State Wildfire Suppression and the Wildland-Urban Interface

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EXECUTIVE SUMMARY

Wildfires are a frequent visitor to the Montana landscape. Mostly they consist of the lone snag ignited by lightning or the neglected campfire easily extinguished and quickly forgotten. But in recent years Montana has experienced some of the worst wildfire seasons in the state's recorded history, burning thousands of acres of natural resources (grass, brush, and timber) and with increasing frequency homes, bridges, powerlines, and other improvements as well.

A wide variety of factors have contributed to this increased level of fire activity, including longer fire seasons caused by changing climate, lower precipitation, and reduced snow pack and increased accumulation of dead or dying trees due to drought or insects and disease. At the same time, people continue to develop property in the so-called "wildland-urban interface." More people, more houses, and more businesses are located in areas at risk from wildfire. As a result, the probability is growing that many Montana communities will pay a tremendous economic, social, and ecological price when wildfires occur.

This study examined current and historical fire data (1995-2006) to compare wildland fires and their suppression in and out of the wildland-urban interface (WUI) on the Montana landscape. The results focus on fires suppressed through DNRC's direct fire protection program. However, additional data is provided in the report for fires suppressed through the State/County Cooperative Fire Program.

The results of this study show that:

- 39% of DNRC's direct fire protection program is within the WUI, but over 66% of the wildland fires suppressed through that program occurred in these areas.
- 95% of wildland fires were contained as small fires and the initial attack success rate was similar in both WUI and non-WUI areas.
- Wildland fires in the WUI cost 46% more to suppress than non-WUI fires.
- Large fires (greater than 10 acres) represented less than 5% of the wildland fires, but over 89% of the total suppression related costs.
- Wildland fire suppression tactics change in the WUI to account for increased structure protection and can sometimes impose additional safety risk to firefighters.

INTRODUCTION

Fire Protection in Montana

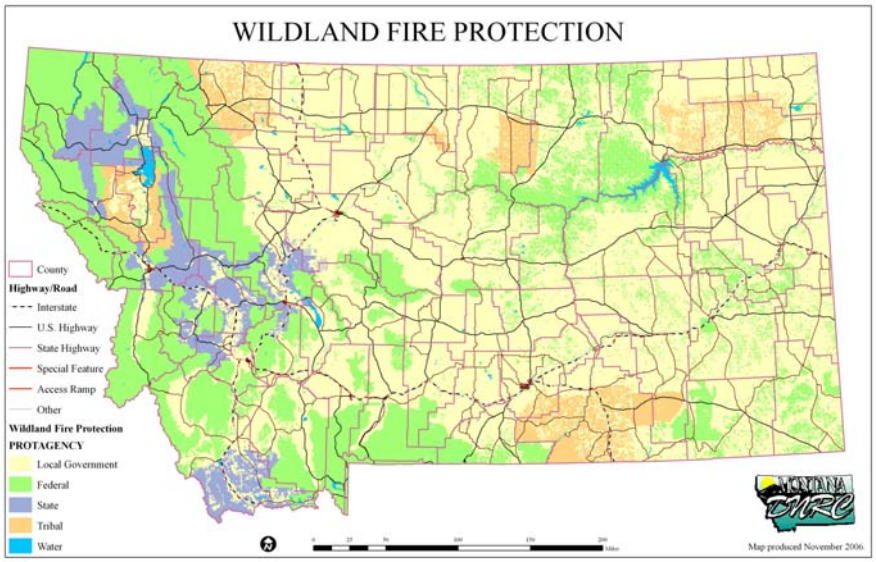
Wildland fire protection in Montana is accomplished through cooperative efforts between the state, federal, and local governments. DNRC is primarily responsible for wildland fire protection on state and private lands, while the five federal agencies (Bureau of Indian Affairs, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and USDA Forest Service [USFS]) are primarily responsible for protection on federal lands. DNRC has a direct protection program that covers a large portion of western Montana. In eastern Montana, local government provides fire protection on private and state lands. The lands protected by the different agencies are intermingled throughout the state, and interagency agreements are used to coordinate efforts for fire prevention, detection, and suppression.

Table 1. Wildland fire protection in Montana on classified forestlands (ARM 36.10.101) and non-forested lands.

Agency	Forest (acres)	Non-forest (acres)	Total (acres)
DNRC	4,494,247	647,594	5,141,841
USFS	16,773,035	394,153	17,167,188
BLM	2,002,772	5,538,305	7,541,077
BIA	219,366	761,160	980,525
USFWS	384,214	542,698	926,912
NPS	1,166,632	7,119	1,173,751

DNRC's direct protection program is responsible for fire protection on 5.2 million acres of land in western Montana. The direct protection program provides wildland fire protection to all state and private classified forest lands in forest fire districts and to individual landowners in affidavit units. Included in the 5.2 million acres are nearly 1.5 million acres of federal land protected by the state in exchange for federal protection on an equal amount of state and private land.

