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Surface Fuel Changes after Severe Disturbances in Northern Rocky Mountain Ecosystems

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Abstract:

It is generally assumed that insect and disease epidemics, such as those caused by the mountain pine beetle, predispose damaged forests to high fire danger by creating highly flammable fuel conditions. While this may certainly be true in some forests, these dangerous fuel conditions may only occur for a short time when evaluated at a landscape level. This study evaluates the effect that exogenous disturbance events, namely fire and beetles, have on future fire hazard. We measured surface fuel deposition rates several forest types after stand-replacement wildfire beetle outbreaks to quantitatively describe fuel dynamics in heavy mortality stands for up to 10 years post disturbance. Fuel deposition was measured using semi-annual collections of fallen biomass. This litterfall was collected using a network of seven, one meter square litter traps installed on sites located across the northern Rocky Mountains USA. We also measured stand and surface fuel characteristics of the plot using FIREMON techniques at the beginning, and yearly until the study's end. Results indicate that after the initial pulse of needlefall 2-3 years after disturbance, few fine woody fuels are actually deposited over the next 10 years.

Additional Keywords: Fire, fuels, litter, litterfall, fuel deposition, fuel accumulation

Introduction

Conventional wisdom in fire management holds that stands with trees that are killed by insects, disease, or fire have high fire hazard because the dead foliage and fine woody material is highly flammable while in the canopy (Axelson *et al.*, 2009; Hicke *et al.*, 2012) and then, when this material falls to the ground, it creates heavy fuel loads that may result in faster fire spread and greater intensities (Gara *et al.*, 1984; Jenkins *et al*, 2015). There is no doubt that the dying and dead needles are more flammable than green needles because of lower moistures and higher flammability (Jolly *et al.*, 2012), but these needles may remain in the canopy for a short time. Of more importance may be how fast the dead canopy material accumulates on the forest floor to increase fuel loadings and hazard. The dead fine woody material may fall quickly to the ground and create surface fuel conditions that could foster wildfires of high intensity and severity. This study evaluated through annual field collections, the effect that exogenous disturbance events, namely fire and beetles, have on future fuel conditions.

Materials and Methods

Study Sites

We selected fifteen sites in Montana and Idaho that were on flat ground, near a road, and had the potential for high tree mortality from a disturbance. Needles had to be present on the killed trees. We attempted to target only stands that had greater than 70% mortality from the disturbance, but it was difficult to evaluate future mortality at the inception of an outbreak, therefore, some selected stands had less than 70% mortality at study initiation. After an exhaustive GIS analysis and numerous reconnaissance trips, we established at least three sites of different forest types after major mortality events from three different disturbance agents: wildfire, Douglas-fir beetle, and mountain pine beetle outbreaks (Table 1). We wanted to select sites in just one forest type but that was nearly impossible under our site selection and disturbance selection criteria.

Table 1. List of all 15 study sites. Three stand-replacement disturbances are represented in this study: wildfire, Douglas-fir beetle, and mountain pine beetle. Sampling period ranged from year established to 2015.

Site Name	Acronym	Overstory Mortality (%)	Forest Type	Elevation (m)	Year Established
			Wildfire		
Jocko Lake	JL2	100	Mixed larch, Douglas-fir, lodgepole pine	1426	2008
Marias Pass	MP1	100	lodgepole pine	1715	2007
Merriwether 1	MW1	25	ponderosa pine (thinning unit)	1231	2007
Merriwether 2	MW2	98	ponderosa pine	1200	2008
			Douglas-fir Beetle		
Morgan Creek	MC1	50	Douglas-fir	2179	2009
Lost Trail	LT1	90	Douglas-fir	1882	2007
Flesher Pass	FP1	90	Douglas-fir	1839	2009
			Mountain Pine Beetle		
Galena Summit	GS1	100	whitebark pine	2737	2007
Bull Run	BR1	98	ponderosa pine	1429	2010
Red River 5	RR5	100	lodgepole pine/subalpine fir	1653	2001
Red River 6	RR6	100	lodgepole pine/subalpine fir	1670	2001
Red River 7	RR7	100	Mixed lodgepole pine, spruce	1328	2001
Homestake Pass	HP1	70	lodgepole pine	1938	2007
Twin Peaks 1	TP1	80	whitebark pine	2828	2009
Twin Peaks 2	TP2	70	whitebark pine	2679	2009

Field Methods

We measured surface fuel deposition and decomposition rates for a number of forest types after severe wildfire, Douglas-fir beetle, and mountain pine beetle events to quantitatively describe fuel dynamics for up to 10 years after the disturbance. Fuel deposition was measured using semi-annual collections of fallen biomass sorted into six fuel components (fallen foliage, twigs, branches, large branches, logs, and all other material) from a network of seven, one meter square litter traps installed on all plots. We took a monitoring approach to describing fuel dynamics after severe disturbances on the 15 selected sites. Fuel accumulation was documented from annual fuel loading measurements at each site. Fuel deposition was measured from litter that fell into wooden traps and were collected twice a year. We measured loadings of all fine woody, shrub, and herbs using the visual Photoload estimation method (Keane and Dickinson, 2007) (Figure 1).

