboration and input was coordinated between a variety of different agencies, municipalities, and community organizations. This plan was published in 2013, and according to our contact at the Okanogan Conservation District, it is currently in the process of being rewritten.

The goals of the plan are outlined as follows:

- To reduce the area of WUI land burned and losses experienced because of wildfires.
- Prioritize the protection of people, structures, infrastructure, and unique ecosystems contributing to our way of life and the sustainability of the local and regional economy.
- Educate communities about the unique challenges of wildfire in the WUI.
- Establish mitigation priorities and develop mitigation strategies in Okanogan County. Strategically locate and plan fuel reduction projects.
- Provide recommendations for alternative treatment methods, such as modifying forest stand density, herbicide treatments, fuel reduction techniques, and disposal or removal of treated slash.
- Meet or exceed the requirements of the National Fire Plan and FEMA for a County-level Wildfire Protection Plan. (OCCWPP, 2003, p. 6)

The mission statement of the OCCWPP outlines that prioritizing the reduction of hazardous fuels in order to restore forest health is of utmost importance to the overall strategy. The plan identifies the need for fuels reduction on both public and private land, and highlights the land ownership delineation as adding complexity to the issue. There are a number of on-going action items identified in the plan that are focused on fuels reduction, including support of the North Central Washington Prescribed Fire Council and Washington State Prescribed Fire Council. Additionally, a list of 49 proposed treatment project areas are included in the plan, each with clear typology, spatial scale, and priority ranking. While there is no specific timeline for treatment, efforts to reduce fuels in high risk areas of Okanogan county are apparent. From our evaluation, the criteria that are missing are identification of barriers, funding pathways, and specific timeline.

WASHINGTON STATE WILDLAND FIRE PROTECTION 10 YEAR STRATEGIC PLAN

The State Wildland Fire Protection Strategic Plan was published in 2019 by the Department of Natural Resources. It is a state level plan that was produced in consultation with federal, state, local, and tribal officials, as well as nearly 1,000 experts in the field of hazard mitigation, planning, and wildfire management.

The goals of this plan are to improve the state's preparedness, response, and recovery systems, foster resilient landscapes, prepare and adapt communities, and facilitate wildfire response that results in zero loss of life.

Fuels reduction is a major theme of this plan, and a clear connection between fuels reduction and current wildfire ecology is presented as a new approach to wildfire

management. As stated in the plan, a goal is to "use lower-intensity fires where appropriate to achieve healthy landscapes and provide for the safety and well-being of communities. Science tells us we need more fire, not less, on many of our lands, particularly more low and moderate intensity fire on the east side of the state" (WSWFPSP, 2019, p. 9). The two criteria in our evaluation that this plan does not meet are funding mechanisms and a specific timeline for fuels reduction, however, this plan is meant to be implemented in alignment with the DNR's 20 year Forest Health Strategic Plan.

20 YR FOREST HEALTH STRATEGIC PLAN: EASTERN WASHINGTON

In 2021, Commissioner of Public Lands, Hilary Franz, and more than 33 organizations and agencies joined forces to address the forest health crisis with a 20-Year Forest Health Strategic Plan. This is a regional plan that is focused on the eastern section of Washington state: it is scientifically-based and establishes the audacious objective of restoring 1.25 million acres of forest to a healthy state, thereby increasing fire resistance and better protecting our communities.

The goals of the plan are to accelerate forest treatments, protect communities and values at risk, promote rural economies and by-product processing, respect landowner objectives, and monitor progress over time. It is also outlined that the 20 year plan is to remain adaptable, as risks, needs, and vulnerabilities may shift over time.

Of the plans that we evaluated, this is the most focused on fuels reduction treatment in our case study area. It is holistic, exhaustive, and considers all of the facets that we outlined in our evaluation protocol.

NATIONAL WILDFIRE CRISIS STRATEGY: CENTRAL WA INITIATIVE

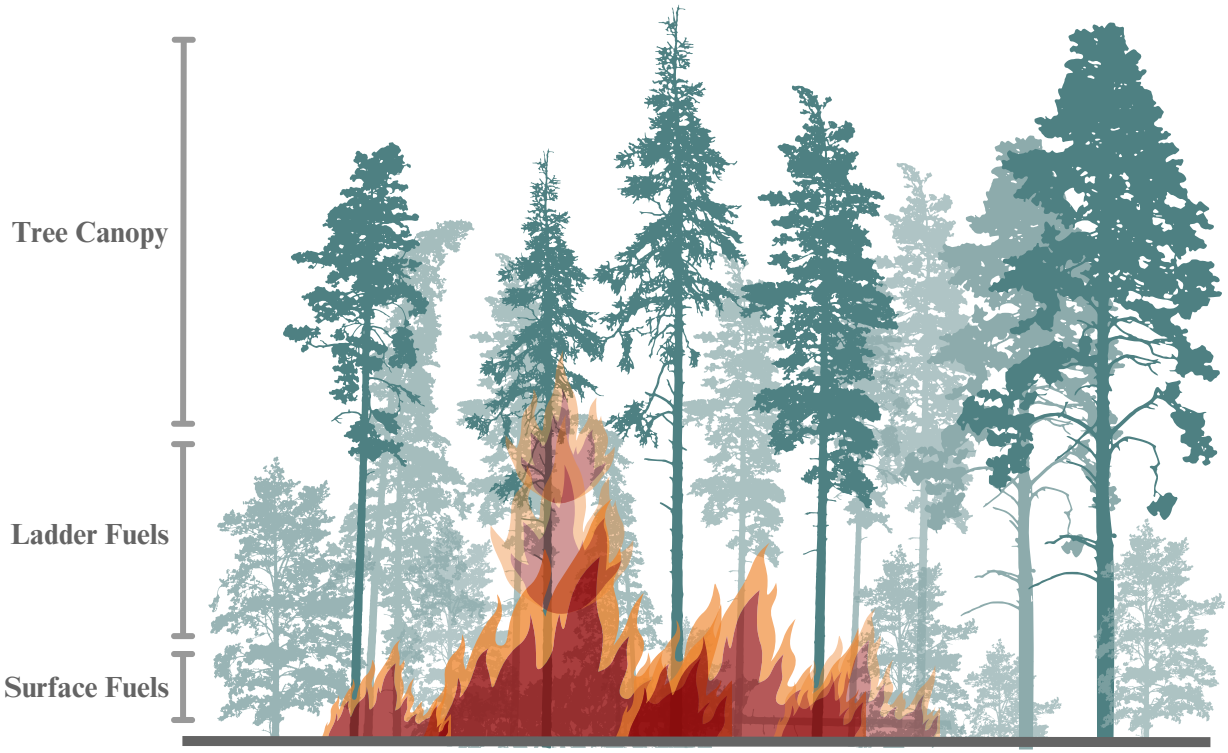
Published in 2022, the Central WA Initiative is a program of the U.S. Forest Service, and was established to reach the goals of the National Wildfire Crisis Strategy. From Winthrop to Naches, Washington, 2.45 million acres of federal, state, Tribal and other lands comprise the Central Washington Initiative landscape; the plan employs a "all hands, all lands" strategy to combat the wildfire crisis on this landscape. The initiative operates in tandem with the 20-Year Strategic Plan by Washington DNR, and many of the strategies will be led by state level agencies.

