Trail Cameras Provide a Low Cost Method to Understand Fire Behavior at the Center of the Fire

Karen Ridenour, Rich Gray, Misty Wilburn

Each year in Texas many small rural communities are impacted by wildfire events. In an effort to understand how the interactions of the fire environment and the communities involved leads to the destruction of homes and properties, case studies are conducted. On Thursday, April 9, 2009, Texas experienced a major outbreak of wildfires in 12 North Texas counties. In Montague County, where seven fires burned independently of each other, 36,408 acres of agriculture land, 86 homes and 4 lives were lost. A case study team was sent to examine the economic, agriculture, and community impacts to the area and, in addition, the x-factors affecting home loss during this fire event.

While collecting data for the case study, several homeowners indicated that they had acquired images of the fire from game cameras placed around their property within the fire perimeter. The cameras provide a firsthand view of the fire movement within the cameras' sight range. Currently, there is equipment that can provide superior quality images, collect data and produce scientific fire outputs for examination. However, this information comes at an extremely high cost. McMahon, Adkins and Rodgers (1986) discuss using low cost video imagery analysis system to measuring fire behavior in both lab and field experiments in connection with the study "Flame Characteristics of Wind-Driven Fires in Surface Fuels" (Nelson & Adkins). Rates of spread, flame lengths and fireline intensity relationships were studied in controlled conditions on small scale fires. In a study by Clark, Reeder, Griffiths, Packham, and Krusel (2005), digital video imagery was used to analyze the convective-scale motion in the plane viewed by the camera and then develop a computational technique necessary to derive quantitative estimates of the convective motion within a grass fire from the digital video imagery. Both studies yielded valuable information regarding fire behavior, but cost of thousands of dollars. This cost makes the technology unattainable to most land managers and fire professionals.

Researchers have used electronic data loggers and thermocouples to characterize temperature dynamics during fires. Yielding information at a specific geographical point in regards to heat outputs and interpolation of rates of spread. Firelogger can be constructed for easy burial while allowing the heat resistant thermocouple cable and temperature sensor to extend out along the ground surface at an expense of $300 per firelogger (Grace, Owens, & Allain, 2005).

By using trail cameras, researchers and professionals could be provided a unique view of fire activity during an event at a low, affordable cost for natural resource managers and forest land managers conducting prescribed burns. When conducting a prescribed burn, objectives for the burn are established but are difficult to observe when in a forested ecosystem. Determining if burn objectives have occurred can only be determined post burn. In regards to the loss of homes in the wildland urban interface (WUI), understanding fire effects and behavior that takes place within different ecosystem types will enable researchers to develop better products for homes in areas of high risk. The Moultrie cameras that captured photos of this fire ranged in price from $80 to $100. The timber fuels throughout the Montague County region were composed of various tree species such as black-jack, post-oaks, and in some places hickory and elm. Dead oak leaves are sizeable and add to forest floor fuels to create a deep litter layer of burnable biomass. These dead leaves increased ember production and spotting ahead of the fire front. The undergrowth was so matted in many places with greenbrier (*Smilax bona-nox*) almost impenetrable "roughs" were formed. Greenbrier can overwhelm the lower canopy of hardwood forests and create elaborate vine communities up hardwood trunks. With each series of photos, visual inference of the fire that took place in specific post-oak areas emerged, but would have otherwise not been possible. Upon early examination of images, some inferences were made in regards to fire behavior in the post oak grass understory ecosystem.

