Roads and Wildfires

Ignition Point for the Command 24 Fire of July 2000, near Hanford, Washington. Looking south along Highway 24.

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Roads closed by wildfire in Southern California.

Executive Summary

This report explores that relationship between roads and wildfires. This relationship is not as simple as it first appears. An adequate understanding of this relationship is critical to informed decisions on how to manage wildfires in the western United States. Some have argued that building more roads across public land would give firefighters critical access needed to quickly control wildfires before communities and natural resources were threatened. "Roads are not only crucial in fighting forest fires but also in promoting forest health," said Matt Raymond, chief of staff to US Congressman Rick Hill, Montana (Environmental News Network, 2000). But we have found that the facts do not line up behind the rhetoric.

While it seems reasonable to assume that building new roads would reduce wildfire risk, we discovered ample evidence to the contrary. This report examines the relationship between roads and wildfires. We examine the role that roads play in fire ignitions, the role that roads play in providing access and the role that roads play as fire breaks. We use Geographic Information System (GIS) analysis to examine the spatial relationship between roads and wildfires across the conterminous US and in individual major fires. To conduct this analysis we overlaid wildfire and road databases that have been compiled by federal and state agencies.

Our examination of the spatial relationship of roads to wildfires we found that 88% of all wildfires nationwide are caused by humans. Of these human-caused wildfires, 95% occurred within ½ mile of a road. Over 90% of all wildfires from all causes occurred within ½ mile of a road. We found that there was an extremely significant relationship between fire occurrence and distance from the nearest road. Areas that are very close to roads have many times more wildfire occurrences than areas distant from roads. We discovered that less than 3% of all wildfires start in wilderness or backcountry areas more than 2 kilometers (about 1.24 miles) from a road.

We examined whether roads enable wildfire ignitions, by providing access to humans who start the vast majority of wildfires. Our analysis revealed that human-caused wildfires occur much more commonly next to roads than would be predicted by random occurrence across the landscape. Nationwide, over 53% more wildfires occur in the zone closest to roads (the first 200-meters) than would be predicted by a random distribution. In road distance zones that are further from roads, there are many fewer wildfire occurrences than would be predicted by random occurrence. All these results are highly statistically significant. Our analysis provides extremely strong evidence that road access is a significant contributing factor in the probability of occurrence of wildfires.

We also examined whether these results hold up for individual western States. In Washington State the relationship between human-caused wildfire occurrence and distance from road was actually stronger than in the US in general. Sixty-nine percent of the human-caused wildfires were within 200-meters of a road and over 96% were within ½ mile of a road. In Arizona over twice as many wildfires occur in the zone closest to roads (the first 200-meters) than would be predicted by a random distribution.

From this spatial analysis, we conclude that the existing high density of roads throughout most of the conterminous US and the high rates of human-caused wildfire ignition enabled by roads creates a situation where nearly all wildfires originate near roads.

We also tackle some fundamental questions regarding the effectiveness of building new roads to control fires. Examination of how actual wildfires have ignited and progressed in relation to roads reveals that roads often do not serve as effective firebreaks. The access provided by roads often appears to have an insignificant effect on the ability of firefighters to control large fires. Current road systems increase risk of human-caused fire. In contrast, areas that are distant from roads have significantly less human-ignited fires.

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Introduction

It has been argued that building more roads across public land would give firefighters critical access needed to quickly control wildfires before communities and natural resources were threatened. During the 2000 wildfire season, Montana governor Mark Racicot and US Congressman Rick Hill denounced the proposal by President Bill Clinton and the US Forest Service to ban road building within over 58 million acres of national forest land. "Roads are not only crucial in fighting forest fires but also in promoting forest health," said Matt Raymond, chief of staff to Hill (Environmental News Network, 2000). In January 2001, a Roadless Area Conservation Rule enacted by the Forest Service to protect undeveloped National Forest land from logging and road building led to increased debate. A July 16, 2002 letter from US Congressman Scott McInnis opposing legislation to codify the Roadless Rule declared that if the rule were codified, "Hundreds of millions of adjacent areas of valuable timber, homes, and other infrastructure assets would be placed at peril."

While it seems reasonable to assume that building new roads would reduce wildfire risk, we discovered ample evidence to the contrary. This report examines the relationship between roads and wildfires and the role that roads play in fire ignitions. We use Geographic Information System (GIS) analysis to examine the spatial relationship between roads and wildfires more closely. We also tackle some fundamental questions regarding the effectiveness of building new roads to control fires. We examine how several major wildfires were ignited and how they progressed in relation to roads during the last decade. We discuss the role that roads play in the ignition of these fires and whether roads served as effective firebreaks. We also discuss whether the access provided by roads had a significant effect on the ability of firefighters to control these large fires.

How do most fires start?

According to the National Interagency Fire Center (www.nifc.gov), during the 10-year period between 1988 and 1997, over 88% of all wildfires were human-caused. The human causes of wildfires include debris burning, arson, careless smoking, equipment use, ignition related to vehicle collisions or malfunctions, ignition from electrical transmission lines, ignition related to railroads, children's activities, etc.

We also analyzed of the National Fire Occurrence database of 976,032 wildfires occurring in the conterminous US during and 11-year period from 1986 to 1996. These results are similar, but break down the cause of the fires into more specific causes (Table 1). Once again, the vast majority of fires are of human origin and less than 15% are from lightning.

Table 1. Causes of 976,032 wildfires occurring in the US during an 11-year period from 1986 and 1996.

Cause	Percent of All Fires
Debris burning (logging slash, fields, trash, etc.)	23.9%
Incendiary (Arson)	18.4%
Lightning	14.7%
Miscellaneous human activities	11.4%
Equipment use	7.8%
Unknown	7.6%
Smoking	5.3%
Children	5.3%
Railroad	2.9%
Campfires	2.5%

Prior studies have indicated that the majority of these human-caused fires start along road systems and spread through roaded landscapes. In an analysis of 20th century fire, the Sierra Nevada Ecosystem Project (Busse and McKelvey 1996) reported that, "the location of multiple-burn sites indicated that they were associated with busy roads." This study suggests that most human-caused wildfires start in or right next to vehicles, making roads a primary contributing cause.

Many of the large fires that dominated the news in the last three years have been human-caused fires that started next to roads. Examples of major fires that were started next to roads include the 2003 Southern California fires (over 500,000 acres), the 2002 Rodeo and Chediski fires in Arizona (468,000 acres), the Hayman fire in Colorado (138,114 acres). These and other fires are discussed in more detail later in this paper.

The spatial relationship between roads and wildfires

Methods

We examined the spatial relationship between wildfires and roads by mapping wildfire fire occurrence locations (both natural and human-caused) and their proximity to roads across the conterminous United States. For this analysis, we used wildfire occurrence information developed by federal, state and local agencies. This data was compiled, reviewed, and corrected by a US Forest Service research team (Schmidt et al 2002). The fire occurrence location data covers all fires that the USFS research team was able to obtain that had reasonably accurate locations during the period from 1986 to 1996. The fire occurrence data contains information about the cause of each fire, its location and other useful information.

We gathered road data from federal and state agencies to create a comprehensive road database for the United States (Figure 1). This road GIS database contains nearly all major and minor roads that are passable by 2-WD vehicles. Some minor roads (especially on private land) and many 4-WD tracks are not included in this GIS road layer.

How far is the nearest road?

From the road location data, we generated a proximity to road GIS layer that records the proximity to the nearest road in 200-meter increments. Nearly 40% of the land area in the conterminous United States is currently within 200-meters (about 1/8 of a mile) from a road (Figure 2). Nearly 84% of the land area in the conterminous US is within 800-meters (about ½ mile) of a road. Only about 4% of the conterminous US is over 2000-meters (1.24 miles) from a road. It is obvious from the map of roads of the US and this proximity analysis that we have built roads to nearly every location in the lower 48 states. Many minor roads and 4-WD tracks and other vehicle accessible areas (agricultural fields, parking lots, etc.) are not included in this analysis. It is literally possible to drive a vehicle very close to nearly all locations in this country (except for Alaska).

The fact that the vast majority of the conterminous US is in close proximity to a road is highly relevant to the wildfire issue. Fire fighters usually have very good road access to wildfire ignition points. There are also abundant roads throughout the landscape to use as firebreaks or staging locations for firefighting efforts. But despite these facts, many fires spread rapidly and quickly overwhelm suppression efforts. We will see later in this paper many examples where the easy access provided by roads and the ample opportunity to use roads for firebreaks did not prevent many of the largest and most disastrous fires that have swept across parts of the western US in the last decade.

