# THE INSULATED LANGSTROTH HIVE


## ABSTRACT

A yearlong study of the impact of an insulated bee hive on the weather sourced stressors of a hive vs the traditional Langstroth commercial bee hive.



Four Acre Farms


A SEMAP TIE Grant study.

In the spring of 2018 we set out to break away from the hive setup of the modern bee keeper. While it may make sense for commercial bee keepers with hundreds if not thousands of hives to have the cheapest, simplest and easiest to work with hives, this is not what's best for the bees. We took a look at few sources of bee stress caused by modern style Langstroth hives:

**Summer Heat – Both from temperature and solar gain.**

**Winter Cold**

**Temperature fluctuations**

**Difficulty with liquid feeding in spring and fall.**

**Increased fuel use (food consumption)**

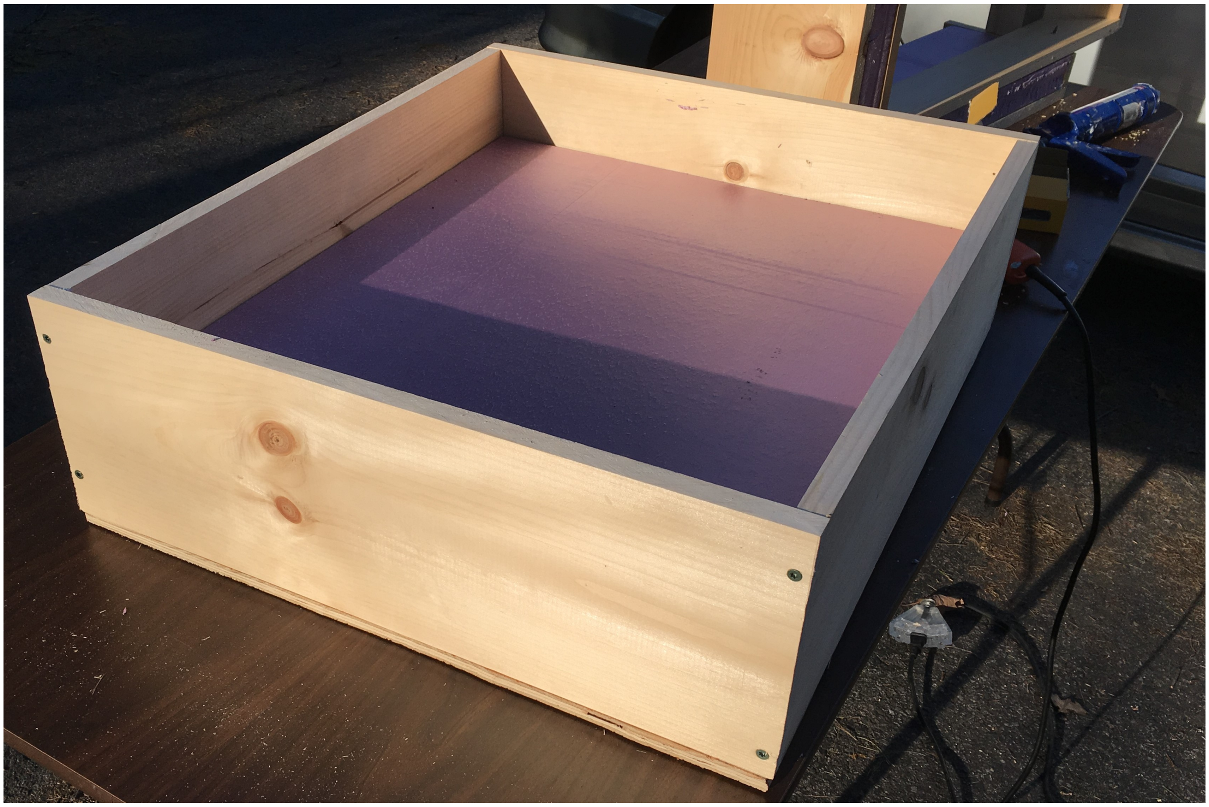
It immediately occurred to us that humans have long ago added insulation to their homes to fix problems from heat loss, yet we were forcing them upon the bees. Our ¾ inch pine box is failing in its ability to protect the bees from Mother Nature. Can bees work hard to deal with heat? Yes. Can bees eat extra food to keep warm in winter? Yes. But why should we force them to deal with this stress? Temperature fluctuations also can bring issues with bees entering brood cycles too early in the year, and not being able to cover their brood properly. They can lead to periods of excessive activity when the hive should be dormant conserving its food instead of thinking it's time to be active and foraging.

Let's see if we can fix the problem. According to universally accepted standards, soft pine offers an R-value of about 1.12 per inch. Therefore, the ¾ inch pine boxes we typically use provide an R-value of about 0.84. Conversely, a colony surrounded by five inches of wood in a natural softwood tree benefits from an R-value of about 5.6 or about six times the insulation quality of a typical bee box and that's just the outside walls.

| Material | Typical R-Value | R-Value Per Inch | Typical Thickness |
| --- | --- | --- | --- |
| Oak | 0.638 | 0.85 | 0.750 |
| Ash | 0.750 | 1.00 | 0.750 |
| Maple | 0.750 | 1.00 | 0.750 |
| Pine | 0.84 | 1.12 | 0.750 |

Building a hive with 5 inch wood walls would create a serious challenge for weight. A hive this heavy would be difficult if not improbable to inspect or move around. To attempt to simulate a natural hive while minimalizing weight we used 2 inch Foam board sandwiched between two pieces of pine board. The R value of the foam board (R10) combined with the pine created walls with an R value of 11.68. The outer cover was built with 4 inches of foam and two layers of plywood providing an R value over 20.