Figure 1. Wildland Fire Protection in Montana



The top priorities of the direct protection program are rapid initial attack and control of large fires that have escaped initial attack, with the goal of protecting lives, property, and resources. DNRC's overall fire suppression strategy is to control 95% of wildfires at less than 10 acres. When fire conditions are extreme, DNRC may make use of "severity" resources to supplement its own initial attack forces; firefighters and equipment which are pre-positioned in areas of high fire danger. In order to contain suppression costs and whenever possible, DNRC uses a "closest forces concept" in cooperation with other agencies to extinguish a fire quickly.

Through the State/County Cooperative Fire Program, local government fire departments protect all state and private lands not protected under the direct protection program -- approximately 45 million acres statewide. In this program, DNRC provides assistance to cooperating counties when wildfires exceed a county's capabilities, and in return the counties suppress wildland fires on all state and private lands not protected by a federal fire agency. The counties provide fire protection through the use of volunteers, county government personnel, and rural fire departments and districts. DNRC provides wildland fire training and equipment to county firefighters, and provides organizational and financial assistance on fires that escape initial attack and are beyond a county's ability to control. This partnership ensures wildfire protections on all state and private lands in Montana.

DNRC ensures wildfire protection with other programs including training, fire prevention, equipment development, communications engineering, aviation, and technical support activities. Training develops a team of wildland fire suppression and fire management professionals within the state. Fire prevention works with the public to provide a proven and effective means to reduce the occurrence of human caused fires, as

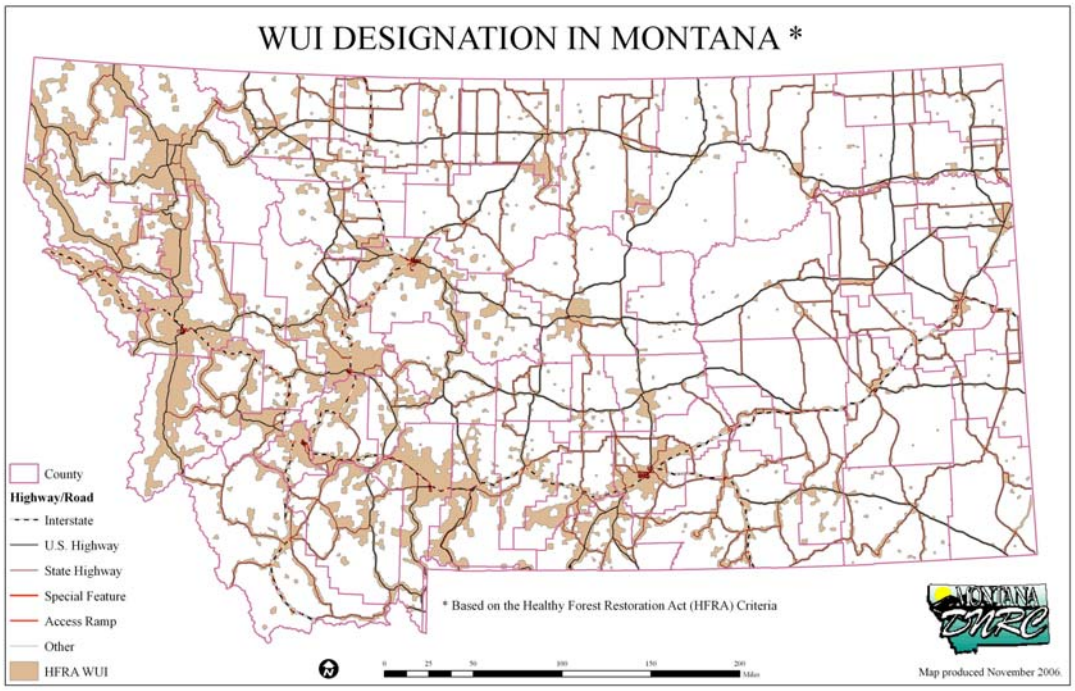
well as providing hazardous fire fuels mitigation cost-share funding for landowners in the WUI. Equipment development provides the specialized equipment used by wildland firefighters. Communications engineering keeps firefighters talking to each other in an age of rapidly changing and ever more complex communications technology. DNRC helicopters and planes provide rapid and effective water delivery, reconnaissance, and transport of firefighters. Technical support includes collection of assessments, cost accounting, mapping and geographic information systems, purchase and acquisition of supplies, dispatch and coordination, and computer support.

Wildland Fire Policy and Management in Montana

The summer of 2000 brought wildland firefighting and the urgency of the WUI problem into the national spotlight. Hundreds of fires scorched over 8 million acres, destroying homes and devastating local communities. As the flames raged on, the U.S. Congress asked for solutions, and the result was creation of the National Fire Plan. The National Fire Plan included several key components, among them: increased fire suppression capability, hazardous fuels mitigation, restoration of burned areas, and community assistance. Many of these programs are still funded and implemented in Montana. Subsequent legislation, including the Healthy Forests Initiative (HFI) and the Healthy Forests Restoration Act (HFRA) are designed to provide federal land managers with mechanisms to expedite the treatment of fuels in and adjacent to the WUI to protect communities and critical infrastructure from the catastrophic effects of wildfires.

