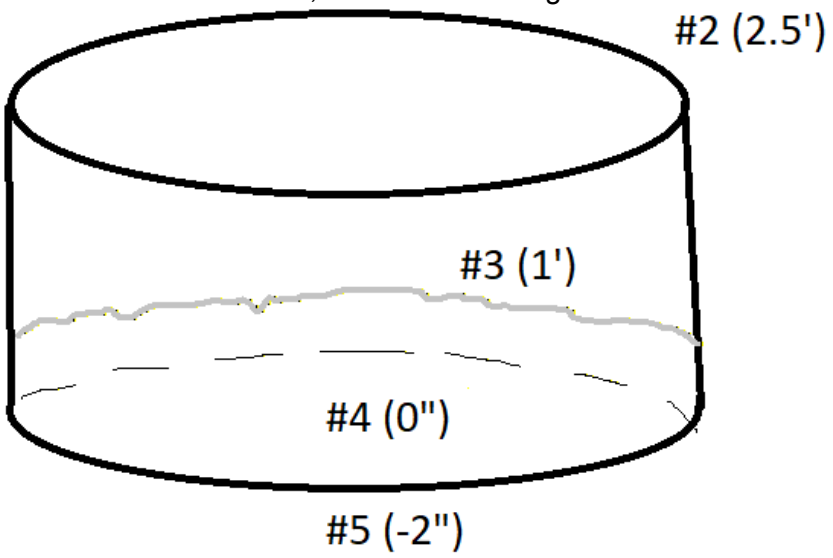
HOBO Temp Data Visualization- NCSA Biochar Coalition Demo 12/13/25

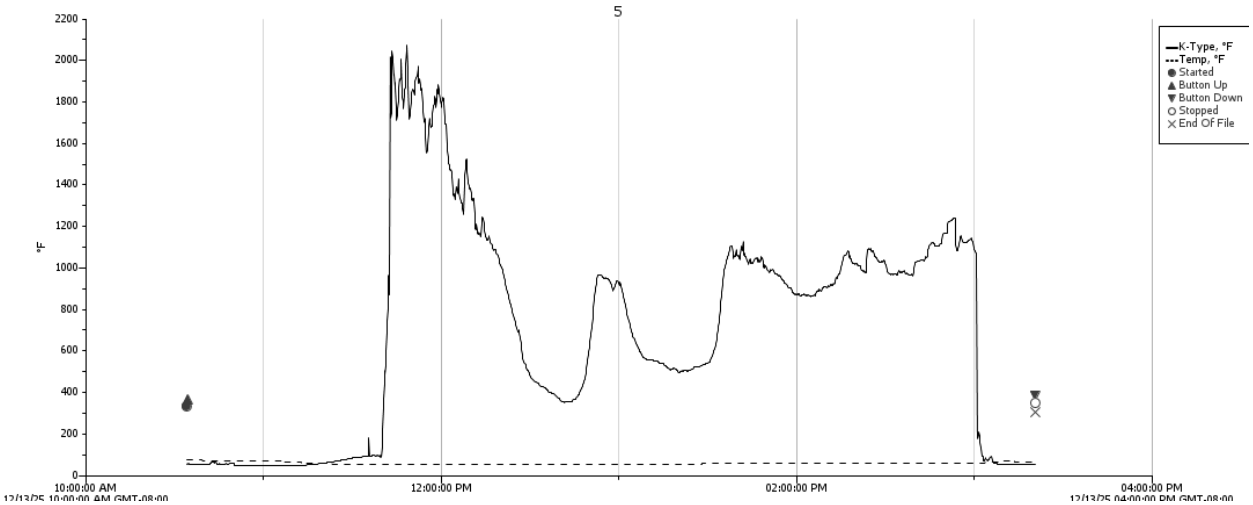
-Christian Noack, SSI Forest Ecologist



HOBO Thermocouple placement Flamewise Unit (first use)
Data Loggers all placed ~3-6” in soil inside PVC containers

