

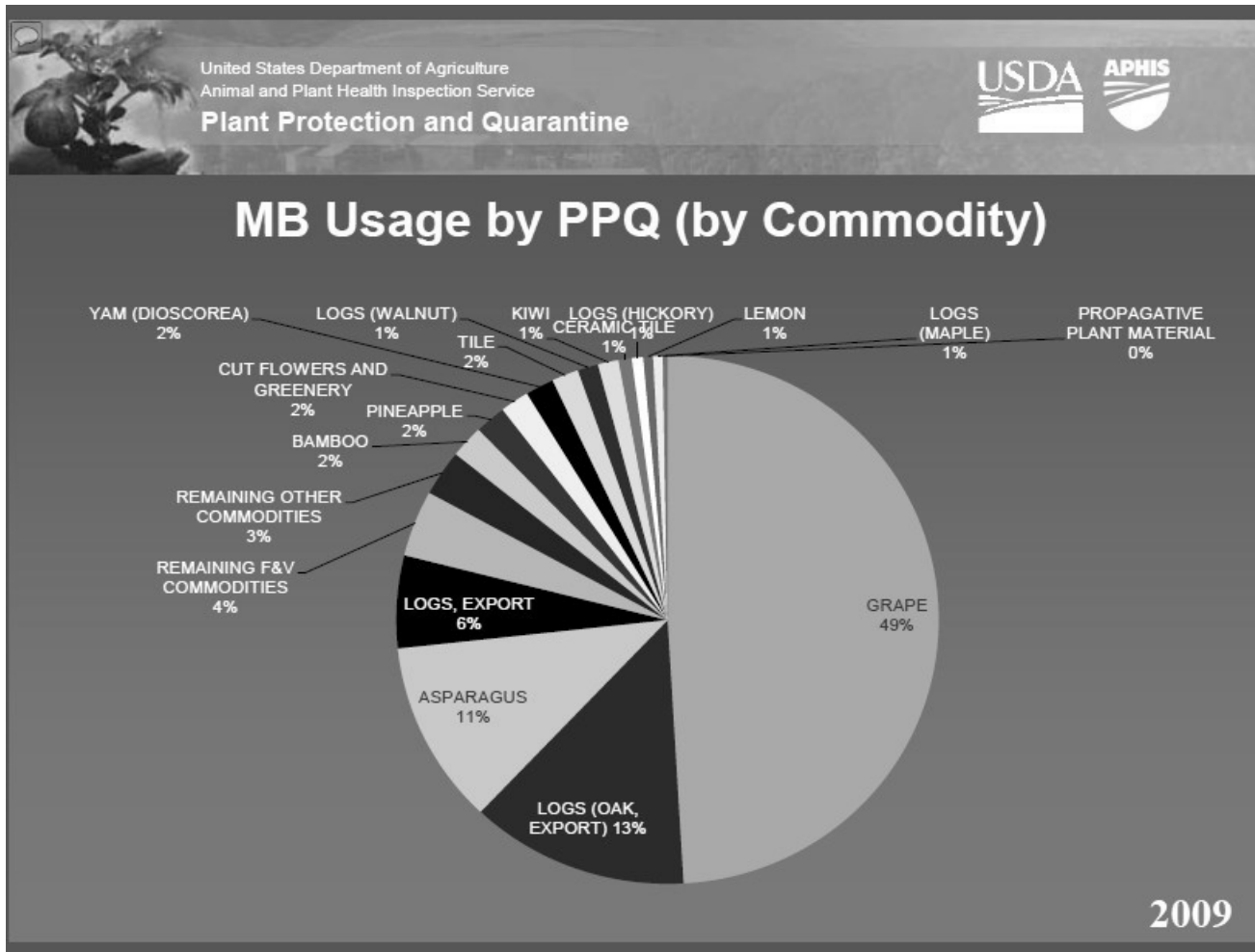
Development of a Non-Chemical Phytosanitation Treatment for Logs and Certain Other Commodities

Virginia Tech, Department of
Sustainable Biomaterials, USDA Forest
Service, USDA Animal Plant Health and
Inspection Service



Virginia Log Exports

Virginia Log Exports				
Year To Date: January - August				
Partner Country	United States Dollars			%Δ 18/17
	2016	2017	2018	
World	\$31,877,603	\$50,371,278	\$54,480,509	8.16
EU	\$ 7,370,359	\$ 6,243,190	\$ 5,662,628	-9.3
China	\$15,773,627	\$33,688,354	\$33,104,759	-1.73
Vietnam	\$ 3,750,220	\$ 4,966,398	\$ 9,008,098	81.38
Italy	\$ 3,491,661	\$ 4,523,117	\$ 4,274,856	-5.49
United Arab Emirates	\$ 497,000	\$ 1,932,251	\$ 2,505,541	29.67
Japan	\$ 1,222,341	\$ 829,534	\$ 1,396,645	68.37
Pakistan	\$ 437,882	\$ 545,026	\$ 561,925	3.1
India	\$ 242,895	\$ 214,682	\$ 414,029	92.86
Germany	\$ 500,958	\$ 278,329	\$ 410,453	47.47
Taiwan	\$ 354,435	\$ 291,040	\$ 350,594	20.46
Portugal	\$ 319,286	\$ 352,966	\$ 338,472	-4.11
United Kingdom	\$ 1,539,543	\$ 585,487	\$ 332,078	-43.28
Turkey	\$ 553,071	\$ 427,170	\$ 324,660	-24
Indonesia	\$ 284,608	\$ 429,888	\$ 278,087	-35.31
Spain	\$ 1,413,277	\$ 430,811	\$ 177,994	-58.68
Egypt	\$ -	\$ 22,382	\$ 117,395	424.51



1. Methyl bromide (MB) is a class 1 ozone depleting chemical and extremely toxic to mammals
2. Under the 2002 Montreal Protocol its use was discontinued, with few exceptions.
3. One exception is the pre-shipment and quarantine treatment of exported and imported logs
4. 22% of MB use or 128,000 pounds is used annually to treat forest products, mostly logs
5. MB use is being further restricted by many states in the US

