The Changing Climate and Effects on Fire in the Pacific Northwest

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"A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." (Aldo Leopold, 1952)

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Mark Finney of the United States Forest Service once said, "It's not a matter of if fire will occur but when it will occur" (Sugihara, Wagtendonk, Shaffer, Fites-Kaufman, Thode, 2006, p. 538). Climate models are projecting mean surface temperature increase and changes in seasonality all throughout the globe (IPCC, 2013). In the Pacific Northwest climate projections apply and have numerous implications for ecology and society. Focusing on one affect from the changing climate is the interaction it has with wild fire. Human activities—such as fire suppression—have been the dominate interaction with fire for the last century. New studies show a relationship with fire suppression practices interacting with spring snow melting earlier and dryer summers that extend the fire season to produce larger fires at a higher frequency. Oregon State University Professor John Bailey says, "Fire is imminently predictable on the small scale and ultimately unpredictable on the large scale". We have altered historical fire regimes on landscapes and it will take active management strategies to combat future fire. I am going to discuss a brief history of fire in the west, basic fire behavior, implications of changing climate, and management processes that can help mitigate the effects of fire.

The 20th century response to fire was exclusion from the landscape. Fire was viewed as harmful to nature and for humanity in terms of economy and living aesthetics. The Great Fire of 1910 burned approximately three million acres in northeast Washington, western Montana, and northern Idaho leaving 87 people dead (U.S.F.S. CIS, 2013). It helped build the attitude for fire suppression. The Smokey the Bear campaign took off in 1944 which further supported suppression practices, leading to our suppression efforts still being carried out today (U.S.FS., 2009).

Suppression practice have changed fire regimes all throughout the Pacific Northwest. A fire regime is a long-term fire pattern characteristic of an ecosystem described as a combination of seasonality, fire return interval, size, spatial complexity, intensity, severity, and fire type (Sugihara, p.580). Fire season is typically in the drier half of the year—late spring all the way to early fall, and in recent news California is burning through the winter. A fire return interval is the time between two fire occurrences (Sugihara, p. 580). The size is the area burned and spatial complexity is the pattern of spatial variability and patchiness of burned areas and fire severity within the perimeter (Sugihara, p.581). Fire intensity is the energy given off and severity is magnitude of effect fire has on the ecosystem (Sugihara, p.580). Fire type is a classification of ground, surface, or crown fires. A fire regime describes the behavior of the fire (Sugihara, p.580).

Fire behavior can be broken down to three interacting components: topography, weather, and fuels—this is known as the fire behavior triangle (Sugihara, p. 46). Topography includes aspect, relief, and elevation. Weather includes temperature, precipitation, relative humidity, wind speed and direction. Fuels includes type: ground, surface, crown, living or dead, moisture content, complexity and continuity that creates the fuel matrix (Sugihara, p. 46). Fire is simply physics—predictable on the small scale and highly variable on the large scale. This is what makes it difficult to manage. The common perception was fire harmed natural resources but it has actually been shown to benefit and help maintain landscapes and was used historically by the indigenous people as a management tool.

Many ecosystems are adapted to a range of fire regimes. I will use; two examples of contrasting fire adapted species. Certain plant communities are adapted to high-frequency, low intensity fires: Douglas-fir (*Pseudotsuga menziesii*) and Ponderosa pine (*Pinus ponderosa*). Others are adapted to low-frequency, high intensity burns: lodgepole pine (*Pinus contorta*) and knobcone pine (*Pinus attenuata*).

The Ponderosa pine is a great example of an ecosystem maintained by fire. The normal occurrence and low intensity burns surface fuels and thins the understory grasses, shrubs, and seedlings. It acts as a selection pressure that keeps the ecosystem in balance. Ponderosa pine are fire resistant with thick bark, self-pruning limbs, needles with high water content, and insulated buds (Bailey, 2014). Fire suppression in Ponderosa stands has changed the fire regime and increased the return interval which changes the composition of understory and over story vegetation which increases the fuel load. When fire hits the stand again, it burns with a higher intensity and usually a higher severity, causing more damage to the ecosystem. This effects site recovery and some Ponderosa pine stand do not regenerate and become lost to invading species, such as the invasive specie cheatgrass (*Bromus tectorum*) (Sugihara, p. 110).

Conversely, lodgepole pine are adapted to high intensity fires that are spaced out over time. They produce seed banks with serotinous cones that do not germinate until exposed to heat from fire and shortly after the burn seeds are released (Bailey, 2014). High-severity, stand-replacing fires can occur and lodgepole pine can reestablish fast after the disturbance.

