Using Surface Winds to Improve the Accuracy of Fire Spread Modeling for Hazard Assessment in the Santa Monica Mountains

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Advisor: Bruce Kendall *Client:* Santa Monica Mountains National Recreation Area

SMMNRA is a mosaic of state, federal and private land. Wildland areas (green), dominated by highly flammable chaparral and coastal sage scrub vegetation communities, occur as patches in the fragmented landscape. Urban areas are shown in gray, and major highways in orange.

DRIVERS OF FIRE

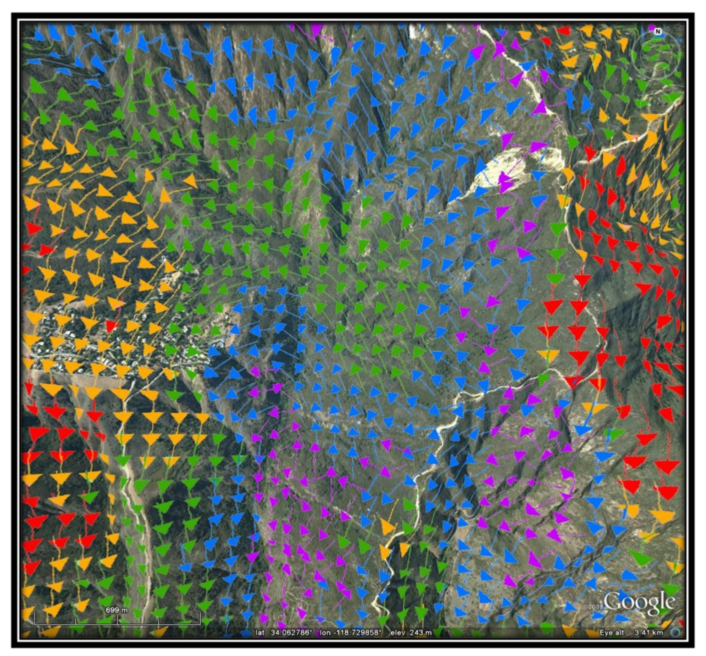
Southern California periodically experiences intense Santa Ana wind (SAW) events: strong, hot, dry winds that come from the northeast. The largest fires in Santa Monica Mountains National Recreation Area (SMMNRA) have occurred when SAWs, which can average 18-31 miles per hour (mph) with gusts over 99 mph, have coincided with severe fire weather conditions, such as dry vegetation, high temperatures and low humidity.

Fire spread is based on three factors: fuels, topography and weather. However, during SAW events, wind becomes the primary driver of fire behavior. Because the landscape is fire-prone, it is in the best interest of land managers to identify areas that may experience extreme wind and fire behavior, in order to efficiently allocate limited resources.

The wildland-urban interface, where human development abuts wildlands, has grown substantially in the last century, and there has been a similar increase in fire ignitions. Since most ignitions in SMMNRA are human-caused, projected population growth within the boundaries of SMMNRA is a concern.

An example of a wildland–urban interface in Topanga Canyon (from Google Earth).

FIRE SPREAD MODELING



A 90 degree, 15 mph surface wind layer for Corral Canyon (shown in Google Earth) illustrates the effect of topography on wind speed and direction (shown by colored arrows). Red indicates high wind speeds, and purple low wind speeds.

Currently, fire ecologists and researchers at SMMNRA use fire spread models to:

- calculate expected fire behavior adjacent to structures;
- identify locations where fire behavior is expected to be especially severe;
- illustrate expected conditions for future wildfires;
- assess the potential value of proposed fuel modification projects; and
- develop educational materials.

This group project specifically focuses on using surface wind inputs in fire spread models to map expected fire hazard throughout SMMNRA.

HFIRE, a fire spread model developed in the Geography Department of UCSB, was used to run the fire simulations in this study.

WIND IN FIRE MODELING

Current fire modeling uses prevailing wind inputs, which assume wind speed and direction are consistent for all areas across a landscape. In contrast, surface wind captures variations in local wind speed and direction, based on topography. The Missoula Fire Sciences Laboratory used the WindWizard model to produce eight wind grids, representing four wind directions (0°, 45°, 90° and 337.5°) and two wind speeds (15 and 25 mph) for this study.

