

INTRODUCTION

Spruce beetle (*Dendroctonus rufipennis*) is the primary mortality agent of mature spruce species in Western North America (Jenkins and others 2014a, Schmid and Frye 1977). The species preferentially colonizes hosts with reduced defenses, including diseased trees or downed material produced by wind events, snow avalanches, and landslides, as well as trees affected by abiotic stressors, such as high temperature, drought, and/or fire. The majority of colonization of live spruce occurs following downed tree disturbances in mature spruce forests. Outbreaks modify stand structure and composition by causing tree mortality and impact timber and fiber production, fuel conditions, fire risk and severity, water quality and quantity, fish and wildlife populations, recreation, grazing capacity, real estate values, human safety, biodiversity, carbon pools, aesthetics, endangered species, and cultural resources, among other factors (Jenkins and others 2014a). These impacts have been frequently observed in Engelmann spruce (*Picea engelmannii*) forests of the Intermountain West (Hebertson and Jenkins 2008, Holsten and others 1999). Describing and quantifying these changes provide land managers guidance for future management actions.

The objectives of our study (INT-EM-F-13-02) were to document changes in residual stand structure and composition associated with ground, surface, and aerial fuel loads; tree age, size, and species diversity; regeneration; invasive plants; and snag demography. To achieve this,

we established monitoring plots in forest stands in Utah and Wyoming spanning a temporal continuum of tree mortality attributed to spruce beetle [i.e., prior to epidemic (pre), during epidemic or incipient epidemic (epidemic), and post-epidemic (post)] (Jenkins and others 2008). This summary focuses on a subset of data collected, namely changes in fine surface fuels (1-, 10-, and 100-hour fuels) and tree size as complete data analyses are ongoing. Our scope of inference is spruce-fir forests in the Intermountain West.

METHODS

In 2013, we established eight 0.08-ha circular plots in each of five National Forests (N = 40) of the Intermountain Region (Region 4) in Utah and Wyoming [Uinta-Wasatch-Cache (UWC), Fishlake (FL), Manti-La Sal (MLS), Dixie (Dixie), and Bridger-Teton (BT)]. Uinta-Wasatch-Cache, FL, and BT each contained plots representing the three different outbreak stages. Plots on the Dixie were all post-epidemic. Plots on the MLS consisted of four that were post-epidemic and four that were epidemic.

In 2013, at each plot, we established three 16.1-m modified Brown's transects (Brown and others 1982, Brown and Roussopoulos 1974, Woodall and Williams 2005) at 0°, 120°, and 240° from plot center where we counted surface fuels by size class and measured litter and duff depth (fig. 14.1). We estimated forest floor composition of herbaceous vegetation in 1-m² subplots at the beginning of each transect on the outer edge of each plot. We also used

CHAPTER 14.

Effects of Spruce Beetle (*Dendroctonus rufipennis*) Outbreaks on Fuels, Carbon, and Stand Structure and Composition in Utah and Western Wyoming (Project INT-EM-F-13-02)

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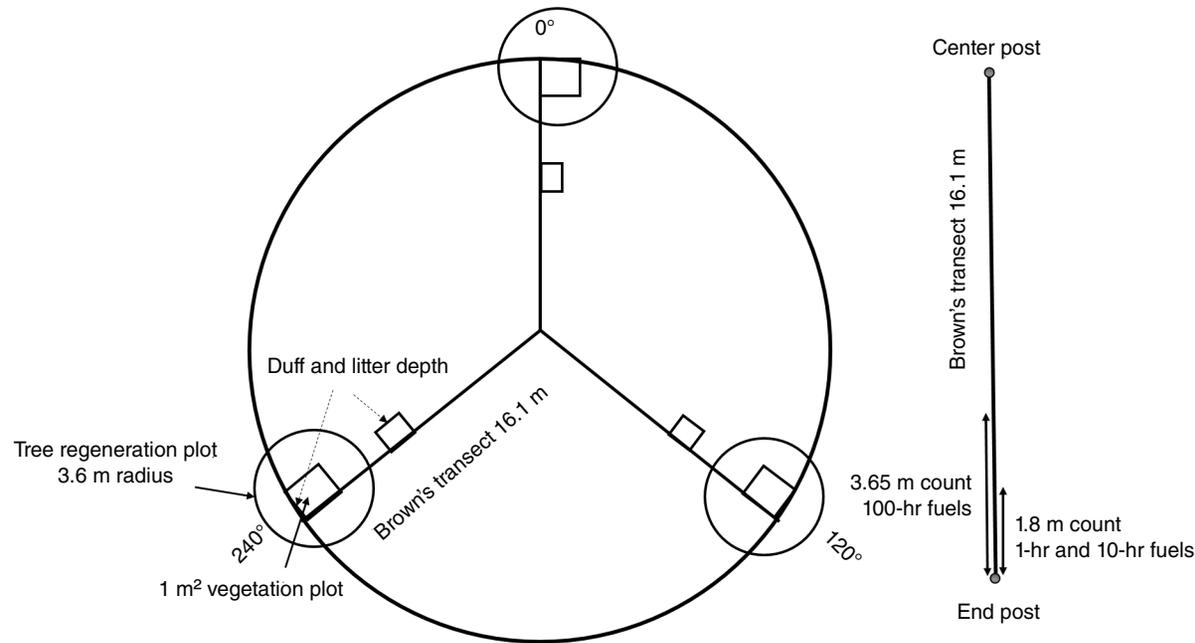


