IBHS PRIMER SERIES ON WILDFIRE

PART THREE

RISK ASSESSMENT, LOSS MODELING, & FIRE SIMULATIONS

IBHS PRIMER SERIES

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Wildfires are no different than the other natural hazards we face such as earthquakes, severe convective storms, hurricanes, or floods. There is a need to understand a community's level of risk to the hazard, simulate the hazard, and determine the potential exposure and loss if an event were to happen. All of these needs are typically addressed by modeling. Models represent a simplified version of reality that are used to predict outcomes based on known factors.

As models become more widely used in the property insurance industry for decision making, it is important to have a good understanding of their differences, and what model is best to help provide insights into a problem. In the property insurance industry, catastrophe models are often what comes to mind when the terms model or modeling are used.

Models can be categorized by type and their basis as follows:

OPERATIONAL

This type is used in fast-paced applications where quick information is needed, like weather forecasting. Wildfire incident management uses these types of models for an active fire to understand possible fire behavior and spread.

RESEARCH

This type is designed to address research questions by isolating certain variables. For natural hazards, especially those linked to the weather and the climate system, this type of modeling is a way to use a control group and experimental group, similar to the way a traditional experiment would be run.

DETERMINISTIC

This type produces a single outcome from one set of inputs. This is suitable for short-term simulations of a hazard. This type of model does not produce a measure of uncertainty.

STOCHASTIC

This type is statistically based and incorporates elements of randomness and uncertainty. The model combines results from thousands of simulations to produce a range of possibilities and probabilities. The output is an event set from thousands of simulations.

The underlying mathematics of a model, representing the hazard and its relationships with other factors, form the basis for the model. There are three general categories:

- **Empirical models** are based on relationships between observed variables both in the field and in laboratory settings.

- **Semi-empirical models** use a blended methodology where some of the physics of the hazard is simulated, while more complex parts are represented by the empirical or statistical relationships between variables.

- **Physical models** use equations of motion and thermodynamics to produce an event simulation, such as fire dynamics and combined weather and fire models.

Regardless of the basis and type of model, it must account for the basic elements of the fire behavior triangle described in Part 1 of this series.

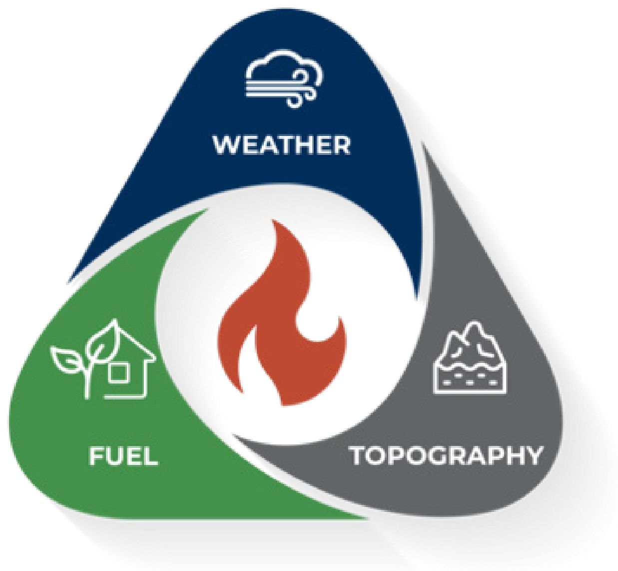

Figure 1. Fire behavior triangle.

RISK ASSESSMENT AND FIRE HAZARD MAPS

The fires of 2017 and 2018 drove fire risk and hazard mapping into the spotlight. Fire hazard mapping describes the intersection of the hazard (wildfires) and the exposure in a geographic context. Hazard mapping applies a stochastic approach coupled with empirical relationships to produce a scoring metric that describes the risk to a given area or community. These analyses are often built on measures of fire occurrence probabilities, severity, and the characteristics of the built environment. These assessments are also used to guide the application of building codes.

Perhaps the most visible risk assessment mapping efforts are those produced by the California Department of Forestry and Fire Protection (CAL FIRE) for the state of California. The Fire Resource and Assessment Program (FRAP) within CAL FIRE develops and publishes these fire hazard maps. The assessments designate Fire Hazard Severity Zones (FHSZ). In addition to these state-specific assessments, the U.S. Forest Service is conducting a Wildfire Risk to Communities project with a goal of providing a similar level of hazard assessment for all 50 states.

