EFFECTIVENESS OF FIRE AND FIRE SURROGATE TREATMENTS FOR CONTROLLING WILDFIRE BEHAVIOR IN PIEDMONT FORESTS: A SIMULATION STUDY

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Abstract—The need for fuel reduction has increased in United States forests due to decades of fire exclusion. Excessive fuel buildup has led to uncharacteristically severe fires in areas with historically short-interval, low-to-moderate-intensity fire regimes. The National Fire and Fire Surrogate (NFFS) Study compared the impacts of three fuel-reduction treatments on numerous response variables. At an NFFS Study research site in the South Carolina Piedmont, fuels were altered by burning, thinning, and the combination of burning and thinning. Each treatment produced a unique fuel complex and altered microclimate for surface fuels by opening stands to wind and light. Fuel-reduction treatments were designed to minimize damage if a wildfire occurred; however, fire behavior in each treatment area is difficult to predict. BehavePlus was used to predict wildfire behavior for treatment comparisons. Fuel and weather data collected from each treatment area were used as inputs to simulate wildfire behavior for extreme weather conditions during the Piedmont fire season. Burn-only treatments had the shortest flame heights, slowest rate of spread, and lowest scorch height. Thin-only and thin-and-burn treatments increased fire intensity for the first growing season after treatment. However, these results are expected to be short term as logging slash decomposes.

INTRODUCTION

Excessive amounts of fuel have accumulated in many forests throughout the United States due to fire suppression over the past few decades. Annually South Carolina suppresses about 5,000 to 6,000 wildfires that burn a total of 30,000 acres.

Two western studies of fuel-treatment effects on wildfire behavior by van Wagtendonk (1996) and Stephens (1998) found that prescribed fire reduced severe fire behavior more than thinning. Stephens also found that thinning followed by prescribed burning would not produce extreme fire behavior at 95th-percentile weather conditions. Van Wagtendonk suggested that managing forests with a combination of fuel treatments is critical in reducing the size and intensities of wildfires.

In a similar study, Brose and Wade (2002) found that prescribed fire was the most effective treatment for immediate fuel reduction. Thinning was less effective than prescribed burning, but more effective than herbicide due to disruption of fuel continuity. Herbicide treatments resulted in no decrease in fire behavior for the first year, but showed a dramatic decrease in fire behavior in the second year. Brose and Wade suggested combining treatments for the most effective reduction of hazardous fuels and maintaining ecosystem health. A study in Portugal by Fernandes and others (1999) found that fuel treatments consisting of any physical fuel elimination, such as prescribed burning and mechanical treatment with slash disposal, were effective short-term solutions for reducing wildfire behavior.

Fuel-reduction treatments at the Piedmont site followed National Fire and Fire Surrogate (NFFS) Study protocols and included three replications of four treatments: control, prescribed burning, thinning, and the combination of thin-and-burn. Treatments altered the fuel complex and microsite climate differently, which could produce different wildfire intensities and severities. Using measured fuel data from the treatments and extreme fire weather as variables in the model, we estimated wildfire behavior to determine if fuel-reduction treatments adequately protect forests from wildfire.

NFFS Study

This national study compares ecological and economic impacts of fuel-reduction treatments. The study consists of 13 sites across the United States where fire has played an historical role. These areas currently have excessive fuel buildup and are considered to be at risk of wildfire. Eight sites are located in the Western United States, with the remainder in the Eastern United States. Each site follows the same protocols for treatments and data collection to allow for a national database of core variables.

Location

The Piedmont NFFS study is located on the Clemson Experimental Forest in northwest South Carolina. The research sites are in second- or third-growth timber with loblolly pine *(Pinus taeda* L.) and shortleaf pine (*P. echinata* Mill.) as the dominant species. The fire-return interval ranges from 1 to 30 years.

METHODS

The Piedmont NFFS Study site consists of three replications of four treatments. Treatments used were burn-only, thin-only, thin-and-burn, and control. Within each treatment 40 grid points were established on 50- by 50-m spacing. At each grid point, fuel data were collected on three fuel transects using the Brown's Planar Intersect Method (Brown

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1974). One-, ten-, and one hundred-hour fuels were inventoried, and fuel height was measured on each transect. Data were used to develop custom fuel models in the BehavePlus fire modeling system (Andrew and others 2002).

