Fuel Treatment Guidebook: Illustrating Treatment Effects on Fire Hazard

Morris Johnson, David L. Peterson, and Crystal Raymond

The Guide to Fuel Treatments (Johnson and others 2007) analyzes potential fuel treatments and the potential effects of those treatments for dry forest lands in the Western United States. The guide examines low- to mid-elevation dry forest stands with high stem densities and heavy ladder fuels, which are currently common due to fire exclusion and various land management practices, such as timber harvesting. These stands are the focus of potential management activities intended to modify forest structure and fuels to reduce crown fire hazard on public lands. The guide is intended for use by fire managers, silviculturists, and other resource specialists who are interested in evaluating the effects of fuel treatments on dry forest ecosystems.

Development of the Guide

In April 2003, the Forest Service initiated the Fuels Planning: Science Synthesis and Integration project (known as the Fuels Synthesis Project) to accelerate the delivery of research information to fuels specialists and others involved in project planning. The geographic focus of the project was on the dry forests of the Western United States. Project goals included developing accessible analyses, protocols, and tools; writing peer-reviewed documents that synthesize and integrate the ecological and social science relevant to fuels treatments; and delivering these products in a user-friendly format to community leaders and educators, fuels management specialists and resource specialists, National Environmental Policy Act (NEPA) planning team leaders, and line officers in the Forest Service and the Department of the Interior. Information derived from this effort is applicable to categorical exclusion documents, environmental impact statements, environmental assessments, and other NEPA documents.

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The goal was to link information from silviculture and fire science to provide quantitative guidelines for fuel treatment that consider desired future conditions for multiple resources.

Scientists at the Pacific Wildland Fire Sciences Laboratory, Pacific Northwest Research Station, developed the guide in cooperation with other scientists and resource managers throughout the Western United States. The goal was to link information and data from silviculture and fire science in order to (1) assist decisionmaking about fuel treatments in dry forest stands and (2) provide quantitative guidelines for fuel treatments that consider desired future conditions for multiple resources (e.g., wildlife, water, and timber production). Developers determined the final structure of the guide after reviews by scientists and resource managers and two test efforts involving national forests.

The scientific basis for fuel treatments is documented in recent syntheses (Graham and others 2004, Peterson and others 2005) and numerous publications (Agee 1996, 2002; Brown and others 2004; Carey and Schuman 2003; Fitzgerald 2002; Kalabokidis and Omi 1998; Keyes and O'Hara 2002; Pollet and Omi 2002; Sandberg and others 2001; Scott and Reinhardt 2001; Weatherspoon 1996). The guide provides quantitative guidelines for treatments based on the scientific principles in these documents and is intended to cover a broad range of possible treatments and stand conditions. However, the representative cases in the guide are not comprehensive, and interpretation and application of quantitative output will typically need to be adjusted based on local conditions and objectives.

Analytical Tools

The Fire and Fuels Extension of Forest Vegetation Simulator (FFE-FVS) (Reinhardt and Crookston 2003) was used to prepare the guide. This tool links forest growth modeling with fire behavior modeling to produce information relevant to management of forest stands, fuels, and fire. FVS has been widely used by resource managers and scientists for over two decades, has been programmed to cover many of the major forest types in the United States, and is regarded as a credible tool for applications in forest management (Dixon 2002). Integration of fire concepts is a recent and valuable extension of the FVS approach to forest stand simulation, but it has not been available long enough to be thoroughly tested. However, it is the only analytical tool currently available that quantitatively links stand dynamics and fire science. At a minimum, FFE-FVS requires input of forest stand attribute data (species, diameter at breast height [d.b.h.], and height), but fuels data are extremely helpful.

In the guide, the effects of fuel treatments are quantified for forest structure, surface fuels, and potential fire behavior. FFE-FVS was used to calculate a variety of fuel treatment combinations (including the no-action alternative, four levels of thinning, three types of surface fuel modification, and prescribed fire alone) for each of 25 representative forest stands (fig. 1). FFE-FVS runs are summarized for each stand with visualizations and extensive tabular data (not included in this article). In addition, forest structure and fuels are calculated for 50 years posttreatment at 10-year increments, so that long-term stand conditions can be assessed and users can determine when additional fuel treatments might be needed. Users familiar with FFE-FVS have the option of running their own simulations to calculate site-specific effects of treatments.

