Droughts and Wildfires in Western U.S. Rangelands

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On the Ground

- Because fire activity fluctuates with short- and long-term term weather and climate trends, understanding trends relative to climate forecasts is critical to mitigating the loss of life and property and rapid vegetation state changes.
- Through the analysis of charcoal and trees scars, historical droughts and fire patterns can be quantified retrospectively for hundreds of years. This evidence suggests that generally fire was most frequent during warm-dry periods as opposed to cool-moist periods. However, arid regions may see an increase of fire activity with an increase of moisture due to inherent fuel load limitations.
- Using federal wildfire and weather data from 2002 to 2015 for New Mexico, Nevada, Oklahoma, and Wyoming, we demonstrate that the worst wildfire activity occurred after average or above average precipitation years followed by drought in Oklahoma and Wyoming. Nevada wildfire activity was correlated with precipitation the preceding year, and New Mexico wildfire activity was not correlated with annual precipitation or preceding year precipitation.
- The effects of future drought on fire intensity and severity are projected to be highly variable because they are both a function of fuel load. However, the potential for very large wildfires is predicted to increase; fire weather is expected to create hotter and drier conditions that start earlier and last longer; and the relative changes may be most noticeable in cooler regions that are of higher latitude and elevation.

Keywords: climate cycles, disturbance, fire, forest, rangeland, weather variability.

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Wildfire size, extent, seasonality, and severity seems to have accelerated in the western United States over the last several decades, with 2006 and 2011/2012 being some of the most active wildfire years on record. Although fire is a disturbance that has regulated plant communities in North America for millennia, the recent escalation and potential correlation with a changing climate and drought, in particular, is a major social and ecological concern. While frequent fires structuring grasslands and park-like ponderosa forests is a regulating ecological process, catastrophic events causing rapid vegetation state change are less understood. Examples from Wyoming of rapid state changes include wildfires in 2003 that eliminated all sagebrush with no apparent recovery to date (Fig. 1A) and wildfires in 2012 that caused over 99% mortality of mature ponderosa pine (Fig. 1B). In fact, both 2003 and 2012 were years with below average precipitation and negative Palmer Drought Severity Index values. This suggests that the regulatory role of fire does not act independently of drought, but rather interacts with short-term weather and long-term climatic patterns that change over time. This interaction is evident in the formation and physiography of characteristic vegetation structure found in the grassland biome, a process hypothesized to have been a function of occasional arid periods restricting woody plants and increasing drought leading to frequent fires.

Because fire activity fluctuates with short- and long-term term climatic trends such as drought and precipitation deluges, understanding current trends relative to future climate projections is critical not only ecologically but also socially. The droughts and wildfires of 2011 and 2012 were some of the worst on record and caused substantial property losses and threats to human lives (Fig. 2). As the financial costs of wildfire management escalate, the socio-ecological consequences of drought–wildfire interactions must be understood.[1] The goals of this paper are to 1) review the historical interaction between drought and wildfire in western US rangelands, 2) summarize the societal impacts of this interaction, 3) use recent weather and state-level wildfire data from four case studies (Southwest: New Mexico; Great Basin: Nevada; Southern Great Plains:

Figure 1. Examples of rapid vegetation state changes from wildfires in drought years. **A,** Burn scar of the Lake Creek Wildfire in the Thunder Basin of Wyoming that burned in August of 2003. The year this fire burned was a below average precipitation year and above average wildfire year. Mortality of sagebrush is estimated at > 90% (note the lack of sagebrush in this picture that was taken in 2015 or 12 years after the wildfire). **B,** Ponderosa pine stand in the Laramie Mountain range of Wyoming three years after the Arapaho wildfire that burned > 100,000 acres in 2012one of the worst drought and wildfire years in the state. Mature tree mortality was estimated at ~ 99%. Photo courtesy of J.D. Scasta.

Oklahoma; and Rocky Mountains: Wyoming) to understand the variability of this interaction at a meaningful social scale, and 4) synthesize what we can expect in the future relative to climate projections and wildfire risk.

Figure 2. Wildfire damage in north-central Oklahoma in 2012. Note the proximity of eastern red cedars to the destroyed property. Photo credit: J.R. Weir.

Historical Fire and Drought

Historically fires did not occur regularly or uniformly through space or time. This spatio-temporal variability is largely a function of fuels, topography, weather/climate patterns, and ignitions. During dry or prolonged drought conditions, if fine fuel cover is adequately contiguous then fire activity often increases. Through the analysis of charcoal and trees scars, historical droughts and fire patterns can be quantified retrospectively for hundreds of years (Fig. 3). In the cooler, northern Great Plains, fire was most frequent over the last 750 years during warm dry periods, especially from 1770 to 1820 and from 1870 to 1920, as opposed to less frequent fire in the moist and cool time from 1820 to 1870.[2] The opposite effect can occur in drier regions that are fuel-limited where century-long and longer moist periods can correspond with increased fire activity.[3] This is important because long-term, decadal to multidecadal droughts have been relatively common in the Great Plains.[4] However, over time these prolonged droughts can reduce biomass production, resulting in increased bare soil and drought-tolerant forbs, which can also lead to a loss of fine fuels and eventually decreased fire occurrence.[5]

The frequency and size of wildfires is also dependent on fuel production and ability of fires to spread. For example, in the central Great Plains of the United States, aboveground net primary production varied greatly from 1975 to 1993 due to irregularity in precipitation resulting in fuel loads being driven largely by precipitation patterns.[6] This fuel load : fire frequency relationship is broadly demonstrated across the Great Plains of the United States where fire frequency generally increases from west to east due to precipitation and north to south due to temperature.[5]

Figure 3. Cross section of a dead ponderosa pine tree collected from Scotts Bluff, Nebraska. Tree-rings cover the years 1527 to 1762. Historical droughts can be determined based on patterns of narrow rings. Historical fire years can be dated from the tree rings where fire injuries occur (white arrows). Photo courtesy of M. Stambaugh.