A Tale of Two Fires: The Relative Effectiveness of Past Wildfires In Mitigating Wildfire Behavior and Effects

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***Abstract**—The incidence of large, costly landscape-scale fires in western North America is increasing. To combat these fires, researchers and managers have expressed increased interest in investigating the effectiveness of past, stand-replacing wildfires as bottom-up controls on fire spread and severity. Specifically, how effective are past wildfires in mitigating the behavior and effect of future fires, and for how long?”*

Our research focused on two recent fires that encountered past wildfires but with significantly different outcomes. The 2006 Tripod Complex fires in Washington State flanked around, but did not reburn, the 1970 Forks Fire, while the 2012 Octopus Mountain Fire in Kootenay National Park in British Columbia reburned much of the 1991 Spar Mountain Fire area. In 2013 we sampled fuels and vegetation in unburned portions of the Tripod/Forks and the Octopus/Spar Mountain fire areas in order to quantify canopy and surface fuel characteristics and elucidate why fire behavior and effects were different between the two wildfire events.

Introduction

Following high-severity fire events, regenerating stands of lodgepole pine (*Pinus contorta* Carr.) and other high elevation forests may act as temporary fire breaks that are not apt to carry fire unless burned under extreme wildfire conditions. Over time, fuel succession recruits surface and canopy fuels that are susceptible to fire spread. Determining when a threshold to burning is reached, and under what fire weather conditions, is of concern to fire managers. In this pilot study, we investigated surface and crown fuel loadings in two post-fire areas (Figure 1) in order to determine which fuel elements of regenerating forests drive flammability and how quickly fuels develop in contrasting ecosystems.

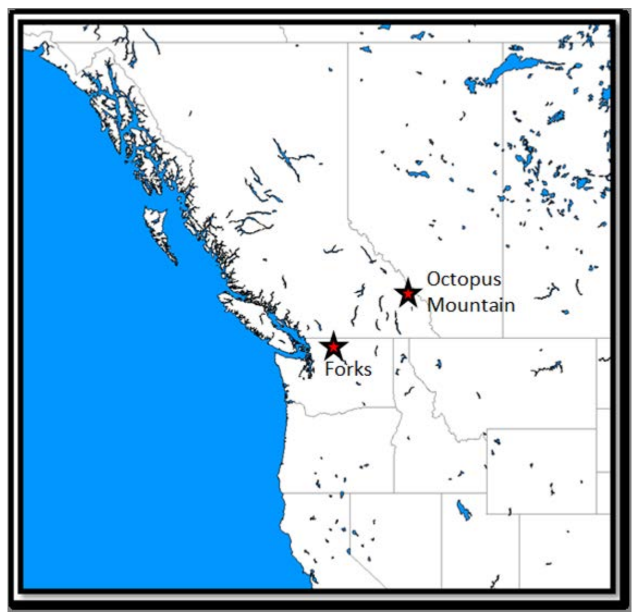

Figure 1—Location map of the Forks/Tripod study area in Okanogan Wenatchee National Forest, Washington State and 2012 Octopus Mtn/Spur Mtn study area in Kootenay National Park, BC.

Methods

Study areas

The first test case involves the 2006 Tripod Complex fires, which burned >80,000 ha of subalpine fir (*Abies lasiocarpa* (Hook.) Boivin.), Engelmann spruce (*Picea engelmannii* Goodman) and lodgepole pine forest in the east Cascades of central Washington State. During a series of significant fire growth days the fire flanked around but did not reburn the 1970 Forks Fire, a 1700-ha patch of 35-year old lodgepole pine regeneration (Prichard and Kennedy 2013, Figure 2). Fire weather varied over the fire progressions that bordered the Forks burn scar, but was generally represented by warm, dry weather conditions. Maximum temperatures ranged from 24 to 29 °C, minimum relative humidity ranged from 17 to 25 percent, and wind gusts were between 22 and 32 kph from the south and southwest. Topography in the study area is rugged with a pronounced ridgeline at the southern edge of the Forks burn perimeter.

