



# **Microwave Treatment of insect-infested wood**

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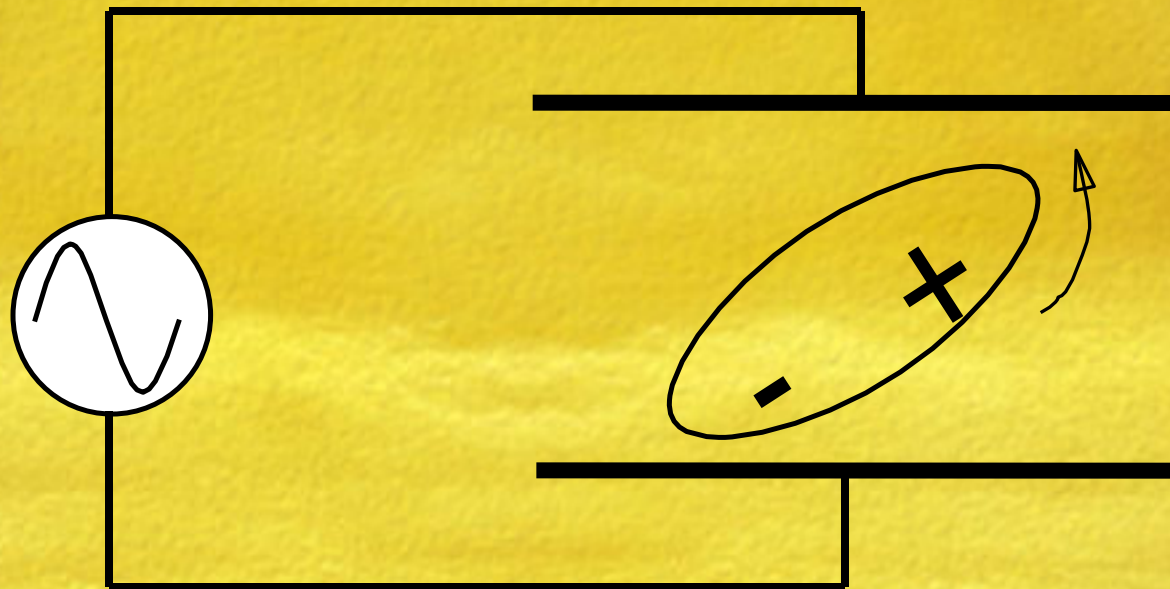
# ISPM-15 Regulations

- Currently, 2 approved measures for wooden packing materials: heat treatment and fumigation by methyl bromide, specified in ISPM-15 (International Standards of Phytosanitary Measures)
- Other treatments may be approved in future once scientific data on efficacy considered and amendment to ISPM15 agreed to by IPPC
- International Plant Protection Convention
  - International treaty relating to plant health, 161 governments (as of 3/07) currently cooperate
  - International Forestry Quarantine Research Group advises IPPC

# How does dielectric heating work?

- Treatment is by absorption of electromagnetic waves by living organisms in or on wood surface.
- Electromagnetic waves (MW or RF) absorbed throughout entire volume of material being treated (= volumetric heating), heating water in wood and organisms infesting wood simultaneously.
- MW/RF energy transformed into heat (thermal) energy as it's absorbed by water contained in both wood and organisms infesting wood.

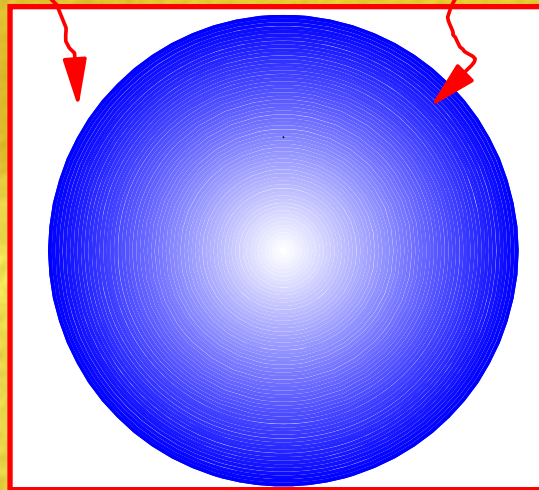
# How does MW/RF work?



