

Impact of Fire on an Alpine Forest Microclimate



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Research Question:

How Does a Forest Fire Affect the Microclimate of an Alpine Forest?

Hypothesis:

We believe the burned area will have a higher temperature and wind speed, but a lower relative humidity compared to the non-burned area.

Equipment and Materials:

2- Kestrel weather units
2- GPS units
2- Soil thermometers
2- 2.0 meter poles
2 - Shade pads
2- Watches

2 Compasses
2 Rain gauges
Digital Camera
Recording equipment
2 Walkie-talkies

Quality Control Measures Instituted:

- Kestrels were calibrated to one another
- Sites characteristics identical except for the fact that one is burned
- Methodology duplicated
- 2 readings for each sample



Jen, Perry, and Pete listen to Nolen explain the history of the Balarat Burn.

Site Descriptions:

"Non-burned" Site:

The non-burned site was located on the grounds of the Balarat Environmental Education Center near Jamestown, Colorado. The site was on a south-facing slope at an elevation of 7818 feet above sea level. Precise coordinates were N 40.14061 ° and W 105.37337 °. As the picture below suggests, the site was chosen for its adequate ground cover, in contrast to the burn site. As previously mentioned, care was taken to duplicate all aspects of burn site other than presence of ground vegetation.

Non-Burned Site, Day 1



Burned Site:

The burned site was also located on the grounds of the Balarat Environmental Education Center near Jamestown, Colorado. The site was also on a south-facing slope but at an elevation of 7849 feet above sea level. Precise coordinates of this location were N 40.13341 ° and W 105.37141°. As the picture below indicates, the site was chosen for its *lack* of adequate ground cover due to a forest fire during the month of October 2003.

Burned Site, Day 2



Parameters Tested:

Parameters	Units	Definition	Instrument
Temperature	°C	Measure of the average, or kinetic energy, of the atoms and molecules in a substance	Kestrel 4000
Relative Humidity	%	Amount of water vapor in the air relative to the maximum amount the air could hold at that temperature	Kestrel 4000
Dew Point	°C	The temperature at which the air must be cooled in order for condensation to occur	Kestrel 4000
Barometric Pressure	mb	Pressure exerted by the weight of air above a given point, usually expressed in millibars or inches of mercury	Kestrel 4000
Wind Speed	m/s	The velocity at which the wind blows	Kestrel 4000
Wind Direction	-	Direction in which the wind blows	Compass

Procedures:

1. We constructed a measuring device by marking PVC pipe into 0.5 intervals, from 0m to 2.0 meters
2. Beginning at 0.0 meters, we measured the temperature, relative humidity, dew point, barometric pressure, wind speed and wind direction. After recording the measurements, we continued measuring and recording these parameters at each interval marked on the pipe, allowing for a one-minute instrument calibration between measurements. To ensure the Kestrel is measuring the ambient temperature of the air we kept the instrument in the shade. (measurements were taken simultaneously at both sites)
3. After measuring at the 2.0-meter mark, we repeated the measurements beginning at the 2.0-meter mark and continuing down to and including the 0.0 meter mark.

4. We repeated steps two and three at 20-minute intervals from the starting point (0.0 meters) for ten consecutive times.
5. After collecting the data we transported the data into spreadsheet to calculate average, standard deviation, and percent change of parameter values per recording time.
6. Using Excel, we graphed the data to better determine the relationships between respective sites and variables measured.
7. Drew appropriate conclusions based on relationships discerned.

Data Analysis:

Temperature:

Three visual representations of the temperature data are attached.

Graph #1 represents the non-burned area temperature versus height data. With exception of the 12:00pm and 12:20 data, the series are almost vertical, representing little change with height. This demonstrates either that the air was well mixed, or that the ground did not radiate enough heat to influence the air directly above it.

Graph #2 is a series of temperature readings over the burned area. In comparison to the non-burned site, the change between the surface and 0.5 meters is significantly greater on the burned site compared to the non-burned site (16.15% compared to 1.85%). However, as on graph #1, the temperatures rapidly approaching similar readings once again most likely as a result of low level mixing.

