# A study of feral honeybee colonies adaptability to temperature variations relating to their overwintering survivablity

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**Overview**

Discrimination of the feral honeybee subspecies is important for the conservation of the honeybee biodiversity. Identifying and preserving northern honeybee genetics with cold weather survival traits could be especially important to the ecology and pollination along the Front Range and other cold weather regions of the US.

There are 2 factors that determine the honeybee Apis mellifera ability to overwinter in northern climates. One we believe is the bee's northern genetic lineage. The other important factor is the nest cavity's thermal regulation. Honeybees Apis mellifera have lived in well-insulated natural cavities for thousands of years. In this paper we look at the natural habitat of honeybee colonies, the cottonwood tree and the thermal-dynamics that occur in this nest cavity; insulation, breath-ability, humidity and condensation regulation. We discovered some very important concepts about weatherization of cottonwood trees and translated the information into a natural product solution that can enable beekeepers to overwinter bee colonies in their standard wooden bee boxes. We concluded by providing an insulating solution that is as close as possible to what the bees experience in nature when living inside a hollow of a tree.

## Climate Change Effect on Colonies

Climate events sometimes termed a Polar Vortex or Flash Freezes are killing bee colonies. Bees need time to adapt to changes in the global climate The research that was conducted on Polar Vortex and its effects on the winter survivability of the honey bee, point to one key shift in the environment, most notably in mid-latitudes of the northern hemisphere [i]**.**

Bees can handle very cold temperatures, even as cold as the Arctic Circle. What bees have not yet adapted to is sudden drops in temperature. We have to provide thermal insulation that internally slows the temperature drop in the hive. This buffering gives the bees time to get to the honey stores and then to organized into a tight cluster to stave off the cold. The most amazing thing is that given the right kind of insulative barrier, the bees don't need to go into a cluster at all. In fact, clustering may be an emergency behavior and actually a sign of stress.

A large, thick tree with a colony of bees in it has nearly infinite insulation above them. Weatherization [ii] is thought of as the practice of protecting a building and its interior from the elements, particularly from sunlight, precipitation, and wind, and of modifying a building to reduce energy consumption and optimize energy efficiency, but what is most important is the “heat transfer rate” of the colonies hive cavity. Thin walled beehives are not even close to what a thick walled tree provides. So as temperatures plummet outside with sufficient insulation it takes a longer time for that rapid change to effect the honeybee nest, giving the bees ample time to do what they need to do to survive, reach their honey stores. The tree has a very low heat transfer rate. Most the bees that died last winter in the US didn't slowly die over the course of the winter, but died in a 24 hour period or died after only a few of these sudden drops in temperature.

## Winterizing: Understanding what is causing the "polar vortex” and the sudden temperature drops in the US

The polar vortex refers to the counter-clockwise flow of air that normally insures that the colder air stays put near the Poles. The polar vortex in its normal configuration will expand sending cold air southward with the jet stream. This occurs many times during the winter in the northern hemisphere and is usually correlated with arctic air flowing down into the United States, but now the effect is getting abnormally unstable. Recently scientists have identified a relationship with the decline in Arctic sea ice and snow cover with weather anomalies linked to the polar vortex. [iii] Basically, when the arctic warms rapidly and the mid-latitudes in the US get colder the jet stream weakens because there is not the big temperature difference to keep the jet stream in its normal place, it begins to waver. When this occurs, a super cold arctic air mass streams directly down into the mid-latitudes, causing sudden drops in temperature.

After enduring two consecutive years of high honeybee colony losses in the US [iv], we could begin to see a serious impact to local agriculture, especially if these extreme climate anomalies continue or deepen. It becomes very hard to catch swarms or split hive if no one has bees. The cause of these hive deaths have not been linked to the typical colony losses caused by the Varroa mite or disease, but to multiple climate events of unprecedented temperature drops in the 40 degree plus range within a very short windows of time.