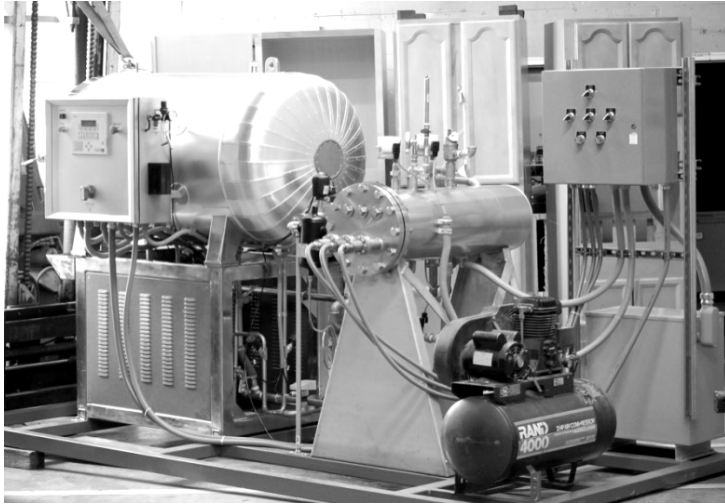
Controlled Atmosphere -Vacuum

- 2005 to 2008 – Chen and White -Vacuum to kill nematodes and insects in wood packaging materials. Research funding from USDA Forest service WERC
- US Patent 0127548, 2008, “Killing insects inside wood by vacuum dehydration” Chen, White, and Robinson.
- Two peer reviewed publications

Heat Treating Logs using Vacuum and Steam

- Saturated steam contains 100 times more energy per cubic meter than hot air at the same temperature.
- Steam condensation is exothermic on surfaces
- Hot air evaporation is endothermic on wet surfaces (lowers surface temperatures).
- Vacuum distributes heat quickly and uniformly to all external and internal log surfaces through the formation of pressure gradients.

**Efficacy of steam/vacuum treatment for the control of
Emerald Ash Borer in naturally infested wood
Fong Industries
2008**



EAB test results

The average 6 inch diameter ash (*Fraxinus* spp.) bolts were treated to 56C for 30 minutes at center using saturated steam at 90C and an initial vacuum Of 200mmHg.

- All EAB larvae were killed.
- Treatment cycle times were 3.5 to 4.5 hours to the center of the bolt.

Development of a highly efficient steam and vacuum phytosanitary treatment for solid wood packaging materials

USDA Forest Service, WERC

February 2011



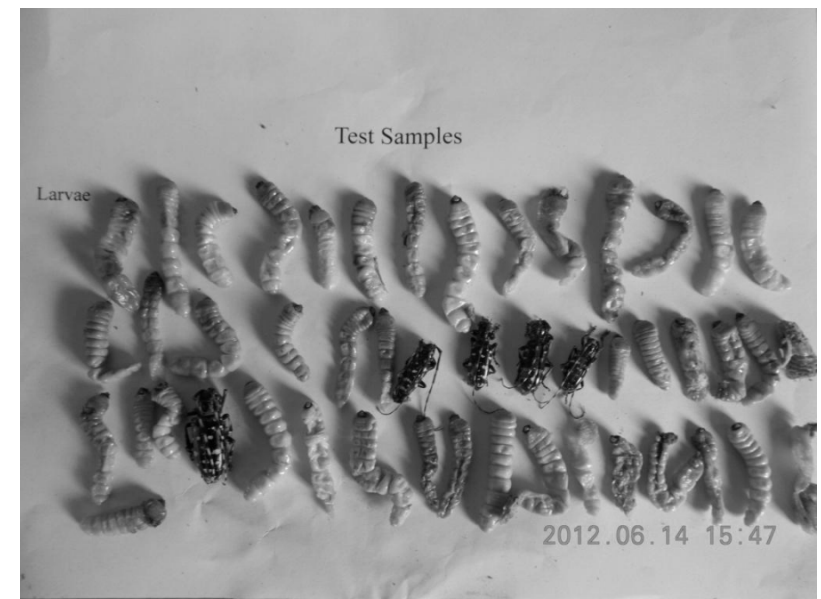
1. 56C/30 in 50 minutes.
2. Steam cleans used pallets.
3. Vacuum dries pallet surfaces in seconds
4. No mold



Steam/vacuum treatment of live Asian Long Horned Beetle infested logs in China

USDA APHIS

2011/2012



ALB test results

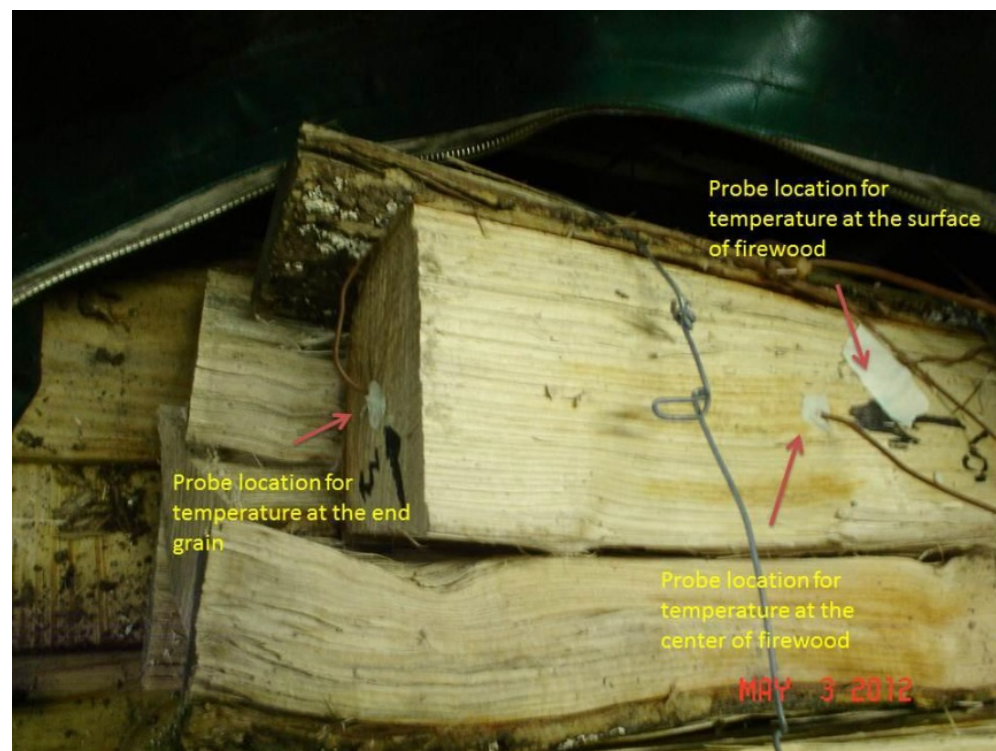
Heat treating naturally infested, 6 to 10 inch diameter willow (*Salix spp*) bolts with saturated steam at 90C and vacuum to 250 mmHg to 60C for 60 minutes at log center, killed all ALB larvae and adult beetles in a total average treating time of **5 hours**