*Several photos of the stages of construction for insulating a deep hive body. We approximately tripled the weight of each empty deep. This 14 extra pounds was still manageable, and a small number compared to later when they were filled with 10 frames of brood, bee bread and nurse bees pushing the total weight well over 100 lbs.*



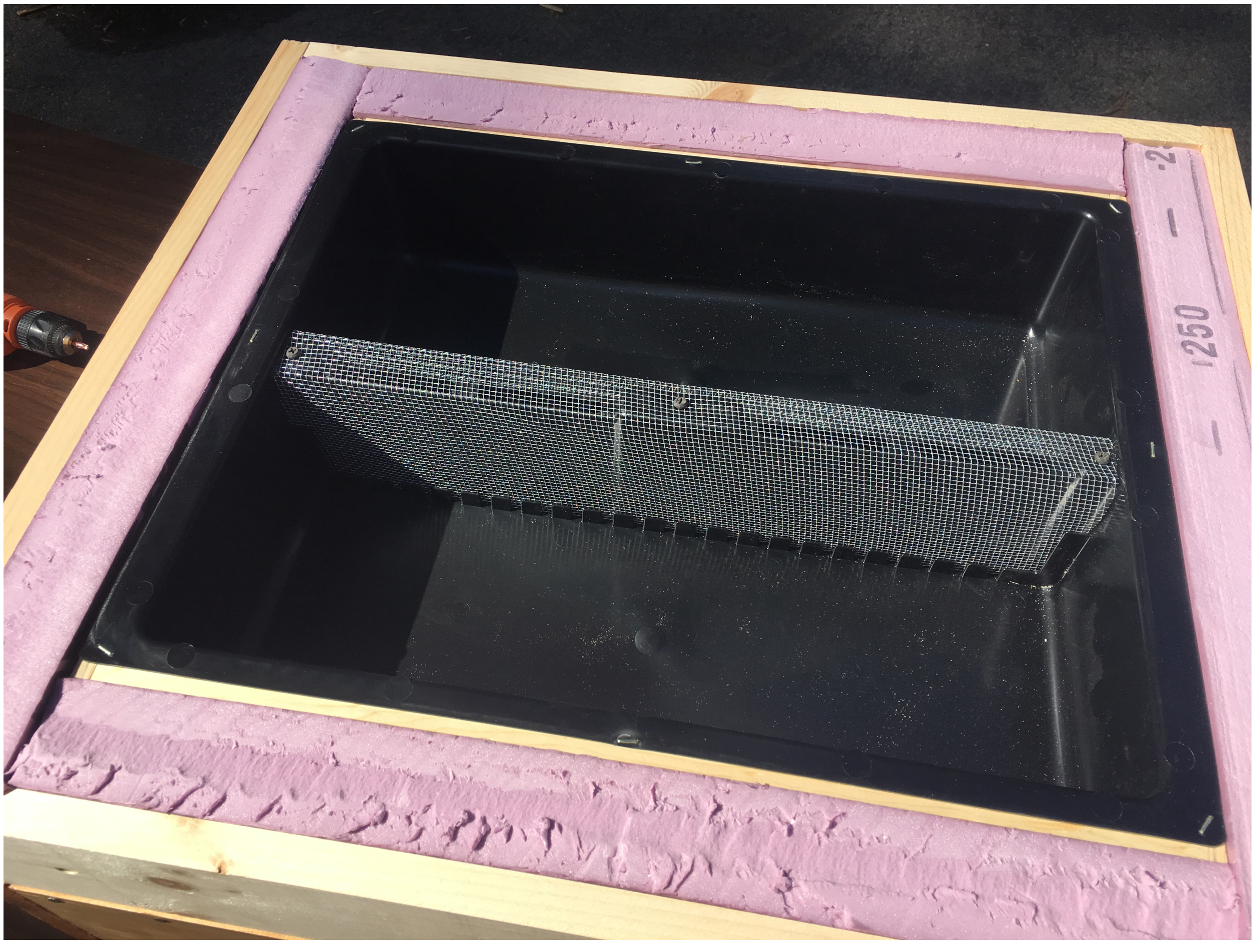
*The outer cover which sits on top of the hive was insulated with 4 inches of foam board. The top and bottom were sealed with plywood and the top was covered with metal roofing material.*

*A standard Langstroth deep on top of the insulated deep gives you a good impression of the added size.*

*This is the hive on the day of the package install. The feeder box on top of the deep brood box is also insulated in the same manner, allowing the bees to retain their rising heat in the sugar water above them and keep it at a temperature which they could continually feed at. This allowed them to eat large amounts of food in the cold spring and later in the year for the chilly fall evenings when the uninsulated hive could not.*