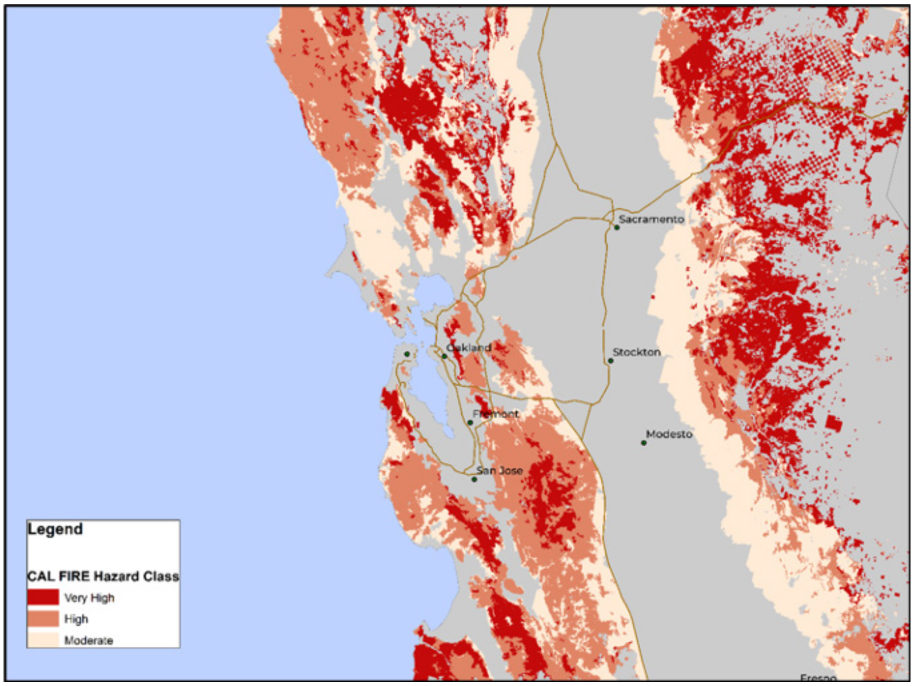

Figure 2. Example of CAL FIRE's hazard classification for part of Northern California.

Unfortunately, hazard maps often do not illustrate the true degree of uncertainty contained in their assessments. This is particularly true for those that provide a single metric as an output. Users of these maps must understand the details of the underlying data analysis techniques to know their limitations. The uncertainty of these assessments was exemplified during the Tubbs Fire in 2017 by the devastated community of Coffey Park in Santa Rosa, California, that had been classified as non-burnable on the existing maps.

WILDFIRE CATASTROPHE MODELING

Catastrophe models are an example of stochastic models. However, as catastrophe models become more sophisticated and availability of high-performance computing expands, catastrophe models have begun to blend different model types together to increase their accuracy and precision.

Catastrophe models are well established and are designed to understand physical and financial risks from a specific hazard. They allow for exploration of the possible loss from a variety of event simulations. The statistical output can be used to develop and manage risk transfer tools that are based on current science and engineering knowledge of the hazard and its impact. These types of models are also useful for a hindcast scenario, where the factors from a historical event are used to explore loss scenarios if the event happened today.

Catastrophe models use stochastic simulations of thousands of events. However, as the models become more sophisticated, more physical modeling is being integrated to represent the hazard itself. Empirical relationships are also applied to produce estimates of damage and loss that are dependent on the severity of the hazard. One of the critical outputs from a catastrophe model is the ability to express uncertainty and present results along with a probability assessment. Both operational and research-driven deterministic models do not provide that assessment.

For the wildfire hazard, catastrophe models are in their infancy relative to the well-established hurricane and earthquake models. Like the other types of models, catastrophe models are limited by the scientific knowledge that underlies the model's framework. Also, as models move toward the individual property level, the sensitivity to variables will increase.