Firewood bundles in flexible steam/vacuum chamber

**Investigation of vacuum and steam to heat
Treat and sanitize ash firewood logs and split
Firewood, 2013, UDSDA FS WERC**

- 1. 56C/30 in 70 minutes**
- 2. No change in moisture content**



Using Vacuum and Steam to sanitize hardwood veneer logs for export

In cooperation with Danzer Veneer Corporation, Edinburgh, Indiana and COSMED, Linden, NJ

USDA APHIS

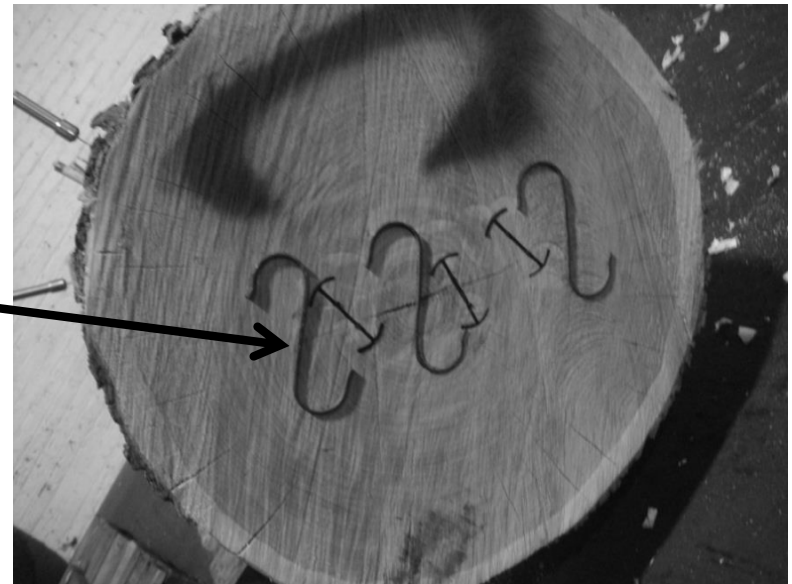
2012/2013



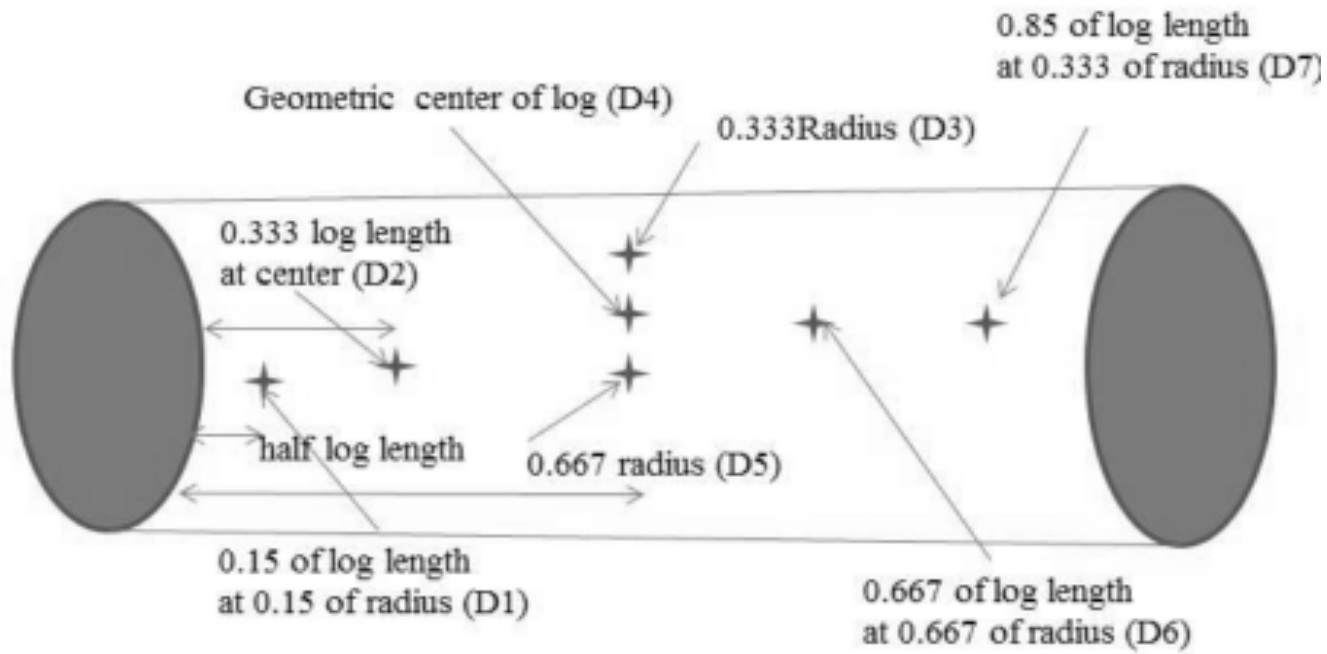
Chamber: 6 ftX9ftX64ft long, pre-heated walls



