



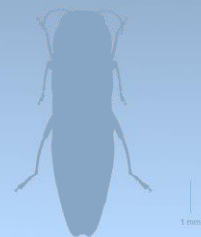
Meghan Noseworthy  
Research Manager



Chris MacQuarrie  
Research Scientist

# CT-Scan Detection and Heat Treatment of *Agrilus* spp.: Towards Efficient and Sustainable Phytosanitary Measures

Véronique Martel, Meghan Noseworthy, Chris MacQuarrie



*Duprestidae Agrilus anxius*



Ressources naturelles  
Canada

Natural Resources  
Canada

Canadian Forest Service

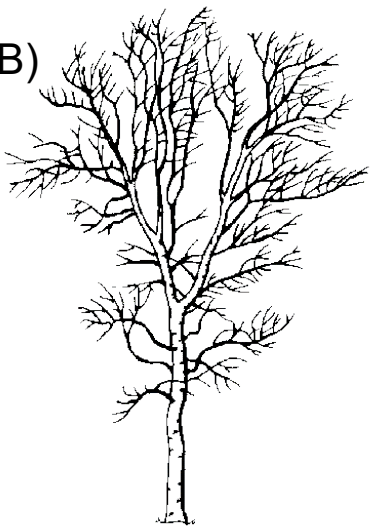
Canada

# *Agrilus* species in North America



*Agrilus anxius*

Bronze Birch Borer (BBB)



**Native**

Tree defense

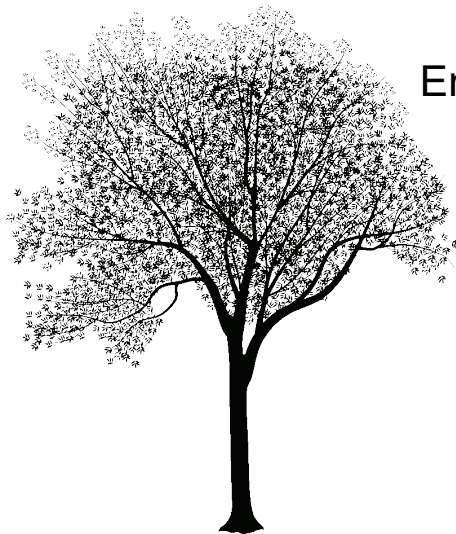


> Natural enemies

Wood Product Exportation!

*Agrilus planipennis*

Emerald Ash Borer (EAB)



**Exotic**

Low tree defense



Few natural enemies

(Classical biocontrol)



# Plan of presentation

- Tomodensitometry as a Tool to Detect and Study Two *Agrilus* (Coleoptera: Buprestidae) Species
  - Martel *et al.* 2022
- Reducing Pest Risk in Birch Wood Products—The Effective Heat Treatment for Bronze Birch Borer *Agrilus anxius* (Coleoptera: Buprestidae) Prepupae
  - Noseworthy *et al.* 2025





# Tomodensitometry as a detection method for *Agrilus* species

Véronique Martel, Sébastien Bélanger, Robert Lavallée, Christian Hébert

*Agrilus anxius*

Bronze Birch Borer (BBB)



*Agrilus planipennis*

Emerald Ash Borer (EAB)

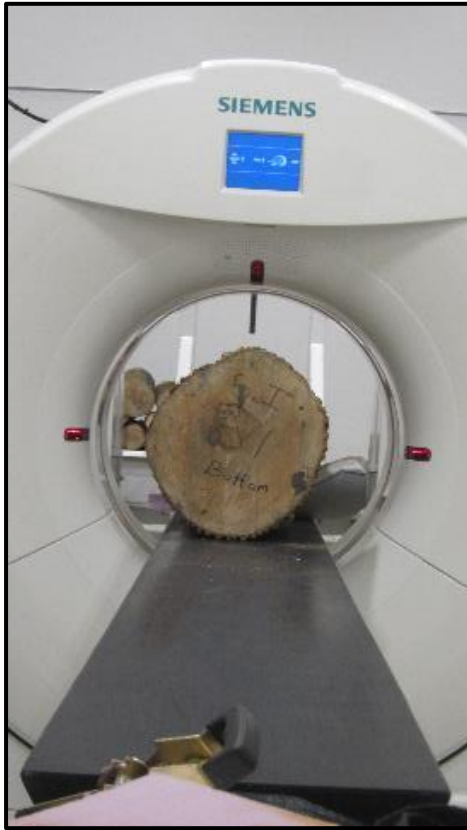
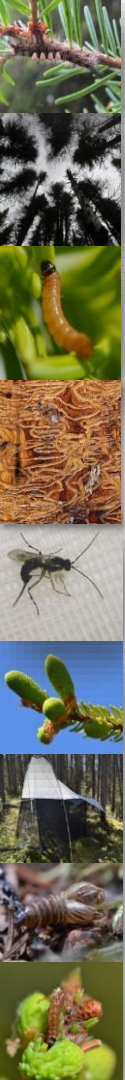


1. Can we detect immatures with CT-scan?
2. Compare efficiency/efficacy of CT-scan and debarking
3. Measure the immatures' depth under the bark