To briefly reiterate, different ecosystems have developed varied responses to the historical fire regimes among regions. Our use of fire suppression has altered the historical regimes for ecosystems like Ponderosa pine, lodgepole pine and Douglas-fir. This change in regime changes the ecosystem structure and composition, and in turn changes the way fire behaves on the landscape. Fuels have been loaded over time, since fire has not come through to burn them and typically results in more intense, severe, and larger fires.

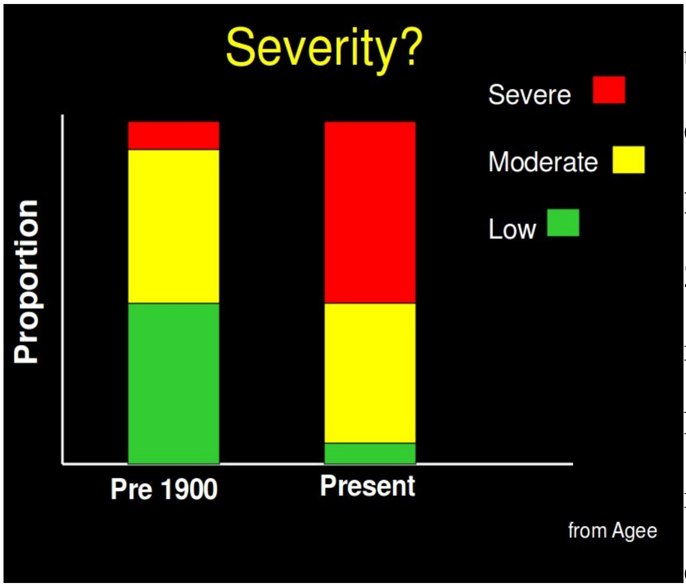
Now to address the climate change factor and how fire is interacting and projected to interact with climatic change. Models from the Intergovernmental Panel on Climate Change (IPCC) show surface temperatures warming and continuing to warm in throughout the century due to natural, and largely anthropogenic causes. Since 1920 temperatures in the Pacific Northwest increased 1.5°F. Regional climate models predict increases in annual temperature of 2.2°F by 2020s, 3.2°F, by 2040s, and 5.3°F by 2080s (Table 1 taken from Littell, Elsner, Binder, Snover. *The Washington Climate Change Impacts Assessment* , University of Washington, Climate Impacts Group, June 2009).

	Temperature Change (F°)	Precipitation Change (%)
2020s	+2.0 (+1.1 to +3.3)	+1.3 (-9 to +12)
2040s	+3.2 (+1.5 to +5.2)	+2.3 (-11 to +12)
2080s	+5.3 (+2.8 to +9.7)	+3.8 (-10 to +20)

Table 1. Average and range of projected changes in temperature and precipitation for the Pacific Northwest. Reported averages are changes relative to 1970-1999, for both medium (A1B) and low (B1) scenarios and all models (39 combinations averaged for each cell in the table). The ranges for the lowest to highest projected change are in parentheses.

Projections for seasonality are calling for increases in seasonality extremes—so wetter autumns and winters but drier and hotter summers (Littell et. al, 2009). There is a potential for drop in annual snow pack as well (Littell et al, 2009). There are varied projections produced by different models, but the overall trend shows an increase in temperature and seasonality; these are projections and always can be questioned but I think we should be wary and utilize the data to prepare for the future.

These climatic changes have direct and indirect effects on fire behavior: “We are seeing earlier snowmelt, lower summer soil moisture and fuel moisture, more drought and longer fire seasons” (Reinhardt, 2013). Fire severity and size are increasing. A major concern with increased size and severity is the post-fire recovery and the ability of sites to regenerate. Dick Fleishman of



the Four Forests Restoration Initiative (4FRI) describes, “A big fire used to be 1,000 acres. Now it's in the tens of thousands” (Stecker, 2013). With suppression and timber management we essentially have homogenized our landscapes and created a more uniformed fuel bed that can burn continuously, instead of in patchwork patterns. These are some examples of direct effects. (Graph 1 Bailey, 2014. FOR 446: Fire Ecology. Taken from Agee, 1993: *Fire Ecology of Pacific Northwest Forests*. The graph details fire severity for pre-1900 and current levels. Data articulated from proxy records: written record, tree rings, burn scars, sediment and ash analysis)

Indirect effects of temperature and precipitation change from warmer winters increase the insect populations, specifically mountain pine beetle (*Dendroctonus ponderosae*). Moisture competition between trees creates more moisture-stress, with drier summers, make trees more vulnerable to insect attack—this can be seen in Colorado forests (Reinhardt, 2013). The dying trees also contribute to the fuel load and increase the fire hazard (Reinhardt, 2013).