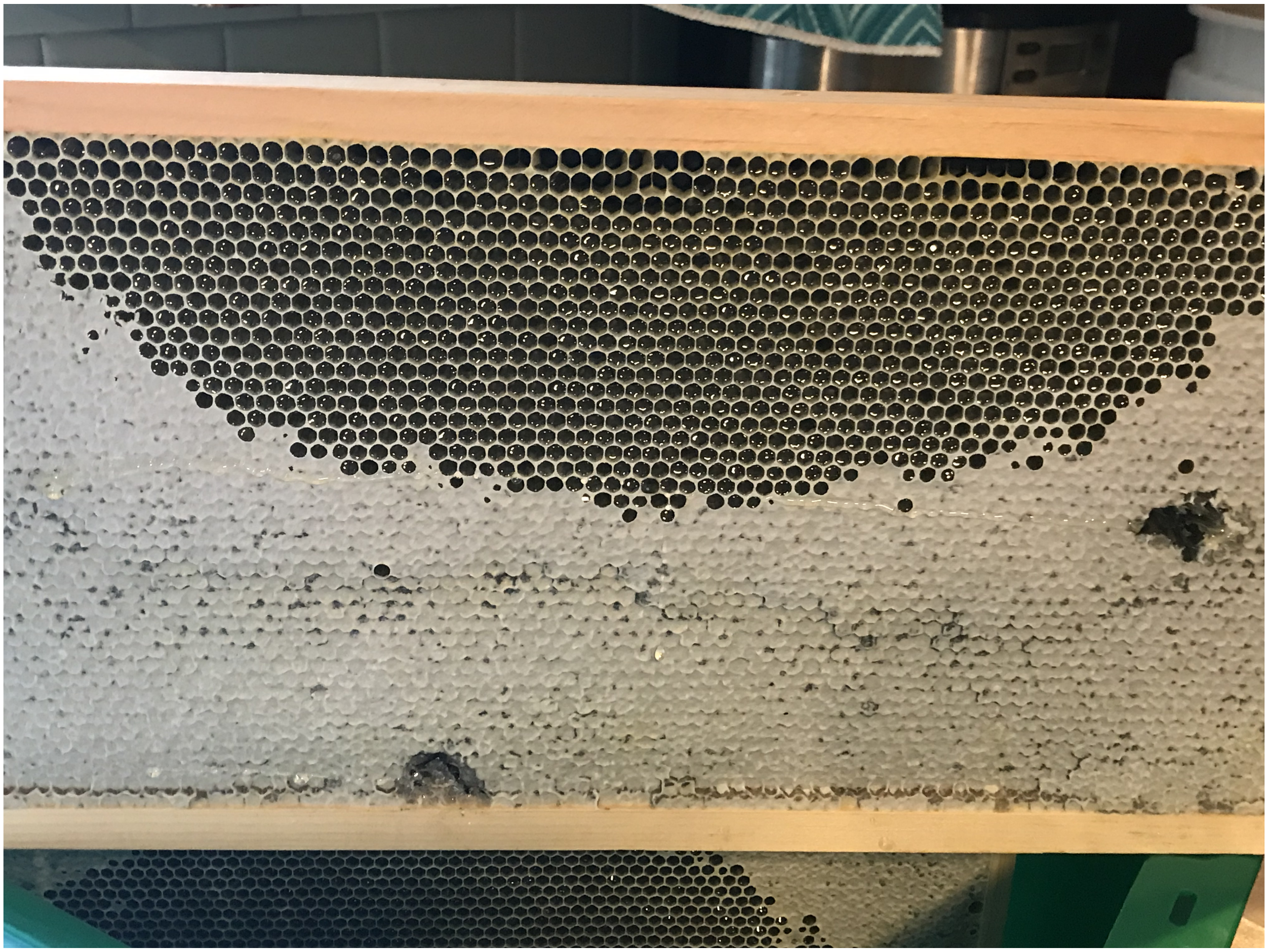

*After an extended stay in the hives, many of the sensors we used became covered in propolis, wax and bodies. We had two sensors fail during our study and they were replaced leaving small gaps of data loss.*

*A booming hive. The insulated hive was heavy with bees and grew quickly expanding into a second brood box and eventually two honey supers.*



*A view of the insulation that was added to the hive top feeder. Trapping the rising heat of the hive around its feed allowed greater feeding opportunities for the colony.*

*Nectar packed around cells of pollen, known as bee bread was plentifully arranged around the brood, a sign of a thriving hive.*



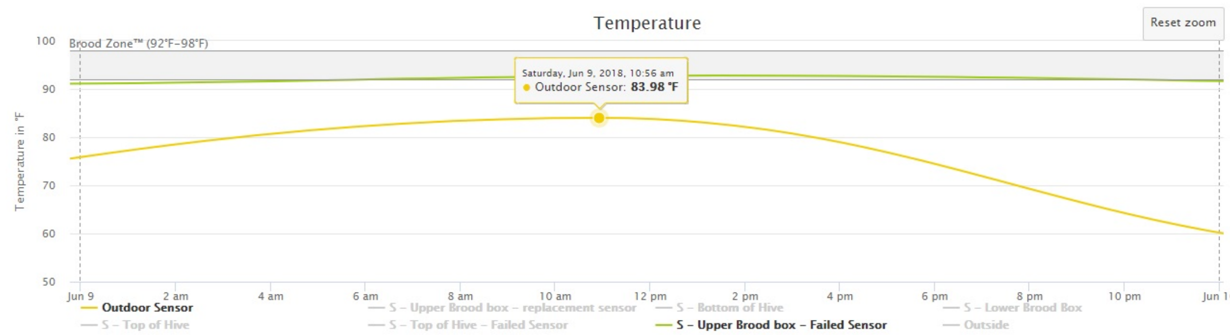
*A brood frame that has become honey bound. The hive was collecting a large amount of nectar and we were forced to extract several brood frames and the honey super frames to ensure the queen would continue to have room to lay eggs.*