Several trends in Montana and across the country continue to focus attention on wildland fire policies and management considerations. Increased population growth over the past two decades in Montana has resulted in an expanded WUI. Fires in these WUI areas have become much larger and burned with greater intensity (Arno, 1996). An accumulation of forest and grassland fuels, over-crowded stand conditions, and extended drought have increased the forest's vulnerability to fire from human activities and natural causes. Fires in WUI areas pose extreme risk to human life and property, increase the cost of fire suppression activities, and have significant social, economic, and natural resource impacts. As the population continues to grow and expand in Montana, fire management policies must address the WUI.

Figure 2. Wildland Urban Interface (WUI) in Montana



Over the past decade fire costs have increased significantly and greatly impacted state, federal, and local government fire suppression agencies. A recent government report shows that the Forest Service spent approximately $1.5 billion in 2006 fighting wildfires which burned over 9.5 million acres. In three of the last six years the USFS has spent over $1 billion on fire suppression. This spending has gained the attention of policy makers and forced fire management agencies to reexamine their funding sources and fire management policies. It is expected that federal agencies will increasingly look to state and local governments to fund fire management in WUI areas (USDA Forest Service, 2006a). Federal agencies are also expected to increasingly adopt "appropriate management response" and modified suppression strategies to decrease suppression costs (USDA Forest Service, 2006b). We can expect that fires with a low risk to human development might be allowed to burn at least until they pose a threat to people. These policy changes will have broad implications for state fire managers in Montana, particularly where DNRC and USFS exchange or share adjoining fire protection responsibilities.

It is interesting to speculate about what might happen should we see a "1910" fire season in "2010". In many ways we are far better equipped to deal with the situation. We have a better understanding of fire ecology. We have more and better equipment, both on the ground and in the air, and our fire response is better organized. But on the negative side, we have forests containing heavier concentrations of dead or dying fuels, many more people who live in the midst of a fire dependent forest, and a climate trend

that appears to be hotter and drier. The price we pay for underestimating the catastrophic potential of fire in fire-dependent ecosystems could be high indeed.

METHODOLOGY

This report summarizes data for wildfires within DNRC direct protection boundaries and fires suppressed through the state/county cooperative fire protection program. DNRC compiles and maintains detailed records for each fire where DNRC is the responsible fire suppression agency. However, the data in this report only accounts for a small number of the total fires that occurred in Montana. Data on fires that fall under the jurisdiction of federal or local government agencies were not available for this report.

A number of variables that affect fire occurrence and severity are not fully analyzed in this report. The effects of changing weather and climatic conditions in Montana are subjects of ongoing concern and debate. It is unclear whether hotter and drier conditions are the result of global warming or the result of some other climate cycle. Whatever the cause, Montana experienced extended drought conditions for the seven-year period from 1999 to 2005 (Montana Drought Advisory Committee, 2006). Many forests appear out of sync with cycles typical of fire-adapted ecosystems, brought about in part by cooler, wetter climate cycles, fire suppression and selective timber harvest. Certainly these factors play a significant role in fire activity in Montana, but their nature is still not fully understood. Our analysis concentrates instead on those variables where we do have a good understanding.

Much of the analysis provided in this report is based on simple descriptive statistics readily available and easily understood. In addition, where quantified data is not available, the report relies on observations and expert opinions from emergency incident managers and fire management professionals familiar with DNRC's fire management program.

The focus of this report is on the comparison of fires that occur in the WUI versus undeveloped wildlands. Therefore fire locations were mapped using a geographic information system (GIS) and then overlaid with a WUI data layer to classify fires into WUI and non-WUI. The WUI data layer was developed by the USDA Forest Service, Northern Region and is based on criteria found in the Healthy Forest Restoration Act of 2003. Communities with population densities greater than 28 people per square mile (2000 U.S. Census data) and communities at risk (identified in the Federal register January 4, 2001) were buffered by a 1/2 mile boundary. Since the WUI layer was based on census data from 2000 and there has been continued residential development, the data examined in this report was restricted to fires which occurred during the past decade (1996-2006).

This report also focuses on a comparison of the occurrence and costs of small versus large fires, as this is an important distinction in the DNRC fire program. Small

fires (less than 10 acres) are more easily suppressed and relatively inexpensive when compared to large fires (10 acres or greater).

Fire cost data are compiled for each fire where DNRC is responsible for suppression activities. For this report we did not include costs associated with severity resources, fire rehabilitation, or general assistance costs. We also adjusted fire costs to 2005 values based on the Consumer Price Index. Fire costs include a wide variety of goods and services including personnel costs, equipment usage, facilities rental, and aviation operations. County cooperative assistance fire cost data reflects only the DNRC component of suppression costs and may not reflect the total cost of suppressing that fire.