Risk-based information will be used to engage with collaborators and establish shared priorities for landscape-scale work to equitably and significantly alter the trajectory of risk for people, communities, and natural resources, including water, carbon, and wildlife-sensitive areas. The Federal Bipartisan Infrastructure Law allocates nearly $3 billion for the removal of hazardous substances from the nation's forests, and this funding will be used to initiate the work of the Central WA Initiative. Together with state and other stakeholders, the Okanogan-Wenatchee National Forest anticipates treating 124,000 acres in fiscal years 2022, 2023, and 2024. These investments will continue to reduce wildfire risk across four counties and address a variety of pressing issues, including the growing threat to communities, natural resources, and regional economies.

Fuels reduction is the primary strategy of the Central WA Initiative, along with treatment planning, analysis, and collaborative efforts. Federal level funding, which will be funneled through state level agencies, is highlighted. In our evaluation, the only facet that is unmet is the discussion of barriers.

IV. FUEL REDUCTION EXPLAINED

A century of fire suppression and the removal of large trees during timber harvests have resulted in denser, more flammable forests. This has led to larger and more catastrophic wildfires, which frequently destroy the majority of trees in vast areas. It has been demonstrated that fuel reduction initiatives and vegetation remedies can reduce wildfire risk, threat to emergency first responders and public safety, and property damage, as well as restore and maintain ecosystems.



By reducing surface and ladder fuels, wildfire is easier to manage and forests become more resilient.