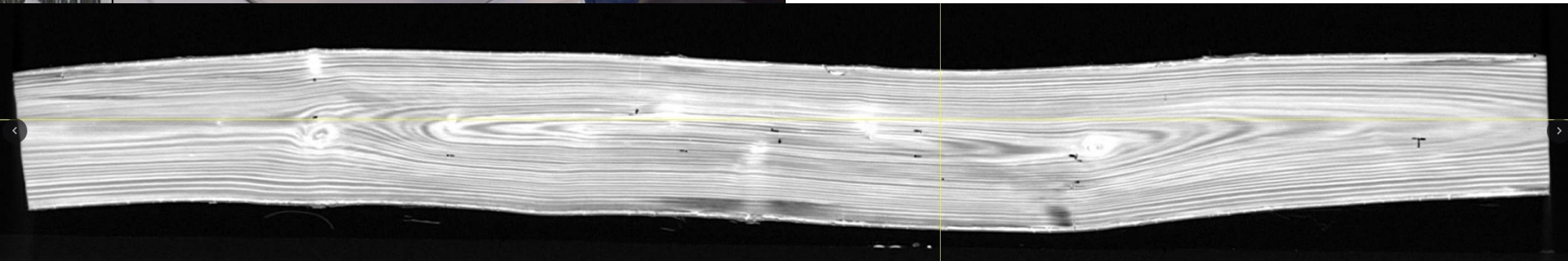
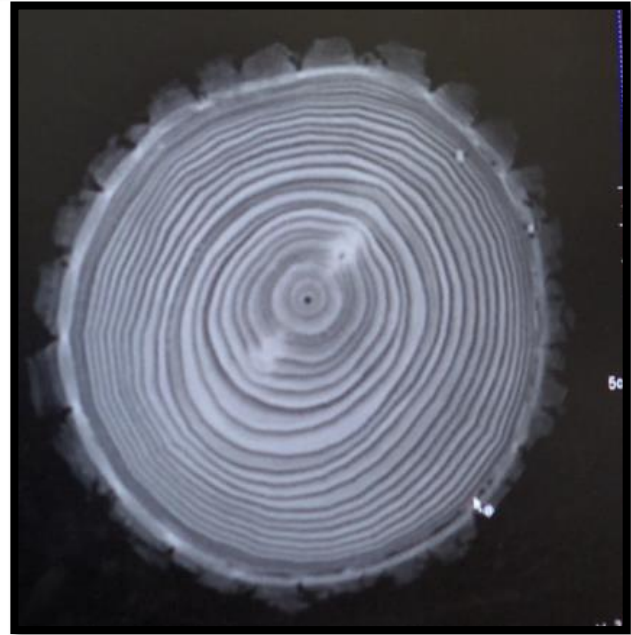
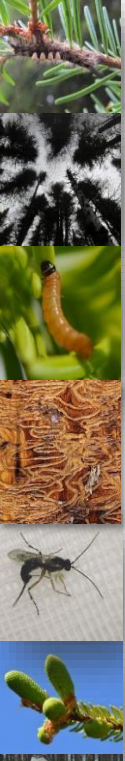


# Tomodensitometry - Methodology



- Used for medical purposes
- Several research applications:
  - Entomology
  - Archeology
  - Geology
- X-rays produce transversal images
  - Can build longitudinal images