OBJECTIVES

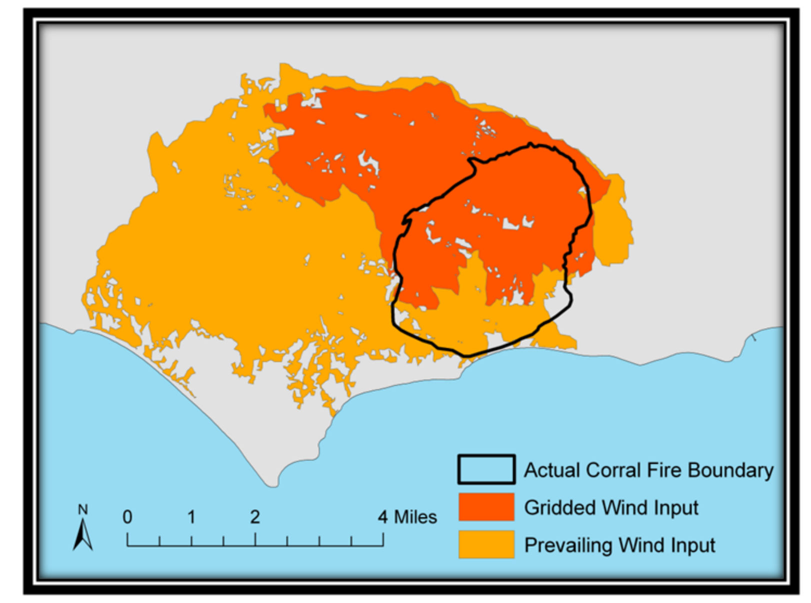
The purpose of the project was to create recommendations for the use of wind and fire modeling in SMMNRA by:

- Comparing fire simulations using surface wind inputs to fire simulations using prevailing wind inputs for a historic fire that occurred within SMMNRA;
- Modeling fire hazard in HFire (a fire spread model) incorporating surface wind output from WindWizard using historic and random ignition locations;
- Creating a fire hazard index map for SMMNRA by using the WindWizard output in HFire; and
- Identifying potential applications of surface wind models combined with fire spread models to inform land management decisions in SMMNRA.

SURFACE WINDS IMPROVE FIRE MODELING

Although fire spread modeling has previously been used in fire prevention and incident management, inaccuracy has limited its utility. Specifically, predictions of fire spread during extreme weather conditions have not been reliable.

To evaluate the effectiveness of surface wind inputs, they were tested against prevailing wind in recreating the 2007 Corral Fire. Although all of the fire simulations were generally larger than the actual Corral Fire, the surface wind input did more accurately model the Corral Fire than the prevailing wind input. We would expect surface wind to produce more accurate predictions for the entire study area as well.



Both prevailing and surface wind inputs resulted in larger simulated fires than the actual Corral Fire boundary, however, the surface wind input was more accurate.

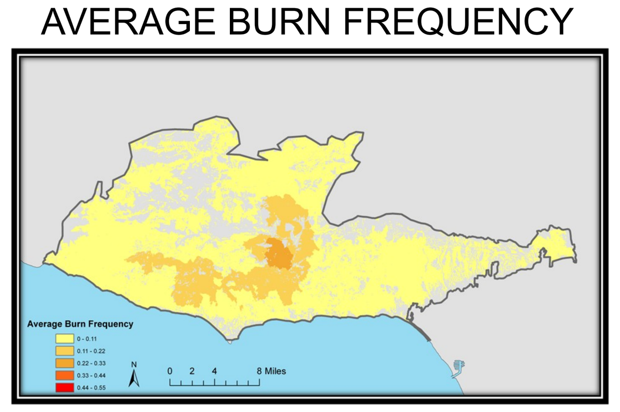
SENSITIVITY ANALYSIS

The sensitivity analysis measures how much results change when inputs are varied. We wanted to determine which inputs had the greatest influence on the magnitude and location of fire hazard. Our sensitivity analysis revealed that the spatial distribution of modeled fire hazard is the most sensitive to the distance from the nearest ignition point and accounts for approximately 20% of the variation in hazard ($p<0.0001$). The magnitude of modeled fire hazard was most sensitive to wind speed.

FIRE HAZARD MAP

We conducted additional fire simulations throughout SMMNRA to construct an overall hazard map based on 1) how frequently, and 2) how quickly a given location burned. We used historic and random ignition locations and four wind grids at a speed of 15 mph. Because HFire does not model fire fighting, each simulation was run for a 24-hour period to limit the size of fires.