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Scenarios displayed in the guide are intended to represent a range of dry forest types in the Western United States, specifically those forests dominated by ponderosa pine (*Pinus ponderosa* Dougl. ex Laws), mixed conifers—often including Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) as a codominant—and pinyon-juniper (*Pinus* spp. and *Juniperus* spp.). Specific stand data were obtained from resource managers on national forest units throughout the Western United States. Stands selected for analysis had high stem densities and had not experienced recent fire or thinning. In the guide, only stands at relatively low elevations and slopes of less than 40 percent were considered as potential candidates for fuel treatment. Fuel treatment scenarios are organized according to Forest Service regions in the Western United States.

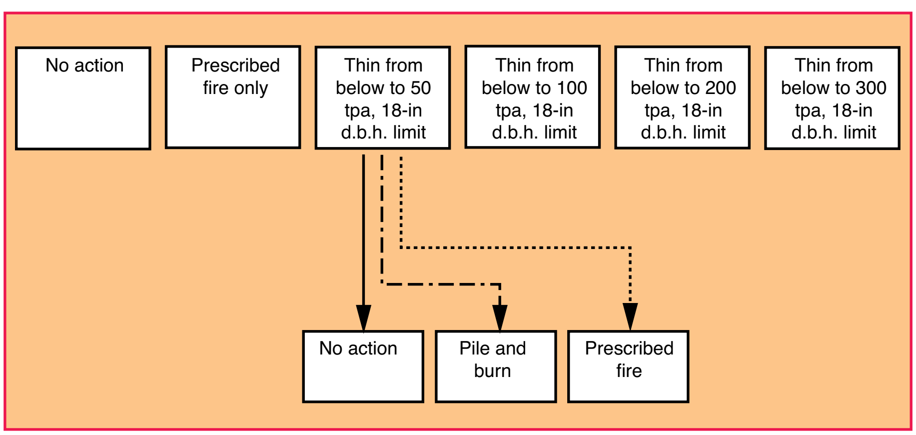

Figure 1—*Matrix of thinning and surface fuel treatments implemented for each stand in the guide to Fuel Treatments. Each stand was projected through a series of 14 potential treatments.*

Fuel Treatments

Fuel treatment scenarios analyzed in the guide to Fuel Treatments were determined with extensive feedback from Federal resource managers. These scenarios cover a range of potential thinning and surface fuel treatments that would be reasonable and appropriate alternatives for NEPA analysis and similar documentation. The scenarios illustrate representative situations that might be encountered in operational management and planning and do not illustrate all possible treatments.

Thinning from below (or low thinning) refers to removal of stems starting from smallest to increasingly larger stems until the target density is reached. In practice, thinning from below often has a d.b.h. limit below which no stems are harvested, with that lower limit set to reduce costs and maximize value of harvested material.

In guide scenarios, stem harvesting begins with trees smaller than 1 in (2.5 cm) d.b.h. and then proceeds to larger stems. For all thinnings, no trees larger than 18 in (44 cm) d.b.h. are harvested. This limit is intended to retain larger, more fire-resistant individuals. In practice, this upper d.b.h. limit could

Table 1—*Summary of values and assumptions used in FFE-FVS for surface fuel treatments.*