# Tomodensitometry - Methodology

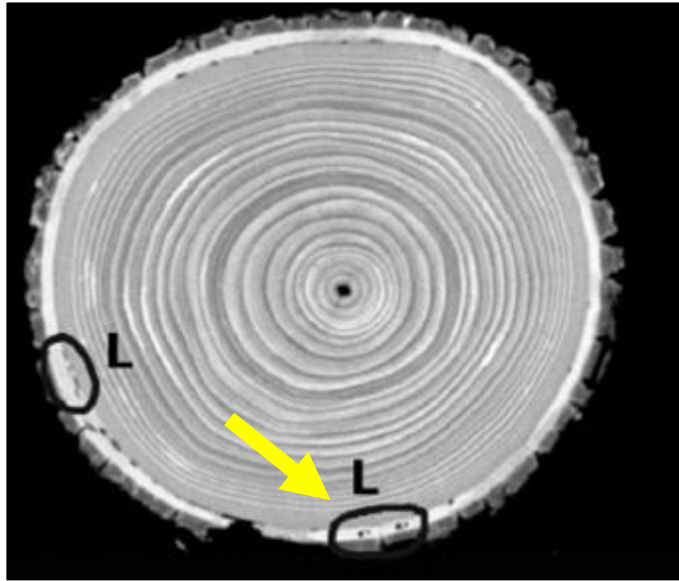




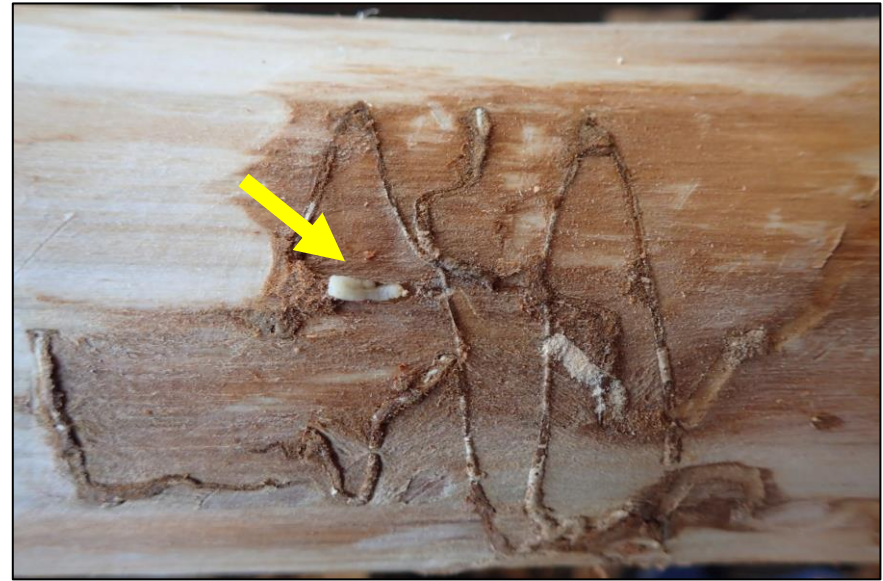


# Tomodensitometry – Comparison of methods

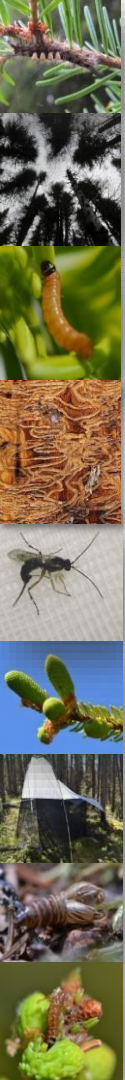
Counting the number of larvae/prepupae per sample



CT-scan



Debarking





# Tomodensitometry - Comparison of methods

EFFICACY

Tree species	No of <i>Agrilus</i>	
	CT-Scan	Debarking
Ash (n=130)	1490	1625
Yellow Birch (n=3)	326	426
Paper Birch (n=36)	166	167

 New data!



**EAB in Ash**  
**Diameter:  $P < 0.01$**   
 Method: ns  
 Diameter\*Method: ns

**BBB in Paper and Yellow Birch**  
 Diameter:  $P < 0.01$   
 Method:  $P < 0.01$   
**Diameter\*Method:  $P < 0.01$**

CT-Scan detects more insects in small diameters;  
 Debarking detects more insects in large diameter



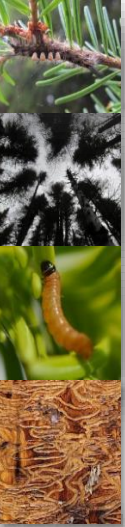
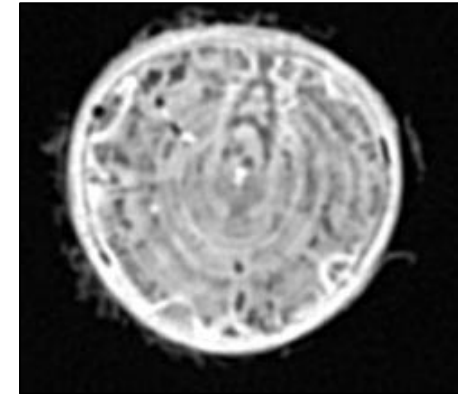
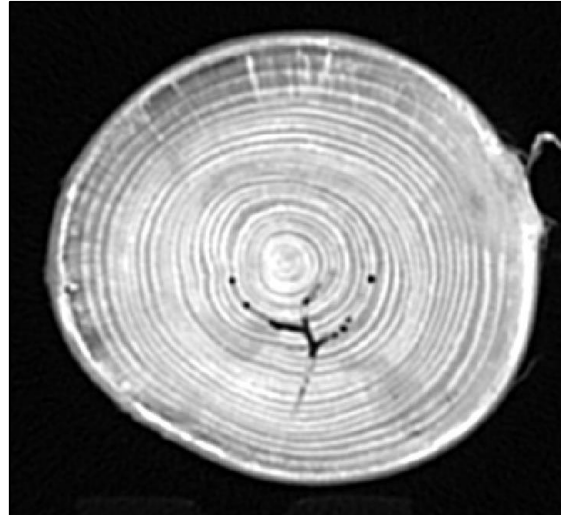
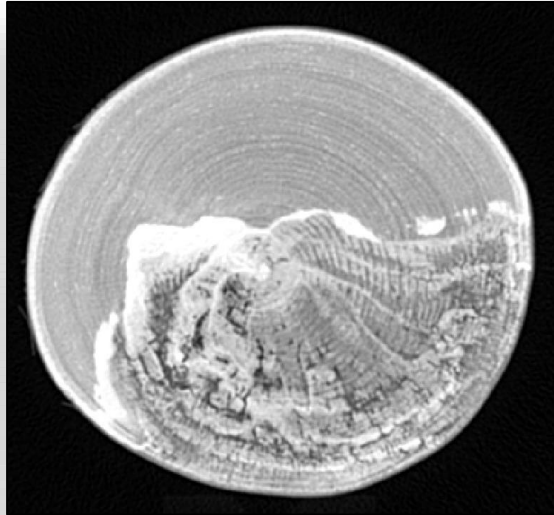


# Tomodensitometry - Comparison of methods



- Small samples dried between scanning and debarking
- Predators found when debarking
- Many decayed samples – difficult on CT-scan
- Many other insects – difficult on CT-scan

