Thermal impacts of apiculture on the bee colony

Dan Cook


SMOKERS

Who & Why?

- PhD Candidate at Queensland University of Technology
- Transdisciplinary Research
- Gap between apiology and apiculture
- Manage the QUT Research Apiary

HIA Project Ph17001

"Development of non-destructive methods and systems for the assessment of hive health"

Hort Innovation

QUT

Plant & Food RESEARCH

RANGAHAU AHUMARA KAI

+Several industry & funding partners

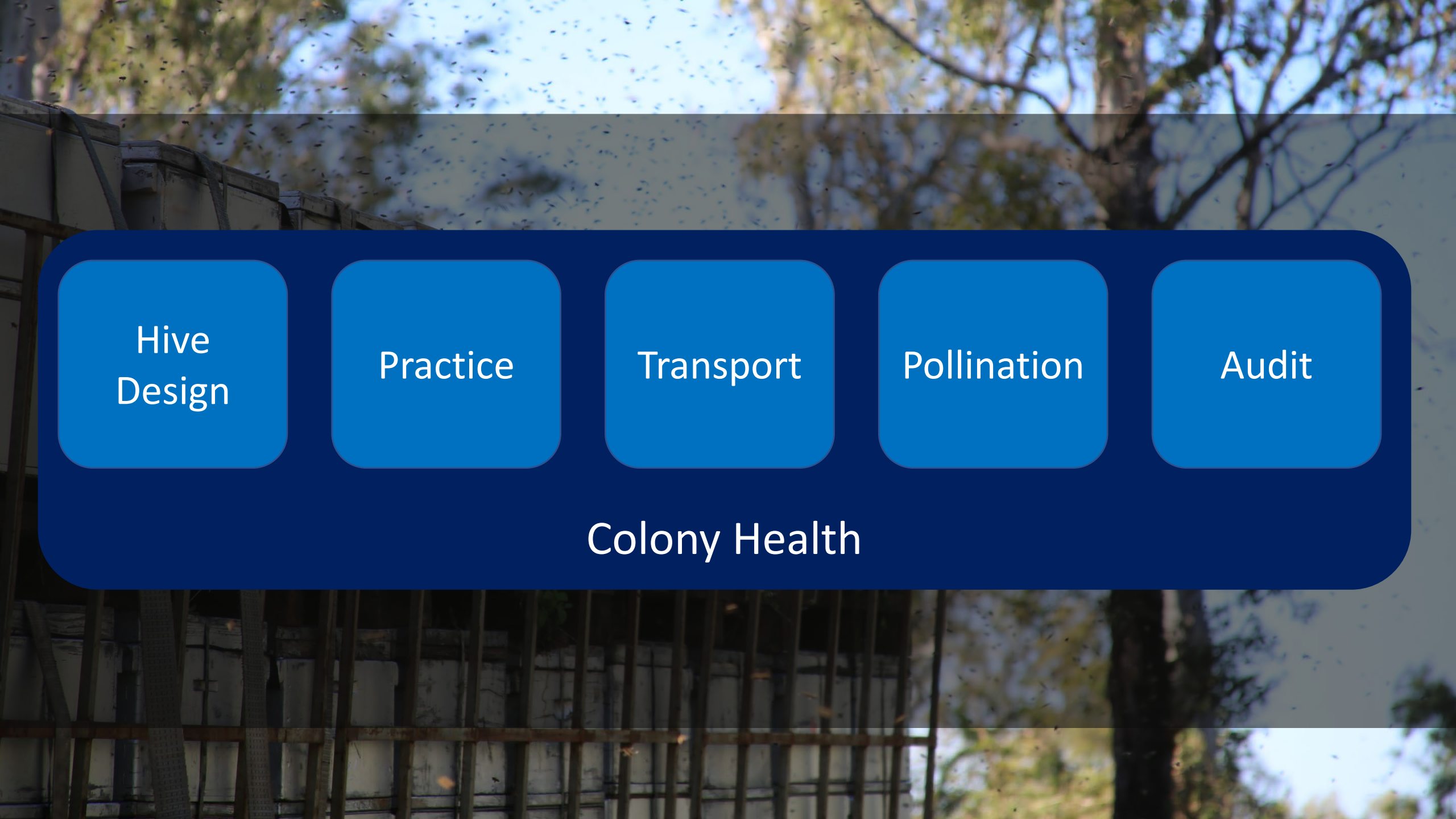
Summary of recent research

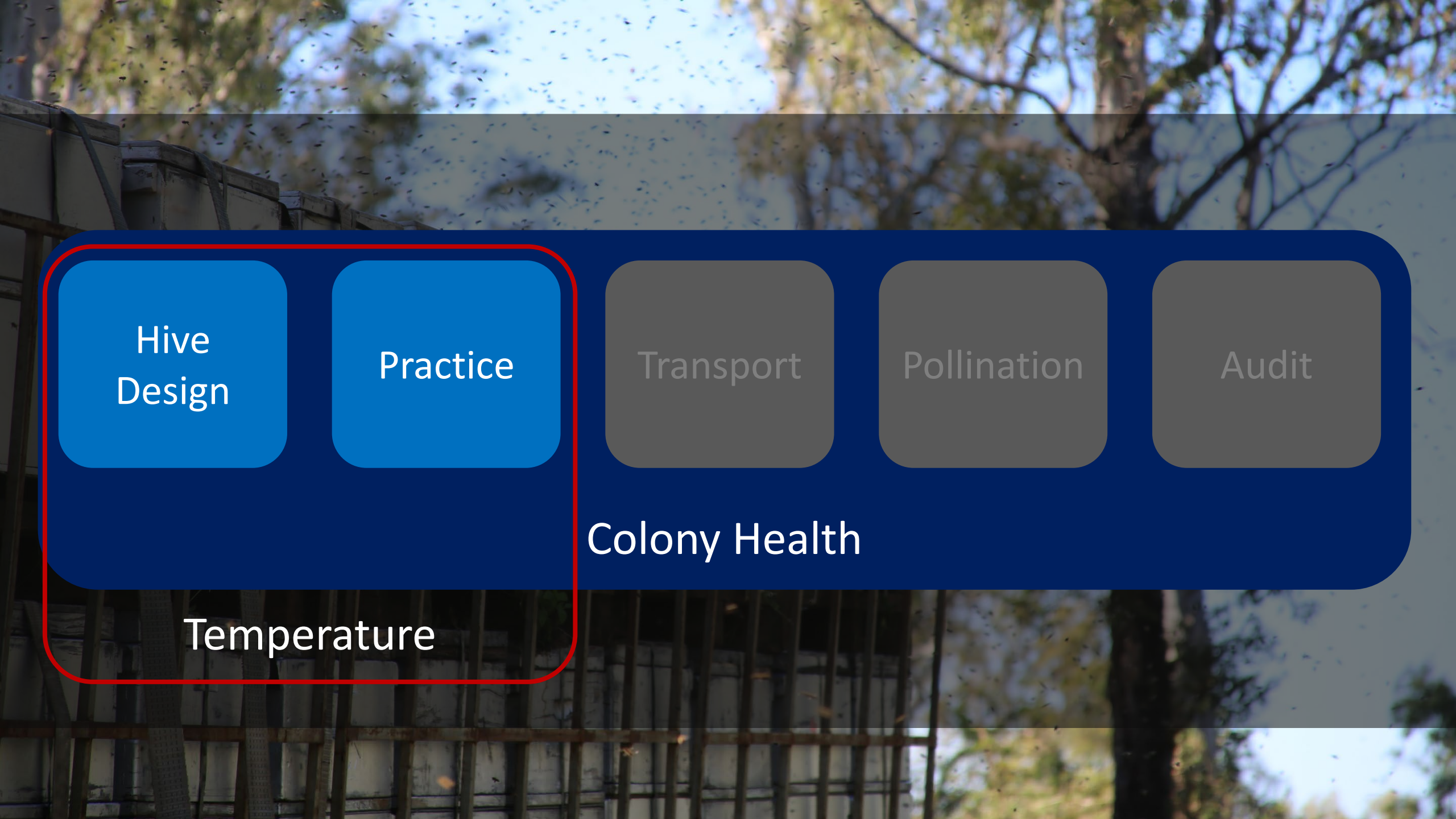
Thermal Impacts of Apicultural Practice and Products on the Honey Bee Colony

Journal of Economic Entomology

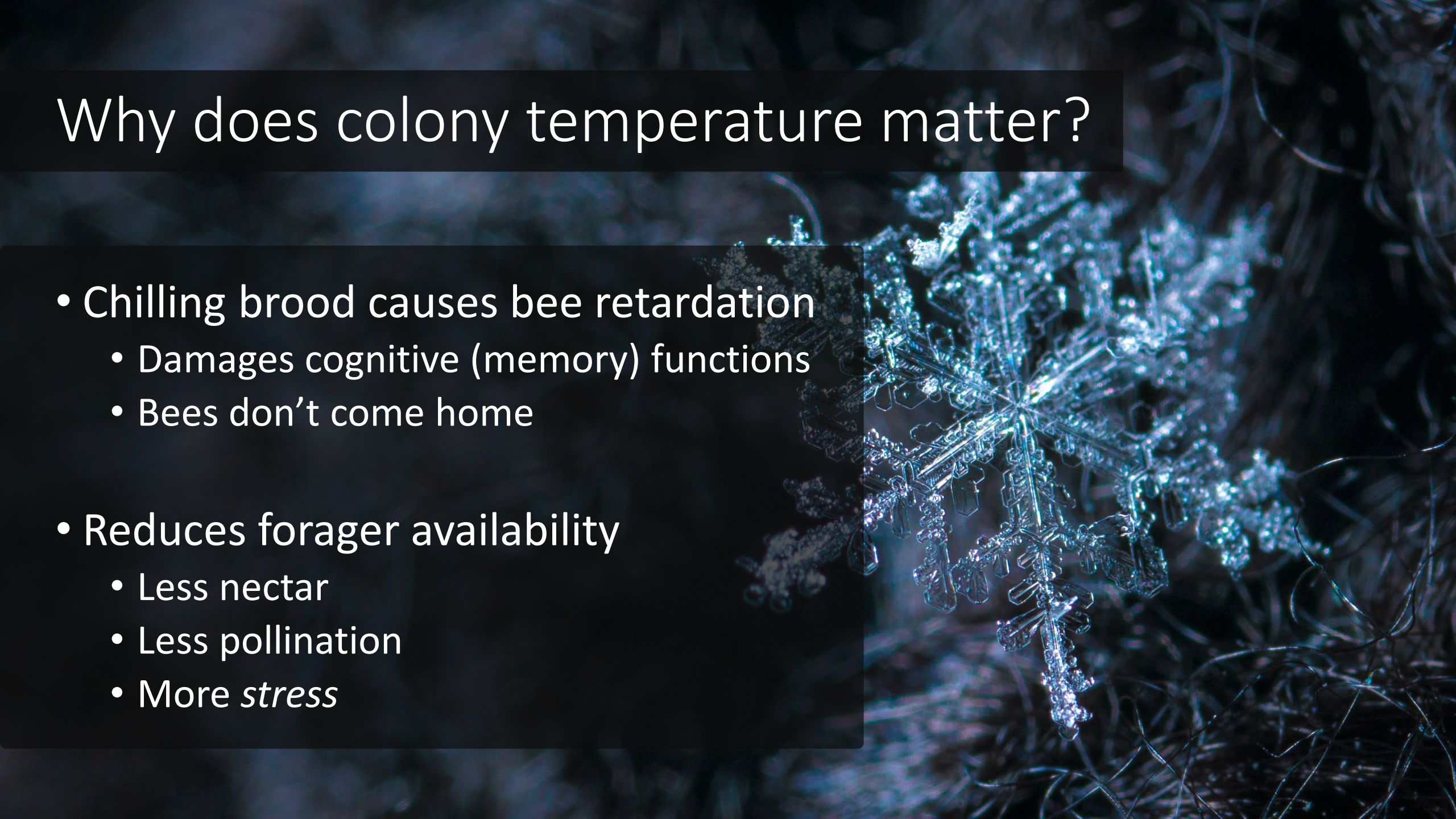
Daniel Cook, Alethea Blackler, James McGree, Caroline Hauxwell, Thermal Impacts of Apicultural Practice and Products on the Honey Bee Colony, *Journal of Economic Entomology*, Volume 114, Issue 2, April 2021, Pages 538–546, https://doi.org/10.1093/jee/toab023

- How does migratory apiculture impact bee colonies?
- What are the processes and pain-points in migratory apiculture?


Hive Design
Practice
Transport
Pollination
Audit
Colony Health


Hive Design
Practice
Transport
Pollination
Audit
Colony Health
Temperature

Why does colony temperature matter?

