GROUP PROJECT BRIEF

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USING SURFACE WINDS TO IMPROVE THE ACCURACY OF FIRE SPREAD MODELING FOR HAZARD ASSESSMENT: A CASE STUDY IN SANTA MONICA MOUNTAINS NATIONAL RECREATION AREA, CALIFORNIA

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INTRODUCTION

Figure 1: SMMNRA is a complex mosaic of wildland and urban areas and is bisected by several highways. The dark gray line is the SMMNRA boundary. The green represents wildlands within SMMNRA and orange represents highways.

Santa Monica Mountains National Recreation Area covers 90,000 hectares across Ventura and Los Angeles counties in southern California (Figure 1), consisting of highly flammable Mediterranean habitat. SMMNRA is a complex mosaic of federal and state land, as well as many privately owned parcels which could still be developed.

TERMS

SMMNRA – Santa Monica Mountains National Recreation Area, our study area

Fire hazard – refers to the likelihood that an area will burn based on physical conditions

SAW events – Santa Ana Wind events are seasonal hot, dry wind that is the primary driver of fire in southern California

Prevailing wind – wind speed and direction assumed to be consistent for all areas across a landscape

Surface wind – wind speed and direction varies across a landscape based on topography (also known as fine-scale or gridded wind)

WUI – the wildland-urban interface is where homes abut wild areas

The wildland areas are fragmented by development, and dominated by highly flammable chaparral and coastal sage scrub vegetation. Keeley et al. found that the WUI (Figure 2) has grown substantially in the last century, concurrent with an increase in the number of fire ignitions in southern California (Syphard et al., 2007). Most historic ignitions within SMMNRA have been human-caused, and therefore, further projected population growth within the WUI is a concern.

Figure 2: GoogleEarth image of a WUI in Topanga Canyon, located within SMMNRA.

The Santa Monica Mountains periodically experience intense SAW events: strong, hot, dry winds that come from the northeast. These extreme winds, which can average 18-31 miles per hour (mph) with gusts over 99 mph (Keeley et al. 2004), often coincide with severe fire weather conditions such as high temperatures, low humidity and low live fuel moisture.

Fire spread rates are generally based on three factors: fuels, topography and weather. However, during SAW events, wind becomes the primary driver of fire behavior (Dennison et al. 2008). Because the landscape is fire-prone, it is in the best interest of land managers to identify areas that are highly susceptible to extreme wind and fire behavior in order to efficiently allocate resources.

Many residents within the WUI assume that they can rely on firefighters to defend their homes from the threat of wildfire. However, successfully protecting a property begins long before a fire starts. Fire departments are now advocating that residents make their homes more fire-resistant and develop evacuation plans ahead of time.

Although fire breaks and prescribed burns can reduce the probability of ignition and facilitate containment of fires (Fernandes & Botelho 2003), they are also detrimental to ecosystem health (Keeley 2002). Managers would also like to limit the use of fuel modification because of maintenance costs (Keeley 2002).

Several methods have been used in fire hazard assessment, including fire spread modeling. Although fire models have been used to make prevention and on-the-ground fire-fighting decisions in the past, their utility has been limited by inaccuracies, especially with respect to extreme fire weather. Improvements in wind and fire spread modeling may make long-term planning applications possible. For example, surface wind input may more accurately represent wind and topography interactions critical to predicting fire spread in our study area. Surface wind takes topography into account so that wind speed and direction values vary across the landscape. This is different from prevailing wind inputs, which assume a uniform wind direction and speed across the landscape.

RESEARCH QUESTIONS

1. Do simulated surface winds improve fire spread predictions?

2. Can the highest fire hazard locations within SMMNRA be mapped using a gridded wind and fire spread model?

3. Which is the biggest factor influencing modeled fire hazard (e.g. wind speed, wind direction or ignition location)?

APPROACH & METHODS

As part of our methodology for determining the location of fire hazard (Figure 3), we ran fire simulations in HFire, a fire spread model. HFire (Department of Geography, UCSB) has been used in previous studies in SMMNRA and runs faster than the industry standard fire spread model, FARSITE. We gathered information on the topography, vegetation and historic ignition locations in SMMNRA to input into our simulations.

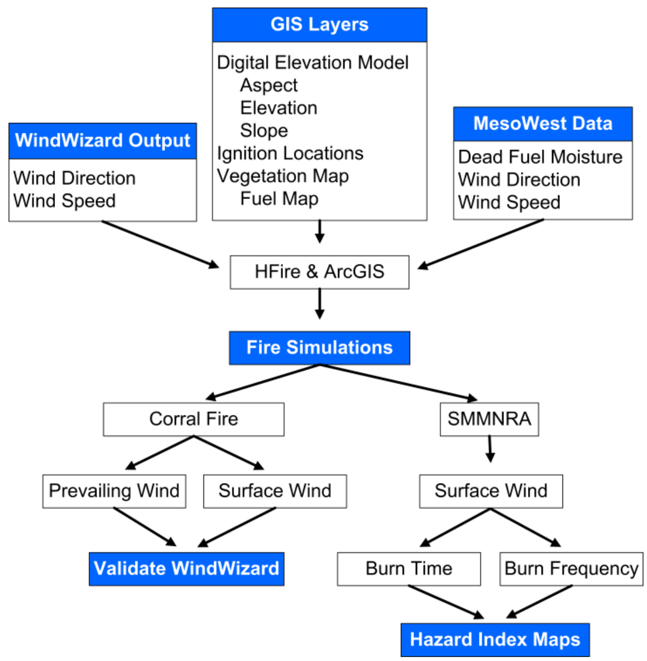

Figure 3: Flow chart diagram showing the process in creating a fire hazard map.