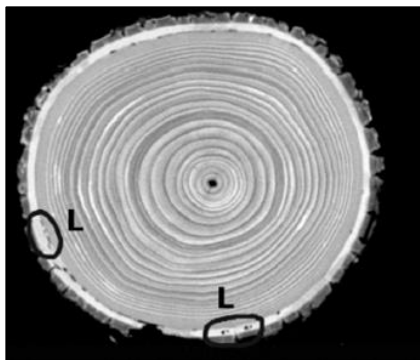
## EFFICACY





# Tomodensitometry - Comparison of methods

EFFICIENCY



CT-scan



Debarking

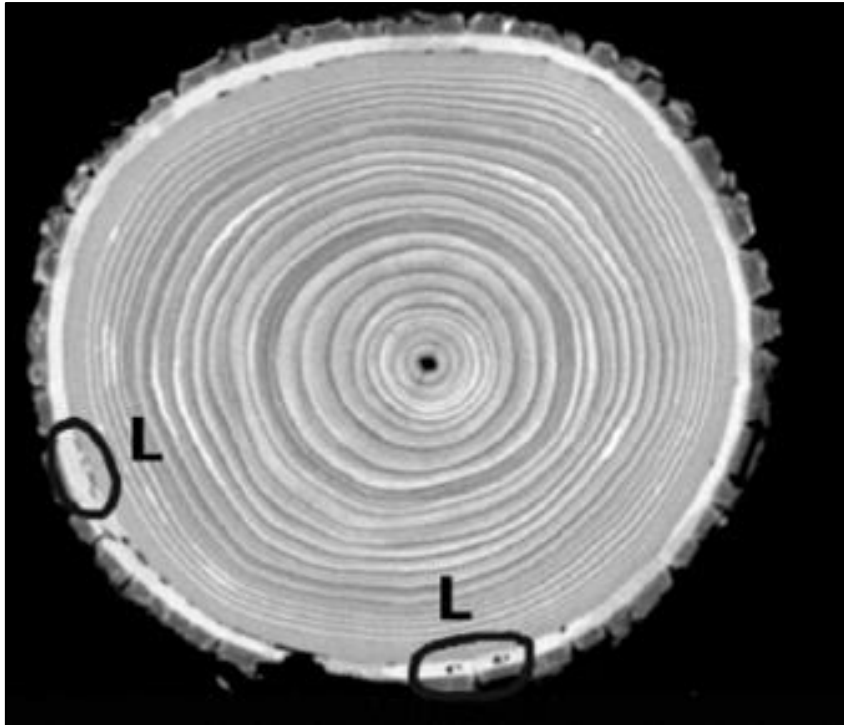
<b>Time</b>	Quick	Long
<b>Cost</b>	Expensive (\$/h)	Cheap (but requires staff)
<b>Other</b>	Thousands of images to analyse...	Degradation of samples with time (were larvae alive or dead?)





# Tomodensitometry – Depth of immatures

## Measuring the depth of galleries and pupal chambers



Informs on debarking requirements for phytosanitary measures





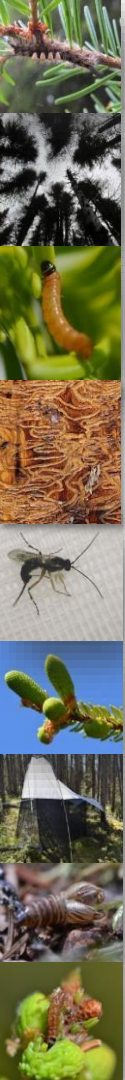
# Tomodensitometry - Depth of immatures

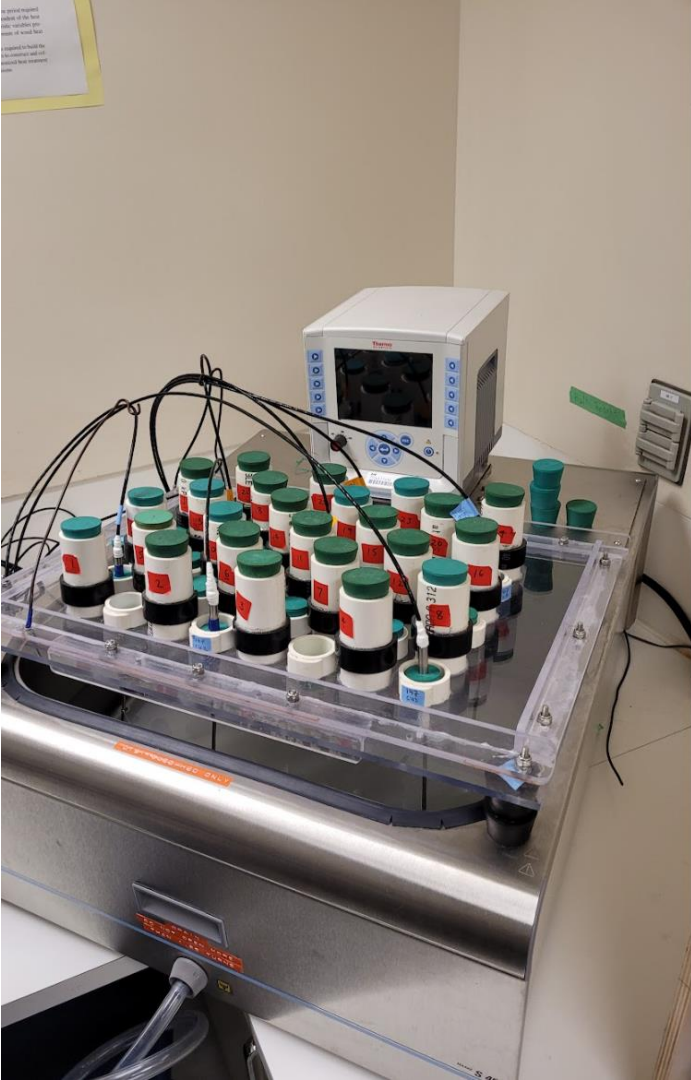
Tree species	Larvae – Depth incl. bark (mm)		
	Mean	Minimum	Maximum
Ash (n=1067)	10.6±4.2	3.9	<b>22.1</b>
Paper Birch (n=12)	6.6±1.4	4.1	<b>9.2</b>
Yellow Birch (n=11)	7.5±2.1	4.4	<b>10.7</b>