**Here is a look at the data we collected in Colorado**

Below is a graph we put together using an algorithm that pulls the number of these 40 degree drops in temperature over several years. In 2008 the Front Range beekeepers experienced unusually heavy winter losses and we didn't know why. In 2017 very few beekeepers came out of the winter with bees. The ones who did we interviewed to find out why. They all had super insulated their hives. The only swarms that we heard of were coming from peoples warm attics or soffit or feral bees in huge cottonwood trees.

Honeybees in a soffit of a house


Closeup of honeybees in a soffit of a house

**Table 1:** Temperature data collected by NOAA was from Boulder weather monitoring stations.

| # of days in each yr | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|---|---|---|---|---|---|
| >40 degree delta | 25 | 12 | 10 | 16 | 17 | 7 | 17 | 10 | 19 | 21 |
| Sept-Jan: >40 degree change w/in 24 hrs | 9 | 7 | 7 | 3 | 6 | 1 | 4 | 4 | 10 | 11 |
| Sept-Jan: >55 degree change w/in 48 hrs | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Sept-Jan: >60 degree change w/in 72 hrs | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 3 | 1 |

*Delta is the difference between two numbers*

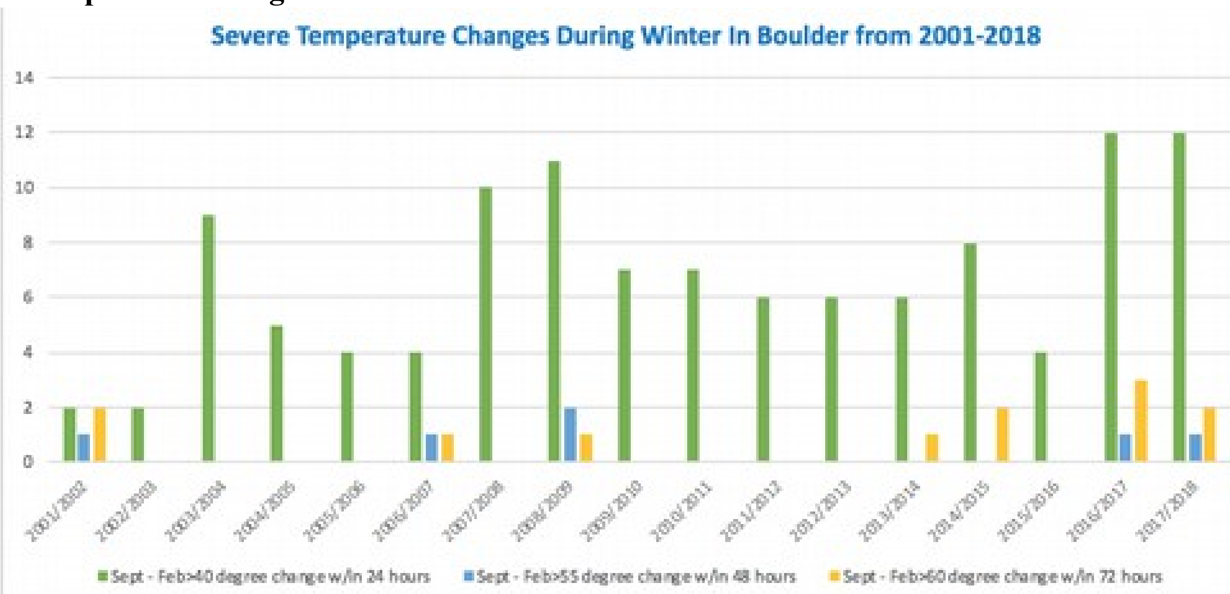
An example of a 65 degree drop was on October 25th-27 2017, which was observed by beekeepers to be the cause of the first big die-off of colonies along the Front Range.
Here we show that the actual fall in temperature starts from 84.9 degrees and drops to 19.9 degrees in less then 36 hours.

| Date | High | Low | High/Low Delta |
|---|---|---|---|
| 10/25/17 | 84.9 | 42.1 | 42.8 |
| 10/26/17 | 71.1 | 30.9 | 40.2 |
| 10/27/17 | 44.1 | 19.9 | 24.2 |

Each of these events have accumulative effects on the winter colony. A weak colony will die after the first event. Strong colonies will have big losses of numbers after each event, but when even a strong colony looses sufficient numbers they drop below the critical mass of bees needed to sustain the temperature of the cluster. So each of these events have a huge impact on the bees survival chances.