*Filling the honey supers.*

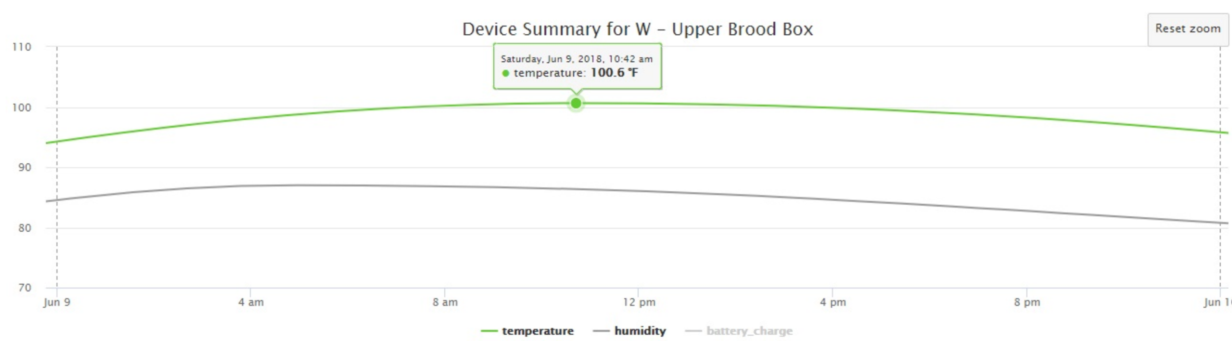
*Honey. Normally a package of bees does not produce enough honey to extract for the bee keeper. We extracted 4 gallons of honey which we used as a fall feeding instead of sugar water for the hive to ensure they were maxed out and ready for winter. In addition to the 4 gallons that we returned to the hive, we extracted over 30 lbs. and jarred it for ourselves. Happy bees make more honey!*

**Summer Heat – Both from temperature and solar gain.**

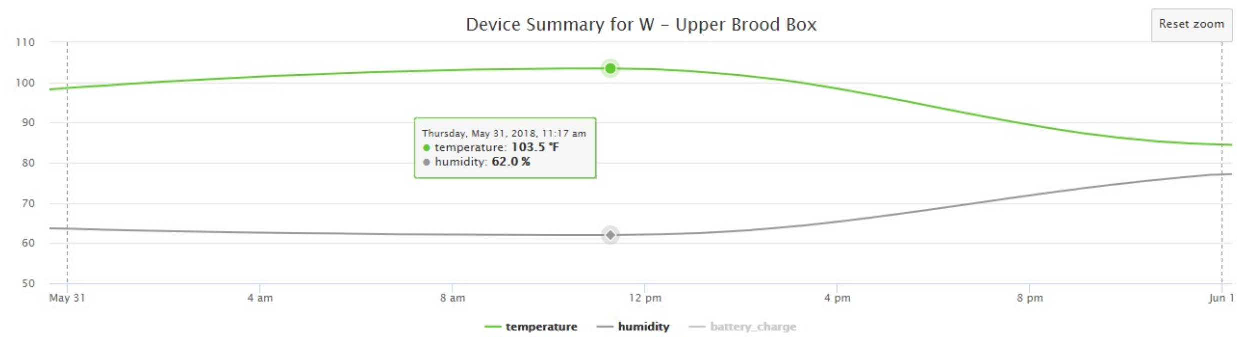
The hives locations allowed them to get some morning to mid-day sun, which shade in the afternoons. Both hives were situated approximately 5 ft. apart from each other to ensure they shared precise environmental influences. During the hot days of the summer, the insulated hive (Marked as the S hive) stayed within the ideal temperature range with very little fluctuation.