Camera 1

84F 04/09/09 05:05 PM

84F 04/09/09 05:06 PM

85F 04/09/09 05:07 PM

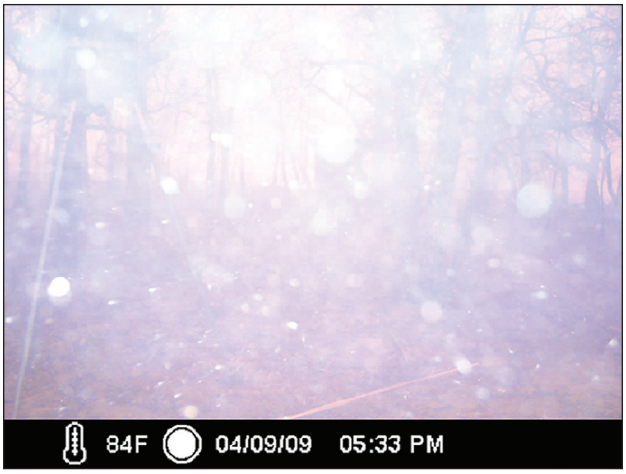
109F 04/09/09 05:18 PM

116F 04/09/09 05:24 PM

89F 04/09/09 06:34 PM

Camera 2

84F 04/09/09 05:33 PM


84F 04/09/09 05:33 PM

93F 04/09/09 05:38 PM

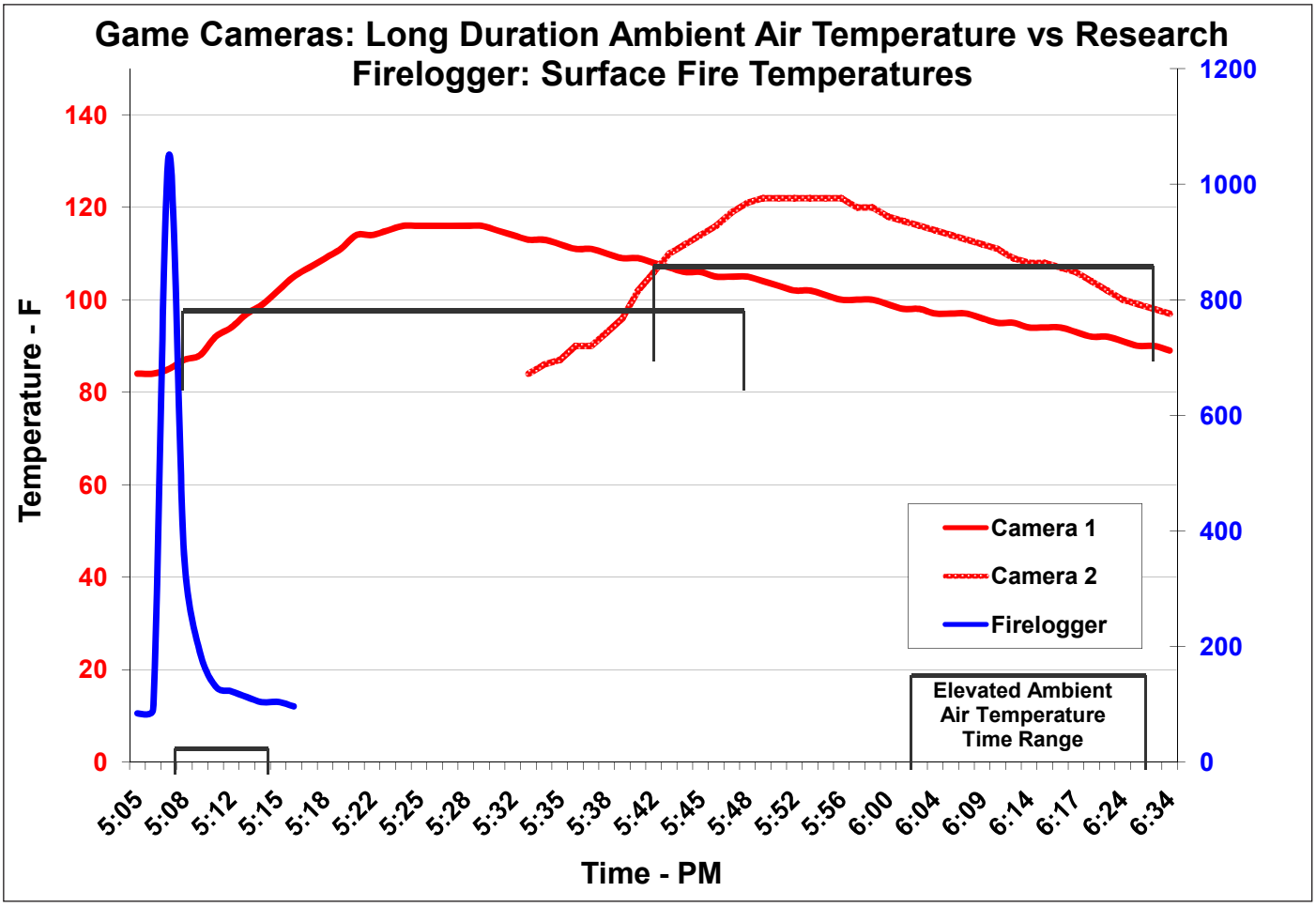
112F 04/09/09 05:44 PM

122F 04/09/09 05:55 PM

91F 04/09/09 06:56 PM

Routinely fire spread is mapped and modeled as a linear progression. Most homeowners believe that when a fire moves through an area there is a spike in temperature resulting in a short duration impact to vegetation and homes in a distinct area. The trail cameras provided a micro-site view point that revealed not a spike, but an arc in ambient air temperatures. Ambient temperatures for this trail camera were elevated to 116 F° for six minutes. The fireloggers located at ground level created an extreme temperature spike of more than 1,000°F for several seconds, but then dropped to similar ambient temperatures which was displayed by the trail cameras. The trail cameras revealed that the elevated temperatures were throughout the vertical profile of the landscape and not just at ground level. Not radiant heat, but a heated air mass in the area affected the fire environment. This heated air mass contributed to long duration burning in 100- and 1000-hour fuels. These fuels exhibited complete consumption due to both radiant and convective heat as well as residual burning which verified dry fuel conditions in heavy down and dead fuels that were represented in the images. The massive heat given off by the fire created extreme heat pulses which increased the ambient air temperature as much as 32° F in a matter of minutes, but kept it elevated for 60 minutes above the initial ambient air temperature. A different trail camera located a mile away on the same property produced a similar long-duration heating arc after the fire passage. This is not a direct measure, but it gives researchers and land managers a base line to verify cannot be seen because temperatures are too hot to be in the center of the fire activity.

The focus should be on the fact the duration of the heated fire environment is prolonged beyond parameters of models. These high elevated temperatures possibly allowed for re-burning of fuels even after the fire front had passed. Local remote area weather stations (RAWS) validated initial ambient air temperature recorded by the trail cameras throughout the burn area.



Typically, onsite weather is taken at the flank or back of the fire to give current localized weather, but this data cannot be taken from the center point of fire activity. The trail cameras could be used to provide onsite fire weather information in the most extreme area of the fire as well as images. A commonly used fire modeling program is BEHAVE, a Windows software application used to predict wildland fire behavior for fire management purposes. The model maxis out at dry bulb temperature of 110° F when setting parameters to determine fine dead fuel moistures, which contribute to fire behaviors such as reaction intensity and rates of spread. As firefighters and land managers have observed, many times actually fire behavior exceeds predicted behavior. As land managers establish parameters for prescribed burns and model expected fire behavior on baselines, there are things that could aid in developing objectives for burns and obtaining desired outcomes. The