Executive Summary

FINAL REPORT to Joint Fire Sciences

JFSP Project:	01-1-3-21
JFSP Title:	Cumulative effects of fuel management on landscape-scale fire behavior and effects
Principal Investigator:	Mark A. Finney

A simulation system was developed and used to explore long-term landscape-scale effects of fuel treatment programs on large fires. The system consisted of FVS (Forest Vegetation Simulator) linked a spatial fuel treatment optimization program. The system was exercised on study areas in Montana, California, and Oregon.

The system took most of 3 years to build and debug. The fuel treatment optimization program required parallelization for a 16-processor computer to permit efficient simulation. Customizations were required for the Parallel Processing Extension of FVS to permit its use as part of a simulation system and to receive instructions on treatment priorities from the spatial optimization. Numerous challenges were discovered and overcome, namely spatial data required for each study area included FVS tree-lists assigned to all portions of the landscape. Problems with poor-quality or insufficient data required substitutions of study areas twice in California and once in the Blue Mountains of Oregon. FVS prescriptions were custom developed for each study area based on local species compositions, stand structures, management histories, and fuel types. We found that custom fuel logic was required for each study area to permit surface and canopy fuels to be derived from FVS outputs because the FFE (Fire and Fuels Extension) was not realistic or precise enough for the variety of treatment prescriptions used (especially with shrub and grass fuels). Our custom logic utilized the new set of 40 surface fuel models rather than the original 13.

Treatment effects were measured in terms of changes to average fire spread rate, conditional burn probability, and relative fire sizes (as determined by further simulation of wildfires across each landscape). The simulation scenarios required for each study area over five-decades were factorial combinations of fuel treatment size (200, 400, 800, 1600m), decadal treatment rates (0, 10, 20, 30, 40, 50), treatment pattern (random vs. optimal), and different fractions of area reserved from treatment (15%, 35%, 45%, 65%). Typical simulations required 3 to 10 days to run. We exercised the simulation system with the following conclusions related to the five main questions:

1. **What effect does treatment rate have on cumulative landscape-scale effects?**

   Minimum treatment rates were found to be 1% to 2% per year in an optimal pattern for cumulative benefits to be accrued. Maximum treatment benefit appeared to be realized in the 2nd decade, with diminishing improvement in later decades. This is probably a direct reflect of the l-2 decade longevity of individual treatments in mitigating fire behavior.

2. **What impact does treatment pattern (optimal vs. random) have on cumulative treatment effects?**

   The treatment optimization produced results similar to theoretical modeling and was about twice as efficient as random arrangements in reducing large fire movement for the amount of area treated.

3. **What effect does restriction of treatment (i.e. conflicting land management objectives resulting in reserves) have on potential for achieving cumulative treatment benefits?**

   Artificial restrictions of treatment above about 45% reduced the effectiveness of optimal treatment patterns to a similar level as random patterns. Land management activities that effectively reserve areas from consideration from treatment can completely remove benefit of an optimal spatial treatment strategy.

4. **How does uncertainty in weather affect treatment effectiveness when patterns are designed only for extreme conditions?**

   Treatment prescriptions and optimal patterns designed to change fire behavior at the 99th percentile were still more effective than random patterns under more moderate weather conditions (95th and 90th percentile). This suggests that optimal spatial patterns can remain effective outside the range of weather specified for optimization.

5. **What mixture of maintenance versus new treatment is desired for future treatment regimes?**

   Optimal patterns for treatment required a mixture of maintenance and new treatments throughout the five decades. The spatial location of the treatments relative to the major corridors for fire spread were the most important factor in determining if treatments were maintained or not. By comparison to random patterns, optimal treatment specifically avoided some areas that did not contribute to landscape fire behavior.

Deliverables

The overall simulation system was judged to be too complex for any direct hand-off or packaging for general use. The system required a team of three to five experts with a combined skill-set not routinely found outside of research. The team must be expert in modeling fires, proficient with modeling stand development and generating fire and fuel treatment prescriptions (i.e. FVS), and dexterous with development/analysis of spatialtemporal data. The computing facilities required for this work also greatly exceed the ability of any land management agency at this time.

The spatial fuel treatment optimization developed for this project is described in **Part I**: A computational method for optimizing fuel treatment locations. This was implemented as a stand-alone feature of FlamMap (http://fire.org) for use on individual planning areas (**Part III**: An Overview of FlamMap Fire Modeling Capabilities). The importance of optimizing treatments specifically for disrupting fire movement was demonstrated in a manuscript authored by Kim et al. that showed how standard treatment patterns (regular, clumped etc.) had little effect on fire movement. The detailed results of the simulations are reported in **Part II**: Simulation of long-term landscape-level fuel treatment effects on large wildfires. Finally, two papers were published earlier that describe spatial analysis of fuel treatments on BLM land in Utah (Stratton 2004) and the general landscape problems with fuel treatment planning (Finney 2004).

Reports included:

Finney, M.A. 2004. Chapter 9, Landscape fire simulation and fuel treatment optimization. In: J.L. Hayes, A.A. Ager, J.R. Barbour, (tech. eds). Methods for integrated modeling of landscape change: Interior Northwest Landscape Analysis System. PNW-GTR-610. p 117-131.

Finney, M.A. Final Report. A computational method for optimizing fuel treatment locations.

Finney, M.A., R.C. Seli, C.W. McHugh, A.A. Ager, B. Bahro, and J.K. Agee. Final Report: Simulation of long-term landscape-level fuel treatment effects on large wildfires.

Finney, MA. *In press*. An overview of FlamMap Fire Modeling Capabilities. Proceedings of the 1st Fire Behavior and Fuels Conference Fuels Management--How to Measure Success. March 27-30, 2006. Portalnd OR.

Kim, Young-Hwan, P. Bettinger, M.A. Finney. *In review*. Spatial optimization of fuel management activities. Submitted to Ecological Modeling.

Stratton, R.D. 2004. Assessing the effectiveness of landscape fuel treatments on fire growth and behavior. J. For. Oct.-Nov., vol. 102, no. 7, pp. 32-40