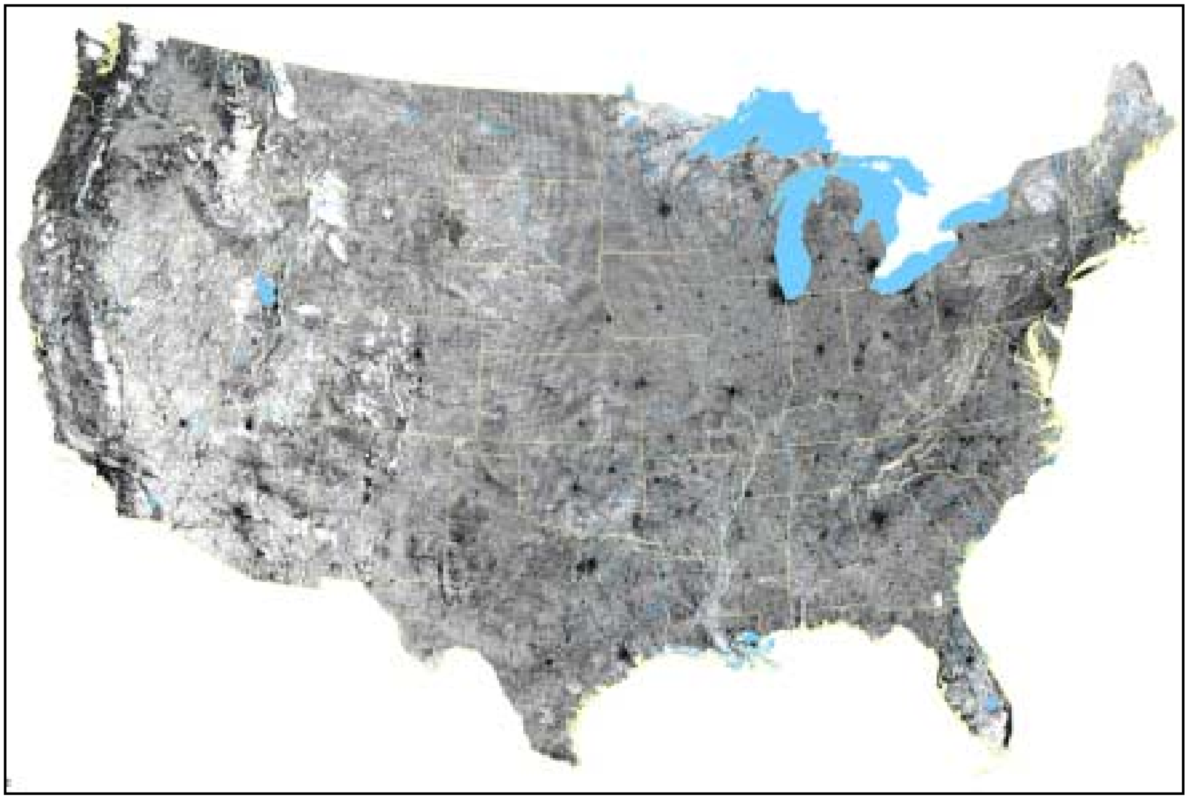

Figure 1: Map showing all roads in the United States

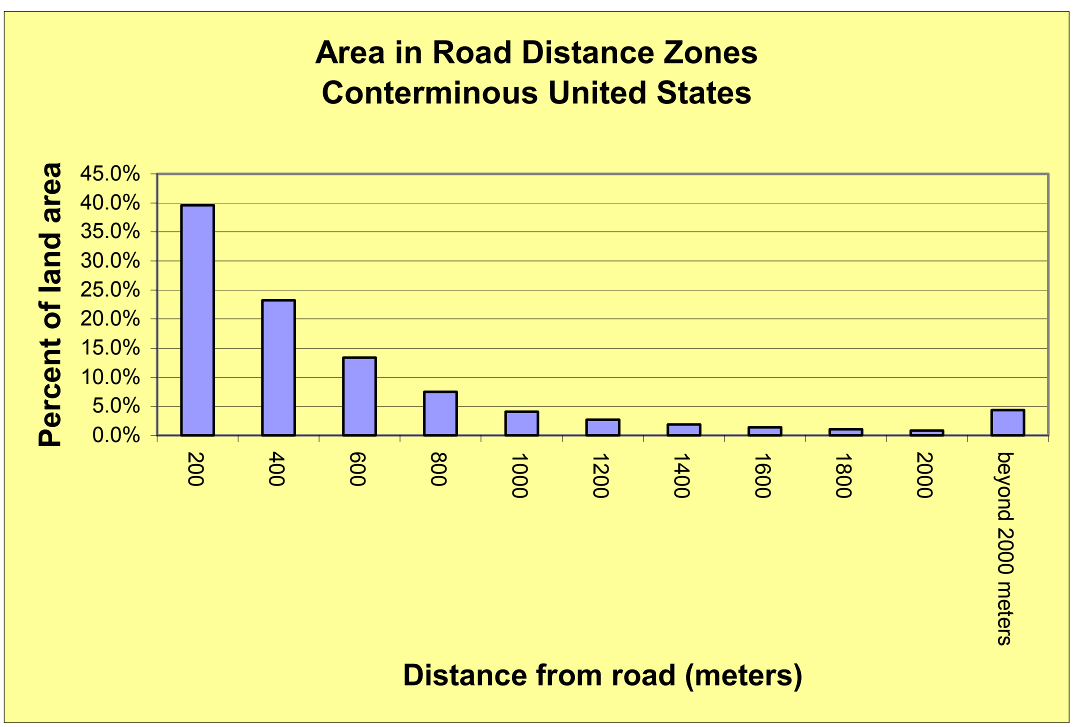

Figure 2. Area in the conterminous United States in progressive distance zones from the nearest road.

How are wildfire occurrences distributed in relationship to roads?

To determine the spatial relationship between wildfire occurrences and roads we overlaid fire occurrence data for the conterminous US on the road proximity data. Through this process, we determined the proximity of each fire occurrence to the nearest road. The results of this overlay were then analyzed to determine the road distance distribution for all the fires segregated by cause of fire.

The results of this analysis are quite startling. 94.9% of human-caused wildfires in the conterminous US (lower 48 states) occur within 800-meters (about ½ mile) of the nearest road. 60.7% of human-caused wildfires occur within the first 200-meters (about 1/8th mile) from the nearest road (Figure 3). Because the vast majority of wildfires are human-caused, the statistics for all fires (including those caused by lightning and from unknown causes) is similar. 90.1% of all wildfires (from all causes) in the conterminous United States occur within 800-meters of a road and 55.3% occur within 200-meters of the nearest road.

A statistical analysis of these results indicates that they are highly significant. Using linear regression analysis, we determined that there is a highly significant relationship between the number of fires and distance from road. They are strongly negatively correlated and 99.17% of the variation in the number of fires can be explained by distance from road (r-squared value of .9917, F 953.77, p-value <.0001). This means that there is an extremely high likelihood that human-caused fires will occur close to roads.

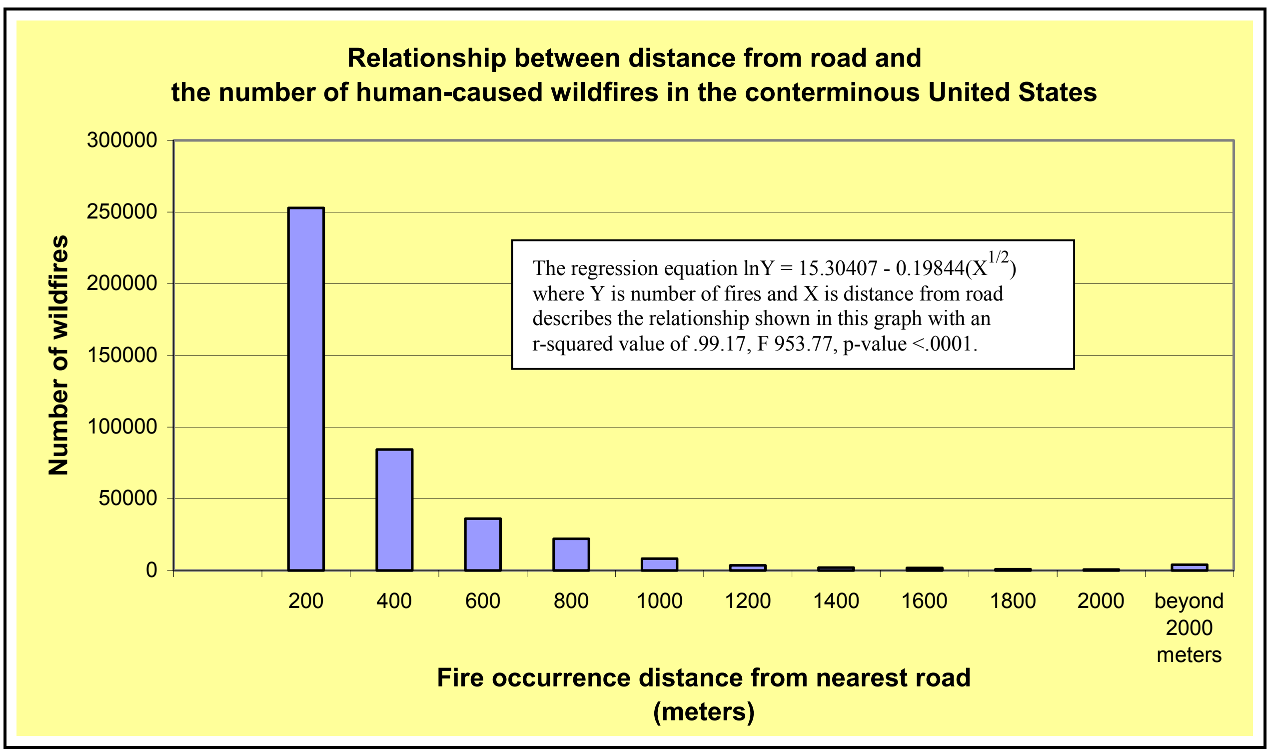

Figure 3: The number of human-caused wildfire occurrences in the conterminous United States vs. distances from nearest road.

Do Roads Enable Wildfire Ignitions?

To determine whether roads enable human-caused wildfire ignitions, therefore promoting higher levels of fire activity than would be expected if human-caused fire activity was randomly distributed across the landscape we compared the observed wildfire occurrence road proximity to what would be expected from a random distribution of wildfires (where the expected number of wildfire occurrences in a road proximity zone would be proportional to the overall area of that zone in relationship to the area of the conterminous US).

The results of this analysis clearly show that human-caused wildfires occur much more commonly next to roads than would be predicted by random occurrence across the landscape (Table 2). Over 53% more wildfires start in the zone closest to roads (the first 200-meters) than would be predicted by a random distribution. In road distance zones that are further from roads, there are many fewer wildfire occurrences than would be predicted by random occurrence. In areas over 1600-meters from a road the occurrence of human caused fires is 78% less than would be predicted by random occurrence. A statistical analysis of these results (Appendix 2) indicates that our results are highly significant (chi-squared value is 64730 with 10 degrees of freedom - extremely significant with $p<.0001$). This analysis provides extremely strong evidence that road access is a significant contributing factor in the probability of occurrence of human-caused wildfires.

Table 2. Occurrence of Human Caused Wildfires in the Conterminous US in Relationship to Distance from Road.

Distance from road (200 meter wide zones)	Percent of land area	Occurrence of human-caused fires	Increase (or decrease) in occurrence over that predicted by random fire occurrence proportional to the area in the road distance zone
0 - 200	39.6%	60.7%	53.3%
201 - 400	23.2%	20.3%	-12.8%
401 - 600	13.4%	8.7%	-35.5%
601 - 800	7.5%	5.3%	-29.4%
801 - 1000	4.1%	2.0%	-51.3%
1001 - 1200	2.7%	0.8%	-68.7%
1201 - 1400	1.9%	0.5%	-74.1%
1401 - 1600	1.4%	0.4%	-70.6%
1601 - 1800	1.1%	0.2%	-78.6%
1801 - 2000	0.8%	0.2%	-78.2%
beyond 2000 meters	4.3%	1.0%	-77.7%

Do These Results Hold Up In Western States?

We tested this data to see whether the strong relationship between wildfire occurrence and distance to the nearest road held up in western states where there are fewer roads and a significant amount of unroaded area. We selected two states (Arizona and Washington) that contained relatively large amounts of wilderness and sparsely roaded land for this test.

In Washington State the relationship between human-caused wildfire occurrence and distance from road was actually stronger than in the US in general (Figure 4). Sixty-nine percent of the human-caused wildfires were within 200-meters of a road and 96.2% were within 800-meters of a road. For all wildfires (including lightning–caused fires), 62.4% of the wildfire occurrences were within 200-meters of a road and 91.4% were within 800-meters of a road. This is very significant, since Washington State contains over 16.8 million acres (27.1% of the state) of unroaded land (Pacific Biodiversity Institute, unpublished data).

