Impacts of the Pole Creek Wildfire on Fish, Wildlife and Aquatic Habitat, and on Public Health

Oregon Health Authority and Oregon Department of Forestry
February 2014

This report is available in print and online:

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Executive Summary

The Oregon Health Authority and Oregon Department of Forestry present this report to the Oregon Legislature in response to HB 3109 (2013). This legislation directed the agencies to assess the impacts of the 2012 Pole Creek wildfire on public health, fish and wildlife, and aquatic habitat, and to provide recommendations to prevent or reduce impacts and to improve state or local government responsiveness to wildfires.

The report is intended to increase public awareness of the impact of wildfires, and includes recommendations for better tracking of the public health impacts of wildfires, enhanced public outreach and education resources so Oregon communities can adapt to minimize detrimental effects of wildfire to life and property, and for restoring ecosystem resilience to wildfire through active forest management, and continued improvement in implementing safe, effective, wildfire management decisions and response.

The Pole Creek Fire was ignited by lightning and burned 26,584 acres in federal lands within Deschutes National Forest. It sent dense smoke into Sisters and the surrounding area. Fires in the area are increasing in size and frequency, and this trend is expected to continue. Since 1900, 39 fires have burned 83,141 acres in this watershed. Twenty-five of these fires have occurred since 1990, and the Pole Creek fire was the largest of 7 large wildfires in the watershed since 1994.

A longstanding policy of fire exclusion, along with a lack of active forest management and extensive tree death due to a chronic insect outbreak, has produced an unprecedented accumulation of fuel for wildfires. At the same time, warm, dry climate trends have lengthened fire seasons and increased the potential for fires to grow large. Given these factors, fires burn more intensely and extensively than in the past and the impacts are more severe. In particular, a wildfire such as Pole Creek, burning in a populated and heavily used scenic natural area, can have broad affects on human and wildlife communities.

Impacts on Public Health

The Pole Creek wildfire burned primarily in uninhabited forest areas and did not envelop Sisters or other communities. Direct injuries from burns and inhalation of hot gases were not noted. However, smoke containing fine particles ($PM_{2.5}$) affected communities throughout Deschutes County. Sisters experienced six days of degraded air quality, when the 24-hour average for levels of $PM_{2.5}$ remained in the *Very Unhealthy* to *Hazardous* range. High levels of $PM_{2.5}$ in the air have been associated with increases in heart-related and respiratory-related health problems in people with pre-existing heart and lung disease. This represents the greatest health risk posed by the Pole Creek wildfire, particularly for those living in the Sisters area.

Review of available data showed that no hospital discharges involving cases of severe burn trauma or smoke inhalation occurred from Deschutes County hospitals during the time when the Pole Creek wildfire was at its height. Two motor vehicle crashes, with no reported injuries, occurred in Sisters during the period of the Pole Creek wildfire and were reported to the Oregon Department of Transportation as smoke-related. There was no increase in hospitalizations related to heart and respiratory health problems during or immediately following the Pole Creek wildfire. Deaths from heart-related and respiratory-related causes occurred in Deschutes County during the Pole Creek wildfire; however, it is difficult to determine which of these deaths, if any, were attributable to smoke from the wildfire. Complete, timely data on emergency department and immediate care visits for relevant conditions during the wildfire were difficult to obtain.

Impacts on Fish, Wildlife, and Aquatic Habitat

The fire produced varied impacts across the landscape; about 40% of the fire area experienced the most severe impacts, with entire forest stands burned, and another 36% experienced moderate impacts. Some of these impacts are potentially beneficial; others are detrimental to fish, wildlife, and aquatic habitat. Among the greatest impacts are the loss of interior older forest habitat and connectivity among older habitats, loss of headwater streamside habitats, abrupt changes in forest vegetation composition, potential for earlier snowpack melting with loss of forest canopies, and loss of soil cover. Soil damage kills primary food web species, affecting the primary food web. Equally significant effects include increases in stream temperatures from streamside vegetation loss, potential for ash flows and flooding over surfaces and in streams, and degradation of water quality with increased surface erosion. There was a loss of mature closed canopy habitat used as wildlife cover, and an increase in open habitats. Particularly notable was full destruction of forest canopy in areas that historically would have experienced fire at much lower intensity. Heat from burning of thick, unmanaged stands was sufficient in some cases to kill older, normally fire-resistant trees that had been retained in neighboring managed stands.

Recommendations

- To better coordinate public health response, local communities should use the *Oregon wildfire Response Protocol for Severe Smoke Episodes*, available online here: http://www.deq.state.or.us/aq/burning/docs/WFresponse.pdf.

- The Oregon Health Authority encourages all Oregon hospitals to implement Oregon ESSENCE to improve timely reporting of emergency department data. This would improve the ability to track health effects associated with wildfires and other events affecting Oregon communities.

- Encourage implementation of the National Cohesive Wildland Fire Management Strategy in the region. The Blue Mountain Pilot Project in Northeast Oregon is an excellent example of a collaborative approach to implementing this strategy, which seeks to:

  - Create communities that are adapted to wildfire, through such measures as community wildfire planning, public education, and creating fire-defensible space around homes.
  - Restore ecosystem health and wildfire resilience, for instance by supporting current fuel reduction projects, and by working with communities to design landscape-level, socially, environmentally, and economically acceptable forest health restoration practices.
  - Implement safe, effective, wildfire response, including continued support for safe, aggressive initial attack to keep wildfires smaller, less damaging and less costly.

- Develop policies that allow timely post-fire recovery and restoration work. The risk of fire reoccurrence and fire severity increases substantially if salvage and other fuel reduction actions do not occur promptly. Failure to address this issue ultimately transfers fire risk to adjacent landowners.

- Support efforts to increase active forest management, including the steps identified in the Oregon Board of Forestry's federal forests action plan and the Governor's eastside forest restoration package.

- Continue with steps taken in 2013 to improve communication and coordination among fire agencies and landowners, as identified in the Department of Forestry review of 2012's large multi-jurisdiction fires.

- Engage in public outreach and education efforts to share the findings of this report.

Contents

Introduction

On September 9, 2012, lightning struck 6 miles southwest of Sisters, Oregon. A wildfire was discovered burning intensely in dense timber and brush. The forest at the origin near the Pole Creek Trailhead had been completely consumed, save for one large fir tree which was burnt and broken at the base, which, along with eyewitness accounts and a history of lightning strikes in the area, investigators used to determine the cause of the fire.

The Pole Creek Fire burned 26,584 acres within the Whychus Watershed in Deschutes National Forest. The fire burned entirely on federal lands. The fire burned in an area containing the upper Whychus Creek subwatershed, designated as a National Priority Watershed in 2010. Whychus Creek is designated a Wild and Scenic River due to its natural history and cultural prehistory.

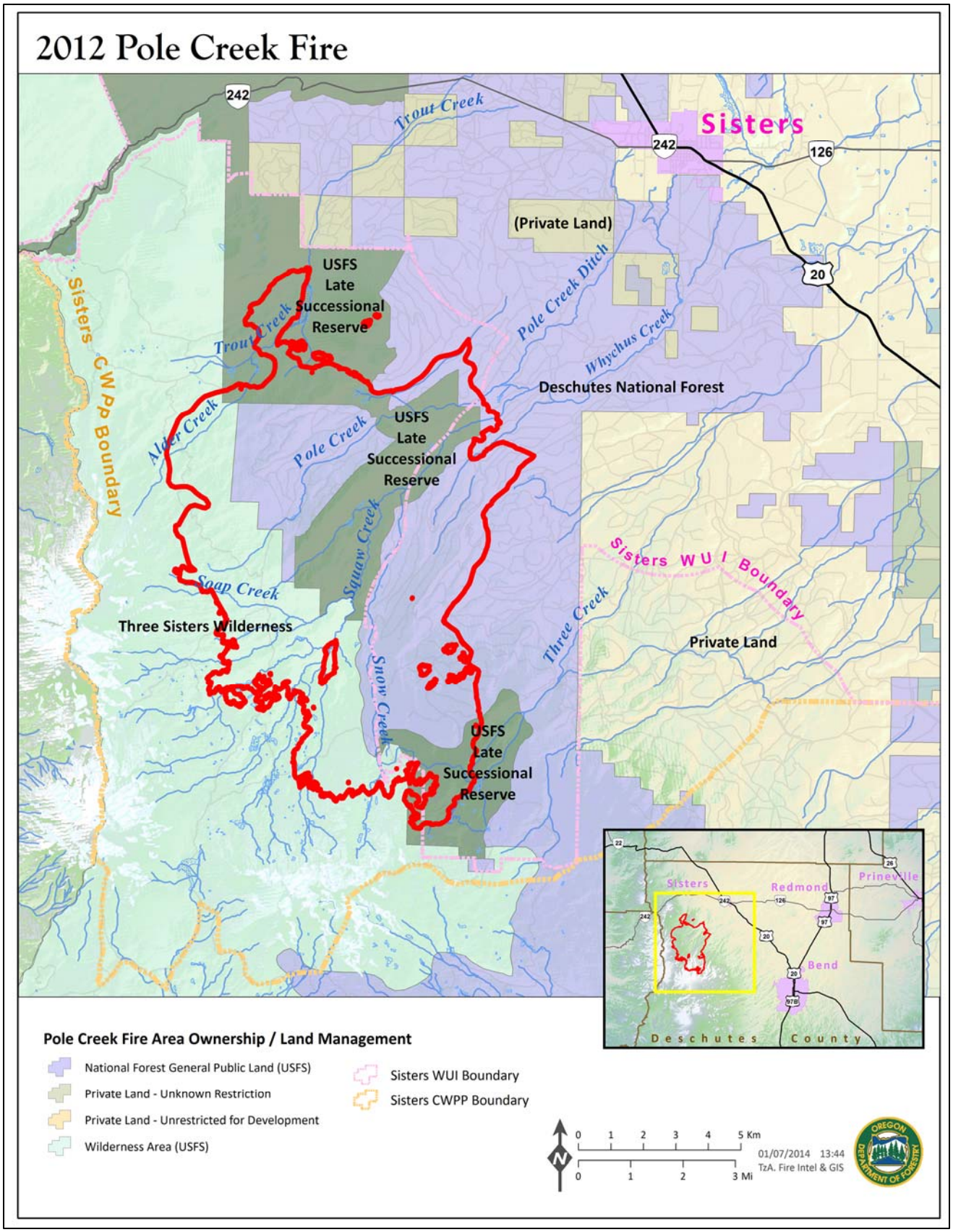
Since 1900, 39 fires have consumed 83,141 acres in the watershed; 25 of these fires occurred since 1990. The Pole Creek fire was the largest of 7 large wildfire disturbances in the watershed since 1994. Fires in the area are increasing in size and frequency, and with historic fire suppression, inactive forest management, and a chronic insect outbreak killing trees and producing an unprecedented amount of wildfire fuels, the fires are burning more intensely, causing severe effects.