AVERAGE BURN FREQUENCY



Burn frequency is the probability that an area will burn under simulated conditions. According to our model, burn frequencies within SMMNRA range from 0 to 32 percent. The burn frequency map is a weighted average of simulations using four directions at 15 mph.

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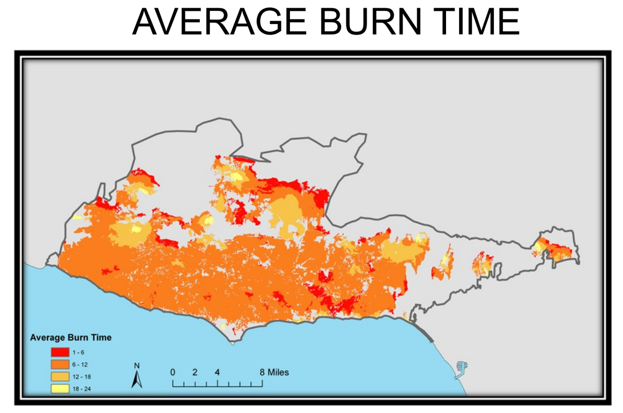
AVERAGE BURN TIME



Burn time is a score from one to 24. A score of 24 represents areas that burned fastest in the simulations, while a score of one represents the areas that burned slowest in the simulations. The burn time map is a weighted average of the four wind directions at 15 mph.

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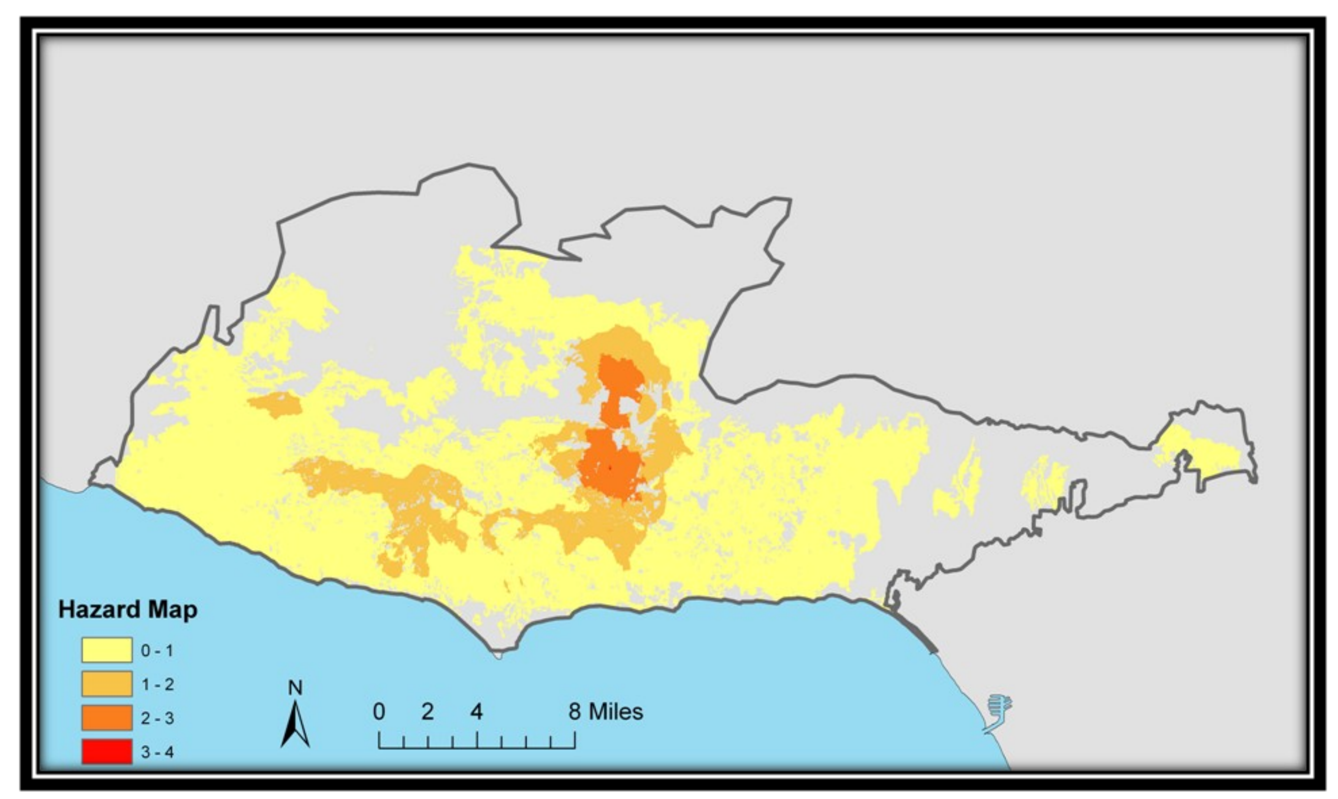
WEIGHTED HAZARD MAP