The second test case involves the 2012 Octopus Mountain Fire in Kootenay National Park, British Columbia. The 1,200 ha fire originated in 300+ year old subalpine fir/white spruce (*Picea glauca* (Moench) Voss) forest but also burned

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Figure 2—Landscape photo of the 2006 Tripod Complex Fire with the 1970 Forks burn scar in the distance. Right panel—representative photo of surface fuels within the Forks burn.

through most of the 21 year old lodgepole pine forest that established following the 1991 Spar Mountain Fire (Figure 3). Fire weather on August 23rd when the fire reburned the Spar Mountain Fire area, was highly variable due to the influences of topography and a passing cold front. The fire was located on a steep, west-facing slope of Lachine Creek with a number of side-drainages both below and above it. These drainages contributed to complex, and highly variable wind patterns throughout the day and into the early evening. Maximum temperatures ranged from 21 to 23 °C while minimum relative humidity dropped to 30 to 40%. At 1300 hours winds were generally out of the south, southwest at 11.5 kph; however, between 1300 and 1700 hours the wind direction became highly variable with periods of sustained flow from the south then the north. At approximately 1750 hours, the winds stabilized out of the south and the fire made its run through the 1991 regeneration.

As part of a preliminary field study, sampling was conducted on five randomly located plots within the unburned interior of the Tripod/Forks study area, and four plots in unburned patches within the Octopus/Spar Fire study area. Fewer plots were sampled in Octopus/Spar because so little of the pre-fire fuels remained after the 2012 reburn. The standard plot used for the two studies consisted of four 30-m transects radiating 90° from a central point. At plot center we collected stand density by species and estimated canopy base height by species within a 1/100-ha fixed radius plot. Each of the four 30-m transects was inventoried for surface fuel load and vegetative cover.

Fuels were inventoried by time lag size class with 1-hr fuels recorded for the first 1.8 m, 10-hour fuels for the first 5 m, and 100- and 1000-hr fuels along the entire 30 m transect. Starting on the 5-m mark, litter and duff depths were measured every 5 m along each transect. Litter and duff depths were converted to loading using published bulk density values in Brown and others (1982). For cover transects the distance that an element bisected the line was recorded. Cover was recorded for vascular plants (grasses, forbs, shrubs, and trees), bryophytes, rock, litter, bare ground and coarse woody debris. Species and height were also recorded for all vascular plants.

Potential fire behavior was modeled using FMAPlus (http://www.fireps.com/fmanalyst3). Measured surface fuel characteristics were represented by fire behavior model 8 (timber litter) for Tripod/Forks and fire behavior fuel model 2 (short grass) for Octopus/Spar based on day-of-burn observations of fire behavior during the 2012 Octopus Mountain fire. Because the underlying Rothermel (1972) fire spread model only considers fine fuels as important for surface fire behavior (i.e., spread rate), coarse woody debris did not factor into modeling. Basic canopy characteristics including canopy base height and cover were used in FMAPlus to calculate canopy bulk density.

Results and Discussion

There was significant variability in fuel loading and vegetation cover between plots and between fires, and a higher sampling intensity was needed to adequately characterize surface and canopy fuels. Both study areas had low shrub and herbaceous cover (Table 1). Average shrub cover was 25% (± 15%) and herbaceous cover was < 2% (± 2%) in the Tripod/Forks area compared to an average shrub cover of 7% (± 5%) and average herbaceous cover of 21% (± 13%) in the Octopus/Spar Mountain area.

Fine wood was comparably low in both study areas (Table 2). Coarse wood and litter differed dramatically between the study areas with 83.0 (± 40) Mg ha^{-1} of ≥ 1000 hr fuels in the Octopus/Spar Mountain area versus 30.0 (±16) Mg ha^{-1} in the Forks/Tripod area and 16.5 (±17) Mg ha^{-1} of litter versus 8.3 (±4) Mg ha^{-1} (Figure 4).

Figure 3—Overflight photo of the 2012 Octopus Mountain fire which burned over a portion of the 1991 Spar burn area. Right panel—representative photos of surface fuels that burned and did not burn within the Octopus Mountain fire.

Table 1—Comparison of measured percent cover (%) between the two study areas.

	Octopus/Spar Mountain		Tripod/Forks	
	Mean	**SD**	**Mean**	**SD**
Graminoid	5.25	± 3.73	0.20	0.62
Forbs	15.88	± 8.91	1.00	1.84
Shrubs	7.13	± 5.02	24.90	14.77
Litter	37.75	± 8.74	52.45	14.64
Downed wood	17.38	± 4.70	10.45	4.57
Bare ground	16.88	± 13.21	8.95	6.96

Table 2—Comparison of estimated surface fuel loading (Mg ha-1) between the two study areas.

Surface fuel	Octopus/Spar Mountain		Tripod/Forks	
	Mean	**SD**	**Mean**	**SD**
1 hr	0.3	± 0.2	0.5	± 0.5
10 hr	1.8	± 1.5	2.0	± 1.6
100 hr	3.9	± 1.6	4.6	± 2.6
1000 hr	83.7	± 39.7	29.6	± 15.7
Litter	16.5	± 17.0	8.2	± 4.0
Duff	1.8	± 2.8	9.2	± 8.9
Total	108.1	± 55.6	54.2	± 18.8

Based on representative fuel models, predicted surface fire behavior was very different between the two study areas with much higher flame lengths and rates of spread predicted for the Octopus/Spar study area (Table 3). In contrast, based on the input canopy characteristics, the Tripod/Forks had greater potential for torching and crowning than the Octopus/Spar study area.

