Effects of Spatially Optimized Fuel Reduction Treatments on Simulated Human-Caused Wildfires

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Background

Fuel reduction treatments have received considerable interest as a primary wildfire mitigation strategy and have been extensively applied to western forests of North America. The beneficial effects of fuel reduction treatments have been noted in many studies, but most studies were conducted at a local scale. It has been suggested that fuel reduction activities should be spatially arranged on a landscape to effectively and efficiently disrupt the progress of wildfires. In this study, fuel reduction activities were distributed across a large landscape in a way as to optimize an even-flow of timber harvest volume and a spatial pattern of activities. Also we simulated wildfires that originated from hypothetical human-caused ignition points to determine whether a broad-scale schedule of fuel reduction treatments would be effective in reducing wildfire size or severity.

Fuel Reduction Activities

Two management prescriptions for fuel reduction purposes were designed with the goal of maintaining a desired stand density target by low thinning. The harvestable diameter limit ranges were $_{1)}$2.5–17.8cm, and $_{2)}$2.5–25.4cm. These two management prescriptions included a residual basal area constraint of 18.4m^2/ha and the need to maintain stand density within a specific range (35–55%). Then two additional prescriptions of 'thinning followed by prescribed fire' were produced by modifying the first two prescriptions with the following assumptions: $_{1)}$prescribed fires are implemented within the same period of thinning, and $_{2)}$surface fuels less than 2m in height are removed. Using these assumptions, all trees less than 2 m in height were removed from the associated tree lists in the period of treatment.

Optimization using a Heuristic Algorithm

A forest scheduling model based on a heuristic algorithm (Great Deluge Algorithm) was developed to optimize an even-flow of timber harvesting volume (10,000MBF) and four spatial patterns (dispersed, clumped, random, & regular pattern) of fuel reduction activities(Figure1). Using the scheduling model, we were able to generate management scenarios that achieved an even-flow of harvest volume target through the management time horizon (100 years), and arranged in the four patterns(Figure2). Totally five management scenarios (4 scenarios for patterns and one control) were adopted in the fire grow simulation.