Figure 14: Ladder Fuels Behavior

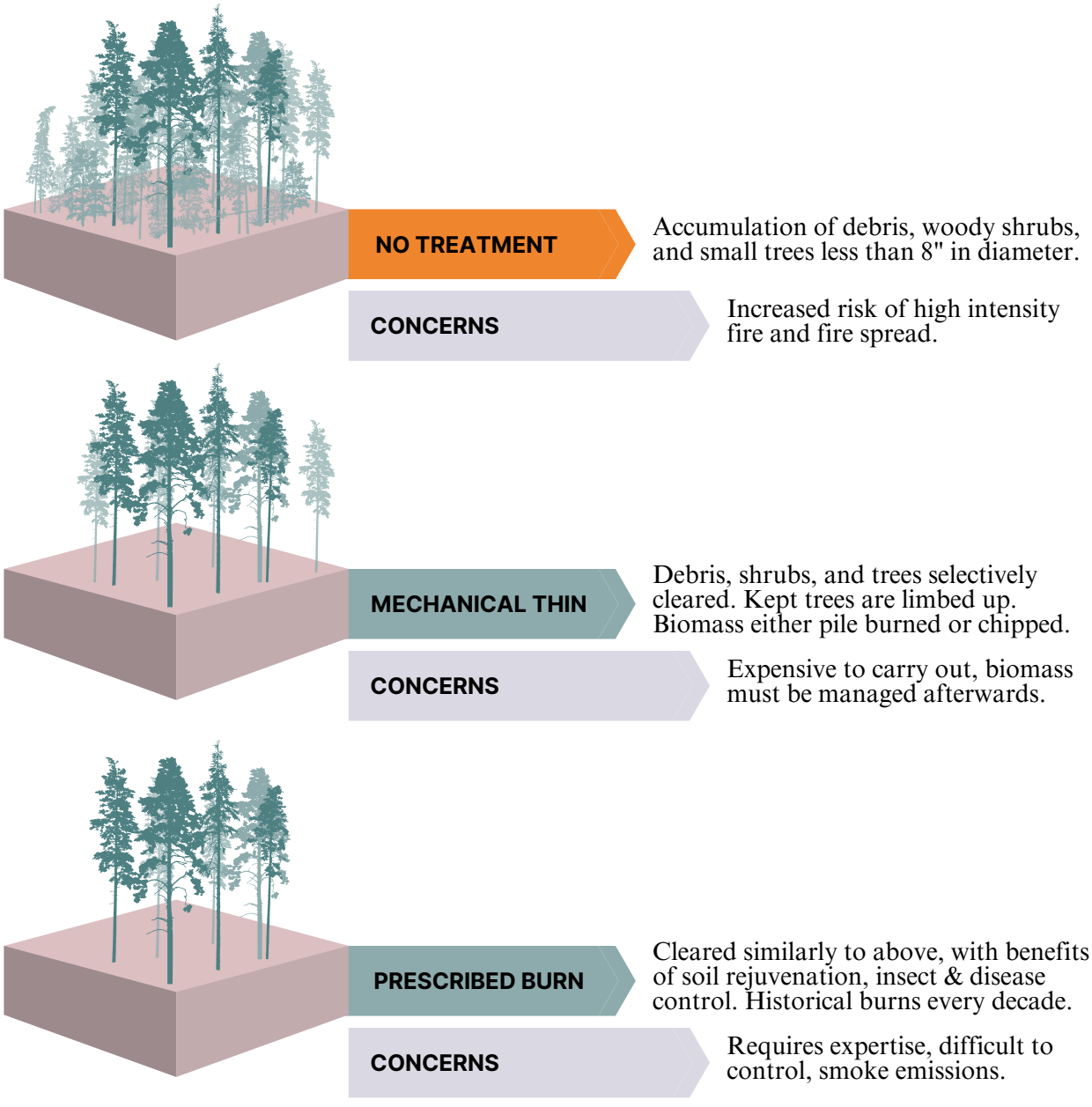


Figure 15: Fuel Reduction Strategy Comparison

All types of plant material, including grasses, shrubs, trees, decaying foliage, and fallen pine needles, can serve as fuel during a wildfire. As these combustible materials accumulate, the likelihood of a catastrophic wildfire increases. When conditions are favorable, excess fuel causes fires to burn stronger, larger, longer, and quicker, which can be difficult to control. Wildfires can be fatal but not all flames are destructive. Fire is a natural and necessary component of many ecosystems. Periodic low-intensity fires accelerate forest decomposition, generate open regions for new plant habitat and food sources, and deliver nutrients to surviving plants. Fire may also increase groundwater recharge and water transport to aquatic habitats. They increase fire resilience by reducing ladder fuels and by creating a mosaic of charred, partially burned, and unburned areas. Some trees, such as lodgepole pine, require flames to open their cones and disseminate their spores. Homes and other structures in the WUI are susceptible to wildfires because they are surrounded by fuel. Firefighters ability to prevent a structure from catching fire is impacted by the surrounding vegetation and defensible space. Additionally, wildfires can damage or disrupt utility services. Fuel treatments reduce the likelihood of unwanted wildfires and make them simpler to control.

Typically, reducing hazardous fuels requires reducing surface and ladder fuels. In some cases, it may also necessitate thinning out dense tree stands while preserving trees of mature size. The thinning of trees, removal of undergrowth, and limbing of trees are performed by hand laborers or machines. Prescribed fires also known as “prescribed burns” or “controlled burns” are used to meet management objectives. In Washington State, most prescribed burns are conducted during the fall, typically in the month of October, however, the DNR allows for yearly burns, when conditions are ideal for the containment of smoke. During the winter, cut material is ground into chips or heaped

and incinerated. Biological methods, such as grazing, provide a less invasive application, though aren't typically employed in national parks. Before fire can be used in a park, an authorized fire management plan must be approved, and the fire itself must meet predetermined criteria. In many regions, the use of fire to reduce fuel hazards is prohibited. In these instances, generally mechanical remedies are used to prepare an area for the safe use of prescribed fire.

At the federal level, the U.S. Forest Service prescribed fires are approved based on permitting requirements, and the park must develop a fire management plan and a prescribed burn plan. Before ignition, each prescribed fire must satisfy all of the conditions outlined in a checklist. When fire cannot be used, the majority of hazard fuel reduction is carried out through mechanical treatment, utilizing saws and laborious removal. In some instances, it is a multi-step procedure in which the materials are mechanically treated first, then piled and burned, weather permitting (NPS, 2020).

In the autumn of 2021, the Washington DNR reintroduced a cost-effective tool with a high success rate for forest restoration and the reduction of wildfire risk in central and eastern Washington. Formerly known as the cost-share program, the DNR's financial assistance program concentrates on financial and technical support to implement forest health or wildfire mitigation remedies or to assist landowners in writing forest management plans. In the 20-Year Forest Health Strategic Plan, prescribed fire is highlighted as a crucial tool for achieving the plan's objectives. The Washington DNR Forest Health Tracker is an interactive online platform that seeks to collect and display information regarding forest health projects on all Washington lands. Knowing the location and specifics of planned and completed projects enables proactive stewardship across a variety of landowners. Treatment tracking is a useful

indicator for assessing progress in enhancing the rate and scope of treatments, but it is insufficient to completely comprehend the movement of Washington's forests toward a state of health and resilience. To assess how treatments and other disturbances affect forest conditions and hazards to shared values, additional monitoring is required. This framework reflects the 2020 Forest Action Plan and incorporates the Eastern Washington 20-Year Forest Health Strategic Plan. Increasing forest health and resilience across all lands in Washington is a profoundly collaborative endeavor that requires coordination between individuals and organizations from across the state. The evolving data regarding federal, state, local, and tribal land ownership reflects this collaboration and decision (DNR, n.d.).

