USING BEHAVEPLUS FOR PREDICTING FIRE BEHAVIOR IN SOUTHERN APPALACHIAN HARDWOOD STANDS SUBJECTED TO FUEL REDUCTION TREATMENTS

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Abstract—There is a crucial need for fuel reduction in United States forests due to decades of fuel accumulation resulting from fire exclusion. The National Fire and Fire Surrogate Study (FFS) addresses this issue by examining the effects of three fuel reduction treatments on numerous response variables. At an FFS site in the southern Appalachian Mountains, fuels were altered by burning, mechanical treatment, and a combination of burning and mechanical treatment. Each treatment produced a unique fuel complex and altered microclimate for surface fuels by opening stands to wind and light. Treatments were designed to minimize potential wildfire damage although fire behavior is difficult to predict. BEHAVEPlus fire modeling system (Andrews and others 2004) was used to compare predicted fire behavior among treatments based on actual fuel and weather data from the site. These data were used to simulate wildfire behavior during extreme weather conditions in the southern Appalachian fire season. Mechanical only treatments had the tallest flame and scorch heights and fastest rate of spread. Burn treatments had lower fire intensities but the mechanical + burn treatment had the lowest fire intensities of the three treatments. These results could be short-term with continued burning and fuel decomposition.

INTRODUCTION

Excessive amounts of fuel have accumulated in southern Appalachian forests over past decades due to fire suppression. North Carolina annually suppresses about 4,700 wildfires averaging 20,000 acres. Application of fuel-reduction treatments in the southern Appalachians are limited, especially prescribed fire. There has been little study of fuel reduction treatments and how they relate to wildfire.

Many land managers in the southern Appalachians have an immediate need to reduce hazardous levels of forest fuels but limited choice of effective techniques. Western United States studies by van Wagtendonk (1996) and Stephens (1998) found that prescribed fire reduced severe fire behavior more than thinning. Stephens (1998) also found that thinning followed by prescribed burning at 95th percentile weather conditions would not produce extreme fire behavior. Brose and Wade (2002) suggest combining treatments for the most effective reduction of hazardous fuels and maintaining ecosystem health in pine flatwood forests. This study is the first to examine wildfire behavior in several fuel reduction treatments in the southern Appalachians.

Fuel reduction treatments at the southern Appalachian site followed National FFS protocols and included prescribed burning, mechanical treatment and a combination of mechanical treatment followed by prescribed burning. These treatments change the fuel complex and microsite climate differently, which could produce different wildfire intensities and severities. Using fuels data, weather data from the 12 treatment areas and extreme fire weather variables we developed custom fuel models to determine if the fuel-reduction treatments had an impact on fire behavior.

National Fire and Fire Surrogate Study

This national study compares ecological and economic impacts of fuel-reduction treatments. It includes 13 sites across the United States where fire has played an historical role. The areas are characterized by excessive fuel buildup and are considered to be at-risk of wildfire. Eight sites are located in the Western United States, and five are in the eastern States. We followed the same protocols on each site both for the treatments themselves and for data collection, which helped us build a national database using core variables.

Location

The southern Appalachian Fire and Fire Surrogate study is located on the Green River Game Lands in Polk County, NC. The overstory is primarily mixed oak-hickory with some yellow pines and a well-developed shrub layer of mountain laurel (*Kalmia latifolia*), rhododendron (*Rhododendron* spp.), and blueberry (*Vaccinium* spp.).

METHODS

The study design was a randomized complete block consisting of three blocks of four treatments; burn only, mechanical only, mechanical + burn, and control. Each was replicated three times. Treatments were 10-ha areas marked by 40 points on a 50 x 50 m grid arranged in a north-south and east-west orientation. At grid points fuel data were collected on three fuels transects using Brown's Planar Intersect Method (Brown 1974) where 1, 10 and 100 hour fuels, as well as fuel height, were measured. These data were used to develop fuel models in the BEHAVEPlus3 fire modeling system (Andrews and others 2004).

HOBO® Micro Station weather stations were placed in a central location within each treatment area to compare microsite differences. Each weather station collected temperature, relative humidity, and wind speed on a 10-min interval. Three additional HOBO® Micro Stations were placed in open clearcuts near treatment areas. These units collected temperature, relative humidity, wind speed, and rainfall on a 10-min interval. The weather data were downloaded onto a laptop computer in the field once every three weeks from September 1, 2006 to December 31, 2006.