Surface fuel treatment FFE	FVS values and assumptions	FVS keywords
No action	All boles greater than 6 in diameter at breast height (d.b.h.) are removed from stand. The entire tree (branch and bole) and branch material from trees greater than 6 in d.b.h. are left in stand.	Yardloss
Pile and burn	All boles greater than 6 in d.b.h. are removed from stand. The entire tree (branch and bole) and branch material from trees greater than 6 in d.b.h. are left in stand. 80 percent of the remaining fuel from the entire stand is concentrated into piles that cover 10 percent of the stand area. No tree mortality will result.	Yardloss PileBurn
Prescribed fire	All boles greater than 6 in d.b.h. are removed from stand. The entire tree (branch and bole) and branch material from trees greater than 6 in d.b.h. are left in stand. Windspeed at 20 ft above vegetation = 10 mph. FVS predefined moisture group (3) selected to represent fuel moisture percentages for prescribed fires. Temperature equals 70 °F. Note: predefined moisture values are specific to FVS variants.	Yardloss SimFire

be higher or lower depending on local harvest specifications and resource objectives. Thinning from below is the most commonly used approach to modify stand structure, density, and fuels, although many other silvicultural approaches are available (Graham and others 1999). Thinning as used within FVS is applied equally across a given stand. In practice, variable-density thinning—a spatial pattern of tree clumps and openings—can be used to achieve the same final tree density but attain greater heterogeneity in stand structure. Variable-density thinning cannot be represented in FVS and is, therefore, not considered here. For target densities different than those in the guide, users can interpolate or extrapolate the results found in tables and visualizations. Exploratory runs of FFE-FVS indicate that thinning to densities greater than 300 trees per acre (TPA) (741 trees per hectare [TPH]) rarely changes fuel conditions enough to modify fire hazard significantly from initial stand conditions.

Some managers prefer to use basal area (BA) as a target for thinning. This measurement may be more appropriate for even-aged stands with relatively low variability in tree size. BA is calculated for each thinning treatment, so both BA and stem density are available for all scenarios.

In practice, techniques used for modification of activity fuels and residual surface fuels vary considerably, as does the effectiveness of those techniques. Options included in the guide are intended to capture the more common approaches currently used in the field and to represent moderately high effectiveness. Assumptions regarding slash disposal, material left on site, area affected, and effectiveness of treatments are summarized in table 1. Prescribed fire is considered to be a broadcast burn that covers the entire treatment area.

The following is an example of scenarios derived from the guide.

Figure 2—*Computer simulation of forest structure prior to the four thinning treatments in the Forest Vegetation Simulator. Stand visualization taken from stand data for the Bitterroot National Forest.*

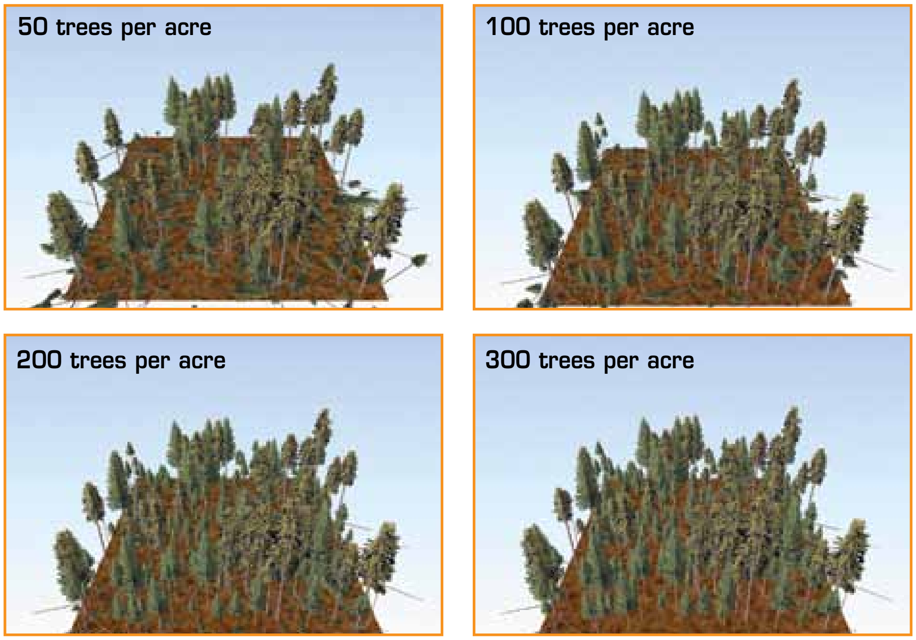

Figure 3—*Computer simulation of forest structure following the four thinning treatments in the Forest Vegetation Simulator: thinning to 50, 100, 200, and 300 trees per acre. Stand visualization taken from stand data for the Bitterroot National Forest.*