RainWise, Inc., WS2000 weather stations were placed in a central location within each treatment area for 2 weeks to compare treatment microsite differences. Each WS2000 weather station collected temperature, relative humidity, windspeed, wind direction, and rainfall at 10-minute intervals. Four additional RainWise, Inc., MK3 weather stations were located in open fields on the Clemson Forest for a total of 6 weeks. These units collected temperature, relative humidity, windspeed, and wind direction at 10-minute intervals. The 12 treatment areas also had a HOBO® weather recorder that logged temperature and relative humidity for 5 weeks. Weather data were downloaded weekly.

Regression equations were developed to predict stand weather conditions based on weather reported in open areas. These equations estimated the high temperature, low relative humidity, and high midflame windspeed that would occur in each treatment on an 80th-percentile day during the fire season. Using estimated weather variables, BehavePlus simulated fire behavior in each treatment.

RESULTS

Fuel Loads

Thin-only treatments increased 1-, 10-, and 100-hour fuels, with 100-hour fuels increasing the most (fig. 1). Burn-only reduced 1- and 10-hour fuels more than 100-hour fuels. Thin-plus-burn reduced 1-hour fuels, but 10- and 100-hour fuels increased.

Weather Conditions

Ambient temperatures were lowest in thin-only treatment areas and highest in thin-plus-burn areas (fig. 2). Relative humidity was lowest in control treatments and highest in thin-only treatments (fig. 3). Highest midflame windspeeds were recorded in burn-only and thin-plus-burn areas; both were approximately 7 miles per hour (fig. 4). Control and thin-only treatments had midflame windspeeds averaging 4 miles per hour. Prescribed burning reduced cover of understory trees and shrubs; therefore, winds in burn-only and thin-and-burn treatments were higher.

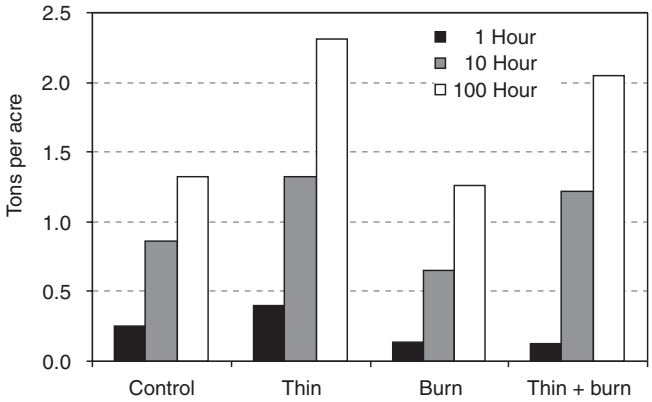

Figure 1—Average fine woody fuels in tons per acre on all treatments posttreatment.

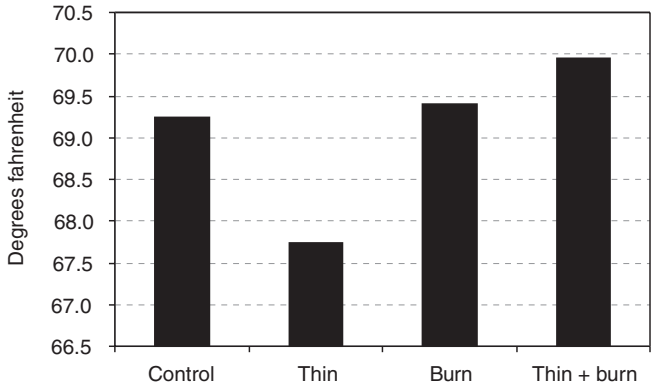

Figure 2—Maximum ambient temperature in degrees Fahrenheit posttreatment.

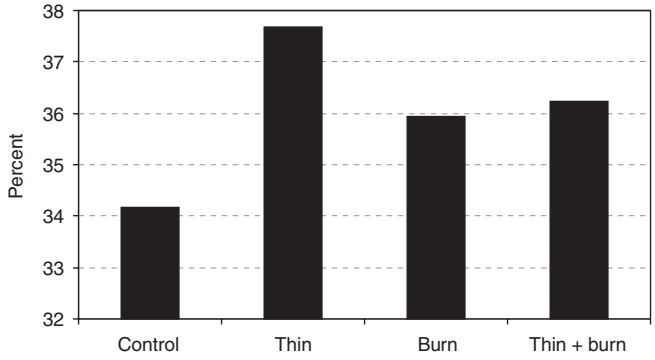

Figure 3—Lowest percent relative humidity posttreatment.