Graph #3 is a graph that developed an average temperature profile of both the burned and the non-burned area. The outliers were removed, resulting in a graph. The profile of the non-burned area is nearly vertical, representing very little temperature change between the surface and the upper layer (2 m). At the surface, the temperature difference is 6.2°C , however, by 1 m, the temperatures are within 1 standard deviation of each other. This demonstrates that the surface controls microclimate temperature variations, but the surface only has an influence up to the 1 meter mark.

As hypothesized, there was a difference in the stratification of temperature between the burned and non-burned site. At a height of 0 meters, the difference in average Day 2 temperature between the burned and non-burned site of was 21.68%. This value decreased to 8.36% at 0.5m, -0.26% at 1.0 m, 1.78% at 1.5 m, and -3.74% at 2.0 m. As demonstrated, the greatest decrease in temperature was between the surface and the 0.5 m reading, a difference of

13.32%. The data also demonstrates that as the height increased, the temperatures converged towards one another, resulting in very small temperature difference between the two sites. These results are influenced by low level mixing, essentially dissipating any heat that is released from the surface. However, the surface temperatures are significantly different. This is as result of the suspected difference in heat capacity of the burned versus non-burned soil. The burned soil, which is primarily black in color, heats up more quickly than the non-burned site, and also radiates heat outwards at a greater rate. The burned soil does not have a great effect on temperature at even moderate heights, but does affect the microclimate on the surface.

Relative Humidity:

Three visual representations of the relative humidity data are also attached.

Graph #4 shows the time series of the burned area representing relative humidity versus height. For each of the series relative humidity was greatest at ground level. There was a significant decrease between 0.0m and 0.5m then the relative humidity became fairly stable. This result is not unexpected, since 0.6 inches of rain had fallen the previous day and the ground was still saturated with water at the surface.

Graph #5 is a series of relative humidity data collected over the non-burned area. Similar to the burned area for each of the series the relative humidity was greatest at ground level. Although not quite as great, there was also a significant decrease between 0.0m and 0.5m in each sounding then the relative humidity became fairly stable. Again this result is not unexpected, since a similar rain had fallen the previous day and the ground was also saturated with water at the surface.

Graph #6 is a graph that displays the average relative humidity versus height for the burned and the non-burned area. The composite soundings for both the burn and the non-burned areas are similar, and the average relative humidity at both sites was about 50% at ground level. Since the average temperatures were higher at ground level on the burned site, more absolute moisture is required to register a similar percent relative humidity as a cooler site with less moisture. At higher levels there was a slight difference in the average relative humidity of the two sights. However, the lower relative humidity levels above ground level at the burn site could be due simply to the ability of the warmer air over the burn site to hold more absolute moisture. These results seem to be contrary to our hypothesis; that relative moisture levels would be lower at the burned site. However, given the

recent rainfall at the test sites, the ground was saturated throughout our sampling time providing ample moisture for evaporation. The higher temperatures at the burn site are likely to drive increased evaporation as long as the ground is wet. Were we able to return to the test sites for additional time/days, the researchers continue to believe that the non-burn area will sustain higher relative humidity levels over a longer time period.

Using a vapor pressure of water at various temperatures table, we compared the absolute amount of moisture at the two sites at ground level. The burn site averaged 9.89mg/l of water vapor at ground level and the non-burned site averaged 6.67mg/l of water vapor at ground level. As mentioned earlier this result although contrary to our original hypothesis is likely a result of the recent rainfall. However at the 2 meter measurement level the absolute moisture content of the two areas was consistent with our hypothesis. The non-burned site had 6.42mg/l of water and the burned site had 3.64mg/l.

Dew Point:

Since dew point and relative humidity give the same information, we chose to use relative humidity data, since more people are familiar with this parameter. In addition, the variable of relative humidity takes into account the air temperature, which dew point does not. Therefore, when comparing sites that differed even slightly in temperature, it is imperative to compare them with a variable that neutralizes the temperature difference.

Barometric Pressure:

According to our data, there were no trends between non-burn site and the burn site. Since both sites were selected to be at the same elevation, and were located less than a mile apart, no significant differences were expected. Though a decrease in pressure is expected to be found at higher elevations (even small height differences such as tested in this experiment), factors such as differentiation between the Kestlers could account for the lack of correlation in pressure data.