The two unburned islands in the Spar Mountain Fire contained high fuel loads of downed logs and substantial litter accumulations. The islands are also situated in the middle of a uniform and steep (>55%) slope on a westerly aspect (270°). These factors suggest that conditions of fuels and terrain were sufficient for both islands to burn; the reason they didn't could be due to patterns of fire spread. Fire spread over the course of the Octopus Mountain Fire was highly erratic with spread direction appearing to be influenced by slope, wind direction, and pockets of heavy fuel. It is possible that both islands did not burn due to shifting convection columns as the fire spread up the slope.

In contrast, the Tripod/Forks burn contained much lower large wood and litter loads than the Octopus/Spar study area. Although the Forks burn is surrounded by evidence of high-severity crown fire, the combination of low surface fuels, young lodgepole pine regeneration and a ridgeline that likely created a terrain break to fire spread, created an effective barrier to fire spread.

Conclusions

With such a small sample size it is difficult to explain with confidence why the Forks Fire did not reburn in 2006, 34 years since the last fire, but the Spar Mountain Fire reburned after only 21 years. However, the results from this pilot study suggest that after two decades following fire, sites with fuelbed characteristics similar to the Octopus/Spar study area will burn with very high intensity and severity. The dominant variables are likely surface loading of large woody fuels and consistent cover of a flammable substrate. Topography may have also played an important role in contrasting fire spread between the two study areas. A prominent ridge at the southern perimeter of the Forks fire, combined with the low

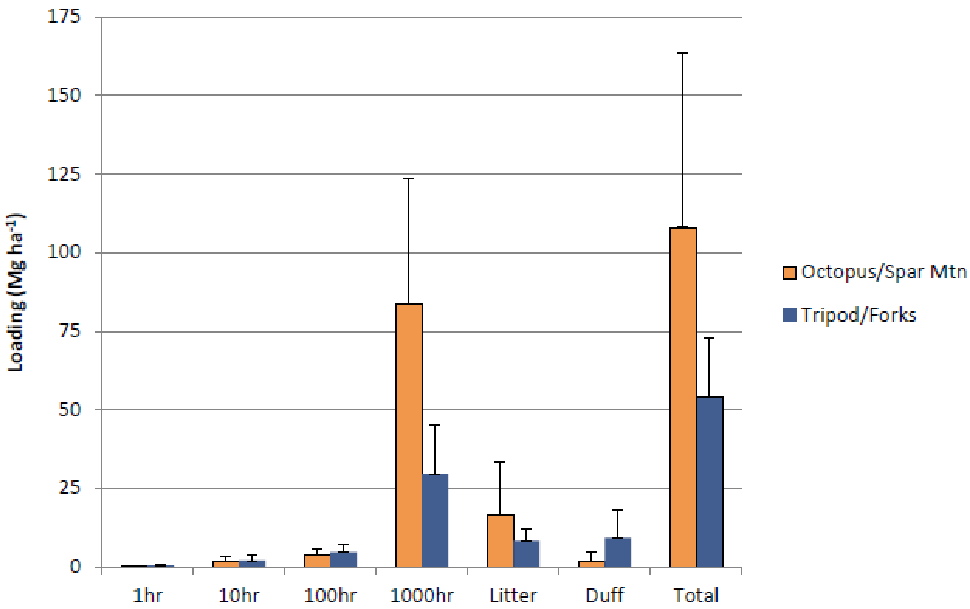

Figure 4—Comparison of fuel loading (Mg ha-1) between the two study areas.

Table 3—Predicted fire behavior from FMAPlus.

	Tripod / Forks	Octopus / Spar
Canopy base height (m)	0.3	0.3
Canopy bulk density (kg m^{-3})	0.4437	0.2515
Fuel model (13)	8	2
Torching index (km/hr^{-1})	31.9	0
Crowning index (km/hr^{-1})	5.6	3.4
Rate of spread (m/min^{-1})	0.46	16.8
Flame length (m)	0.26	2.5
Fire intensity (kW/m^{-1})	14	1698

surface fuels of the burn scar, may have acted as an effective barrier to fire spread. In contrast, the Octopus Mountain fire spread up a steep west-facing slope with no topographic barriers.

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