In Washington State, we examined the occurrence of human-caused fires compare to that expected by random occurrence proportional to the area in road distance zones. This analysis clearly shows that the same relationship that was described in our nation-wide study applies to this northwestern state. Human-caused wildfires occur much more commonly next to roads than would be predicted by random occurrence across the landscape (Table 3). Over 45% more wildfires occur in the zone closest to roads (the first 200-meters) than would be predicted by a random distribution. In road distance zones that are greater than 200-meters from roads, there are many fewer wildfire occurrences than would be predicted by random occurrence. A statistical analysis of these results (Appendix 3) indicates that our results are highly significant (chi-squared value is 3682 with 10 degrees of freedom - extremely significant with p<.0001). This analysis provides extremely strong evidence that road access is a significant contributing factor in the probability of occurrence of human-caused wildfires.

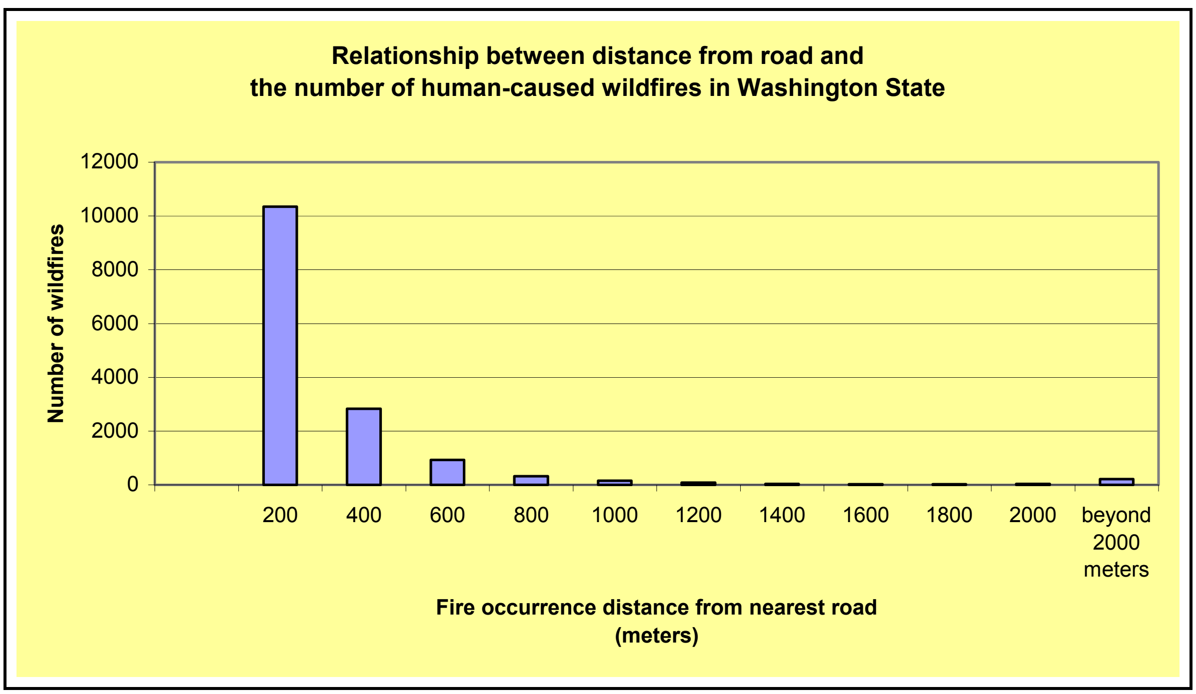

Figure 4: The number of human-caused fire occurrences in Washington State vs. distances from nearest road.

Table 3. Occurrence of Human Caused Wildfires in Washington in Relationship to Distance

Distance from road (200 meter wide zones)	Percent of land area	Occurrence of human-caused wildfires	Increase (or decrease) in occurrence over that predicted by random fire occurrence proportional to the area in the road distance zone
0 - 200	47.4%	69.0%	45.7%
201 - 400	19.4%	18.9%	-2.6%
401 - 600	9.8%	6.2%	-36.9%
601 - 800	5.6%	2.1%	-62.0%
801 - 1000	3.2%	1.0%	-67.2%
1001 - 1200	2.0%	0.5%	-73.9%
1201 - 1400	1.3%	0.3%	-80.0%
1401 - 1600	0.9%	0.2%	-79.5%
1601 - 1800	0.7%	0.1%	-79.4%
1801 - 2000	0.6%	0.2%	-63.7%
beyond 2000 meters	9.1%	1.4%	-84.3%

In Arizona nearly 54% of all human-caused wildfire occurrences were within 200-meters of a road and over 90% of the human-caused wildfire occurrences were within 800-meters of a road (Figure 5). Because lightning-caused wildfires are much more frequent in Arizona 46.8% of wildfires from all causes occurred within 200-meters of a road. But 83.8% of all fires were still within 800-meters of a road. Arizona has fewer roads and lightning-caused fires are more frequent than in Washington State.

We examined the occurrence of human-caused fires in Arizona compare to that expected by random occurrence proportional to the area in road distance zones. This analysis clearly shows that the same relationship that was described in our nation-wide study also applies to this southwestern state. Human-caused wildfires occur much more commonly next to roads than would be predicted by random occurrence across the landscape (Table 4). Over 100% more wildfires occur in the zone closest to roads (the first 200-meters) than would be predicted by a random distribution. In road distance zones that are greater than 400-meters from roads, there are many fewer wildfire occurrences than would be predicted by random occurrence. A statistical analysis of these results (Appendix 4) indicates that our results are highly significant (chi-squared value is 11225 with 10 degrees of freedom - extremely significant with $p<.0001$). This analysis provides extremely strong evidence that road access is a significant contributing factor in the probability of occurrence of human-caused wildfires.

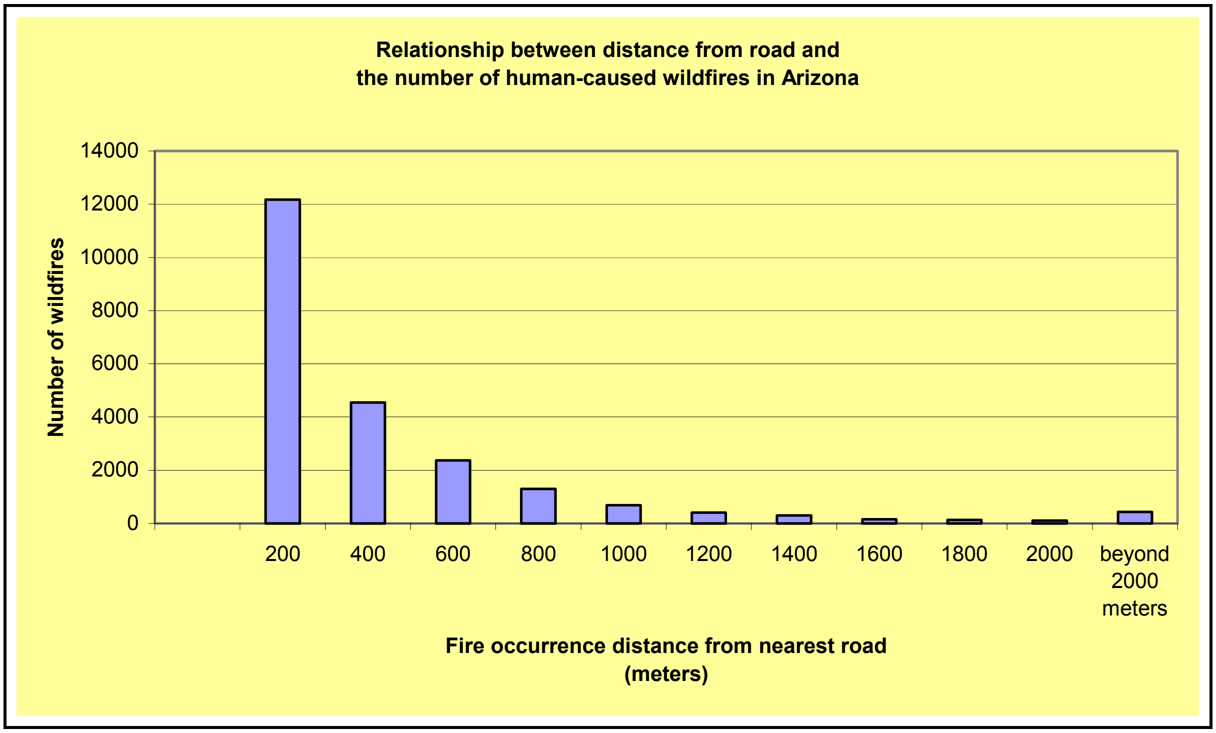

Figure 5: The number of human-caused fire occurrences in Arizona vs. distances from nearest road.

Table 4. Occurrence of Human Caused Wildfires in Arizona in Relationship to Distance from Road.

Distance from road (200 meter wide zones)	Percent of land area	Occurrence of human-caused wildfires	Increase (or decrease) in occurrence over that predicted by random fire occurrence proportional to the area in the road distance zone
0 - 200	26.9%	53.8%	100.2%
201 - 400	16.2%	20.1%	24.3%
401 - 600	11.3%	10.5%	-7.2%
601 - 800	8.4%	5.7%	-31.4%
801 - 1000	6.4%	3.1%	-52.1%
1001 - 1200	5.0%	1.8%	-64.4%
1201 - 1400	4.0%	1.3%	-66.6%
1401 - 1600	3.2%	0.7%	-78.7%
1601 - 1800	2.6%	0.6%	-78.3%
1801 - 2000	2.2%	0.5%	-79.0%
beyond 2000 meters	13.8%	1.9%	-86.0%

Wildfires in Wilderness or Backcountry Areas

It should be noted that nationwide less than 3% of all wildfires start in wilderness or backcountry areas more than 2 kilometers (about 1.24 miles) from a road. Human-caused fires are less than 77% as likely to occur in these wilderness and backcountry areas than would be predicted by random occurrence. This trend is even stronger in western states like Washington and Arizona where wildfires are 84 and 86% (respectively) less likely to occur in the backcountry than would be predicted by random occurrence. In these states, despite the fact that a significant portion of each state is wilderness and unroaded land only about 4% of all wildfire occurrences (including lightning) are over 2 kilometers from a road.

From this analysis, we can conclude that the existing high density of roads throughout most of the conterminous US and the high rates of human-caused wildfire ignition enabled by roads creates a situation where nearly all wildfires originate near roads. Very few wildfires originate in backcountry areas. The argument that we need to build more roads to be able to better suppress wildfires does not stand up to the results presented in this analysis.

In order to further evaluate the policy of road building as a fire prevention strategy, it is necessary to look at the record from past fires. The following section of this report analyzes the effect that road systems have had on the ignition and behavior of some of the prominent wildfires in the last decade. So what is the track record of the existing dense road network in preventing and controlling wildfire?