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We developed regression equations to predict stand weather conditions based on weather reported at the closest weather base station at Asheville Regional Airport in Asheville, NC. Those equations were used to estimate the high temperature, low relative humidity, and high mid-flame wind speed that would occur in each treatment area on an 80th percentile day during the fire season. We used the predicted weather variables as input in BEHAVEPlus3 to simulate fire behavior in each treatment.

RESULTS

Fuel Loads

Mechanical treatment has increased 1, 10, and 100 hour fuels each year over the last 6 years (fig. 1). Burning increased fuels slightly for the 1, 10, and 100 hour fuels. Mechanical + burn treatments have reduced the 1 and 10 hour fuels. The 100 hour fuels in the mechanical + burns have steadily increased over the last 6 years. Shrubs are most abundant in the control sites with over 6 tons per acre and much less abundant in the mechanical + burn sites with less than 1 ton per acre.

Weather Conditions

Ambient temperature was highest in the burn treatments and lowest in the mechanicals (fig. 2). Relative humidity was lowest in the burn and mechanical + burn treatments (fig. 3). The highest mid-flame wind speeds were in mechanical treatments at around 4 mph (fig. 4). Mechanical + burn treatments had the lowest wind speed of 1.5 mph.

Wildfire Behavior

BEHAVEPlus3 shows that a wildfire would produce the tallest flame lengths in mechanical treatments where large amounts of brush were left after treatment and least in the mechanical + burns (fig. 5). Rate of spread was slowest in mechanical + burn sites which contained the least amount of 1 and 10 hour fuels (fig. 6). Scorch heights were tallest in mechanical sites which had the highest fuel loading for 1, 10, and 100 hour fuels (fig. 7).

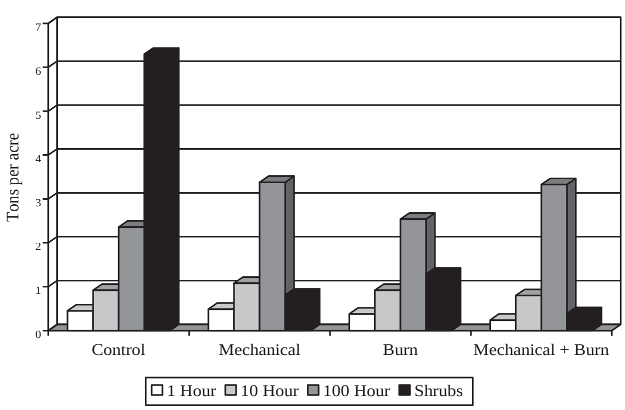

Figure 1—Average fine woody fuels and shrubs in tons-per-acre on all treatments post-treatment.

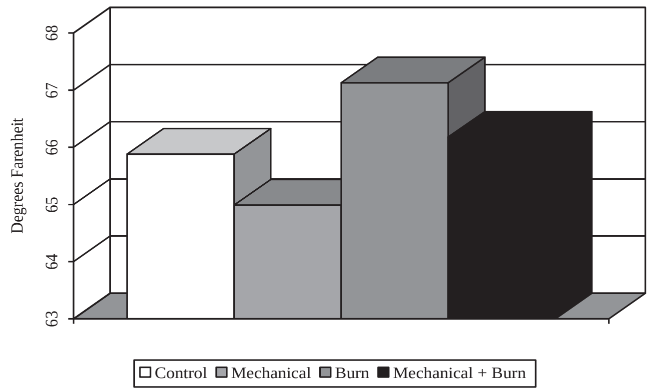

Figure 2—Maximum ambient temperature in degrees Fahrenheit post-treatment.

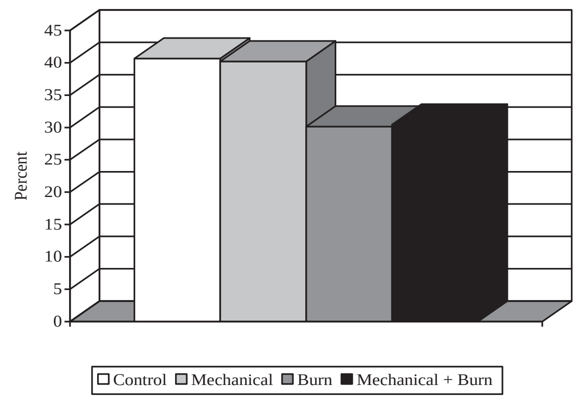

Figure 3—Lowest percent relative humidity post-treatment.

