Scale-dependent factors controlling burn probability in the southern Sierra Nevada mountains, California

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PART 1 STUDY AREA: Southern Sierra Nevada mountains, California

Our southern Sierra Nevada study area contains portions of Sequoia-Kings Canyon National Park, Sierra National Forest, Sequoia National Forest, as well as some Bureau of Land Management and private lands (figure 1). Elevation ranges from 212 m to almost 4300 m. Vegetation is an intermix of hardwoods, shrub/chaparral, conifer, and alpine barrens. The study area has a mixed-severity fire regime; the fire season generally runs June through October.

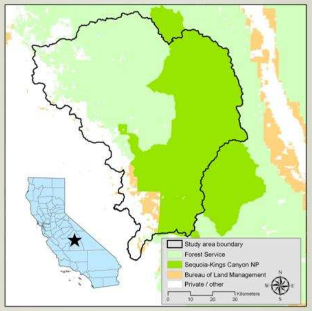

Fig 1. Study area boundary in the southern Sierra Nevada mountains.

PART 2 BACKGROUND: Burn Probability Modeling and purpose of study

Burn probability (BP) models can be used to understand how spatially heterogeneous landscapes in fire-dominated areas are generated and maintained. These modeling techniques combine the stochastic components of fire regimes (ignitions and weather) with sophisticated fire growth algorithms to produce high-resolution spatial estimates of BP for a snapshot in time (as opposed to models that account for vegetation succession). BP is generally derived by simulating a very large (e.g., >10,000) number of fires.

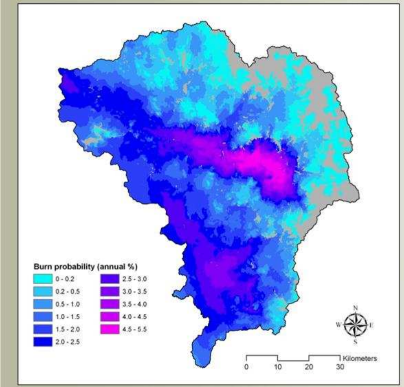

Fig 2. Annual burn probability. Areas in grey represent open water and non-fuels.

The FlamMap burn probability model was used to compute annual estimates of BP. Inputs include fuel layers, topographic layers, an ignition density layer, and weather conditions. We buffered the study area 13 km to minimize edge effects.

The factors affecting burn probability are expected to vary with spatial scale. Understanding at what spatial scales are most influential gives insight in comprehending BP patterns and fire regimes in the southern Sierra.

RESEARCH QUESTION

What is the most relevant spatial scale of some environmental factors contributing to the burn probability in the southern Sierra Nevada mountains?

PART 3 DETERMINING RELEVANT SPATIAL SCALE USING MOVING WINDOW ANALYSIS

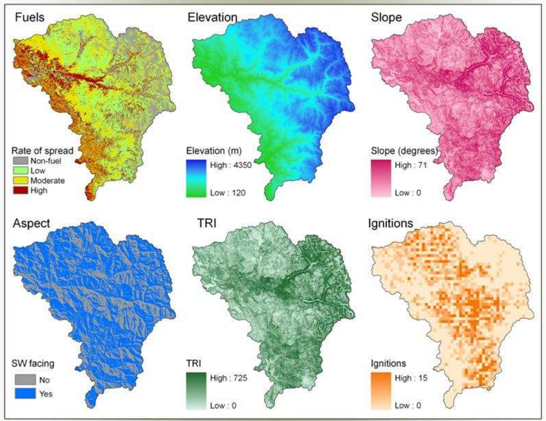

Fig 3. Maps showing the variables we analyzed using the multi-scale approach.

We converted the fuels layer into four categories based on rate of spread (ROS) under dry, windy conditions. Each of these fuel categories were converted to binary layers and analyzed separately. Aspect was converted to a binary layer, with all southwest pixels assigned a value of 1 and all other pixels assigned a value of 0. Moving window analyses (neighborhood statistics) were executed using multiple spatial scales to determine at which spatial scale each input variable was operating.

We compared burn probability to four categories of fuels (based on rate of spread), elevation, slope, aspect, topographic ruggedness index (TRI), and ignitions at 30 spatial scales (100 ha to 40,000 ha). We calculated Spearman's correlation, comparing BP to each variable at each scale, to determine the most relevant spatial scale.

PART 4 RESULTS: BP is affected by local and regional scale conditions

Results suggest that factors influence burn probability at different spatial scales. Fuels tend to have higher correlations with BP at broader spatial scales (12,500 to 22,500 ha), while slope and topographic ruggedness are correlated at more localized scales (100 ha). Elevation, while related to fuel type, operates at a more intermediate scale (3000 ha). Obviously, some variables are more correlated to BP than others (figure 4); not all variables tested were highly correlated with BP.

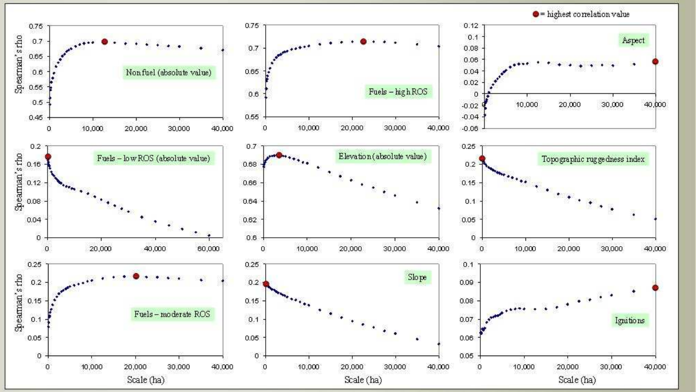

Figure 4. Multi-scale correlations between our variables of interest and burn probability.

Annual burn probability appears to best correlate with fuels (amount of non-fuel and high rate of spread fuel), and does so at fairly broad spatial scales. However, these relationships warrant further examination. Figure 5 shows the relationships between BP and fuels at the most appropriate spatial scale. Figure 5A shows a non-linear relationship; the reason for this relationship is that, in the areas with a high proportion of high ROS fuels, there were few to no ignitions. Thus, ignitions have an effect on BP in the lower-elevation, high ROS fuels, but do not show a strong relationship over the entire study area (figure 4).

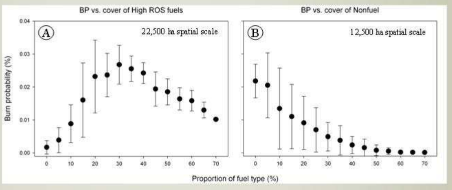

Figure 5. Mean (±SD) BP as a function of the proportion of high ROS fuels and non-fuels

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