Flamewise Unit Timeline:
Ignition ~11:05 AM
Dowsing ~2:55 PM

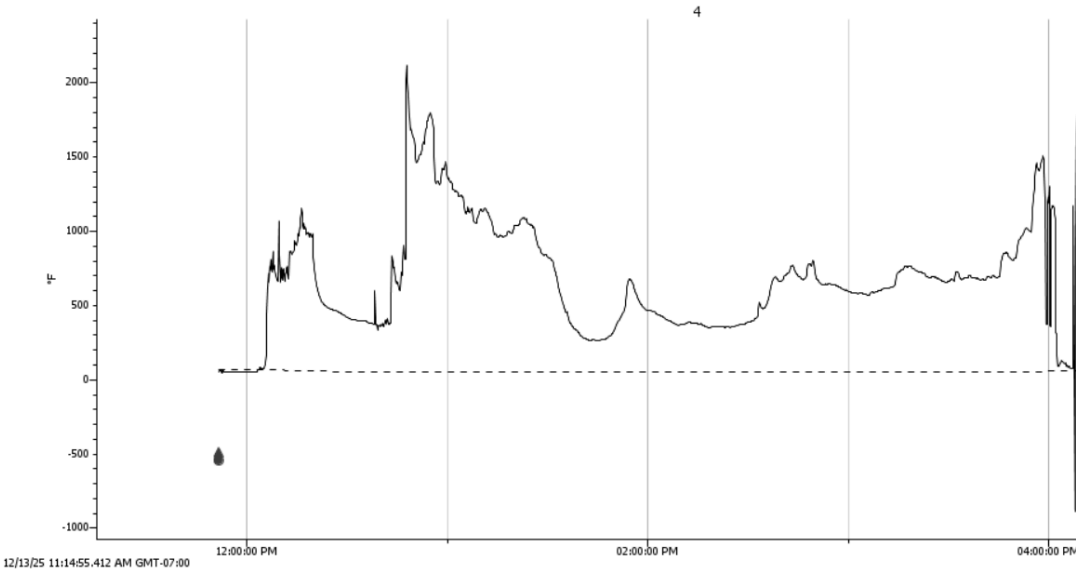
#5 center- elevation 2 inches under soil



Max Temp: 2,072.52°F @11:48AM
Avg Temp: 822.5°F
First time above 100°F: 11:40am
Time above 600°F: 46 mins, 17 mins, 1h28 (total 2h48)
Data Logger Max Temp: 61.4°F (under soil in PVC)

#4 center- at soil level

*This datalogger was 1 hour ahead (12:00PM should read 11:00AM)