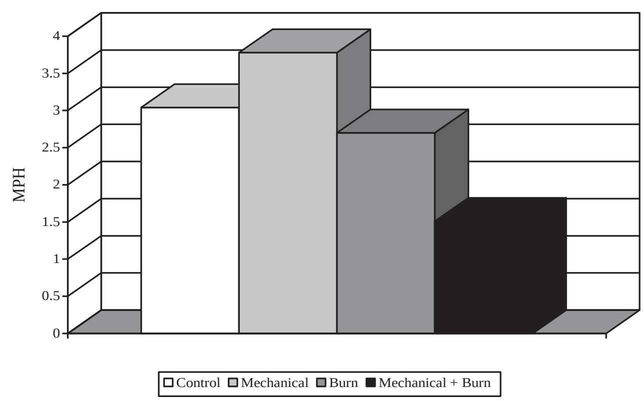

Figure 4—Maximum wind speed in miles per hour post-treatment.

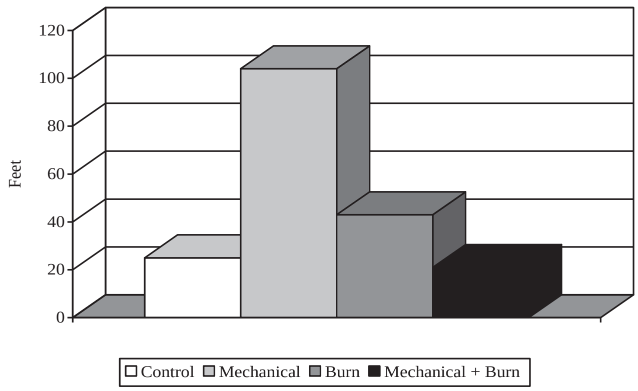

Figure 5—Maximum simulated flame length post-treatment in feet by BEHAVEPlus3.

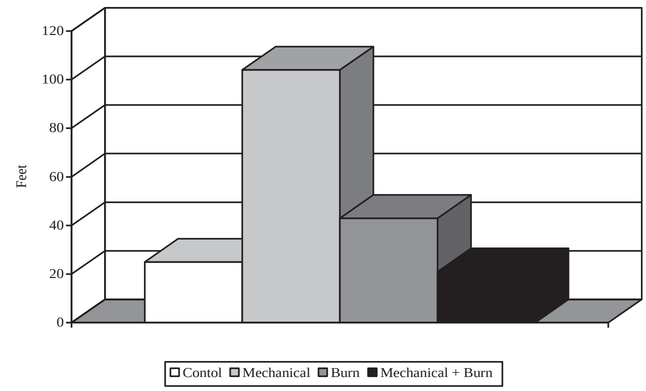

Figure 6—Maximum simulated scorch height in feet post-treatment by BEHAVEPlus3.

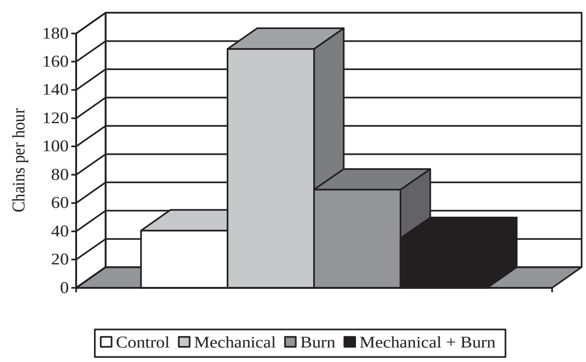

Figure 7—Maximum simulated rate-of-spread post-treatment in chains per hour by BEHAVEPlus3.

DISCUSSION

Mechanically treating then burning as a fuel reduction treatment was the best at reducing wildfire damage on the Southern Appalachian Fire and Fire Surrogate site. Continued burning of these sites will have to occur over the long term to keep fuels from building up to high levels, therefore increasing the chance of wildfire. The burn treatments may decrease fuels if burning continues over the long term. With continued data collection and treatments on the Fire and Fire Surrogate study we will be able to more clearly see the ecological impacts of repeated treatments.

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