Here is a graph of the data we put together using the Boulder Colorado weather station

**Sept 2017 through March 2018 winter bee season have been the most severe since 2008/09**




NOAA Boulder Station ID: GHCND:USC00050848
Coordinates: 39.9919N, 105.2667W, 1671.5 meters above mean sea level

## Why do bees have difficulties with extreme and rapid temperature drops.

Genetic behaviors determine the colonies ability to respond and survive extreme temperature anomalies.

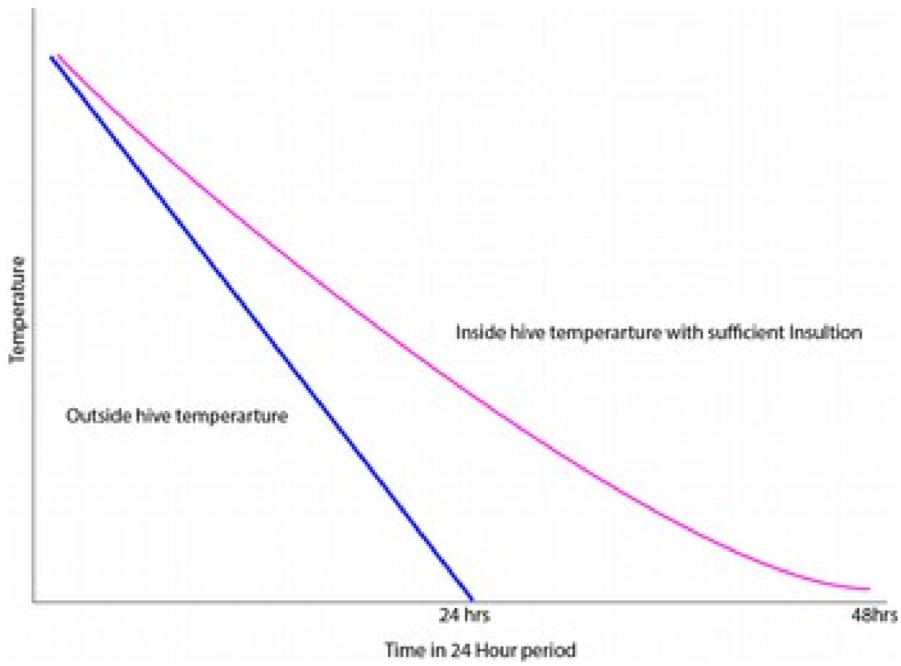
Here is the very simplified example of behavioral mechanics needed for a colony of bees to survive a typical extreme drop in temperature.

1) Colony needs to quickly organize and assemble within the honey stores of the nest to consume honey stores.
2) Bees need to consume and store in their honey stomachs a predicted amount of fuel (honey). The predicted amount would be based on typical historical normal's.
3) After securing fuel the colony needs to reassemble in the brood chamber before the temperature in the hive drops so much that the mobility of the bees is affected
4) The colony must now organize into a formation called a “cluster” where half of the bees are head first in empty insulative wax comb cells and the other half of the bees are covering the

open cell of their hive-mates with their thorax. The cluster then begins shimmering their wing muscles which starts the heating of the bee cluster.

The amount of honey each bee has or was able to consume would have to be well calculated and would need to be based on surviving a typical, but still relatively extreme, historical 40 degree drop in temperature. If the bees are "programmed" genetically to prepare for a typical temperature drop rate of around 40 degrees, the bees would have survived the event perfectly. On the other hand, if there are multiple events or a single event that is an unprecedented 40 degree plus change, then the colony will likely run out of what they collected and perish.