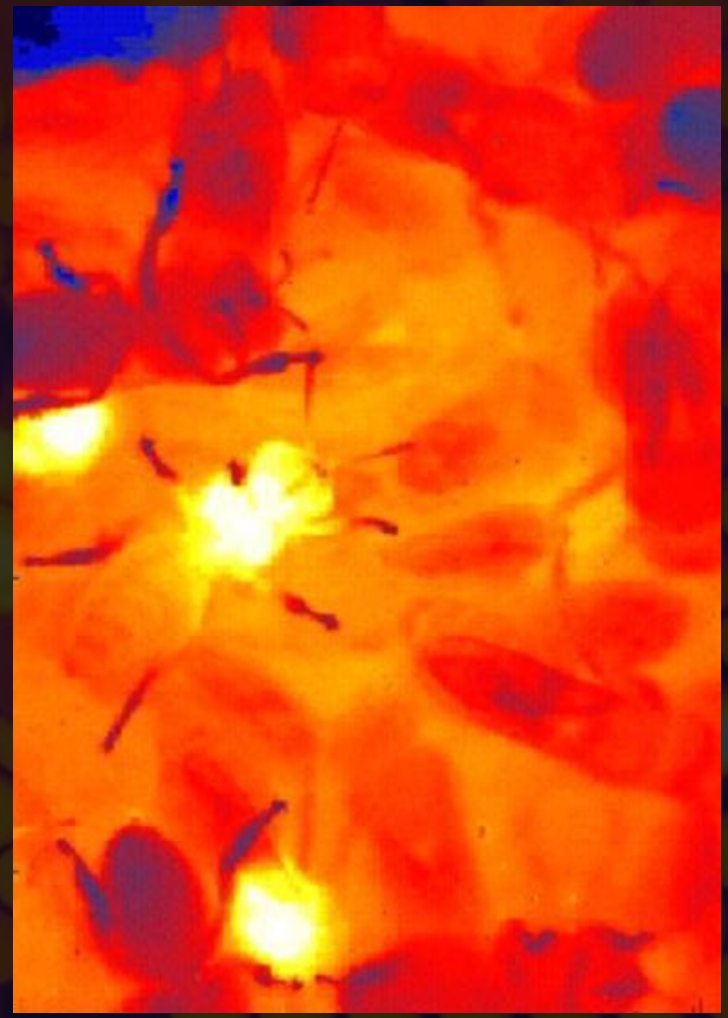


- Chilling brood causes bee retardation
  - Damages cognitive (memory) functions
  - Bees don’t come home
- Reduces forager availability
  - Less nectar
  - Less pollination
  - More *stress*


“**Stress** occurs when animals have to make prolonged *physiological and behavioural* adjustments in order to cope with their environment.”
www.hsa.org.uk/stress-in-animals/

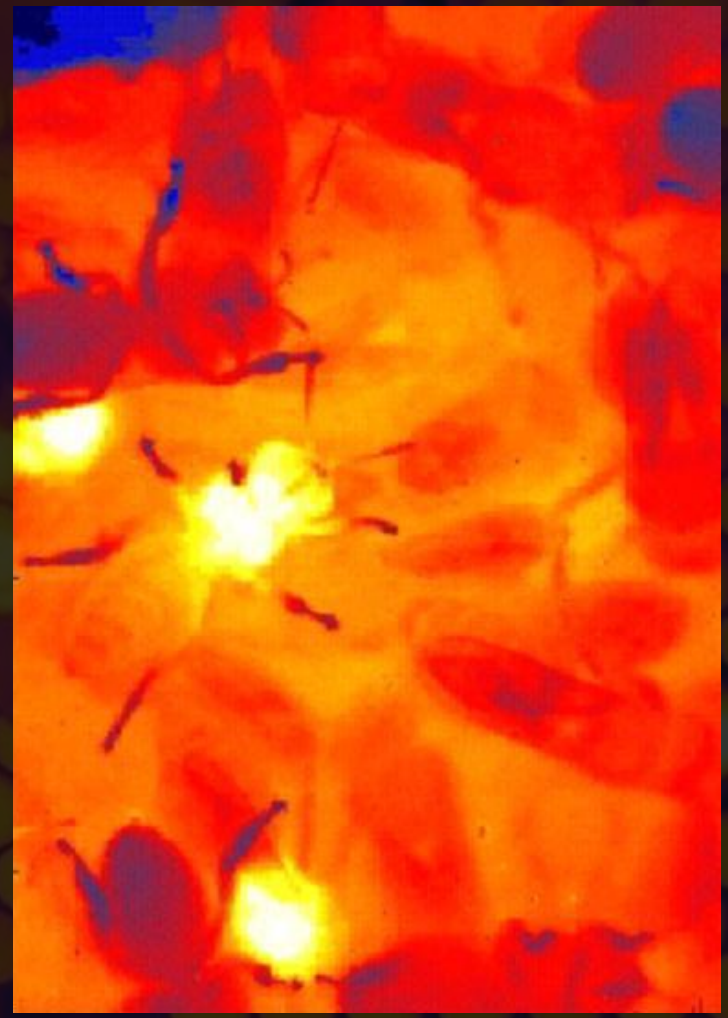
How do bees heat the hive?

- A bee can generate temperatures up to 43°C
- Heat generation uses the antagonistic wing muscles pairs.
- Heating is also part of preflight preparation
- Heater bees are aged from 3 to 27 days
  - (They jump back into this role as needed)



How do bees heat the hive?

- Two methods of heating capped brood:
  - Thorax pressing
  - In-cell heating
    - 5-10% cells left empty in the brood area
    - Previously thought to be bees “resting”
    - Look for the abdomen pumping in and out
- Up to 30 minutes duration



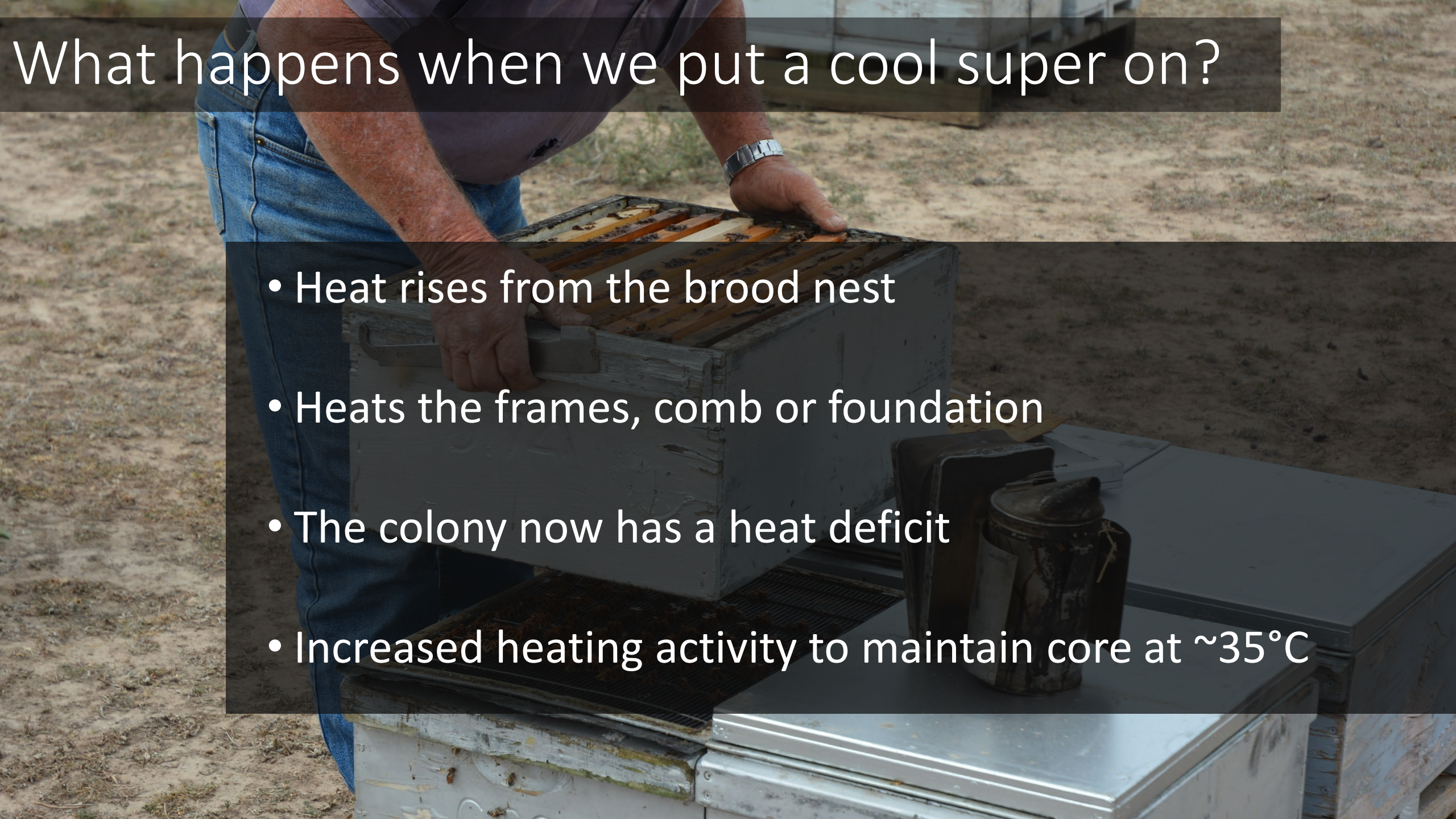
Heat generation takes a *lot* of energy

- 65mJ per second (3.9J minute) for 40°C thorax (Tautz, 2008)
- 1mg Honey contains 12J
- 1g honey = 12kJ (~3 Calories)
- Adult human needs around 8700kJ per day
- A watt is 1 joule per second

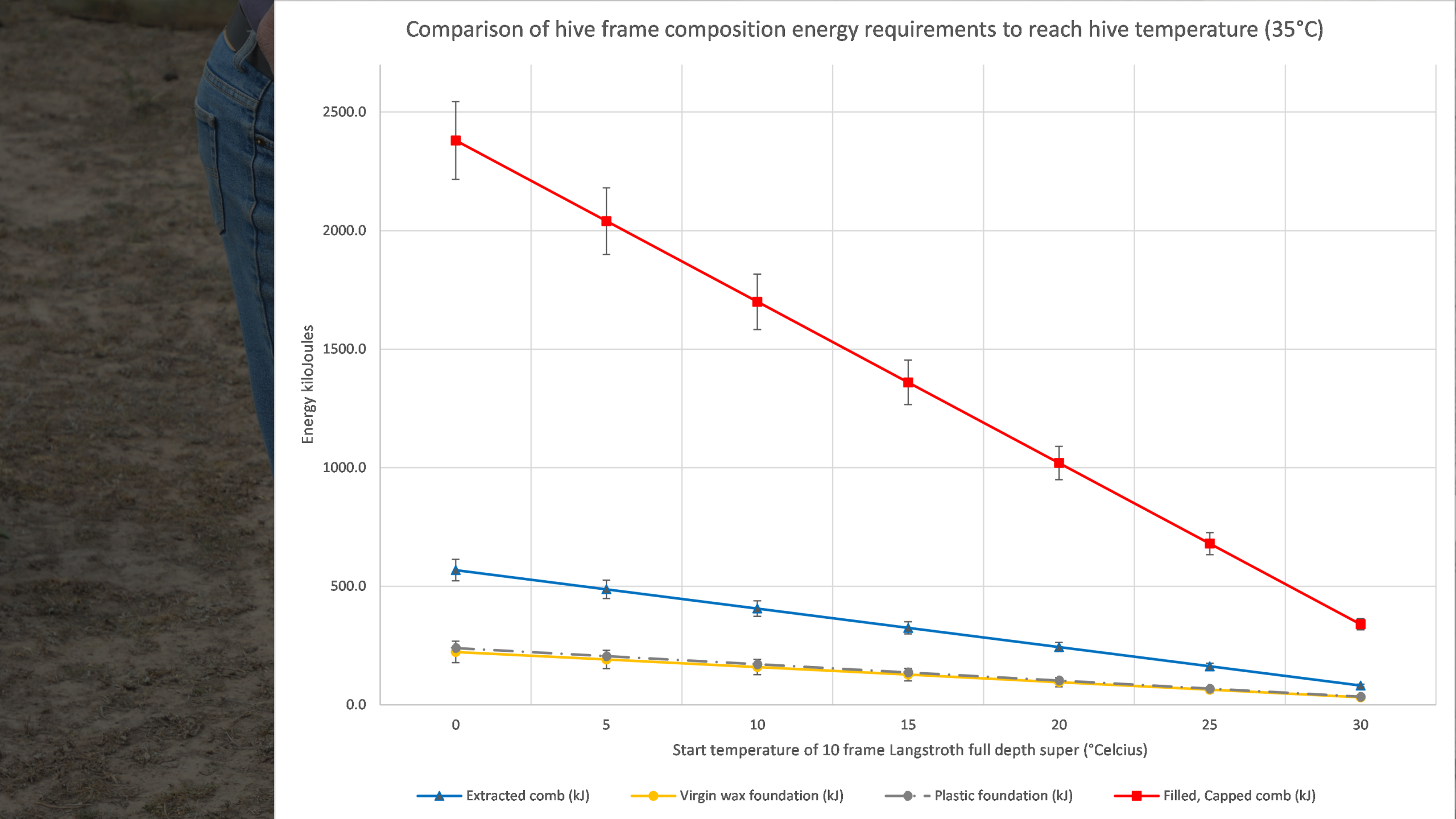
Jurgen Tautz. (2008). The Buzz about Bees. Springer-Verlag Berlin Heidelberg.

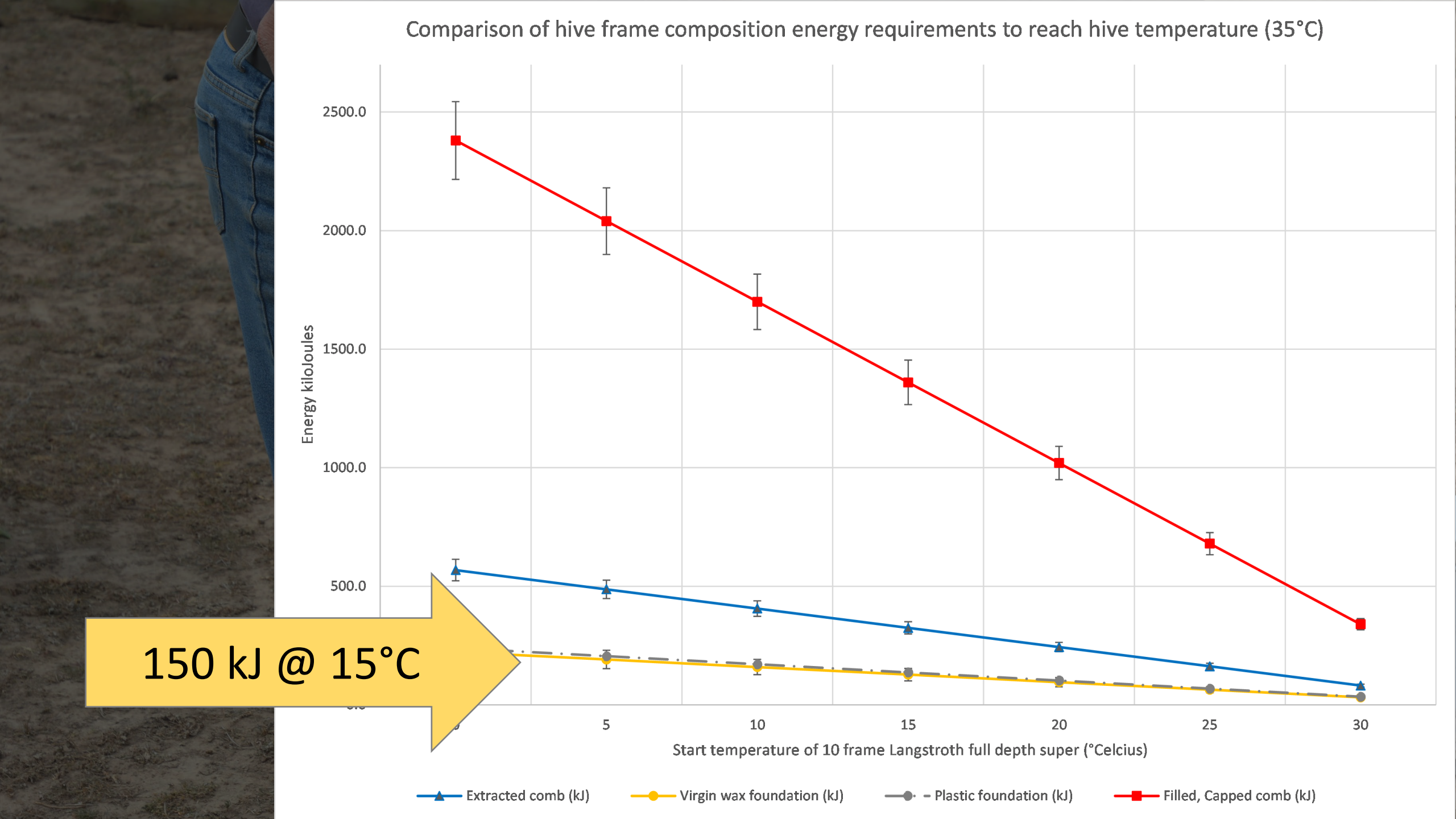
Maintaining brood nest temperature uses the same amount of energy as running a 20W lightbulb.