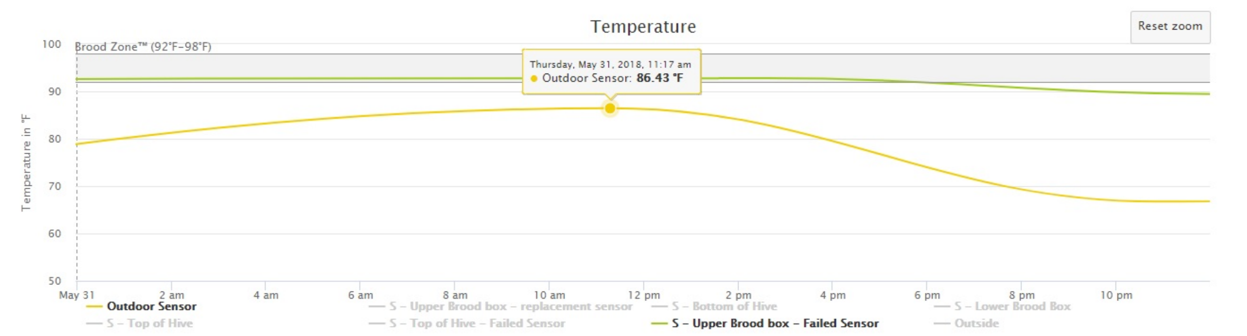


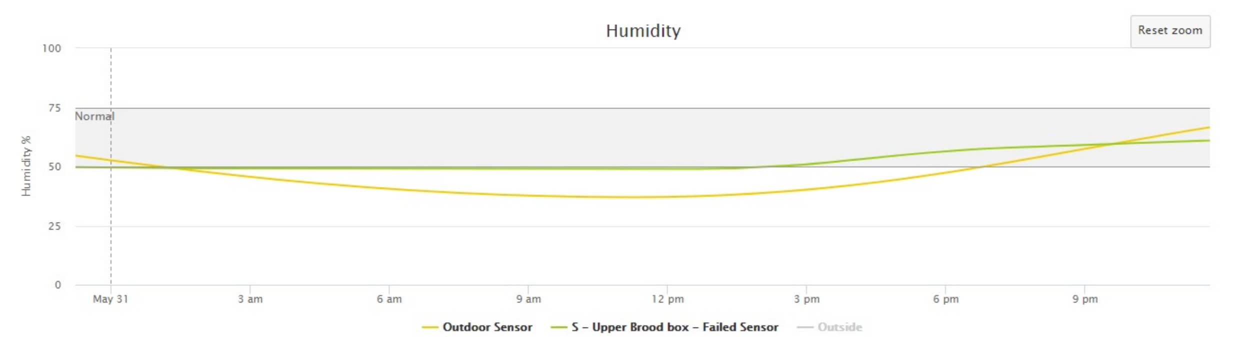

In the figure above, the green line represents the upper brood chambers temperature. At the peak of the day the hive was happily in the low 90s. In the figure below, we see the uninsulated hive (Marked as the W hive) increasing in temperatures and leaving the ideal temperature zone peaking at 100.6 on the same day.




This excess of heat requires that the hive workers divert their attention from brood rearing to temperature control. Workers that would normally be gathering nectar or pollen are diverted to gather water which is used to evaporatively cool the hive. We noted this pattern repeat on several occasions during the warmer spring and summer days. Another example:

