Fuel Dynamics in Southern Pine Beetle Killed Stands and Its Implication to Fire Behavior

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Introduction

Based on results from USFS Forest Health Monitoring (FHM) Detection Monitoring, *Dendroctonus frontalis* (Figure 1) is the most serious pest of pine forests throughout the southern U.S. Because of increased severity of drought, recent outbreaks have been among the worst ever, and South Carolina was the most severely impacted state in 2002, with 25,000 outbreak spots. Since 2001, South Carolina alone has detected over 92,000 southern pine beetle (SPB) killed spots and the death of approximately 25 million trees, commercially valued at over $300 million. Severe outbreaks can produce 100 percent mortality of pines over an area of a hectare or more, and dead pines fall within one to two years. As a result, fuel loading in these SPB-killed spots increases suddenly and dramatically soon after SPB outbreak, representing a serious fire hazard with extreme fire behavior. Over time, this unique fuel complex will also change gradually due to natural decomposition. However, few studies have quantified fuel characteristics of SPB-killed stands, and none has studied the dynamics of this fuel complex. Moreover, how changes in fuels affect fire behavior remains unknown. Our project will use a combination of field measurements and modeling to study fuel dynamics in SPB killed stands and its implication to fire behavior. Although the field data collection was conducted within national forests of the Piedmont, our results will be generally applicable to the entire Southern U.S. More importantly, our study will help managers to predict fire behavior associated with the fuel complex resulting from current and past SPB outbreaks. Understanding fuel dynamics and its implication to fire behavior is essential for managers to make fuel management decisions, especially when prescribed fire is used.

Figure 1. SPB (left) compared to grain of rice and black turpentine beetle. Credit: Southern Forest Insect Work Conference, www.forestryimages.org

Objectives

The objective of this project is to study fuel dynamics and its implication to fire behavior in forest stands killed by southern pine beetle. Fuels were measured in healthy stands and in stands killed by SPB outbreak at different years so that fuel dynamics (i.e., change with time since SPB kill) can be characterized and compared with healthy stands. Based on the measured fuel data, we will model fire behavior to understand the consequences of fuel changes.

Methods

The study area included the Clemson Experimental Forest (CEF) in South Carolina and two national forests within the Piedmont (Oconee National Forest (ONF) in central Georgia, and Sumter National Forest (SNF) in northwestern South Carolina).

Within the study areas, 26 loblolly pine stands killed by SPB outbreak at different years were identified based on existing records and aerial photos. These stands formed a chronosequence, spanning from 2 years since outbreak to 8 years since outbreak. In addition, 16 healthy loblolly pine stands (i.e., not affected by SPB) were also identified (Table 1). Within each stand, downed woody fuels were measured using the planar intercept method (Figure 2) (Brown 1974). Three 15 m transects were established at each of 4 randomly-selected points within each stand. Fuels were classified by size class: 1-hour fuels (0 – 0.635 cm in diameter), 10-hour fuels (0.636 – 2.54 cm), 100-hour fuels (2.51 – 7.6 cm), and 1,000-hour fuels (>7.6 cm). One- and 10-hour fuels intercepts were counted along the first 1.8 m and 100-hour fuels were counted along the first 3.6 m. Fuels in the 1000-hr class were recorded by species, diameter, and decay class along the entire 15-m transect. Aboveground height of dead and down wood was measured along 30 cm sections beginning at 4, 8, and 12 m. Litter and duff depth were measured to the nearest 1 mm at 4, 8 and 12 m along every transect.

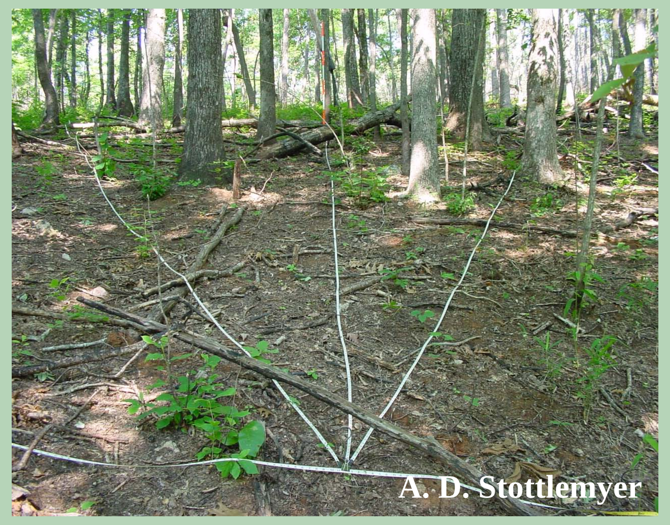

Figure 2. Planar intercept method

Counts of 1-, 10-, 100- and 1000-hour fuels obtained from transect sampling in the field were converted to weights using equations given by Brown (1974). Litter and duff weight were converted using regression equations developed by Waldrop *et al*. (2004). Changes in fuels along the chronosequence will be quantified using regression (fuel loading vs. year-since-outbreak) and/or analyses of variance (breaking the chronosequence into groups). Fuels in the SPB-killed stands along the chronosequence will also be compared to healthy pine stands using a simple t-test. Based on measured fuel data, fire behavior under various burning conditions will be modeled using BehavePlus. Data collected from our recent experimental burn of SPB-killed stands will be acquired and used to evaluate predictions from BehavePlus. Under each modeled burning condition, changes in fire behavior along the chronosequence will be quantified and compared to healthy pine stands.

