

Spatial Analysis of Fuel Treatment Options for Chaparral on the Angeles National Forest¹

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Abstract

Spatial fuel treatment schedules were developed for the chaparral vegetation type on the Angeles National Forest using the Multi-resource Analysis and Geographic Information System (MAGIS). Schedules varied by the priority given to various wildland urban interface areas and the general forest, as well as by the number of acres treated per decade. The effectiveness of these spatial treatment schedules was compared to ‘No Action except fire suppression’ using stochastic simulation performed by the model Simulating Vegetative Patterns and Processes at Landscape Scales (SIMPPLLE). Results are presented in terms of acres burned by wildland fire. The effectiveness of treatments in reducing acres of high-intensity wildland fire varied by the spatial distribution of fuel treatments.

Introduction

Chaparral shrublands of southern California comprise one of the most fire-hazardous landscapes in North America (Keeley 2002). Fires in this vegetation type tend to be stand-replacing crown fires with spectacular fire behavior (Philpot 1977). A large percentage of the acreage that burns occurs during severe weather when fire suppression efforts are least effective (Minnich 1983, Keeley and Fotheringham 2001b).

Complicating this situation is the fact that the wildland urban interface has been continually expanding in recent decades (Davis 1988, Keeley and others 1999, Keeley and Fotheringham 2001a) and the number of visitors on the forest has increased. As a result, there are more people on the landscape, which increases the chance of a human-caused fire. With more housing in the interface there is greater property loss from fires regardless of ignition source.

Fuel treatments have been suggested and applied to reduce the hazard from wildland fire (Philpot 1974, Minnich and others 1993). Alternative strategies have ranged from the use of prescribed fire to create a mosaic of age classes on the landscape (Philpot 1974, Minnich and Franco-Vizcaino 1999) to concentrating treatments in the wildland urban interface (Rice 1995, Conard and Weise 1998).

¹An earlier version of this paper was presented at the 2002 Fire Conference: Managing Fire and Fuels in the Remaining Wildlands and Open Spaces of the Southwestern United States, December 2–5, 2002, San Diego, California.

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Ability to conduct fuel treatments is limited by a number of factors, including budget, smoke, and number of days suitable for controlled burns. Forest managers need tools and methods for analyzing where to place treatments on a landscape to maximize their effectiveness.

This paper presents an analytical approach for spatially and temporally scheduling fuel treatments and comparing their effectiveness in reducing wildland fire and suppression costs in chaparral. It was conducted as part of the Joint Fire Science project “A Risk-Based Comparison of Potential Fuel Treatment Trade-off Models.”

Study Area and Treatment Scheduling Criteria

The San Gabriel River District of the Angeles National Forest served as the study area. It is a 472,000 ac area with an extensive wildland urban interface bordering the suburbs to the northeast of Los Angeles, CA. Chaparral is the dominant vegetation type covering 63 percent of the area.

According to direction from the National Fire Plan, Angeles National Forest managers developed spatial priorities for fuel treatments based on housing densities in the wildland urban interface (*fig. 1*). The forest plan directs managers to conduct fuel treatments on 15,000 ac of chaparral per year. Current funding levels, however, are sufficient to treat only about half that amount annually. For hydrologic reasons, managers desire to treat no more that 40 percent of any fifth code watershed per decade. Finally, managers want to treat every 15 yr on priority areas and every 25 yr on the general forest outside priority areas.

Four fuel treatment scenarios were developed for this study (*table 1*). Scenario C represents the desired level of treatment (150,000 ac per decade), applies the spatial priorities and the watershed treatment limit of 40 percent, and follows the current policy of no active treatments in designated Wilderness. Scenario B reduces acres treated to 75,000 per decade (the current funding level) while maintaining the remaining criteria in C. Scenario A differs from B in that spatial priorities are not applied. This provides a test of the effectiveness of spatial priorities. Finally, Scenario D includes all treatable chaparral acres, while relaxing the watershed treatment limit.



Figure 1—Spatial priorities for fuel treatments.

Modeling Approach

The approach presented here involves the sequential use of two models, SIMPPLLE (Chew 1997), a simulation model, and MAGIS (Zuuring and others 1995), a decision model for scheduling activities.

Table 1—Fuel treatment scenario specifications.