Although DNRC fire report data is available from at least the early 1980s, this report examines data from 1996 to 2005, primarily so that the information would be relatively current with the WUI spatial analysis layer. The report includes estimated data for 2006 based on the fires that have occurred and the associated expenses that have been received to date.

RESULTS

General Summary of Fire Report Data

Between 1996 and 2006 DNRC provided fire suppression on 4,271 fires through the direct protection and state/county cooperative assistance programs. These fires burned over 1.1 million acres. County cooperative fires were generally larger than direct protection fires due to the fuel and topography differences between eastern and western Montana. Only 11% of the fires suppressed by DNRC were through the county cooperative program, but 88% of the burned acres occurred in this category. Most fires in eastern Montana burn in grass and sagebrush fuel types and although larger, generally are suppressed more quickly. In general, DNRC only becomes involved with wildfires on local government protection after they have escaped initial attack and the responsible fire suppression agency has requested state assistance.

Through the direct protection and state/county cooperative assistance programs, DNRC suppressed an average of 388 fires and 101,650 burned acres per year. The annual number of fires ranged from a high of 565 in 2003 to a low of 203 in 1997. The annual acreage burned ranged from a high of 473,760 in 2006 to a low of 1,479 in 1997 (Figures 3 and 4).

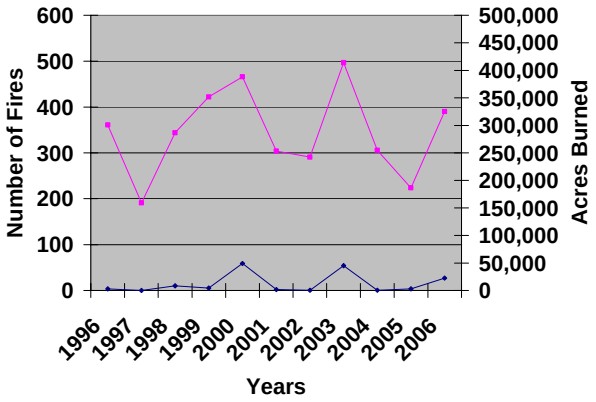


Figure 3: Number of fires (pink) and acres (blue) burned through DNRC's direct protection program from 1996-2006.

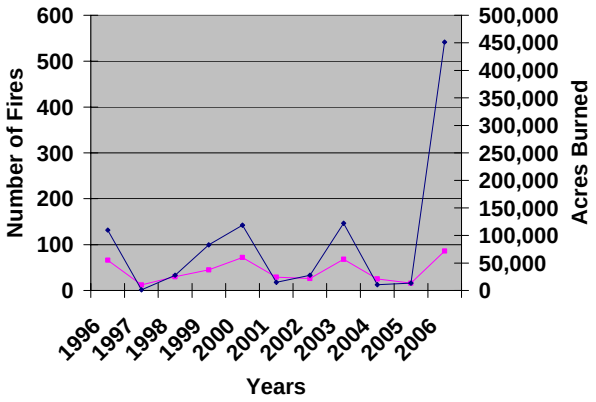


Figure 4: Number of fires (pink) and acres (blue) burned through DNRC's state/county cooperative assistance program from 1996-2006.

Wildland Fire Occurrence in WUI and Non-WUI Areas

Fire report data shows that through the direct protection program 50% more fires occurred in WUI than non-WUI areas during the 1996-2006 periods (Figure 5). This is particularly significant given that only 39% of DNRC's direct protection program is within the WUI. Clearly, significantly more fires occur in the WUI than the non-WUI areas, which is reasonable given that more people live in those areas, increasing the likelihood of human-caused fires.

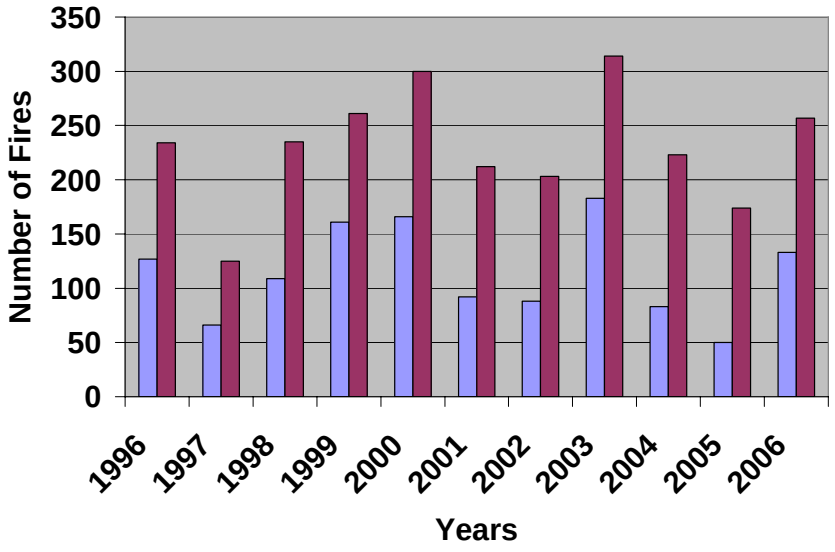


Figure 5: Number of fires occurring in WUI (red) and non-WUI (blue) on DNRC direct protection from 1996-2006.