Figure 14.1—Monitoring plot design with Brown's transects. Diameter of fuels: 1-hour = 0–0.64 cm, 10-hour = 0.64–2.54 cm, 100-hour = 2.54–7.62 cm.

3.6-m radius subplots at the beginning of each transect to count tree regeneration by species and seedling (< 7.6 cm in diameter and < 30 cm in height) or sapling (> 7.6 cm in diameter and > 30 cm in height) class. We recorded tree diameter at breast height (d.b.h., 1.37 m), total height, species, status (live or dead), and spruce beetle presence. The year of spruce beetle colonization was determined to be: (1) current year attack (presence of boring dust and immature brood, occasional fresh pitch tubes, green needles); (2) previous year attack [symptoms ranging from fading needles to some or most needles fallen, possible presence

of live beetles (especially at the root collar)]; (3) second year attack (fine twigs attached, most or all needles fallen, no live brood present); or (4) older attack (no needles, some or many fine twigs missing). Related to aerial fuels, we quantified height-to-crown and determined ladder fuels for each tree. On each plot, three of the largest trees based on d.b.h. and tree height were cored to determine stand age and site productivity (10-year growth increment). Ongoing changes in tree mortality, spruce beetle colonization, and tree fall rates were recorded in 2014 and 2015. In 2015, we remeasured surface fuels using modified Brown's transects.

RESULTS AND DISCUSSION

In 2013, significant differences were measured in fine surface fuels for 100-hour fuels among outbreak phases, but not for 1- or 10-hour fuels (table 14.1, fig. 14.2). Following remeasurement in 2015 significant differences in 10- and 100-hour fuels were observed, which indicates the current epidemic may be winding down since no differences were measured in 1-hour fuels as seen in other systems [e.g., mountain pine beetle (*Dendroctonus ponderosae*) in lodgepole pine (*Pinus contorta*)] (Jenkin and others 2008, 2014b).

Between 2013 and 2015, analyses showed consistent d.b.h. distribution in pre- and post-epidemic stands (figs. 14.3–14.5), while increases in standing dead and decreases in standing live

Table 14.1—Analysis of Variance (ANOVA) of 1-, 10-, and 100-hour fuels measured in 2013 and 2015

ANOVA	1-hour 2013	10-hour 2013	100-hour 2013	1-hour 2015	10-hour 2015	100-hour 2015
F-value	1.08	2.7	7.59	0.79	10.16	4.97
Pr > F	0.35	0.08	0.002	0.46	0.001	0.01

trees occurred. Figure 14.6 illustrates spruce beetle-caused tree mortality was initiated in the largest study trees and then shifted to smaller diameters, but caused very little mortality in trees ≤ 20 cm d.b.h. Preliminary observations indicate that subalpine fir (*Abies lasiocarpa*) regeneration is dominant, perhaps indicative of a future shift in tree species composition.