Fifteen miles north of Bend, Oregon, the scenic Whychus Watershed area is in the USDA Forest Service Deschutes National Forest and within Deschutes and Jefferson Counties. Within the larger Columbia River Basin, the watershed is part of the Upper Deschutes River Basin. Waters from the Whychus Creek area reach the Deschutes River to flow further into the Columbia River, then on to the Pacific Ocean. Elevation ranges from 3,200 feet at Fremont Canyon north of the City of Sisters to 10,358 feet at the top of South Sister Mountain in the Cascade Range. The area has a very steep rain gradient where precipitation increases dramatically with elevation from 11 inches to 150 inches in one year over a short distance of 12 miles.

The vegetation in the area is adapted to a prevailing dry, continental climate. Vegetation composition changes on an elevation gradient from grass and shrub lands and western juniper at lower elevations, to forests of lodgepole pine and Ponderosa pine, to higher elevation mixed conifer including mountain hemlock and subalpine fir. Area soils are highly permeable outwash plains of sand and gravel left by glaciers. Whychus Creek historically had a large steelhead fishery; reintroduction efforts have been underway for steelhead and Chinook salmon, and the Northern Spotted Owl is here at the marginal edge of its range. Pine species such as goshawks and woodpeckers occupy this area, as well as big game such as mule deer.

Public lands occupy 71% of the watershed (66% USDA Forest Service (USFS), 5% USDI Bureau of Land Management (BLM)) and the area is a popular outdoor recreation destination with campgrounds, and an extensive footpath and livestock trail system. The nearest incorporated area is the City of Sisters with a 2012 population of 2,118, all rural.

The area has experienced 121% population growth since 2000 and long-term growth is expected to continue. Unincorporated areas continue to be important Wildland-Urban Interface (WUI) areas, where people reside outside city limits, adjacent to public lands. Please see ***Map 1***, Pole Creek Fire Reference Map.



Map 1. Pole Creek Fire Reference Map. The fire occurred on federal lands, with the community of Sisters approximately 6 miles northeast of the fire. Sisters and Deschutes County have active Community Wildfire Protection Plans (CWPPs) and have identified Wildland Urban Interface (WUI) areas where people live within and adjacent to wildlands.

The Fire Environment

To set the context of wildfire impacts, and whether they may be within or beyond a normal range of variability and threat, we briefly review the fire environment of the area including some fire history and ecology, and review the general health effects of wildfires, including a discussion of the composition of wildfire smoke.

Fire History and Ecology

A *fire regime* is a description of the general characteristics of wildfire in an ecosystem over an extended period of time, dependent on topography, weather, vegetation, and fire history. Wildfire characteristics include fire frequency, intensity, size, pattern, season, and severity of effects. These characteristics determine impacts on fish and wildlife and their habitats. How intensely the fire burns produces a range of impacts on vegetation, soils, and water resources, from low to high severity, impacting forested and aquatic habitats differently, therefore impacting those species and organisms inhabiting them differently.

Individual fires vary, but the overall impacts of a fire will depend on the historic fire regime and the influence of changes to the historic regime through changes in forest structure, composition, and processes.

High severity fire regimes modify forested ecosystems most dramatically - 80% or more of the dominant vegetation is killed as a result of fire. The structure and composition of the vegetation is changed substantially. High severity “crown fires” kill trees by burning live leaves and needles, replacing entire forest stands.

In mixed-severity regimes ecosystem modification varies depending on the severity of the individual fire and the susceptibility of the dominant vegetation to fire. Variation can also occur within a single fire. Mixed severity and stand-replacement fires alter wildlife habitat structure more than low severity understory fires.

In a low-severity regime, there is relatively little change to the overall structure of the ecosystem – 80% or more of the dominant vegetation is able to survive a fire. Trees like the Ponderosa pine with its thick fire-adapted bark were able to survive historic frequent low intensity fires; the fires burned ground vegetation to clear competing plants and taller, older Ponderosa pines weren’t killed.

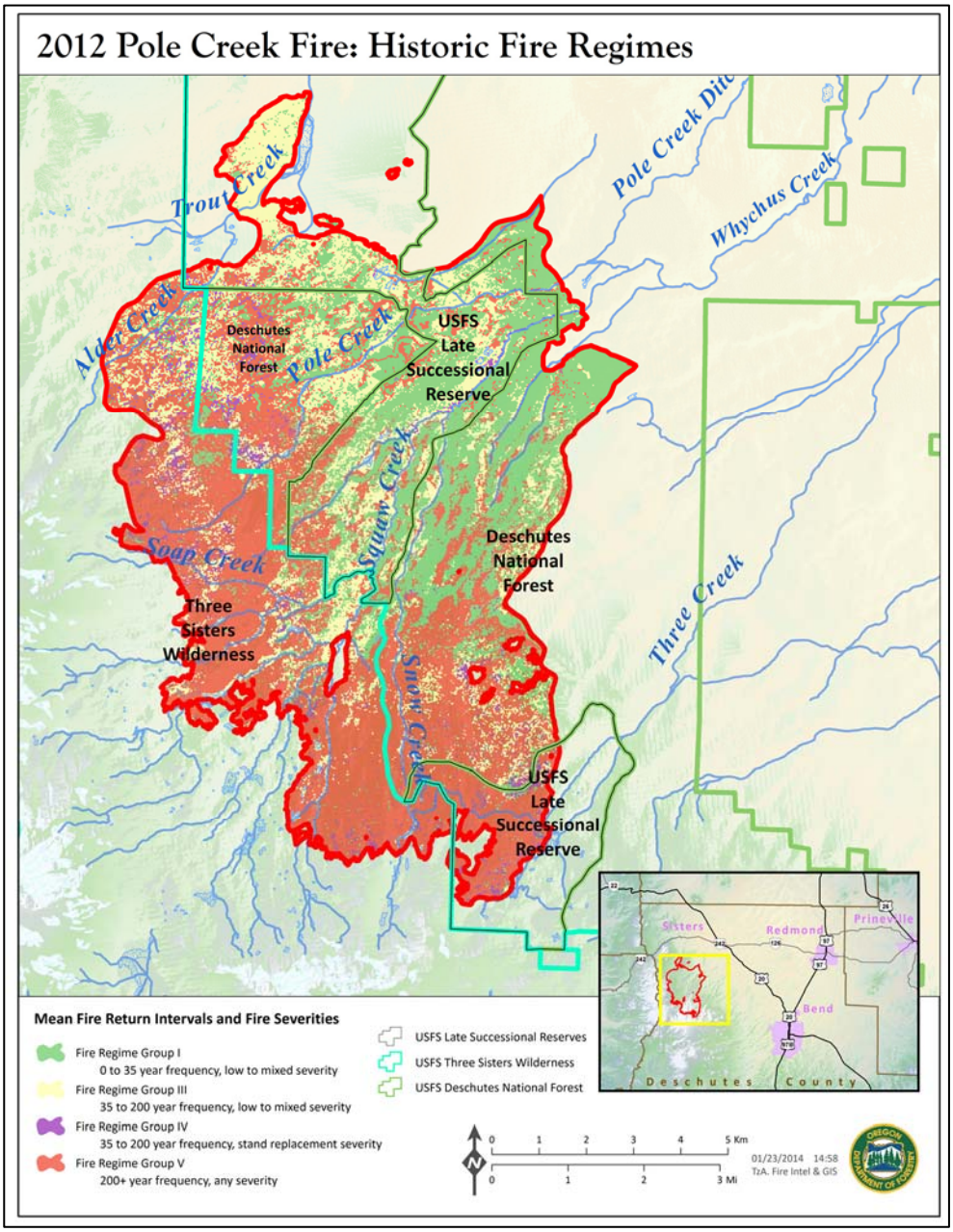
These wildfire characteristics determine whether full forest stands are replaced, largely affecting mammalian and avian wildlife and habitat, whether all streamside habitat is replaced, affecting aquatic habitat, in-stream habitat and water quality, and how deeply and severely the soil is impacted, affecting primary food web species, water quality, and water quantity through erosion and chemical changes. Fire directly impacts animal habitat by impacting food, cover, and water resources.

There are 4 Fire Regimes defined within the Pole Creek fire perimeter, ranging from low to high severity and respectively, from high to low fire frequency. Please see ***Map 2***, Historic Fire Regimes.