Figure1. Heuristic Optimization Process

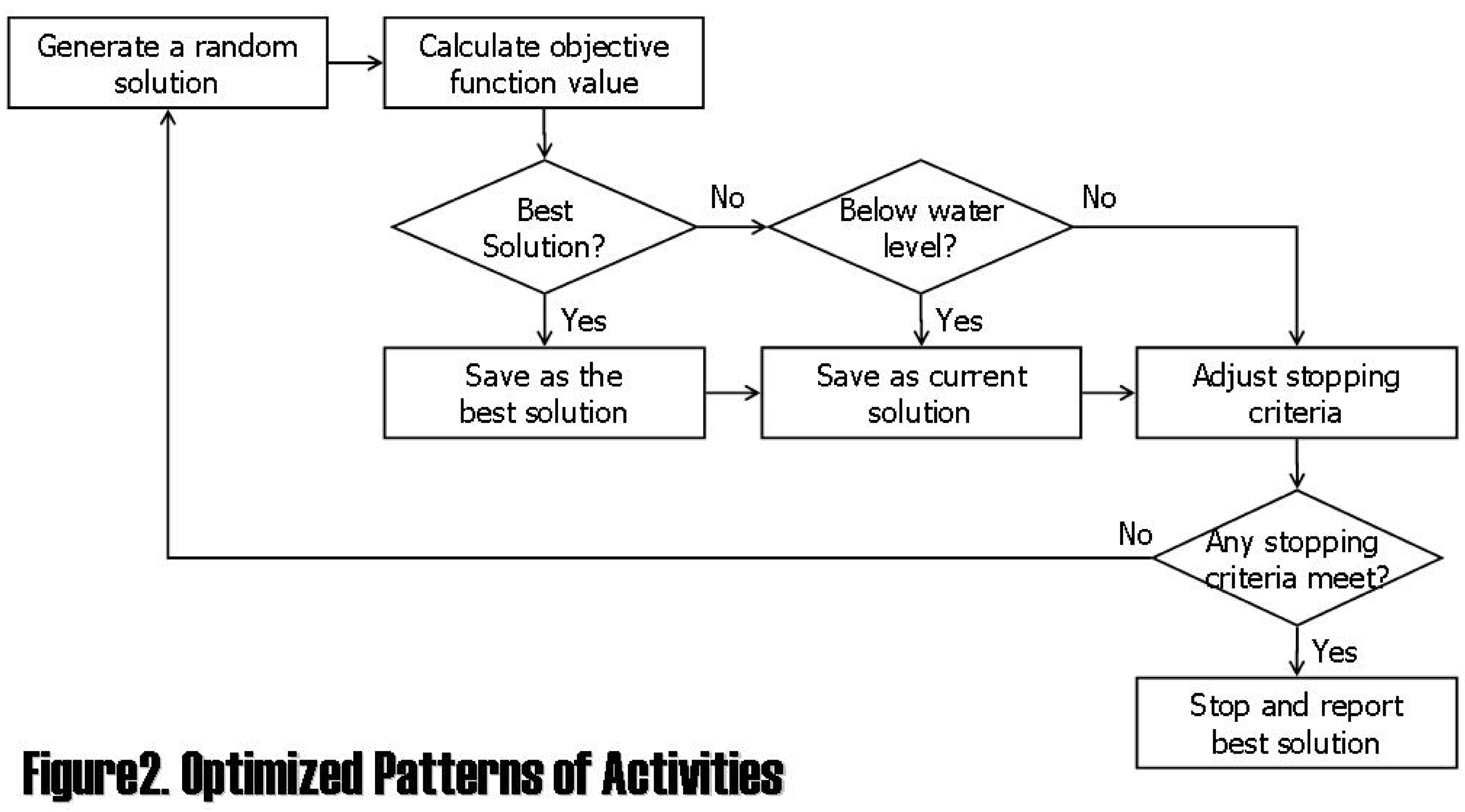
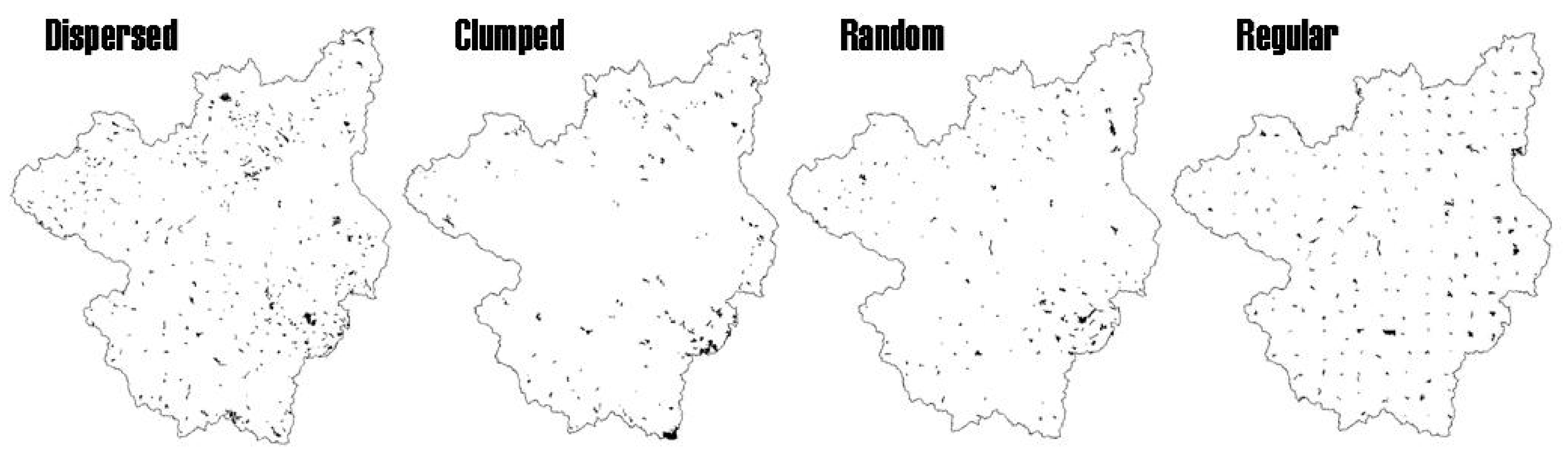