Item	Scenario A	Scenario B	Scenario C	Scenario D
Chaparral acres treated per decade	75,000	75,000	150,000	230,600
Apply spatial priorities	No	Yes	Yes	Yes
Apply treatments in wilderness	No	No	No	Yes
Treat <40 pct of each 5 th code watershed per decade	Yes	Yes	Yes	No

SIMPPLLE

Simulating Vegetative Patterns and Processes at Landscape Scales (SIMPPLLE) (Chew 1995) is a stochastic simulation modeling system that predicts changes in vegetation over time and space by using a vegetative state/pathway approach. A vegetative state is defined by the dominant existing vegetation, size class/structure, and density. Change between vegetative states is a function of natural disturbance processes (insects, disease, and fire), and management treatments. The probability of a natural disturbance process occurring in a given plant community polygon is determined by both the state present in that polygon and the vegetative pattern represented by neighboring polygons. The disturbance probabilities provide the basis for stochastic simulation of location and timing of disturbance processes. Once a process occurs for a plant community polygon, logic is used to model its spread to neighboring polygons. Whether wildland fire spreads to a neighboring polygon is based on vegetation and type of fire on the polygon where fire is present, location of the neighboring polygon with regard to slope and direction of prevailing winds, and vegetation within the neighboring polygon.

For chaparral and the associated vegetation, we developed vegetative states and associated pathways for use in SIMPPLLE applying corporate information provided by Region 5 of the National Forest System from their Forestland and Resource Database (FRDB) and associated ArcInfo⁶ coverage. Vegetation data was derived from crosswalks of the regional types, the CALVEG⁷ hierarchical classification system, and the western forest types used by the Forest. A rule-based system was developed to translate vegetation information from the initial data-set into the vegetative state categories of habitat type group, species, class/structure, and density. Time steps were set at 10 years, and 5-acre grid polygons represented plant communities. We overlaid these 5-acre polygons onto the stand polygons, and assigned each 5 acre polygon the vegetative state of the predominant stand. Probability of fire starts was based on fire history for the area, and fire-spread logic

⁶Trade names are provided for information only and do not constitute endorsement by the U.S. Department of Agriculture.

⁷Developed by USDA Forest Service, Region 5 Remote Sensing Lab, 1920 20th Street, Sacramento, CA 95814.

was developed for two types of weather—spread under average conditions and extreme fire-behavior conditions.

We tested the version of SIMPPLLE developed for chaparral by making 20 stochastic simulations of a “No Action” scenario (fire suppression is the only management activity) and comparing the results with fire history for recent past decades. Average acres burned by wildland fire per year in the 20 stochastic simulations fell well within the range of average acres burned in the 1970s, 1980s, and 1990s (*fig. 2*). Distribution of fires by size classes up to 99 ac for the 20 simulations were also quite comparable to the same three past decades, although simulations predicted fewer fires in the larger fire size classes (*fig. 3*). This suggests that additional work may be needed in the fire spread and suppression logic in SIMPPLLE for the chaparral vegetation type for the fire-size distribution from simulations to more closely match past decades.

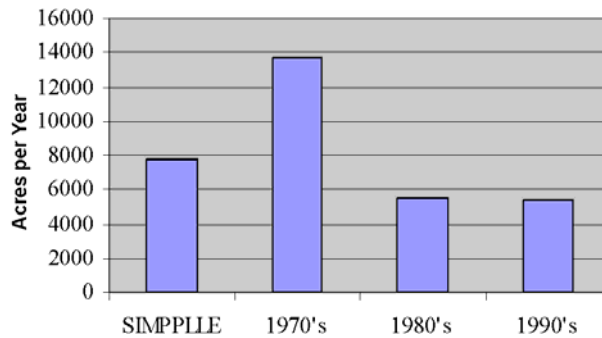


Figure 2—Average acres burned per year from 20 SIMPPLLE simulations for “No Action” compared to fires in three past decades.

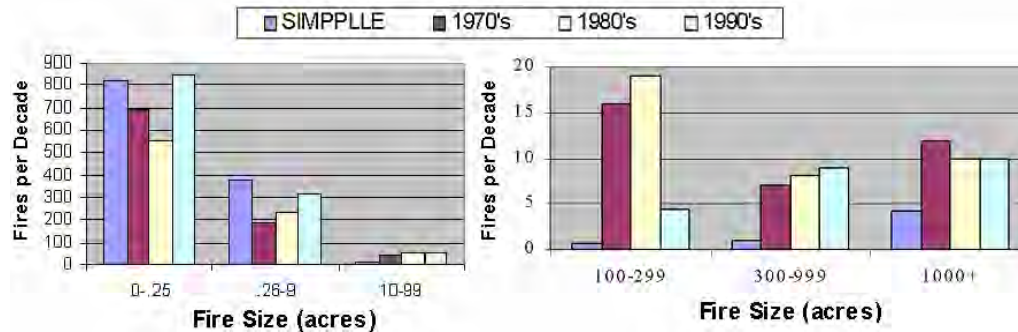


Figure 3—Distribution of fires by size class from 20 SIMPPLLE simulations for “No Action” compared to fires from past decades.

