Climatic Extremes,Variability and Fire

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Main Focus

1. Key issues in considering (or modeling) the influence of climate on fire regimes.

2. Examples of insights from the paleofire and paleoclimate record and modern fire records in western North America.

Main Points

1. Fire can act as a catalyst of climate-induced ecosystem change because:

- Extreme fire events result in most (>90%) of the total area burned over time in fire regimes.
- In many forests ecosystems the largest fires are typically also the most severe. Hence, such extreme events have profound and long-lasting impacts.
- Extreme fire events are partly caused by extreme climate and weather events. The climate/weather events can develop over periods of days and seasons to years. Extreme fire events can occur over periods of days to months and spread over vast areas.
- Direct influences of climate/weather on ecosystems through natality, growth, mortality typically occur over longer periods.

As a consequence, fire may be a more important (albeit indirect) mechanism of climate-caused change in ecosystems than the more direct climate effects on growth and demographic processes.

2. Fire regimes are temporally and spatially autocorrelated because:

- Fire is a contagious (i.e., spreading) process.
- Previous fires influence the abundance of fuels, sometimes generating more fuels, thus enhancing fire occurrence, extent, severity and sometimes consuming fuels, thus delaying subsequent fires.
- Fuel legacies and quasi-stable fire regimes can arise from the nature of long-lived woody plants, e.g., recruitment cohorts can persist for decades and centuries, influencing water balance, fuel loads, continuity, types, etc.
- Climatic events and weather processes influencing fire are often spatially and temporally coherent/persistent (e.g., regional, multi-year droughts).
- Prior weather/climate events in previous seasons, years, decades, etc. can affect fuel production, which affects subsequently fires -- e.g., wet/dry cycles and entrainment of fire regimes in SW.

As a consequence, temporal and spatial ***variability*** of climate over various scales can be as, or more, important than ***means*** or ***extreme*** events in driving fire regimes (***extreme variability*** may be key)

3. Disturbance synergisms are important because:

- Other ecological disturbances affect fuels and microclimates, and hence fire regimes. The most important examples in forest ecosystems include, insect outbreaks, wind throw events, and direct drought-induced mortality of plants.
- These other disturbances are also partly driven by climate/weather processes and extremes. Sometimes these are the same processes and events (or the same type), and the other disturbances may respond in a similar or dissimilar way than fire responds to climate (e.g., droughts, insect outbreaks).
- These synergistic effects are expected to introduce lags and feed backs to ecological systems. This may introduce complexity or more predictability.

As a consequence, the response of fire (and ecosystems) to climatic extremes may require combined assessments of multiple disturbance responses to climate.

4. Humans have directly altered ecosystems and fire regimes worldwide because:

- People have always used fire to modify their environment. The spatial extent and magnitude of this modification depends upon the length of time of human occupation and population sizes, as well as the natural fire regime (i.e., lightning driven regime).
- Initial settlement of regions typically results in extensive and extreme burning and destruction of forests and woodlands.
- Livestock grazing and organized fire suppression greatly decrease fire occurrence and extent in many settled areas.
- Reduction or elimination of surface fires has led to extraordinary accumulations of fuels (especially in pine-dominant forests), leading to an increased number of extreme fire and geomorphic events.

As a consequence, it is often difficult to disentangle human from climatic causes of past and current fire regime variability .

5. Importance of scale and synchroneity

- internal and local ecological processes often overwhelm external and regional controls over fire regimes
- large fires and/or synchronized fire across spatial scales is more likely to be associated with climatic events than internal ecological drivers, or humans
- large fire events are dominant in many (most?) ecosystems, i.e., >90% of all area burned through time burns during a small number of fires (<10%) that are extreme in size
- large fires also tend to be more intense and severe in effect on ecosystems (especially in ecosystems with woody species)
- extreme fire events are more reliably detected in fire-scar and charcoal based reconstructions than other fire regime properties, including (and perhaps especially) fire frequency
- detection and evaluation of fire regime and climate synchrony/asynchrony across multiple points in space (i.e., paleofire and paleoclimate reconstruction networks) is a powerful means of identifying the nature of fire-climate relations.

Fire Regimes

The spatial and temporal characteristics of the fire process over a specified landscape (area) and time period.

Parameters:

Frequency -- number of events per time period; often cited as the inverse (1/f) "mean fire interval". Another variant is "fire cycle" or fire rotation", which are the time periods required to completely burn over a landscape (once) of a given size.

Extent -- area burned by individual fires, or combinations of fires.

Seasonality -- seasonal timing of fire.

Severity -- effects on vegetation, e.g., amount of mortality or scorch

Intensity -- measure of heat generated at the flaming front.

Fire regime types:

These are generalized categories of fire regimes that are typical of various vegetation physiognomic types and regions. For example:

- Crown fire or stand-replacing fire regimes
- Surface fire regimes
- Mixed fire regimes