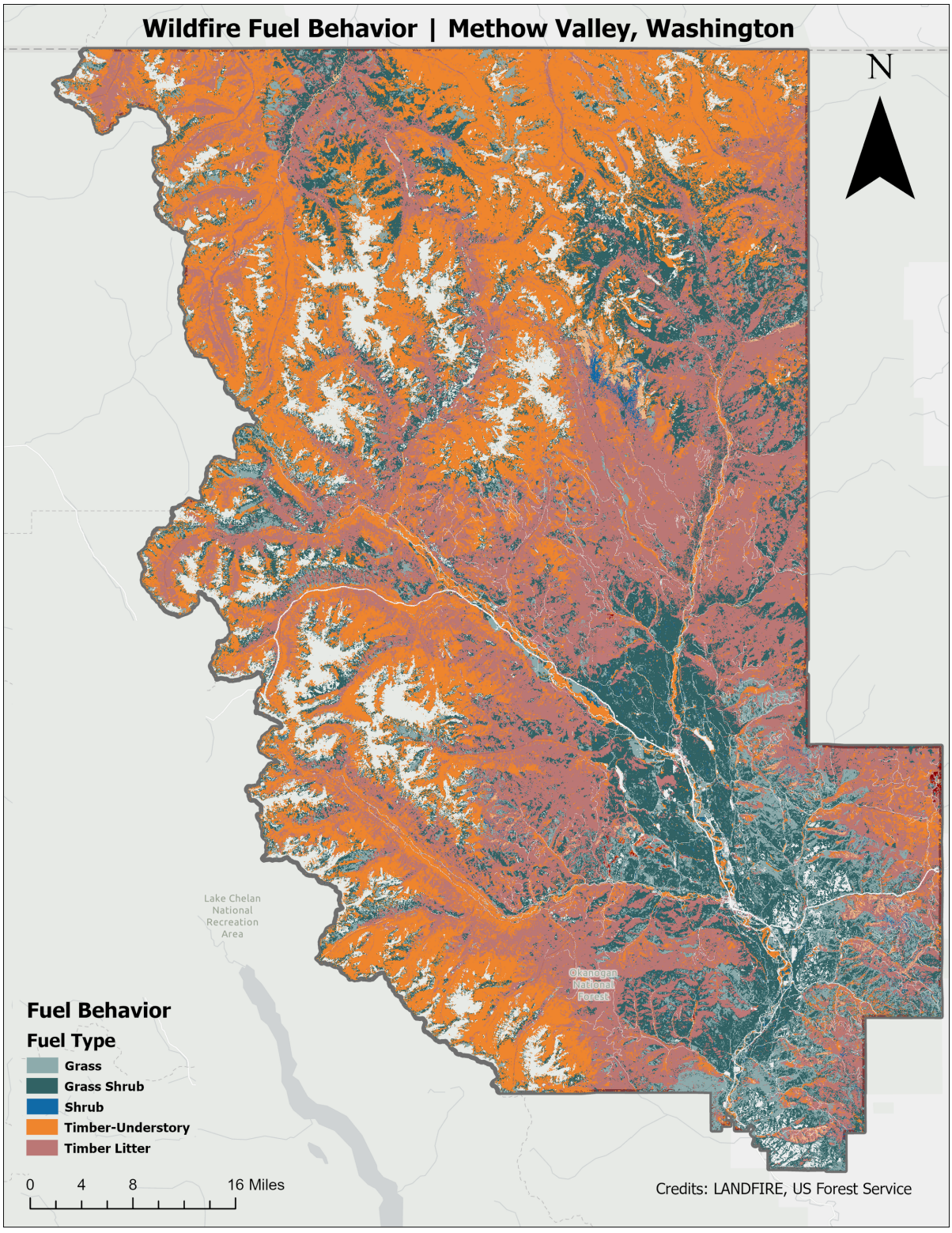


Figure 16: The wildfire fuel behavior model characterizes fuel loading across all vegetation and ecological types.

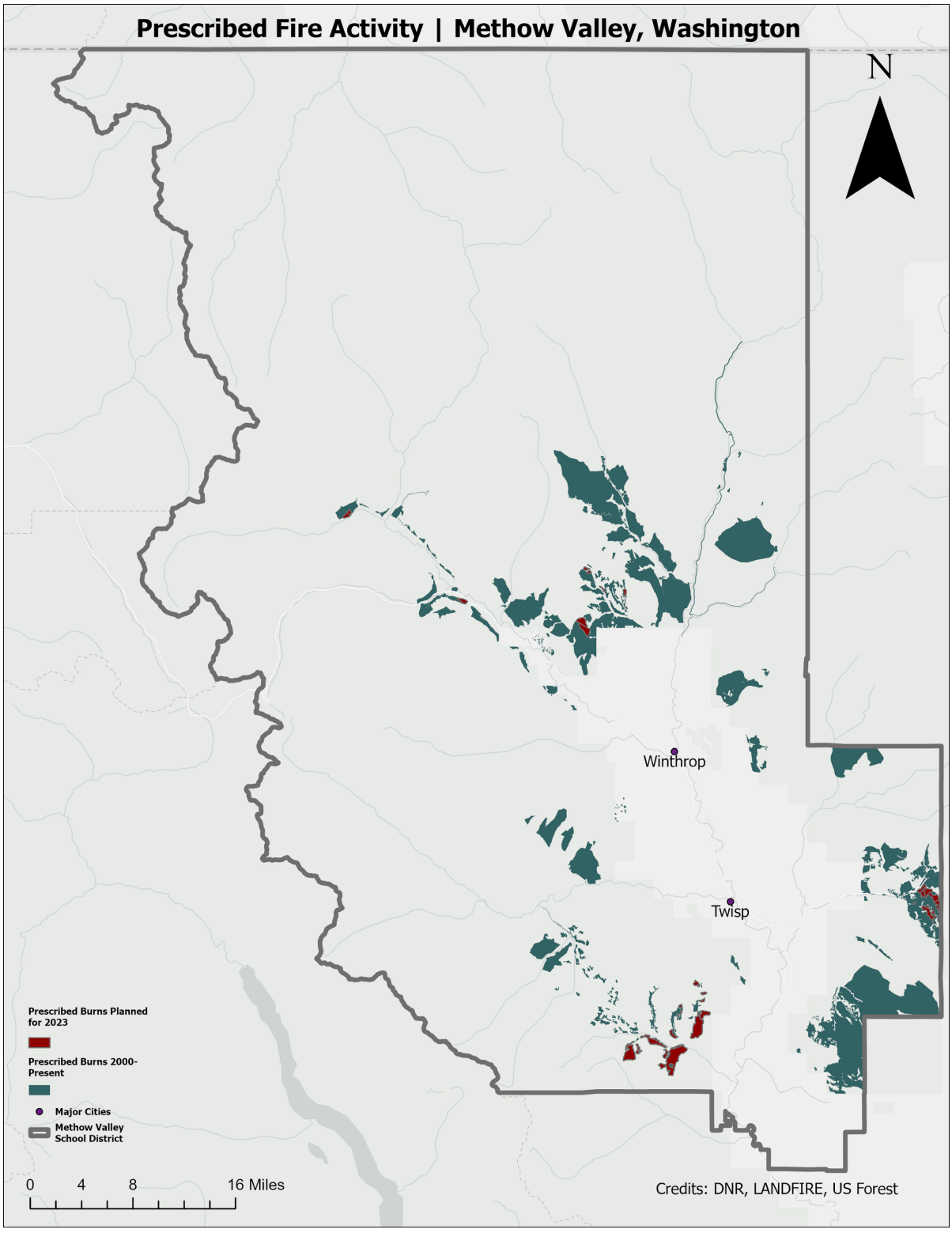


Figure 17: The prescribed fire activity map, shows prescribed burns planned for 2023 (red), and the prescribed burns 2000-present (green).