There were many more human-caused fires in the WUI than the non-WUI areas. Within the WUI areas, 64% were human-caused, with the majority of the causes being

campfires, debris burning, and miscellaneous. Outside of the WUI, only 27% of the fires were human-caused. The number of naturally occurring lightning fires was similar in the WUI and non-WUI areas (Figures 6 and 7).

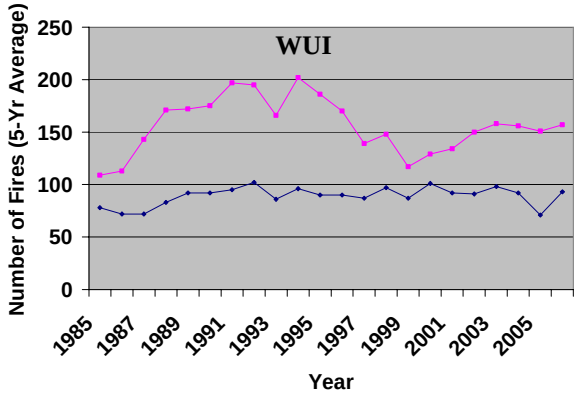


Figure 6. Five-year moving average of natural (blue) and human-caused (pink) fires in the WUI from 1981-2006.

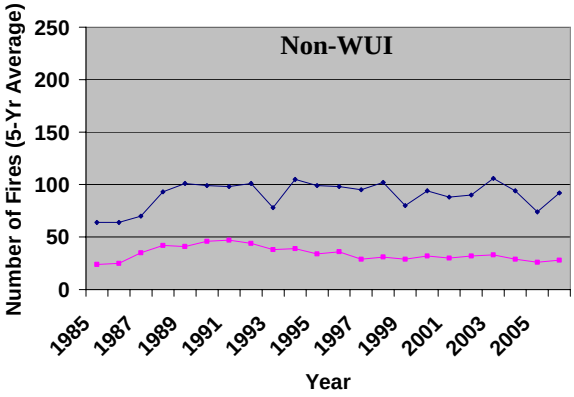


Figure 7. Five-year moving average of natural (blue) and human-caused (pink) fires in the non-WUI from 1981-2006.

While there were more wildland fires in the WUI and a majority of those fires were human-caused, there was not a significant increase in fire occurrence over time during this period. This is somewhat surprising given that the population in Montana grew by over 7% during that period (U.S. Census Bureau) and many of those people were moving into the WUI areas. Potential explanations for this include improved engineering, enforcement, and increased education and awareness. Potentially more important is the increased number of fire departments that develop or expand in conjunction with a growing population. These local fire departments undoubtedly extinguish many smaller fires that were not included in the DNRC databases.

While more wildland fires occur in the WUI, there does not appear to be a strong correlation with the density of structures and the number of fires that occur. However, the data suggests several underlying patterns. The number of human-caused fires surpasses the number of natural-caused fires when structures are present. Natural-caused fires appear to decrease with structure density. This may be due to increased land-clearing and reduced fuel loading that is associated with higher structure density. The top three human-caused fires in the WUI are debris burning, miscellaneous, and campfires. Campfires are the top cause for low structure density (less than 5 per square mile), while debris burning becomes the more common cause with higher structure density (greater than 41 structures per square mile). Railroads, powerlines, equipment, smoking, and arson related causes account for a small proportion of fires in the WUI (Figures 8 and 9).

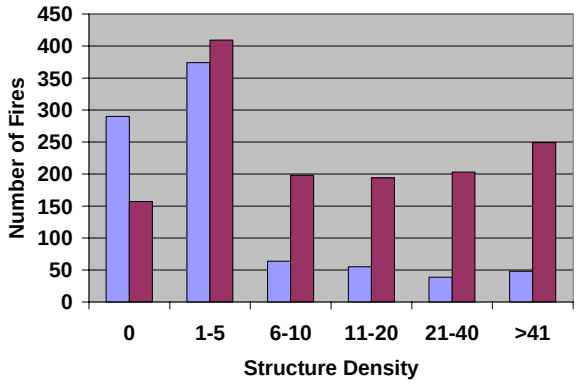


Figure 8. Number of natural (blue) and human-caused (red) fires by structure density (structures per square mile) in the WUI from 1995-2006.

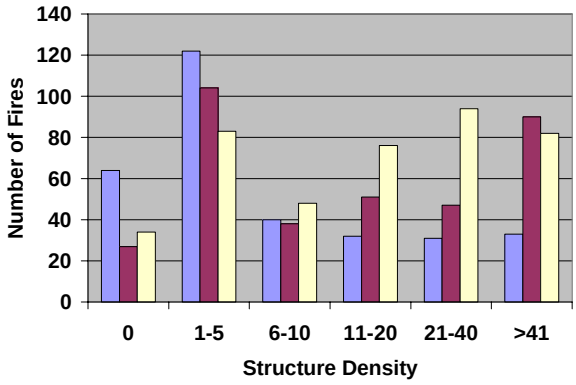


Figure 9. Number of fires by the top 3 human-causes (debris burning [blue], miscellaneous [red], and camp fires [yellow]) by structure density (structures per square mile) from 1995-2006.