Tree species (n)	Prepupae - Depth incl. bark (mm)		
	Mean	Minimum	Maximum
Ash (n=270)	12.6 ± 4.4	5.33	<b>28.64</b>
Paper Birch (n=127)	7.4 ± 1.2	4.12	<b>11.01</b>
Yellow Birch (n=301)	6.7 ± 1.3	3.83	<b>14.16</b>

The diameter affects the depth

Informs on debarking requirements for phytosanitary measures





# The Effective Heat Treatment for BBB Prepupae

Meghan Noseworthy, Eric Allen, Christian Hébert, Sébastien Bélanger,  
Esme John, Chris MacQuarrie, Véronique Martel, Tyranna Souque

*Agrilus anxius*  
Bronze Birch Borer (BBB)



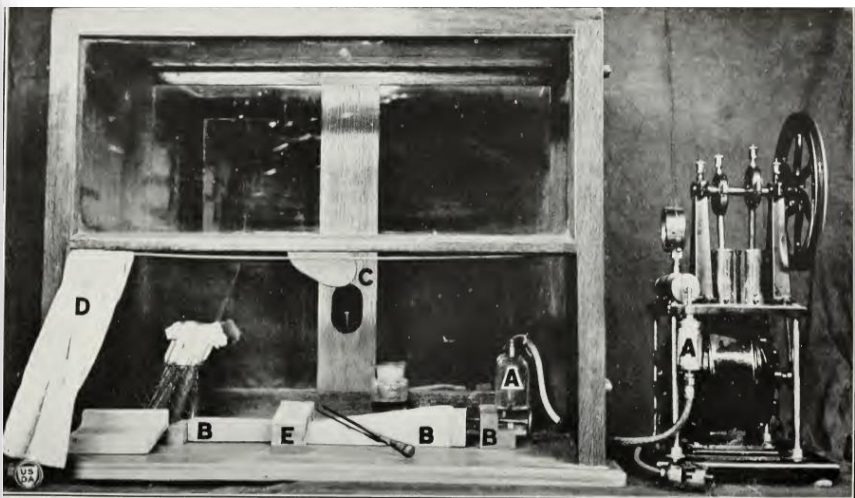
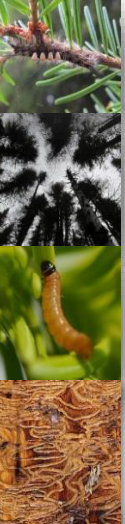
- At what temperature/duration do immatures die?






## Heat treatment


- Common and accessible phytosanitary measure
- Kiln drying in conventional heat chambers
- Improved quality and strength



UNITED STATES DEPARTMENT OF AGRICULTURE



DEPARTMENT BULLETIN NO. 1262



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Washington, D. C.
▼
August, 1924

**EFFECT OF KILN DRYING, STEAMING, AND AIR SEASONING ON CERTAIN FUNGI IN WOOD.<sup>1</sup>**

By ERNEST E. HUBERT, *Assistant Pathologist, Office of Investigations in Forest Pathology, Bureau of Plant Industry.*

[In Cooperation with the Forest Products Laboratory of the Forest Service.]



## Heat treatment *in vitro* research

- Finding minimum temperature to cause mortality of wood pests
- Uniform heat delivery and control of rate mimicking kiln (0.5 °C/min)