Wind Speed:

Graph #7 shows the average wind speeds over the time period of our study. Only the averages were graphed because the winds were extremely variable at both sites. Although variable, as shown by the averages the winds were consistently stronger at the burn site. The winds at the burn site averaged 1.1 m/s and at the non-burned site the average was only 0.438 m/s. The higher winds at

the burn site may be attributed to the reduced air resistance (no living trees or brush), and/or the increased heating of the air above the darkened ground surface.

Rainy Day vs. Sunny Day:

Graph #8 and graph #9 show a comparison between Day 1 and Day 2. Day 1 weather consisted of steady rain, temperatures averaging 5.41 C at the burn site and 6.08 C at the non-burn site. Day 2 temperature readings are referenced in the above sections. As demonstrated in the graphs, both graphs show that during the rain the temperatures were both consistently lower as well as showing less variability. The temperature ranges were greater during the day with increased sunshine than in the day with 100% cloud cover and steady rain (4.22 C versus 2.4 degrees C). In both these graphs, it is evident that the radiative properties of the soil did not play a role in determining the microclimate of the site.

Summary:

In summation, three variables were found to vary significantly between the two sites. Darker surfaces are better absorbers of visible light energy than light colored surfaces. These surfaces with a higher radiative property heat the air above them more efficiently than lighter ones. This explains why temperatures at the burn site were higher than temperatures at the non-burned site.

Relative humidity at ground level was essentially equal at both sites. Higher ground level temperatures at the burned site translate into more water vapor in the air above the ground. The darker, hotter soil is evaporating the soil moisture at a higher rate than the soil cover with vegetation. Had we returned to the site another 24-48 hours after our last observation, we suspect that the relative humidity at the burned site would be lower than at the non-burned site. This would be due to the water rapidly evaporating from the burned soil due to higher surface temperatures and less canopy cover. However, due to the soaking rains of day 1, this was not found to be the case.

Average wind speeds were greater at the burned site than at the non-burned site. This may be attributed to the lack of interference by vegetation, as the canopy in the burned site was incinerated, or due to the increased rate of heating off of the blacked ashy surface. In addition, the burned site was on a steeper upslope, which may have contributed to increased wind speeds.

At the burned site, there was less temperature variation with height on the rainy day than on the sunny day. This confirms our suspicions that solar heating of the darker surface has at least a moderate effect on temperature.

Applications and Uses:

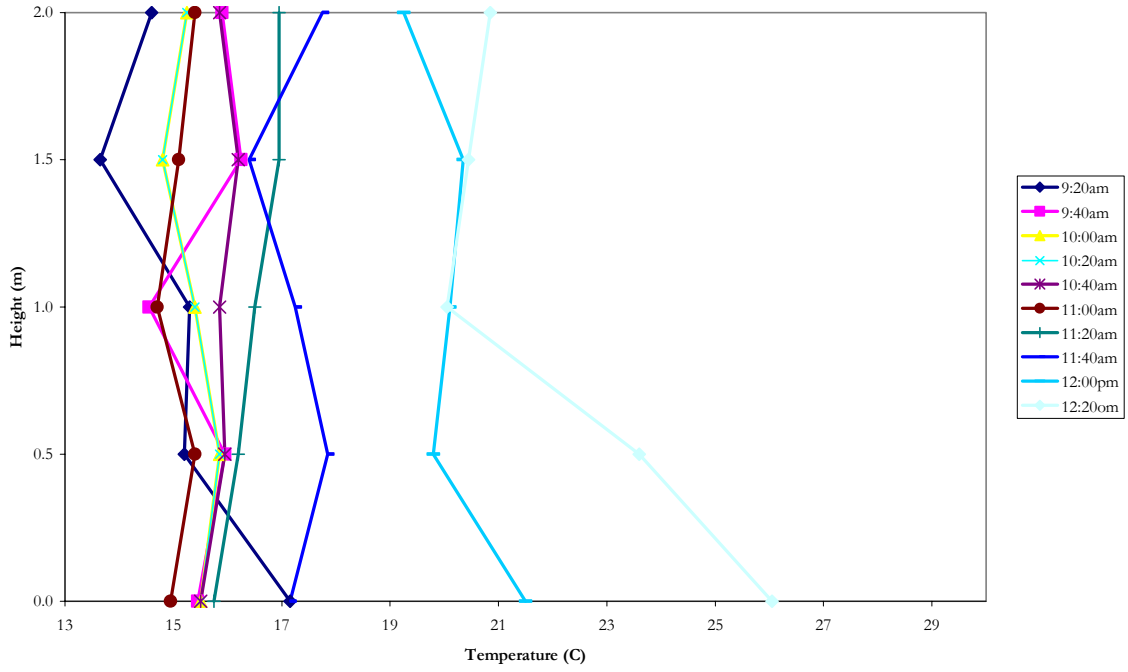
1. Using information to help illustrate how the Earth warms its atmosphere (greenhouse effect).
2. Using information to compare and contrast the color and texture of other earth surfaces, i.e. freshly plowed field vs. snow covered fields.
3. Using the current data collected to compare the same sites at different times of the year.