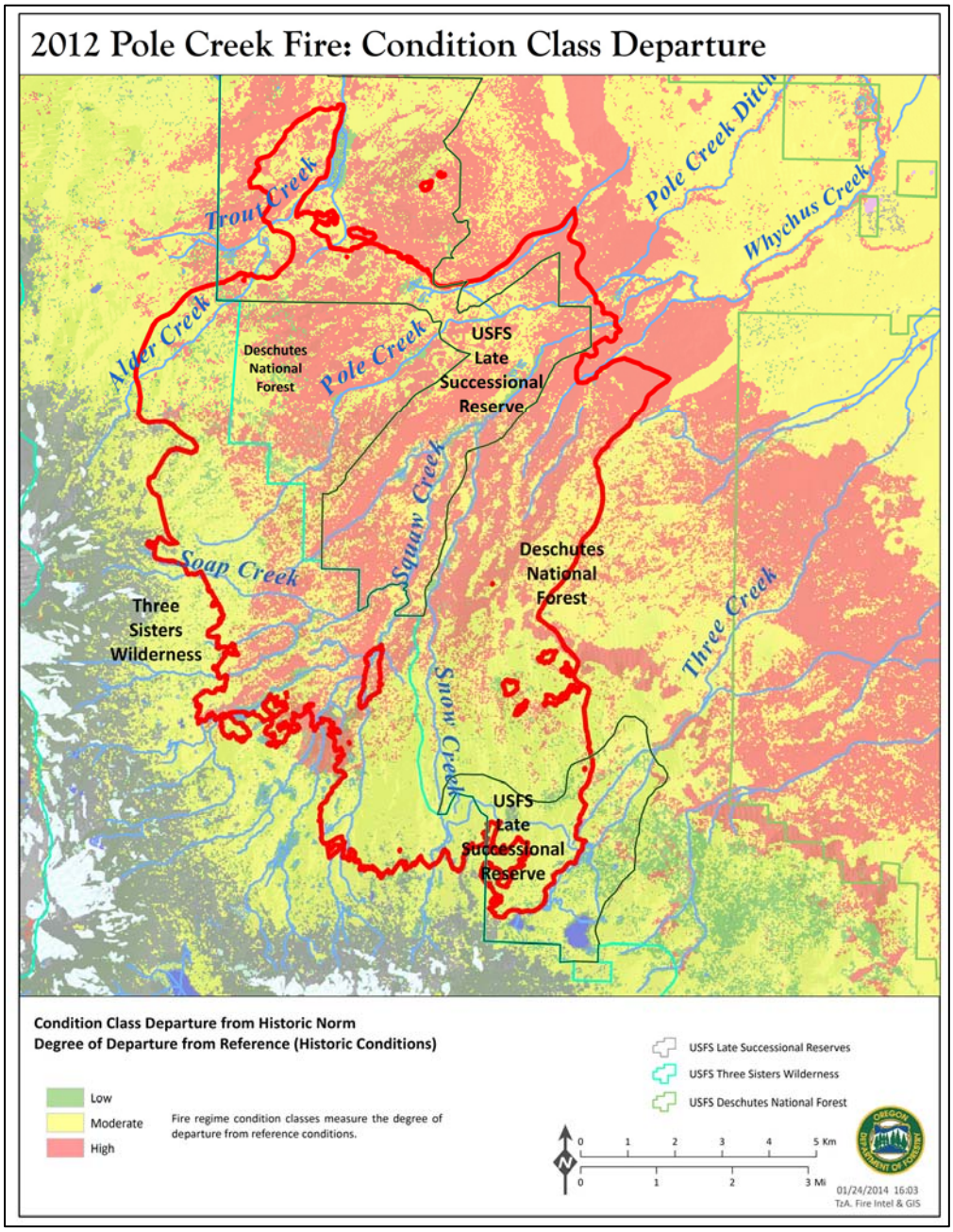
Referring to Map 2, as one moves from the lower elevation Ponderosa Pine forests of Regime Group I in the northeast of the fire area, rising up in elevation to the higher mixed conifer and subalpine fir forests of Regime Group V in the southwest of the fire area, the fire return interval increases, or fire occurs less frequently, but when wildfire strikes, it can have more severe impacts, even killing entire stands (stand replacement fires). In the lower elevations, fire historically burned more frequently but with lower severity impacts.

The breakdown of acreage within the fire perimeter shows that nearly half of the fire area is within Regime V (in red on Map 2), where stand replacement fires would very likely occur. The other half of the fire area would, under historic conditions, burn at mixed and lower severities.

However, the forests in this area have deviated from their historic conditions. The most significant changes to the fire environment in the Pole Creek fire area include historic fire exclusion, extensive acreages of forests experiencing insect mortality, and inactive management, resulting in accumulation of contiguous wildfire fuels. Plants are stressed through fierce competition for moisture and nutrients. Stressed trees invite insects, disease, and mortality, producing accumulated vertical and horizontal wildfire fuels.



Map 2. Pole Creek Fire Area Fire Regimes showing much of the fire area in Regime Groups I and V, lowest severity and highest severity. Especially note the Fire Regime Group I where the Ponderosa Pine forests are.



When a fire burns in this environment, it has more concentrated fuel to consume, and it will burn hotter or more intensely, for a longer period at any one site, producing more severe fire effects, including more smoke. Vast acreages of this kind of fuel connectivity allow for the spread of larger fires as well. Please see ***Map 3***, Condition Class Departure Map, showing degree of departure from historic fire regimes in the area.

Map 3. Pole Creek area Condition Class Departure Map showing high and moderate degree of departure from historic fire regime conditions.

Health Effects of wildfires

Wildfires such as Pole Creek can affect the public's health in several ways. These include:

- Direct injury from burns and from inhalation of hot gases, both of which can be life-threatening.
- Acute worsening of existing heart or lung disease due to decreased air quality from fine particles ($PM_{2.5}$) in wildfire smoke
- Injury from motor vehicle crashes due to decreased visibility from wildfire smoke.
- Minimal longer-term risk of chronic lung disease or cancer due to hydrocarbons and other contaminants in wildfire smoke. While cumulative exposure to these compounds over a lifetime can increase long-term risks, the exposure experienced during a wildfire is generally small compared to the lifetime exposure experienced from sources such as automobile exhaust, wood burning stoves, and others. Any increase in risk from exposure to smoke from one wildfire is therefore negligible.

Other health effects not related to direct physical injury or poor air quality include health problems from degraded quality of drinking water due to fire-induced damage to the watershed and mental health issues related to the trauma from the event.

A number of factors influence the possible health effects of wildfires. These include the size of the wildfire, proximity to population centers, duration of the wildfire, and the composition of wildfire smoke. The size of a wildfire and its proximity to where people live are major determinants of its health impact. Large, fast-moving fires close to populated areas have the widest range of possible health effects. The health effects of a smaller fire at greater distance from densely settled communities will be more subtle, but even distant fires can have health impacts if they are large enough and last long enough. Health impacts from wildfires that are more distant from population centers tend to be related to exposure to wildfire smoke, especially high levels of fine particles in the smoke, such as $PM_{2.5}$.

Composition of wildfire Smoke

The content of wildfire smoke varies depending on the fuel involved. Generally, carbon dioxide and water vapor are major components. Neither have acute public health implications. Other components include:

Carbon monoxide

- Carbon monoxide is an odorless, colorless gas that reduces oxygen carrying capacity in the bloodstream, which can be life-threatening.
- In a wildfire setting, carbon monoxide mainly poses a health risk to those in close contact with smoldering material, such as fire fighters.

Particulate Matter

The size of particles in wildfire smoke determines the health effects for people exposed to it.

- Particles >10 microns (PM_{10}) exacerbate asthma and can cause burning sensation in eyes and throat.
- Particles <2.5 microns ($PM_{2.5}$) are associated with:
    - Increased risk of heart attack and other acute coronary events in those with pre-existing coronary artery disease.
    - Exacerbation of pre-existing lung disease, including asthma.
    - Exposures of any duration can elevate risk, although longer exposures increase the likelihood that people will experience health effects.

Poly-aromatic and other hydrocarbons

- These are not a major source of acute health risk. Cumulative exposure over time can increase long-term risks of certain types of cancer.
- Benzene exposure is also associated with an increased risk of aplastic anemia, a serious blood disorder.
- As noted above, any increase in risk from exposure to smoke from one wildfire is negligible, as this makes a very small contribution to an individual's lifetime exposure.

Determining whether or not a wildfire made some small contribution to these long-term health outcomes is generally not possible, given the small impact from exposure to one wildfire, the difficulty in determining the quantity and duration of exposure to these compounds from a wildfire for any individual, the time from exposure to outcome, and the variety of factors unrelated to wildfire smoke exposure that may affect disease occurrence.

Impacts of the Pole Creek Fire

The public health impacts of the Pole Creek Fire are presented first, followed by the impacts on vegetation, soils, water, and aquatic habitat, and the fish and wildlife inhabiting the area.

Impacts on Public Health

Data interpretation for hospitalizations, deaths, and emergency department visits related to air quality

Data examining the relationship between wildfires and health outcomes such as hospitalizations, deaths, and emergency department visits should be interpreted with caution for a variety of reasons, including:

- Changing environmental conditions and limited information from environmental monitors make it difficult to know the intensity or duration of exposure to harmful particles or compounds produced by a wildfire for any person who experiences a particular health condition.

- Many illnesses that could result from exposure to wildfire smoke are common. Heart attacks and asthma attacks occur every day, whether or not wildfire smoke is present. There may be an increase in these types of illnesses when air quality is worse due to a wildfire, but it is not possible to know which illness was due to the wildfire, and which would have occurred anyway. This determination is particularly difficult when the number of illnesses is small and hospitalizations for those conditions vary substantially even when there is no wildfire event.

- When deaths that occur during a wildfire are the result of chronic illnesses that can be worsened by wildfire exposure, they may occur due to the wildfire or they may be the result of a prolonged illness that coincidentally resulted in death at the time of the wildfire; similarly, chronic disease deaths related to a wildfire could potentially occur after the wildfire event.