V. BARRIERS AND OPPORTUNITIES

In this section, we will present the barriers to fuels reduction that we have identified over the course of our research, along with corresponding opportunities. The barriers were revealed through qualitative interviews with stakeholders at the U.S. Forest Service, Washington Department of Natural Resources, Okanogan Conservation District, community members at a public meeting held in February 2023, and fire ecologists that have research experience in the Methow Valley. Below is a table that presents a brief summary of each barrier and corresponding opportunity, followed by an expanded explanation of each.

Barrier	Description	Opportunity
Funding	Forest treatments are very expensive to carry out and funding pathways are disjointed and limited.	**Explore grant funding, highlight gaps, and connect community to resources.**
Processing Timber	There is no large mill operation in the Methow Valley for processing thinned timber and biomass.	**Partner with small scale mill operations and explore mobile processing options such as biochar & cross laminated timber.**
Insurance Incentive	There is currently no monetized incentive for private landowners to reduce fuels on their private property.	**Incentivize fire adapted and Firewise communities through insurance subsidies at the state level.**
Infrastructure Capacity	The remote and rugged character of the Methow has led to limited access and infrastructure development.	**Plan and construct additional egress, access roads, and multi-use trails to use as defensible space.**
Smoke Emissions	Emissions in WA state are highly regulated and there is public concern surrounding smoke from prescribed burns.	**Using smoke modelling and "smoke savings" theory, loosen AQ regulations. Educate communities on benefits.**
Fear & Distrust	Extreme fire impacts have created a general fear of fire. Legacy of mismanagement has fostered distrust of government.	**Coordinate ongoing community meetings and collaborative planning sessions.**

Figure 18: Barriers and Opportunities Table

FUNDING

Grant funding from the Bipartisan Infrastructure Bill is earmarked for fuels reduction treatments on public lands across the Methow Valley (USFS, 2021). On private property, funding for fuels reduction is one of the most prominent barriers. Fuels reduction, whether it be prescribed burning or mechanical thinning, is incredibly expensive. A ten acre parcel of land can cost tens of thousands of dollars to treat, and treatment typically needs to be done at regular intervals in order to maintain forest health. Discussion of funding was a major theme of the community meeting that we attended in February 2023. Assistance with the removal of fuels of all size and composition was repeatedly suggested as a program idea by community members.

Washington Department of Natural Resources does offer a cost share program, now called the Financial Assistance for Wildfire Resilience and Forest Health program, which reimburses private landowners 50% of the cost of treatment. At present, this is the only funding pathway that is available to private landowners. If fuels reduction treatment costs upwards of tens of thousands of dollars and must be repeated at a semi-regular interval to maintain forest health, the financial burden becomes substantial. This is not a valid option for Methow Valley residents that are living on a fixed or overburdened income.

OPPORTUNITIES

Increased funding for fuels reduction within 100 feet of any structure should be prioritized, as this would create a “defensible space” which has been proven to effectively mitigate wildfire impacts (Syphard et al., 2014). The primary opportunity in the funding realm is for the state to secure grant

funding that is targeted specifically towards building resilient communities, such as FEMA's BRIC funding program. This funding could be channeled through the Department of Natural Resources (DNR), and used to lessen the individual expense in their current cost sharing program. With increased funding, the cost of fuels treatment within 100 feet of any structure could be fully subsidized. DNR and the Okanogan Conservation District have made great strides in building community networks and engagement, and would benefit tremendously from increased federal funding in order to alleviate the financial burden for private landowners.

PROCESSING BIOMASS

Another critical barrier for community members is processing biomass that results from clearing fuels. Pile burning, chipping, and community composting events are all strategies that the Methow Valley community has used successfully, but from their feedback at the meeting, there is a need for more assistance in this realm. There is currently no large-scale mill operation in the valley, so the pathway to remove and process downed trees and other vegetation is somewhat limited.

OPPORTUNITIES

Washington State University operates a public-facing Forestry Consulting Directory and there are currently nearly 50 privately owned forestry companies that offer fuels reduction services in Okanogan County. It would be beneficial to identify which of these foresters has the capacity to sell thinned trees to timber companies in order to alleviate cost burden for landowners, and share that information with the Methow Valley Community. This partnership would be mutually beneficial, and there is opportunity for similar partnerships in processing biomass from fuels reduction.

A small-scale, portable mill operation could process timber onsite, for example. Chipping equipment could be used similarly. Biomass can be processed into compost, wood chips, biochar, or cross laminated timber, with the appropriate system in place. The opportunity lies in creating a processing node in the system, in which the materials left behind from fuels reduction treatment can find a beneficial use while alleviating the cost burden on the landowner. Alternatively community wide biomass reduction could include the introduction of feral goats and other ungalates in a controlled setting around firebreaks in the WUI. A recent study in Mallorca, Spain (Pareja J., et al., 2020) determined feral goats introduced into fenced plots using water and salt, reduced the biomass accumulation around firebreaks. The study determined the biomass of herbaceous plants within the fenced plots decreased, indicating grazing as the most influential factor compared to zones outside the fenced plot. This method could provide continuous and rotational management of grazeland between settlements in the Methow Valley, and the US Forest Service managed lands.