Acknowledgements:

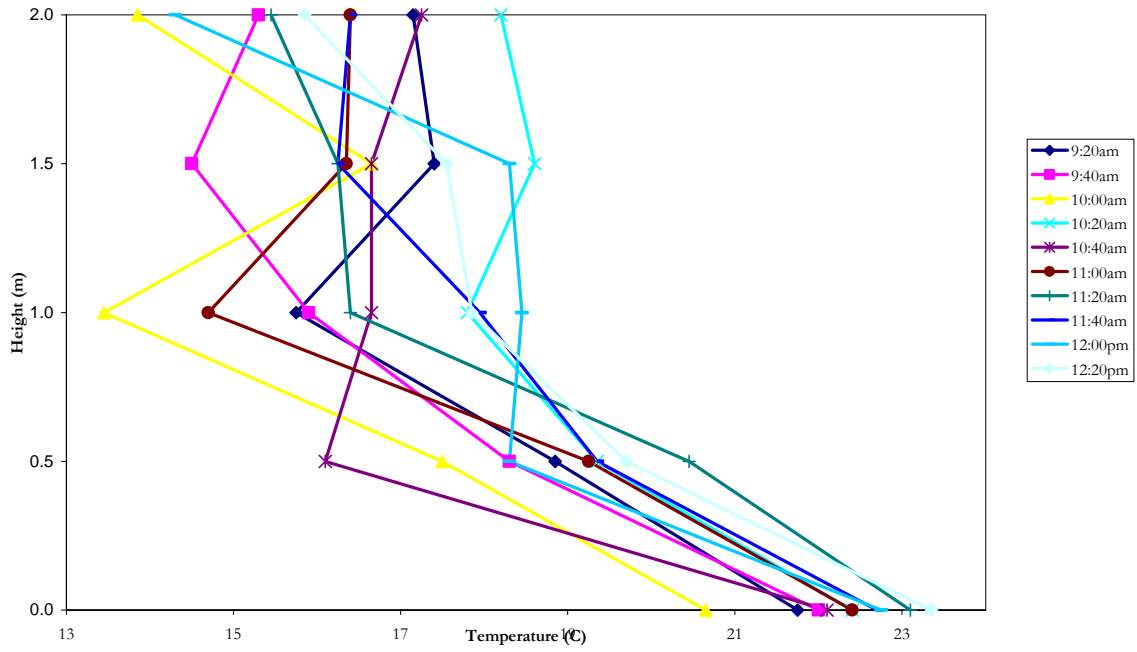
Our group would like to thank all the scientists who contributed their time and talents to help us with this project and expand our knowledge of the atmospheric sciences.

We wish to also thank the entire Earthworks staff. Without their tireless efforts and support, our project would have been a good deal more difficult to accomplish!

