Wildfire Behavior Case Study of the 2010 Machine Gun Fire, Army Garrison Camp Williams

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BACKGROUND AND RESEARCH OBJECTIVES

A case study is presented for the major run of the Machine Gun Fire on September 19, 2010, which started within the confines of Army Garrison Camp Williams (AGCW) and spread beyond installation boundaries to the north, destroying three homes and requiring an evacuation of approximately 1600 people in an adjacent community. This fire was selected for a wildfire behavior case study analysis because of its large size and destructive nature in relation to the wildland urban-interface area adjoining the base. Alexander and Thomas (2003) suggest that a wildland fire behavior case study should include, at the minimum, introduction remarks regarding the significance of the fire, fire chronology and development, detailed description of the fire environment (i.e., topography, fuels, and fire weather), an analysis of fire behavior, and concluding remarks regarding lessons learned and significant contributions, if any, to the broader general fire behavior knowledge database.

FIRE CHRONOLOGY AND DEVELOPMENT

The Machine Gun Fire started at approximately 1237 hours on September 19, 2010; all times given are Mountain Daylight Time (MDT). An initial attack fire suppression crew employed by the Utah National Guard stationed at AGCW were initially dispatched to the fire. Two distinct surges in the fire's forward advance subsequently occurred, the first at 1330 hours and a second at 1400 hours were stopped at firebreaks in grass and sparse shrub cover northeast of the fire's point of ignition (fig. 1). Near 1500 hours, high winds gusting to at least 28 km hr-1 produced spot fires north of the firebreaks that had initially stopped fire spread. After 10 minutes of extensive spotting the fire advanced 706 m and jumped yet another set of firebreaks in grass at 1530 hours.

In the next 30 minutes, from 1530 to 1600 hours, the fire spread forward an additional 800 m, and breached a trail at 1600 hours (fig. 1). From 1601 to 1625 hours, fire spread continued at a rapid pace until it jumped a set of trails at the EQA pad area. For the next 20 minutes (from 1626-1645 hours), a large portion of the fire's edge moved upslope in a northwesterly direction. At 1646 hours, the fire jumped two sets of firebreaks, each approximately 8-m wide, and spread rapidly upslope in a north-northeast direction until running into a goat-maintained fuelbreak (Lovreglio et al. 2014) in Gambel oak (*Quercus gambelii*, Nutt.) where the fire was stopped.

At 1656 hours, spot fires were observed developing on the other side of the fuelbreak that eventually spread beyond the northern boundary of AGCW. Meanwhile, the northwestern portion of the fire continued spreading from 1626-1645 hours (fig. 1), eventually breaching the same set of firebreaks at 1700 hours. From 1700 to 2000 hours, the fire burned northward until spotting over the goat-maintained fuelbreak at 2000 hours. In addition, the fire burned

