Description of a Perimeter Clipping Suppression Algorithm

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Problem:

Suppression activities on large fires do two things:

1. Reduce the length of active perimeter, and thus, the length of fire edge that is capable of growing
2. Limit the duration of active fire growth

It is the process of progressively restricting the active segments of perimeter (#1) that limits the spread and ultimate duration of the fire (#2). The challenge for modeling is that fire suppression for large fires are very complicated and highly variable. Suppression depends on resource availability, choice of tactics, weather patterns, fire behavior, fuel types, and politics and all change over time and with fire growth. Consequently, it has not been possible to produce a general description of fire suppression effects on large fires, not to mention model such things.

Work to date:

Through regression modeling, it has recently been shown that the probability of containment might be influenced by patterns of fire activity and fuel type (Finney et al. 2009). Containment was found to be more likely during long periods of slow spread. Shorter periods are required for fires in grass or shrub fuels than in timber fuels. Thus, with a known pattern of fire activity in a particular fuel type, the probability of containment at each interval can be calculated. Thus, when embedded in a stochastic simulation, this equation would effectively reduce fire duration if a random number generated at each interval was less than the containment probability from this equation.

Current Work:

Assuming that the duration of the fire can be statistically predicted based on the patterns of fire activity (#2 above), it was thought possible to produce a very general model for the effect of suppression on censoring or trimming of perimeter growth. The huge uncertainty and variability in fire suppression activities was to be avoided by having the smallest set of rules to guide this algorithm:

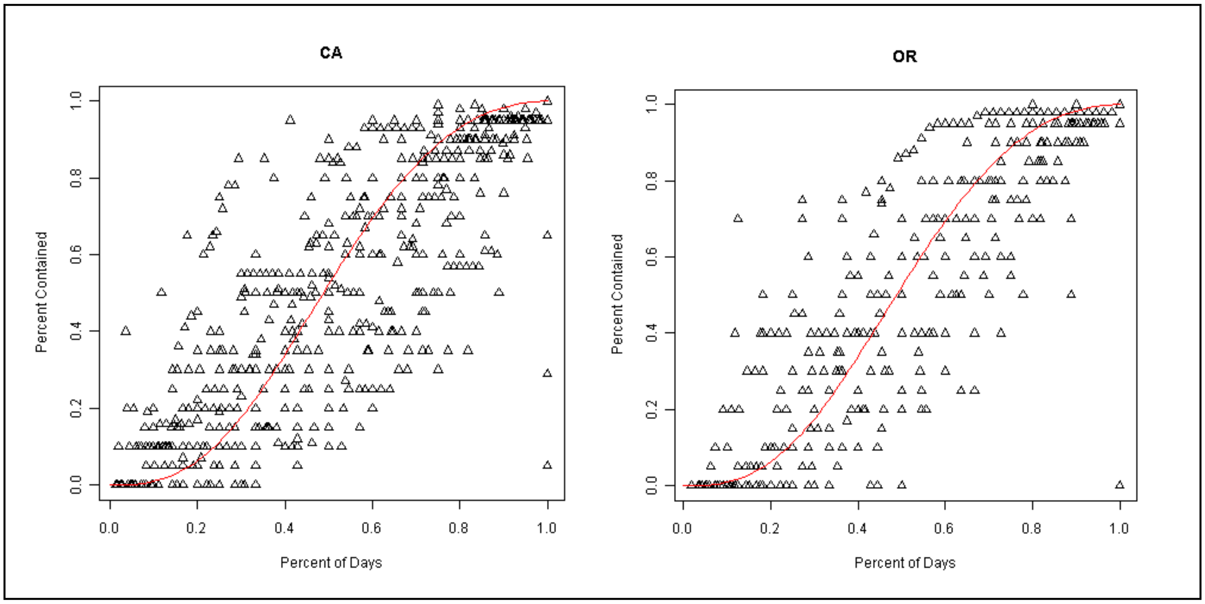
1. The percentage of containment at any given time would follow an empirical function.
2. Fire perimeter containment would take place only along the slowest contiguous segments of fire perimeter.

Step #1 was achieved by analyzing ICS-209 data on historical fires where percentage containment was reported by day. The fires were stratified by State for purposes of examining variation across the U.S.

The analysis scaled the duration of each fire as a fraction of the total number of days that each fire burned. Visual inspection of the scatter plots suggested a sigmoidal curve form was the most common and, since all variables were normalized, the function must start at 0.0 and finish at 1.0. Thus, a single-parameter function for Fraction Contained (FC) fitted by non-linear regression was of the form:

$$FC = \left(\frac{2x}{1+x^2}\right)^a$$

Where *x* is the fraction of fire days and *a* is the regression coefficient. For most of the regressions, the value of *a* has been between 2.0 and 3.0 as for California and Oregon below which produces approximately symmetric curves:



Using a Fraction of Containment model above, the steps in producing a geometric algorithm for containment as intended for step #2 were as follows:

1. Simulate each fire using the Minimum Travel Time algorithm for the period of time determined by the fire duration. This produces two main kinds of data:
    a. fire arrival time grid,
    b. Minimum Travel Time pathways (fire travel paths among nodes/cells on the landscape)
2. For each day in the fire duration, determine FC
3. Find the cells on perimeter at the end of each day from the arrival time grid (NumCells)
    a. Sort these cells by fire spread rate, from lowest to highest
    b. Sort the cells into groups that are contiguous
4. Determine the number of new cells to be extinguished each day such that the total is FC*NumCells

    a. Extinguish groups of contiguous cells as in 3b until the required number of cells is extinguished.

5. Using the Minimum Travel Time pathways, determine all cells that would have burned as a result of burning through the extinguished cells identified in Step 4a.
6. Extinguish all cells in Step 5. And repeat steps 2-5 until all days of fire growth are exhausted.