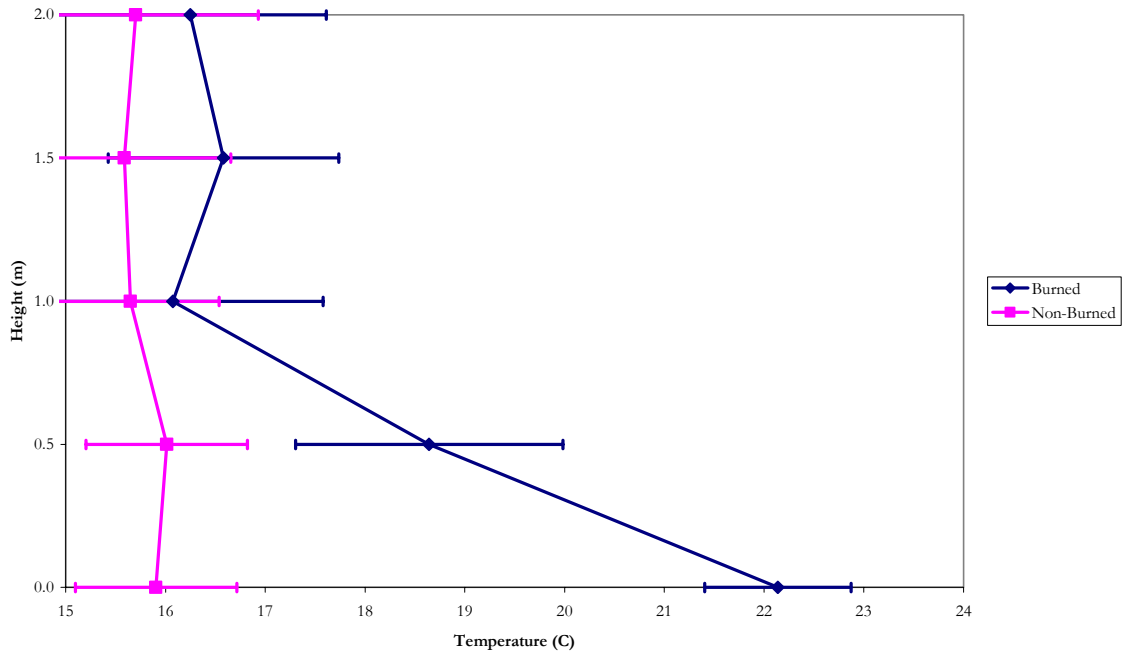
Day 2 Temperature vs. Height (Non-Burned Site)
Graph #1



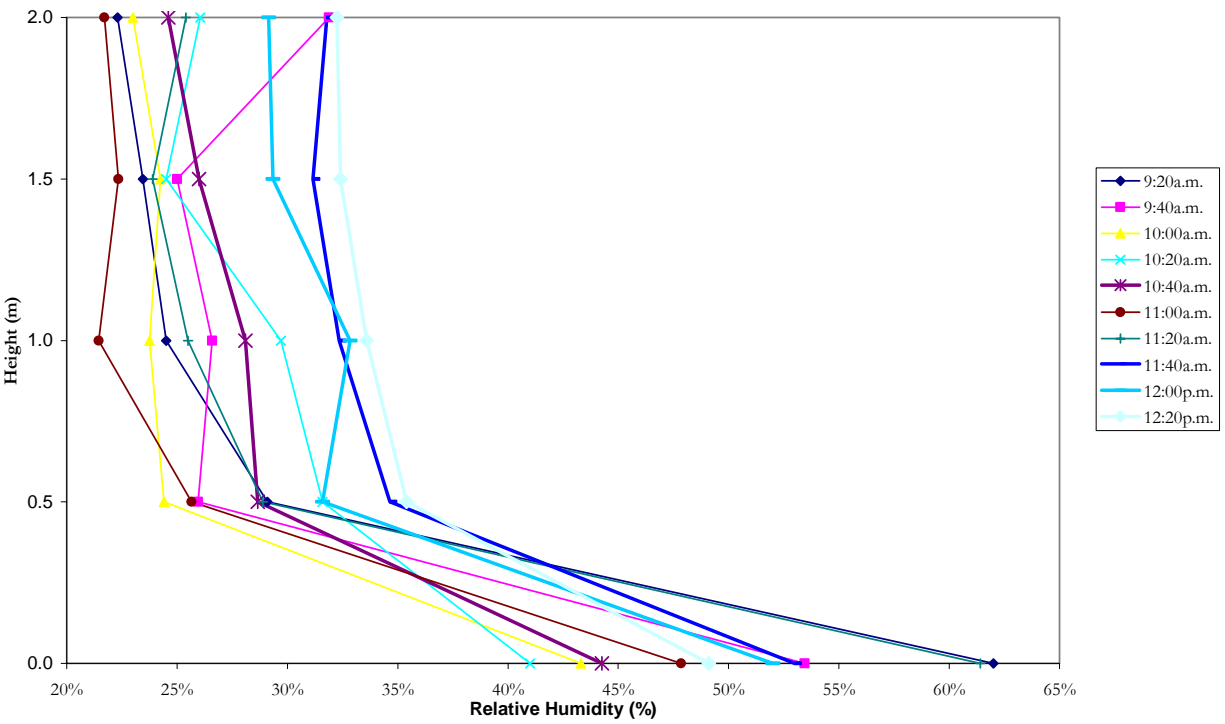
Day 2 Temperature vs. Height (Burn Site)
Graph #2