S irons



Thermal couple placement



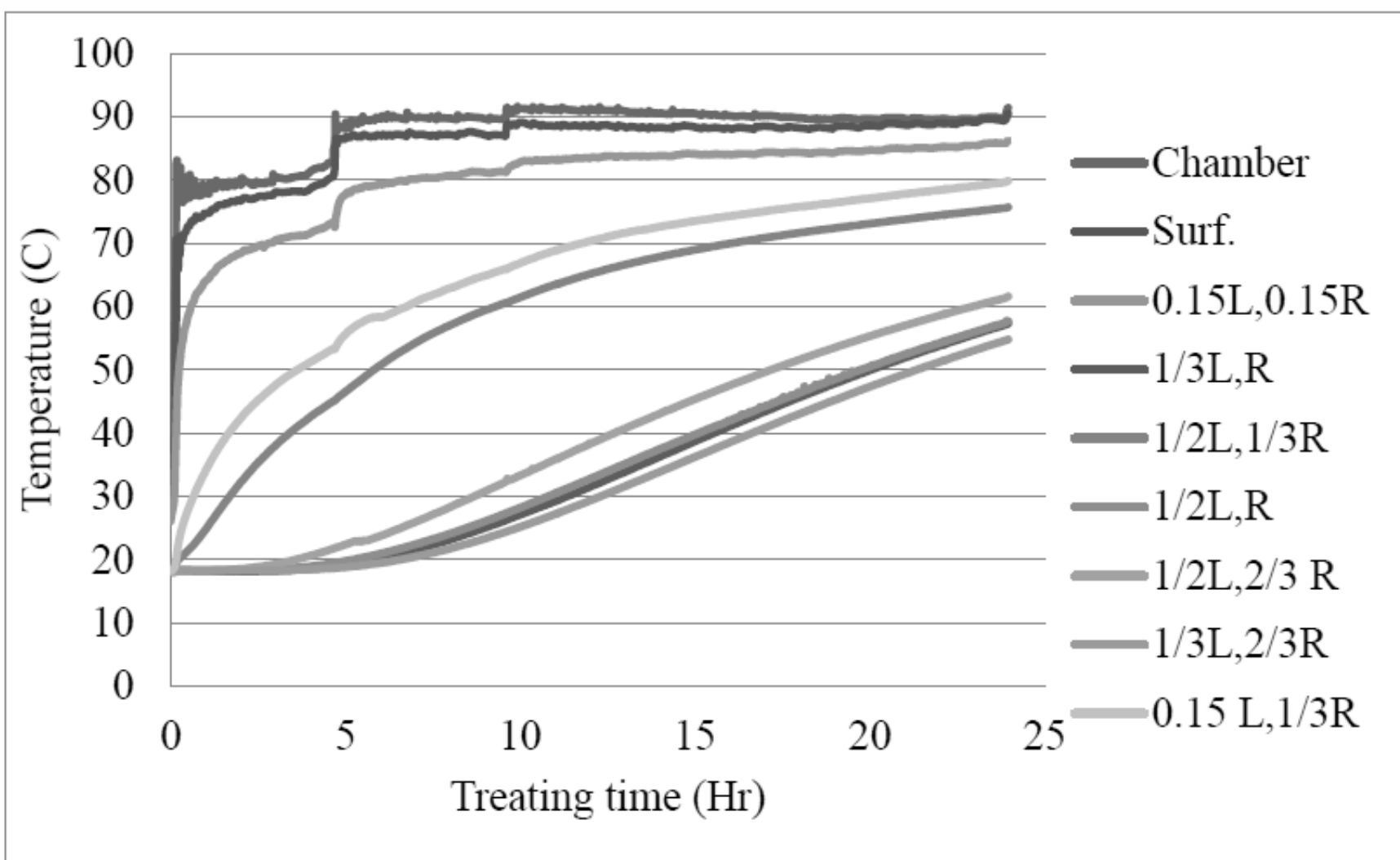


Figure A13. Temperature profile during test 3 of red oak log (R8).

Conclusions

1) 15 to 22 inch diameter, cherry, walnut, red oak, hickory and yellow-poplar veneer logs were heat treated to 60°C for 60 minutes at the log center, using saturated steam at 90°C **in 16 to 20 hours at 25 mm Hg** depending on the log diameter and wood species.

2) The treatment process does not affect flitch or veneer yield or quality.

3) The energy required to treat the veneer logs to 60°C for 60 minutes at the log center varied from **1.32 to 2.17 kwh/kg of log mass**

Phytosanitary treatment of the Mediterranean snails *Cernulla cisalpina* and *Eobania vermiculata* hitchhiking with imported tiles in packaging using steam and vacuum