- Illnesses and deaths caused by wildfires are not flagged in any way in databases used by public health, as wildfire exposure is not routinely documented by clinicians as a cause of illness or death. Similarly, codes used to describe injuries, such as burns, do not distinguish between burns caused by fire or hot gases from those due to chemicals, radiation, or electricity.

Direct injury from burns, smoke inhalation, or carbon monoxide poisoning

There were no cases of severe burn trauma or smoke inhalation reported in the Oregon Hospital Discharge Dataset from Deschutes County hospitals during Sep. 8 – Oct. 2, 2012, the time of the Pole Creek wildfire; nor were there hospitalizations for these conditions involving Deschutes County residents at hospitals elsewhere in the state during that time. There were no reports of carbon monoxide poisoning-related hospitalizations at Deschutes County hospitals or among Deschutes County residents at hospitals throughout the state. The Pole Creek wildfire burned primarily in uninhabited forest areas and did not envelop Sisters or other communities. The risk of direct injuries from burns and inhalation of hot gases or carbon monoxide was therefore minimal in this remote wildfire.

Effect of Pole Creek wildfire on air quality in Deschutes County

While the actual fire did not reach populated areas, the smoke from the Pole Creek wildfire, and the harmful particles it contained, spread to other Deschutes County communities, although at lower concentrations. As seen in ***Figure 1***, Sisters experienced six days of severely degraded air quality, during which the 24-hour average

for levels of fine particulate matter ($PM_{2.5}$) remained in the *Very Unhealthy*[1] to *Hazardous*[2] range. Average $PM_{2.5}$ concentrations were lower in Bend. On two days, $PM_{2.5}$ levels in Bend were considered unhealthy for people with underlying heart or lung disease, and potentially for children and the elderly.[3] These are the only two Deschutes County communities in which the Department of Environmental Quality maintained particulate matter monitors at the time of the fire.

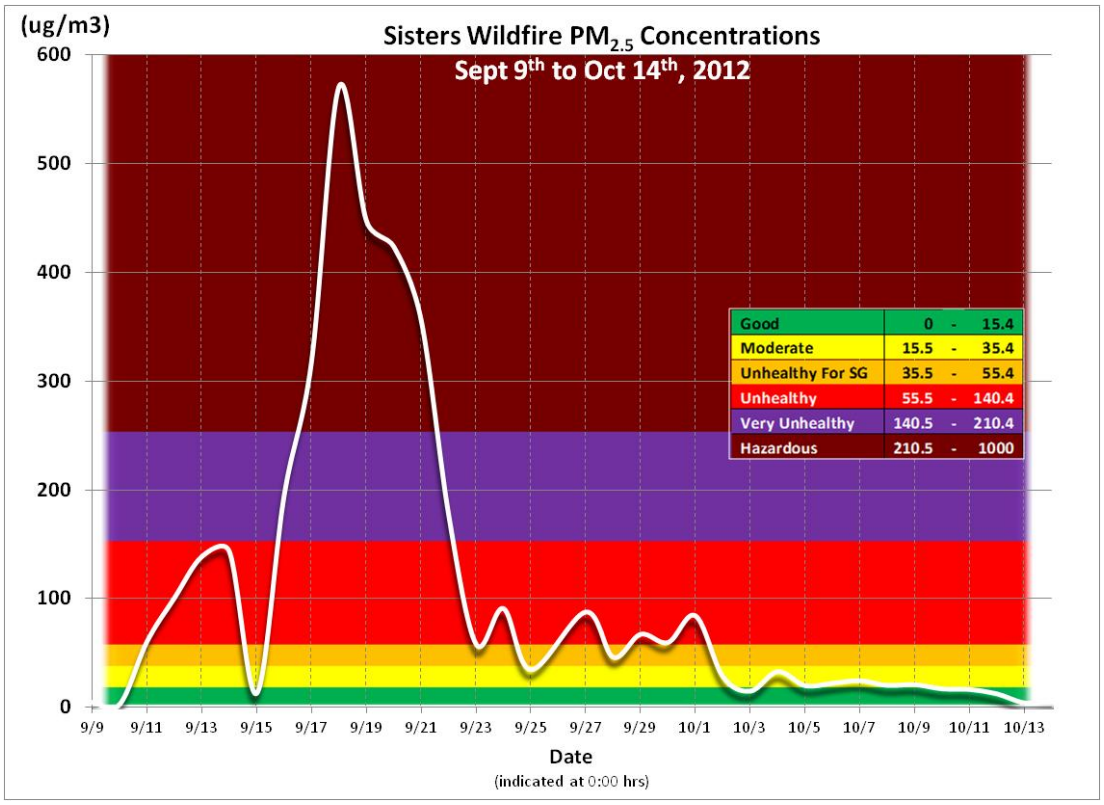


Figure 1. 24-hr averages for levels of $PM_{2.5}$ by day, Sisters, Oregon, during the Pole Creek wildfire.

Hospitalizations related to air quality

The Oregon Hospital Discharge Dataset was used to assess hospitalizations for conditions that are known to be triggered or aggravated by high levels of $PM_{2.5}$. This analysis included data from Deschutes County hospitals and for Deschutes County residents hospitalized throughout the state Conditions assessed included: heart attack, acute coronary syndrome, unstable angina, asthma, and chronic obstructive pulmonary disease. The number of people admitted to the hospital with these conditions during the peak of the Pole Creek wildfire (Sep. 8 – Oct. 2,

[1] $PM_{2.5}$ =151-250 micrograms per cubic meter ($\mu g/m^3$):This would trigger a health alert signifying that everyone may experience health effects, including irritation of the eyes, nose, and throat, coughing, phlegm, chest tightness, and shortness of breath.

[2] $PM_{2.5}$ greater than 250 $\mu g/m^3$: This would trigger health warnings of emergency conditions. The entire population is more likely to be affected by the symptoms listed for the $PM_{2.5}$ 151-250 $\mu g/m^3$ range.

[3] $PM_{2.5}$ =36-65 $\mu g/m^3$: Although the general public is not likely to be affected at this range, people with existing heart and lung disease, older adults and children are at greater risk for worsening of their existing conditions from the presence of particles in the air.

2012) was compared with the same time period in 2011, to see if there was evidence of increased illness during the time of the wildfire that could be due to high levels of $PM_{2.5}$.

No meaningful differences in hospitalizations for acute heart or lung disease were seen during the time of the Pole Creek wildfire, either at Deschutes County hospitals or among Deschutes County residents at hospitals in other parts of the state. Comparing the same time period during 2011 vs. 2012 revealed the following number of hospitalizations: 17 vs. 18 for acute cardiac events; 51 vs. 46 for asthma attacks; 57 vs. 44 for chronic obstructive pulmonary disease.

Deaths related to air quality

Oregon death certificates were used to assess deaths among Deschutes County residents that might be related to high levels of $PM_{2.5}$ from the Pole Creek wildfire. For this analysis, deaths that occurred among Deschutes County residents involving conditions that are known to be triggered or aggravated by high levels of $PM_{2.5}$ were assessed before, during, and after the wildfire. These conditions included: heart attack, acute coronary syndrome, unstable angina, asthma, and chronic obstructive pulmonary disease.

Table 1 shows the number of deaths in Deschutes County for which these illnesses were the principal cause or a contributing cause of death. The first column shows deaths during the 24-day period before the wildfire occurred. The second column shows deaths during the 24 days from the wildfire's onset until air quality levels in Sisters returned to normal. The third column shows deaths associated with these illnesses during the 24 days after the period of degraded air quality. These data were compared with the same time periods in 2011, when there was no major fire.

As the Table shows, during the Pole Creek wildfire, the number of heart disease deaths in Deschutes County was higher than in 2011, but similar to the period immediately preceding the fire in 2012. The number of respiratory deaths during and immediately after the wildfire was higher than in 2011 and higher than the period immediately before it in 2012. However, it is unclear if any of this difference can be attributed to health effects from the Pole Creek wildfire.

Only one of the 2012 heart-related deaths and one of the respiratory deaths during the Pole Creek wildfire involved residents of Sisters. All other deaths occurred in communities 20 or more miles away from Sisters. Direct monitoring of $PM_{2.5}$ for communities outside Sisters was available only for the Bend area (please see ***Figure 2***). Levels there were markedly lower than in Sisters and did not reach concentrations that have been demonstrated to be associated with increased mortality.

Relevant Underlying or Contributing Cause of Death	Year	Number of Deaths Aug. 14 – Sep. 7	Number of Deaths Sep. 8 – Oct. 2	Number of Deaths Oct. 3 – Oct. 27
Acute Cardiac Event (Heart Attack or Severe Rhythm Disturbance)	2011	9	4	5
	2012	8	8	6
Chronic Respiratory Disease, including Asthma	2011	8	4	10
	2012	7	14	10

Table 1. Number of deaths due to various conditions associated with exposure to fine particulate matter, Deschutes County residents, before, during, and after Pole Creek wildfire, 2012, compared with same time periods, 2011.