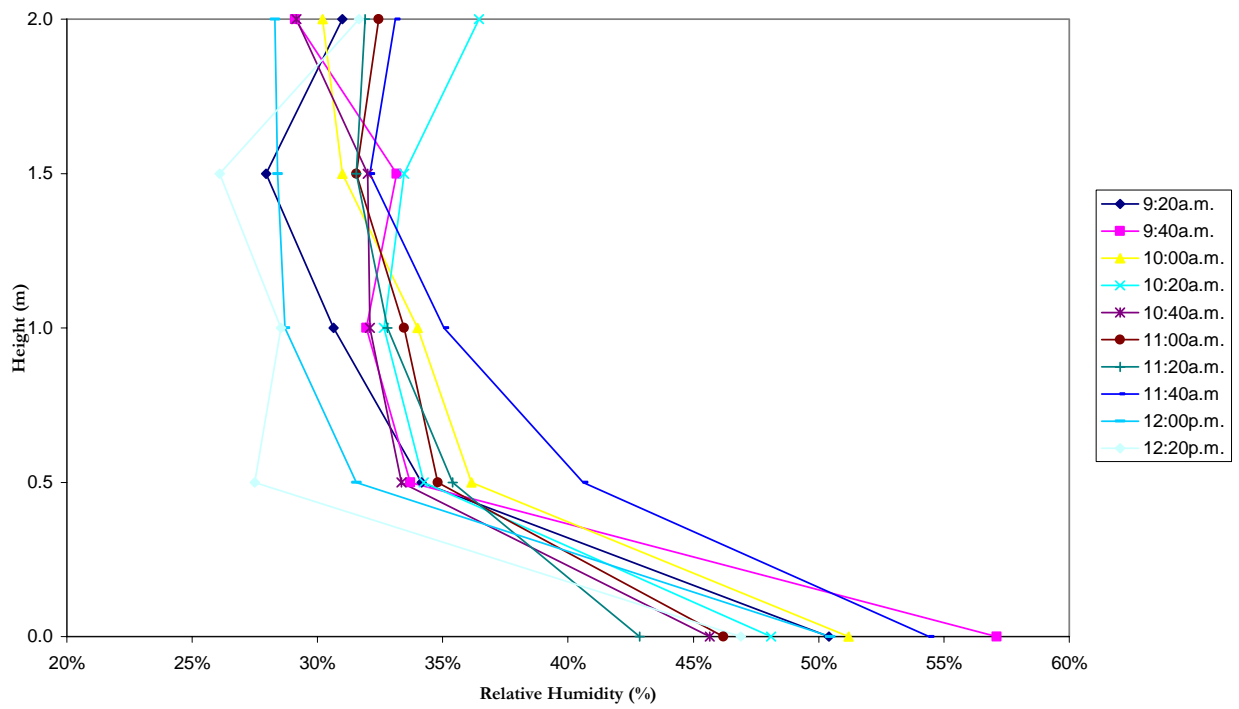
Day 2: Average Temperature vs Height
Graph #3