Examples From Recent Wildfires

To better assess the relationship between roads and wildfires, we examine some of the largest and most destructive wildfires that have occurred in the last decade. The first group of wildfires that we examine includes large human-caused wildfires or fire complexes that start near roads and then spread rapidly across densely roaded landscapes. Next, we examine a set of wildfires fires that were caused by lightning, but spread rapidly through densely roaded landscapes and had good road access to the ignition location. The last set of fires that we examine are human-caused fires that start near or on a road and then spread into wilderness, roadless areas, or sparsely roaded landscapes.

Examples of large human-caused fires that started near roads and then spread rapidly across dense road networks

Southern California Fires, October 2003

A series of 15 wildfires swept across southern California in late October and early November 2003. Humans started all of these fires and arson is suspected for most of the fires. These fires burned more than 750,000 acres. According to the San Bernardino Fire Information Joint Information Center and the California Department of Forestry and Fire Protection, 3,640 homes, 33 commercial properties, and 1,141 other structures were destroyed by these fires (Figure 6). There were 22 fatalities attributed to this group of fires.

These wildfires burned largely through open terrain covered with brush and grass. Most of the land that burned was not forested. The strong Santa Ana winds that initially drove these fires, caused the fires to spread rapidly across this open terrain.

In many cases, roads proved to be ineffective fire breaks. The fires even swept across six lane freeways and interstate highways in multiple cases (Figures 7-9). Many roads were closed to all traffic due to the fact that they were engulfed by the wildfires.

Most of the fire ignition locations were adjacent to roads. There are over 3100 miles of roads within the perimeters of these fires (Figure 10). The average road density in the fire area is 2.67 miles of road per square mile. There was good road access throughout most of the fire area.

Figure 6. A few of the 3,640 homes that burned in subdivisions with dense road networks during the October 2003 wildfires in southern California.

Figure 7. Spot 5 satellite image illustrating overburn of Interstate 8 by the Cedar Fire, October 2003.

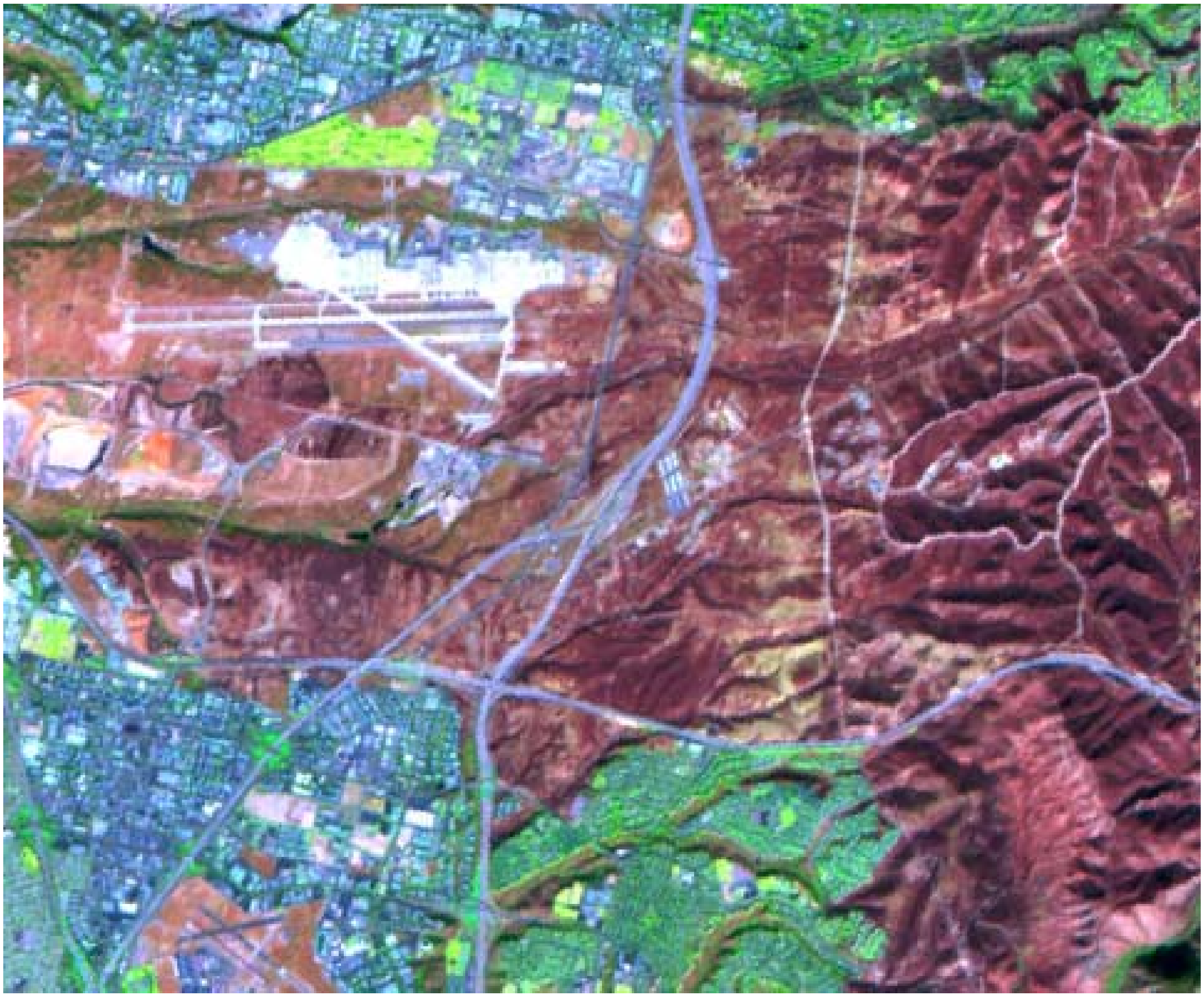
Figure 8. Overburn of freeways and major highways, Cedar Fire, October 2003.


Figure 9. Satellite image of Simi Fire showing overburn of roads and subdivisions, October 2003.

Rodeo-Chediski Fire, Arizona, 2002
The Rodeo and Chediski Fires were human-caused fires that started on roads in the White Mountain Apache Indian Reservation in Arizona on June 18 and June 20, 2002. Together, they burned a total of over 468,000 acres of ponderosa pine forest, pinyon-juniper woodlands, and non-forested land.

Most of the Rodeo-Chediski Fire Complex was densely networked with roads (Figure 10). Over 2,140 miles of logging and multi-use roads existed within the perimeter of the fire (Morrison and Harma 2002). The fire crossed one state highway and several major roads. The density of roads within the fire perimeter is nearly 3 miles of road per square mile. In many places the fire crossed over 25 roads before reaching its final perimeter. Road access to the fire ignition points and ample road access throughout the fire area did not prevent this fire from becoming the largest in recent Arizona history and one of the largest and most destructive fires in our nation's history. This fire eventually destroyed over 500 structures in and near the communities of Aripine, Linden, Overgaard, Pinedale, and Show Low (Figure 11).

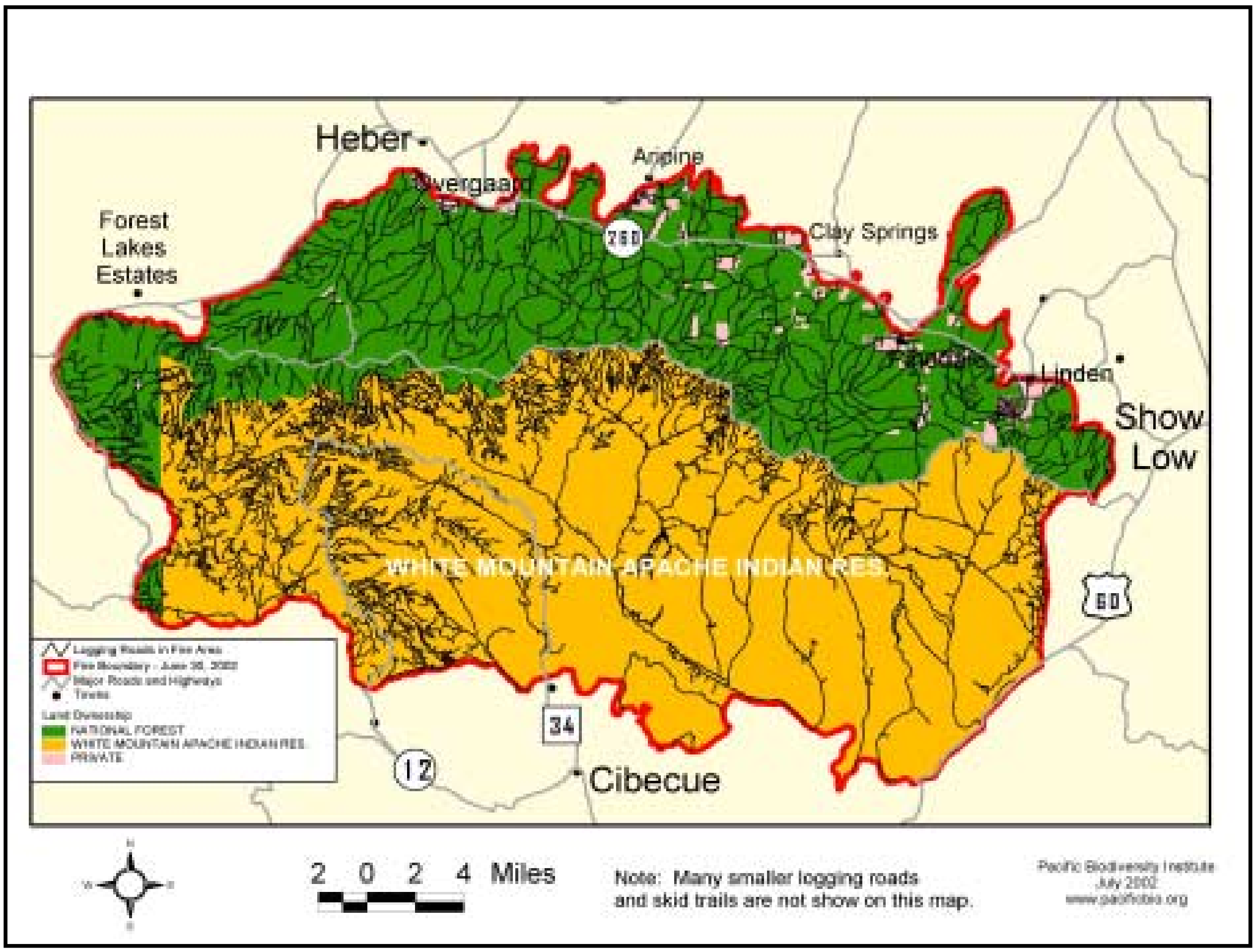

Figure 10. Network of logging roads and other roads in the Rodeo-Chediski Fire Area, Arizona, as of June 30, 2002 (Morrison and Harma 2002).