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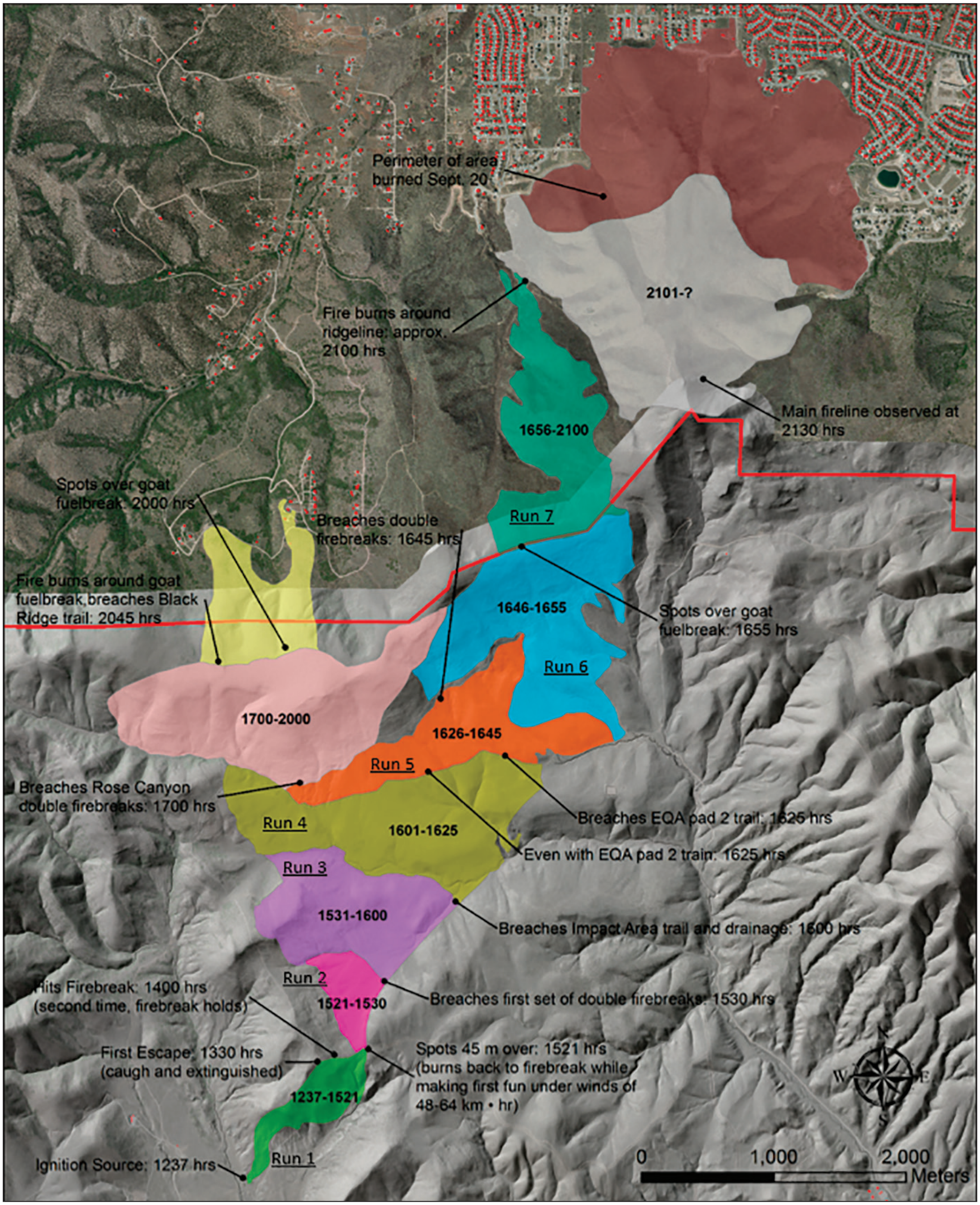

Figure 1—Progression map and narrative of events associated with the major run of the Machine Gun Fire on September 19, 2010.

along the fuelbreak towards the west and subsequently hooked around the fuelbreak at 2045 hours, eventually coalescing with the spot fire activity that developed at 2000 hours. The fire then burnt farther northward and consumed one home before being stopped along roads and property boundaries later the night of September 19. At the northeastern portion of the fire, spread continued through the evening of September 19 and on into the morning of hours of September 20.

DESCRIPTION OF THE FIRE ENVIRONMENT

Information on vegetation and fuel type at the time of the 2010 Machine Gun Fire was acquired via LANDFIRE (Reeves et al. 2009) for existing vegetation type (EVT) and fire behavior fuel model (FBFM) classifications as per Anderson (1982). EVT is a baseline LANDFIRE data product that represents species composition at a given site. The EVT map for AGCW was mapped, with the perimeter of the Machine Gun Fire overlaid onto LANDFIRE data compiled in 2008. Using general vegetation groups, the EVT map indicates that within the boundaries of AGCW, the Machine Gun Fire burned predominantly through shrubland vegetation and small patches of grassland. Once the fire crested Black Ridge on the northern boundary of AGCW, the vegetation type transitions to hardwoods, which on the ground is represented by Gambel oak. The FBFM map for AGCW at the time of the Machine Gun Fire in 2010 indicates that the shrubland vegetation is primarily FBFM 5 and secondarily FBFM 2. Grasslands are modeled as FBFM 1, while Gambel oak stands were modeled as FBFM 8 and possibly FBFM 2.