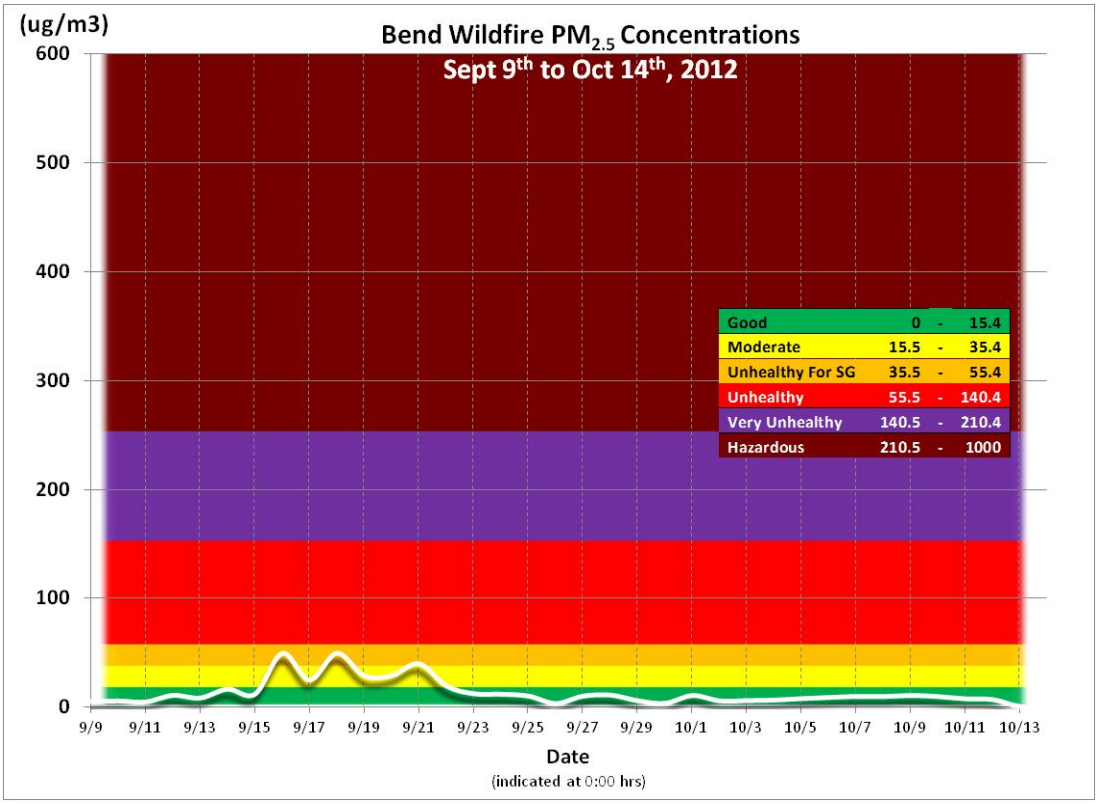


Figure 2. 24-hr averages for levels of $PM_{2.5}$ by day, Bend, Oregon during the Pole Creek wildfire.

Emergency department and immediate care visits related to air quality

To further assess acute health effects from the Pole Creek wildfire, the Public Health Division Hospital Preparedness Program Liaison for mid- and south-central Oregon collected information from Deschutes County hospitals about numbers of emergency department and immediate care visits for acute cardiac events and acute worsening of chronic lung disease. This assessment included visits with a chief complaint of chest pain thought to be cardiac in origin, and worsening of asthma or other chronic lung disease.

This evaluation was done to detect illnesses requiring immediate medical evaluation, even if they did not ultimately result in death or hospitalization. Also, review of emergency department records allows much timelier monitoring for the burden of illness than would have been possible through the Hospital Discharge Dataset, which is only updated and released for analysis every six months. One immediate care facility reported information on each of the three days that this information was collected. Another facility supplied information for one day, and the other facilities queried supplied no information.

While data were limited, monitoring of emergency department and immediate care visits revealed no clear increase in relevant illnesses related to the Pole Creek wildfire at Deschutes County hospitals.

Smoke-related motor vehicle crashes

According to Oregon Department of Transportation records, there were five smoke-associated[4] motor vehicle or motorcycle crashes (MVCs) in Deschutes County during Sep. 8 – Oct. 2, 2012. Two of these MVCs appeared to be associated with the Pole Creek wildfire, as they occurred in Sisters during the height of smoke output from the fire. Neither were associated with injuries. The 3 other smoke-associated MVCs that occurred in Deschutes

[4] The Oregon Department of Transportation has a variable on its accident reporting form that allows the reporter to designate decreased visibility due to smoke as a contributor to the cause of the accident.

County during this time involved minor injuries to 3 people, but occurred in areas more distant from Sisters and less affected by smoke from the Pole Creek wildfire.
By comparison, one smoke-associated motor vehicle crash involving one minor injury occurred in Deschutes County during the same period in 2011, when there was no major fire in the area. It is not clear what the source of the smoke was for the one smoke-associated crash in 2011.

Lessons Learned from Pole Creek wildfire

A. Inter-agency collaboration and communication

After the Pole Creek wildfire, state agencies involved in the public health response to the event conducted an after-action evaluation. This evaluation identified the need for better coordination and communication between the agencies involved in the response and for effective, consistent, and more timely communication with local authorities and the general public. As a result, the Public Health Division, the Department of Environmental Quality, the Department of Forestry, and OR-OSHA developed a protocol to clarify agency roles and to improve coordination and communication in wildfire response.

The protocol specifies the roles of various state agencies in responding to wildfire smoke events, and clarifies lines of communication between state agencies and with relevant federal, tribal, and local partners. The protocol also provides template public health messages for the general public, as well as a comprehensive "menu" of potentially useful public health interventions, based on the severity and duration of wildfire smoke exposure. The *Oregon wildfire Response Protocol for Severe Smoke Episodes* is available online here: http://www.deq.state.or.us/aq/burning/docs/WFresponse.pdf.

After each fire season, the protocol will be re-evaluated and updated based on lessons learned.

B. Data collection and reporting

As noted above, multiple challenges exist in trying to assess the health effects of a natural event such as a wildfire. In addition, available data from the Hospital Discharge Dataset and death certificates only allow for a retrospective analysis of the event rather than a real-time assessment of events as they are occurring.

These considerations, combined with the challenge of collecting timely and complete data on emergency department and immediate care visits related to this event, point to the need for improved collection and reporting of real-time data that can be monitored for trends and used to guide responses to events like the Pole Creek wildfire. To address this need, the Oregon Public Health Division is working to implement the Oregon ESSENCE system throughout the state.

Oregon ESSENCE

The Oregon ESSENCE system is the result of a partnership between the Oregon Public Health Division and Johns Hopkins University. Oregon ESSENCE provides real-time data for public health and hospitals to monitor what is happening in emergency departments at participating hospitals across the state before, during and after a public health emergency. Oregon ESSENCE is a web-based, fully-automated system, so hospitals will not be burdened with additional reporting requirements, but hospital users and public health will have a window into the health effects of emergencies and planned events (e.g., festivals, athletic events, conventions, etc.). Using an automated, daily feed of de-identified data from emergency departments, Oregon ESSENCE analyzes data to detect changes in levels of diseases and health conditions. Oregon ESSENCE meets federal standards for ensuring data security and patient privacy.

Impacts on Fish, Wildlife, and Aquatic Habitat

Habitat changes from fire influence wildlife more than direct injury and mortality, although those with limited mobility are more vulnerable to injury and mortality. Animal species are adapted to survive the Fire Regime(s) that characterized their habitat in pre-human-settlement times. Fire impacts on vegetation, soils, and water directly and indirectly impact species and organisms that inhabit these landscape elements, and we present these impacts here.

Vegetation and Wildlife

The burned area had an accumulation of wildfire fuels due to historic fire exclusion and extensive acreages of dead trees from insect damage. This allowed the Pole Creek fire to burn with greater intensity, and promoted easier ignitions and rapid fire spread to increase the size of the fire. This created more severe, but heterogeneous impacts across the landscape with low, moderate and high severity impact areas. Please see, Fire Severity in Historic Fire Regimes.

10,448 acres (40%) of the Pole Creek Fire produced severe impacts and were considered forest stand-replacing. The fire burned 9,403 acres (36%) at a moderate severity producing mixed mortality, and 24% or 6,269 acres were under-burned at a lower intensity. In the higher elevation areas, fire severity was within historic High Severity fire regime characteristics, but more extensive areas were burned from the contiguous heavy fuel loading due to historic fire suppression and adjacency to dead insect-killed stands.

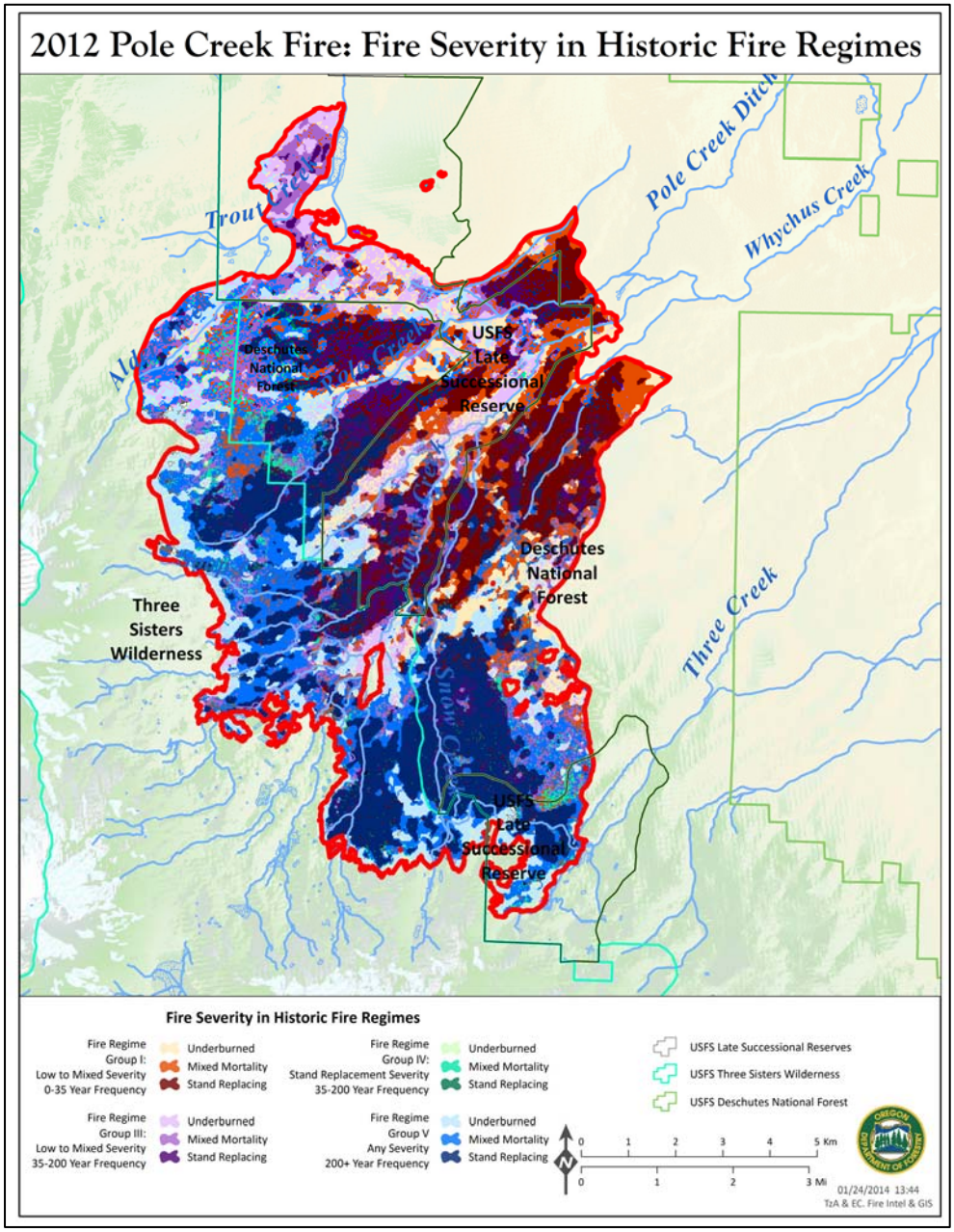
A notable impact was total canopy tree kill from heat in a historically low intensity regime. Heat from a burning neighboring unmanaged forest stand, killed the dominant canopy trees in a stand *that had been managed (mechanically thinned)*, where normally these older, dominant, more fire-resistant trees may have survived (Ponderosa pine).