**2014/2015
USDA APHIS**



20 meter
Trailer



5X5X8.5 foot vacuum chamber



100 KW electric boiler



7 hp, busch mink vacuum pump



Unit load of tile in chamber

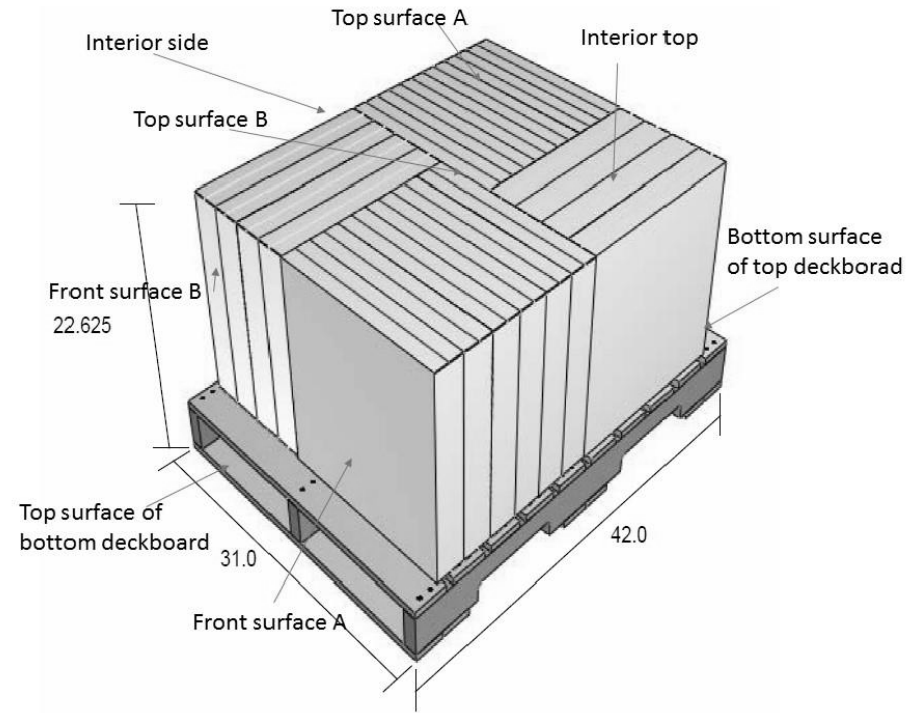


Figure 38. The location where packet of snails was inserted into the opening.



Figure 1. The *Cernuella cisalpine*, growing in Baltimore, Maryland.



1. Average treating time to 56C/30 throughput was 48 to 51 minutes. All snails deceased.
2. No significant thermal effects on the stone or ceramic tiles.
3. Shrink film and gummed labels not visibly affected.
4. Corrugated ECT and Burst strength was fully restored following a vacuum drying cycle.

Vacuum and steam treatment of large timbers in solid wood skids
2015/2016
USDA APHIS



20X20cm timbers



Pine sawyer beetle larvae



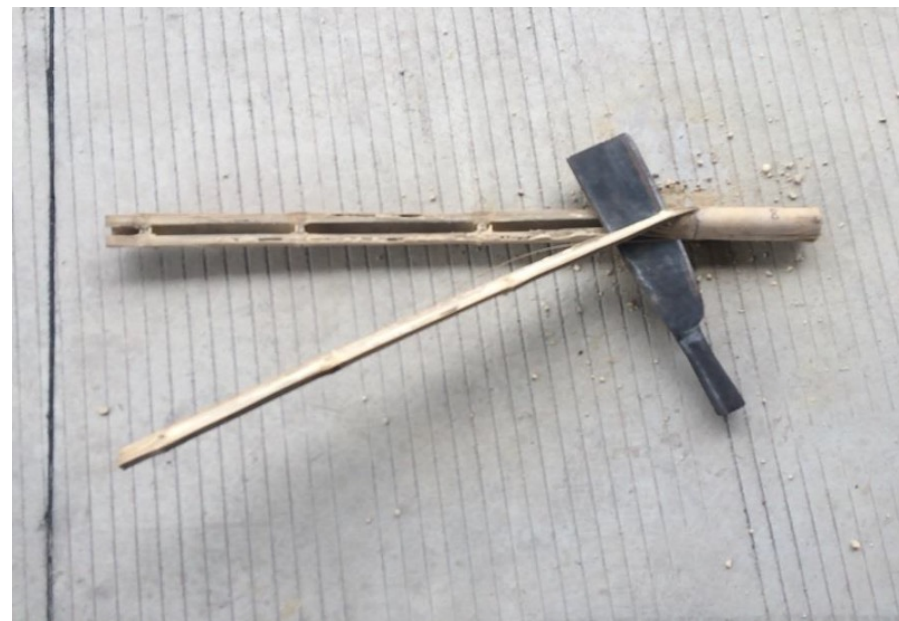
Inoculation of timbers



Results of large timber tests

- Initial vacuum – 100 mmHg
- Test temperature – 90 deg. C
- Treatment – 56C/30 minutes to center
- Treatment time 5.2 to 6.8 hr.
- All larvae were killed
- No degrade in 8X8 or 4X4 timbers
- All skid connections were unaffected

**Steam Vacuum Treatment to Control *Chlorophorus annularis* Beetles in
Naturally Infested Bamboo
2017, USDA APHIS/AQSIQ P.R. China**



7. Conclusion

- 1) The vacuum and steam can be effective for killing *Chlorophorus annularis* with the initial vacuum level of 100 mmHg. The temperature to kill *Chlorophorus annularis* was estimated to be around 47.5 to 50 C.
- 2) It took average **45.5** minutes to treat the bamboo poles of average outside diameter of 5 cm and wall thickness of 1.47 cm.
- 3) The average moisture content increased about 3.5% during the treatment.
- 4) Vacuum steam treatment does not affect any bamboo pole quality, ie. color, split and other qualities.
- 6) The effective steam vacuum treatment schedule for the bamboo poles can be recommend the temperature at the inner surface reach **50C and hold for thirty minutes.**

**Feasibility of Using Steam and Vacuum to Control Coconut Rhinoceros Beetle
Infestations in Ground Mulch
2017/2018
USDA APHIS**



1. Cycle times to 56C/30 was 45 minutes
2. Moisture content increased by 12%
3. All surrogate larvae killed

**Efficacy of steam-vacuum treatment to eradicate thousand canker and oak wilt disease
In naturally infected and inoculated oak and walnut logs
Minnesota, Pennsylvania, Washington
2016/2017
USDA APHIS**





Walnut logs 9 to 15 SED

Oak Logs 9 to 19 inch SED



Results

- Treatments – both 56C/30 minutes and 60C/60 minutes at **2 inches (5 cm) depth in oak and 1.5 inches (3.8cm) in walnut**
- Initial vacuum – 100 mmHg
- Average oak treatment time to **56C/30 was 6.4 hr. and to 60C/60 was 8.2 hr.**
- Average walnut treatment time to **56C/30 was 4.6 hr. and to 60C/60 was 5.1 hr.**
- Average energy consumption - 56C/30 - .052kwh/kg and at 60C/60 - .048 kwh/kg of log
- **All oak wilt fungus and all vector insects killed and in walnut only one out of 899 specimens, positive for TCD and all vectors killed at 56C/30.**
- Juzwick J. et.al. 2018 Vacuum steam treatment eradicates viable *Bretziella fagacearum* from logs cut from wilted *Quercus rubra* . Plant Disease. 07-18-1252-RE