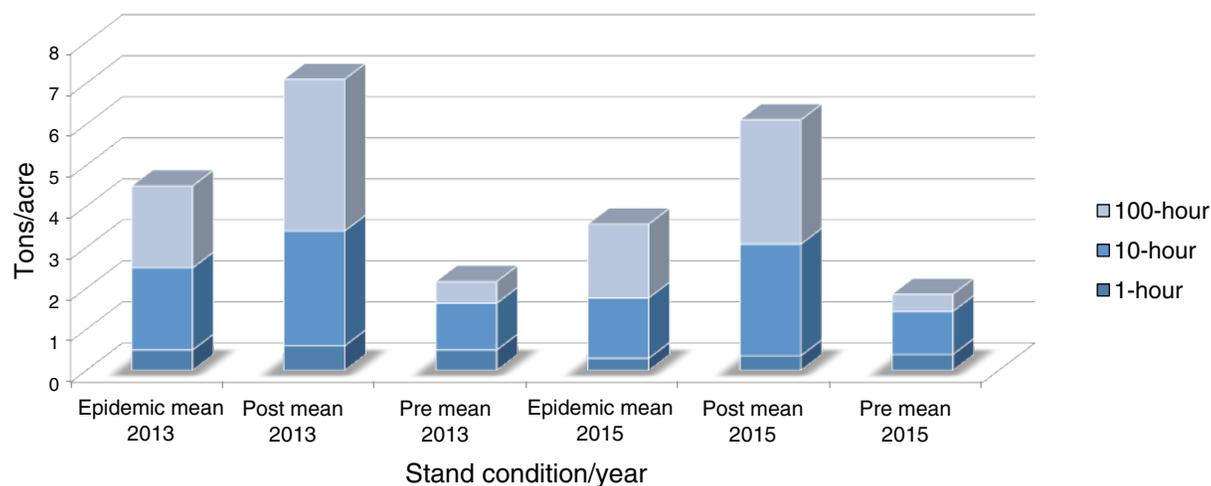


Figure 14.2—Distribution of 1-, 10-, and 100-hour fuels among outbreak phases. Plots were sampled in 2013 and 2015.

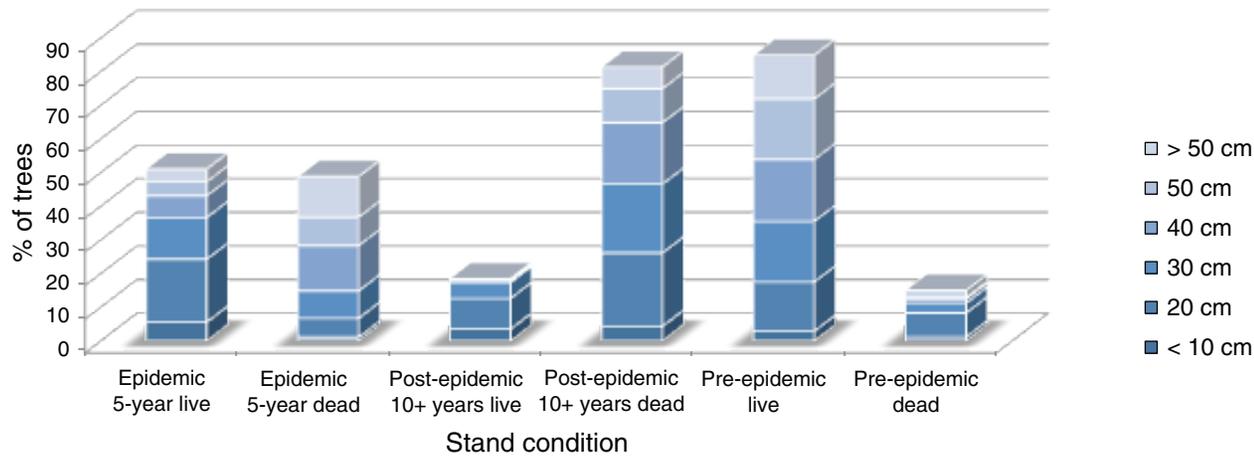


Figure 14.3—Tree distributions by diameter at breast height (d.b.h.) class, 2013.

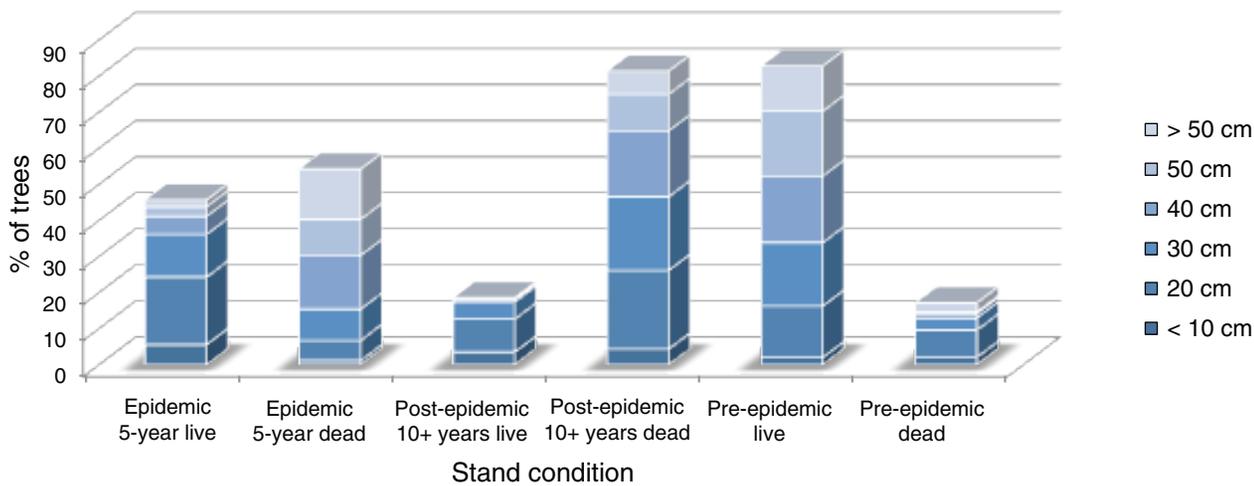


Figure 14.4—Tree distributions by diameter at breast height (d.b.h.) class, 2014. Downed trees since 2013 include one in epidemic 5-year dead stands and seven in post-epidemic stands. No downed trees were found in pre-epidemic stands.