duration of elevated temperatures in the environment in regards to the actual temperatures should be considered and models should be developed to reflect this increased temperature exposure to vegetation. Trail cameras could be placed in predetermined locations prior to the prescribed burn and used to verify BEHAVE runs, flame lengths, residence time of fire in a particular area. These trail cameras could also be used to evaluate how prolonged heat duration, even after the fire front passage, affects management objectives and how the fire effects targeted vegetation.

When examining homes in the WUI, customarily the tactics are to protect homes until the fire front passes. There is a need to re-examine tactical decisions to pre-treat or protect homes, retreat when safety becomes an issue, but then re-engage after the fire front passes to prevent ignition of homes exposed to these prolonged elevated temperatures. Ember production is routinely noted in literature as a major source of home loss in the WUI. Images from the trail cameras reveal the showering of embers in to both receptive and non-receptive fuels. Large fuels located in dirt can be seen burning because of embers, not flame contact.

Each trail camera presents a unique series of photos that provides different information. This information can be used to make visual inferences that would not be available when access to an area is impossible. Current fuel models are based on averages, the data from trail cameras could be utilized to verify if averages are correct when compared to real time data. Rates of spread in different surface fuels, such as grass or leaf liter, could be examined by this low cost method. After wildfire events, data from these trail cameras could provide reference photos of fire behavior that can be used to verify rates of spread, ember production, flame lengths and other fire behavior in the area. As a management tool, trail cameras could aid in validating fire progression models with real-time fire progression captured by systematically placed trail cameras during prescribed burns. Also, these trail cameras would help managers determine if prescribed fire objectives had been achieved by looking at vegetation impacts based on visual time of heat duration and visual fire intensity. Further investigation of using these trail cameras as a low cost technique in the study of fire behavior needs to be explored. The answers they may provide could aid in improving defensible space and other Firewise activities around homes and communities, along with improved management of delicate or native ecosystems.

Thanks to Dan Cordonnier and Robert Linsdey for providing trail camera data.

References

Clark, T. L., Reeder, M. J., Griffiths, M., Packham, D., & Krusel, N. (2005). Infrared observations and numerical modelling of grassland fires in the Northern Territory, Australia. *Meteorology and Atmospheric Physics*, *88*(3-4), 193-201.

Grace J., Owens, A., & Allain, L. (2005). *Firelogger user's manual*. U.S. Geological Survey National Wetlands Research Center Fire Science Team. Version III.

McMahon, C. K., Adkins, C. W., & Rodgers, S. L. (1986). A video image analysis system for measuring fire behavior. *Fire Management Notes*, *47*(1), 10-15.

Nelson, Ralph M., Jr.: Adkins, Carl W. Flame characteristics of wind-driven fires in surface fuels. In preparation; to be submitted to Can. 1. For. Res. 9. Rothermel, Richard C.; Deeming,