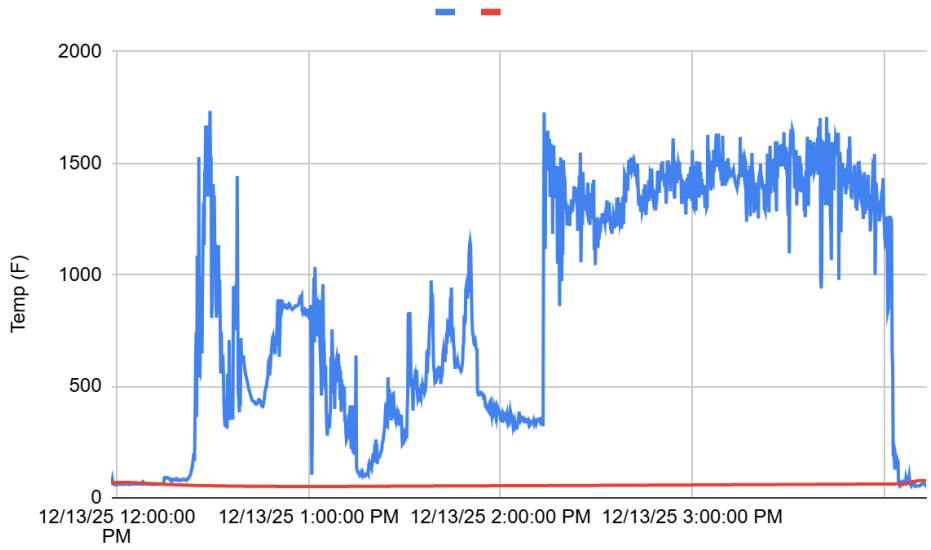


Max Temp: 2,123.58°F @11:48PM*
Avg Temp: 711.09°F
First time above 100°F: 11:05PM*
Time above 600°F: 14 mins, 50 mins, 3 mins, 23 mins, 50mins (total 2h20)
Data Logger Max Temp: 58°F (under soil in PVC)

#3 inside- on top of char ~1ft.

At 1:13 pm*, #3 was moved from the side (2.5' elevation) to inside the kiln, on top of the char.

*This datalogger was 1 hour ahead (12:00PM should read 11:00AM)

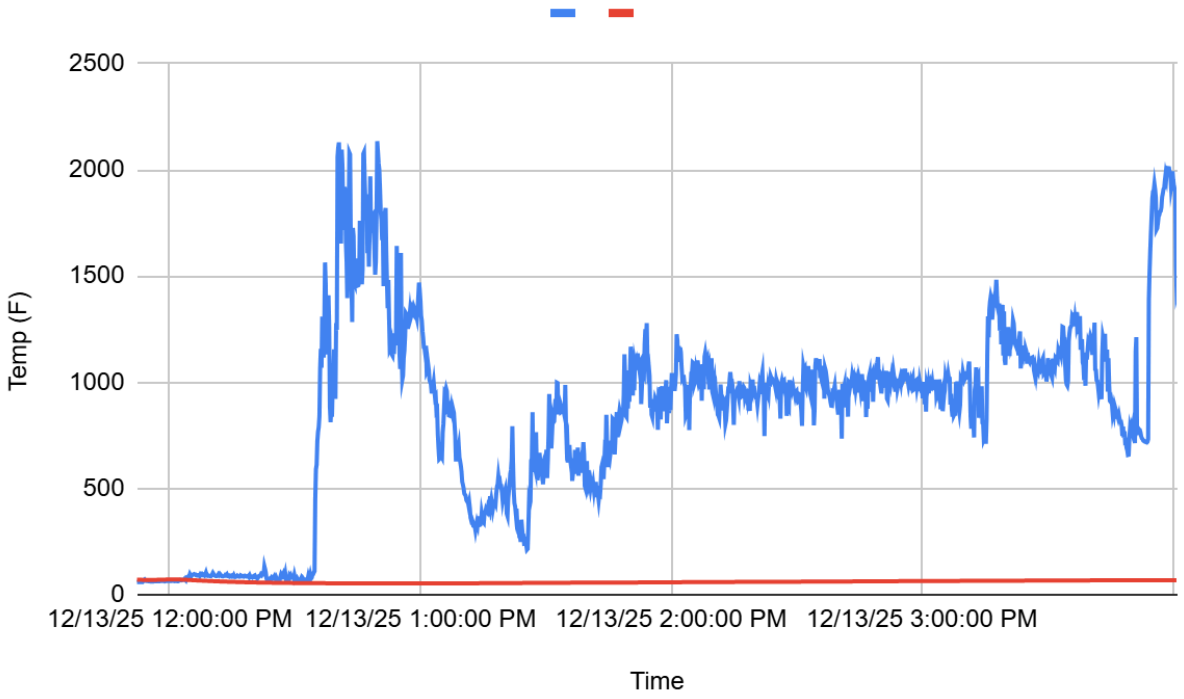


#3 continued…

Max Temp: 1,735.11°F @11:29PM*
Avg Temp: 964°F
First time above 100°F: 11:23PM*
Time above 600°F: 2h01 (after 2pm, sporadically before that)
Data Logger Max Temp: 79.358°F (under soil in PVC)

#2 side- elevation ~2.5 ft.