Initial Conditions/No-Action Trajectory

This stand (fig. 2) has a high tree density of 2,345 TPA (5,795 TPH) primarily composed of grand fir and Douglas-fir with a ponderosa pine overstory. Woody fuel loading is 9 tons/ac (20,175 kg/h), and litter and duff loading is 7 tons/ac (15,692 kg/h). Canopy bulk density is 0.0087 lb/ft^3 (0.14 kg/m^3), and canopy base height is 3 ft (0.91 m), so ladder fuels are sufficient to enable passive crown fire, but canopy fuels are not sufficient to enable active crown fire spread. Crowning index is 19 and severe weather wind speed is 17 mph (27 km/h), so although this stand is not classified as active crown fire, crown fire hazard is high. Potential BA mortality is 97 percent for severe fire weather. With no action, flame lengths, surface fuels, and canopy base height increase slightly over time, with crown fire potential decreasing in 20 years and then increasing again in 40 years. Crown fire potential and flame lengths remain low for moderate fire weather for the entire 50-year projection.

Silvicultural and Surface Fuel Treatments: Immediate Effects

According to results from FFE-FVS, the prescribed fire-only treatment decreases canopy bulk density and slightly increases canopy base height, but not enough to prevent passive crown fire for severe fire weather. This treatment reduces surface fuels in all size classes, but flame lengths increase after treatment owing to grass fuels associated with the use of fuel model 2. Grass fuels are not tracked in FFE and may or may not be the primary fuel following prescribed fire.

All thinning treatments reduce canopy bulk density and increase canopy base height; the greater the thinning, the greater is the change in forest structure (fig. 3). The predicted fire type after treatment is surface fire for all thinning options, but the more open stands are characterized predominantly by fuel model 2, so flame lengths increase and potential BA mortality remains above 20 percent regardless of surface fuel treatment. The 200 and 300 TPA (494 and 741 TPH, respectively) treatments have a more closed canopy and fire behavior is influenced less by grass fuels, so flame lengths and potential BA mortality are lower than the more open stands. Activity fuels are reduced by the pile-and-burn treatment and, to a greater extent, by the prescribed fire treatment, which also reduces litter and duff, but flame lengths and BA mortality remain high owing to grass fuels.

Silvicultural and Surface Fuel Treatments: Long-Term Effects

Although the prescribed fire-only treatment does not reduce crown fire potential in the short term, the predicted fire type is surface fire after 10 years. Crown fire potential continues to decline as canopy base height increases and flame lengths decrease. In all thinning treatments, flame lengths decrease over time as canopy cover increases and fuel model assignment shifts from predominantly fuel model 2 to predominantly fuel model 9. The 200 TPA treatment has the greatest long-term effect on crown fire potential, with a predicted surface fire type for 50 years with pile-and-burn or no surface fuel treatment and 40 years with prescribed fire treatment. The 50 TPA (124 TPH) treatment had the most short-lived effect on crown fire potential, with regeneration causing a drop in canopy base height in 30 years regardless of surface fuel treatment.

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This Issue...

This issue provides a glimpse into the role that research and technology play in the management of fires today and into the future. Over the years, the Forest Service and the interagency fire community have considered not only the science behind fire itself, but also the science of predicting fires and what is likely to happen when a fire-start occurs. Many aspects of fire management—fuels, wildland-urban expansion, and environmental factors among them—are different today than they were even a decade ago, making it more critical than ever to use emerging science and state-of-the-art methods of prediction to keep firefighters and the public safe. The articles in this issue reflect just a few of the models, tools, and approaches that are currently shaping and advancing the science and management of fire to achieve that end.

—Tory Henderson, Issue Coordinator

Erratum

In *Fire Management Today* vol. 69, no. 1 [Winter 2009], the caption for the photo of snow geese near a Marsh Master in the "Myth Busting about Wildlife" article gave an incorrect credit. It should have credited Drew Wilson, Virginia Pilot.

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