MAGIS

The Multi-resource Analysis and Geographic Information System (MAGIS) is an optimization model for spatially scheduling treatments that effectively meet resource and management objectives while satisfying user-imposed resource and operational constraints (Zuuring and others 1995). MAGIS accommodates a wide variety of types of land management treatments, together with associated costs, revenues, and effects, all of which can be used to control a treatment schedule.

MAGIS also contains a road -network component for analyzing road construction, re-construction, and closure.

The version of MAGIS developed for this study used decade time steps and the same vegetative states and pathways used in SIMPPLLE. We believed it impractical to schedule treatments for land units as small as 5 ac, so treatment unit polygons used in MAGIS were aggregations of the 5 ac vegetation polygons used in SIMPPLLE. Possible treatments included machine crush and burn; cut only; cut and burn; cut, stack, and burn; and burn only. Re-treatments were assumed to occur every decade in the priority areas (*fig 1.*), and every second decade in the general forest. We established 5th code watersheds and priority areas as zones within MAGIS and developed effects functions to compute critical information for these zones, such as acres treated in the watersheds.

Developing Spatial Fuel Treatment Scenarios

The process used to develop treatment scenarios is illustrated in *Figure 4*. Frequencies of fire on polygons from the 20 “No Action” simulations represent an estimate of relative fire danger on the landscape. We used them to develop a risk index that was input into MAGIS (Jones and Chew 1999). This fire-frequency risk index is combined with the scenario specifications (*table 1*) in MAGIS to control allocation of treatments.

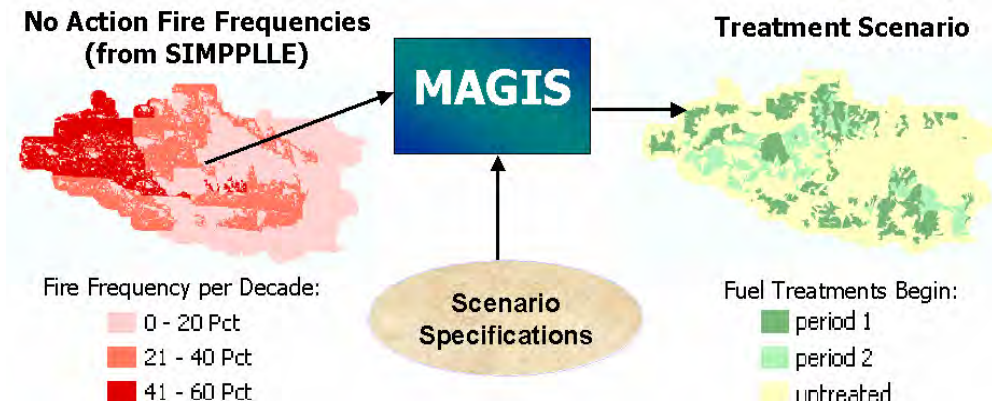


Figure 4—Process for developing spatial fuel treatment scenarios.

We made a series of MAGIS solutions in the process of developing each treatment scenario. Treatments were allocated by first minimizing the risk index for the highest priority level. In the next solution, risk for the highest priority was held at the minimum level while minimizing the risk index for the second priority level, and so on. In the last step we minimized the overall fuel treatment cost while holding the value of previously minimized risk indexes constant.

Treatment schedules developed for the scenarios are displayed in *figure 5*. No new areas are treated after decade 2 because treatment acres are achieved by re-treating areas scheduled initially for decades 1 or 2. We imported the four treatment scenarios into SIMPPLLE to model their effect on extent and frequency of wildland fire (*fig. 6*). Twenty simulations were run for each scenario, and fire frequencies were tabulated by polygon.