Journal of Pest Science  
<https://doi.org/10.1007/s10340-022-01567-4>

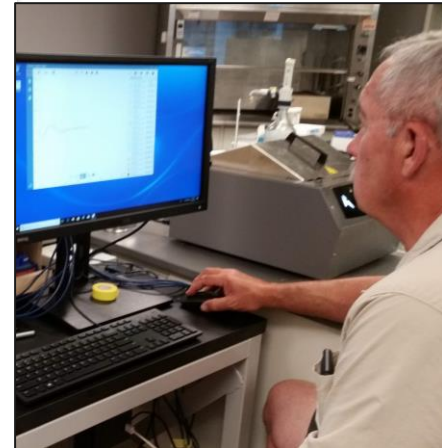
ORIGINAL PAPER



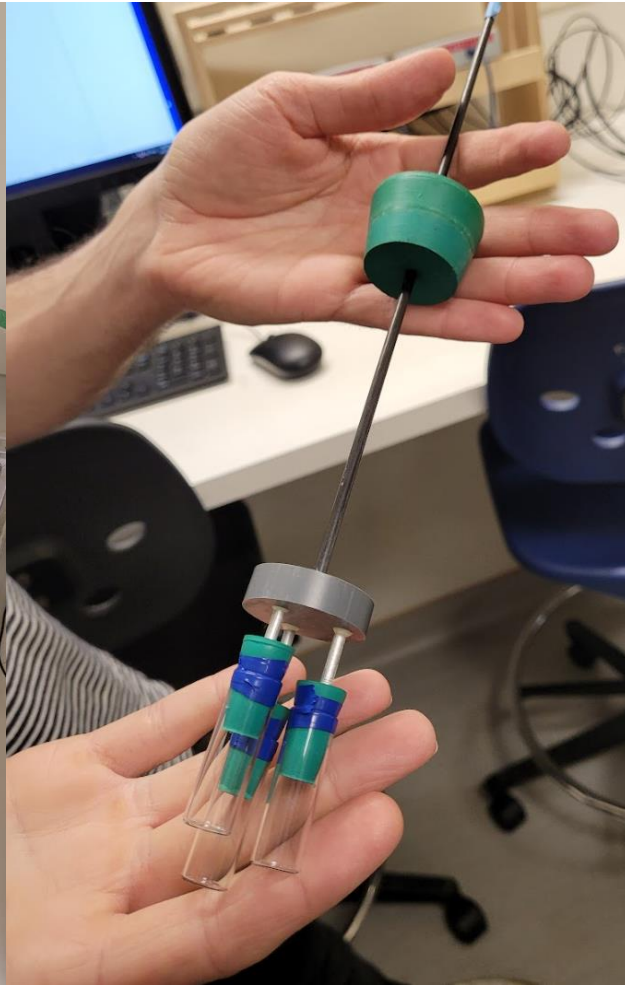
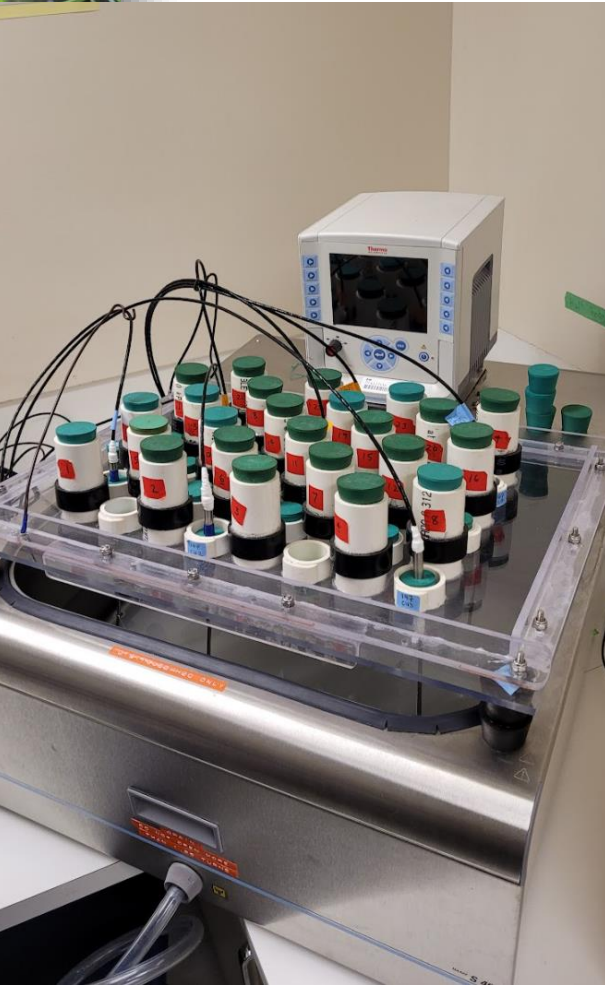
### Determination of specific lethal heat treatment parameters for pests associated with wood products using the Humble water bath

M. K. Noseworthy<sup>1</sup> · L. M. Humble<sup>1</sup> · T. J. Souque<sup>1</sup> · E. P. John<sup>1</sup> · J. Roberts<sup>2</sup> · C. R. Lloyd<sup>1</sup> · E. A. Allen<sup>1</sup>

Received: 29 June 2022 / Revised: 3 August 2022 / Accepted: 21 September 2022  
© Crown 2022



# Water bath - Methodology

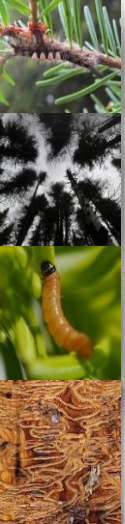
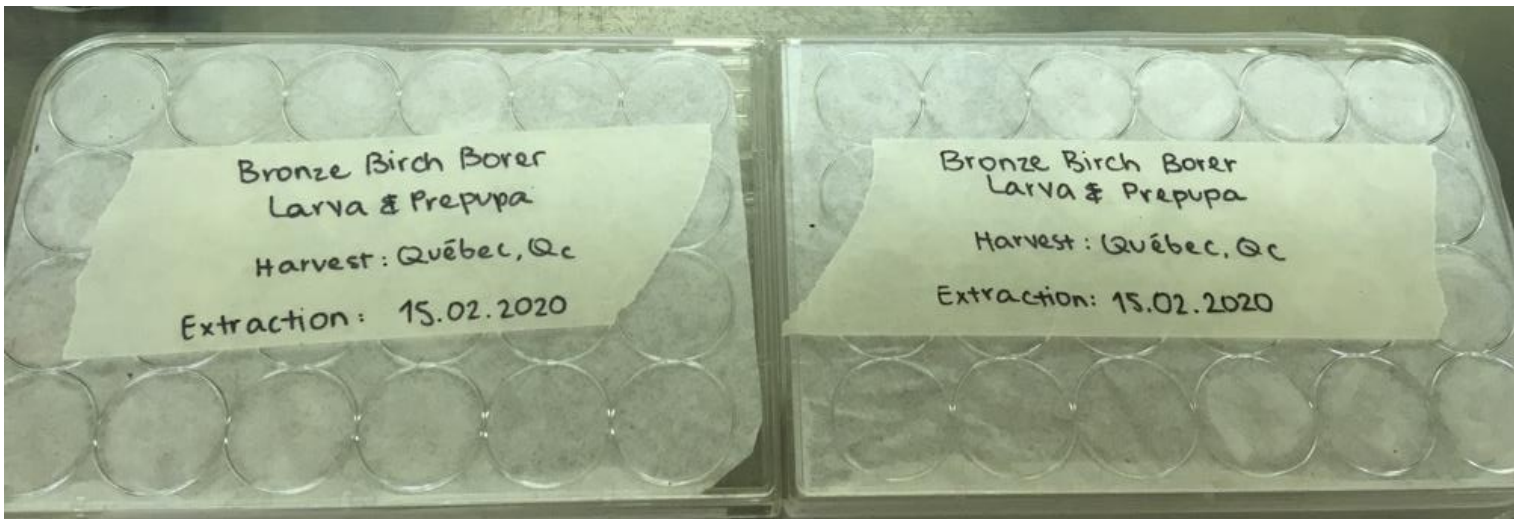
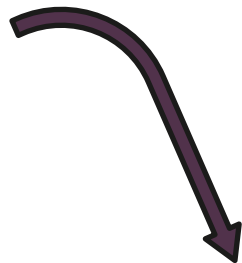