Proper insulation on a hive decelerates or extends the fall in temperature allowing the colony to respond effectively.




## Solution: Mimic the bees natural enclosure

In a recent study, researcher Derek Mitchell used thermal mass calculations rather the R value to demonstrate the "heat transfer" or loss of heat of a tree compared to a typical man made hive. Typical bee hives were shown to lose four to seven times more heat them a colony residing in a tree.

"Many honey bee behaviors previously thought to be intrinsic may only be a coping mechanism for human intervention; for example clustering in a tree enclosure may be an optional, rare, heat conservation behavior for established colonies, rather than the compulsory, frequent, life-saving behavior that is in the hives in common use. The implied improved survival in hives with thermal properties of tree nests may help to solve some of the problems honey bees are currently facing in agriculture." Derek Mitchell [v]

*Image of bees dead on a comb, in a small cluster*

The insulation debate and confusion seems to dwindle when you just go back and look at the properties of the bees original nest properties, the tree. Having seen first hand that most hives that die over winter have plenty of winter stores, then the debate that to much insulation causes the bees to be to active and eat up all their stores falls apart. In fact the bees died because they couldn't migrate to the honey stores because it was too darn cold in the hive to move.

## How the insulation solution creates a natural cavity for the bees.

Bees generally select nests in deciduous trees of a particular diameter and thickness. The trees that best match the bee's criteria is the cottonwood tree. Having observed many wild bee hives in trees and rescued several bees nests that have been cut down, I found that there is typically at least a thickness of four to 10 inches of wood surrounding the nest.

The R-value for wood ranges between 1.41 per inch (2.54 cm) [vi] for most softwoods and 0.71 for most hardwoods (R-value is a measure of insulating ability of a material or thermal conductivity[vii]. Cottonwood is a soft wood, so if you calculate the insulating ability of cottonwood at four inches, you get an R-value of 5.6. The 1 inch thick blue board insulation panels have an R-value of 5.0 . If you add the thickness of the pine wood of the hive itself, you can add an R-value of .71 (virtually nothing) to insulation panels making a total R-Value of 5.71. If you refer back to the bar graph that the blue board panels worked fine for many years, but now that the environment is changing, insulating with blue board only is just not sufficient we need to be bundling up our hive for winter in a big cottonwood tree. Figure in that a tree has near infinite insulation above and below the nest. We now need higher R values and better insulation properties. 3 layers of wool insulation is R22.5

## Another part of the equation - Thermal mass

Insulating hives has two important effects. First, if a hive has marginal honey stores, insulating greatly increases its chances of overwintering. Secondly, because the bees create warmth by eating honey and using this fuel to generate heat by flexing their wing muscles, a hive that is insulated will have many more honey combs to harvest in the spring as the bees will not need to use the combs for fuel during the winter. The thermal mass of the honeycombs greatly reduces the fluctuation of the nest temperature because the honeycombs act like "thermal batteries" and can store heat during the day and gradually release it at night. The insulation substantially adds to this effect by buffering both hot and cold outside temperatures.

## Thermal properties of Wool [viii]

Wool is by far the best way to insulate a bee hive.
***Moisture and climate control –** moisture and mold happens in your walls. Wool absorbs moisture and adsorbs it against 65% relative humidity.
***Suppresses mold and mildew –** natural keratin prevents against the spread of mold and mildew.
***Absorbs sound –** wool exceeds other forms of insulation as an acoustic buffer.
***Thermal conductivity –** wool batts are industry standard at 3.6 per inch
***All natural –** wool insulation is entirely renewable and sustainable
***Long lasting –** inherent characteristics allow stated R-values to exceed other forms of insulation.
***No off-gassing –** natural characteristics make our insulation devoid of harmful chemicals.
***Installs easily –** batts are installed like other mediums but with no protection required. Wool is biodegradable and compostable.
So why haven't beekeepers been using wool to insulate? Wool is expensive but now bees are expensive to replace a colony if they die over the winter. The simple answer is cost and how to keep wool dry without putting it in a plastic bag.