**Evaluation of Vacuum and Steam Heat as a Methyl Bromide
Alternative for Phytosanitary Treatment of Hardwood and Softwood
Logs
2018/ 2019
USDA NIFA MBT**

- Eugene, Oregon, October 2018 - walnut
- Seymore, Indiana, March 2019 – red oak
- Results confirm 56C for 30 minutes at 5 cm depth is adequate to kill all pathogens and associated vectors in the red oak and walnut logs.
- **USDA NIFA MBT, 2019, Phase II, Control of Pinewood Nematode in Pine logs and Oak Wilt in White Oak Logs-grant application submitted.**

**Determine the efficacy of steam and vacuum to control *Cyratocystis wilt*
Fungus in naturally infected ohia logs
USDA Forest Service
2018/2019**



Results

- Both 60C/60 and 56C/30 to a depth of 2/3 log radius was 100% effective. No positive post treatment pathology.
- Heat treating cycle times varied from 7 to 14 hours depending on target temperature and log diameter.
- No re-infestation after post treatment inoculation.

Potential Steam and Vacuum Phytosanitary Treatment Applications

- Logs
- Pallets and solid wood packaging
- Firewood
- Chips



Bag house batch treatment concept



- Other heat tolerant commodities – Textiles, metals, ceramics, plastics

Peer reviewed publications

- Zhangjing Chen, Marshall S. White, Ron Mack, Zengchu Qiu. 2018. Steam and Vacuum Treatment of Large Timber in Solid Wood Skids. BioResources. BioRes. 13(4), 9132-9142.
 - Juzwik, J., A. Yang, Z. Chen, M. White, and R. Mack, 2018. Vacuum steam treatment eradicates viable *Bretziella fagacearum* from logs cut from wilted *Quercus rubra*. Plant Disease. DOI10.1094/PDIS-07-18-1252-RE
 - Chen, Zhangjing, **M. S. White**, Z. Qiu. 2017. Investigation of Vacuum and Steam Treatments to Heat Treat and Sanitize Firewood-Grade Ash Logs and Ash Firewood. Forest Products Journal. 67(3/4):258-265, doi:10.13073/fpj-D-16-00045
 - Chen Zhangjing, **M. S White**, R. G. Mack. 2016. Evaluating vacuum and steam process on hardwood veneer logs for export. European Journal of Wood and Wood Products. () 1-8. 2016. DOI 10.1007/s00107-016-1138-7
 - Chen, Z., **M.S. White**, Y. Wu. 2012. Vacuum – Steam phytosanitation of hardwood pallets and pallet stringers. Forest Products Journal, 62(5):378-382
 - Chen, Z., **M. S. White**, M. A. Keena, T. M. Poland and E. L. Clark. 2008. Evaluation of Vacuum technology to kill larvae of the Asian longhorned beetle, *Anoplophora glabripennis* (Coleoptera: Cerambycidae) and the emerald ash borer, *Agrilus planipennis* (Coleoptera: Buprestidae), in wood. Forest Products Journal, 58(11):87-93.
- Chen, Z., **M White**, and W.H. Robinson. 2006a Preliminary Evaluation of Vacuum to Control Wood-boring Insects in Raw Wood Packaging Materials. Forest products Journal 56(7/8):21-25.

Commercialization

- The Science is near completion.
- Heat treatment of logs is a currently accepted pre-shipment and quarantine treatment by the US and most of its trading partners.
- HT phytocertificates are available for logs.
- A new accelerated HT schedule is being considered by USDA APHIS PPQ CPHST for schedule T314 in the Treatment Manual.
- Commercial scale equipment designs are available.

Thank you



**Commercial vacuum and steam heat treatment of logs,
solid wood packaging materials, and other commodities**



A PARTNERSHIP FOR ADVANCED TECHNOLOGY.

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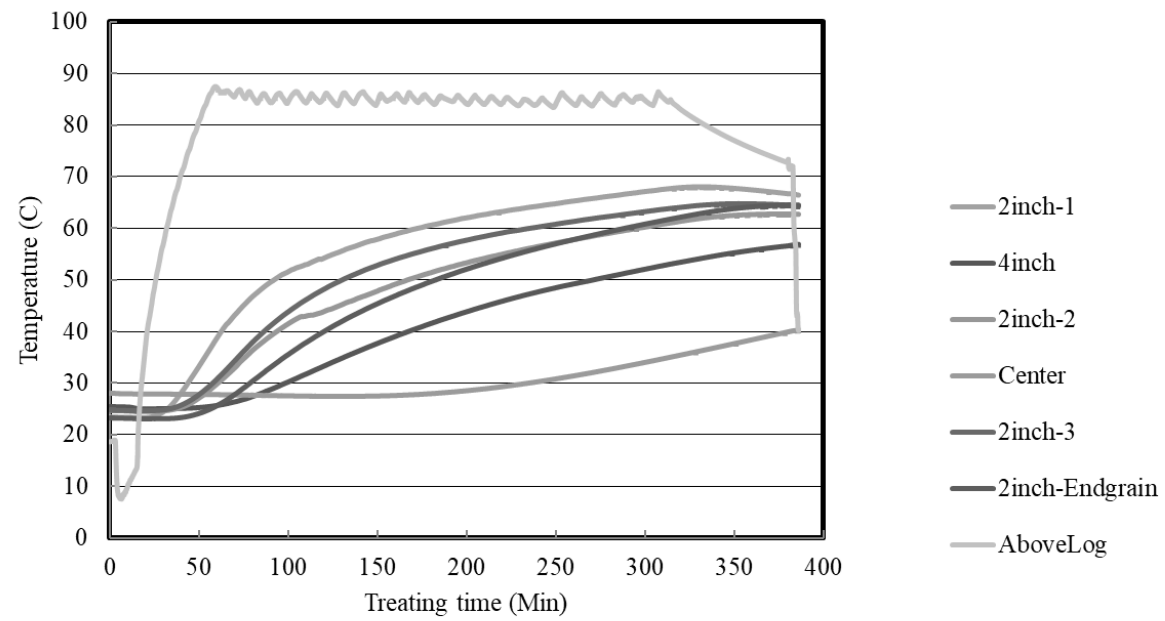
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Web site phytovac.com