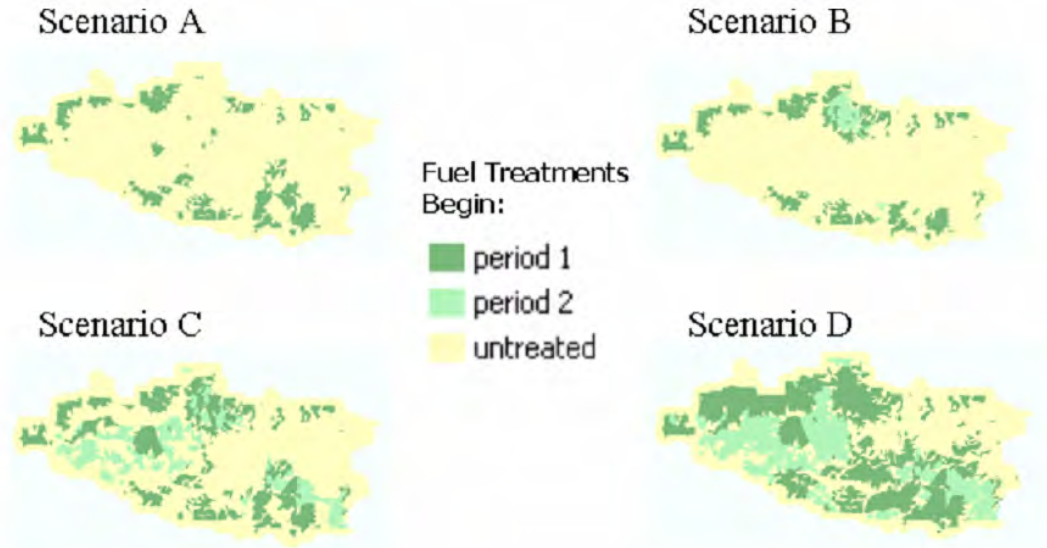


Figure 5—Spatial location of treatments in the four scenarios.

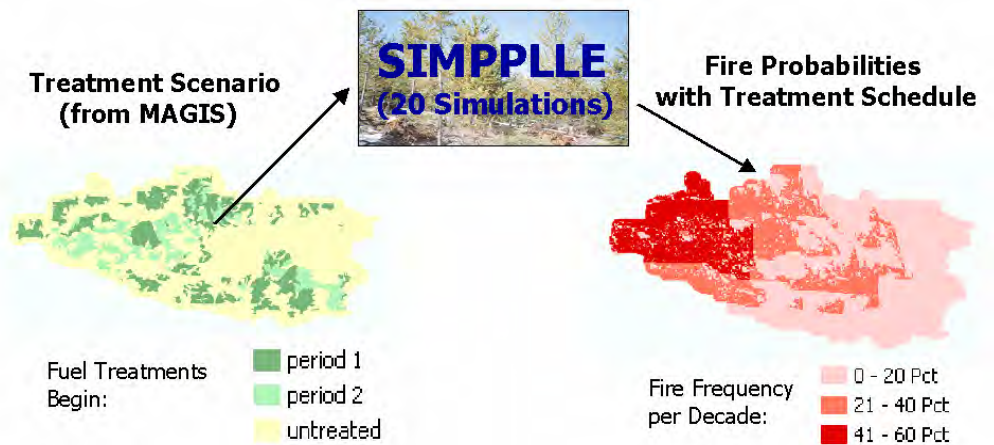


Figure 6—Process for developing spatial fuel treatment scenarios.

Results

Fuel treatments imposed by these scenarios made little difference in the average percent of the total landscape burned by wildfire per decade over 5 decades (*fig. 7*). In fact, the average percent of area burned for Scenario B is slightly higher than the “No Action” Scenario. This unexpected result was explained when we discovered there were some very large fires simulated for that Scenario, apparently by random chance in the stochastic process. This suggests more than 20 stochastic simulations are needed for this vegetation type to average out effects of low probability disturbance events. Measurable reductions, however, are observed in the average percent of Urban Defense Zone burned by wildland fire (*fig. 7*). Similar reductions in wildland fire due to fuel treatments were observed within other priority zones.

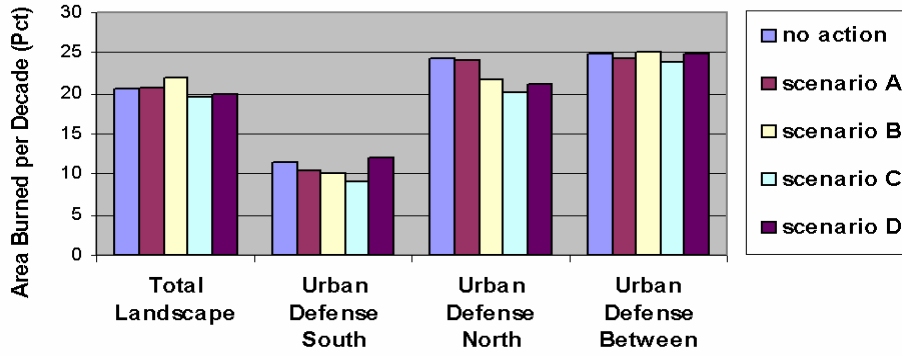


Figure 7—Percent of total landscape area burned per decade compared to the Urban Defense Zones.

