Fuel Treatment Effectiveness in Reducing Fire Intensity and Spread Rate – An Experimental Overview

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Introduction

Fuel treatments represent a significant component of the wildfire mitigation strategy in the United States. However, the lack of research aimed at quantifying the explicit effectiveness of fuel treatments in reducing wildfire intensity and spread rate limits our ability to make educated decisions about the type and placement of these treatments. As part of a larger project designed to address this knowledge gap, an experiment was conducted in the New Jersey Pine Barrens.

This experiment, the first in a set of two, both of which aim to compare bounding levels of fuel treatment, was focused on evaluating fire behavior in an untreated block of forest. The evaluation was carried out via the observation and measurement of an operational prescribed burn. Within the larger framework of the study, this experiment was designed from the outset to provide information that is easily translatable to fire modeling applications. By simulating these experiments, as well as other similar hypothetical cases, this project will serve as a proof of concept that such models can be an effective tool for studying fire behavior and eventually informing management policy and decisions.

Study Site

The experiment was conducted in the Pinelands National Reserve in southern New Jersey, USA. The Pinelands is the largest continuous forested landscape on the Northeastern coastal plain, and covers about 23% of New Jersey. The climate is cool temperate, with mean monthly temperatures of 0.3 in January and 24.3 °C in July. The terrain consists of plains, low-angle slopes and wetlands, with a maximum elevation of 62.5 m. Uplands consist of oak- and pine-dominated forests that have a higher frequency of severe wildfires than most forests in the northeastern United States. The Pinelands are the focus of an active fuels management program by the New Jersey Forest Fire Service and federal wildland fire managers. The stand was approximately 15 acres, and was predominantly Pitch pine (*Pinus rigida* Mill.) with scattered oaks (*Quercus* spp.). Understory vegetation consisted of scrub oaks, huckleberry (*Gaylussacia* spp.) and blueberry (*Vaccinium* spp.).

Methods

Data related to the fire-environment were collected by a combination of 4 overstory (12.5 m) and 12 (6.5 m) understory measurement towers. 8 thermocouples and a sonic anemometer were positioned on each overstory tower, with one tower being positioned outside of the burn area to monitor ambient conditions. The understory towers supported 5 thermocouples, a vertically oriented flow sensor, and a vertically oriented dual-band radiometer. Additionally, 3 Fire Behavior Packages recorded temperature, vertical and horizontal flow, total heat flux, and both hemispherical and narrow angle radiative heat flux at a height of ca. 1 m. Fire spread was also monitored using the RIT WASP multi-spectral airborne imaging equipment. This provides a time series of georeferenced still aerial imagery in the spectral ranges of 1.0-1.7 μm, 3.0-5.0 μm, 8.0-9.2 μm, and visible, at an accuracy of less than 1 m. Lastly, visual observation was supplemented by the strategic placement of 14 visible spectrum cameras, intended to captured details of local fire spread and flame heights.

Data on the fuel loading within the plot were obtained through a combination of field sampling and remote sensing. In the field, 3 clip plots, 1 m^2 in area, were taken at each of the 12 understory tower locations both pre- and post-burn. This provided information on the distribution of surface and shrub fuels amongst various classes (foliage and live and dead 1-hour, 10-hour and 100-hour fuels), as well as the relative consumption of each class. Pre- and post-fire 3D canopy structure was assessed via airborne Light Detection and Ranging (LiDAR). Data were collected at 400 kHz and the resulting pulse density was ca. 5.12 points m^{-2}. Processing will result in outputs of typical LiDAR derived parameters such as mean and max height and canopy height profiles at ca. 10 m x 10m x 1 m resolution. LiDAR outputs will be calibrated to profiles of CBD from an upward-sensing LiDAR unit in twelve 20 x 20 meter plots within the burn area. This unit has been previously calibrated to represent profiles of CBD using equations developed through destructive harvest by Clark et al. (2013).

Results and Discussion

The fire was ignited by drip torch along a road, starting at the northern tip of the block, at approximately 11:53 am EST on 5 March 2013. Ambient temperature during the burn was ca. 6 to 7 °C, with a relative humidity of 40%. Winds were predominantly from the northwest and did not exceed a magnitude of 7 m s^{-1}, with mean values in the range of only about 1.6 m s^{-1}, measured at 12.5 m by the sonic anemometers. While a portion of the fire behavior data remains to be processed, a preliminary assessment can be made. Video footage confirmed observations that the fire was predominantly a surface fire, with some torching of crowns. Using simplified assumptions, an initial estimate of spread rate was 0.19 m s^{-1}, which falls within the range reported for other surfaces fires with low wind by Morandini and Silvani. Additionally, measurements of integral radiant flux correspond to the range for high intensity surface to brush fires reported by Frankman et al. . Canopy architecture and fuel consumption data from the

LiDAR is also in the processing stage at this time. However, the clip plot data shows that the majority of fuel mass consumed was fine and 1hr fuels on the forest floor, and 1hr fuels in the shrub layer.

Conclusions

The eventual availability of additional data, particularly aerial IR imagery, will serve to provide a much more complete picture of the fire timeline, as well as detailed information about local spread rates. LiDAR data will yield more information about the 3D distribution of consumption throughout the block, and can be tied to fire behavior data to calculate fire intensities. The importance of this experiment can be evaluated when seen in the context of the additional experimental and numerical aspects of the project. This presentation of preliminary data shows the detailed manner in which the fire was documented and measured. Such detail will provide an excellent platform for comparison to the second planned experiment, and to the results of numerical simulation. In turn, detailed comparisons will yield valuable insights into the effectiveness of prescribed fire treatment measures in modifying fire behavior. In a broader context this experiment provided detailed data useful for understanding fire behavior and validating models.

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