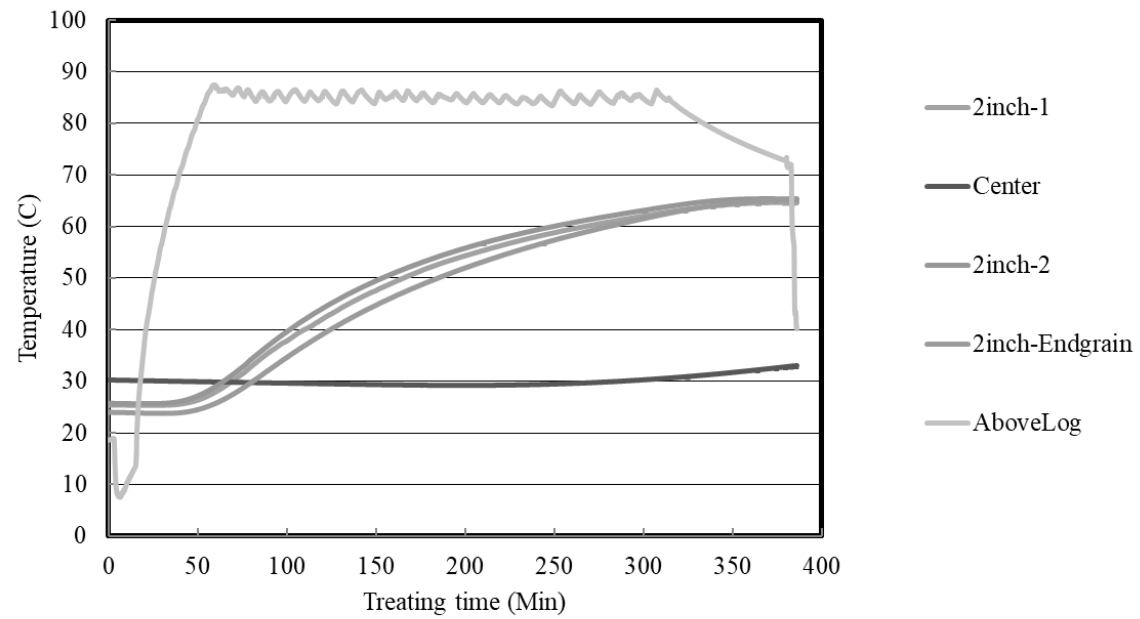
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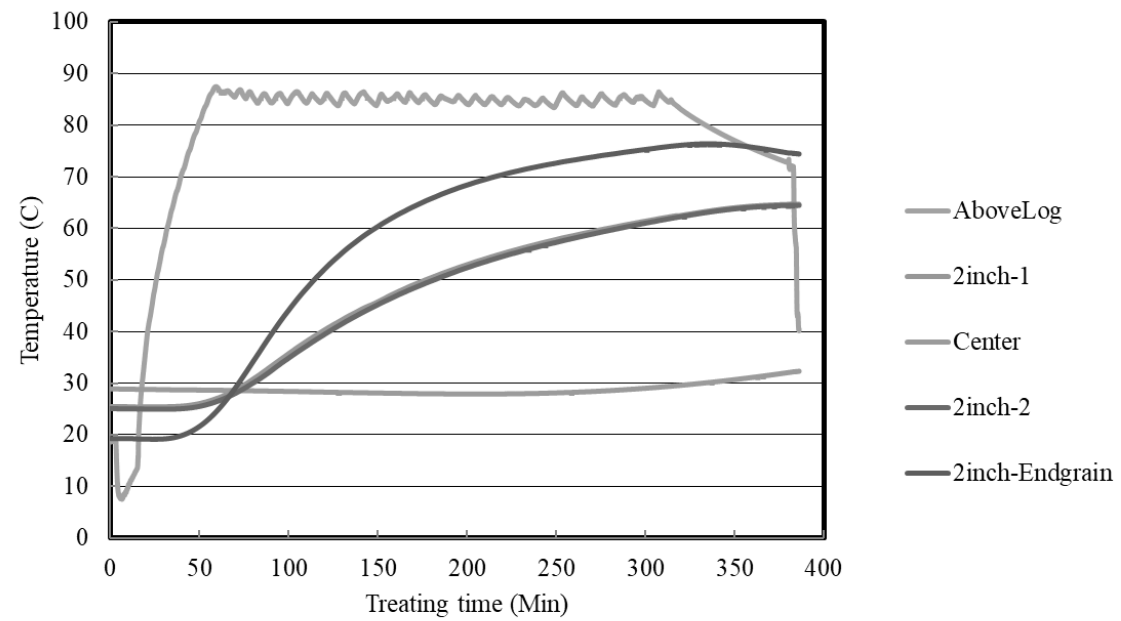
Log 1, Ash