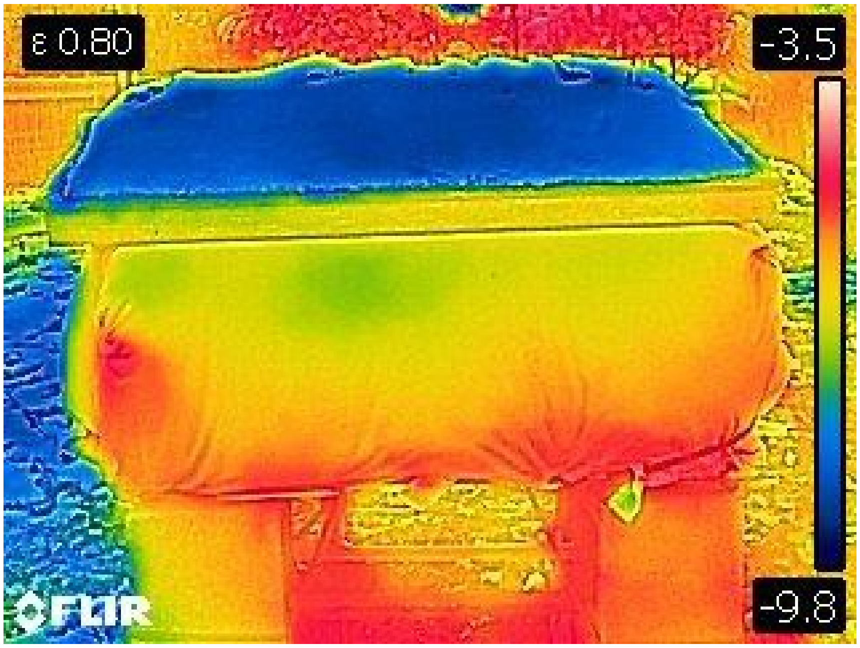
## Conclusion

The final outcome of this study was to create a breathable canvas cover with wool insulation which has been put out to over 75 beekeepers across the US and Canada. We will find out the results come 2019!

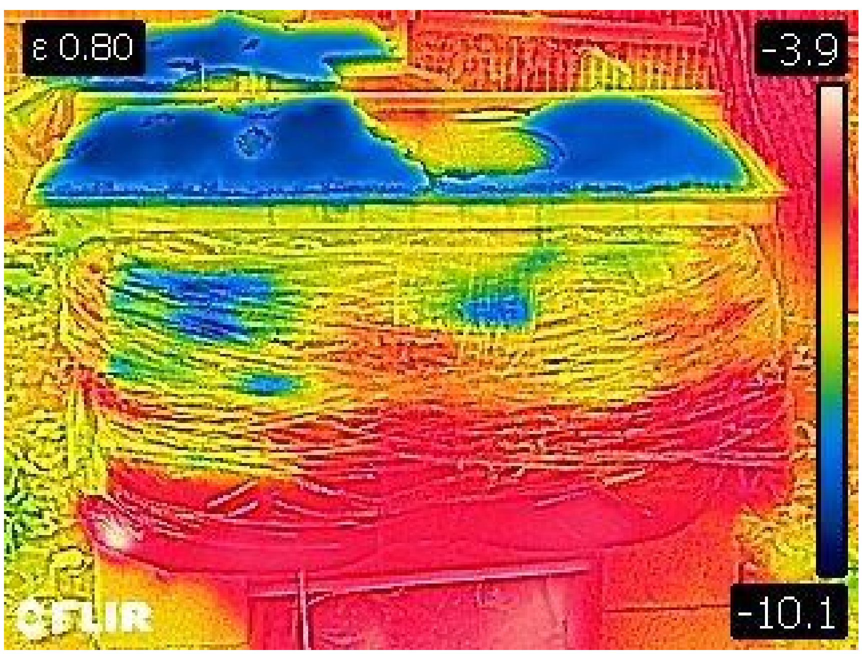
*Image of breathable canvas and 4 layers of wool around bee hive*

***Image of  4 layers of wool in the canvas cover***

These images shot with an inferred camera show the heat signatures of hives after a snow and a couple of very cold days.