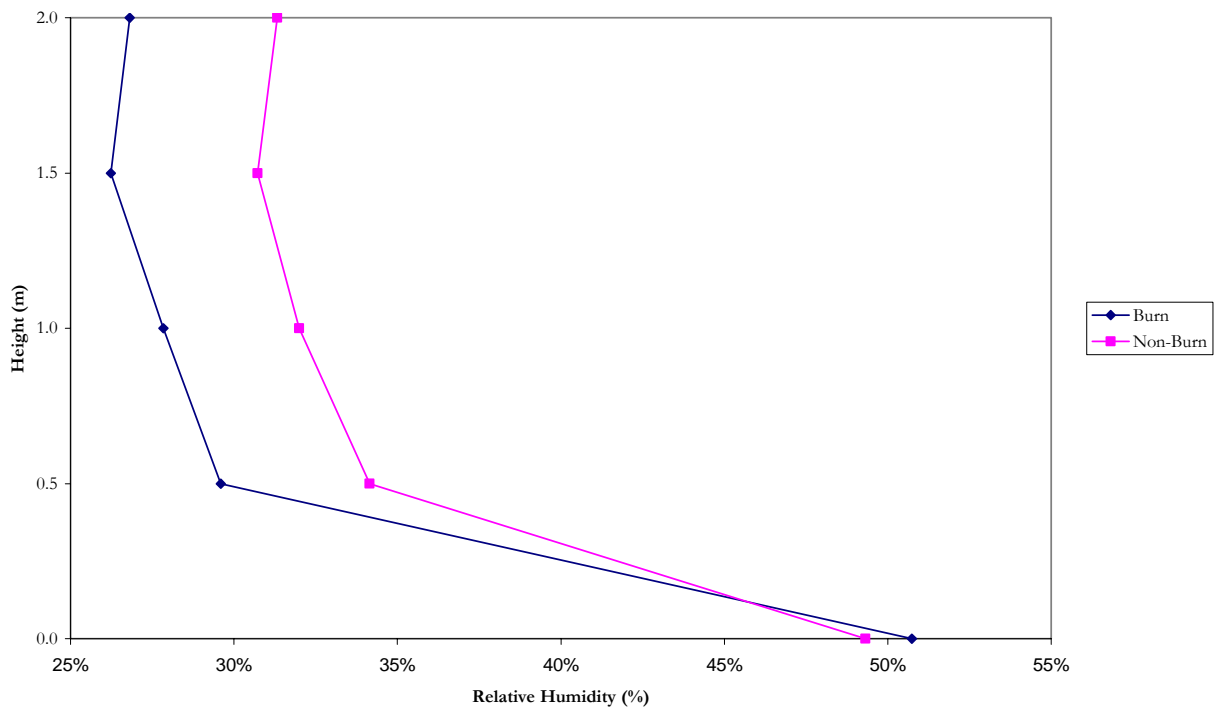
Relative Humidity vs. Height- Burn (Day 2)
Graph #4



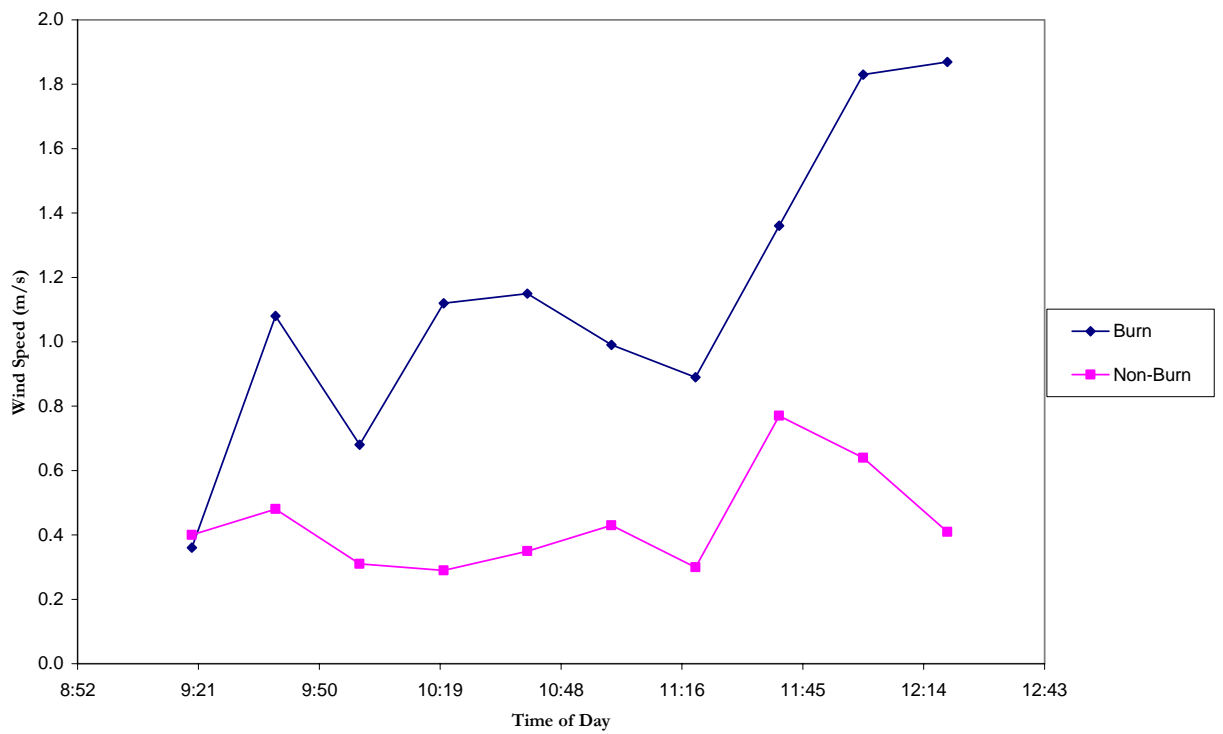
Relative Humidity vs Height- Non-Burn (Day 2)
Graph #5