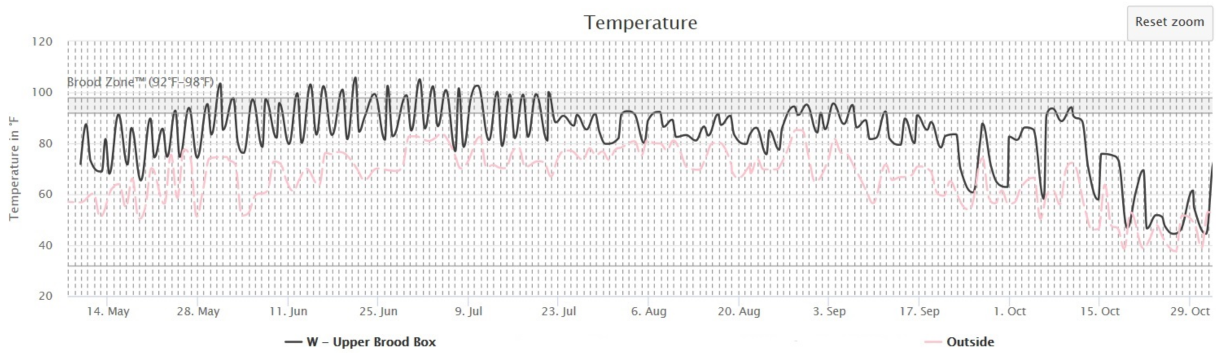


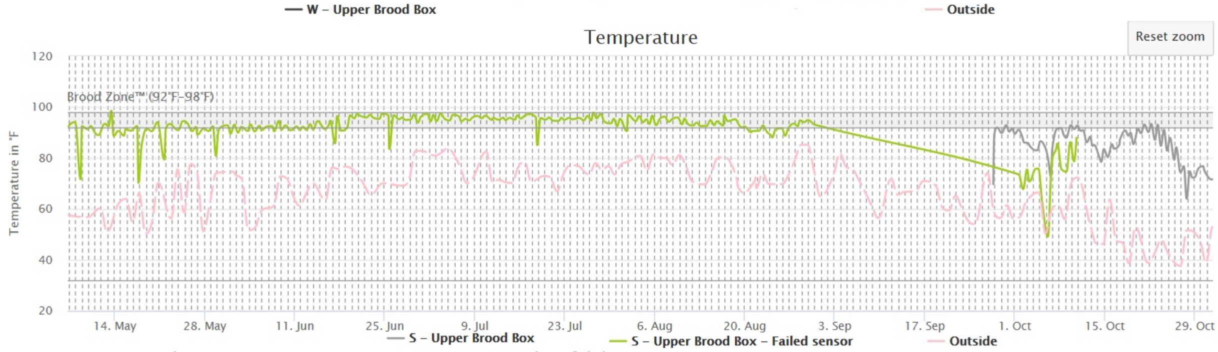



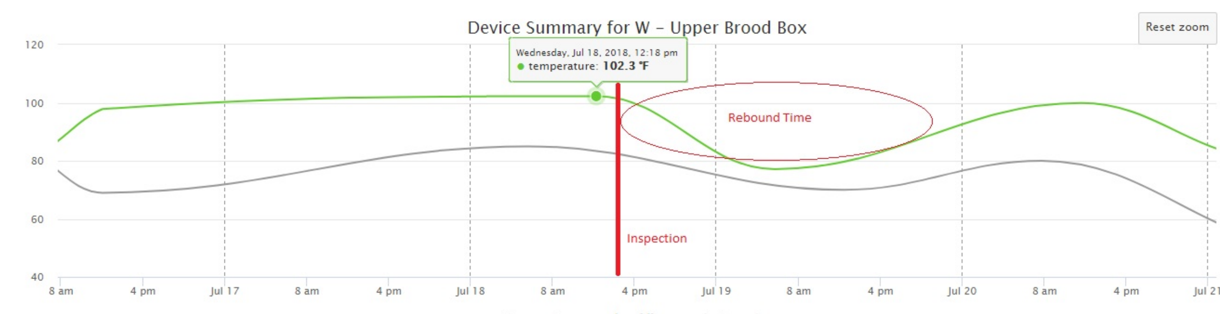

**Temperature fluctuations**

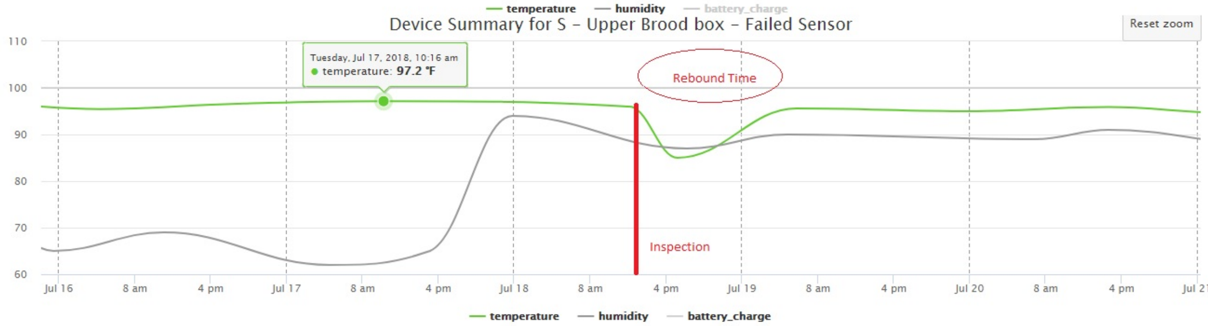
As we take a look at the bigger picture, and view the hives over a longer period of time, we can see that the uninsulated hive varies greatly throughout the active period of the bees in spring, summer and fall. Temperatures swing up and down through the ideal brood temperature zone as outdoor temps trigger the bees to switch from cooling and heating to struggle against outdoor temperatures. You can see that on or about July 21$^{st}$ the W-Hive's temperature swing patterns changed. This cause of this was the loss of their queen, and thus the cessation of brood rearing. The queen was replaced and the hive returned to normal brood production within a few weeks and was able to build up a winter bee population. We did not have any obvious cause for the loss of the queen, and it could have been any number of factors such as poor genetics, disease, poor mating, supersedure etc. The excessive temperature swings that the hive had to deal with certainly wouldn't have helped.




You will note very few dips of the insulated hive outside of the ideal brood temperature range, and the cause of these are actually the bee keeper. The hive is routinely inspected to ensure the bees are healthy and performing their activities properly. During inspections the ambient temperature in the hive will always drop to match outdoor conditions temporarily. The bees will restore the ideal temp as quickly as they are able, and this recovery or rebound time is impacted by how much heat is lost and continues to be lost from an uninsulated wall or outer cover. This effect can be seen in the graph below.