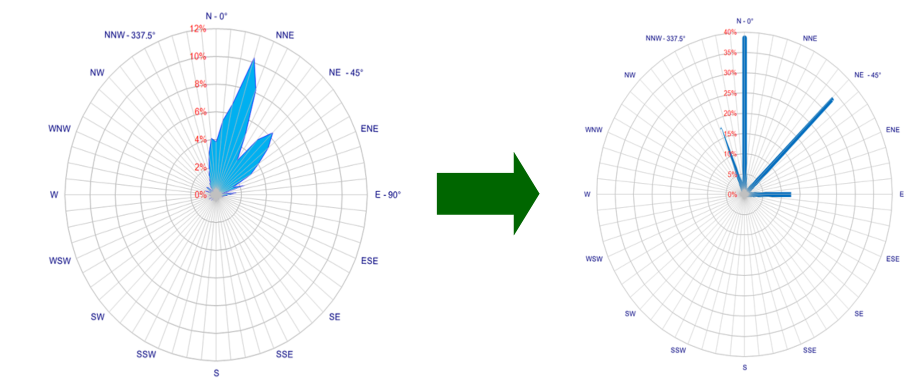
The weighted hazard map is calculated as the average burn frequency multiplied by average burn time. The highest hazard area, according to these calculations, is located between Simi Valley, Thousand Oaks, and Calabasas.

CONCLUSIONS

Our research assessed the use of surface wind in a fire spread model. SMMNRA sought our assistance to determine whether using a surface wind model, like WindWizard, would be a worthwhile investment of time and financial resources. Based on our simulations of the Corral Fire, we found that surface wind does improve the accuracy of fire spread when compared to the prevailing wind input. According to our model, the highest fire hazard is located between Simi Valley, Thousand Oaks and Calabasas. A surface wind program represents an additional tool that can be utilized by land managers to assess the effectiveness of specific management options in reducing fire hazard within SMMNRA.

