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Fire Severity Trends

We are testing the idea that climate may affect forest fire severity independent of fire intensity. Pervasive warming can lead to chronic stress on forest trees (McDowell et al. 2008, Raffa et al. 2008), resulting in higher sensitivity to fire-induced damage (van Mantgem et al. 2003). Thus, there may be ongoing increases in fire severity (the number of trees killed), even when there is no change in fire intensity (the amount of heat released during a fire). We will consider this question at a subcontinental scale by synthesizing existing information from plot-based prescribed fire monitoring databases across the western United States of America (USA). Prescribed fire data are particularly well suited to exploring the relationship between climate and fire severity because prescription burns are conducted over a relatively narrow range of fire weather but over a potentially wide range of inter-annual climatic conditions. Results of this study will determine the role of climate on fire severity. Relationships developed here will also help managers predict changes in fire severity from large-scale climatic anomalies (e.g., ENSO, PDO) and from secular trends in climate.

Project Details

There is a growing realization that regional warming may be linked to increasing forest fire size and frequency (McKenzie et al. 2004, Westerling et al. 2006), a trend occurring in concert with increased fuel loads in forests that historically experienced frequent surface fires (Brown et al. 2004). Recent studies have also suggested that, at least in the Sierra Nevada of California, warming temperatures are correlated with increased fire severity (post-fire tree mortality) (Miller and Safford 2008). The mechanism whereby fire severity might increase in response to warming is presumed to be increasing probabilities of severe fire weather (higher air temperature, lower relative humidity and fuel moisture). While likely true, this view discounts the biological context of the fire event. Indeed, it has been demonstrated empirically that trees subject to chronic stress are more sensitive to subsequent fire damage (van Mantgem et al. 2003), suggesting that recent climatic trends may lead to a de facto increase in fire severity, even when there is no change in fire intensity.

There is evidence suggesting that regional warming may be contributing to increasing tree stress. From the late 1980s to 2006 (the period including the bulk of our data; see Methods), mean annual temperature of the western USA increased at a rate of 0.3 to 0.4° C decade-1, even approaching 0.5° C decade-1 at the higher elevations typically occupied by forests (Diaz and Eischeid 2007). This regional warming may increase tree stress by (i) increasing water deficits and thus drought stress on trees (McDowell et al. 2008), (ii) enhancing the growth and reproduction of insects and pathogens that attack trees (Raffa et al. 2008), or (iii) both. A contribution from warming is consistent with the apparent role of warming in episodes of recent forest die-back in western North America (Breshears et al. 2005, Raffa et al. 2008), and the positive correlation between short-term fluctuations in background tree mortality rates and climatic water deficits observed across the western USA (Bigler et al. 2007, van Mantgem and Stephenson 2007, van Mantgem et al. 2009). An additional consequence of these trends may be that forests are becoming increasingly sensitive to burning.

Specifically, we will consider two topics, (i) quantifying the contribution of climate, both preceding and following fire, on fire severity (as measured by post-fire tree mortality), and (ii) detecting any secular trends in fire severity.

Current Activity: We have collected data from 14 National Park fire effects monitoring networks and have begun to manage these data for upcoming analyses. We anticipate completing the analyses in FY2010 and having a product ready for publication soon thereafter. We will have all data downloaded, compiled, error checked, and formatted for analysis. We will also begin exploratory data analysis.

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