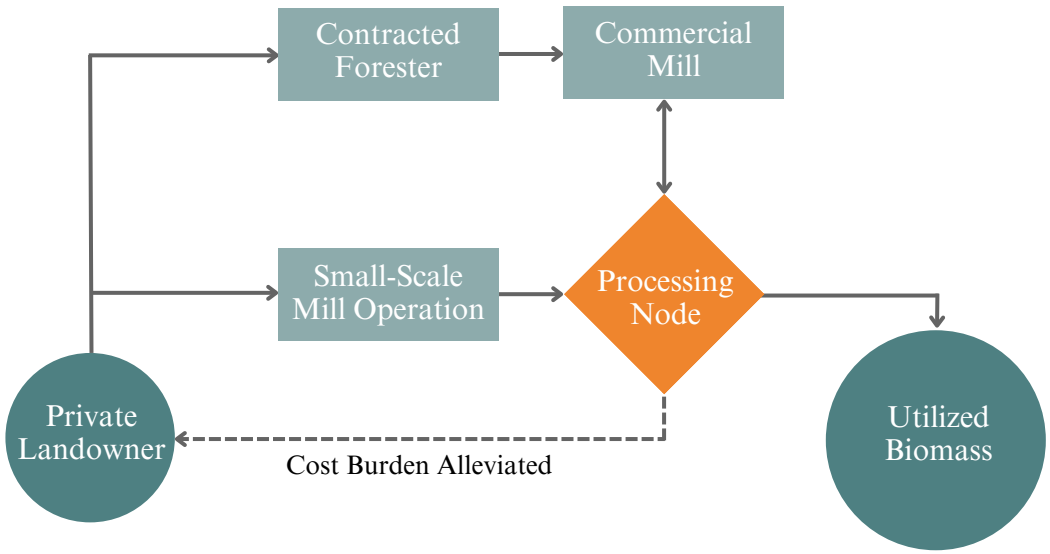


Figure 19: Proposed Biomass Processing System

INSURANCE INCENTIVE

At present, there is no monetized incentive or subsidy available for landowners to carry out fuels reduction treatments in the Methow Valley. In 10 states across the country, USAA homeowners insurance discounts are available for those that participate in Firewise mitigation strategies on their property (National Fire Protection Association, 2023).

The subsidy encourages and rewards homeowners when they prepare their home for wildfire impacts. Steps that are required include fuels reduction within 100 feet of the home, fire resistant roofing materials, and maintaining debris free gutters. In the state of California, there are 12 additional insurance groups that offer discounts for members that practice fire hardening and fuels reduction on their property. The Insurance Commissioner of California, Ricardo Lara, has been pivotal in securing subsidies for the state's residents since he took office in 2019 (California Department of Insurance, 2023).

OPPORTUNITIES

The Insurance Commissioner of Washington, Mike Kriendler, has been in office since 2000 and is currently the chair of the National Association of Insurance Commissioners' Climate Risk and Resilience Work Group (Office of the Insurance Commissioner, 2023). While Commissioner Kriendler is outspoken about climate resiliency, there is little transparency regarding why Washington does not offer an insurance discount specifically for wildfire mitigation; since the increase in wildfire impacts is directly correlated to climate change, it should be a priority of the commissioner. There is a huge opportunity for our state to follow in the footsteps of California and recognize the work of homeowners that mitigate wildfire impacts on their property through direct incentives. During the community outreach meeting, Methow Valley residents consistently brought up the need for some form of insurance subsidy. A monetized insurance incentive would lessen the financial burden on private landowners to conduct regular fuels reduction treatments, thereby increasing fire resiliency in the Methow Valley and beyond.

INFRASTRUCTURE CAPACITY

Because of the rural nature of the Methow Valley and the adjacent expanse of wilderness lands, road infrastructure and access is somewhat limited. In the community meetings, residents spoke of the need for additional egress along narrow roadways, both for fire defense access and community navigability. On the narrow roads that connect through the Methow Valley, shoulders and opportunities to turn around are few and far between. This is an issue in times of wildfire evacuation, as residents have experienced difficulty changing course when attempting to flee the area. It is also a barrier to fuels reduction, as it can be challenging to get large vehicles and processing equipment into areas that require treatment.

OPPORTUNITIES

Additional shoulder and turnouts along roadways for egress would increase access to the remote regions of the Methow Valley. Increased infrastructure capacity would make it easier for fuels reduction treatment to be carried out, and would also serve as expanded fire breaks. Additionally, Methow Trails is a nonprofit organization that maintains over 130 miles of multi-use trails throughout the valley; it is currently the largest cross country ski trail system in North America, and the trails can be used in the summer months for hiking and mountain biking (Methow Trails, 2023). A map of the summer trails system surrounding Winthrop and Mazama is included on the following page. Expanding this system, including trail widening and increased fuels reduction within 50 feet of a trail, would create additional firebreaks and access for firefighting equipment, when necessary. This is potential for Methow Trails to receive wildfire mitigation grant funding in order to carry out this level of trail maintenance.