Figure 11. Remains of three of the homes destroyed in a subdivision with high road density by the Rodeo-Chediski Fire Complex. (Photo Credit: Peter Morrison, August 2002)

Hayman Fire, Colorado, 2002

The Hayman Fire was ignited on June 8, 2002 by a Forest Service employee (convicted of arson) in a campground accessible by road. The fire burned 138,114 acres southwest of Denver, Colorado. Before it was over, the Hayman Fire destroyed 133 homes, 1 commercial building and 466 outbuildings.

The fire was subject to an intensive post-fire study and assessment (Graham 2003). Approximately 426 miles of road were within the fire perimeter including two state highways (Figure 12). The average road density within the burn area was 1.8 miles per square mile. There was ample road access to the fire ignition location and to most parts of the fire area.

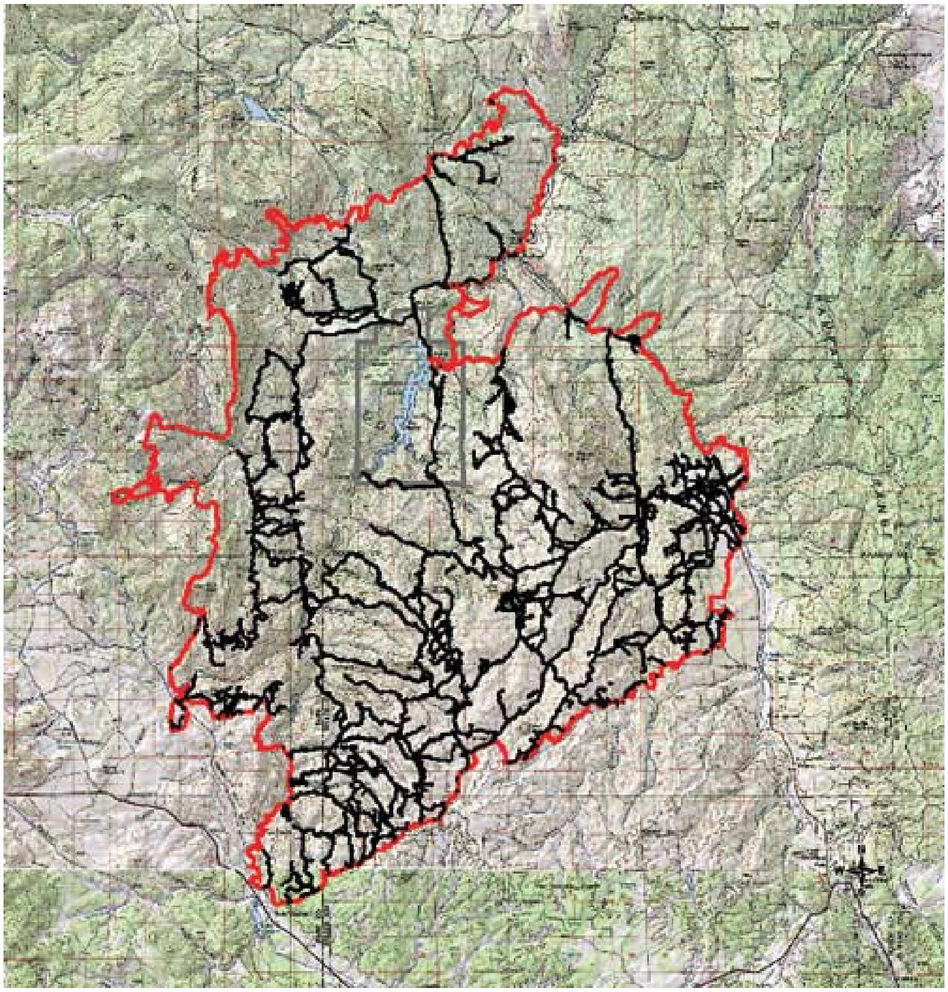

Figure 12. Road network within the Hayman Fire perimeter. Red line is fire perimeter; black lines are roads (McHugh and Finney 2003).

The Jasper Fire, Black Hills National Forest, South Dakota, 2000

The Jasper Fire was one of the large fires that swept through heavily roaded and managed landscape in the year 2000 (Figure 13). This fire was caused by arson along US Highway 16 in an area of very high road density due to logging and thinning activities (Figure 14) (Morrison et al 2000). The fire burned very rapidly in this actively managed forest and in several days burned 83,510 acres. "This has been a very actively managed area," said Sharon Kyhl, acting public-affairs officer for the Black Hills National Forest. “The Jasper Fire area has been logged and thinned recently” Kyhl said (Miller 2001).

The Final Environmental Impact Statement on salvage logging of the fire area aptly describes the existing road network in the fire area: “There are approximately 508 miles of roads within the perimeter of the fire, or about 4 miles of road per square mile of land. Included in this total are 31 miles of arterial roads, 67 miles of collector roads, and 409 miles of local (non-system or two-track) roads” (USDA Forest Service. 2001). The excellent road access to the fire ignition point and the dense road network throughout the fire area were ineffective in controlling this fire (Figure 15). As noted by the Forest Service, the extensive logging and thinning that had been conducted in the area also did nothing to prevent this fire from developing into an enormous firestorm (Figure 13).

Figure 13. Convection cloud of smoke from Jasper Fire, August 26, 2000. *Photo by Cissie Buckert*

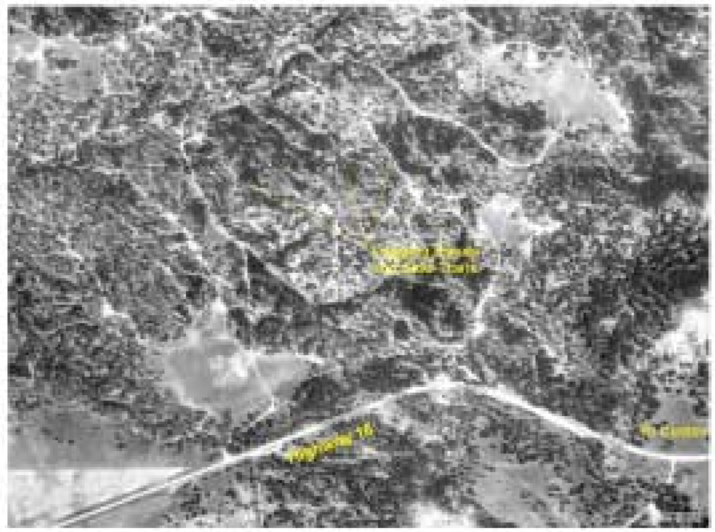

Figure 14. Digital Orthophoto of area to the north of Highway 16, near the ignition point. This area is crisscrossed with skid trail and roads. It has been recently logged and thinned (Morrison et al 2000).

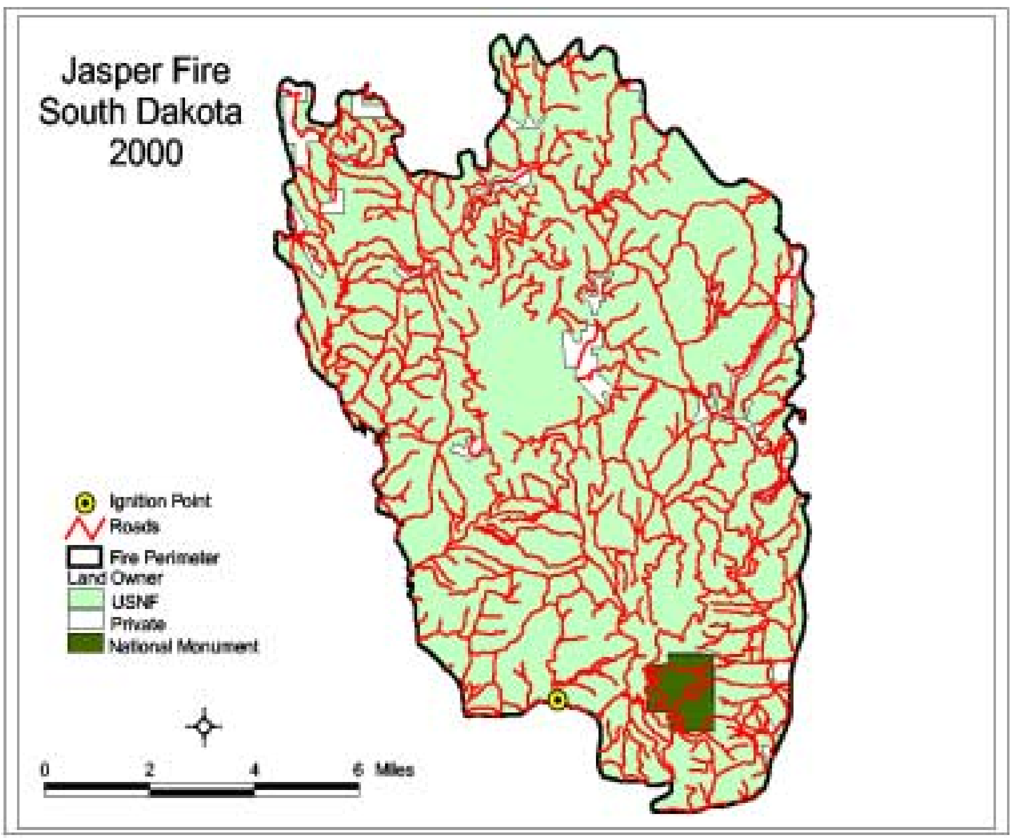

Figure 15. Jasper Fire, South Dakota. This map shows the fire perimeter in relation to the fire ignition point and roads (Morrison et al 2000). Note the dense road network throughout the fire area.

Examples of wildfires that were caused by lightning, but spread rapidly across densely roaded landscapes.

The Valley/Skalkaho Complex, Bitterroot National Forest, Montana, 2000
The largest fire complex during the year 2000, the Valley/Skalkaho Complex was ignited in an intensely roaded landscape managed for grazing and timber production. It burned primarily through parts of the Bitterroot National Forest, Darby Lumber Company land and land owned by the State of Montana. Over 213,000 acres were burned in one of Montana's largest fire events.

The fires in this complex blazed across hundreds of roads before containment. Extensive road access and road/firebreaks did not play a significant role in prevention or control of one of the largest fires in Montana's history. There are 1,645 miles of roads within the fire perimeter. The average road density in the fire area exceeded 5 miles of road per square mile.