The fire report data show that from 1996 to 2006, 95% of fires on direct protection lands were small fires (i.e., 10 acres or less). If we accept that many or most of these fires would have grown considerably larger without an initial attack response this statistic demonstrates the success of DNRC's rapid response initial attack strategy. Surprisingly, the proportion of small versus large fires did not change with respect to whether fires occurred in the WUI or non-WUI. One might expect earlier detection and a quicker response on WUI fires, but this doesn't appear to be the case, or at least does not affect the agency's ability to catch the fire at less than 10 acres (Figures 10 and 11).

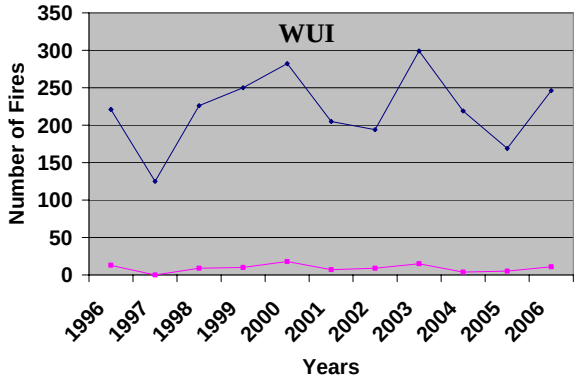


Figure 10. Number of small fires (blue) and large fires (red) in the WUI from 1996-2006.

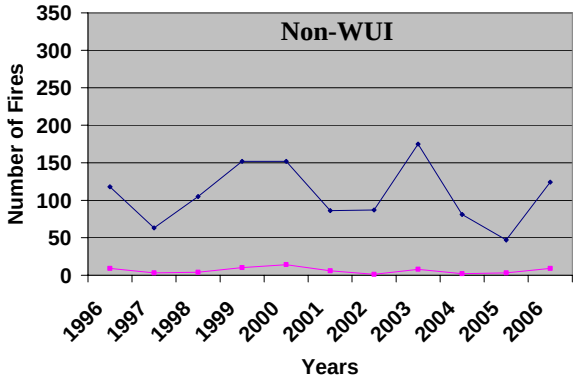


Figure 11. Number of small fires (blue) and large fires (red) in the non-WUI from 1996-2006.

Fire Suppression Costs in WUI and Non-WUI Areas

The fire report data show that for fires occurring on DNRC direct protection from 1996-2006, fires in the WUI cost an average of 46% more to suppress than non-WUI

fires (Figures 12 and 13). WUI fires cost a total of $74.9 million over this period, whereas non-WUI fires cost $51.4 million. This increased cost of fire suppression in the WUI is largely due to the higher costs in the WUI associated with suppressing larger fires. Large fires cost 49% more in the WUI than the non-WUI areas likely due in part to greater costs associated with structure protection – structural fire engines and aviation costs (retardant and helicopters). Structure protection often involves creating buffer zones around the structures by removing vegetation, pre-burning around the structures to remove potential fuels, and pre-treating homes with foam, aluminum wrap, and/or other products. These tactics require additional effort and resources. Small fires in the WUI do not exhibit this same large increase in cost likely because they are controlled before structure protection costs are incurred.

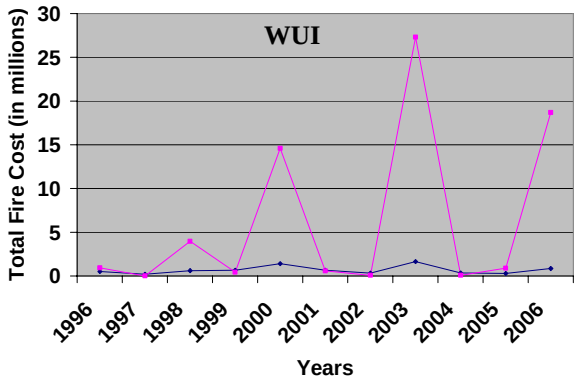


Figure 12. Total fire cost for small (blue) and large fires (pink) in the WUI from 1996-2006.

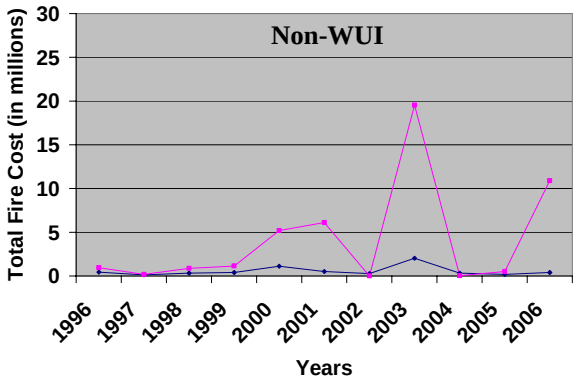


Figure 13. Total fire cost for small (blue) and large fires (pink) in the non-WUI from 1996-2006.