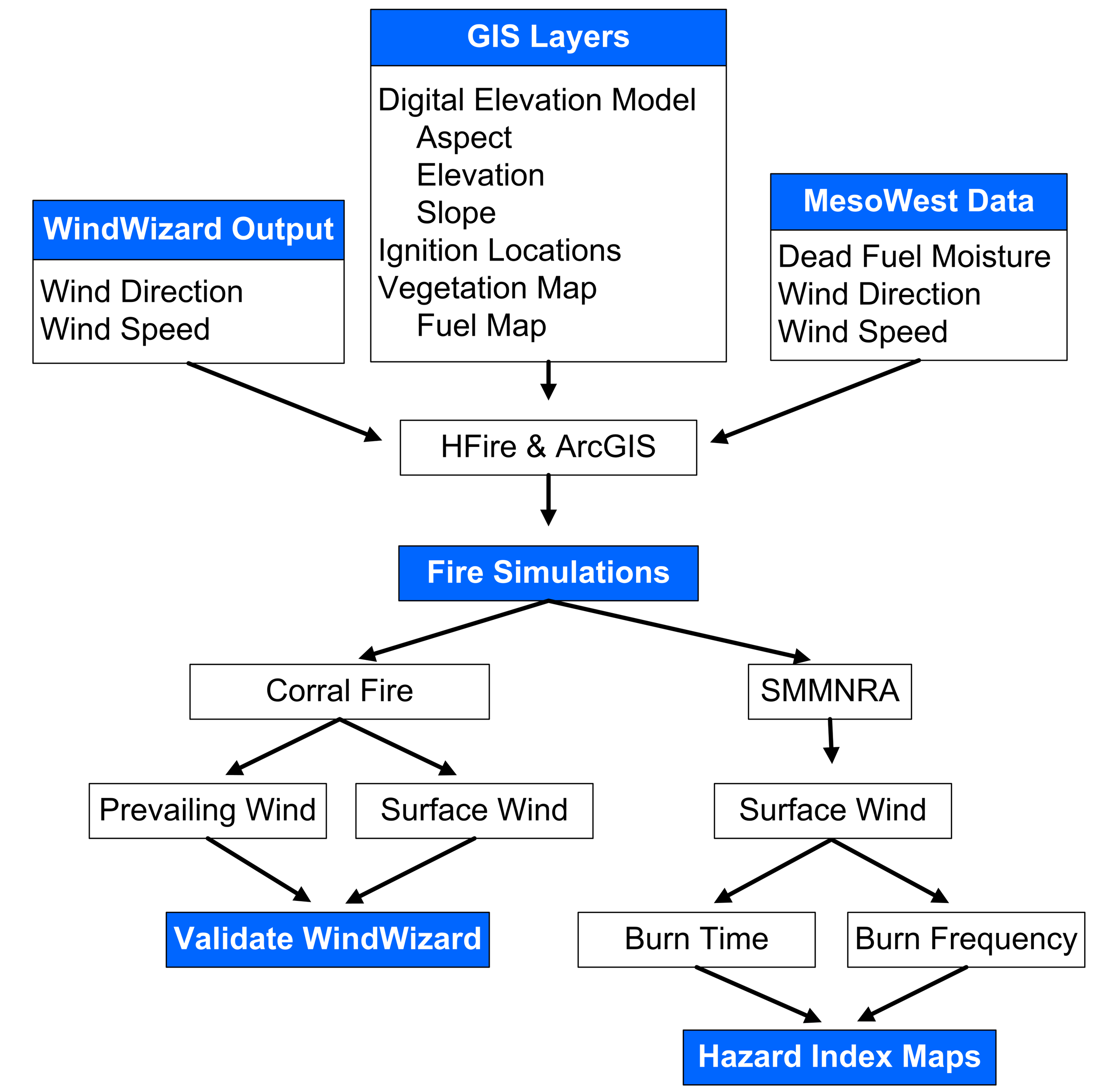
ANALYSIS OF SAW EVENTS

We analyzed SAW event data from the last four years, gathered from weather stations in the SMMNRA vicinity. Hourly conditions were categorized according to the four wind directions for which we had surface wind layers. The data indicated that 15 mph was the most appropriate wind speed.



Santa Ana Wind (SAW) Simplified SAW

APPROACH



POTENTIAL APPLICATIONS

SMMNRA can use a refined version of our model to evaluate the impact of the following on fire hazard: development scenarios, property acquisition, development mitigation programs, regulations for defensible space, implementation of local versus regional building code policies and strategies to limit ignitions.

Managers can also use it to assess the effectiveness of specific management strategies and scenarios, such as evaluating the location and size of strategic fuel modification zones. Effectiveness could be measured in terms of total fire hazard reduction, or fire hazard reduction per dollar spent.

Increased coordination and education could promote awareness about fire risk and fire hazard. Finally, our project could advise community-based action groups, such as Fire Safe Councils and arson watch programs, on where to target their resources.

FIRE MODEL REFINEMENT

We have identified the following opportunities to improve the model:

- A longer period of Santa Ana wind data would increase confidence that the model captures climate variations, such as El Niño. HFire's season simulator could randomize surface wind inputs within the range of past SAW events.
- Repeat analysis with multiple simulations, varying sets of random ignition points.
- Include a buffer around SMMNRA to model fires that may ignite outside the boundary.
- Vary wind grids hourly to represent changing wind speeds and directions during SAW events.

Thank You To
Frank Davis, James Frew, Darren Hardy, Bruce Kendall, Catherine Shields, Christina Tague — UCSB Donald Bren School of Environmental Science & Management
Dar Roberts, Seth Peterson — UCSB Geography Department
Charles Jones — UCSB Institute for Computational Earth System Science
Max Moritz — UC Berkeley Environmental Science, Policy and Management
Robert Taylor, Marti Witter — Santa Monica Mountains National Recreation Area, National Park Service
Missoula Fire Sciences Laboratory, U.S. Forest Service