The larger implications are these "...variations in climate and fire interact with environmental stresses such as insects, drought, and invasive species has potential to cause drastic changes in structure, productivity and even carbon storage across Pacific Northwest landscapes" (Reinhardt, 2013). Taking it a step further, some ecosystems may see long-term changes in species composition and distribution (Reinhardt, 2013).

There is always levels of uncertainty but I believe it is imperative we proceed with caution and take active measures to adjust for the changes to come. The world around us is changing and is going to continue, so if we do not adapt our systems we are only hampering ourselves more; in other words, the game is changing so we need to change the way we play the game. Referencing back to the fire behavior triangle, we obviously cannot actively manipulate weather or topography. That leaves fuels to manage. By reducing the fuel matrix we can gain more control on how fire burns on the landscape—aiming to reduce fire size and severity.

The Forest Service is taking active measures to increase resilience for both ecosystems and communities with their fuels management program by using mechanical and prescribed burning methods (U.S.F.S, 2013). Remember some ecosystems are adapted to high severity fires, and some are not, but what is a concern for forests is the spatial and temporal component of fire and the resilience of these ecosystems to regenerate post-fire with the imposing climatic projections. That is why taking active measures is essential to hopefully reduce some of the damage: "Fuel reduction and restoration treatments can increase resiliency by reducing density-dependent tree mortality and excessive insect and or disease problems and can increase spatial heterogeneity” Stephen, 2013).

Historical forest fire regimes: (Top) Mixed-conifer forest in northern California with fuels accumulated from a century of fire suppression (left), mature surviving and regenerating trees in an area that had been mechanically thinned to reduce fuels and residues either removed or burned (center, 10 years after the 2002 Cone Fire), and an adjacent untreated area lacking live seed trees, now dominated by shrubs (right, 10 years after the Cone Fire). (Bottom) Lodgepole pine forests in Greater Yellowstone (left) regenerated abundantly from the canopy seedbank after the stand-replacing 1988 Yellowstone Fires (center, 15 years postfire), but regeneration was greatly reduced in forests of comparable age and serotiny after the 2000 Glade Fire, which was followed by summer drought 1 year after the burn (right, 10 years postfire). Forests are within 4 km of each other at each site. (Taken from Stephens et. al, 2013)

The goal is to get a handle on fire and restore some characteristics of the historical fire regimes, an example is for Ponderosa pine and Douglas-fir. Our traditional view of fire as a menace needs to change, and we need to start allowing it back on the landscape as a management tool. It is a part of the natural system and plays a role that we have been altering for long enough. An effective fire management plan is going to have a combination of suppression and fuels treatment methods to manage the landscape, based on ecological principles and site-specific treatments. This is a highly complex phenomena to manage. The largest issue for fuels treatments and restoration is funding; the rate of treatment is far off what is needed for resilience (Stephens et a, 2013). With funding and time as core issues, there will be a need to evaluate land to prioritize specific areas for treatment; this is an entirely new dilemma to create a standard for site evaluation.

Approximately half of the land in the western United States is publicly owned and managed. Suppression costs in 2012 exceeded $2 billion and is only predicted to increase in the next bit of time. It is not sustainable and burns through too much money and "..only delays in the inevitable, promising more dangerous and destructive future forest fires" (Stephens et al, 2013). We also need to acknowledge a large proportion of money spent on fighting fires in the wildland-urban interface (WUI), which is continually being developed as sprawl perpetuates throughout the United States (U.S.F.S., January 2013). This aids in the rise of suppression costs and is also dangerous for homeowners and firefighters. That is one tangent I have yet to address but I will briefly. I have been discussing fire suppression but not acknowledging that fires get contained by people risking their lives. We need to consider this as a society and remember lives are at risk.

I was once told that the only true constant in life is change. Climate change is inevitable and a lot of uncertainty still exists with the severity, but that is life. We are seeing environmental change at a rate we have never observed before. In the western United States fire is predicted to grow in frequency, area, and severity. This is the temporal and space component that is attached to the resilience of ecosystems and communities. Specifically fire in the Pacific Northwest is an ecological and societal issue that needs to be reexamined and a new strategy needs to be accepted , and funded, so we can create a more harmonious future for us and the landscapes in which we live. It's exactly as Mark Finney said, it is not a matter of if fire will happen but when it will happen, and the severity it impinges.

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