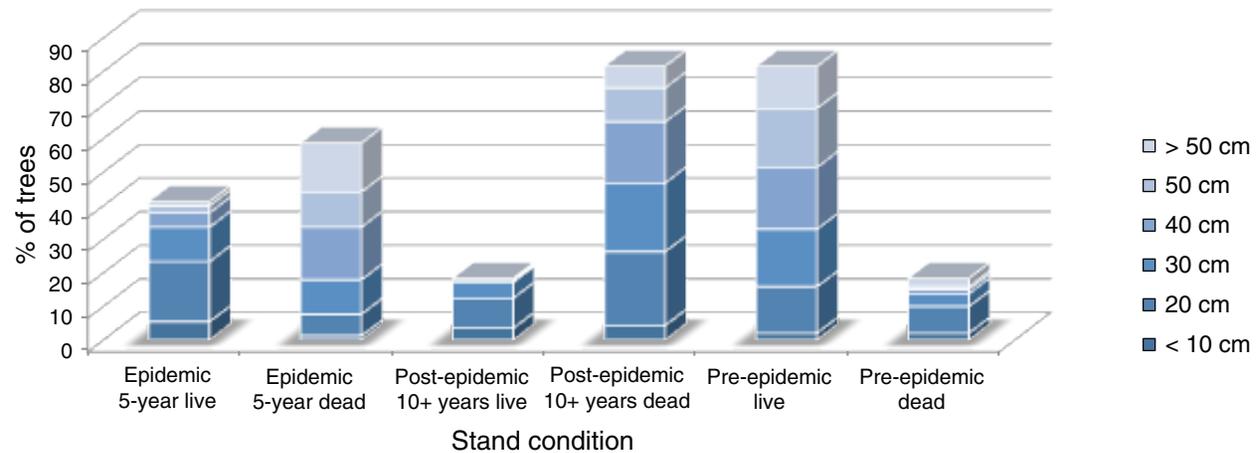


Figure 14.5—Tree distributions by diameter at breast height (d.b.h.) class, 2015. Downed trees since 2013 include eight in epidemic 5-year dead stands and 15 in post-epidemic dead stands. No downed trees were found in pre-epidemic dead stands.

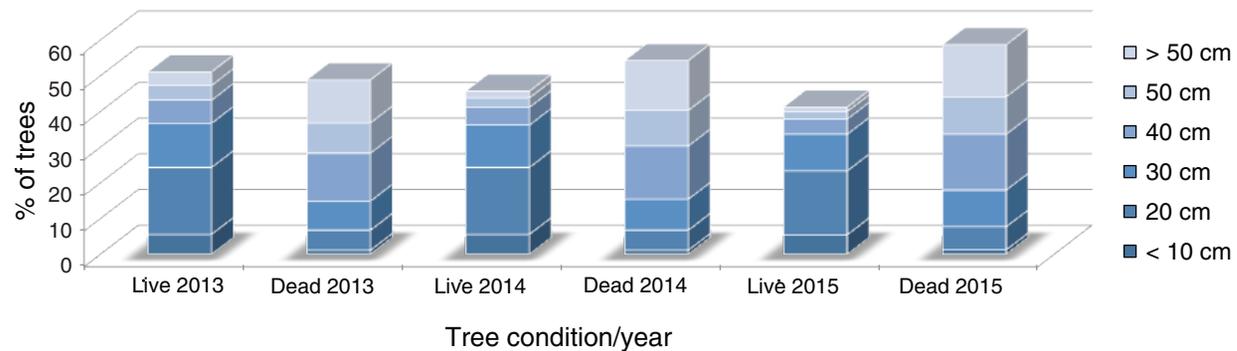


Figure 14.6—Changes in size class distribution of epidemic sites.

In summary, changes in fuel loading and stand structure were consistent with other studies, where fine fuels increase during epidemics, standing live trees decrease, and standing dead trees increase (Jenkins and others

2014b). Changes in regeneration were consistent with DeRose and Long (2007) with subalpine fir regeneration dominating and Engelmann spruce regeneration low.

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CONTACT INFORMATION

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