EVALUATION OF PASSIVE FLAME HEIGHT SENSORS FOR THE CENTRAL HARDWOOD REGION

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Purpose

We conducted a pilot study to determine the best material for measuring flame height in the oak-hickory forest litter fuels present in the Central Hardwood Region of Missouri. The use of a passive device to measure flame height eliminates:

➢Human bias in flame length estimation

➢Hazards associated with observers being too close to the active fire edge or standing in unburned fuel.

Flame-tilt angle, which is combined with flame height to derive flame length, can be measured at a greater distance by fewer observers than direct observation of flame length (Ryan 1981).

Materials

Senor material tested included:

➢Fire-retardant-treated cotton string

➢Four different compositions of tin/lead solder (63/37, 60/40, 50/50/, and 40/60).

Preparation

➢Number 36 cotton string was soaked for 24-hour in a 10% by weight solution of ammonium phosphate dibasic then air dried (Ryan 1981). Samples of dried string were tested to assure they would not sustain combustion once removed from a heat source.

➢Four different compositions of 16-gauge solder, having progressively higher melting temperatures (Table 1), were used instead of larger gauges of 63/37solder (Simard 1989). Sixteen-gauge solder is also more readily available than larger gauges.

Table 1.--Temperatures at which different compositions of solder become plastic and melt.

Composition tin/lead	Plastic Temp. °F	Melting Temp. °F
63/37	361	361
60/40	361	370
50/50	361	415
40/60	361	453

Methods

In a spring 2002 prescribed burn we evaluated six replicates containing four strands of each material suspended vertically between two guy wires. The predominant fuel was oak-hickory leaf litter typical of the Central Hardwood Region in Missouri. Two height poles were positioned within view of a video camera. Backing and head fires were set so that the flaming front advanced perpendicular to each replicate.

➢String was measured to the highest point where it was uniformly blackened.

➢Solder sensors were measured where they melted off.

Analysis

Averages for each sensor type were computed for each replicate and regressed on actual average flame heights determined from the video taken during each replicate (Simard et al. 1989, Adkins 1995).

Results

➢String soaked in fire retardant performed the best having the highest R^2 and the lowest predicted residual sum-of-squares (PRESS) (Table 2).

✓Average Flame Height = [.53]*[Average Uniformly Blackened String Height]

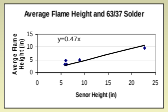
➢All compositions of solder had $R^2 > 0.96$, with 50/50 solder having a R^2 of 0.98 (Table 2).

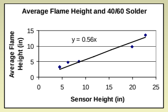
✓ Average Flame Height = (X)*(Average Melted Off Height)

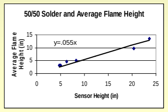
Table 2. Sensor type and associated statistics.

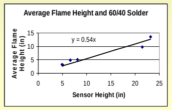
Sensor Type	R^2	PRESS	Flame Height Parameter (X)
cotton string	0.996	1.3	0.53
63/37	0.967	19.0	0.47
60/40	0.980	15.5	0.54
50/50	0.986	9.1	0.55
40/60	0.985	9.9	0.56

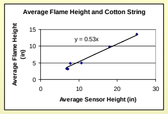
Results: Reaction of Sensors to Fire Behavior











Solder:

➢With the intercept forced through zero, a majority of the points fall above the regression line.

➢This indicates possible melting due to radiant or convective heat, especially at lower flame lengths; most likely the result of longer residence times during backing fires.

String:

➢Again, with the intercept forced through zero, data points are more evenly distributed about the regression line.

➢This indicates the fire-retardant treated string is less affected by radiant and convective heat.

Conclusions

➢For larger applications, such as landscape scale burns, fire-retardant treated cotton string is the most cost effective. Despite high initial cost, the same fire retardant solution can be used multiple times to treat long lengths of string. However, rain or heavy dew could leach out the fire retardant.

➢For smaller applications or where preparation time may be a constraint, 50/50 or 40/60 solder is recommended.

➢Further testing of solder compositions having higher melting temperatures might yield a solder that directly measures average flame height.

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Literature Cited:

Adkins, C.W. 1995. Users guide for fire image analysis system - version 5.0: a tool for measuring fire behavior characteristics. GTR-SE-93. USDA Forest Service, Southern Research Station. 15 p.

Ryan, K.C. 1981. Evaluation of a passive flame height sensor to estimate forest fire intensity. Research Note PNW-390. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 13 p.

Simard, A.J.; Blank, R.W.; Hobrla, S.L. 1989. Measuring and interpreting flame height in wildland fire. Fire Technology. 114-133.