There does appear to be an increasing trend in suppression costs incurred by DNRC from 1996 to 2006. The trend is largely driven by cost of large fires in 2000, 2003, and 2006. During that same period, the cost of small fires remained constant over time.

DNRC's primary suppression strategy is rapid and aggressive initial attack to keep fires as small as possible. The fire cost data shows that this is a justifiable cost containment strategy, since fire cost increases rapidly as the size of fires increase. Small fires (less than 10 acres) cost an average of $4,070 per fire, whereas the largest fires (greater than 5,000 acres) cost 606 times more at over $2.5 million per fire.

Table 2: Fire costs by fire size (1996-2006).

Fire Size (acres)	Number of Fires	Average Cost Per Fire	Increased Cost Over Small Fires
Less than 10 acres (small fires)	3,327	$4,070	n/a
10 to 100 acres	173	$46,505	11
100 to 300 acres	59	$99,833	25
300 to 1,000 acres	66	$190,187	47
1,000 to 5,000 acres	53	$528,070	130
Greater than 5,000 acres	26	$2,465,458	606

When comparing costs of fires on DNRC direct protection to those fires where DNRC provided county assistance, the data shows that the direct protection fires cost 55% more than county-assist fires from 1996 to 2006 (Figure 14). While the county assistance fires represented far more burned acres, 87% of the total numbers of fires suppressed by the DNRC were direct protection fires resulting in higher suppression costs. Once again, however, uncharacteristically large fire seasons in 2000, 2003 and 2006 significantly increased the overall costs from 1996 to 2006.

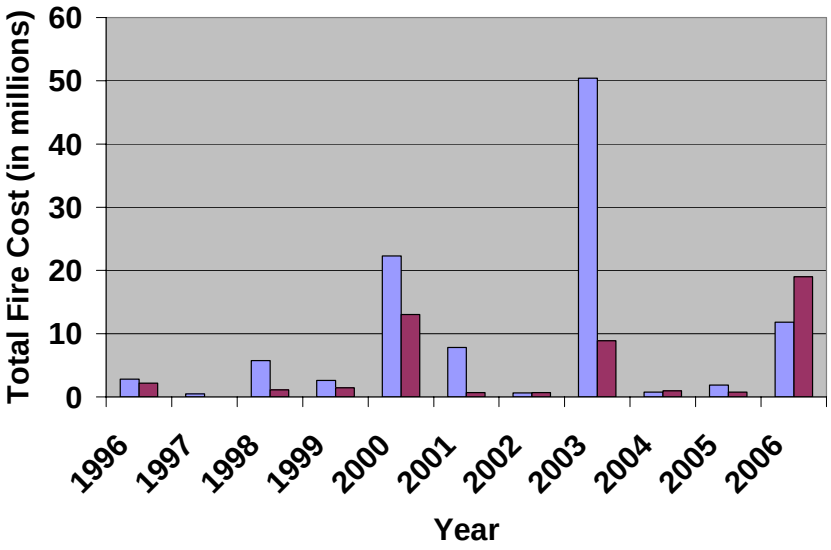


Figure 14. Total fire cost for the DNRC direct protection fires (blue) and county assistance (red) from 1996-2006.

Fire Suppression Tactics in WUI and Non-WUI Areas

The WUI is where human development meets or intermingles with forests and wildland vegetation and therefore where wildfire poses the highest risk to human lives

and property. Due to these increased risks, wildland fire managers often have to change the focus of their suppression tactics from traditional wildland firefighting (offensive) to include structure protection (defensive). This often comes with an increased cost for suppression resources and an increased risk to firefighter safety. The following case studies highlight examples of how the WUI impacts wildland firefighting.

Case Study: The Woodchuck Fire

The Woodchuck fire was a 1,060-acre fire that started east of Florence, Montana in August 2006. As is typical of most WUI fires in western Montana, there were homes scattered throughout a heavily timbered region that had an inadequate road network. The roads were established before there were many home sites and future growth and access for emergency resources was not accounted for in the design. These circumstances pose significant threat for firefighting resources since there is a much greater risk of blocking ingress and egress routes, often which are the same road.

When wildland fires occur in the WUI, home and structure protection become an additional responsibility for wildland fire managers, often taking a higher priority than protecting forest or range resources. By allocating firefighting resources for structure protection, there are fewer resources available to aggressively suppress the fire. This sometimes results in larger fires and the structure protection component of the suppression effort comes with a significantly higher cost.