Since 1998, 60,000 to 70,000 acres of lodgepole pine have been killed by the mountain pine beetle – much of this area and adjacent live forest areas burned during this fire. Contiguous dead standing trees with understory smaller trees to act as ladder fuels increase the fuel load vertically and horizontally, making for a more hazardous fuel complex.

The Three Creeks lake area, Trout Creek swamp, Pole Creek Swamp, Glaze Meadow and Indian Ford area all contain significant wet meadows, and the area contains unique habitat for rare endemic wildflowers and native plants. Whychus Creek, Pole Creek, and Snow Creek experienced the highest burn severities with stream channels burning to the water's edge. 42% of the headwaters, or 4,327 acres burned along Whychus Creek. Further downstream, 54%, or 4,114 acres were burned. Little to no vegetation was left unburned along Pole Creek and Snow Creek: 37% of Pole Creek and 61% of Snow Creek riparian and wetland forests burned at moderate to high severity.

Severe forest-stand-replacement fires reduce habitat for species that require canopy cover but improve habitat for species that prefer open spaces thereby causing emigration and immigration responses and reorganizations in wildlife communities.

General Impacts to vegetation that can be expected include: the loss of snow and rain interception and evapo-transpiration capability of the forest due to canopy cover loss; loss of soil cover with removal of ground cover plants; susceptibility to invasive plants such as cheatgrass; and importantly for wildlife, a loss of interior older forest nesting and cover habitats and the loss of connectivity among those habitats, but an increase in open canopy habitats – early forest successional habitat. Essentially, the forest grows in successional stages, referred to as stand dynamics, from open stand establishment to older closed canopy stands, until a disturbance such as active management or a wildfire "resets" or changes forest composition and structure.



Map 4. Vegetation mortality showing Fire Severity in Historic Fire Regimes. Color sets are grouped by fire regime. The darker the color within the color set, the more severe the impacts.

Birds such as the Northern Spotted Owl, with marginal habitat in this area, use closed canopy older forest habitats for cover, nesting, and forage, and these birds will be impacted from closed canopy habitat loss. 2,280 acres (8%) of the recently designated 27,837 acres of critical nesting, roosting, and foraging habitat for the Northern Spotted Owl was lost in the watershed in recent years.

Pine forest species such as goshawks and white-headed woodpeckers, and other upland birds and secondary cavity nesters are in this area and may benefit from newly disturbed open canopy habitats and rotted standing dead snags.

Wildlife such as big-game mule deer will use the open canopy habitat and rapid post-fire regrowth of vegetation for forage, and will experience a loss in closed canopy cover habitat, so there will be a short term increase in forage productivity and availability moderated by the ability to thrive in a post-fire simplified forest structure.

Raptors such as osprey and eagles in this area will benefit by increased prey exposure with a reduction in their hiding cover. Wood-boring insect populations can increase due to extensive fire killed trees favoring insect-eating species.

Potential dispersal habitat for the gray wolf may have been affected, and is under analysis by USFS.

The North American wolverine, with habitat in this area, is proposed for listing as threatened under the Endangered Species Act. Removal of canopy cover will increase the potential for earlier snow melt, impacting wolverine habitat. The wolverine inhabits high-elevation areas and depends on deep, persistent snow cover for successful denning.

Other notable species with habitat in the watershed include Regional Forester Sensitive Species and Survey and Manage Species such as the Fringed Myotis bat, the Evening fieldslug, the Western bumblebee, the Crater Lake Tightcoil snail, and the Great gray owl. Survey and Manage Species are those identified as very rare, sensitive to disturbance, and/or relatively immobile, within or close to areas managed under the Northwest Forest Plan.

"13 large wildfires in Sisters Ranger District since 2002 have caused loss of mixed conifer habitat District-wide, reduced connectivity, and increased the importance of remaining habitat. Endangered Species (Spotted owl) and other late successional species habitat has been lost or altered and will take many decades to recover. The area contains two Late Successional Reserves."

The Fringed Myotis bat may benefit as it roosts in trees, snags, and cave and rocky openings and consumes insects. The Evening field slug may be adversely impacted due to vegetation and ground cover removal in higher moisture areas. Moisture is needed for movement, respiration, and hatching of eggs. Direct mortality is likely as movement is over very short distances, usually only to find food or reproduce. The Western bumblebee initially is adversely affected by reduction in food supply (flowers that produce the nectar and pollen they require), nest sites (e.g. abandoned rodent burrows and bird nests), and hibernation sites for over-wintering queens.

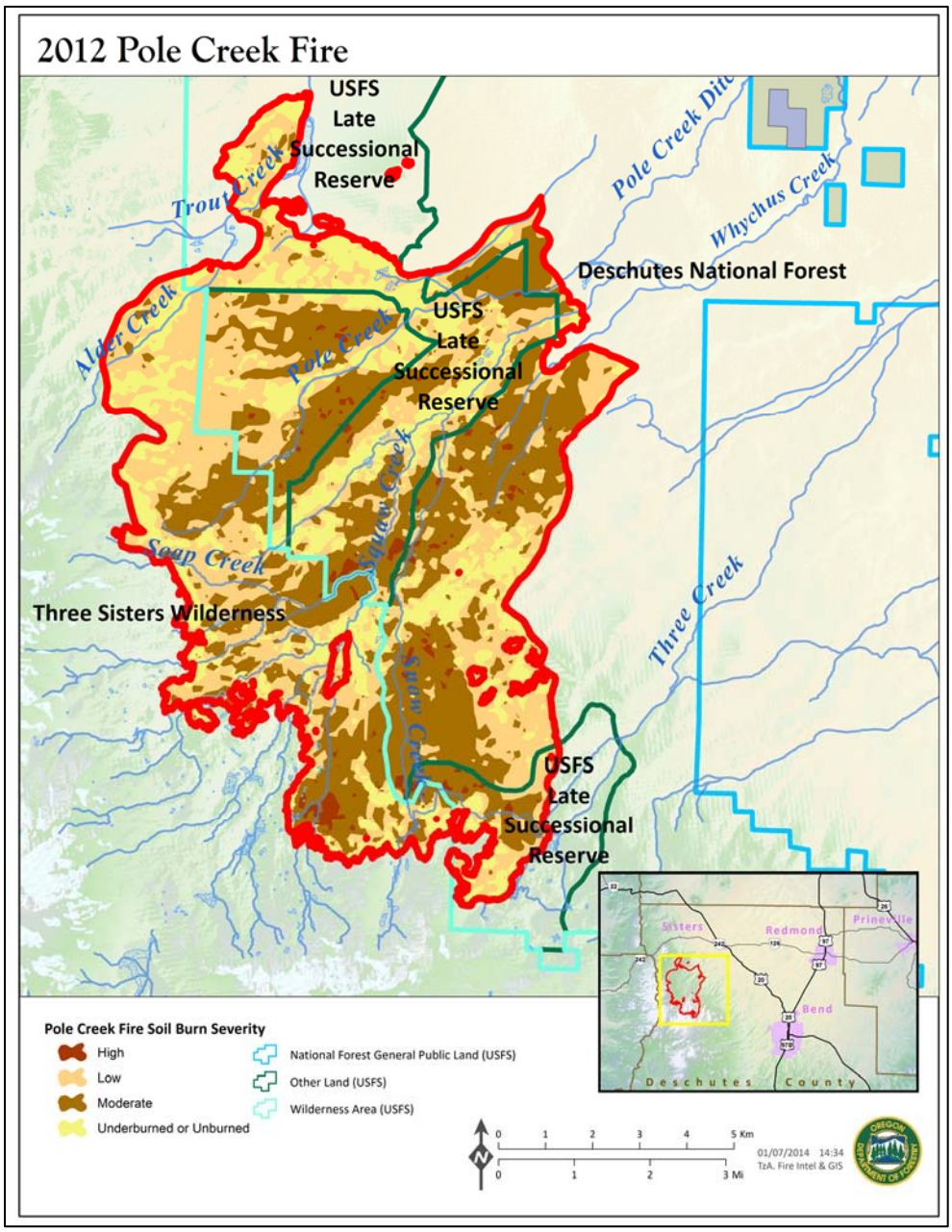
Soils, Water, Fish and Aquatic Habitat

Soil burn from the Pole Creek Fire was rated at 38% moderate, 61% low, and less than 1% high, but 35% of riparian (streamside) reserves had a high to moderate soil burn severity. Soil burn can be measured in terms of lethality, where low severity fires are lethal to 1 cm depths, moderate severity fires are lethal at 3-5 cm depth, and high severity fires are lethal at 9-16 cm depth. Please see ***Map 5***, Soil Burn Severity.