Figure 8 depicts two specific locations that received priority treatments, and the effects of those treatments in Scenarios B and C. The oval area (fig. 8) received numerous fuel treatments in Scenario B. The fire frequency map developed from the stochastic simulations for Scenario B shows a corresponding lower wildland fire frequency in the oval area (lighter color) than does the “No Action” map. The average acres burned per decade in the oval area dropped from 6,998 for “No Action” to 3,533 in Scenario B. The rectangular area (fig. 8) provides a second example of location-specific effects of fuel treatments. This area received numerous fuel treatments in Scenario C, and fire frequency map shows a noticeably lower fire frequency (lighter color) than does the map for “No Action.” Here average acres burned per decade dropped from 8,668 for “No Action” to 6,996 for Scenario C.

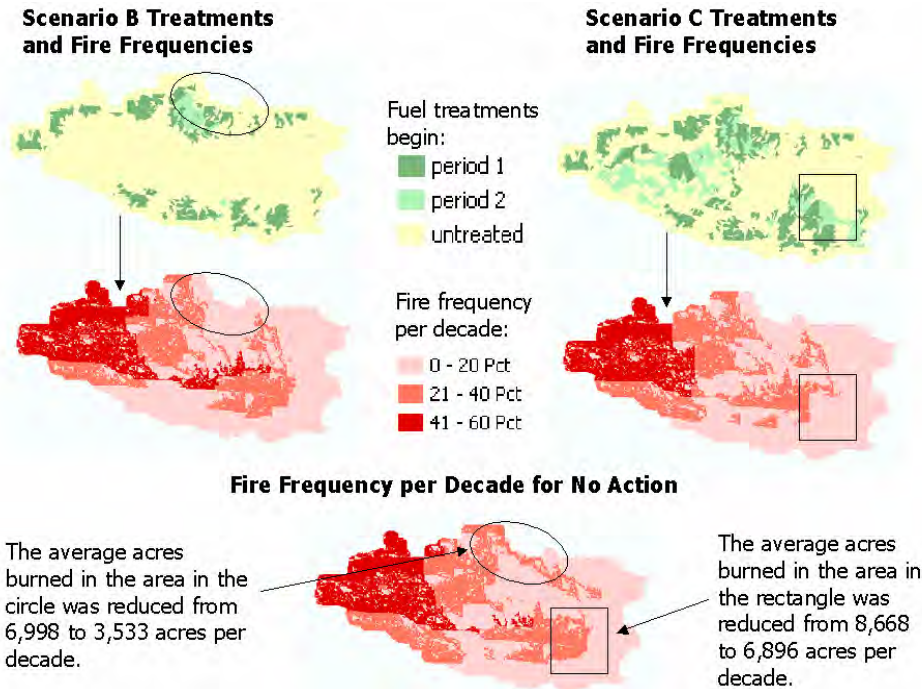


Figure 8—Fuel treatments and fire frequencies in two areas.

Discussion

Measurable reductions in wildland fire due to fuel treatments are observed in the Urban Defense Zone and other priority zones. However, this modeling effort shows essentially no reduction in the percent of total landscape burned as a result of fuel

treatments. This may in part be a function of fire spread/suppression logic used in these simulations. Compared to three recent decades (*fig. 3*) the simulations for “No Action” predicted a higher percentage of the fires stopping in the .26 to 9 ac size class and not expanding into larger fires. This has the potential of masking the effect treatments have on the ability to suppress fires at smaller sizes. Additional work is needed in SIMPPLLE’s fire spread/fire suppression logic to draw conclusions about the effect of fuel treatments on reducing wildland fire on this landscape.

This study did demonstrate the two models’ valuable capability to conduct spatial fuel treatment analyses on a 400,000+ ac landscape. First, fuel treatments were scheduled spatially and temporally, despite a relatively complex set of spatial priorities for treatment, watershed limitations, treatment acreage limitations, and a cost minimization objective. Second, the modeling approach estimated the extent and location of wildland fire on the landscape, both with and without fuel treatments. This provides a good basis for evaluating the effectiveness of spatial fuel treatment strategies. Third, the stochastic simulations of treatment scenarios provide a good foundation for future work to quantify other important aspects in fuel treatment analyses. For example, location and severity of individual fires in the stochastic simulations, along with GIS information on the location and value of private structures, provide a basis for estimating private property loss due to wildland fire. This would offer the capability to predict reduction in private property loss associated with a specific spatial pattern of fuel treatments.

Another promising possibility is to use the treatment locations and the stochastic simulations to predict the combined resource effects of treatments and wildland fire. This offers the capability to compare overall resource effects (from treatments and wildland fire) across scenarios, including “No Action,” which in some instances may display the greatest resource effects. This modeling approach has the potential to address many of the landscape fuel treatment questions posed at this fire conference.

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