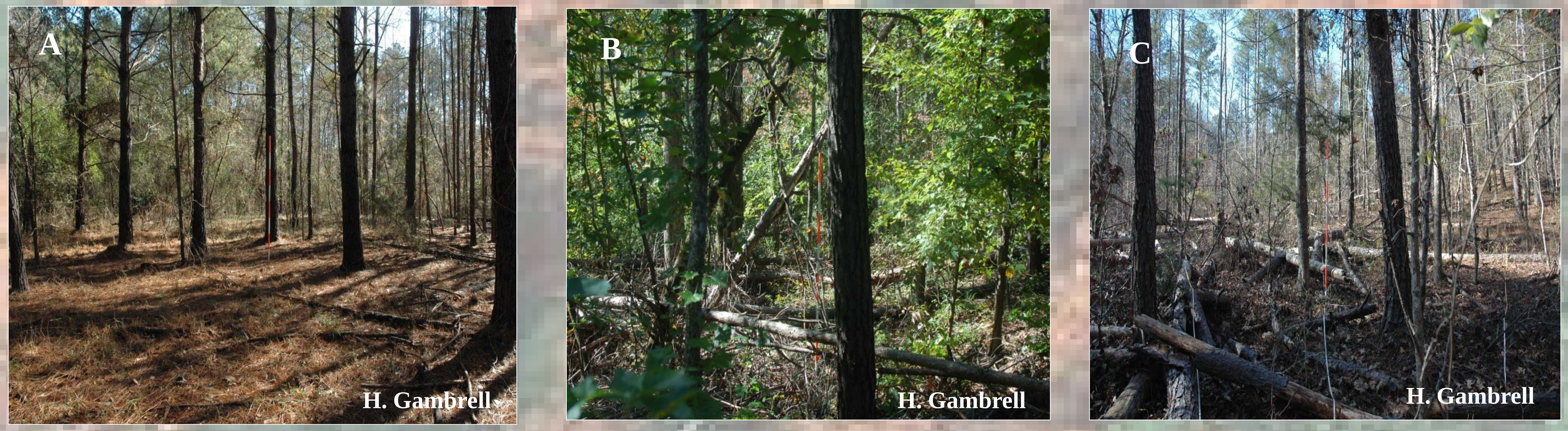

Plate 1: A = healthy stand; B = stand at two years since outbreak; C = stand at eight years since outbreak

Table 1. **Number of stands measured at the Clemson Experimental Forest, Sumter National Forest, and Oconee National Forest.**

Forest	Healthy	2 years since outbreak	8 years since outbreak	Total No. of stands	Total No. of plots
CEF	3	0	3	6	24
SNF	6	7	9	22	88
ONF	7	7	0	14	56

Preliminary Results and Discussion

We compared mean downed woody fuel (DWF) estimates for each of the stands at varying times since SPB outbreak (Table 2). DWF was lowest in the healthy. 100-hour fuels, 1000-hour fuels, and litter were greatest at 8 years since kill.

Future work to be completed will include further quantifying changes in fuels along the chronosequence as well as modeling fire behavior. Based on measured fuel data, fire behavior will be modeled using BehavePlus using a range of specified burning conditions. Under each modeled burning condition, changes in fire behavior along the chronosequence will be quantified and compared to healthy pine stands.

Table 2. **Mean fuel loading for Healthy Stands and Stands 2 and 8 Years Since SPB Outbreak.**

Years Since Kill	1-hr (ton/acre^{-1})	10-hr (ton/acre^{-1})	100-hr (ton/acre^{-1})	1000-hr (ton/acre^{-1})	Litter (ton/acre^{-1})	Duff (ton/acre^{-1})	BA Live Pine (ft^2/acre)	BA Dead Pine (ft^2/acre)	BA Live Hardwood (ft^2/acre)	BA Dead Hardwood (ft^2/acre)
0	0.37	1.20	1.60	7.5	1.5	1.4	122.7	5.3	38.9	2.2
2	0.62	2.20	3.40	23.6	1.4	1.1	6.3	81.6	61.6	3.2
8	0.40	1.61	4.57	26.9	1.9	1.3	13.8	17.3	80.4	0.8

Literature Cited

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Acknowledgements

This study was funded by the US Forest Service, Forest Health Monitoring. We thank Dale Starkey, Forest Health Monitoring Program Coordinator (Region 8), for his assistance. We express our great gratitude to Eddie Gambrell for collecting the data.