What happens when we put a cool super on?



- Heat rises from the brood nest
- Heats the frames, comb or foundation
- The colony now has a heat deficit
- Increased heating activity to maintain core at ~35°C


Comparison of hive frame composition energy requirements to reach hive temperature (35°C)
Energy kiloJoules
2500.0
2000.0
1500.0
1000.0
500.0
0.0
0
5
10
15
20
25
30
Start temperature of 10 frame Langstroth full depth super (°Celcius)
Extracted comb (kJ)
Virgin wax foundation (kJ)
Plastic foundation (kJ)
Filled, Capped comb (kJ)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Energy kiloJoules
2500.0
2000.0
1500.0
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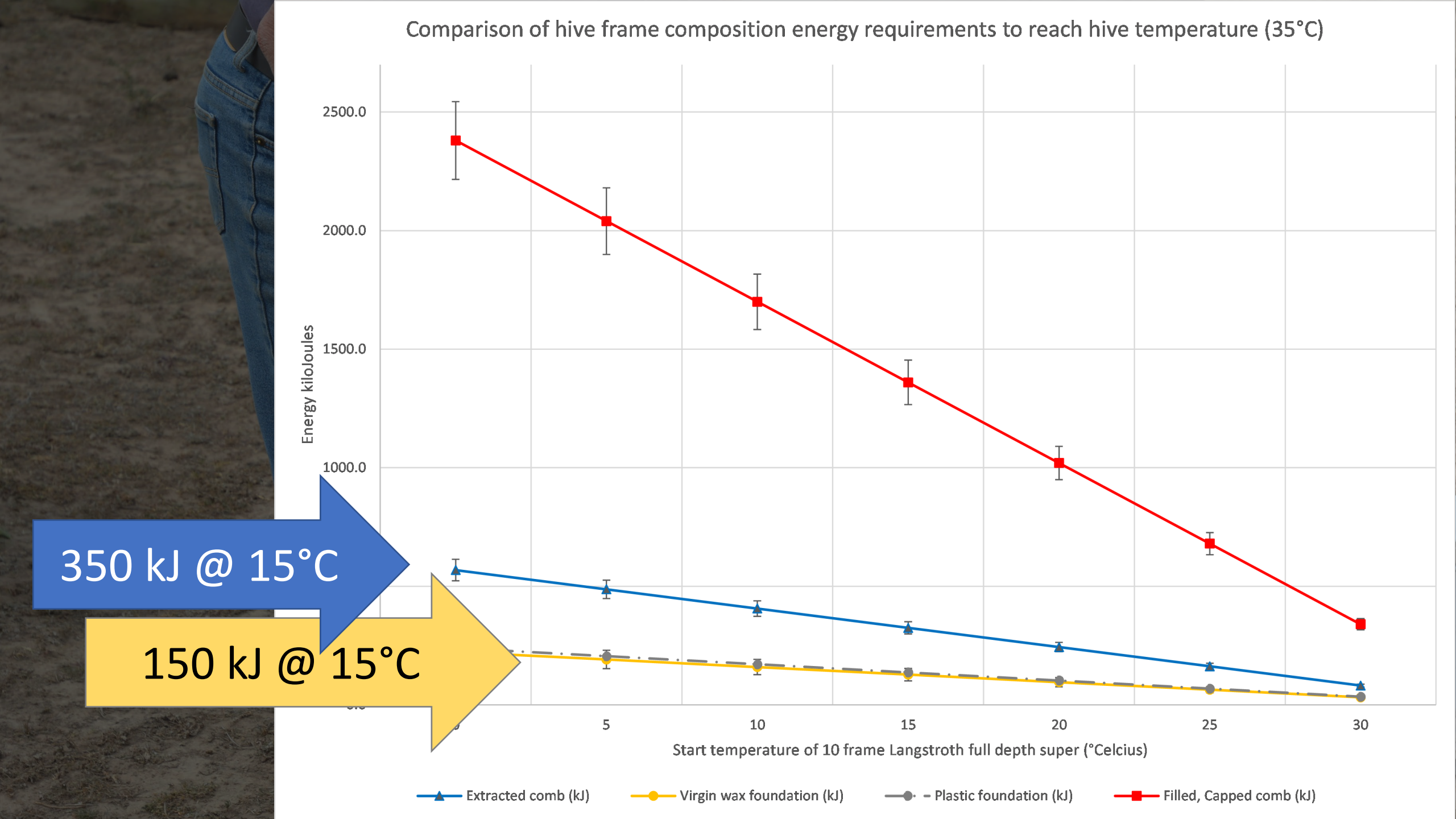
5
10
15
20
25
30
Start temperature of 10 frame Langstroth full depth super (°Celcius)
Extracted comb (kJ)
Virgin wax foundation (kJ)
Plastic foundation (kJ)
Filled, Capped comb (kJ)
150 kJ @ 15°C


350 kJ @ 15°C
150 kJ @ 15°C
Comparison of hive frame composition energy requirements to reach hive temperature (35°C)
Energy kiloJoules
2500.0
2000.0
1500.0
1000.0
5
10
15
20
25
30
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Virgin wax foundation (kJ)
Plastic foundation (kJ)
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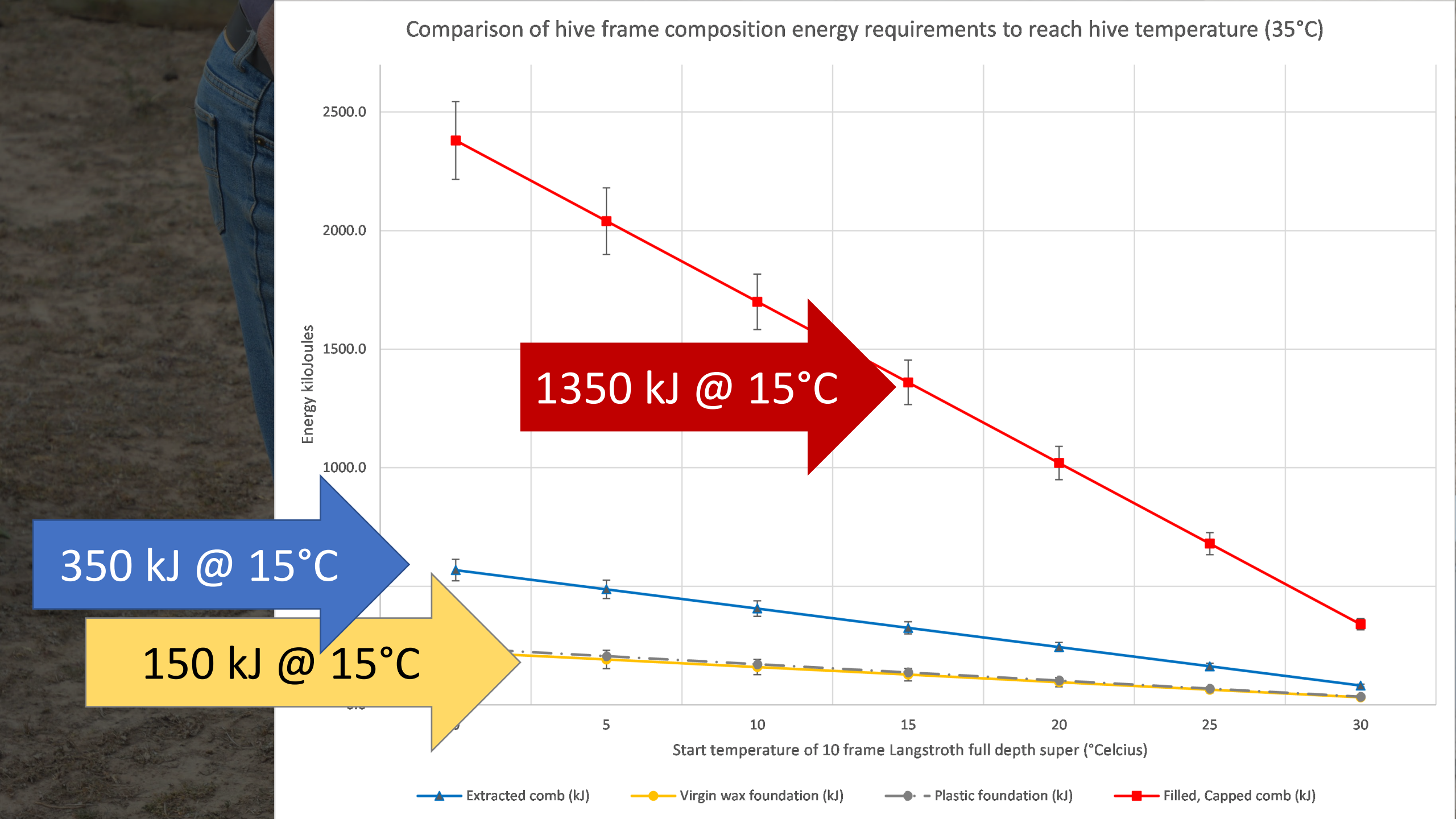

Comparison of hive frame composition energy requirements to reach hive temperature (35°C)
Energy kiloJoules
2500.0
2000.0
1500.0
1000.0
1350 kJ @ 15°C
350 kJ @ 15°C
150 kJ @ 15°C
5
10
15
20
25
30
Start temperature of 10 frame Langstroth full depth super (°Celcius)
Extracted comb (kJ)
Virgin wax foundation (kJ)
Plastic foundation (kJ)
Filled, Capped comb (kJ)

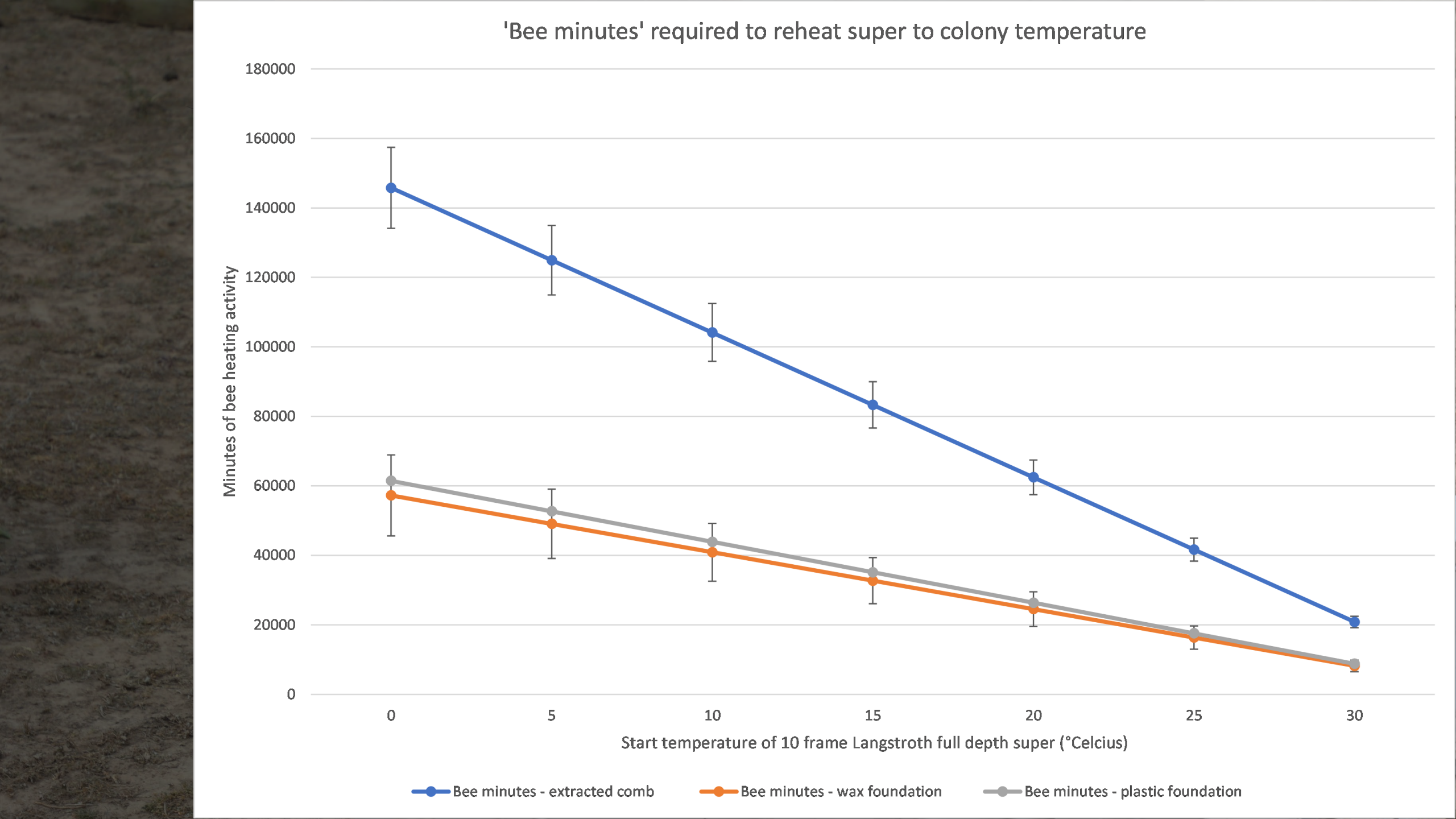
So, should I always use foundation?