FIRE SIMULATIONS USING PHYSICAL MODELING

Physical modeling of fire behavior and spread are commonplace in the research community, but for the wildfire hazard they are also becoming a part of the operational incident management process. These models are based in physics and solve a system of equations that describes the hazard to produce what is often a very detailed picture of a hazard. These types of models are also referred to as numerical models or numerical simulations. The models can range in complexity from simple two-dimensional simulations to coupled fluid dynamics and fire models in three dimensions. The most sophisticated physical models need to run on high-performance computing systems.

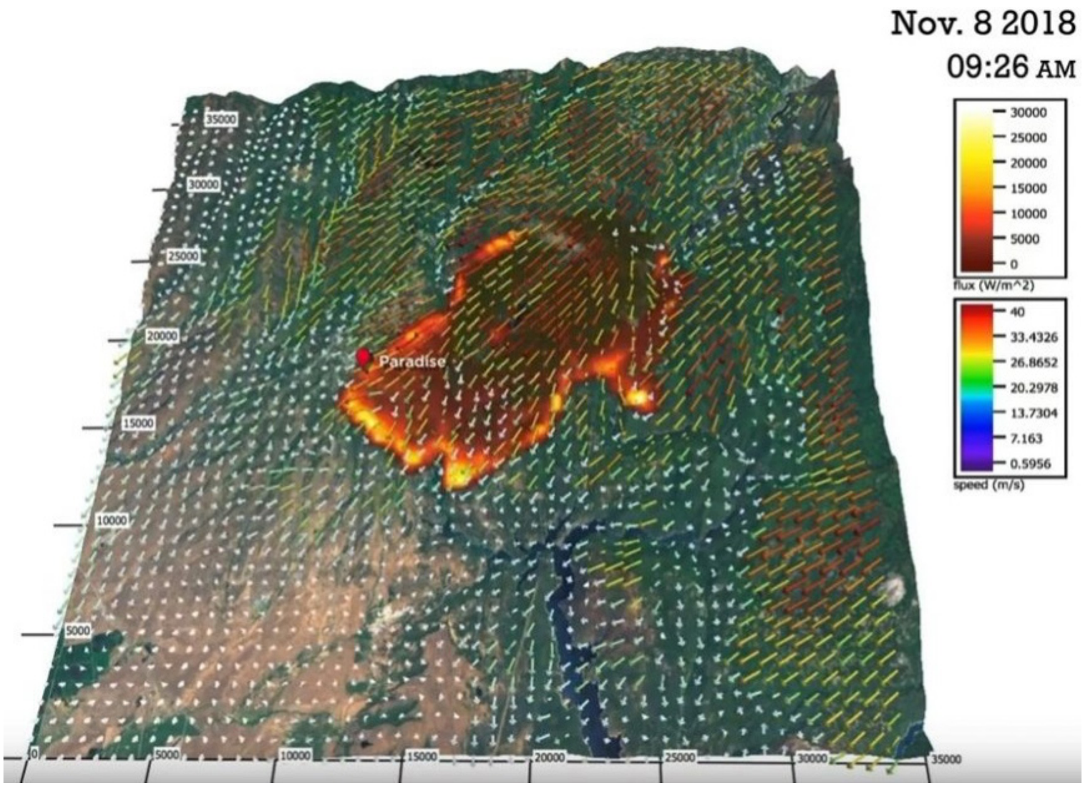

Figure 3. Example of a research simulation of the 2018 Camp Fire using a coupled fire and weather physical model (Coupled Atmosphere-Wildland Fire Environment Model). It shows the surface wind vectors and the modeled flaming front of the fire at a given point in time. Image courtesy of the National Center for Atmospheric Research.

All the model types described here are dependent on the data that is fed into them. They have an inherent level of uncertainty as a result of their baseline assumptions, and gaps in the scientific knowledge about the hazard and other variables. For the wildfire hazard, the gaps in science that affect modeling efforts also affect the fire behavior triangle. In general, wildfire science lacks the detailed field measurements needed to validate many of the assumptions and empirical relationships used in modeling. New scientific research is needed to better understand ember transport, thermal exposure of building materials, interaction between fires and the local weather, fire behavior and how it changes with fuel types, and how climate changes influence fire occurrence and severity.

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