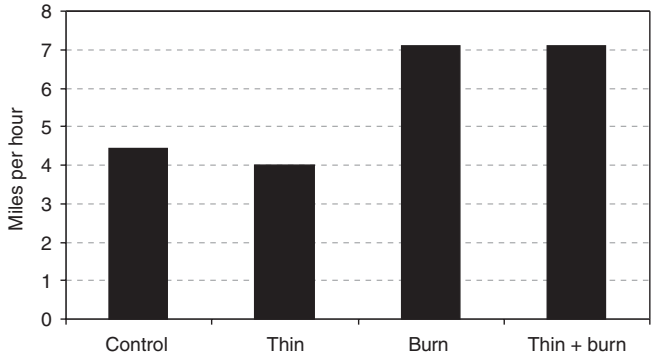

Figure 4—Maximum windspeed in miles per hour posttreatment.

Wildfire Behavior

BehavePlus (Andrews and others 2002) predicted that wildfire flame lengths would be tallest in thin-and-burn and thin-only treatments where 10- and 100-hour fuel loads were high (fig. 5). Rate of spread was slowest in burn-only areas where most 1- and 10-hour fuels had already been consumed (fig. 6). Scorch height was lowest in burn-only areas, again due to reduced fuels (fig. 7).

CONCLUSIONS

The BehavePlus model suggests that prescribed burning as a fuel-reduction treatment is an effective method for reducing wildfire damage in the Piedmont. Burning must occur periodically over the long term to maintain low fuel loads, thereby decreasing the chance of wildfire. Thin-and-

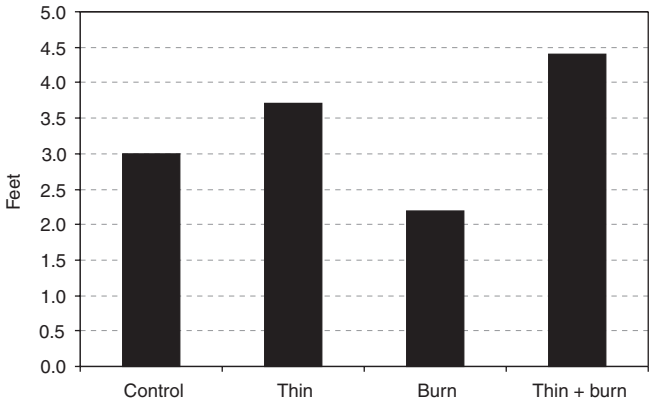

Figure 5—Maximum simulated flame length posttreatment in feet by BehavePlus.

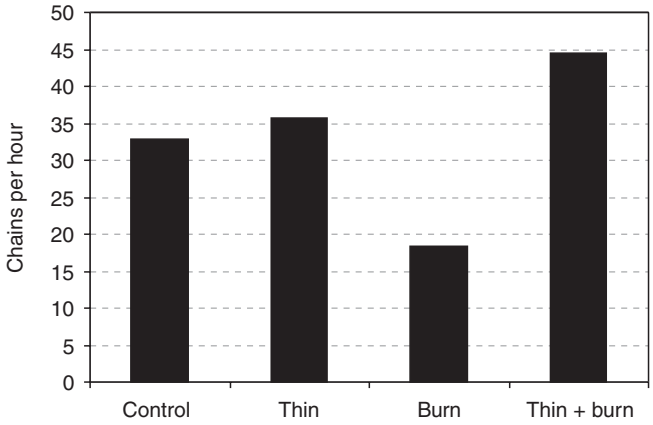

Figure 6—Maximum simulated rate of spread posttreatment in chains per hour by BehavePlus.

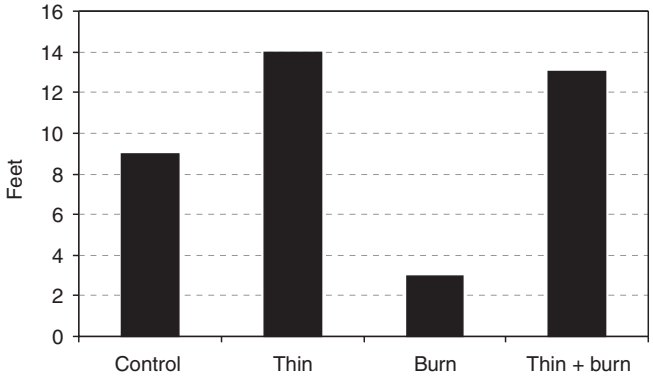

Figure 7—Maximum simulated scorch height in feet posttreatment by BehavePlus.

burn treatments may also decrease fuels if burning is repeated periodically over the long term. Continued data collection and treatments on the NFFS Study allow us to more clearly see the ecological impacts of repeated treatments.

ACKNOWLEDGMENTS

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