No!

382MJ of energy to build fresh comb on wax foundation

That’s **283** times more energy than heating stickies!


65


'Bee minutes' required to reheat super to colony temperature
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Minutes of bee heating activity
0
5
10
15
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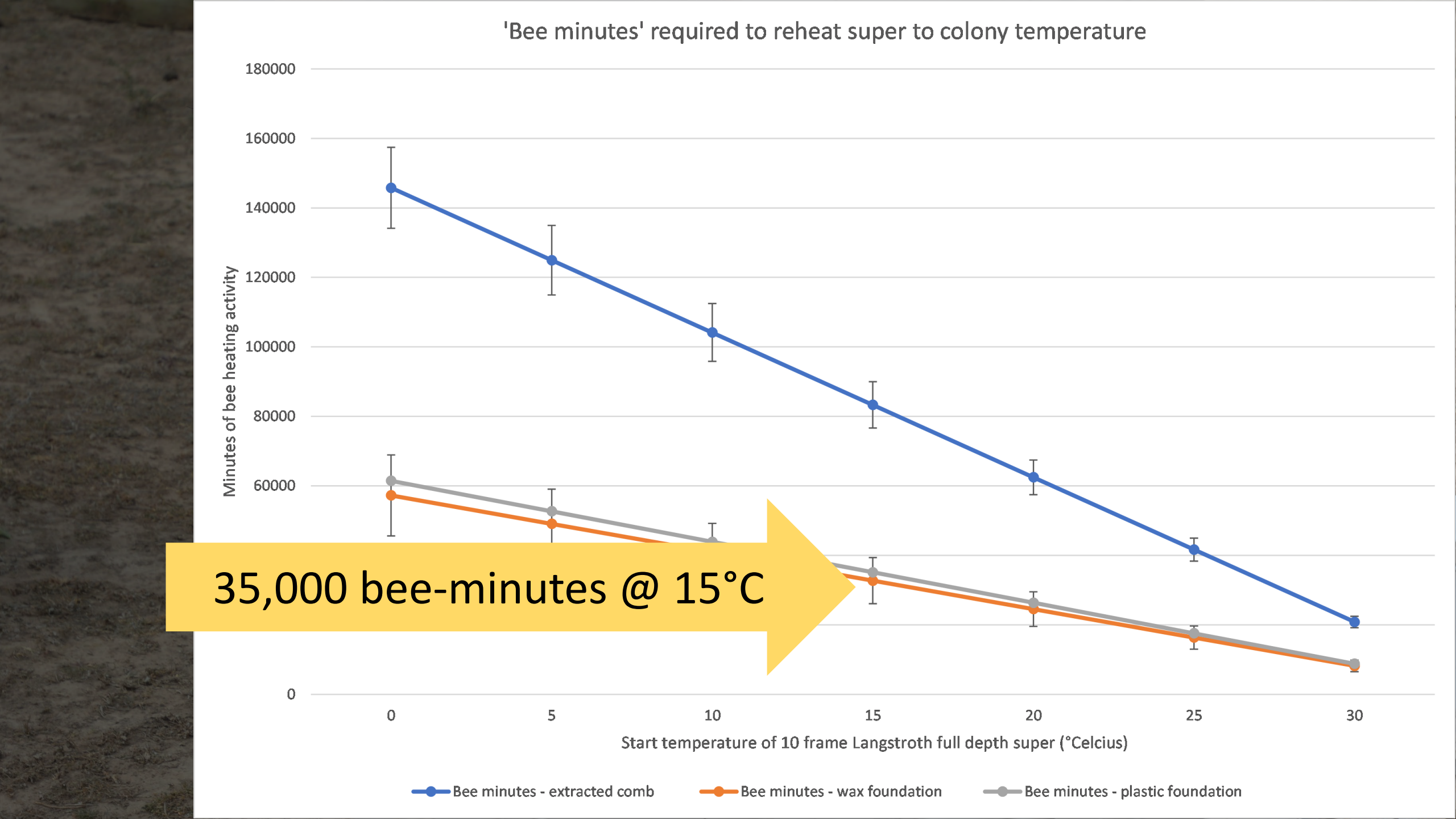
25
30
Start temperature of 10 frame Langstroth full depth super (°Celcius)
Bee minutes - extracted comb
Bee minutes - wax foundation
Bee minutes - plastic foundation


'Bee minutes' required to reheat super to colony temperature
180000
160000
140000
120000
100000
80000
60000
0
Minutes of bee heating activity
0
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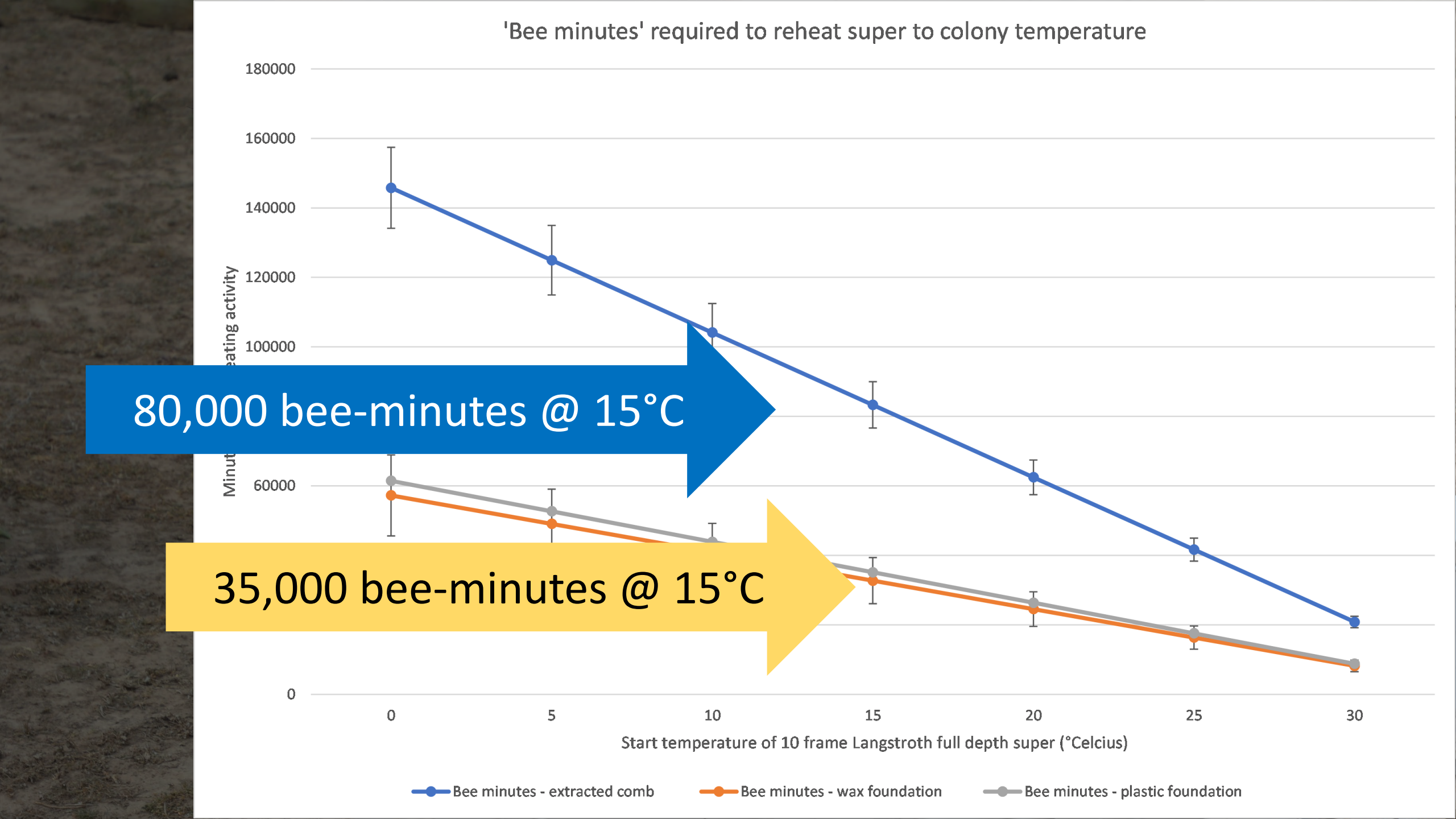
10
15
20
25
30
Start temperature of 10 frame Langstroth full depth super (°Celcius)
Bee minutes - extracted comb
Bee minutes - wax foundation
Bee minutes - plastic foundation
35,000 bee-minutes @ 15°C


'Bee minutes' required to reheat super to colony temperature
180000
160000
140000
120000
100000
60000
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5
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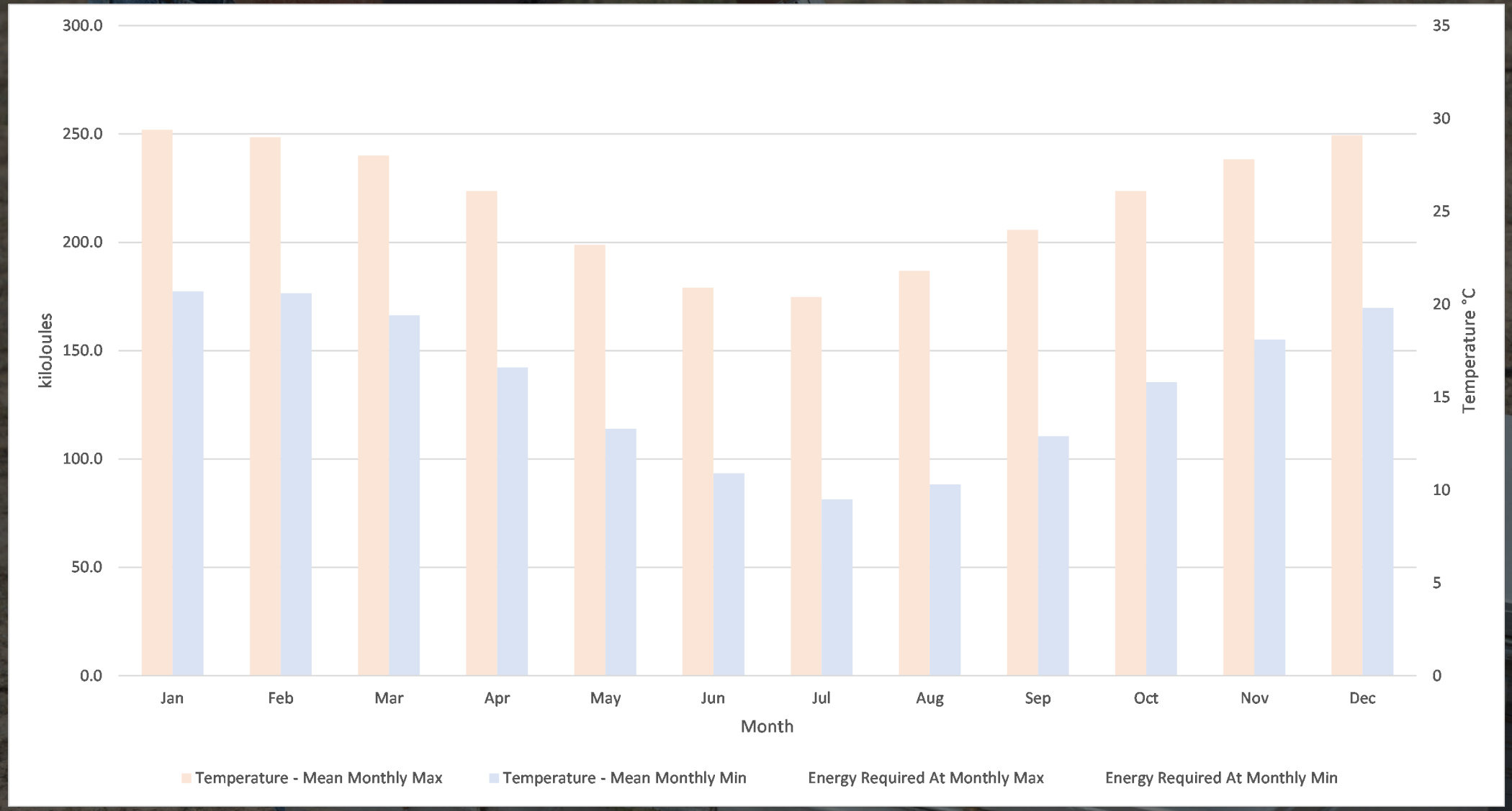
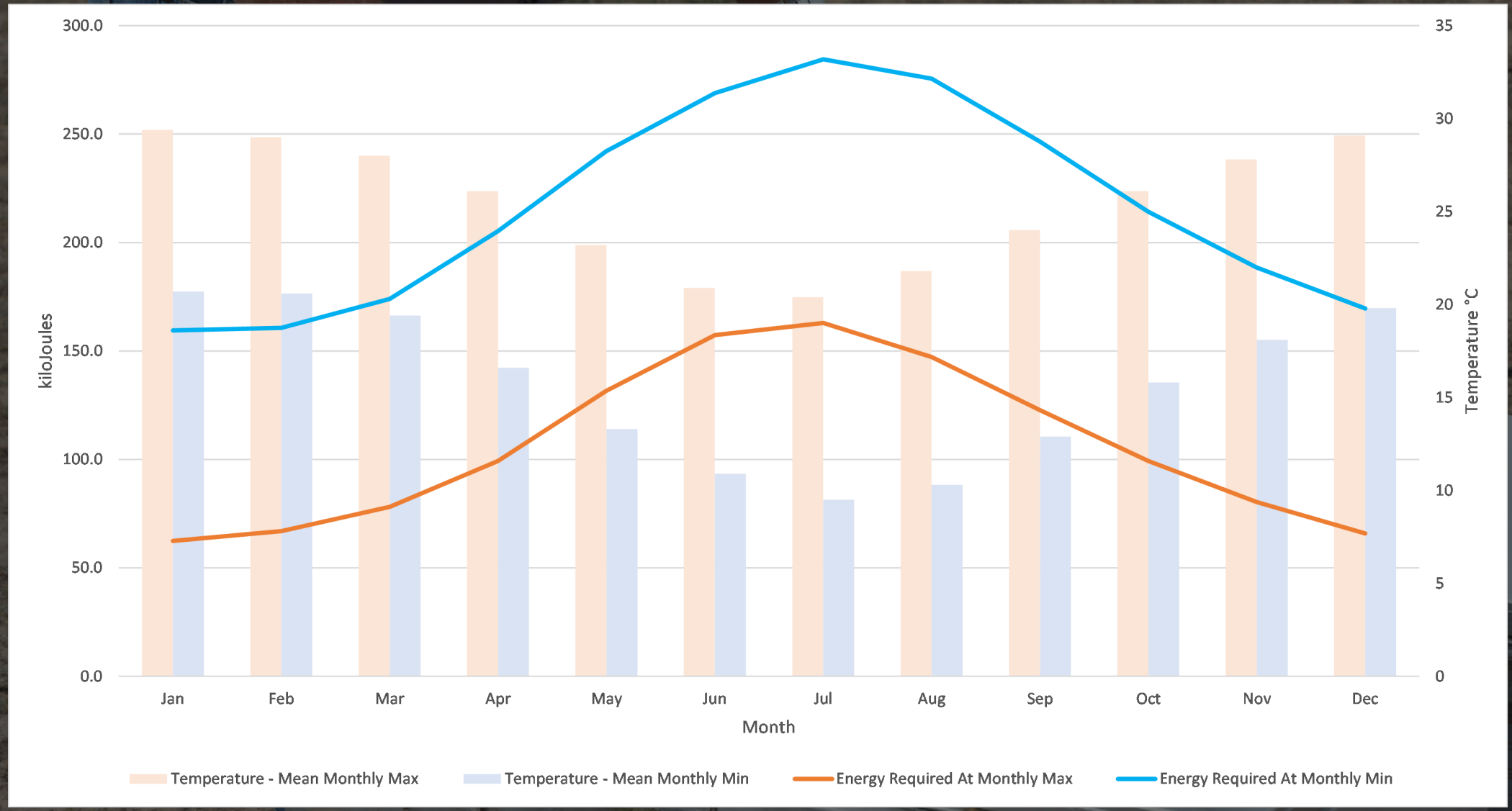
15
20
25
30
Start temperature of 10 frame Langstroth full depth super (°Celcius)
Bee minutes - extracted comb
Bee minutes - wax foundation
Bee minutes - plastic foundation
80,000 bee-minutes @ 15°C
35,000 bee-minutes @ 15°C