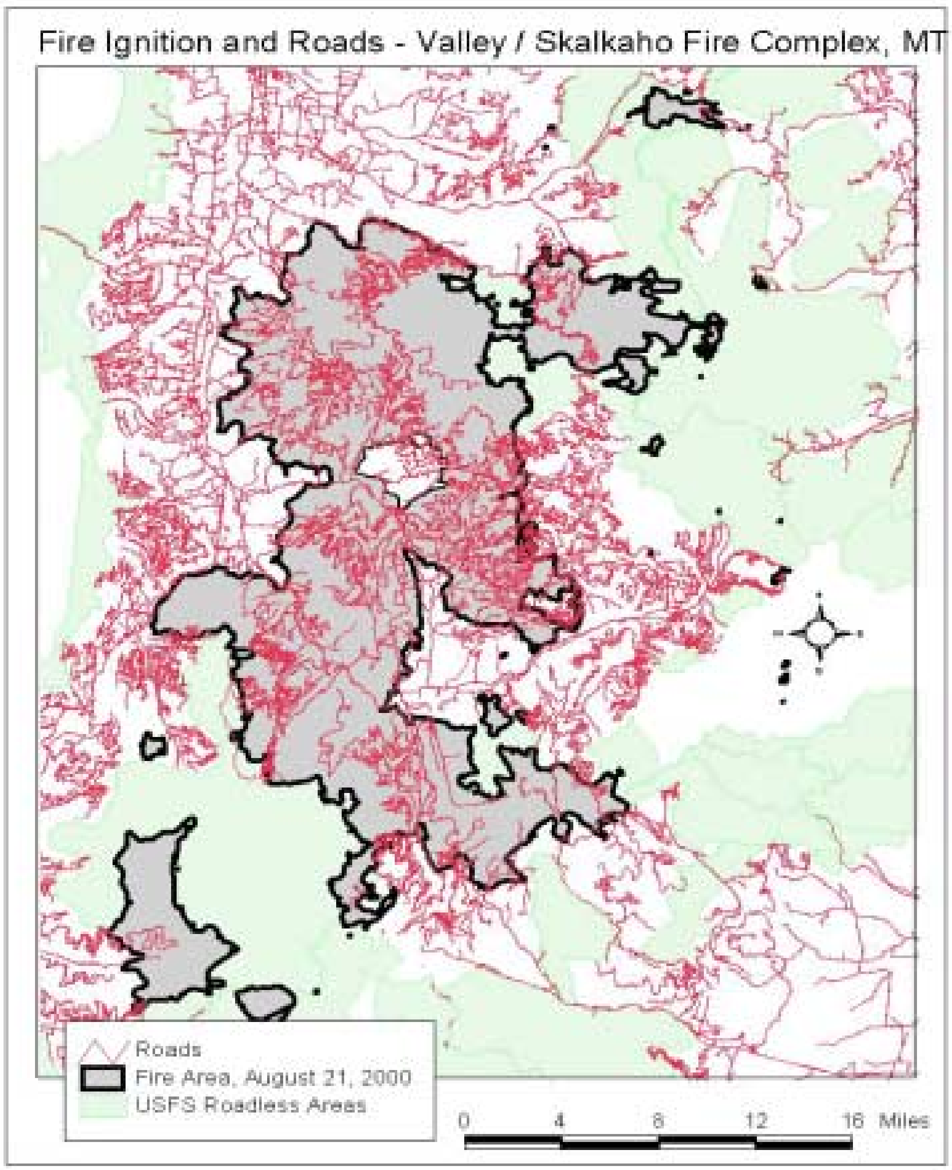

Figure 16. The Valley/Skalkaho Fire Complex, Montana, 2000 in relation to roads (Morrison et al 2000).

Moose Fire, Montana, 2001

The Moose Fire, ignited by lightning on August 15, 2001, burned through portions of the Flathead National Forest in northern Montana. Roads and clear-cuts characterize the landscape where this fire spread and gained intensity. Despite the fact that most of the initial burn area was accessible by a dense network of logging roads, neither road access nor thinned forests prevented this fire from growing to 71,000 acres. There are 211 miles of road within the fire area - a road density of 1.9 miles per square mile.

"*There was adequate access by ground and by helicopter for the initial attack resources. Initial attack fire engines drove right to the fire."* Moose Fire webpage

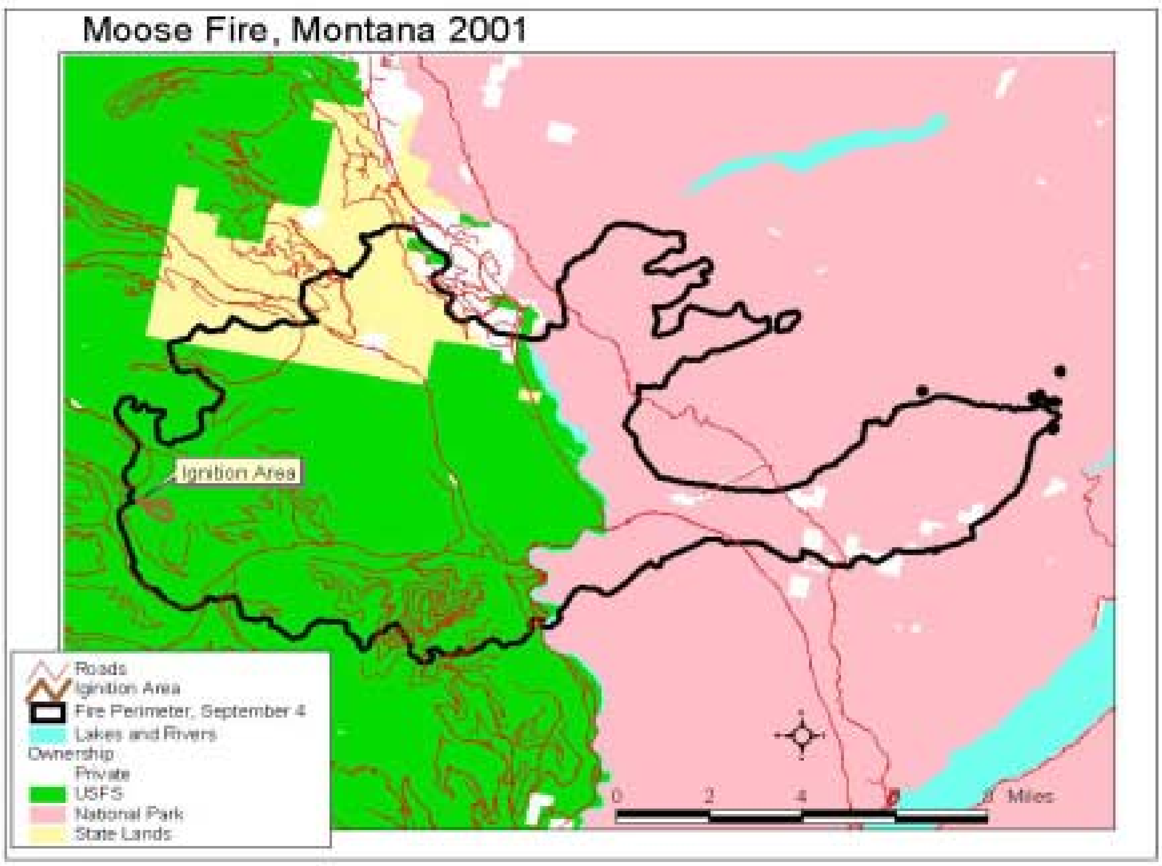

Figure 17. Moose Fire, Montana, 200, in relation to the ignition point and roads (Morrison et al 2001).

The Tyee Fire, Wenatchee National Forest, Washington State. 1994

The Tyee Fire started near a logging road in an area that had recently been thinned. It proceeded to burn across a densely roaded landscape and across previously constructed fire breaks to become one of Washington State's largest wildfires in recorded history, burning over 140,000 acres. There were over 240 miles of roads within the fire perimeter (Figure 18). During the course of fire's course, it burned over more than 30 roads before it reached its eastern perimeter. More roads would not have helped in the control of this fire.

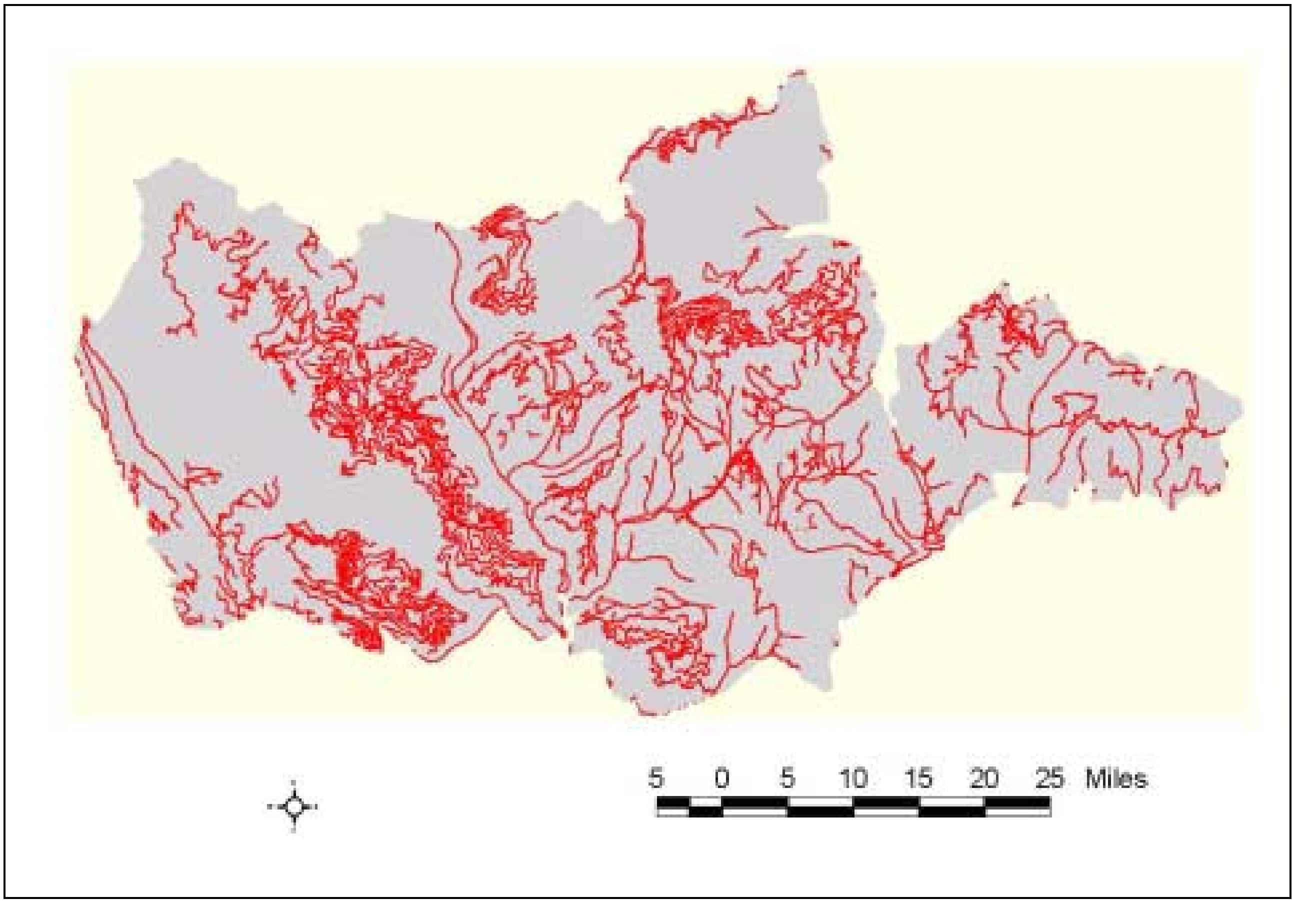

Figure 18. The 1994 Tyee Fire in Washington State illustrating the road network that existed within the fire perimeter.