General Impacts that can be expected include: forest floor litter combustion and reduction of organic matter impacting soil species abundance, diversity, and density of soil and litter invertebrates; a change or breakdown in soil structure reducing moisture retention and capacity and development of water repellency; there will be a change in nutrient pool cycling rates and an atmospheric loss of elements; and there will be a partial elimination (through decomposition) of plant roots.

Some soil vertebrates are mobile enough to escape direct fire impacts by burrowing deep enough to avoid lethal temperatures. However, indirect impacts include loss of habitat and exposure to soil burrow openings resulting in increased predation and a potential reduction in vertebrate diversity and abundance.

There is a moderate to high soil erosion hazard in 6,800 acres of the fire area and a potential for unstable stream banks. Increased bank and upland erosion and sedimentation, ash flows, and channel instability will affect water quantity and water quality as discussed below.



Map 5. Soil Burn Severity from the Pole Creek Fire.

The Pole Creek fire burned in sensitive forest areas of the headwaters of the Whychus, Upper Whychus, Upper Trout Creek, Lower Trout Creek, and Three Creek subwatersheds. Impacts from the Pole Creek Fire were greatest in the Upper Whychus and Headwaters Whychus subwatersheds. Please see ***Map 6***, Sensitive Forest and Riparian assets in the Pole Creek Fire area.

Whychus Creek, Trout Creek, Snow Creek and Indian Ford Creek contain populations of resident native redband trout (USFS Region 6 sensitive species). Summer Steelhead were reintroduced in 2007 in Whychus Creek (need fish passage around irrigation dams). Spring Chinook were reintroduced in 2009 in Whychus Creek.

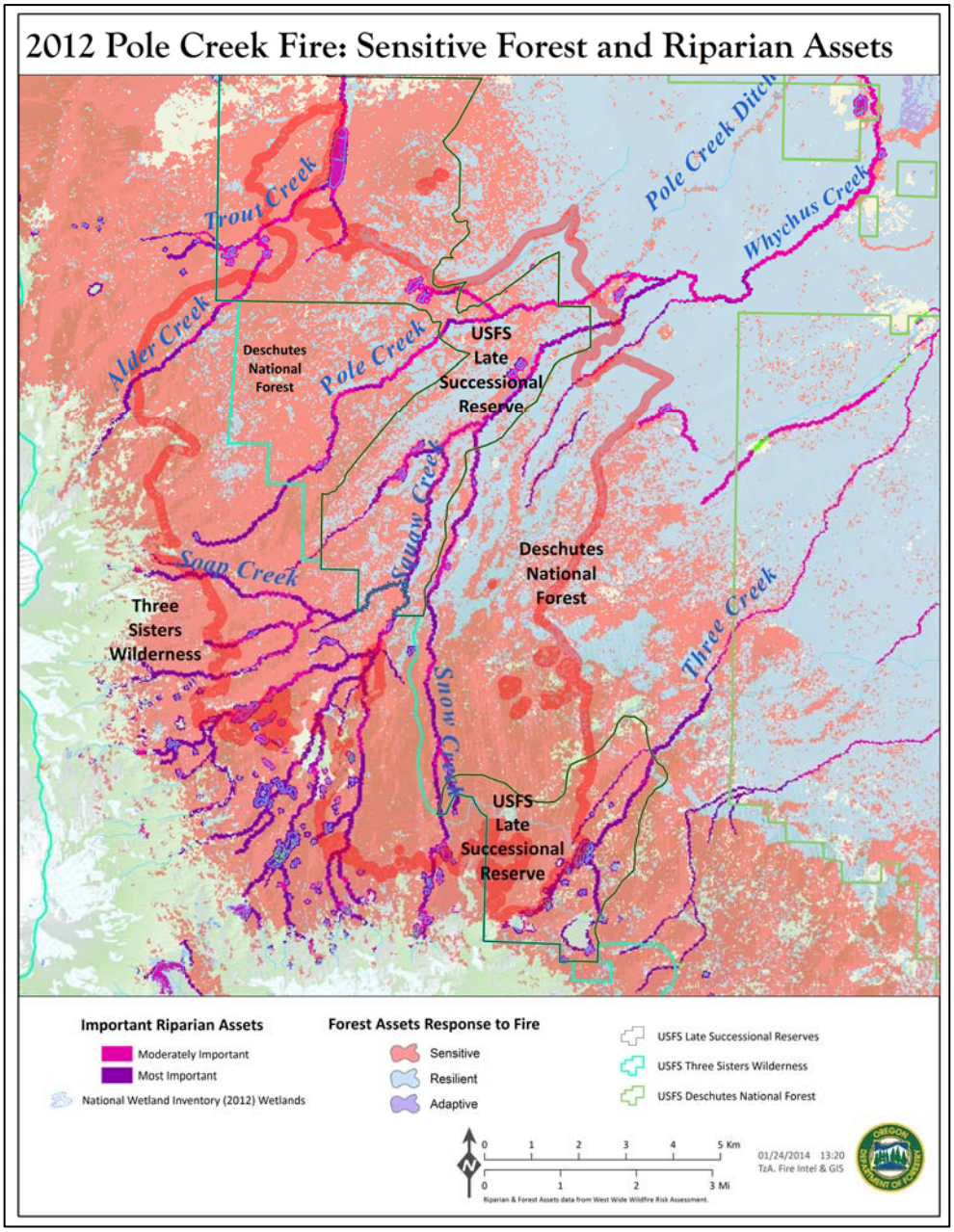
Middle Columbia River summer steelhead are an experimental population present above Pelton Round Butte dams. Columbia River bull trout are federally listed as threatened and may be present, they are found in lower Whychus Creek. Stocked Rainbow trout and brook trout are in the Three Creeks area. Non-native Brook trout and Brown trout are present in the area.

Streamside vegetation was impacted to a great extent in the Pole Creek fire, and this will have an impact on fish and streamside wildlife and aquatic species. High severity fires in heavy streamside fuels are identified as common factors contributing to direct fish mortality and Whychus Creek, Pole Creek, and Snow Creek may be areas to examine. High severity fire in heavy fuels in streamside areas predispose aquatic and streamside animals to direct mortality can kill relatively immobile streamside species and produces indirect impacts due to habitat loss. Please see ***Map 7***, Riparian (streamside) area burn severities in the Pole Creek Fire.

Impacts to water quantity and water quality that can be expected to impact fish and other aquatic species as well as downstream dependents include: higher water flows and more frequent peak flows due to reduced precipitation interception in tree canopies and increased snow pack but with streamside canopy removal there may be earlier snowpack loss; an increased risk of flashy runoff during rain-on-snow events. Higher nitrates and higher turbidity have been documented in streams in high severity burn areas. Immediate changes in water temperature and chemistry can kill aquatic species.

With riparian canopy vegetation mortality, there will be reduced streamside moisture storage and increased stream temperatures resulting in an increase in algal blooms and other temporary primary productivity impacts like insect population increases benefitting the food web, but potentially inviting non-native fish and other invasive aquatic species. Amphibian streamside habitat may benefit with regeneration of post-fire streamside vegetation.