We used output generated from WindWizard as an input. WindWizard (Missoula Fire Sciences Laboratory) is a surface wind model that simulates wind flow under different wind speed and wind direction scenarios. Eight wind grids based on four wind directions (0°, 45°, 90° and 337.5°) and two wind speeds (15 and 25 mph) were produced for us by the Missoula Fire Sciences Laboratory.

Before using surface wind in large-scale hazard assessment, we evaluated its effectiveness compared with prevailing wind inputs in recreating the 2007 Corral Fire. Our results indicated that surface wind inputs were more accurate in modeling a historic fire than prevailing wind inputs.

Additional fire simulations were subsequently conducted throughout the study area using many historic ignition points and four wind grids at 15 mph, the most appropriate wind speed for the representative SAW events. Because HFire cannot model fire-fighting efforts, we modeled each fire for a 24-hour period to limit the spread of fires. An overall hazard map was constructed for SMMNRA based on how frequently, and how quickly, a given location burned.

RESULTS

Surface wind input more accurately modeled the Corral Fire than prevailing wind input. Simulated fires were larger than the actual Corral Fire boundary, but the surface wind simulation had a more accurate spatial distribution than the prevailing wind-driven simulation (Figure 4).

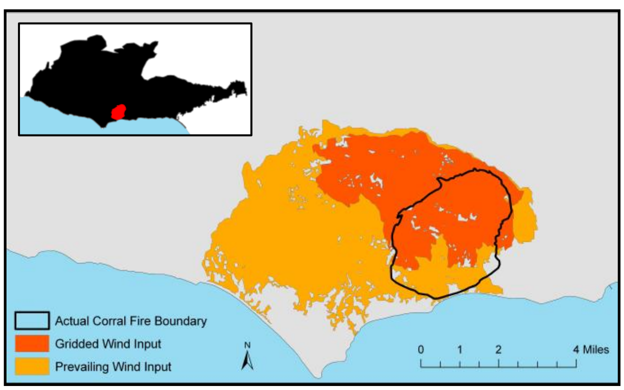

Figure 4: Overlay of fire boundaries using prevailing wind inputs (orange) varied hourly and set to match the four wind grids (0°, 45°, 90° and 337.5°) and surface wind inputs (red) varied hourly using the four wind grids.

The output maps generated by using surface wind and historic ignition locations demonstrate that central SMMNRA has the highest relative fire hazard (Figure 5).

A sensitivity analysis measures how much the outcome changes when the inputs are varied. We wanted to determine which inputs had the greatest affect on the magnitude and location of hazard. Our sensitivity analysis revealed that the

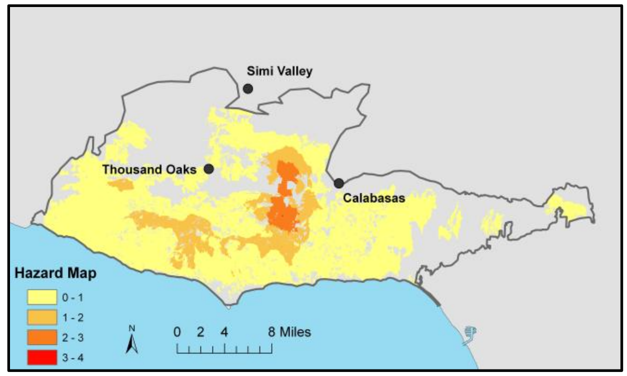

Figure 5: Weighted overall fire hazard index map for historic ignition locations. Dark orange represents the highest fire hazard areas within SMMNRA.

spatial distribution of modeled fire hazard is most sensitive to the distance from the nearest ignition point location, accounting for approximately 20 percent of the variation in hazard ($p<0.0001$). The magnitude of modeled fire hazard was most sensitive to wind speed.

CONCLUSIONS

SMMNRA sought our assistance in determining if using a program such as WindWizard, a surface wind model, would be a worthwhile investment of time and financial resources. Our research represents a preliminary assessment of the use of surface wind in a fire spread model.

Based on our simulations of the Corral Fire, we found that surface wind input does improve the accuracy of a fire spread model when compared to prevailing wind input. According to our model, the highest hazard in SMMNRA is located between Simi Valley, Thousand Oaks and Calabasas (Figure 5). Finally, wind speed and the distance to ignition location were found to be the most influential determinants of fire hazard.

Surface wind 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.

FIRE MODEL REFINEMENT

We have identified the following opportunities to improve the analysis:

1. A longer period of Santa Ana wind data would increase confidence that the model is capturing climate variations, such as El Niño. HFire's season simulator could incorporate and randomize surface wind inputs within the range of past SAW events to simulate the various possible conditions.
2. Repeat analysis with multiple simulations based on many random ignition points.
3. The effects of ignitions located outside the Recreation Area boundary should be included.
4. The model could be further improved by varying wind grids hourly, to represent changing wind speeds and directions during SAW events.

IMPORTANT POINTS

- Surface wind inputs do improve fire spread predictions.
- The highest hazard areas in SMMNRA are between Simi Valley, Thousand Oaks and Calabasas.
- Wind speed and distance from the ignition source is the most important determinant of fire hazard in our model.

POTENTIAL APPLICATIONS

SMMNRA can use our refined 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.

SMMNRA can also use the model 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 as fire hazard reduction per dollar spent.

SMMNRA can also influence fire hazard outside its boundaries by effectively communicating with other stakeholders. Increased coordination and education could also increase general awareness about fire hazard and risk. Our project could inform current community-based action groups, such as Fire Safe Councils and arson watch programs, regarding where to target their resources.

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