Ben Wilson, PSC Inc.

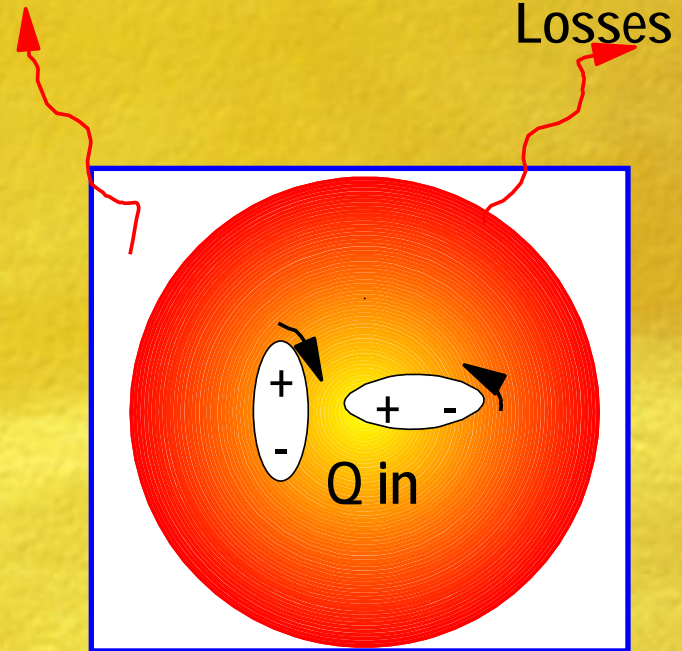
# How does MW/RF work?

Q Heat in



Conventional Heating

Q



Dielectric Heating