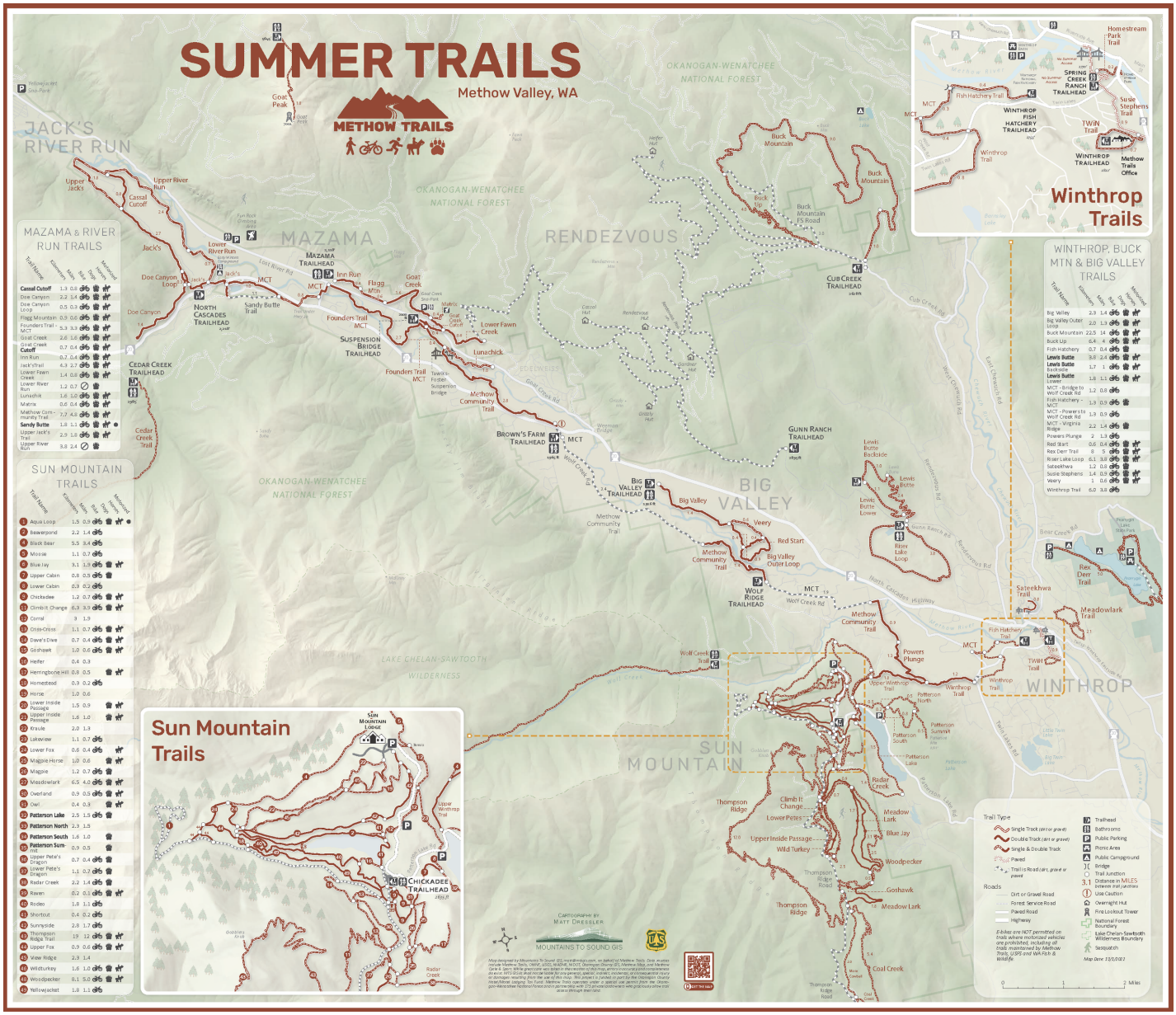


Figure 20: Methow Trails Summer Network

SMOKE EMISSIONS

A major barrier in relation to prescribed burning is correlated smoke emissions. Washington DNR issues permits for prescribed burns, and does so based on daily modeling of smoke emissions and potential air quality impacts. The Washington Clean Air Act, which is upheld by the Department of Ecology, delegates the responsibility of prescribed burn permitting to DNR. However, since the implementation of the Smoke Management Plan (last updated in 1998) the thresholds for smoke emissions are exceedingly restrictive in Washington state, limiting the application of prescribed burning as a holistic fuels reduction strategy. According to the plan, "Reduction of emissions produced from burning, coupled with the use of alternative methods of debris disposal, will meet these goals by improving general air quality" (WA Smoke Management Plan, 1998, p. 13). Furthermore, the Washington Clean Air Act instructs DNR to discourage the use of prescribed burning whenever possible; As stated, "The department of natural resources shall encourage more intense utilization in logging and alternative silviculture practices to reduce the need for burning" (WA Clean Air Act, 1990, p. 98).

OPPORTUNITIES

In 2022, an application to the Environmental Protection Agency (EPA, 2023) was made by DNR to update the state's Smoke Management Plan. This update would adjust the smoke emissions evaluation protocol to better accommodate prescribed burns for fuels reduction and forest health restoration across the state. This amendment to the Smoke Management Plan is a critical opportunity for DNR to better facilitate their 20 Year Forest Health Strategic Plan. Pending approval by the EPA, a new protocol would allow for more fuels reduction treatments over a shorter period of time.

FEAR & DISTRUST

There is a great deal of community fear surrounding wildfire, as impacts have been severe and traumatizing. After a long legacy of fire suppression, it is understandable that public sentiment may be slow to shift towards embracing fire as a natural part of the ecology. Residents of the Methow Valley have lost their homes, have suffered through severe air quality issues, and have had to evacuate on short notice because of wildfires in the region. Prescribed burns have also gotten out of control in the past, so hesitation to accept the practice remains. There is ongoing discourse surrounding prescribed burning, and while the majority of data supports its use, some environmental groups actively discourage it (Baker, 2021).

OPPORTUNITIES

The Methow Valley is an engaged and resilient community, and there are a variety of agencies that are working together to educate the public about the benefits of fuels reduction. Fire Adapted Methow, the Washington Prescribed Fire Council, and the Okanogan Conservation District all conduct outreach efforts to keep residents informed. Furthermore, residents have been working together to build a sentiment of fire acceptance and risk reduction. Susan Pritchard, a fire ecologist and Methow Valley resident, collaborated on a video that highlights the need for fuels reduction and fire adaptation in the region. Continuing these key partnerships are vital to shifting community acceptance of fuels reduction, and prescribed burning in particular. Ongoing community meetings and outreach efforts, in which residents feel acknowledged and supported, will help to alleviate lingering distrust.

VI. DISCUSSION AND CONCLUSION

Fires are an integral part of the Pacific Northwest landscape, and both social and ecological resilience must be considered in the context of wildfire hazard mitigation. In order to protect public health and safety, communities that develop in the WUI must be fire adapted, much like the landscape itself. For the purpose of this project, we have defined resilience as the ability for an ecosystem to recover after an impact event. The practice of long-term fire suppression is no longer a viable option in Pacific Northwest forests; a new trajectory, focused on forest health and adaptation, is taking shape.