**The hive is covered with canvas and wool insulation cover.** You can see the cold snow on the top and the smooth color of a breathable surface. It also shows the superior retention of warmth from the wool insulation.




**This hive is wrapped in plastic.** Here you can see it loosing a lot of heat around the bottom of the hive where the insulation is not secure and also the cold blue blotches where moisture has been trapped in the plastic and has condensed, causing cold spots.

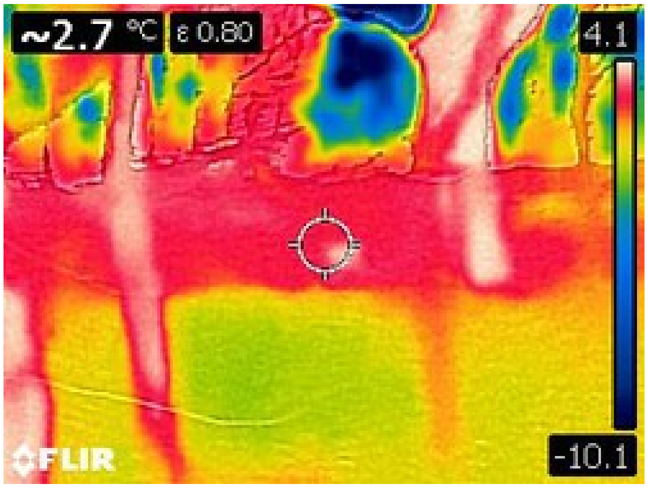

T**his hive just wrapped over the top with R30 insulation.** It demonstrates a lot of heat escaping around the hive, especially at the front of the hive.

## Colonies on Boulder County Open Space

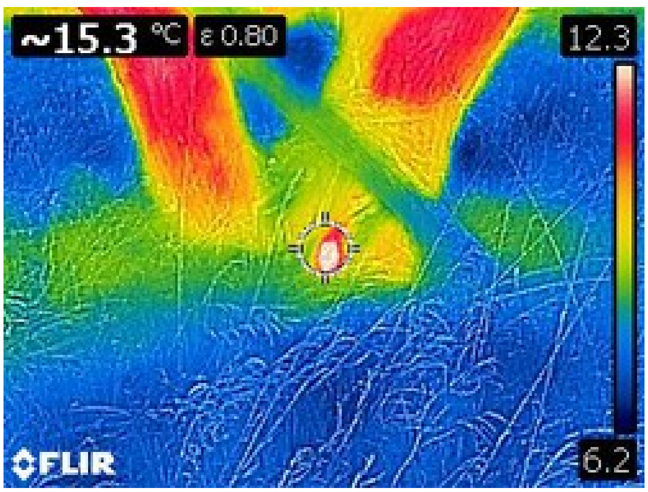
To be continued in spring 2019. We found only 2 colonies in Open Space. Here are images of the bees in the tree and the GPA location.

**Rock Creek Colony – 1**
**Latitude:  39°55'37.19"N -**
**Longitude: 105°10'7.47"W**

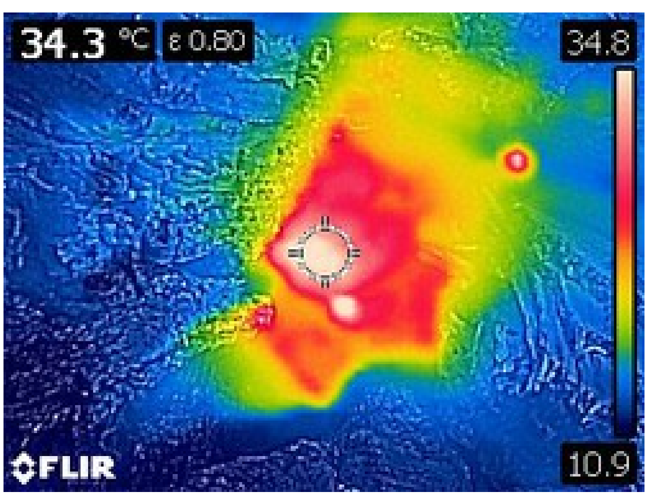
**Rock Creek Colony – 2**
**Latitude: 39°55'35.48"N -**
**Longitude: 105°10'11.29"W**