Log 2 Yellow Poplar



Log 3 Yellow Poplar



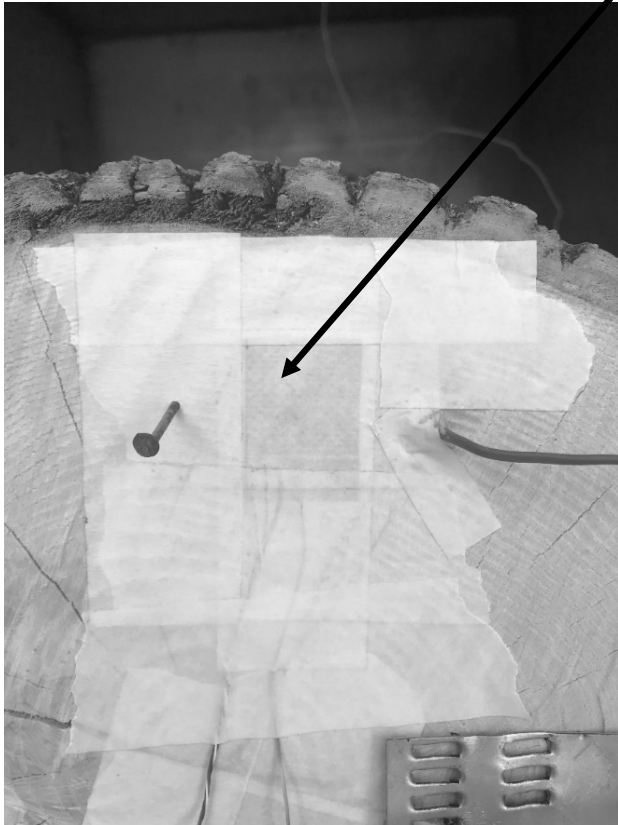
AccuTemp Thermometry Log Application

Ali Roghanizad
6/5/2019

12 inch SE, 8 Ft. Ash Wood Log

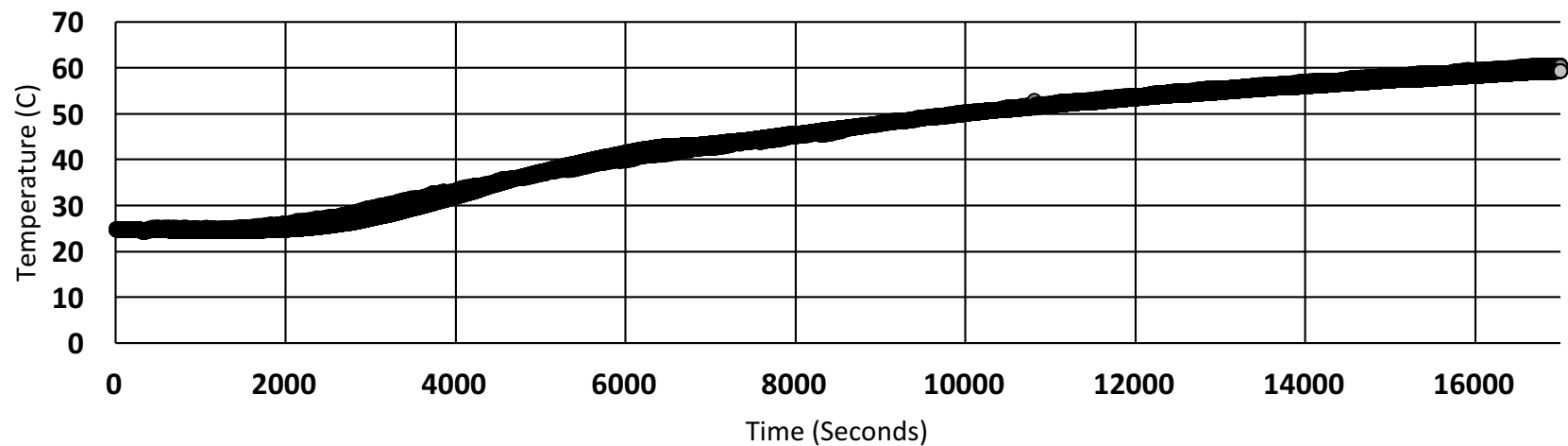


Mounted Sensors at 2 inch and Center 6 inch Depth



Results: 2 Inch Depth From Bark

Comparison of Results: 2 INCH DEPTH

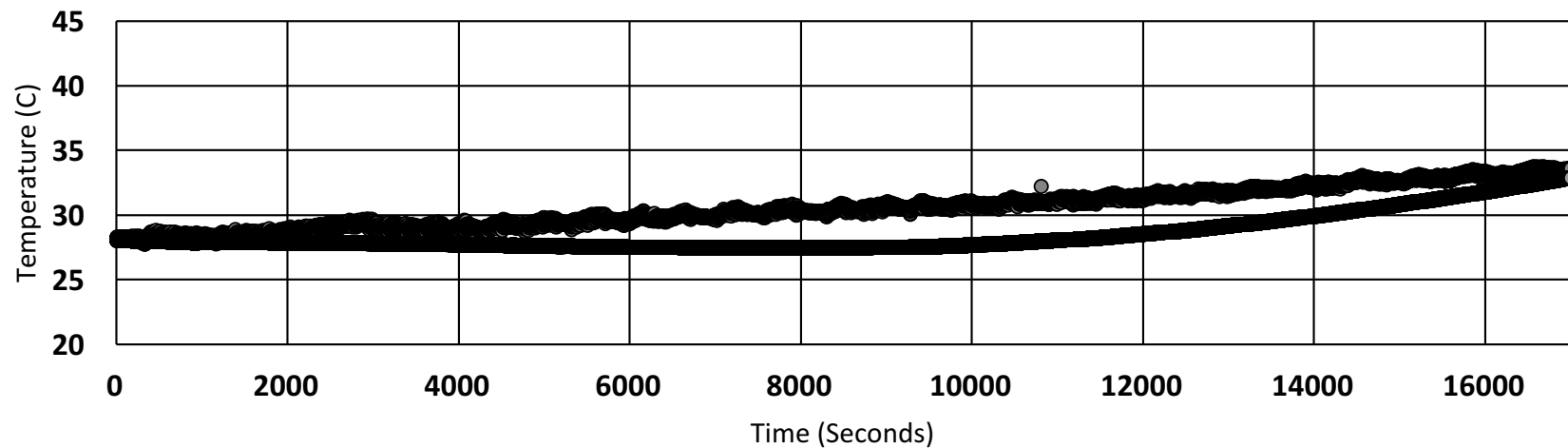


● Non-Invasive AccuTemp Technology (Placed on Log End)

○ Log Midpoint Location

Results: Center, 6 inch Depth From Bark

Comparison of Results: 6 INCH DEPTH



● Non-Invasive AccuTemp Technology (Placed on Log End)

● Log Midpoint Location