Our thesis argues for improved and holistic wildfire fuels reduction as a resilience measure in the Methow Valley. Our scope of work emphasizes key linkages between active and passive mitigation strategies, highlighting the need to improve fuels reduction approaches as a means to reduce the potential for social and ecological damage. We have identified six key barriers to fuels reduction in our case study area: funding, processing timber, insurance incentives, infrastructure capacity, smoke emissions, and fear and distrust. Associated with each of these barriers, we outlined opportunities to overcoming them, and will now offer focused recommendations. The table on the following page (see Figure 21), expands upon the barriers and opportunities table to include correlated recommendations.

First, there is a substantial need for grant funding, both for private property owners to carry out fuels reduction treatments around their homes, and for rural communities to increase infrastructure capacity. Increased funding for fuels reduction within 100 feet of any structure should be prioritized, as this would create a defensible space which has been proven to effectively mitigate wildfire impacts (Syphard et al., 2014).

Grant funding is also necessary for communities to increase infrastructure capacity in dealing with wildfire impacts. Expanding egress, bolstering forest roads, and fortifying multi-use trail systems will allow for increased defensible space in the instance of wildfires, and potentially serve as breaks to slow wildfire spread. Expanded infrastructure capacity will also increase access to forestlands in need of fuels reduction and assist with evacuation from the remote edges of the Methow Valley.

We emphasize the role of silviculture burning, which provides the most effective solution to fuels reduction in the wildland urban interface, but mechanical thinning is another effective fuels reduction strategy. However, there is a need for processing biomass that is produced through mechanical thinning. For this barrier, we recommend partnerships and initiatives that generate business development to establish a "processing node" for biomass. Thinned trees and vegetation can be used for chipping, biochar, or even cross laminated timber. Partnerships with goat farmers, in which goats are used to thin surface and ladder fuels, is another potential processing pathway.

Barrier	Description	Opportunity	Recommendations
Funding	Forest treatments are very expensive to carry out and funding pathways are disjointed and limited.	Explore grant funding, highlight gaps, and connect community to resources.	**Grant Funding: Assist private landowners in carrying out fuels reduction treatments.**
Processing Timber	There is no large mill operation in the Methow Valley for processing thinned timber and biomass.	Partner with small scale mill operations and explore mobile processing options such as biochar & cross laminated timber.	**Business Development: Develop a "processing node" for timber and vegetation.**
Insurance Incentive	There is currently no monetized incentive for private landowners to reduce fuels on their private property.	Incentivize fire adapted and Firewise communities through insurance subsidies at the state level.	**Policy Change: WA State Insurance Commissioner must allow subsidies for adapted communities.**
Infrastructure Capacity	The remote and rugged character of the Methow has led to limited access and infrastructure development.	Plan and construct additional egress, access roads, and multi-use trails to use as defensible space.	**Grant Funding: Assist communities in increasing infrastructure capacity.**
Smoke Emissions	Emissions in WA state are highly regulated and there is public concern surrounding smoke from prescribed burns.	Using smoke modelling and "smoke savings" theory, loosen AQ regulations. Educate communities on benefits.	**Policy Change: Adapt WA State Smoke Management Plan to allow for more prescribed burns.**
Fear & Distrust	Extreme fire impacts have created a general fear of fire. Legacy of mismanagement has fostered distrust of government.	Coordinate ongoing community meetings and collaborative planning sessions.	**Community Engagement: Continue to build and strength interagency and community partnerships.**

Figure 21: Barriers and Opportunities Table, Expanded with Recommendations

Included in our recommendations are two distinct policy changes. Clear policy procedure to address allowable wildfire smoke inventory, including a revolving door of public facing information to assure residents of the safety and benefit of silviculture burns on state controlled forestland will be necessary. The Washington State Smoke Management Plan must be updated to account for a necessary increase in prescribed burning. Fuels reduction at the WUI should be prioritized to limit impacts to people and property, while fire in the wilderness should be allowed to burn whenever possible (Hessburg et al., 2021). Additionally, a policy update that allows for insurance subsidies for private property owners that participate in wildfire hazard mitigation strategies is needed. Creating defensible space, using fire resistant materials, and taking other Firewise approved precautions should earn property owners a discount on their homeowner's insurance rates, as is the case in California.

Lastly, ongoing community engagement is needed to ease fear and distrust amongst residents. The Methow Valley community is active and informed, and public outreach carried out by the DNR and Okanogan Conservation District has been successful in the region. In the most recent public meetings in 2023, Methow Valley residents requested the need for a public facing portal, showcasing wildfire mitigation strategies, funding mechanisms, and other community resources. Accessible career opportunities and fuel reduction training will further empower residents of the WUI to protect themselves from wildfire impacts. These and all other reasonable requests must be addressed in order to build and strengthen interagency and community connections. The work of DNR and Okanogan Conservation District, as well as community groups in the Methow Valley, should be used to develop best management practices for other regions. Interagency and community partnerships are key in fostering long-term resilience.

Forest management should be designed to restore forest ecosystem health. Today, forestry should be used to replenish the forest's value and functionality. Utilizing the profits from time sales or stewardship contracting is one method of financing restoration. Forests in poor condition are more vulnerable to the destructive effects of wildfires. However, forest resilience is not limited to plants. Restoring river systems increases their resilience to the effects of fire and climate change. When prescribed fires are part of a healthy forest management plan, they cause trees and woody detritus to fall intro streams, creating optimal habitat for trout and salmon (Wood., 2020).

Through our qualitative research we have identified inconsistencies between federal and state agencies, tribal governments, and different socioeconomic groups. Fire is not prejudice, and as global climates continue to alter our ecosystems, our capacity for adaption has become paramount. Our thesis project highlights the barriers and opportunities surrounding fuels reduction in the Methow Valley, and encourages developing new industry standards to reduce impacts on the environment and empower residents of the WUI to work towards becoming fire adapted communities.

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