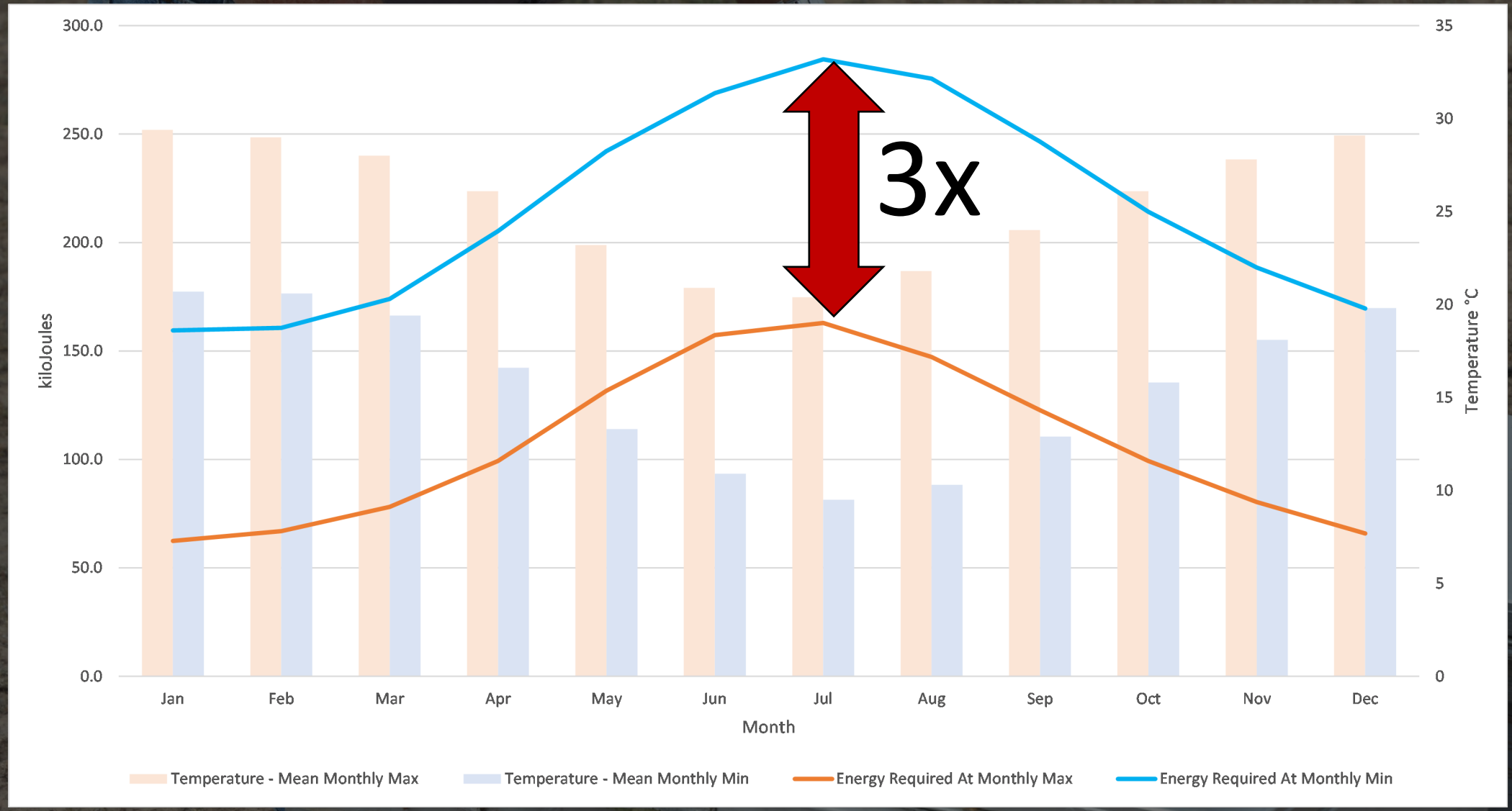
Real world application



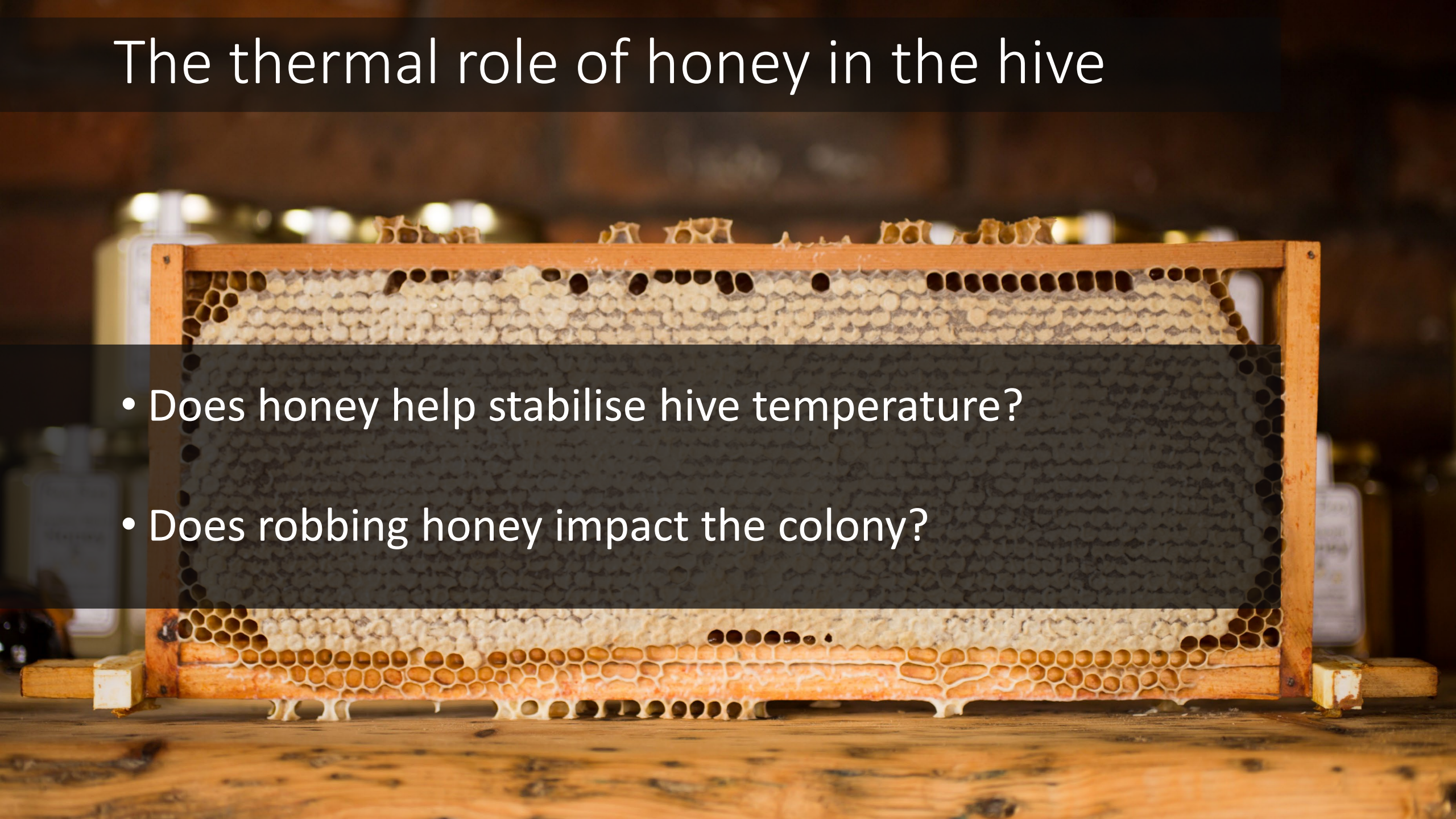
Real world application



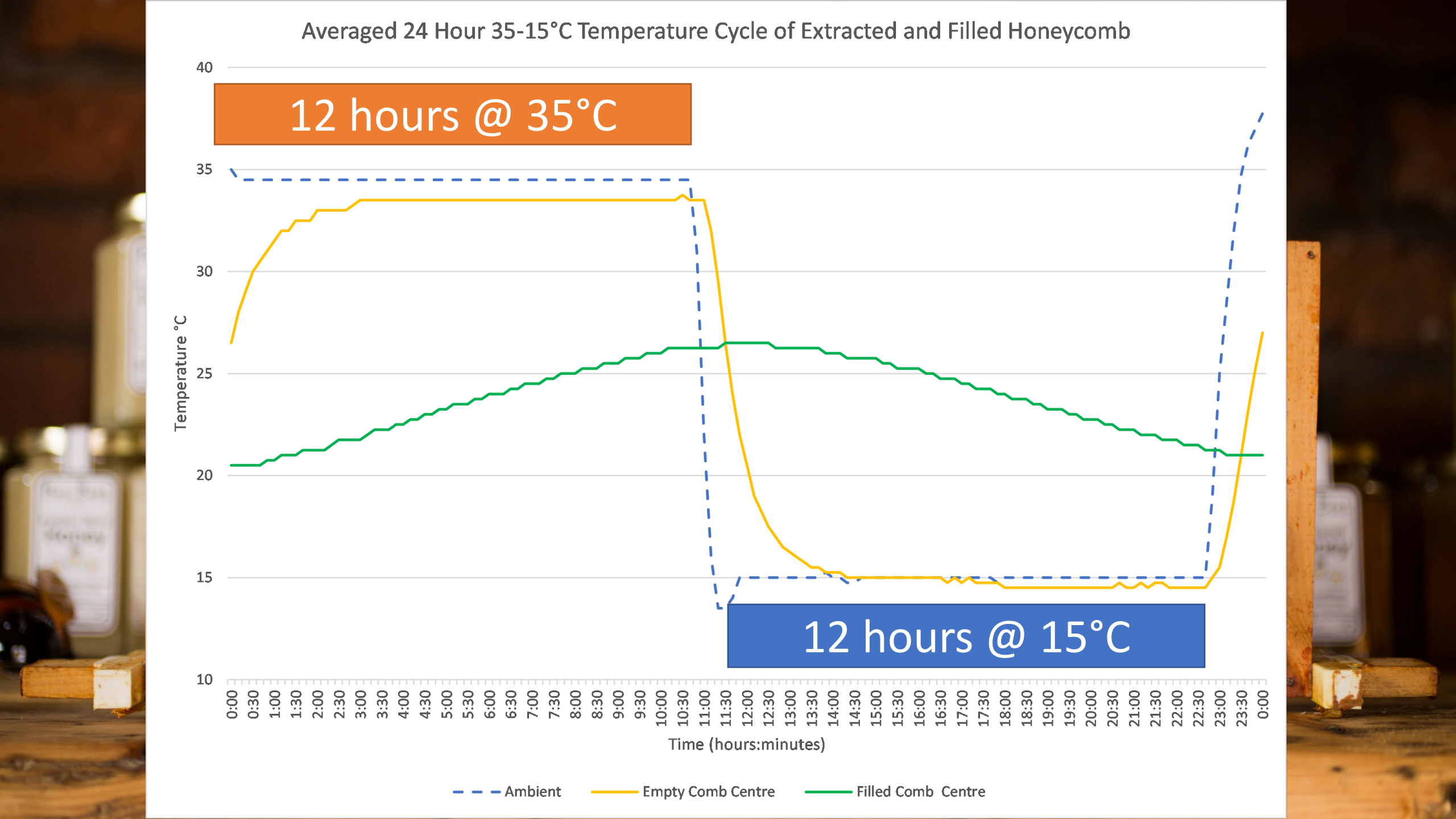
Real world application



The thermal role of honey in the hive



- Does honey help stabilise hive temperature?
- Does robbing honey impact the colony?