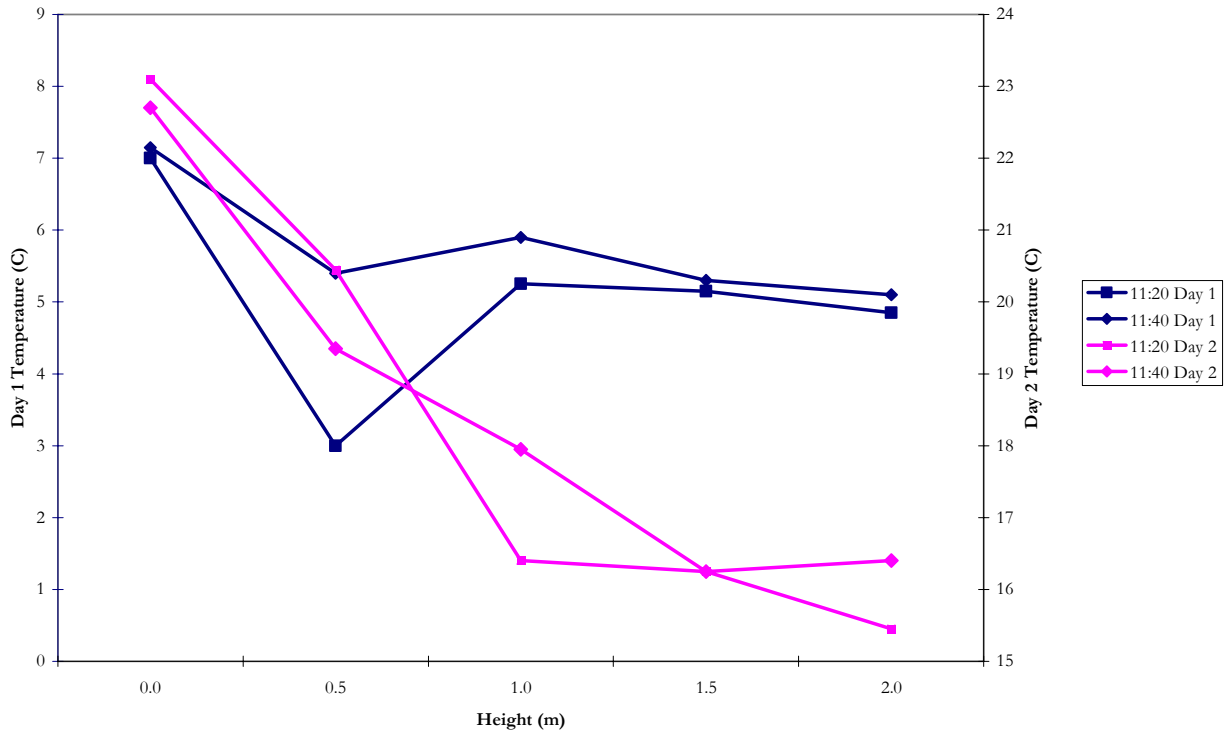
Day 2 Average Relative Humidity vs. Height
Graph #6



Average Winds
Graph #7



Two Day Comparison: Temperature vs. Height (Burned Site)
Graph #8



Two Day Comparison: Temperature vs. Height (Green Site)
Graph #9