# Methods for efficacy testing MW of cerambycid adults



Observational unit



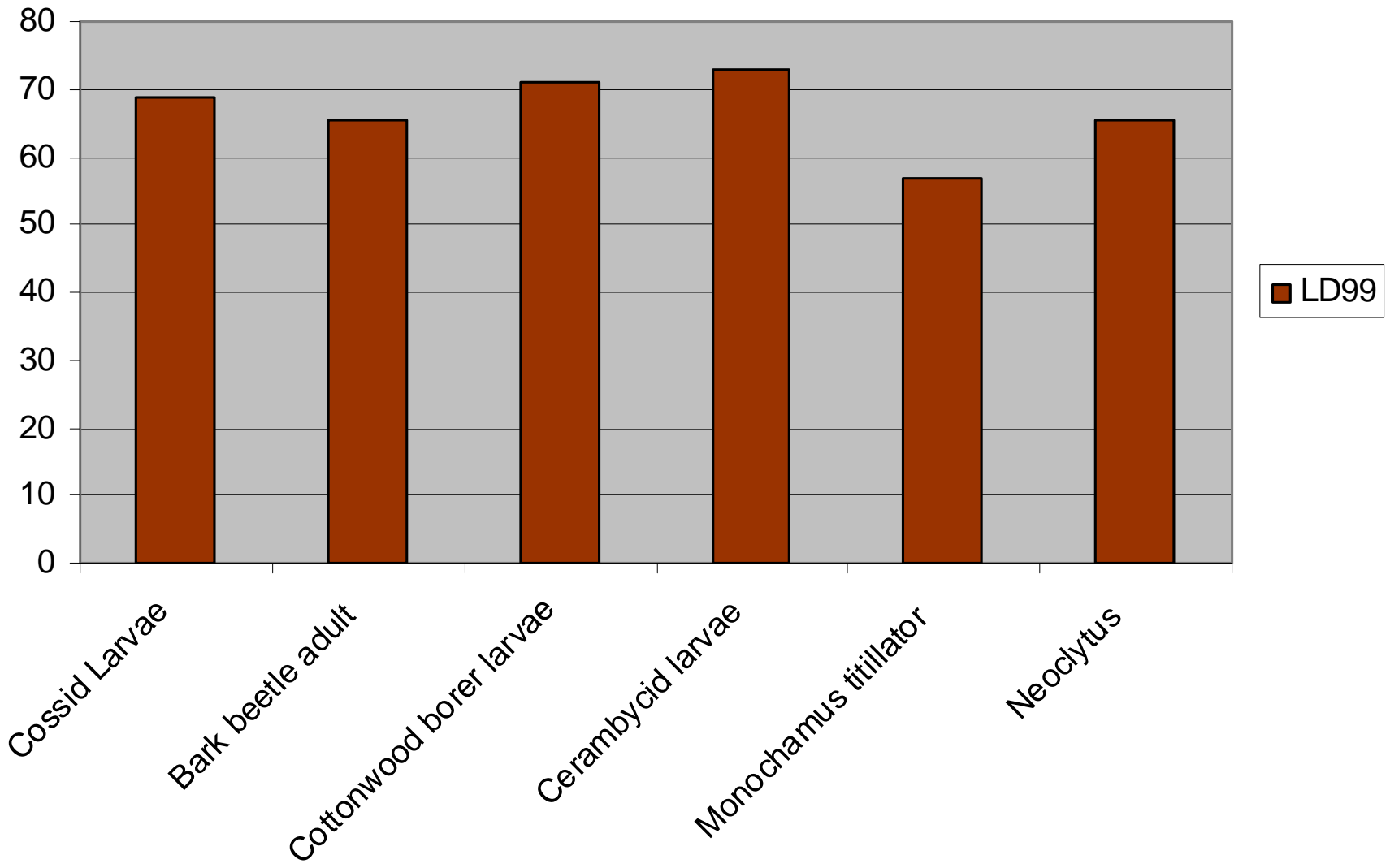
# Methods for MW of bark beetle naturally infested pine