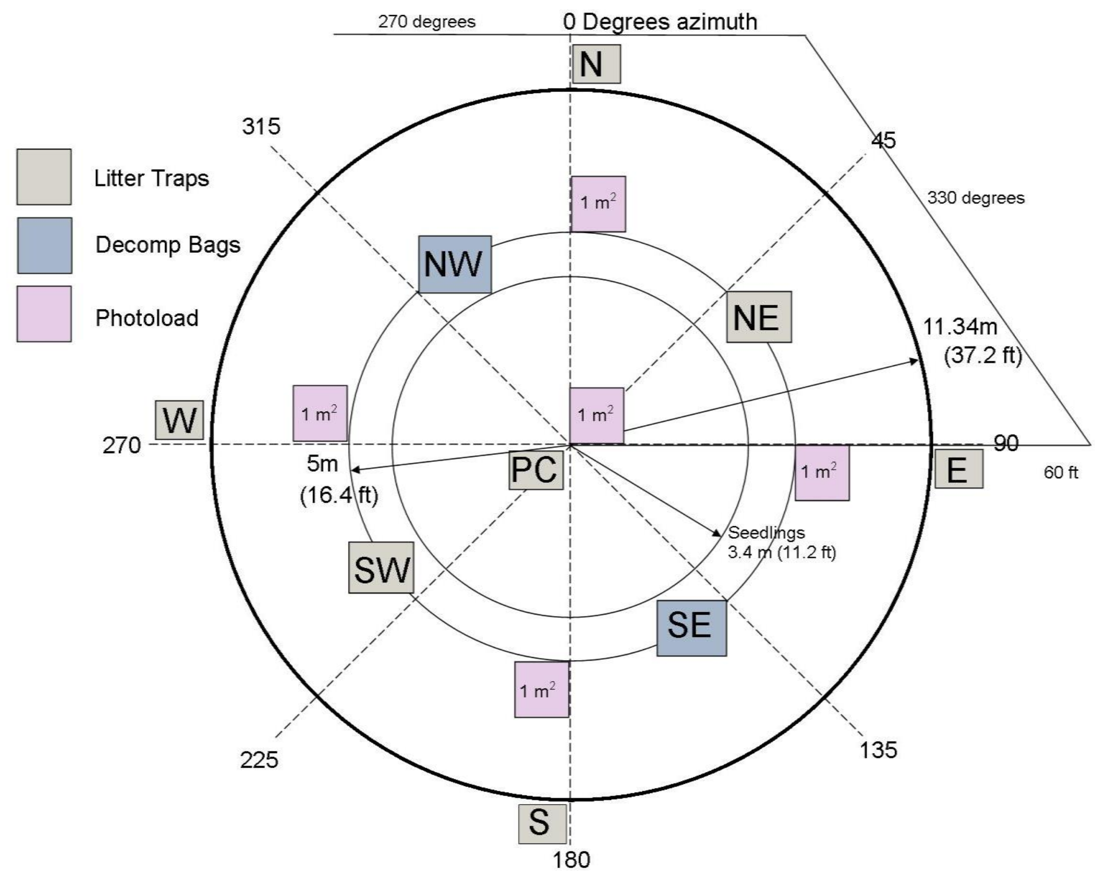

Figure 1. Plot Layout

Analysis

We performed an analysis of variance for litterfall across all fuel components on each plot to determine if we had statistically significant changes by year. We summarized fuel loadings and deposition rates by fuel component for each plot to create an annual time series of box-whisker plots (Sokal and Rohlf, 1981) to display temporal changes, and then pooled these data to create a time series by disturbance agent. For the loading time series, we calculated the trend (increasing, decreasing, same) and rate of fuel accumulation over the sampling time by plot and then summarized to disturbance agent. For the litterfall analysis, we visually estimated three parameters from each plot: (1) number of years it took for dead foliage to fall to ground, (2) number of years it took before substantial amounts of FWD to fall to the ground, and (3) number of years in which CWD was detected. We then summarized these statistics by disturbance agent.

Results & Discussion

Analysis of box-whisker plots of measured litterfall indicate that deposition of foliage across all 15 study sites occurred during the first 1-4 years post-disturbance, independent of site location or forest type. When site data was pooled by disturbance type these trends were repeated across all sites, foliage deposition took place within 1-4 years of disturbance regardless of disturbance type. Initial analysis of the fuel loading time series showed mostly constant, unchanging fine and coarse woody debris levels across nearly all study sites. A minor increase in coarse woody debris was noted on the Red River site but it is likely negligible. Fallen snags were rare on all of the study sites during the entirety of the study and did not contribute to overall fuel deposition. Preliminary analysis of litterfall rates and loading following stand-replacement disturbance on Northern Rocky Mountain ecosystems indicate there is little change to surface fuels regardless of forest or disturbance type. While the majority of foliage tends to fall within the first 1-4 years following disturbances on all sites, generally we do not see any substantial increases or decreases to surface fuels over the long term. Generally, there was little fuel accumulation during the first 5 years after severe disturbances.

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