Fortunately, ample local government structure protection resources were available to respond to the Woodchuck Fire. Therefore, the fire managers did not need to modify their suppression tactics, but rather could easily incorporate a structure component to their suppression tactics. However, air resources were initially directed to cool the areas near structures first, which prevented them from being available to directly attack the head of the fire for the first few hours. Once it was safe to get ground forces in the area, the wildland resources were assigned to work on the wildfire, while structure protection forces were placed at the structures. Two structures were lost to this fire. It is difficult to predict whether the fire would have been smaller had air support not been diverted for structure protection.

While the general philosophy of wildland fire suppression is to make sure firefighters lives are not being jeopardized, there is often an increased safety risk in WUI fires. In addition to the inadequate road access for evacuation of resources, firefighters often assume increased risk when structures are involved in an effort to save lives, homes, and property. There were several examples of this happening on eastern Montana fires the 2006 fires season.

Case Study: Derby and Emerald Hills Fires

The Derby fire was a lightning-caused fire that began on USFS lands and protection on August 22, 2006, approximately 21 miles south of Big Timber, Montana. This fire was initial-attacked by the USFS and local government firefighters. The Derby

fire began as a remote fire in timberland that eventually moved onto private land and into the WUI. While the initial objectives were to control and contain the fire, the initial attack resources (i.e., smoke jumpers) had limited success due to heavy fuels, limited access, and weather conditions. A Type 2 incident management team was assigned to the suppression effort due to the complexity and potential of the fire. A developing weather pattern, along with extremely dry fuels, heavy fuel loadings, extreme fire behavior, and resource shortages challenged suppression efforts. Early assessment was made that structures may become threatened, but no additional resources were available. Fire activity was high across the country (64 large fires) and within USFS Region 1 (seven large fires). In addition, most available resources were initially directed to the nearby Emerald Hills Fire which was burning in the wildland-urban interface and was threatening a number of homes and structures. Within a week of the fire start, a severe dry cold front, with winds in excess of 50 mph moved over the fire, creating extreme fire behavior and pushed the fire down the Stillwater River drainage. By the end, 199,500 acres had burned and 46 structures were lost.

The potential threat of fire spreading onto private lands was identified early on and resulted in coordination with the county volunteer fire departments on contingency plans for when the fire spread into the wildland-urban interface (i.e., Bridger Drainage). When the fire did move into the wildland-urban interface and it was apparent that structures were in the path of the fire, some firefighting resources were re-directed from the direct attack operations in order to engage in structure assessment and protection. When the weather event occurred and it was clear that suppression efforts were no longer effective, additional firefighting resources were pulled back to provide structure protection. The Derby fire was eventually controlled and contained, but it took a break in the fuel types (from timber to grasslands) for suppression efforts to ultimately be effective.

In contrast to the Derby fire was the Emerald Hills Fire, which started on the same day. The fire was a human-caused fire in the Lockwood community on the outskirts of Billings, Montana. Typical of a grassland fuels-type fire in eastern Montana, the Emerald Hills Fire was fast-moving, grew large quickly, but was contained relatively quickly. Heat, lack of moisture, and winds fanned the fire, and within hours about 200 homes in the Emerald Hills subdivision east of Billings were threatened by the fire, with residents evacuated. The fire quickly became the top priority in the Northern Rockies geographic area, and due to the complexity of the situation, a Type 1 incident management team was put in place on the second day of the fire. This fire was clearly a WUI fire from its initial start. It was assessed as having significant structural values at risk from the onset and therefore had significant resources assigned. There was aggressive initial attack and short turn-around time on resource orders. This fire burned 3,800 acres and destroyed a house and other buildings.

CONCLUSIONS

The results in this report show that wildland fires on state protection in Montana occur more often in the WUI than in less populated non-WUI areas. A majority of those

fires are human-caused and are controlled while they are small. However, when they escape into a larger fire, the results also show that the suppression costs are much higher in the WUI than the unpopulated wildland areas. Finally, anecdotal evidence shows that fires in the WUI often require additional resources, modified suppression tactics, and increase the risk to public and firefighter safety.

Given current population trends in Montana, the WUI will continue to expand. According to data in this report, that means we will continue to see a significant number of wildland fires burning into residential communities. Solutions to this problem need to come from policy-makers, fire protection agencies, and communities and people living in the WUI.

Communities should be designed to sustain wildfires. That means considering ingress and egress issues when designing neighborhoods, planning ahead for firefighting water sources, and implementing Firewise principles and standards for residential and commercial development in WUI areas. Hazardous fire fuels within and adjacent to WUI areas need to be treated through fuels reduction projects. Landscape-level treatments of large ownerships adjacent to WUI areas will likely provide a sound return on investment if they effectively reduce fire behavior on WUI fires.

Wildland fire suppression agencies need to collectively consider the impact WUI fires have on suppression resources and costs and incorporate those issues into wildfire planning. A shift in federal policy on suppressing WUI fires could have dramatic impacts on DNRC and other state fire protection programs. DNRC needs to work diligently to maintain or improve the success of the initial attack program, as that appears to be critical for controlling fires while they are small and thereby minimizing suppression-related costs. The fire suppression community also needs to recognize and support the critical role local government fire departments play in suppressing WUI fires.

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