APPENDIX C – WINDS AND LARGE WILDLAND FIRES

C1. Overview and Scope

The purpose of this section is to provide and discuss the published data that indicate that wind-driven fires in California are responsible for the greatest damage to both life and property, and that illustrate the causal mechanisms that make them so. Work shown in Appendices A and B have established that power lines are more likely to fault and start fires during high-wind conditions – the very same conditions under which fires are more likely to grow to large size. This dramatically amplifies the potential danger from wildland fires. The danger to homes is likewise amplified by the mass transport of airborne brands, which have been repeatedly demonstrated to be a primary cause of home ignitions.

C2. Sources

C2.1. Wind-driven fires, historical data

The primary mechanism for establishing that severe and catastrophic wildland fires are wind events is the study of historical data. The authors below either have analyzed or summarized historical fire data from California and elsewhere and correlated it with weather events. These correlations uniformly show that massive wildland fires in California are wind-driven.

C2.1.1. Moritz, Max, 1997

Moritz analyzed the entire fire history for the Los Padres National Forest (LPNF), which consists primarily of chaparral vegetation effectively similar to some of the vegetation zones transected by the SPL route. Using a "statistics of extremes" analysis, he correlated the largest fire in each year from 1911 to the time that the paper was prepared (1996) versus the intensity and length of Santa Ana events. He found that fires larger than 4000 h.a. were correlated with Santa Ana events, whereas smaller fires were not, suggesting that fire size is driven by weather events and not by fuel characteristics.

C2.1.2. Moritz, Max, 2003

In this expansion of the work done in his 1997 paper, Moritz now correlates the LPNF fire data with spatial distribution and the ages of the vegetation affected. Primarily, the purpose of this paper is to refute the assertion made by Minnich and others that massive wildland fires are an "artificial" phenomenon caused by suppression of natural burning and the over-accumulation of fuels. The data and analyses in this paper effectively prove this for the LPNF region, and demonstrate that even relatively young fuels will support the spread of wildland fires. This paper further strengthened the assertion that major wildland fires are driven by weather and not by fuels.

C2.1.3. Halsey, Richard, 2005

Halsey has collected the data for all major fires in Southern California since the end of the 19^{th} century, and tabulated them on p. 49 of "Fire, Chaparral, and Survival in Southern California." Major, in this sense, means large area burned, a large number of buildings destroyed, or significant loss of life. ALL of these major fires were associated with strong winds and low humidity.

C2.1.4. Mitchell, Joseph W., 2006

The author briefly surveys records provided by the National Interagency Fire Council from 1999 to 2003 and demonstrates that the statistics are dominated by large events at a variety of scales. He also describes an original countermeasure against wind-driven embers.

C2.2. Wind-driven fires, causal mechanisms and theory

C2.2.1. Malamud, B. D., G. Morein, and D. L. Turcotte, 1998

It was first suggested that forest fires would exhibit "self-organized" behavior characterized by their effect being dominated by large events at all size scales by Bak and others who developed the theory of self-organized criticality. Malamud, et al. were the first to compare this model against actual forest fire data. The data come from arboreal forests, and clearly show the predicted power-law type of behavior expected for self-organized critical events. The key result of relevance here is that the damage to be expected from wildland fires will tend strongly to be from large, catastrophic events, rather than the accumulation of damage from smaller events.

C2.2.2. Moritz, Max, et al., 2005

This collaboration between physicists, engineers, and ecologists adapts the theory of "Highly Optimized Tolerance", which has been presented as a more complete replacement for some theories of "self-organized criticality", and applies it to wildland fire. Once again, Moritz uses the historical data from the LPNF for the analysis. However, this time it is compared against two models:
1) A model based upon the 'Highly Optimized Tolerance' (HOT) model of co-authors Carlson and Doyle. HOT models optimize 'robustness' in situations of uncertain potential loss, and like self-organized criticality models predict power-law type behavior when applied to forest fires. HOT models have also been applied to model Web traffic.
2) A model based upon fire propagation using fuel types. This is much more difficult and time-consuming to run, but a large number of runs based on randomly generated potential fires in the LPNF were done.

Both of these models ended up showing an amazingly good fit to the LPNF data. What this implies is that 1) our mechanistic models for fire behavior and spread are good, and 2) that the HOT model is capturing "emergent" behavior of mechanistic processes in a much more abstract and generally applicable form.

One relevant aspect of this work to the SPL fire threat is that model 2 incorporated "Santa Ana" conditions in a tunable form to study their effect on fire spread. This model also confirmed that Santa Ana conditions were also the key drivers for large fires, even for "simulated" fire conditions.

C2.3. Wind-driven fires and home destruction

C2.3.1. Ramsay, G.C., McArthur, N.A. & Dowling, V.P., 1987

This is the classic Australian study of the "Ash Wednesday" fires, which demonstrated through examination of destroyed structures that wind-borne embers were the primary mechanism of structure ignition, rather than radiant heat or flame.

C2.3.2. Foote, Ethan, 1994

A Master's thesis prepared for the University of California at Berkeley, this analysis of the Santa Barbara Paint fire reaches exactly the same conclusions as the Australian results. This was also a statistical analysis of destroyed and surviving homes.

C2.3.3. Cohen, Jack, 2000

Cohen pioneered much of the early work that identified wind-blown firebrands as a primary cause of structure ignition. Much of this work consisted of showing that it was virtually impossible to ignite structures through radiant heat or convection alone if there was a reasonable amount (~100 feet) of vegetation management around them.

C2.3.4. Mitchell, Joseph and Oren Patashnik, 2007

This conference presentation demonstrated an ember entry mechanism that was operative during the Cedar Fire in Scripps Ranch, specifically the entry of firebrands under curved tiles which were not adequately sealed. It also demonstrated that a light water spray, if correctly designed and operated, was sufficient to protect a structure (WEEDS, described in more detail in Mitchell, 2006).