Averaged 24 Hour 35-15°C Temperature Cycle of Extracted and Filled Honeycomb
12 hours @ 35°C
12 hours @ 15°C
Temperature °C
40
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30
25
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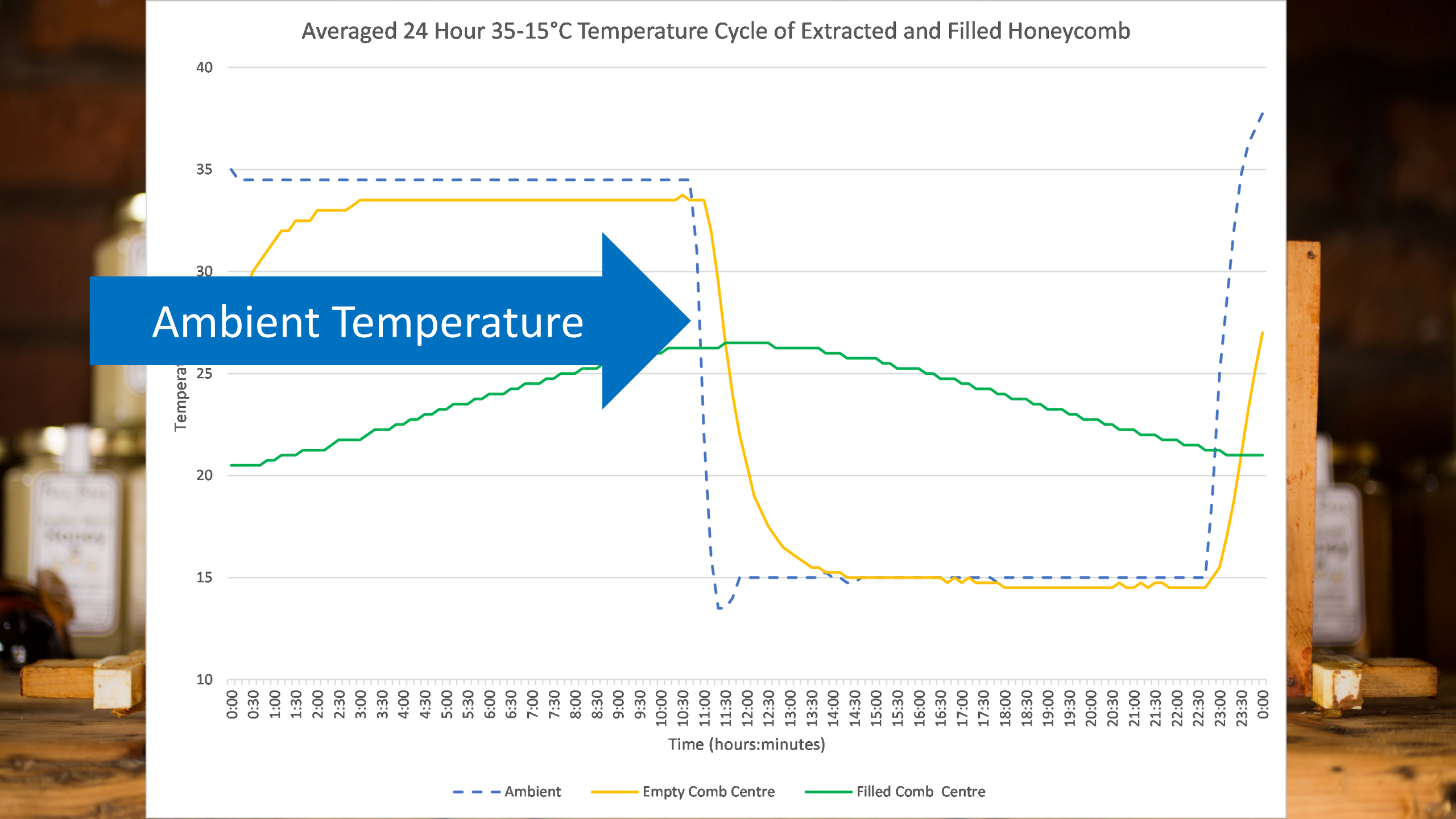
Time (hours:minutes)
Ambient
Empty Comb Centre
Filled Comb Centre


Averaged 24 Hour 35-15°C Temperature Cycle of Extracted and Filled Honeycomb
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Ambient Temperature
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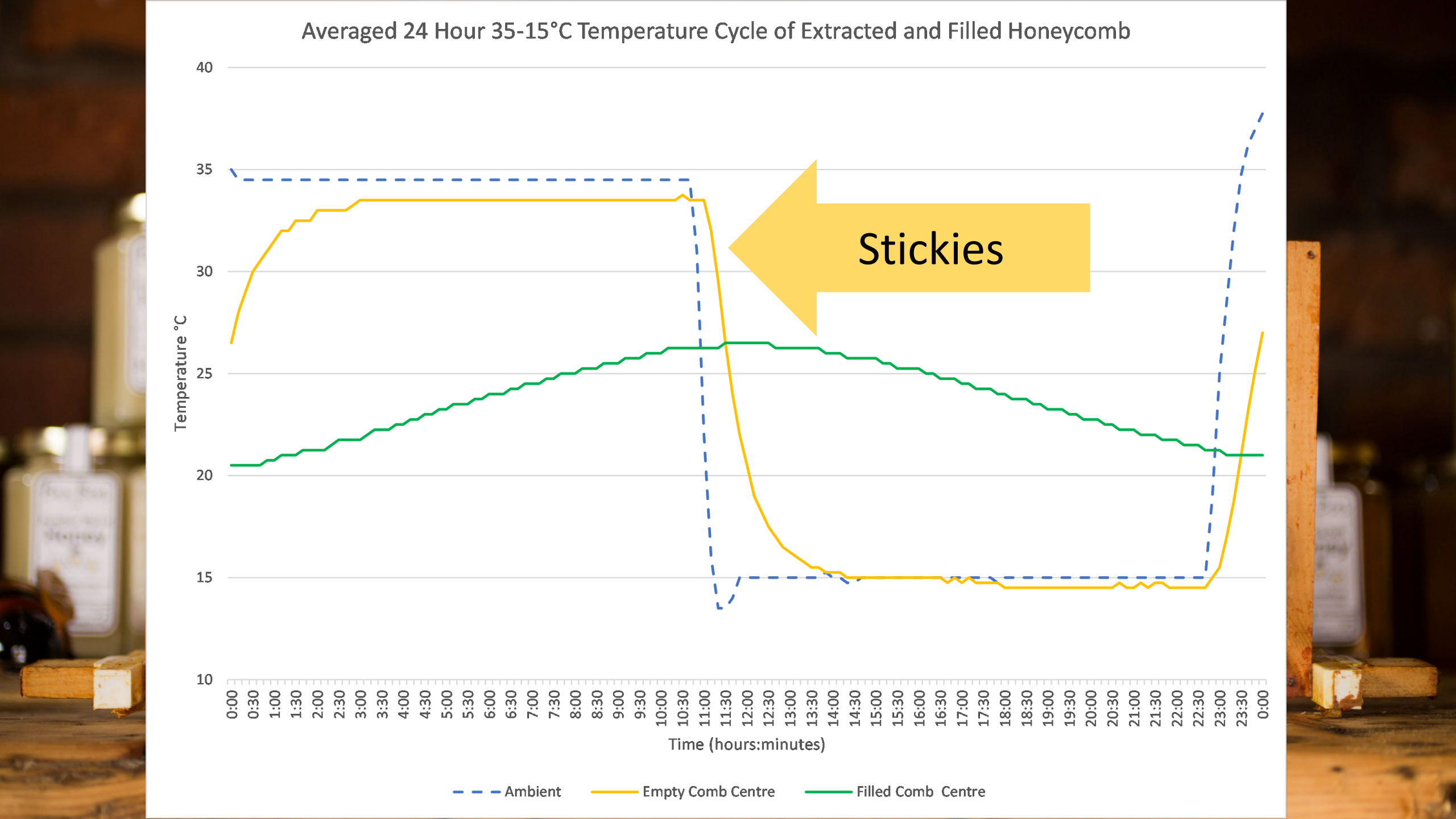
Time (hours:minutes)
Ambient
Empty Comb Centre
Filled Comb Centre


Averaged 24 Hour 35-15°C Temperature Cycle of Extracted and Filled Honeycomb
Stickies
Temperature °C
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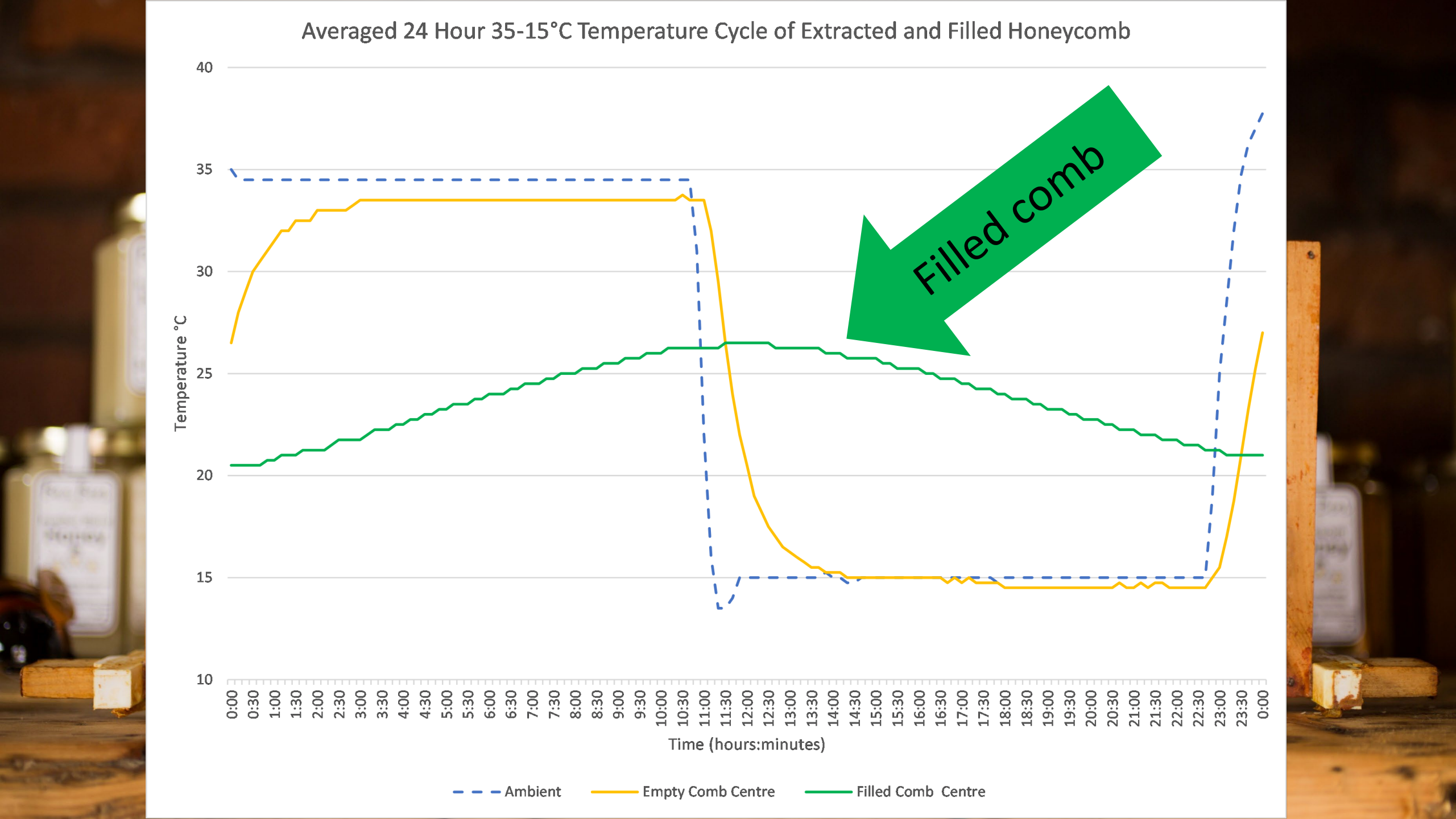
Time (hours:minutes)
Ambient
Empty Comb Centre
Filled Comb Centre


Averaged 24 Hour 35-15°C Temperature Cycle of Extracted and Filled Honeycomb
Filled comb
Temperature °C
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23:30
0:00
Time (hours:minutes)
Ambient
Empty Comb Centre
Filled Comb Centre

The thermal role of honey in the hive

- Does honey help stabilise hive temperature?
  Yes!
- Acts as thermal mass
  - Temperature rate of change is just *4%* of ambient.
  - Provides thermal hysteresis
- Absorbs excess heat
- Releases heat during temperature drop

The thermal role of honey in the hive

- Does robbing honey impact the hive? **Very Likely!**
- More temperature variation means more…
  - Heating activity in the cold
  - Fanning activity in the heat
  - Workers managing temperature, not foraging