*This datalogger was 1 hour ahead (12:00PM should read 11:00AM)



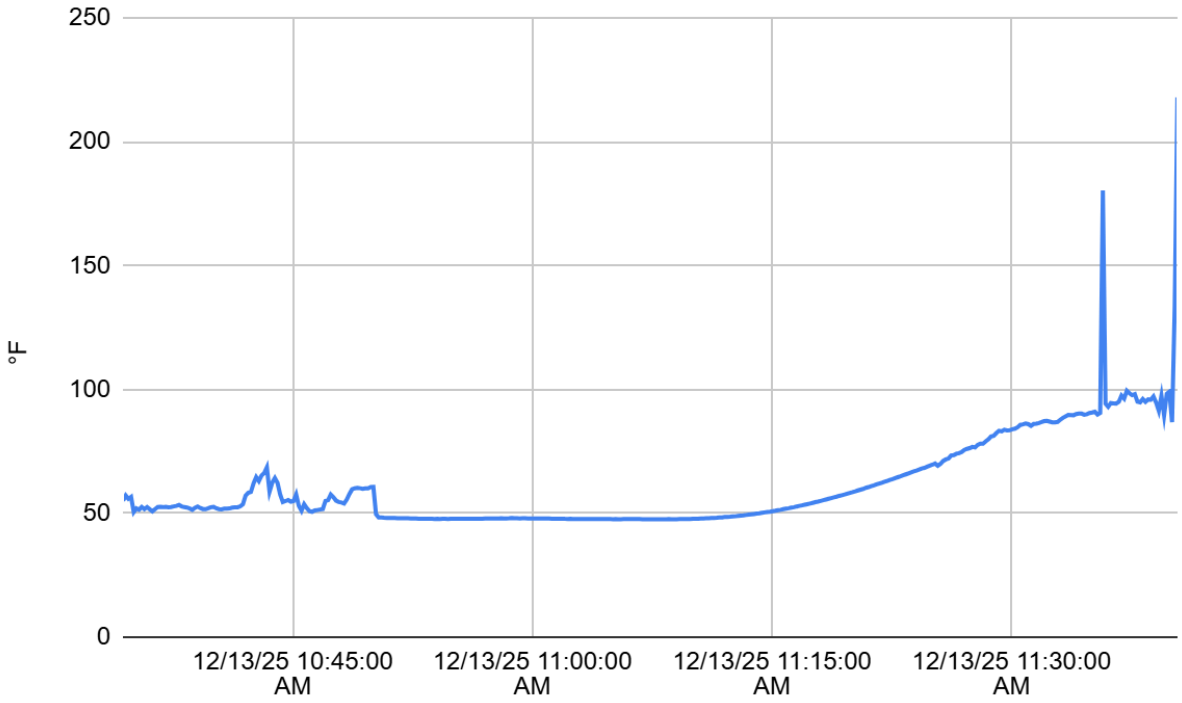
Max Temp: 2,135.05°F @11:49pm*
Avg. Temp: 997.6°F
First time above 100°F: 11:34PM*
Time above 600°F: 2h15
Data Logger starting Temp: 54°F
Data Logger Max Temp: 76.777°F (under soil in PVC)

Takeaways:

HOBO#5 also seemed to have been 1 hour ahead of the others (~3pm dowsing time). All other dataloggers were likely an hour ahead of real time and this is the only one that was correct (daylight savings time?). HOBO#5 matches best with timestamps on pictures and notes.

HOBO#5 logged higher avg. temps than HOBO #4 even though this one was supposed to be under the soil. HOBO#4 also had less dramatic shifts in temperatures later on, suggesting that it remained at soil level or atleast lower than HOBO#5 due to more insulation from higher heats above.

HOBO#5 logged extreme temperatures 35 minutes later than others (217F at 11:40am vs. HOBO#4 163F at 11:05 pm) even though they were both set up at the same time. This is likely explained by it being 2" below the soil and insulated from heat. HOBO#5 dramatically spiked at 11:40AM which leads me to believe that an unknown change altered the location of the thermocouple. This could be explained by HOBO#5 accidentally being pulled out from under the soil, or some specific unseen condition where it was placed.