Examples of human-caused fires that start near or on a road and then spread into roadless areas, wilderness or sparsely roaded landscapes.

Hanford Fire, Washington State, 2000
A fatal automobile collision ignited a brush fire that grew to burn 190,000 acres of land near the Hanford Nuclear Reservation. The Hanford Fire was one of the largest in the nation in the summer of 2000, and received much media attention due to its proximity to the Hanford Nuclear Facility. The Hanford fire is an example of a human-caused fire in a roaded and non-forested area (Figure 13) (Morrison et al 2000). Perhaps aiding the ignition, snow fences along both sides of the highway were buried in tumbleweed over ten feet deep, prior to the blaze.

Figure 18. Ignition Point for the Command 24 fire of July, 2000 near Hanford, Washington. Along Highway 24, looking south towards the Hanford Site.

Thirty-Mile Fire, Okanogan National Forest, Washington, 2001
Road access was directly implicated in the cause of the Thirty-Mile Fire in Okanogan National Forest, Washington. The fire was the result of an unattended campfire next to a major road, which then spread into remote country up the Chewuch River. Firefighters had immediate road access to the location where the fire started and the area where it initially spread. Although the initial fire remained alongside a road with good access, this did not prevent it from growing to over 9,000 acres, killing four firefighters and injuring several others. As the fire grew, it swept up the slopes of extremely steep canyons. No roads existed on these slopes due to the steepness of the terrain. In the Thirty-Mile fire, good road access to the fire initiation site did not prevent a great tragedy or help bring what started as a small blaze under control (Morrison et al 2001).

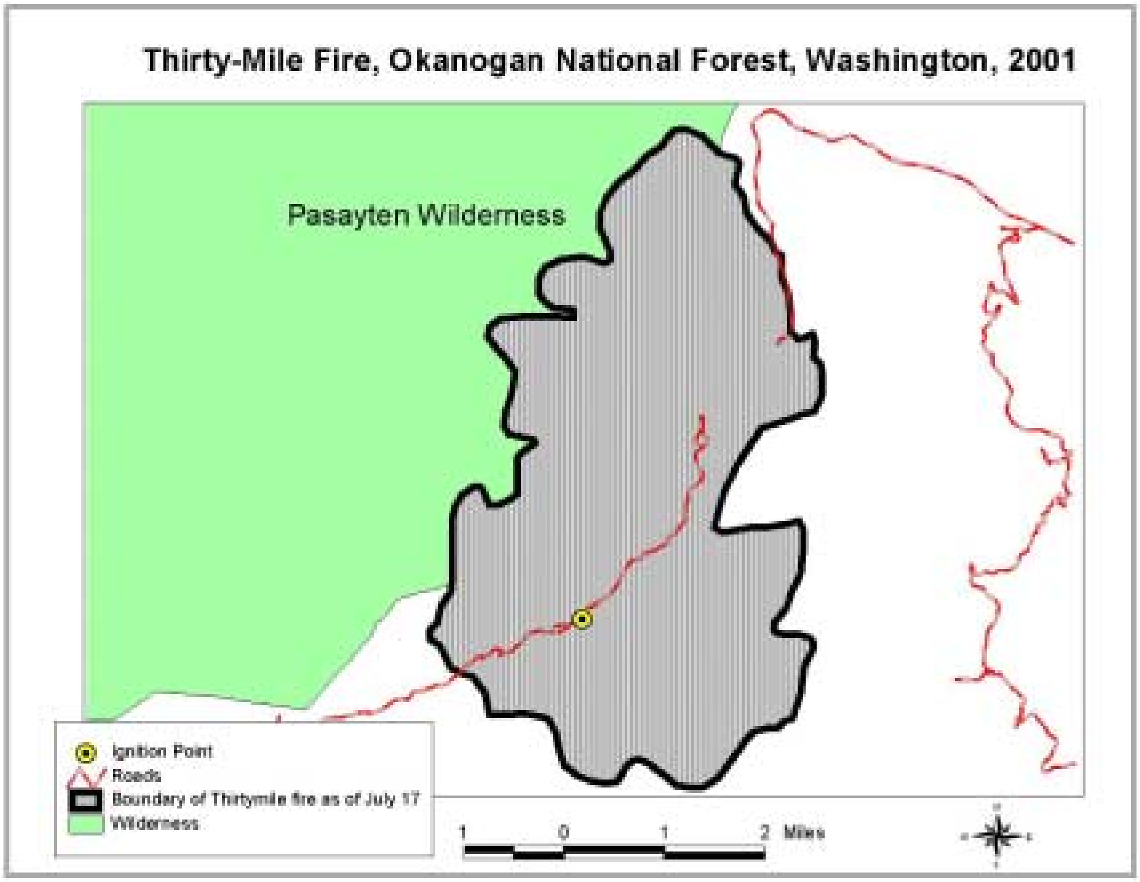

Figure 19: The Thirty-Mile Fire, Washington, 2000 illustrating the fire ignition point and roads (Morrison et al 2001).

Trough Fire, Mendocino National Forest, California, 2001
This human-caused fire began along a road in a densely roaded area of the Mendocino National Forest and burned into Snow Mountain Wilderness. The Trough fire burned over 67 miles of roads before it burned into the Wilderness (Morrison et al 2000).

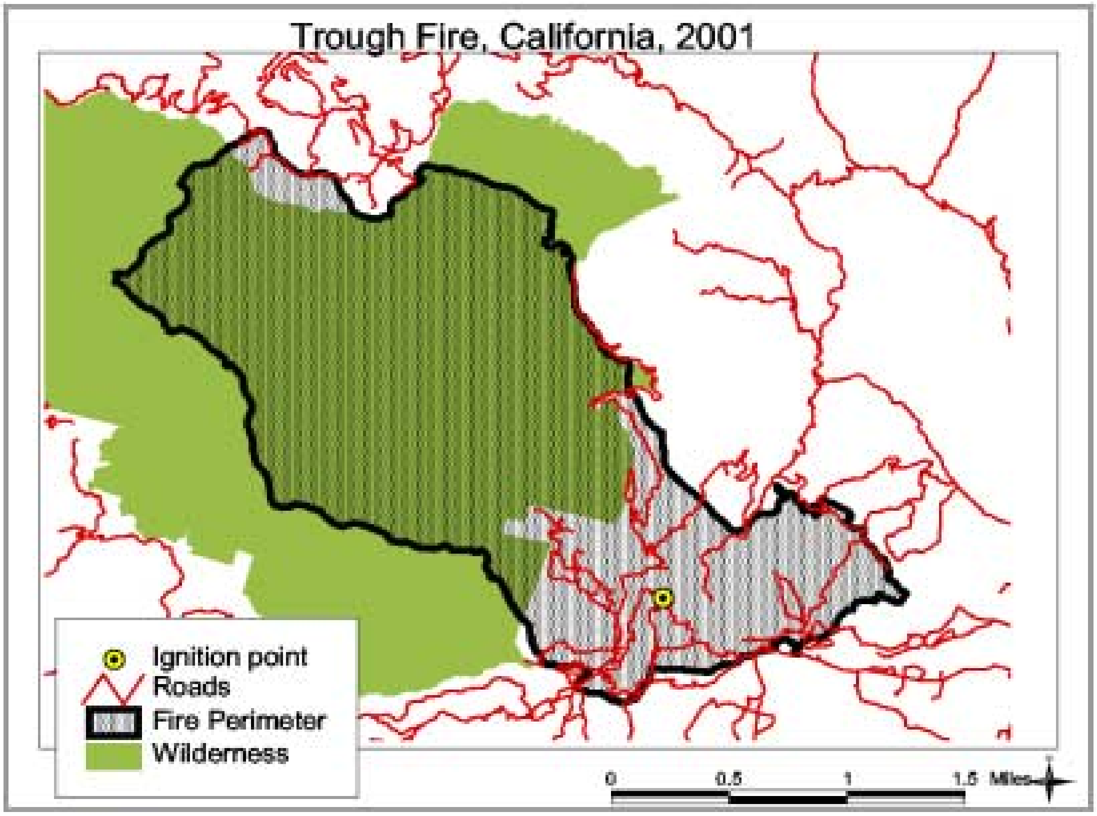

Figure 20. Trough Fire, Northern California, 2001, illustrating the fire ignition point and roads (Morrison et al 2001).

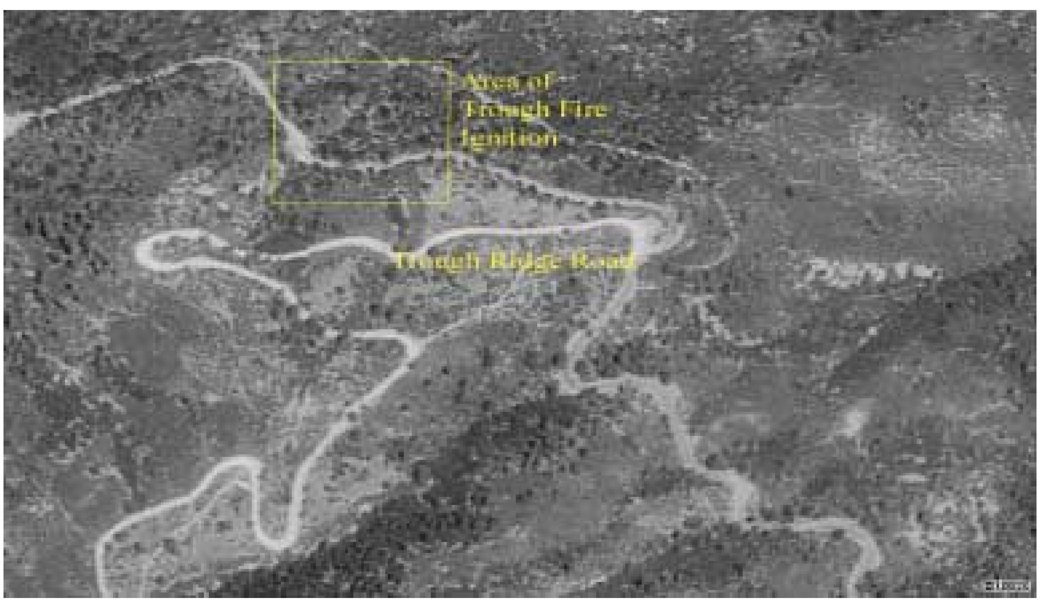

Figure 21. Aerial photograph of landscape conditions near ignition point of Trough Fire. Vegetation is brush and oak woodland. Pre-fire photo is from the US Geological Survey, 1996.