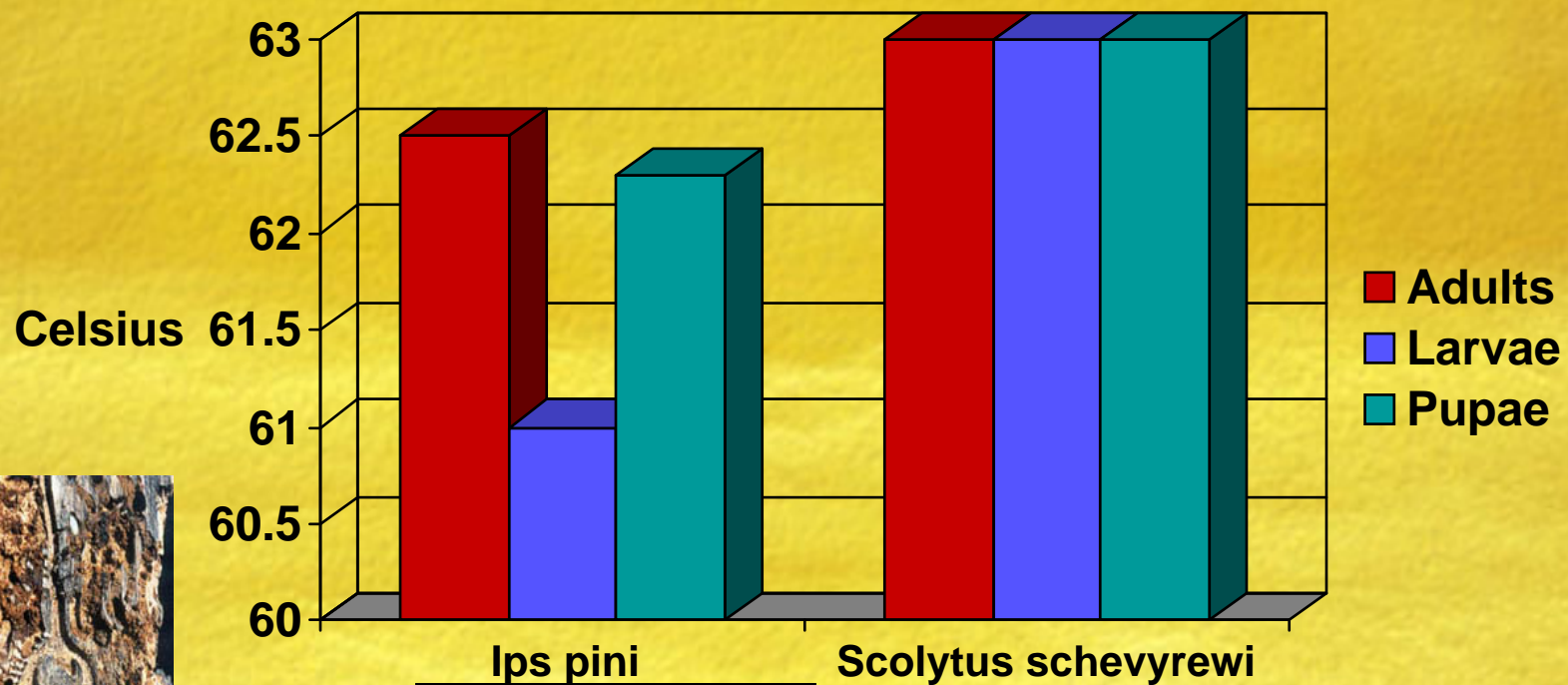
# Lethal temperatures

<b>Insect</b>	<b>LD<sub>99</sub></b>	<b>95% confidence interval for LD<sub>99</sub></b>	<b>Sample size from exp</b>	<b>Standard deviation for LD<sub>99</sub></b>	<b>Calculated sample size</b>
<b>Cossid Larvae</b>	<b>68.9</b>	<b>(62.9 114.6)</b>	<b>35</b>	<b>78.0</b>	<b>244</b>
<b>Bark beetle adult</b>	<b>65.3</b>	<b>(60.7, 81.3)</b>	<b>56</b>	<b>39.3</b>	<b>62</b>
<b>Cottonwood borer larvae</b>	<b>71.1</b>	<b>(63.2, 85.4)</b>	<b>104</b>	<b>57.8</b>	<b>134</b>
<b>Cerambycid larvae</b>	<b>72.8</b>	<b>(63.2, 94.5)</b>	<b>116</b>	<b>86.0</b>	<b>285</b>
<b>Monochamus titillator</b>	<b>57.0</b>	<b>(52.7, 131.9)</b>	<b>28</b>	<b>106.9</b>	<b>444</b>
<b>Neoclytus</b>	<b>65.6</b>	<b>(54.067, 183.981)</b>	<b>19</b>	<b>144</b>	<b>801</b>