The more focused chart above shows HOBO#5 during the beginning ~45 mins after ignitions. It shows a gradual increase in temperature (to be expected under insulating soil) after ignition (11:05AM) until a sharp increase at 11:35AM and again at 11:40AM where it increased to 2,000°F and remained high until dousing.

Given this somewhat improvised experiment, it is difficult to know for certain that these thermocouples remained in a constant location, making it difficult to extrapolate conclusive evidence from these data/charts. This Flamewise unit burned for roughly 4 hours from ignition to dousing. Generally, temperatures increase quickly after ignition up to 1,700-2,120°F for less than 1 hour and stabilize down to slow pyrolysis at ~400-500°F for ~1 hour unless stirred or moved, finally increasing to higher temperatures for the last ~2 hours until dousing.

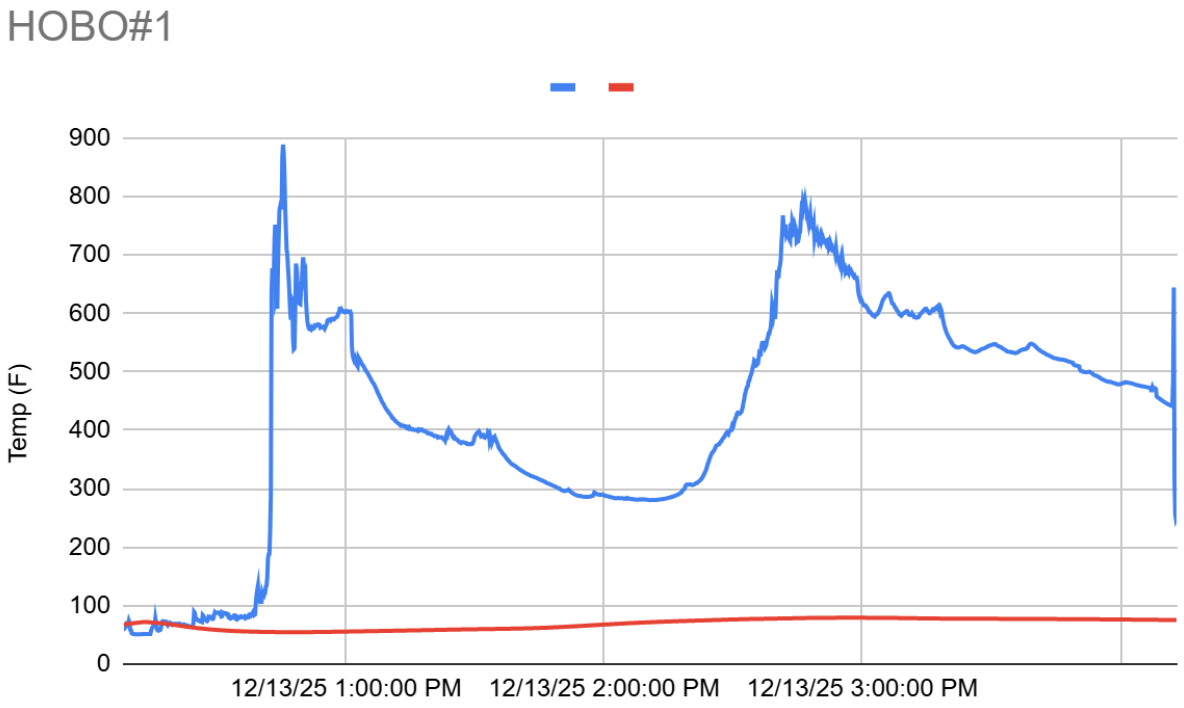
During these final 2 hours, each location measures different temperatures based on height above the soil. HOBO#4 & 5 measured temperatures within/underneath the char, while HOBO#3 measured near the top of the char, and HOBO#2 measured approximately 1.5 feet above the top of the burning char. At 1:32PM for HOBO#5 and 1:36PM for HOBO#4 (suggesting HOBO#5 was pulled out and moved further above the soil than HOBO#4), temps increased from slow-moderate pyrolysis (400-600°F) to above 600°F until dousing.