- Highly controlled heat application
- High resolution and accuracy
- In vitro and in vivo (in wood)

# Water bath - Methodology



In Québec:





# Water bath - Methodology



*HT*

*Control*

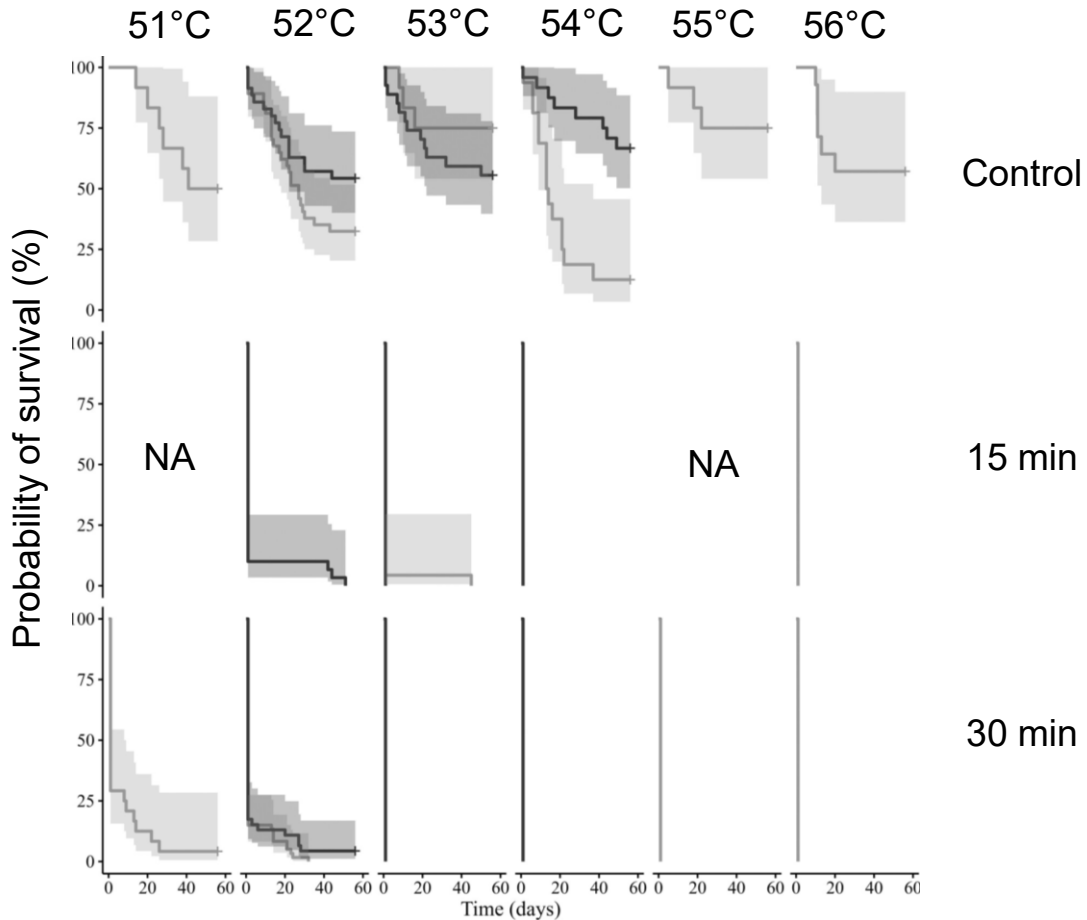
**T:** 51°C, 52°C, 53°C,  
54°C, 55°C or 56°C

**Durations:** 15 or 30 min

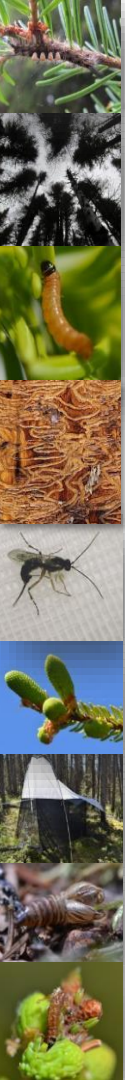




# Water bath - Results



Kaplan-Meier survival curves





# Water bath - Methodology

- $\geq 53^{\circ}\text{C}$  (15 or 30 minutes)  $\Rightarrow$  complete mortality (no adult)  
(15 min  $\Rightarrow$  2% pupation; no adult)
- $\geq 51^{\circ}\text{C}$  (15 or 30 minutes)  $\Rightarrow$  almost complete mortality
- **The Standard 56/30 is thus effective against BBB**