Discussion

What have other researchers found?

In order to recognize the full effect that roads have on wildfires, we must not only examine how and where fires ignite, but also where they burn and how severely they burn. Pew and Larsen (2001) analyzed the spatial and temporal patterns of human-caused wildfires on Vancouver Island. They found that the probability of a section of land burning was negatively correlated with distance from roads. In other words, as the number of roads per given area increased, the probability of fire increased as well.

McHugh and Finney (2003) analyzed the relationship between road density and fire severity in the 2002 Hayman Fire in the Colorado Front Range. They could not find any significant relationship between road density and fire severity. Areas with more road access did not experience any less fire severity.

Does the access provided by roads help fire suppression efforts?

The effectiveness of roads as access points is dependent upon many factors. When roads are used as access points for firefighters, fire lines are often created as a suppression tactic.

In addition, many wildfires in western forests are initially attacked with air-deployed fire crews – making the presence or absence of roads largely moot. Air-deployed fire crews are often used even when the fire is near a road because this is generally the fastest way to get an initial-attack crew to the ignition site. Deployment of water and fire retardant by helicopter and air-tanker has increasingly been used as a general firefighting strategy during and after initial attack. In the Final Environmental Impact Statement (FEIS) on the US Forest Service Roadless Rule (USDA Forest Service 2000), fire management trends were used to determine the effect that the Roadless Rule would have on fire suppression capability. According to the FEIS, "The analysis revealed that a national prohibition on road construction and reconstruction would not result in an increase in wildland fires escaping initial attack. A review of fire occurrence data for inventoried roadless areas further revealed that 98% of all fires ignited inside inventoried roadless areas would be successfully controlled at a relatively small size… The effect of the road construction prohibition on the fire suppression program is expected to be negligible."

Do roads form effective fuel breaks?

The effectiveness of roads as access points and fire breaks is dependent upon many factors. In other cases, roads are themselves used as fuel breaks. According to Green (1977), these fire lines may be totally ineffective in the case of severe fires, whose flames may reach 200 feet and cross fuel breaks that are miles wide.

The recent (October 2003) fires in Southern California fires provided many examples where fires burned across major highways. In at least in one case, these fires burned across an interstate highway (Figure 22).

Figure 22. The Simi Fire burned through brush and across State Route 118, a six-lane freeway (the Ronald Reagan Freeway) running the length of the Simi Valley on October 27, 2003.

Although fuel breaks may be effective in the case of a slower, cooler fire, this type of wildfire does not often pose a threat to communities. Ironically, large, hot burning fires that are affected little by fuel breaks such as roads are the primary impetus for the road building strategy.

Will building new roads help to defend communities against wildfire?

The current network of road systems through US forestland in the US is already very dense. We currently have over 7 million miles of roadway crisscrossing the country. It is rare to find a location that is more than one mile from a road. The few remaining roadless areas are remote backcountry sites, which are usually distant from human population centers and rural communities. Wildfires that do start in the remaining roadless and wild parts of our landscape rarely burn so far as to pose a severe threat to human life or property. In a report by The Wilderness Society entitled, “Roadless Areas Pose no Threat to Communities at Risk from Wildfire”, (The Wilderness Society 2003) a spatial analysis revealed that less that one-tenth of one percent of inventoried roadless land was located within the community protection zone (a one-half mile zone around a community where access fuel removal is deemed important). Clearly, inventoried roadless areas pose little threat to communities.

Wildfires that do start in the remaining roadless and wild parts of our landscape rarely burn so far as to pose a severe threat to human life and property. Our Wilderness Areas and roadless areas are characterized by very steep slopes, sparse and unproductive forests (usually with little commercial value) and high-elevation ecosystems. The health of these ecosystems is highly dependent on wildfire. Few natural resources are at stake in these remote areas and significant ecological benefit occurs as wildfires renew these ecosystems.

What are the financial costs of building fire-access roads across the remaining unroaded parts of our federal lands?
During the last century, roads were built into most of the land feasible for road building and into many other areas with great effort and expense. In 1996 alone, $95 million was appropriated to the Forest Service for the construction and reconstruction of wildland roads. Additionally, $81 million was appropriated for road maintenance. (Wildlands CPR, 2003, What is a Forest Road?) These figures do not include money spent by the federal government to reverse damage done to the environment when roads have blown out and spilled sediment into waterways and homes.

The remaining wild and roadless areas on federal land occupy the most rugged part of the landscape in the US. In many of these areas, it is difficult, if not impossible, to build roads due to the rugged nature of the terrain.

The feasibility of building a road network to provide access to the remaining roadless parts of our landscape needs to be carefully examined by proponents of this strategy. In Washington State, over 70% of the remaining federal forest roadless areas are comprised of slopes over 30 percent in steepness (Pacific Biodiversity Institute unpublished data). Other western states are similar. The cost of building roads through this terrain would be exceedingly costly. Furthermore, the US Forest Service currently does not have sufficient funding to maintain much of it's existing road system and recognizes that many roads must simply be closed because they are unnecessary and too expensive to maintain. The costs of maintaining a greatly expanded road system would be immense given the increased cost of road maintenance in steep, rugged and unstable terrain. But to expand the road system on account of providing better firefighting access would be of questionable merit at best, and at its worst, a prelude to increased conflagration.

What are the environmental costs of building new roads?

Wilderness and roadless areas are characterized by very steep slopes, sparse and unproductive forests, (usually with little commercial value) and high-elevation ecosystems. Before the advent of fire suppression in the early 1900s, the health of these ecosystems was dependent on regular occurring wildfires, which cleaned the forest of excess fuel, and initiated the process of new growth. Commercial developments are few in these remote areas and most of the land is not sufficiently productive to support commercially viable timber stands. Therefore, there is little risk to our society to allowing natural wildfires to continue to play their historically important role in these remote areas. Significant ecological benefits would result as a result from allowing wildfire to return to these ecosystems.

The cost of an expanded road system mounts when considered from an ecological perspective. Trombulak and Frissell (2000) discuss many of the ecological impacts of roads on native ecosystems, fauna, flora and biodiversity.The long-term environmental degradation includes surface erosion and landslide activity due to the steepness of the terrain. West of the Cascades, approximately 25% of recent landslides were tied to road failures while 75% of landslides were caused by roads east of the Cascades. (Wildlands CPR). In the Alder Creek watershed in the western Cascade Range of Oregon, I found that 343 times more landslide-related erosion occurred as a result of road failures than in the surrounding forest (Morrison 1975). Erosion and sedimentation due to roads often results in fishery and aquatic ecosystem degradation. Invasive weed species, which are known to proliferate along new roads, would pose a threat in some of the few remaining areas where pristine, weed-free ecosystems prevail. Roads also cause extensive disruption to many terrestrial wildlife species that are sensitive to human disturbance.

Many Endangered and Threatened species are intolerant of human disturbances associated with roads. Additionally access would be provided for logging, mining, poaching and off–road vehicle abuse.

Road maintenance would involve yearly grading and clearing of downfall. Roadside corridor disturbance opens up the canopy and disturbs the soil, resulting in a flush of deciduous vegetation and leaf litter, which raises the fire risk.

It is clear that the costs of an extended fire road network in the remaining roadless areas goes beyond the direct expenses of constructing the roads and the dubious advantages to firefighting, for they would also cause widespread environmental damage and ecological disruption. It would likely pose increased risks to many endangered species.

Conclusion: Building more roads is not the solution to the wildfire issue.

There is ample evidence to demonstrate that most human-caused wildfires start along roads and that these fires constitute the vast majority of the wildfires that burn across our country. Wildfires blast through heavily roaded landscapes with ease and regularity. While roads do improve access for firefighters, those same roads provide access to careless drivers, campers, and arsonists. The great increase in human-caused wildfire ignition due to an expanded road system greatly outweighs the benefits derived from increased access for firefighters. The financial and environmental costs of such a system would be tremendous. Construction and maintenance of this hypothetical road system would cost billions of dollars and have a distinctly negative impact on some our most fragile ecosystems.

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Appendix 1 - All wildfire occurrences in conterminous US in Wildfire Occurrence Database (Schmidt et al 2002) in relationship to distance from road.

	Human Cause		Lightning Cause		Unknown Cause		All Causes	
Distance from road	Number of fires	% of total	Number of fires	% of total	Number of fires	% of total	Number of fires	% of total
200	252927	60.7%	50928	38.3%	23116	55.1%	326971	55.3%
400	84392	20.3%	24087	18.1%	7817	18.6%	116296	19.7%
600	36053	8.7%	14052	10.6%	4551	10.9%	54656	9.2%
800	22088	5.3%	9921	7.5%	3364	8.0%	35373	6.0%
1000	8285	2.0%	6613	5.0%	1354	3.2%	16252	2.7%
1200	3487	0.8%	4560	3.4%	544	1.3%	8591	1.5%
1400	2021	0.5%	3427	2.6%	290	0.7%	5738	1.0%
1600	1694	0.4%	2640	2.0%	232	0.6%	4566	0.8%
1800	940	0.2%	2148	1.6%	173	0.4%	3261	0.6%
2000	763	0.2%	1732	1.3%	94	0.2%	2589	0.4%
beyond 2000 meters	4017	1.0%	12991	9.8%	407	1.0%	17415	2.9%
Total Fires	416667		133099		41942		591708	
Percent greater than or equal to 1/2 mile from a road		5.1%		25.6%		7.4%		9.9%
Percent within 1/2 mile from a road		94.9%		74.4%		92.6%		90.1%

Appendix 2 – Observed and Expected Values for all human-caused wildfire occurrences in conterminous US in the Wildfire Occurrence Database (Schmidt et al 2002) in relationship to distance from road.

Distance from road	Area in conterminous US (hectares)	Proportion of US in road distance zone	Observed # of wildfires	Expected # of wildfires	Chi-squared value
200	308223736	0.395993547	326971	234313	36642
400	180858153	0.232359332	116296	137489	3267
600	104478840	0.134230241	54656	79425	7724
800	58421214	0.075057243	35373	44412	1840
1000	31754395	0.040796779	16252	24140	2577
1200	20835574	0.026768713	8591	15839	3317
1400	14565869	0.018713647	5738	11073	2570
1600	10749008	0.013809896	4566	8171	1591
1800	8219678	0.010560314	3261	6249	1428
2000	6544399	0.008407982	2589	4975	1144
beyond 2000 meters	33704586	0.043302306	17415	25622	2629
Total	**778355452**	**1**	**591708**	**591708**	**64730**
	chi-squared value is 64730 with 10 d.f. - highly significant with p<.0001				