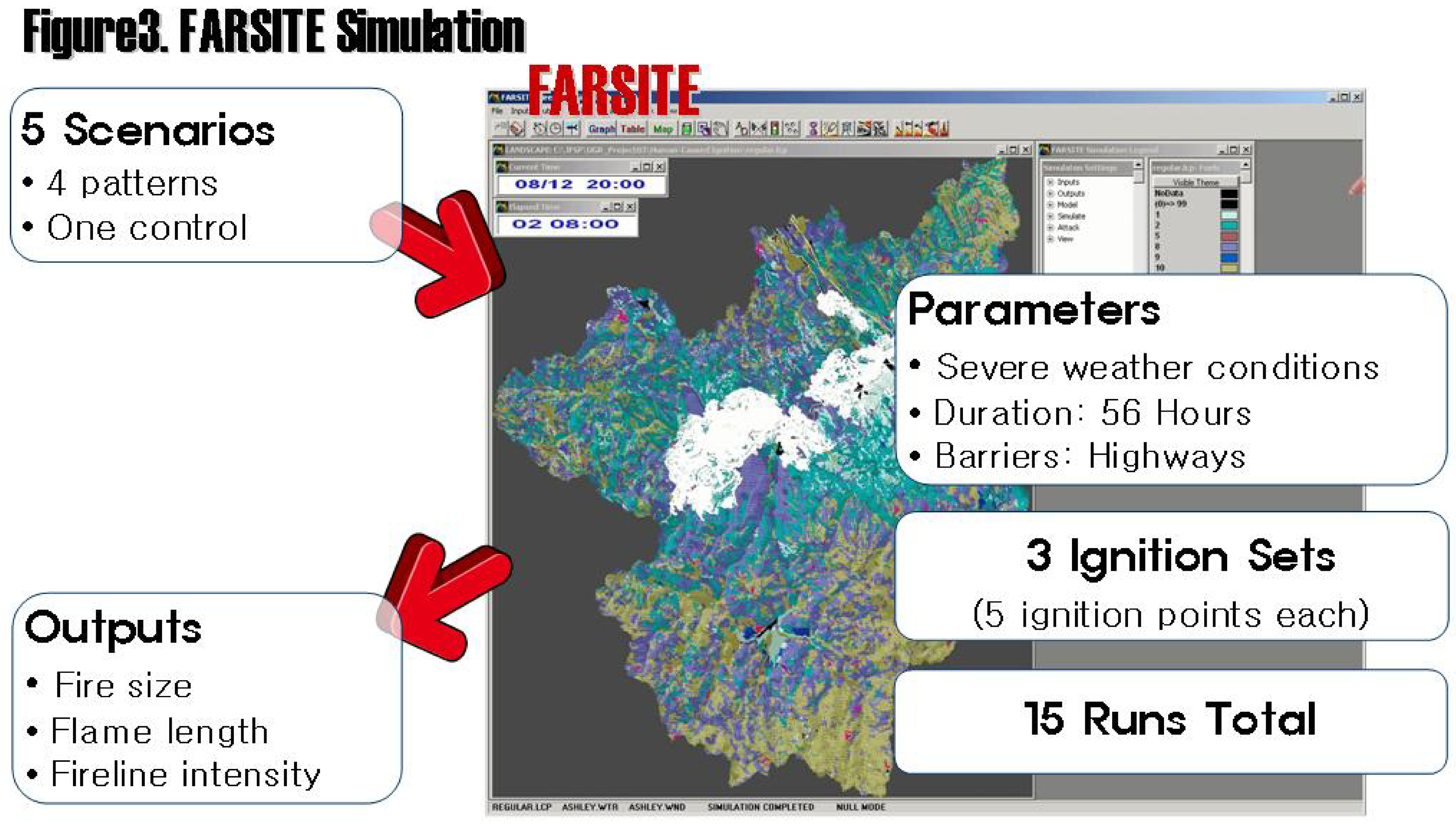
Figure2. Optimized Patterns of Activities



Fire Growth Simulation

For fire simulation, we used FARSITE, a fire growth model, and prepared input data using GIS software. Fuel conditions (fuel type, canopy cover, stand height, and crown base height) were prepared for each management scenario, since fuel reduction activities could influence fuel conditions. A sample set of weather conditions for a hypothetical several fire season in eastern Oregon was utilized. To specify ignition location of hypothetical human-caused fires, a buffer zone was generated within 10m around highways passing through the study site, and ignition points were randomly selected within the buffer zone. 3 sets of ignition points were developed and each set included 5 ignition points. Totally 15 runs of fire simulation (3 ignition sets × 5 solutions) were conducted(Figure3). In each run, fire was simulated from the 5 ignition points simultaneously.

Figure3. FARSITE Simulation



Results & Discussions

The resulted outputs of fire simulation supported the fact that human-caused wildfire could be disrupted by fuel reduction treatment during severe wildfire seasons, but the effectiveness of treatments could be influenced by treatment type and intensity applied. The clumped and regular pattern of fuel reduction treatments seemed to reduce simulated fire severity most effectively in two out of three cases (Table1). Dispersed pattern and random pattern had no recognizable effect on simulated wildfires due to their low treatment intensity (Table2).

Table1. Fire Simulation Results

	Ignition set	Pattern of fuel reduction activities				
		Control	Dispersed	Clumped	Random	Regular
Fire size (±)*	Set1	20,483 –	20,471 (-12)	20,603 (+120)	20,524 (+41)	20,815 (+333)
	Set2	20,317 –	20,169 (-148)	20,060 (-257)	20,181 (-136)	19,891 (-426)
	Set3	19,741 –	19,756 (+15)	19,486 (-255)	19,838 (+97)	19,575 (-166)
Areas in severe fire class** (±)	Set1	2,604 –	2,624 (+20)	2,622 (+18)	2,636 (+32)	2,638 (+34)
	Set2	1,647 –	1,669 (+22)	1,669 (+22)	1,646 (-1)	1,564 (-83)
	Set3	2,360 –	2,347 (-13)	2,354 (-6)	2,360 –	2,330 (-30)

* Changes from the control ** Severe fire class: flame length>2.4m

Table2. Size & Intensity of Fuel Reduction Treatment

	Ignition set	Pattern of fuel reduction activities			
		Dispersed	Clumped	Random	Regular
Size of Treatment Units (ha)	Set1	4,700	1,542	1,872	2,924
	Set2	5,060	2,292	1,914	2,935
	Set3	3,925	1,183	1,021	2,830
Average harvest volume (board ft/ha)	Set1	261	367	198	331
	Set2	279	454	207	426
	Set3	233	370	237	320

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