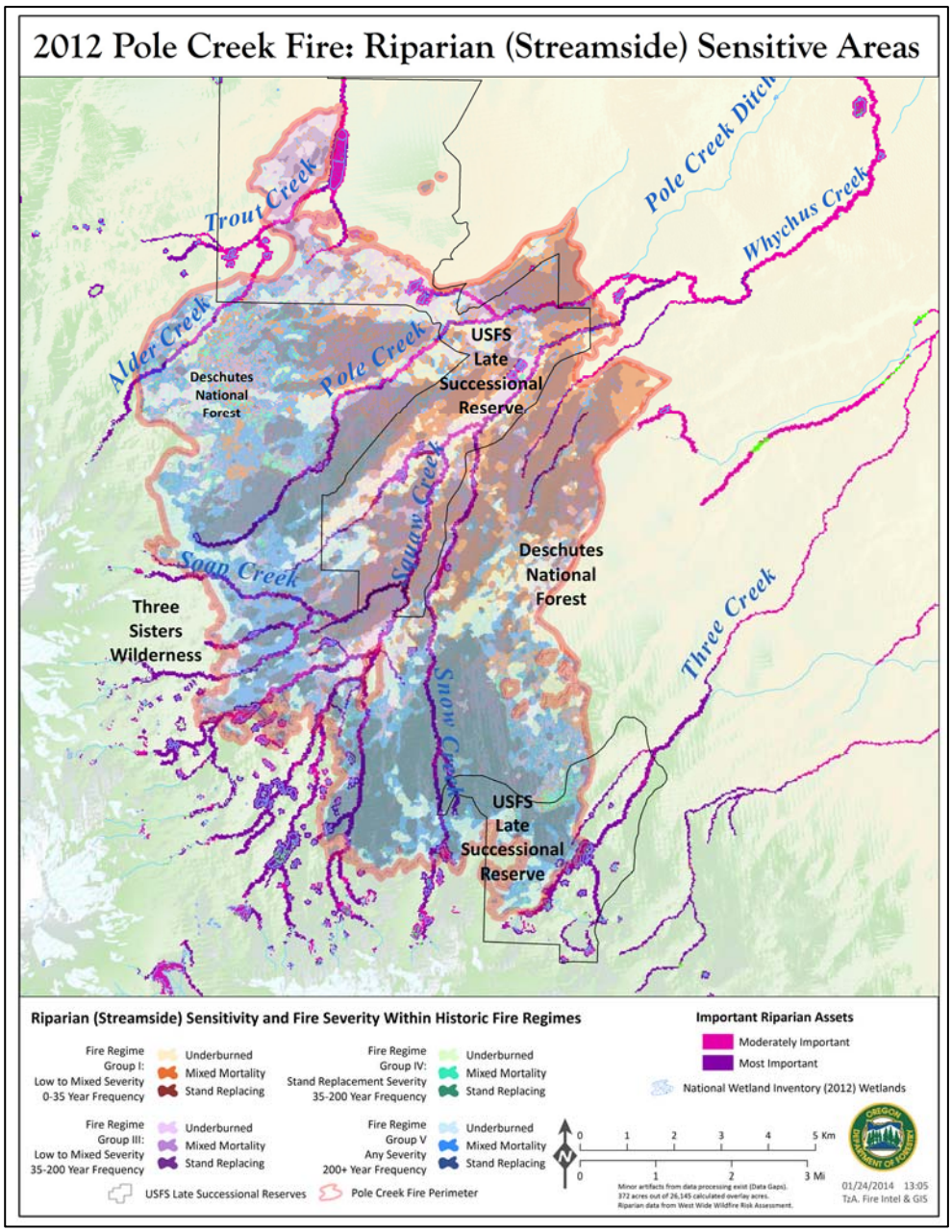
Large woody debris is expected to increase creating pools for fish habitat, but increased water flow and more frequent high flows could scour redds (fish nests) and reduce fish egg survival, and standing bodies of water may reduce habitat for other aquatic organisms, reptiles and amphibians.



Map 6. Sensitive Forest and Riparian (streamside) assets in the Pole Creek fire area.

The Indian Ford Juga was documented in Indian Ford Creek. Degradation of water quality would negatively impact this aquatic, gilled snail. The A caddisfly has not been documented but is suspected in the watershed area and typically inhabits cold headwater spring-fed streams. Headwaters of several streams were completely consumed in the fire and may affect these species.

The Three Creeks Lake area to the south of the burn perimeter is biologically unique and significant for amphibians. It is the longest known amphibian-monitoring site in the United States. A unique morph of the long-toed salamander exists in the area, which may be a new endemic species. Erosion of uplands may increase sediment and produce scouring water flows to amphibian sites along water edges and in small pond, lake, and stream pools. Stream amphibians like frogs may be affected by burned riparian areas normally used after the frogs transform.



Map 7. Riparian (streamside) area burn severities in the Pole Creek Fire.

Amphibians are vulnerable to alterations of the riparian or aquatic zones of streams: changes to the moisture regime, increased stream temperature, increased sediment load, and changed stream bank integrity. Protection of the upper reaches of streams is particularly important for aquatic species.

Aquatic and wetland dwelling mammals are considered relatively more mobile and can therefore be less directly impacted in the fire event and can even seek refuge in wetland and aquatic habitats, but indirect impacts on habitat apply. Changes in habitat and availability of food supply are primary factors affecting response of macroinvertebrate populations. Studies of indirect effects have shown reductions in macro- and microinvertebrates, such as near complete elimination of communities due to flood events, and substantial reduction in organism density due to ash flows.

Conclusion

Wildfires are increasing in size and frequency, and with historic fire exclusion, inactive forest management, and a chronic insect outbreak killing trees producing an unprecedented amount of wildfire fuels, the fires are burning more intensely, causing more severe impacts than historically experienced.

Larger and more severe fires have a greater impact on public health and fish and wildlife, and the trend is expected to continue and worsen. Research and recent fire history predict more fires, hotter fires, larger fires, and longer fire seasons. The number of large fires (greater than 1,000 acres) in Western states has increased. Wildfire seasons are longer now than in the 1970s. Temperature warming in the Western U.S. is expected to continue producing faster snowmelts, and drought stress to plants, drying live fuels, inviting insect and disease damage to plants, and producing more dead fuels. Human population increases and use in the area present potential for more fire starts and increase the risk to life, property and resources.

A Landscape Ranking process has been conducted by USFS, where ranking for nearby Three Creek Lake area increased from #3 to #2 due to the Pole Creek Fire: "The expanse of dead trees will eventually burn and is connected to the Bend Watershed. Post fire landscape is vulnerable to vehicle trespass, increasing recreational use, erosion, and invasive plants. "

We continue to fight wildfire in the short term with continuous improvements in fire fighting strategy and tactics such as initial attack, but without active management, fuel loads will increase for the longer term, increasing fire risk and impacts and inhibiting our ability to fight wildfire effectively *and* safely.

Summary of Impacts on Public Health

There were no reports of direct injuries, such as burns, carbon monoxide poisoning, or evacuation-related injuries, among the general public from the Pole Creek wildfire. There were no differences in the number of hospitalizations for smoke-related health conditions during the Pole Creek wildfire compared to the same time period the previous year, when there was no wildfire.

Deschutes County had larger numbers of heart-related and respiratory-related deaths during the Pole Creek wildfire compared to the same time period during the previous year. However, most of these deaths occurred in residents of areas distant from Sisters, and it is unclear how many of these deaths can be attributed to exposure to fine particulate matter from Pole Creek wildfire smoke. Two motor vehicle crashes occurred in the Sisters area during the Pole Creek wildfire and were reported to the Oregon Department of Transportation as smoke-related. No injuries were reported in association with these crashes.

Collaboration and communication between agencies and with the public can be enhanced if local communities utilize the *Oregon wildfire Response Protocol for Severe Smoke Episodes*. The ability to gather information from emergency departments and immediate care facilities was limited. Timeliness and completeness of information about the health effects of the wildfire would likely have been improved if more hospitals were using the automated Oregon ESSENCE system.

Summary of Impacts on Fish, Wildlife, and Aquatic Habitat

The fire produced varied impacts across the landscape; about 40% of the fire area experienced the most severe impacts, with entire forest stands burned, and another 36% experienced moderate impacts. Some of these impacts are potentially beneficial; others are detrimental to fish, wildlife, and aquatic habitat.

Among the greatest impacts are the loss of interior older forest habitat and connectivity among older habitats, loss of headwater streamside habitats, abrupt changes in forest vegetation composition, potential for earlier snowpack melting with loss of forest canopies, and loss of soil cover. The soil damage kills primary food web species, impacting the primary food web. Equally significant effects include increases in stream temperatures from streamside vegetation loss, potential for ash flows and flooding over surfaces and in streams, and degradation of water quality with increased surface erosion. There was a loss of mature closed canopy habitat used as wildlife cover, and an increase in open habitats.

Particularly notable was full destruction of forest canopy in areas that historically would have experienced fire at much lower intensity. Heat from burning of thick, unmanaged stands was sufficient in some cases to kill older, normally fire-resistant trees that had been retained in neighboring managed stands.

Recommendations

The Oregon Health Authority recommends the following:

- Encourage local communities to utilize the *Oregon wildfire Response Protocol for Severe Smoke Episodes*, available online here: http://www.deq.state.or.us/aq/burning/docs/WFresponse.pdf. This protocol was developed after the Pole Creek wildfire and includes information on roles and responsibilities of various agencies, along with guidance on communications between agencies and with the public during wildfire events.

- The Oregon Health Authority encourages all Oregon hospitals to implement Oregon ESSENCE to improve timely reporting of emergency department data. In addition to allowing for improved analysis of the health effects associated with wildfires, Oregon ESSENCE allows for better coordination of health service delivery during any emergency response.

The Oregon Department of Forestry recommends the following:

- Encourage action towards implementing the goals of the National Cohesive Wildland Fire Management Strategy [8] in the region. The Blue Mountain Pilot Project in Northeast Oregon is an excellent example of a collaborative approach to implementing this strategy, which seeks to:

    - Creating Fire Adapted Communities. Continue and enhance support for Community wildfire Protection Planning efforts and educating community residents about fire prevention and creating fire-safe home environments in the Wildland Urban Interface. Continue to support Firewise educational programs and SB360 implementation in high priority areas.

    - Restoring ecosystem health and resilience to wildfire. Support the current and ongoing efforts of Federal agencies to perform hazardous fuels reduction treatments, including mechanical thinning, commercial harvest, and prescribed fire. Assist the federal agencies to build trust with local communities (through local collaborative) to design economically and environmentally acceptable forest health restoration practices [32] and smoke management strategies.

    - Implementing safe, effective, wildfire response decisions. Continue to support integrated efforts for safe, aggressive initial attack to keep wildfires, smaller and less costly – socially, economically and environmentally. Support efforts that incorporate prevention, fuels treatments, hazard mitigation and aggressive initial attack [8].

- Work to ensure a policy framework is in place that allows a timely response to post-fire recovery and restoration work. The risk of fire occurrence and fire severity increases substantially if salvage and other fuel reduction actions are not implemented in a timely manner – ultimately transferring risk to adjacent landowners.

- Explore and support efforts to increase active forest management as referenced in Oregon's Vision for Federal Forestlands 2009 Board of Forestry Report [32] and the 2012 Fire Reviews.

The Oregon Health Authority and Oregon Department of Forestry will share the findings of this report and a fact sheet / brochure in public outreach and education efforts to our customers and the general public to communicate the impacts of wildfire on Oregon communities. This may include sharing information through news media, social media and the web.

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