The Langstroth Hive

1870’s

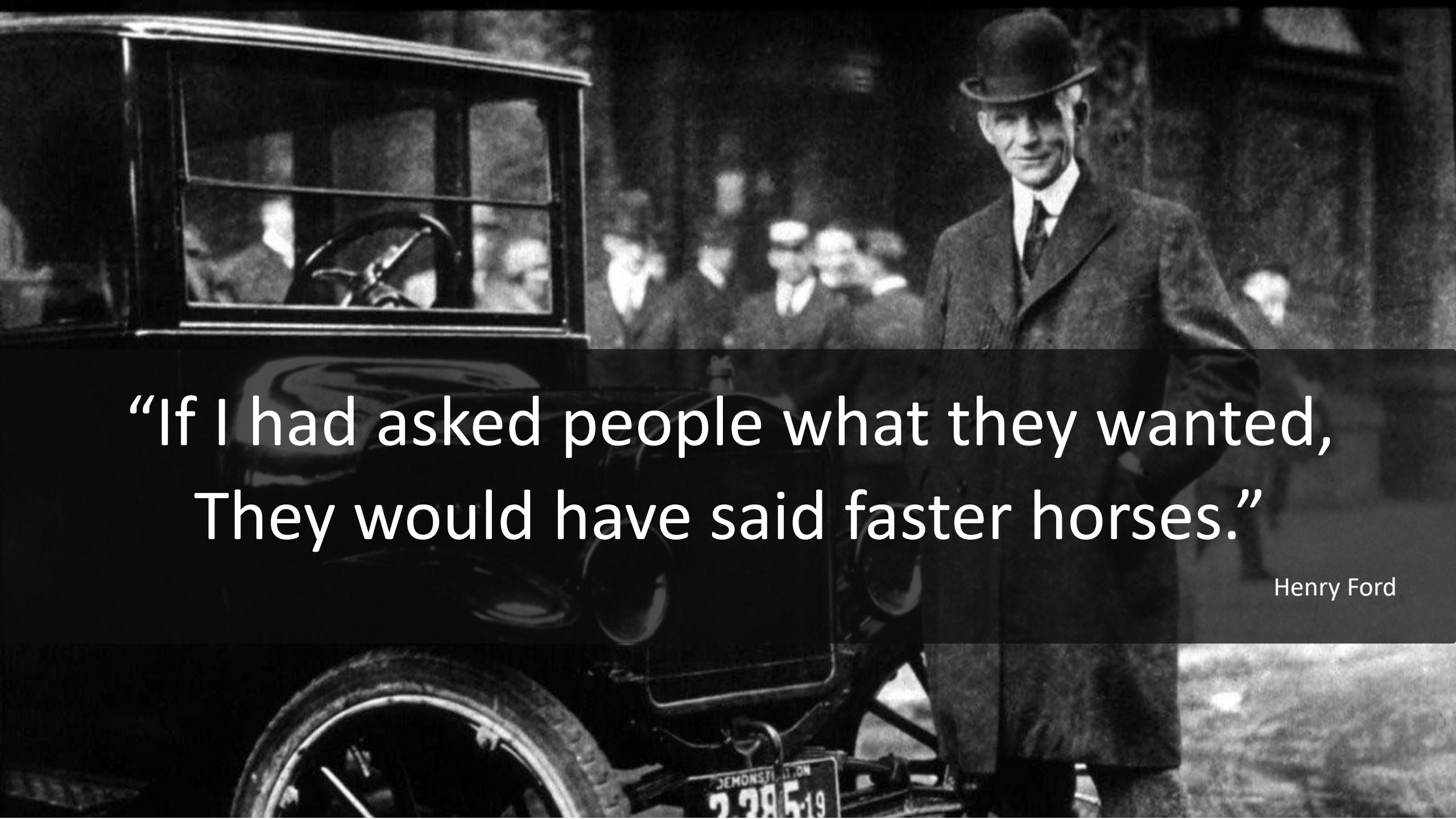
Lorenzo Langstroth. American Philosophical Society (n.d.)

1870's

Danielle Meiners (2010). Agricultural History of Williston

2019

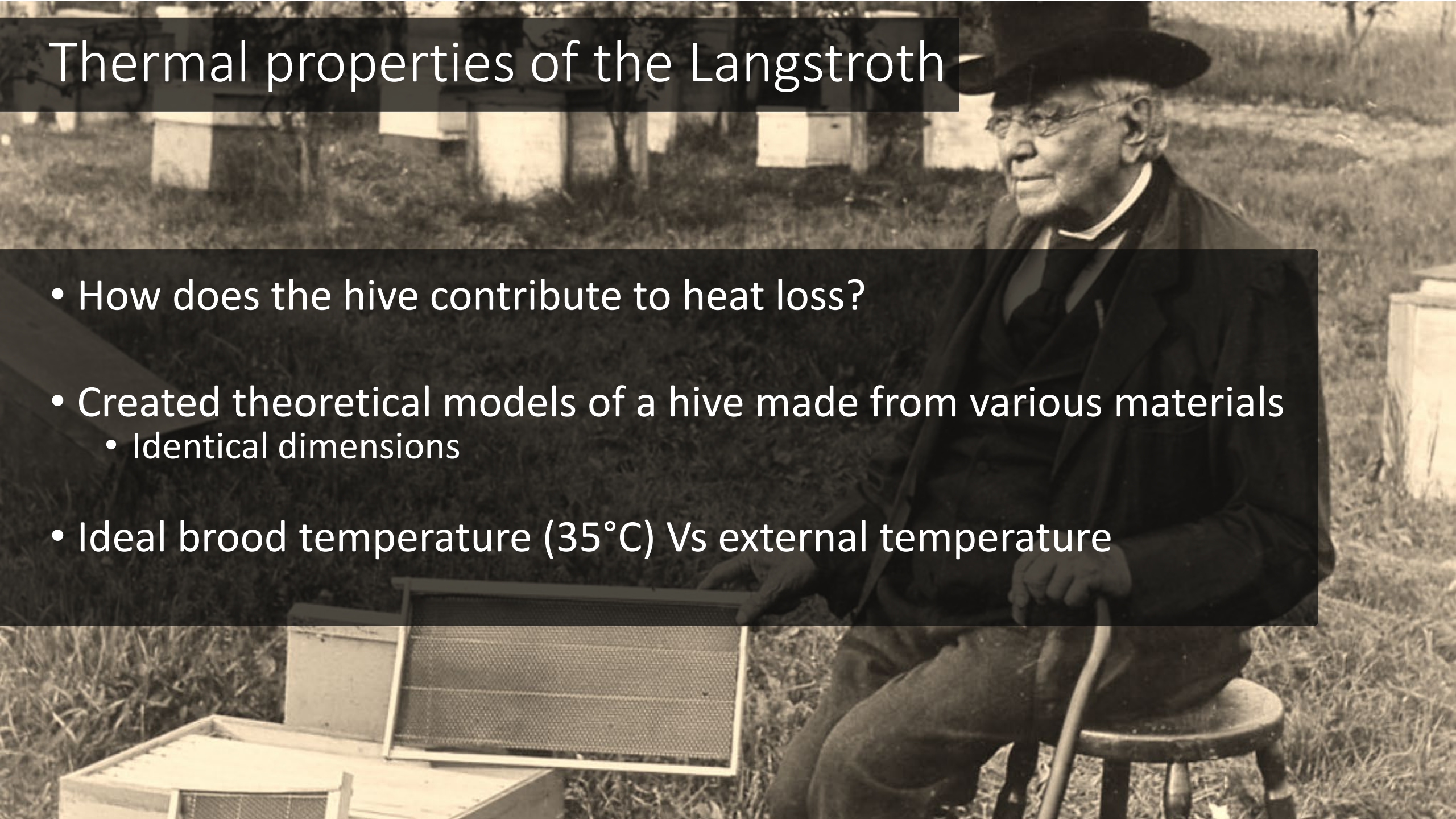
Dairy Farming: Automatic Milking Stall Module DairyProQ. Sebastian Bathen (2014).



"If I had asked people what they wanted,
They would have said faster horses."

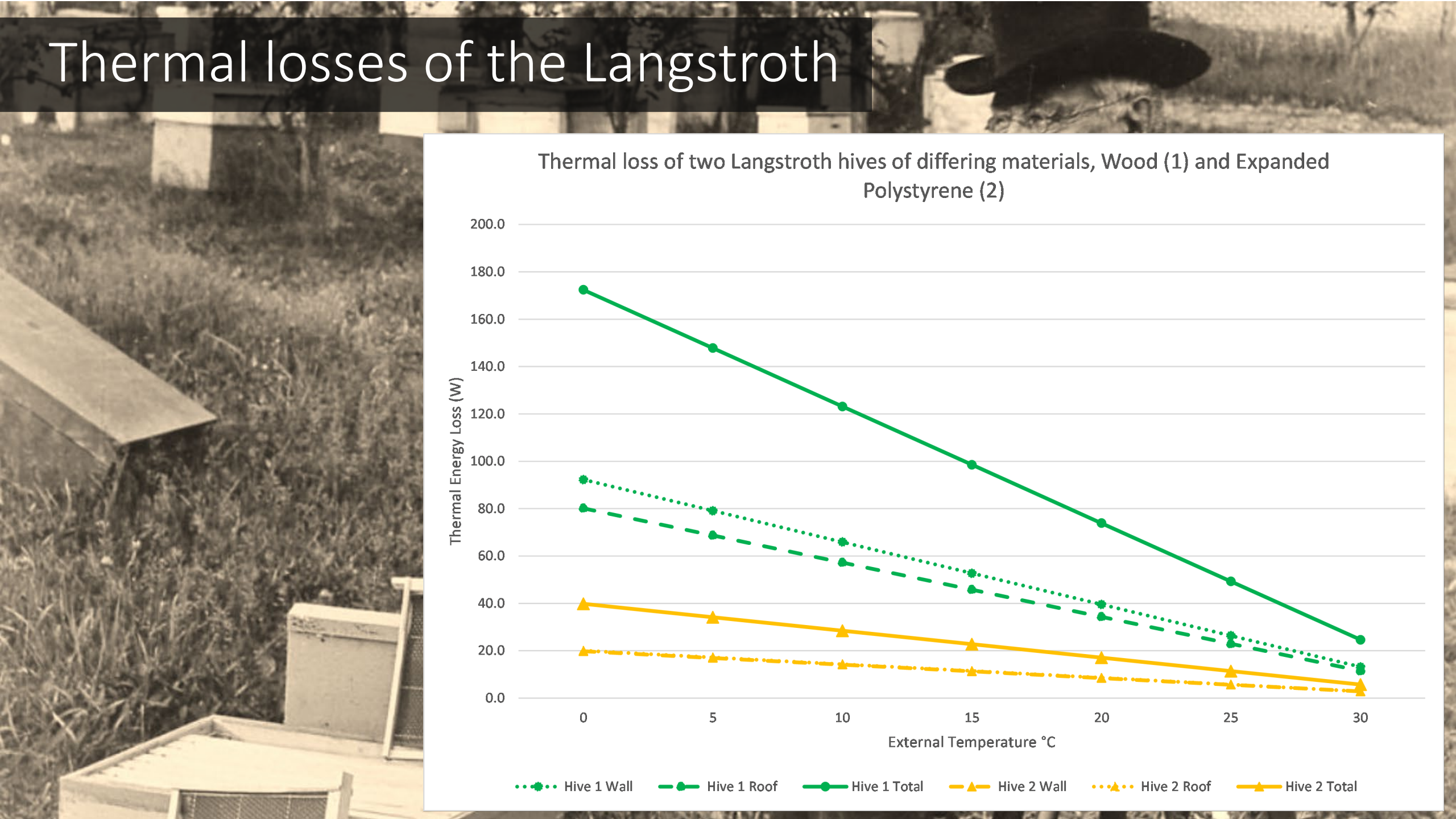
Henry Ford

Thermal properties of the Langstroth



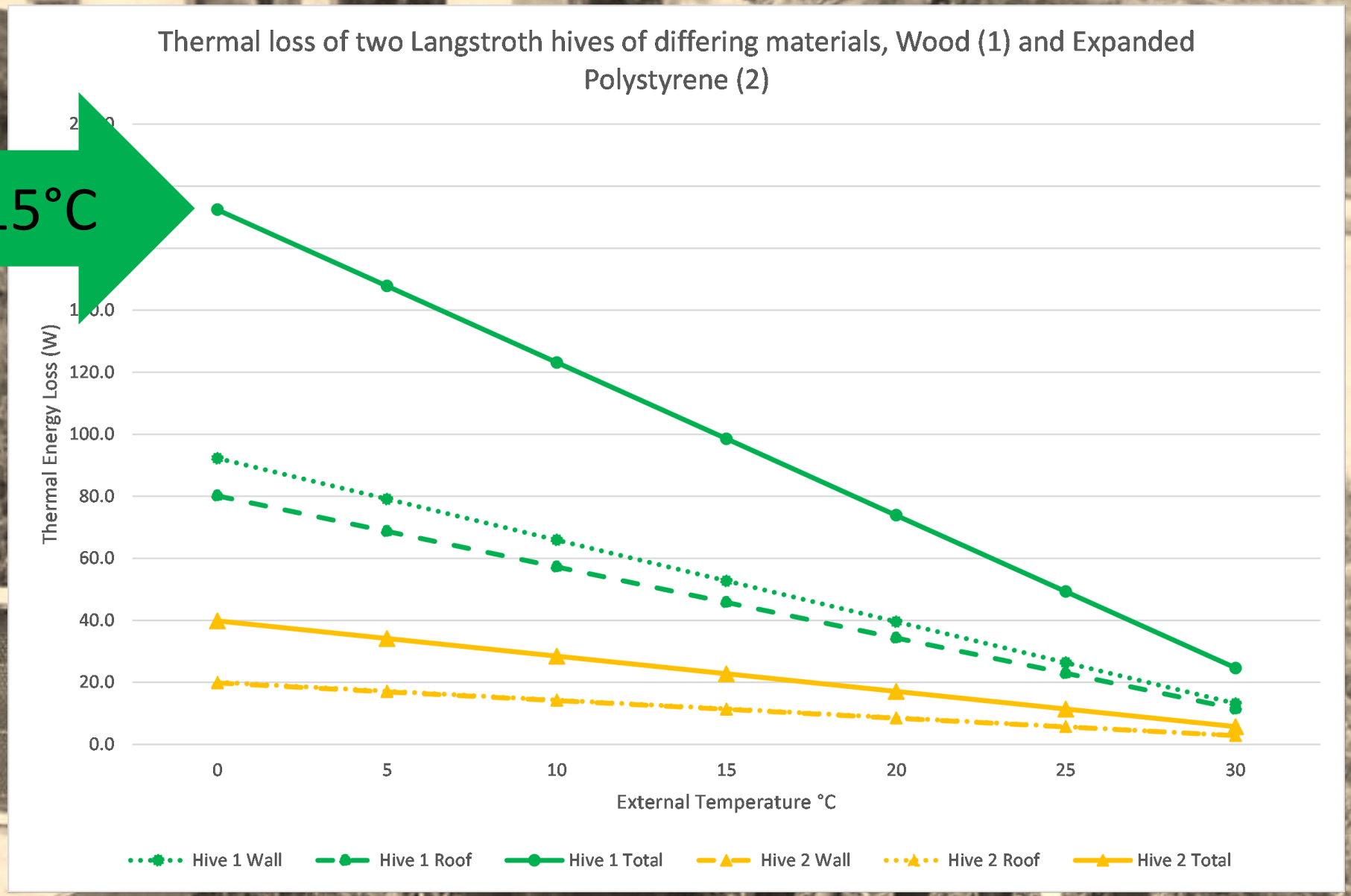
- How does the hive contribute to heat loss?
- Created theoretical models of a hive made from various materials
  - Identical dimensions
- Ideal brood temperature (35°C) Vs external temperature