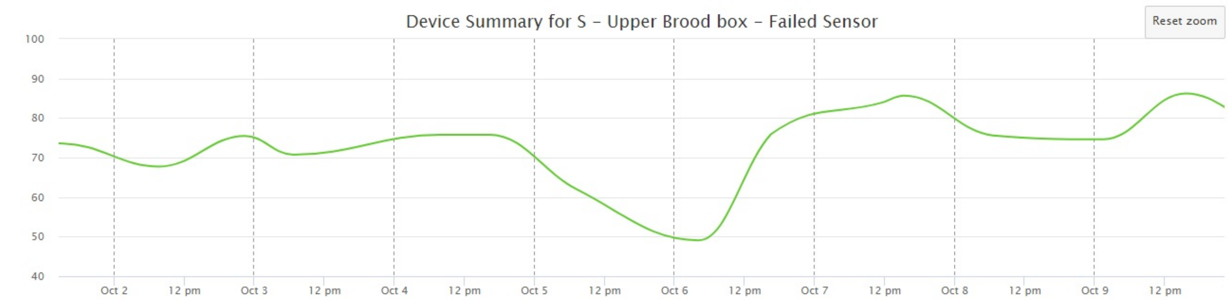
**Unexpected Honey and Nectar.**

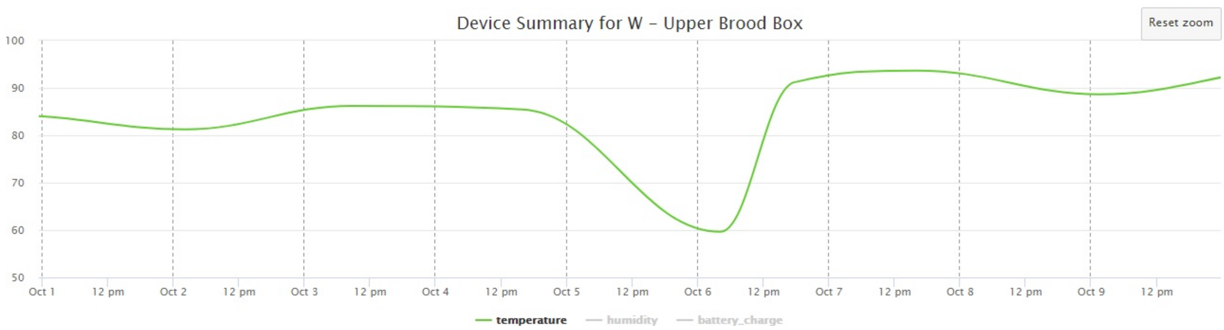
During the summer the insulated hive boomed, and not only built out its brood boxes, but also several honey supers. This is the best scenario for any new package on new foundation and we were very pleased. The bees it seemed were not content with this and stockpiled a honey horde in so much excess that they began to honey bound themselves. We extracted several frames of caped honey and uncapped nectar from the upper brood box and the honey supers. We stored this 4 gallons of honey (about 50 lbs.), and planned to use it to feed back to the bees later in the season as the summer dearth arrived. As winter approached and we removed the honey supers to prepare for the fall, we found they had partially refilled them. We collected about 30 lbs. of honey from the supers, and bottled it for our own use. Collecting honey from a hive the very first year is a rarity.

The uninsulated hive did not produce any honey. In fact it barely pushed into the honey supers, instead it chose to store honey in the brood boxes. We had to extra a small number of frames that had nectar in them to ensure the new queen did not feel congested. This small amount of nectar was returned back to them in the fall. We don't think there could be a clearer sign that an insulated hive is better for the bees, but the year isn't over yet.

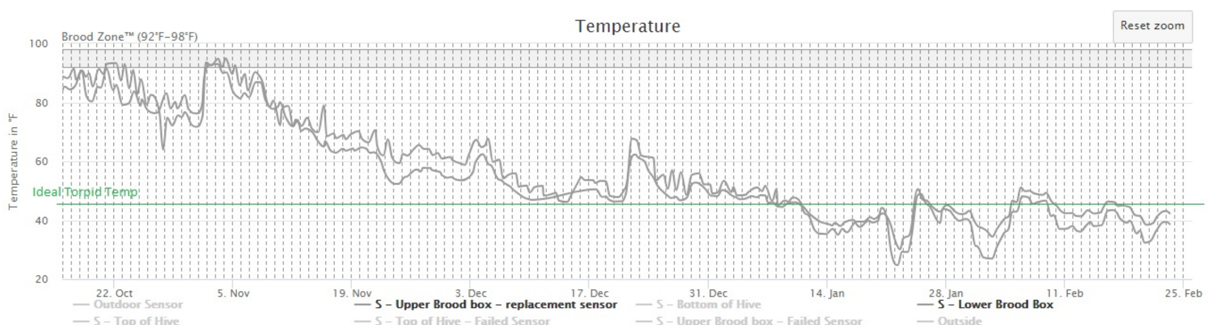
**Difficulty with liquid feeding in spring and fall.**

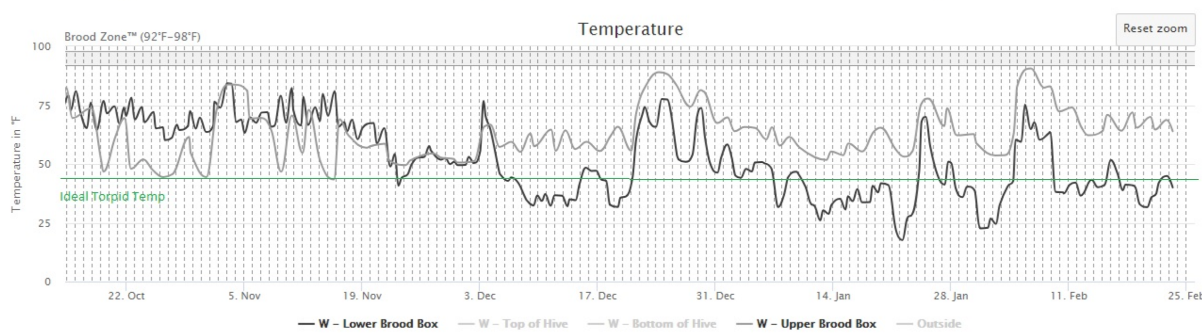
We saw definite behavioral differences in the hives as the fall temperatures dropped. We began feeding at the end of September, returning the honey that we had extracted to the insulated hive. We even shared some with the uninsulated hive as we returned there nectar as well. The insulated hive consumed or stored the honey very quickly, we even topped them off with a small amount of sugar water to keep them from flying around looking for flowers since the season had ended but a few warm days remained. They were found in the feeder night and day, greedily consuming whatever they could. The uninsulated accepted some of the honey and nectar, but was not feeding heavily. The nights were getting cold and this forced the bees to remain in the brood chamber and not go to the feeder. One very interesting piece of the data we collected was that during this time both hives kept a pretty consistent temperature of their upper brood chambers. As you can see from the diagram below, they are nearly identical. We did not have a temperature sensor capable of monitoring the temp of the liquid feed above them. With the loss of heat from the box, and from the feeder we believe the uninsulated hive had to divert its workers away from gathering and into heating for brood or just clustering together for warmth. The insulated hives workers were not forced to divert from the feeder.