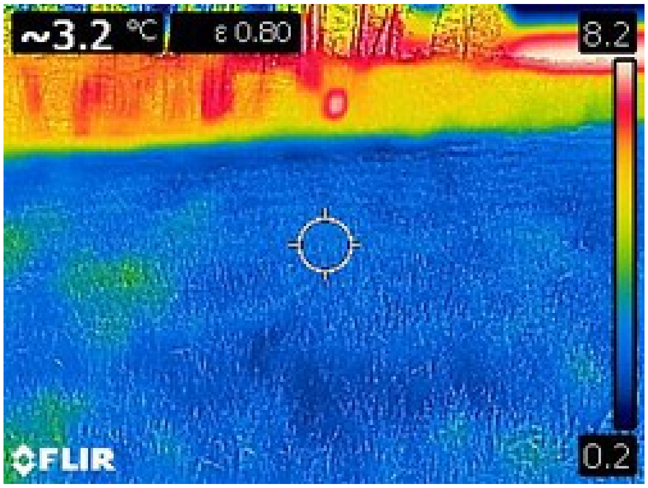
**Rock Creek Colony – 2 in a tree – 30 feet away**




**Rock Creek Colony – 2 in a tree root ball underground – the red/white dot in middle of image**

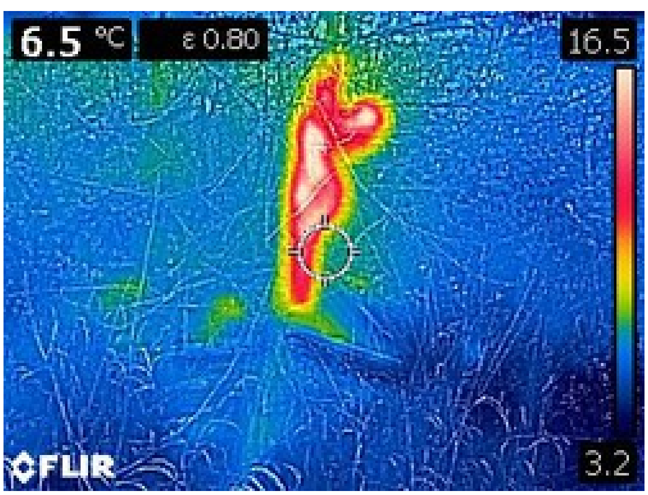



**CloseUp- Rock Creek Colony – 2 in a tree root ball underground – the red/white dot in middle of image**




**Swarm at my property Eldorado Springs– red-white dot in middle from 50 feet away**


**Swarm at my property Eldorado Springs– red-white dot in middle from 30 feet away**




**Swarm at my property Eldorado Springs– red-white dot in middle from 10 feet away**

i InsideClimateNews.org, *Ice Loss and Polar Vortex How a Warming Arctic Fuels Cold Snaps*

ii Wikipedia, *Weatherization*

iii Phys.org, *Arctic Sea ice Affects and is Affected by mid-latitude Weather*

iv Beeinformed.org, *Honeybee Colony Losses 2017-1018 Results*

v Mitchell, Derek. *Winter Management*, Bee Culture Magazine (October 21, 2016)

viWikipedia, *R-Value Insulation*, Softwood

viiWikipedia, *Thermal Conductivity,* Heat Sink

viii Havelockwool.com, *Wool properties*