Thermal losses of the Langstroth



Thermal losses of the Langstroth

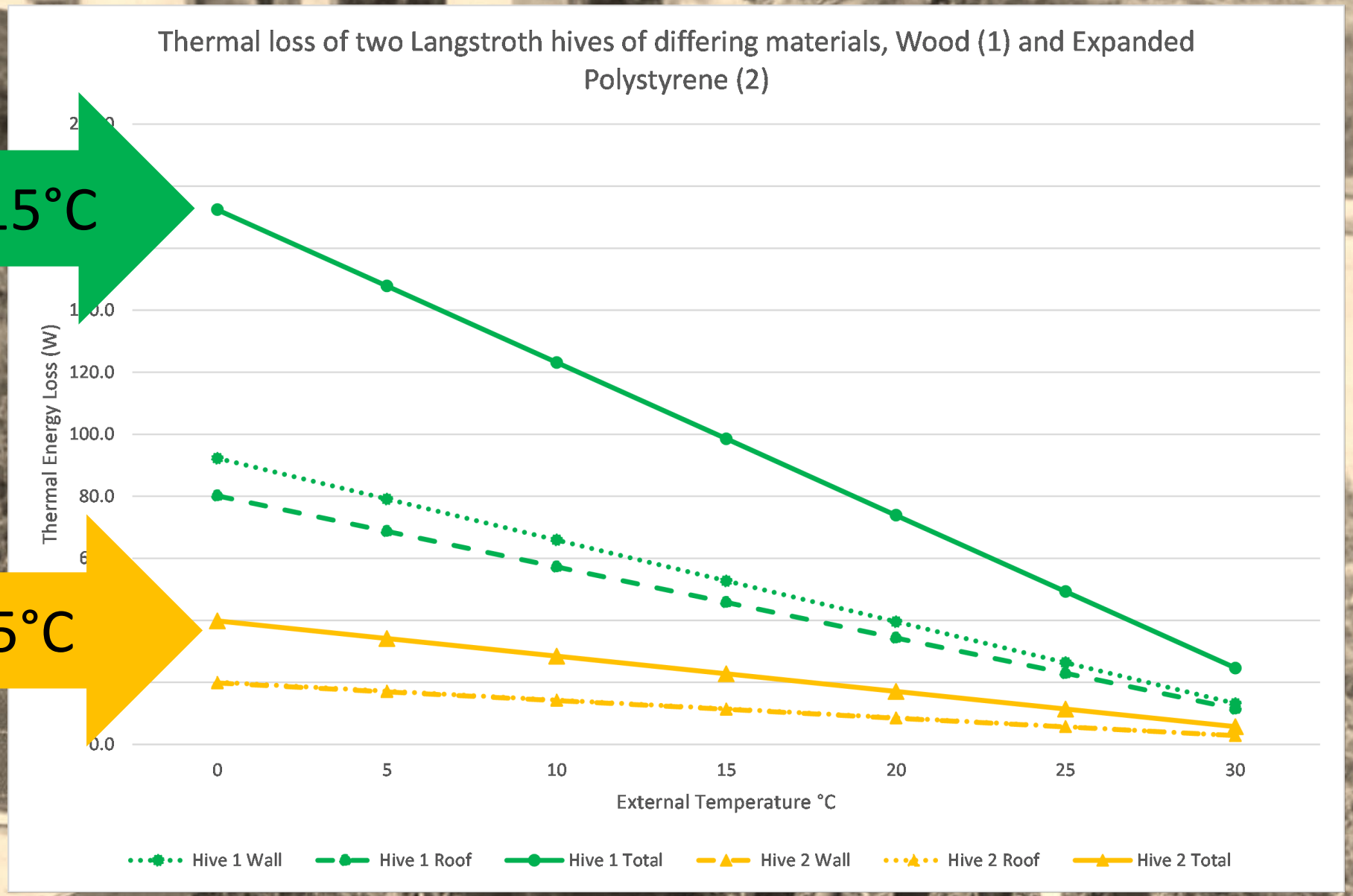
Wood: 95W @ 15°C



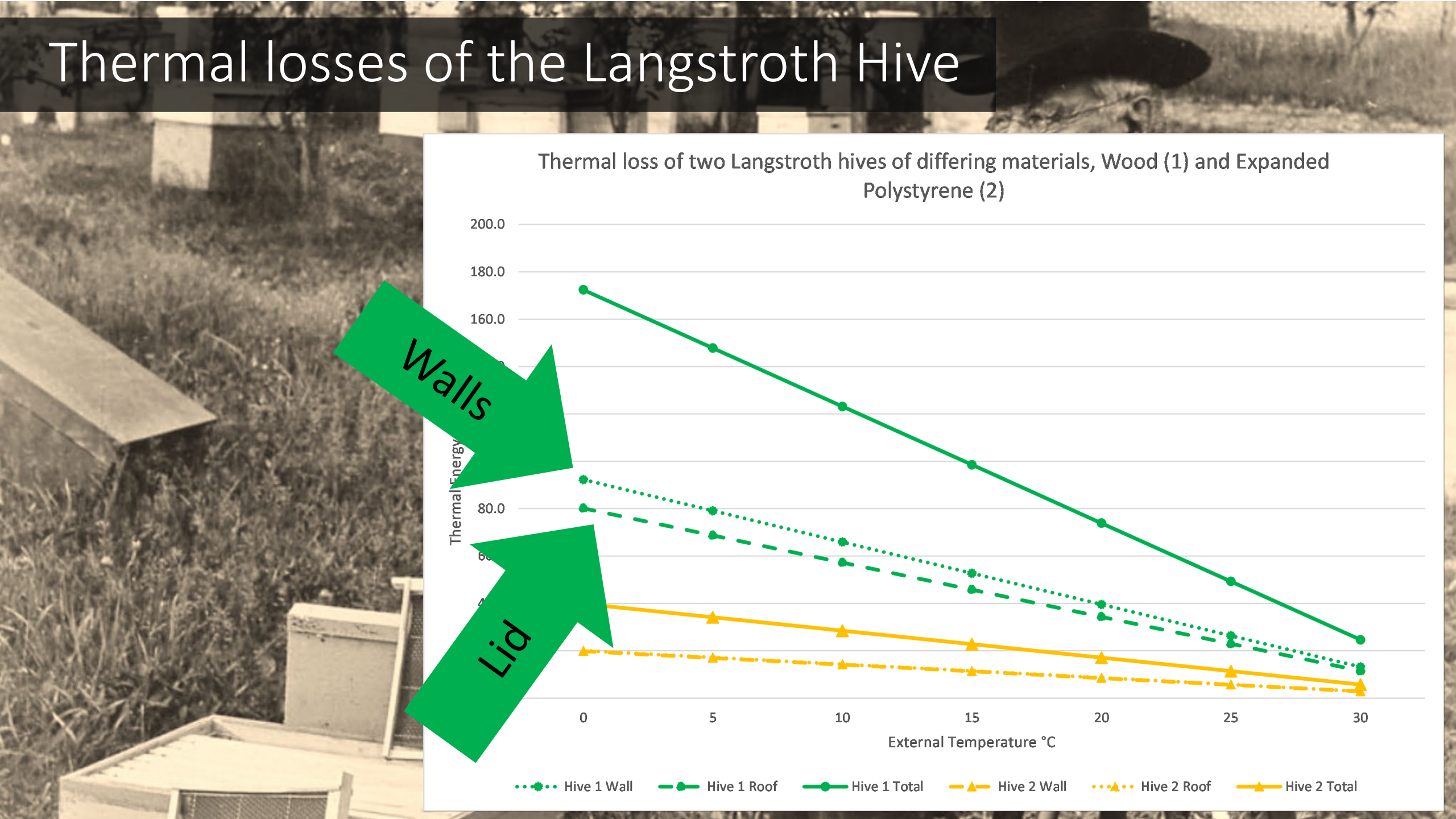
Thermal losses of the Langstroth Hive

Wood: 95W @ 15°C

EPS: 23W @ 15°C



Thermal losses of the Langstroth Hive



Design of the Langstroth

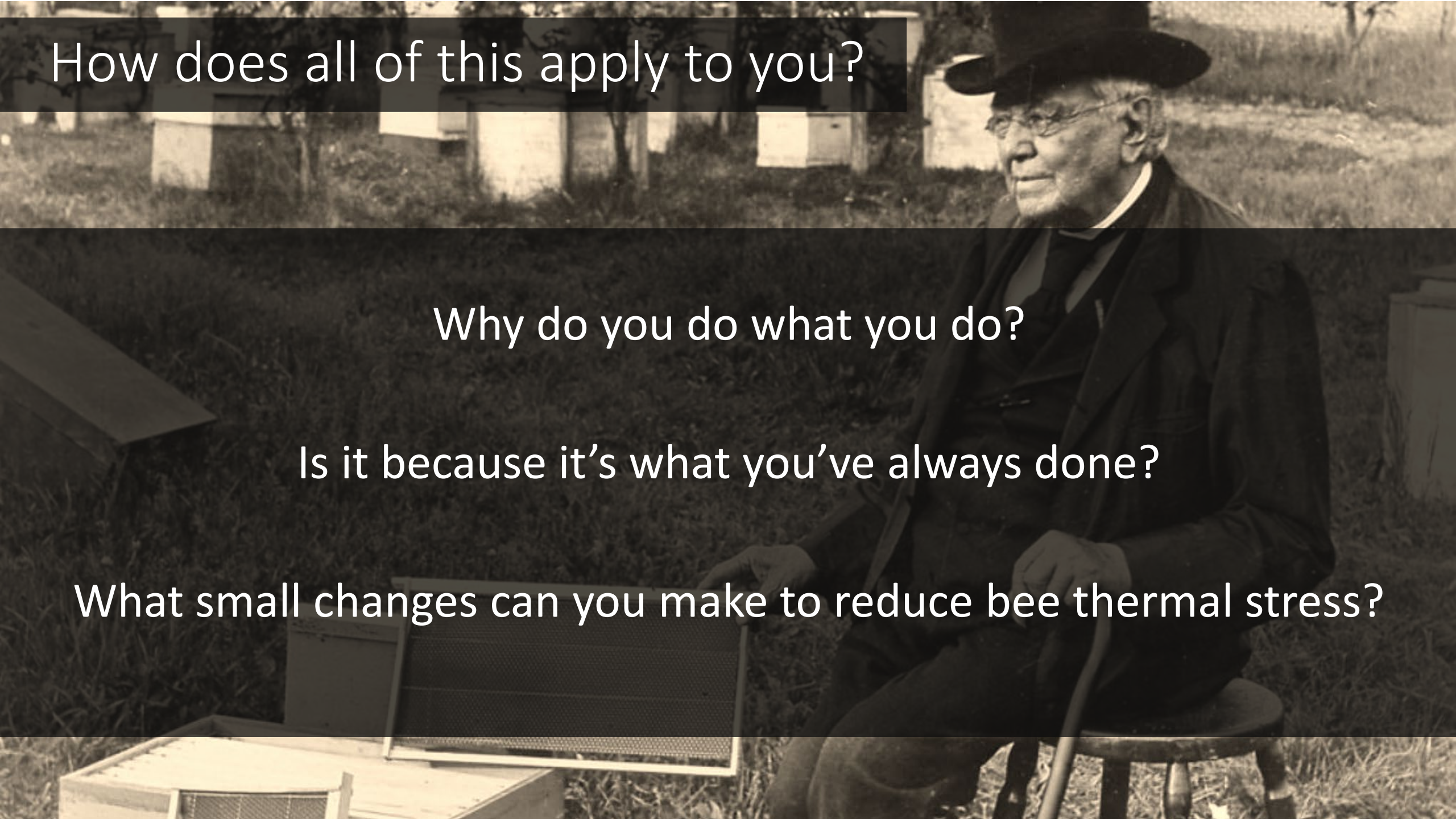
Improve one thing on the Langstroth right now…

Lid insulation

Better lids = *Less* energy loss = *less* colony stress = healthier bees

How does all of this apply to you?

How does all of this apply to you?



Why do you do what you do?

Is it because it’s what you’ve always done?

What small changes can you make to reduce bee thermal stress?

Questions?

Image References

- Lightbulb Photo by **Wilson Vitorino** from **Pexels**
- Question Mark Photo by Matt Walsh on Unsplash
- What now? Photo by Tim Mossholder on Unsplash
- Bee Photo by leandro fregoni on Unsplash
- Heater bees Image todayifoundout (2012). HOW HONEY BEES KEEP THEIR HIVES WARM GIVEN THAT THEY ARE COLD BLOODED. Retrieved from http://www.todayifoundout.com/index.php/2012/06/how-honey-bees-keep-their-hives-warm-given-that-they-are-cold-blooded/
- FLIR background: Teledyne FLIR (2019) Retrieved from https://www.flir.com.au/discover/professional-tools/saving-beehives-with-flir-thermal-cameras/
- Power Pylons Photo by Matthew Henry on Unsplash
- brood frame Photo by Bianca Ackermann on Unsplash
- Honeycomb frame Photo by Jonathan Farber on Unsplash