The ICS-209 report filed at 2100 hours (MDT) on September 19, 2010 briefly mentions a peak or gust wind speed observed at 56 km h-1 and rapid, wind-driven rates of fire spread. The Remote Automated Weather Station (RAWS) hourly weather data indicates similar high wind speed observations with average 6.1-m open wind speeds of 22 to 32 km h-1 from 1400 to 2200 hours. Wind speed in the morning hours on September 19, 2010 were fairly high, with readings consistently between 12-15 km h-1 from 0000 to 0900 hours. Average wind speed decreased slightly from 1000 to 1300 hours, varying from 6 to 14 km hr-1. At approximately 1400 hours, peak temperatures for the day and relative humidity lows coincided with a dramatic increase in average wind speed ranging from 22 to 32 km h-1 for all of the afternoon and evening weather observations. Relative humidity dropped from a morning high of 34 percent at 0800 hours to 7 percent by 1400 hours. Wind direction from 1000 hours onward was a constant southeast to south to southwest. The dead timelag fuel moistures were very low throughout the day ranging from one to four percent for 1-h fuels, two to six percent for 10-h fuels, and six to ten percent for 100-h fuels.

FIRE BEHAVIOR ANALYSIS—OBSERVED VS. PREDICATED RATE OF SPREAD USING BEHAVEPLUS

Observed rates of spread for seven different fire run segments compiled by AGCW personnel in the form a fire progression map were compared to predicted rates of spread using BehavePlus v. 5.0 (Heinsch and Andrews 2010). The required inputs were obtained from a LANDFIRE fuel model classification map, digital terrain model data, and weather observations from the Tickville RAWS. Of the seven different fire run segments compared (table 1), three of the predicted segments were within 60 percent of the observed fire spread rates, while the other four were drastically different. It's of note that the maximum rate of fire spread, as observed over a 9-minute period, was 164 m min-1. Major differences in ROS estimates in the present case study could be due to inaccuracies related to fire progression timelines and generalizations of slope and fuel model type when input into BehavePlus. Fire progression interval 6, which exhibited very high ROS, could be an example of this kind of inaccuracy or of a transition area from surface to crown fuels.

LESSONS LEARNED AND RECOMMENDATIONS

Butler and Reynolds (1997) in their wildfire behavior case study comparison of observed and predicted rate of spread (ROS) values using BehavePlus found that, even in shrub fuel types, transition from a surface fire to crown fire was an abrupt occurrence and was under predicted by BehavePlus. However, once the fire

Table 1—Observed versus predicted rates of spread tabulation for the major run of the Machine Gun Fire of September 19, 2010 patterned after Butler and Reynolds (1997). Predicted rates of spread were computed with BehavePlus using Fire Behavior Fuel Model 5 as per Anderson (1982). The live woody fuel moisture content was set as a constant at 69%, the value obtained from a nearby live fuel sampling location for Wyoming big sagebrush on September 1, 2010.

Fire progression segment	Time interval (duration)	Slope steepness (%)	Spread distance (m)	Avg. 6.1-m open wind (km h^{-1})	Observed ROS (m min^{-1})	Predicted ROS (m min^{-1})
1	2h 50m	8.8	1284	13	22	8
2	10m	-4.8	706	30	78	24
3	30m	-3.0	798	30	28	24
4	25m	3.5	1043	32	43	26
5	20m	3.2	310	32	16	26
6	9m	13.1	1478	32	164	27
7	Unknown	-3.2	2142	32	9	26

reached a quasi-steady state in the crowns of the shrub fuels, the ROS predictions produced by BehavePlus were much more in alignment with the observed values. Major differences in ROS estimates in the present case study could be due to inaccuracies related to fire progression timelines and generalizations of slope and fuel model type when input into BehavPlus. Fire progression interval 6, which exhibited very high ROS, could be an example of this kind of inaccuracy or of a transition area from surface to crown fuels.

It is difficult to ascertain a definitive reason for the differences in observed and predicted ROS from the data available on the Machine Gun Fire. There could be any number of reasons (Alexander and Cruz 2013; Cruz and Alexander 2013). The present wildfire behavior case study represents the first such effort at AGCW. Findings from the present completed case study underscores the need for rigorous protocols to make fire behavior observations in the future in order to evaluate fire behavior models more thoroughly (Haines et al. 1986; Alexander and Taylor 2010) and ultimately to better evaluate fuel treatment effectiveness, amongst other purposes. More in depth analysis of the topic is available in Chapter 3 of Frost (2015).

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