LD99



# Lethal temperatures of bark beetles in naturally infested logs




No. of insects, no. of logs		MC = 88%
2576	57	
906	32	
488	27	

No. of insects, no. of logs		MC = 68%
9	4	
181	4	
84	4	



# Recommendations for treatment schedule

- MW/RF application to achieve a minimum wood surface temperature of 62°C for at least 60 seconds.
  - Wood thickness should not exceed 20 cm without further research.
  - RF has better penetration ability and less variability in field strength throughout chamber
  - RF has great potential for treating more product faster and for larger wood material (saw logs)
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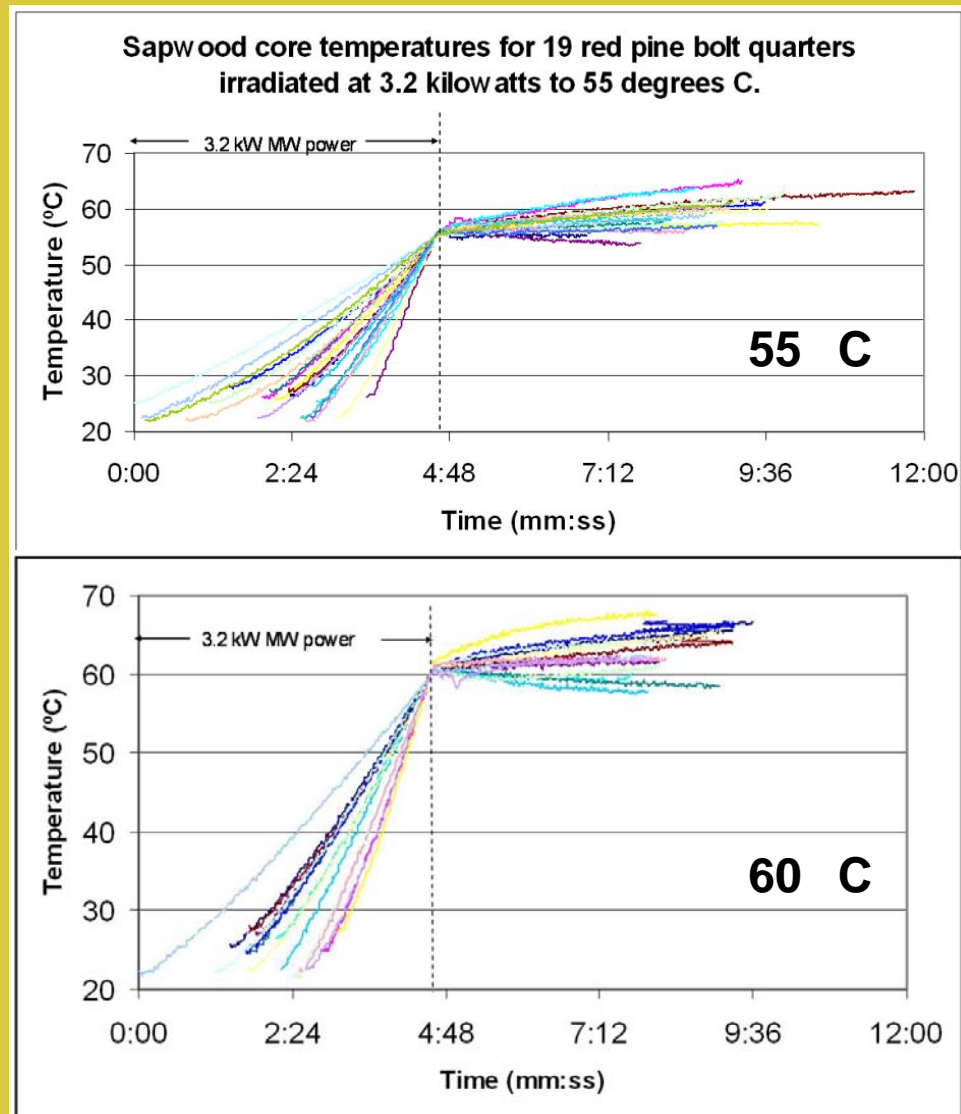
# In line tunnel testing

- Movement reduces treatment time to obtain similar efficacy
- 1"x4"x20"; 5-6 kW for medium MC, high MC at 7 kW
- 6 ft. chamber moving 2.6 ft/min, mean duration in chamber 2.3 min
- Killed 100% of pinewood nematodes and *P. scalator* larvae at  $\geq 62^{\circ}\text{C}$

