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DECADAL VARIATIONS IN FOREST FIRE ACTIVITY IN THE PACIFIC NORTHWEST

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1. INTRODUCTION

Interannual variations in wild fire activity in the American southwest are significantly correlated with the tropical El Niño-Southern Oscillation (ENSO) phenomenon (e.g., Swetnam and Betancourt, 1990). In the northwest, the influence of ENSO is rivaled by the influence of another such irregular variation, this one in the north Pacific basin: the Pacific Decadal Oscillation (PDO). By calculating empirical orthogonal functions (EOFs) of monthly Pacific SST north of 20°N, Mantua *et al.* [1997] identified the PDO as the dominant mode of variability on interannual timescales in the north Pacific.

The PDO is a pattern of Pacific SST anomalies whose positive phase is associated with cold anomalies in the central northern Pacific and warm anomalies along the west coast of North America. It resembles the SST pattern that usually coincides with ENSO, but it is a distinct phenomenon. A time series of the loading of the first EOF (Figure 1) exhibits slow variations in which the dominant sign remains the same for 20–30 years. It was in the negative phase from about 1900 (when a few reliable SST measurements began to be available) to 1925 and from 1945–1977 and in the positive phase from 1925–1945 and from 1977.

This note investigates the relationship between the two climate time series, ENSO and PDO, and a time series of area burned in forest fires in Washington and Oregon.

2. DATA

We have collected data on forest fires in Washington and Oregon and correlated the year-to-year variations with PDO. The fire data include area burned, area monitored, and number of lightning-caused fires. The data come from USDA Forest Service Annual Fire Reports (for the years 1916–1994) and from the United States Archives (1905–1915). The time series of area burned has been normalized by the area under surveillance, which changed with time, to form a “burned area index” (BAI) (see Figure 2).

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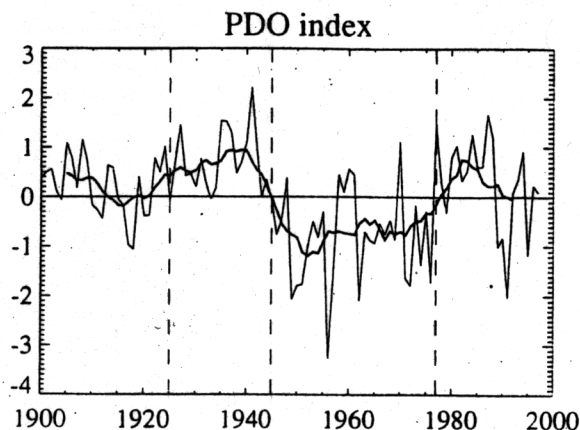


Figure 1. The winter PDO index and its 10-year running mean. See text for details. The dashed lines denote regime shifts.

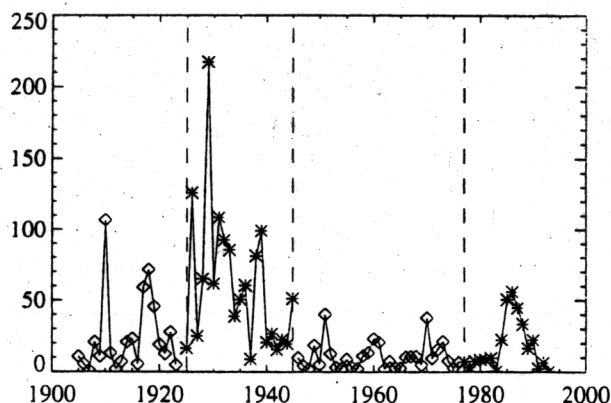


Figure 2. Area burned annually in forest fires in Washington and Oregon, normalized by the area under surveillance.

Interannual variations in the number of lightning-caused fires have no significant correlation with ENSO or PDO and we do not discuss it further.

As a measure of ENSO we use the Niño3.4 index. For the PDO we use six-month means (October–March, or “winter”, and April–September, or “summer”) of the monthly time series generated by the EOF analysis mentioned in section 1.

3. ENSO

The correlation between Niño3.4 and BAI is close to zero. Given the strong relationship between ENSO and burned area in the southwest, and the

strong relationship between ENSO and climate in the northwest, this result may seem surprising. We suggest two possible reasons for the lack of relationship between ENSO and BAI. First, fuel production in the southwest tends to increase during and after a cool, wet El Niño winter, whereas fires in the northwest are more limited by summer conditions favoring ignition and spread (i.e., unusually warm and dry). ENSO and summer climate variations in the northwest are weakly correlated, though the later melting of spring snowpack after a La Niña winter may deter summer fires.

Second, by averaging forest fire activity over a large area, it is possible that we have obscured sub-regional variations. Fire intensity, frequency, and extent are different for forests east and west of the Cascade crest, as a consequence of regional gradients in precipitation and temperature (Agee, 1993). Mechanistic links to climate drivers of fire activity, consequently, are probably lost when fire data are aggregated to the regional scale rather than analyzed by precipitation zone. Heyerdahl (1997) studied forest fire activity from tree ring data collected in the (small) Blue Mountain range in southeastern Washington and northeastern Oregon. She found that the annual extent of low-severity fires was closely correlated with El Niño events on the northern side of Blue Mountains but not in the southern side, and attributed this difference to ENSO modulation of the snowpack on the northern side. If such fine-scale regional variations occur in the Cascades, the Olympics, and Oregon's Coastal Range, then it is possible that ENSO relationships might be found if we can obtain data for smaller areas.

4. PDO

The BAI is, however, more closely correlated with the PDO. On the multi-decadal time scale (see Figure 2), it is clear that nearly all of the largest fire years occurred in the period from 1925–1945, during the previous positive phase of the PDO, and that during the subsequent and previous negative phases of the PDO, forest fires charred far smaller areas.

Unfortunately for our study, the BAI also shows the growing influence of human intervention. Widespread fire suppression began in the 1940's and while the smaller area burned in each year from 1945 to 1977 is consistent with the negative phase of the PDO, the average area burned is also clearly less than it was during the previous negative phase (1905–1925). After 1977, with the PDO in the positive phase again, the area burned in some years exceeded that in any in the previous 40 years. This

too is consistent with the phase of the PDO but also with a relaxation of fire suppression efforts, and the two cannot yet be disentangled.

Considering, however, the year-to-year variations of the PDO (figure 1), we obtain significant correlations. The winter PDO index has a correlation of 0.24, which is statistically significant at the 99% level using Monte Carlo methods. The summer PDO has weak correlations with BAI, probably because it too has little influence over summer climate in the northwest. The winter PDO, however, has a large influence on snowpack and hence on summer soil moisture in the northwest. The influence of the PDO is bigger, in fact, than that of ENSO.

5. CONCLUSION

Forests are subject to a number of disturbances such as insects, pathogens, fire, and wind. The influences of climate on the frequency, intensity, and extent of these disturbances can have a greater influence on forests than the direct effects of climate on the growth rates (Franklin *et al.*, 1991). Our results indicate that the PDO may influence forest fire activity and thereby influence broader fluctuations in forest ecosystem structure, composition and function.

References

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