MacQuarrie et al. 2020:

- EAB in kiln: 55.33°C; 30 min conventional heating kiln

Noseworthy et al. 2024

- EAB Water bath: 55°C; 30 min

Similar results *in vivo* and *in vitro*

*Journal of Economic Entomology*, 117(1), 2024, 199–208  
<https://doi.org/10.1093/jee/toad211>  
Advance Access Publication Date: 18 November 2023  
Research



Forest Entomology

## Testing the heat treatment dose for *Agrilus planipennis* (Coleoptera: Buprestidae) prepupae using the Humble water bath

Meghan K. Noseworthy<sup>1,\*</sup>, Tyranna J. Souque<sup>1</sup>, Chris J.K. MacQuarrie<sup>2,3</sup>, Esme P. John<sup>1,3</sup>, Meghan Gray<sup>2</sup>, Josie Roberts<sup>3</sup>, Eric A. Allen<sup>1,†</sup>

<sup>1</sup>Natural Resources Canada Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada, <sup>2</sup>Natural Resources Canada, Canadian Forest Service, Great Lakes Forestry Centre, Marie, ON, Canada, <sup>3</sup>Canadian Food Inspection Agency, Pacific Forestry Centre, Victoria, BC, Canada \*Corresponding author, mail: [meghan.noseworthy@nrca-nrcan.gc.ca](mailto:meghan.noseworthy@nrca-nrcan.gc.ca)

<sup>†</sup>Retired.



# Challenges to study BBB in Canada

It is very difficult to get birch samples  
with BBB in Canada!



# Challenges to study BBB in Canada

It is very difficult to get birch samples with BBB in Canada!



Looking for birch trees that are naturally stressed







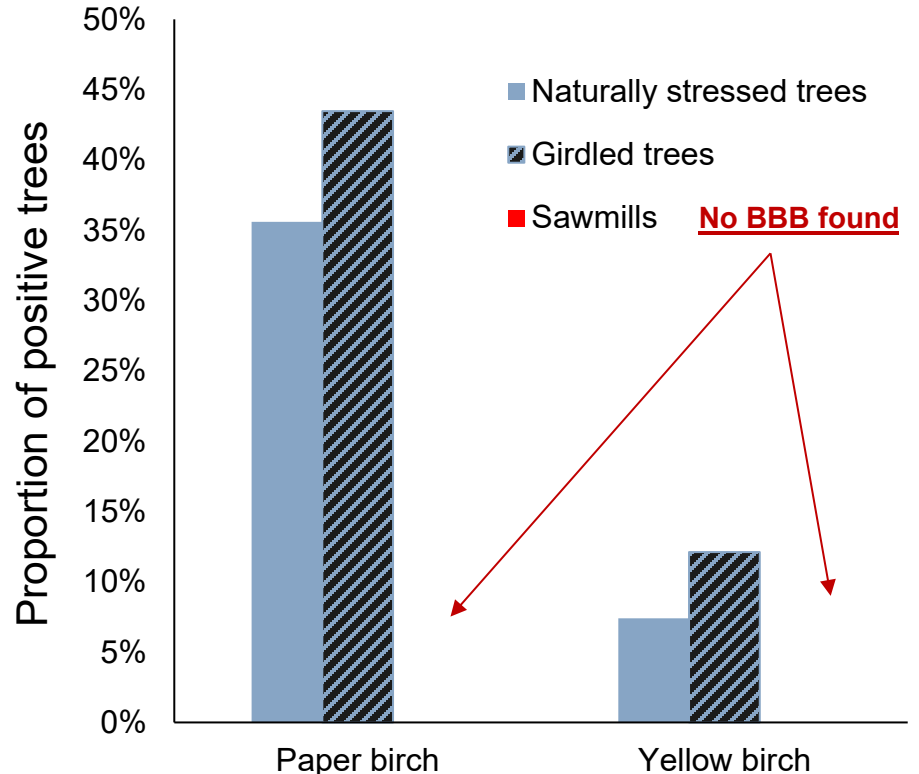
# Challenges to study BBB in Canada

It is very difficult to get birch samples with BBB in Canada!

- Quite low success: few BBB
- Yellow Birch defend itself
- Natural enemies
- Paper Birch dies too fast



# Challenges to study BBB in Canada



# A. *anxius* genome sequencing project

- Collaboration between Canadian Forest Service and Université Laval
- Genomic DNA was processed in two different ways, and two sequencing technologies were used to obtain a high-quality genome:

DNA isolation/treatment	Sequencing method	Purpose
Chromatin crosslinking (Omni-C)	Illumina	For long-range spatial information (scaffolding).
High molecular weight DNA	PacBio HiFi	Main sequence data. Long reads and highly accurate DNA sequence data (>99%).
	Illumina	Genome polishing. To refine draft genome assembly.

- Project is in the genome scaffolding stage. Polishing, curation and annotation to follow.
- Future work
  - Identification of secondary metabolite detoxification genes (host-tree interactions)
  - Characterization of olfactory genes (host- and mate finding)



Daniel Doucet  
Research Scientist

[daniel.doucet@nrcan-rncan.gc.ca](mailto:daniel.doucet@nrcan-rncan.gc.ca)



Dr. Eric Normandeau  
Dr. Brian Boyle  
Laurie Lecomte



[veronique.martel@nrcan-rncan.gc.ca](mailto:veronique.martel@nrcan-rncan.gc.ca)