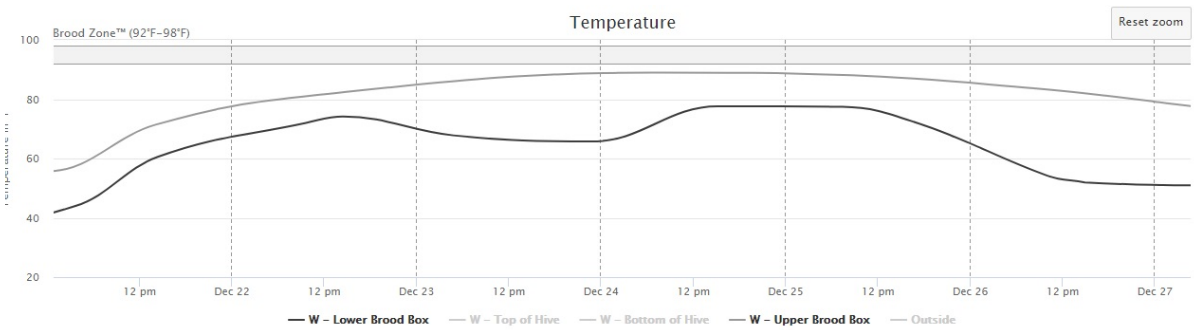

**Winter Cold**

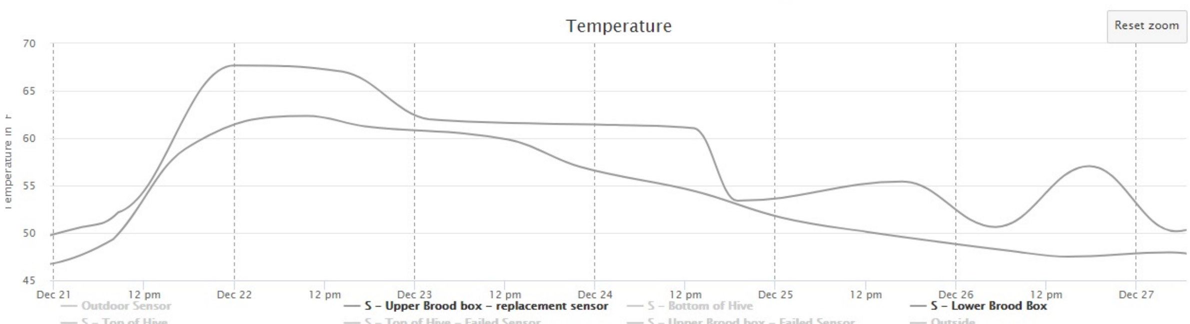



Looking at the hives from a view of both the lower and upper brood boxes temperature ranges from October to the end of February, you can see several things very clearly. First, the insulated hive has significantly less temperature fluctuation. This allows the hive to enter its period of torpid (hibernation) and limit the amount of wasted energy from unnecessary activity. Secondly you can see that the insulated hive is retaining most of its heat and both brood boxes are staying close to each other in temperature. Lastly, the ideal temperature for bees while they are in a torpid state is about 45 degrees. This allows them to maintain their cluster easily, limits activity and minimalizes food consumption. This is denoted by the green horizontal line in the diagrams. The insulated hive spend much of its time around this temperature. The insulated hive various dramatically both above and below it, clearly overly impacted by the outside influences of nature.

On a few days in winter it gets unseasonably warm, and the bees have an opportunity to come outside to purge (use the bathroom). These days are very beneficial for the hives, but too much activity means wasted calories as they attempt to reset themselves and return to the torpid state. In the diagram below you can see how the uninsulated hive was slower to warm and to cool off after the warm day, leaving the hive active and excessively warm for many more hours.




### Increased fuel use (food consumption)

At this time the hives still have a few weeks of winter remaining. This the most critical time for hives, most often when they fail. The uninsulated hive consumed most of its winter stores of honey by December 22nd. This would have normally marked the death of the hive shortly after. We began feeding sugar patties at this time, which they actively began feeding on a few weeks later when they ran out of honey. As of early February the insulated hive had not moved up from its lower brood box, and had its entire upper brood box filled with honey (estimated at 60-70 lbs.). This is more than enough to make it into spring, and should allow for a rapid and robust brood build up. The only down side is that this places the hive at a high risk of early spring swarming.

**A word on mites.**

We had hoped to see a difference in mite populations between the hives. This year was very unusual and mite counts for our hives were very low. In speaking to many other beekeepers we found that they also experienced low mite counts. Without any significant mite populate we were unable to see any impact the insulated hive would have on them. We plan to continue gathering information with our hives and see what experience they have with mites in the New Year.

**Our Conclusion**

We found that our insulated hive outperformed the uninsulated hive in all the areas we had hoped it would. Modifying the hive was greatly advantageous to the bees. The impact of the added size and weight of the hive was manageable for us while inspecting and tending the bees. I will also point out that I'm a young, tall, strong man, so this may not be the case for others. Traditional Langstroth hives are a weight challenge for many already. To address this, we hope to add an experimental hive of medium insulated supers as well.

Additionally besides the added work, the cost of materials and time to modify the hive was also not insubstantial. We are currently working with a carpenter to find out costs of making insulated hives so that we may expand our test base, and have a source available to other keepers who may want to add an insulated hive to their apiary. Having solid numbers is an important step to get others to consider adopting this new setup. If the cost is modest enough, it may be offset by healthier bees who do not have to be replaced with a new package ($130+) or new Nuc ($170+) every spring. We hope that we can convince keepers with small to medium apiary setups such as ourselves to invest into their bees' wellbeing.