1:36PM to 2:50PM		
Datalogger	Range	Avg.
#4 (soil level*)	570°F - 770°F	685°F
#5 (above soil*)	861°F - 1,167°F	998°F
#3 (~1 ft.)	938°F - 1,707°F	1,436°F
#2 (~2.5 ft.)	657°F - 1,482°F	1,010°F

The chart above shows how temperatures increase from the bottom to the top of the char, then decrease above the char.

Mini Ring of Fire

Timeline:
Ignitions: ~12:40 PM
Scotch Broom added: ~2:29 PM
Dousing: ~4:13 PM
HOBO#1 @ soil level in center



Max Temp: 888.5°F @
Avg. Temp: 475.2°F
First time above 100°F:
Time above 600°F: 8mins, 3 mins, 22 mins, 5 mins, 5 mins (44 mins total)
Data Logger starting Temp: 54.55°F
Data Logger Max Temp: 79.23°F (under soil in PVC)

Takeaways:

This thermocouple was likely never moved from its original position at 0” (soil level) and is a better representation of actual soil level temperatures during biokiln burning than for the previous unit. Comparing this to HOBO#4 (Flamewise soil level), temperatures didn’t get nearly as hot. This means there was potentially less air access to the bottom of the unit, which limited combustion to lower levels of pyrolysis. Besides the initial spike from getting the wood ignited and burning and a spike again at 2:39PM, the temperature only read above 600°F for 44 mins as compared to 2 hours and 20 minutes with the Flamewise unit. This likely means that the biochar produced with this unit was of higher quality (Tripathi et al. 2016), but it is unclear if

these differences in temperatures were due to unit design, fuel type (presumably the same), timing, operator, or other specifications.

It is most likely that the spike in temperature around 2:30 PM is from when I added Scotch Broom and Blackberry from the surrounding area. I didn't think it would effect the temperature at soil level this much or for that long. Perhaps more mixing was done at this time or there were other unknown events that changed this temperature.

Notes for next time:

Check clock accuracy for each datalogger..

Set up thermocouples before the kilns are set up.

Use higher-rated beaded sensor cables (these were 6' K-type beaded Thermocouples rated up to 2282F). This should've been enough but beaded sensors for HOBO#1 broke. However, all thermocouples successfully recorded data throughout the burns. HOBO#1 was the only one to record impossible data points before retrieval (likely when water was introduced to quench the fire at 4:13PM

More care can be taken to ensure thermocouple sensors are set up securely under soil to ensure difficult-to-avoid alteration via handtools. Perhaps packing down the soil better or threading the thermocouples through thin PVC pipes to protect them between the datalogger to the measurement point could limit accidental alteration. Alternatively, these thermocouples could be attached to rebar/metal at varying levels to keep in place (must look into how this radiant heat would affect temperature readings).

The majority of this fuel type was from dead (albeit wet) Ponderosa Pine $\leq$ 8" x 20" logs and branches. More testing is desired to see how fuel-type affects max/avg. temperatures.

More testing is needed to improve equipment usage, accuracy, and gain more insight into the spatial temperatures of burning with biokilns.

More note-taking should be done during the day of the burning (time of ignition per kiln, time of dowsing, time of major stages in burn process, stirring activities, slash type, etc)

Pictures:



Mini Ring of Fire (HOBO#1) and Flamewise Unit (HOBO#2-5) -showcasing wonderful firefighting attention by young attendee and Steve Wilensky from Sierra Institute.
-taken by Christian Noack @11:46AM



Four different Units @2:23 PM



/\ Mini Ring @2:28 PM
\/ Mini Ring @2:53 PM





Flamewise @3:00 PM



Flamewise @3:05PM



End of Day @3:26 PM