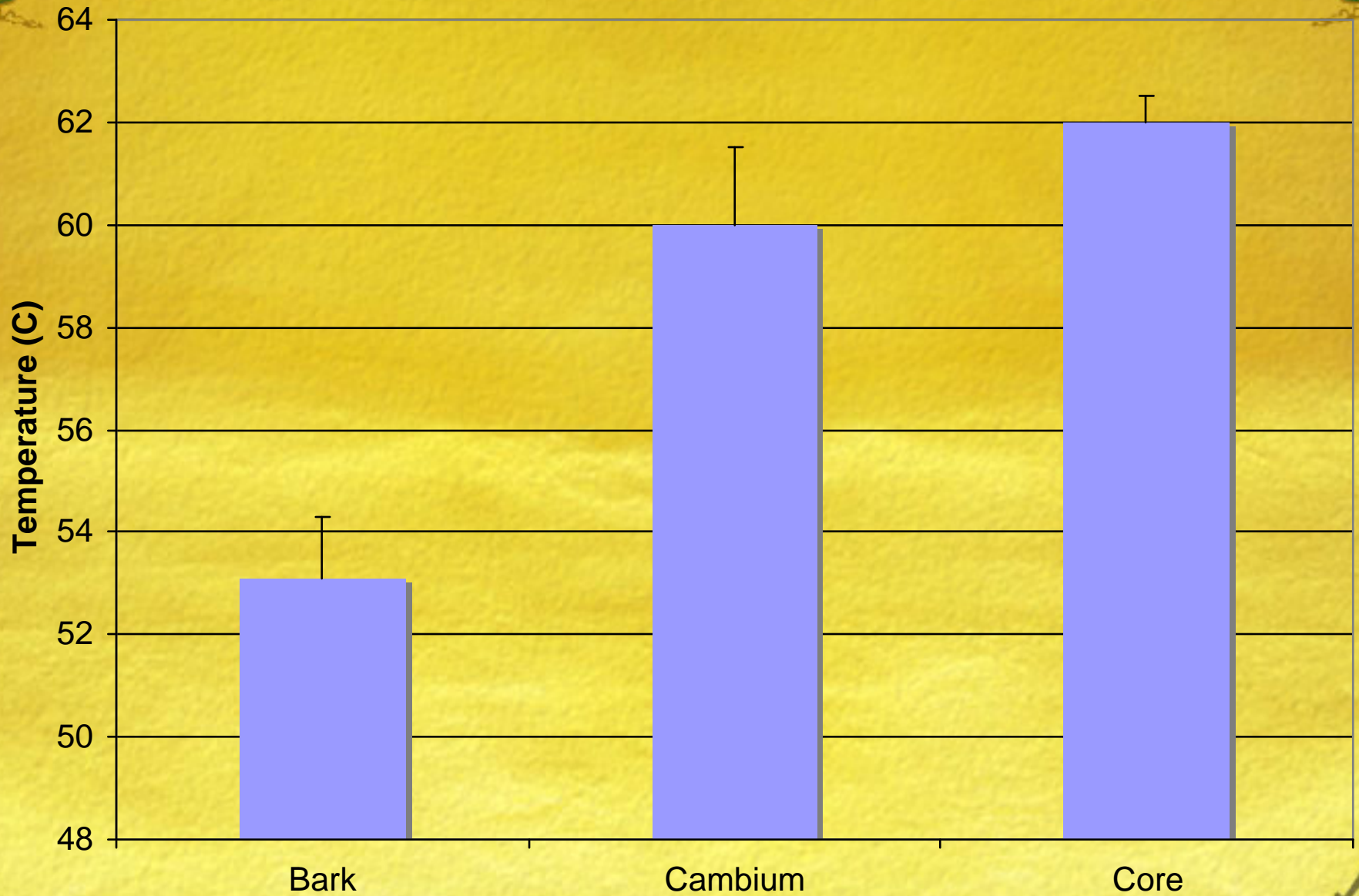


Fleming et al. 2005.

# Temperature increases or remains stable for several minutes after oven off



# Temperatures in red pine



$\beta_0$ 

# Surface to core temp (°C)

$$\text{Core\_T} = \beta_0 + \beta_1 * \text{low\_surface\_T} + \beta_2 * \text{hi\_surface\_T} \\ + \beta_3 * \text{type} + \beta_4 * \text{MC} + \beta_6 * \text{wtSVratio} + \varepsilon$$

From the parameter estimate, for MW treatment

$$\text{Core\_T} = 42.524 + 0.776 * \text{low\_surface\_T} + 0.262 * \text{hi\_surface\_T} - 0.145 * \text{MC} - 0.006 * \text{wtSVratio}$$

For RF treatment

$$\text{Core\_T} = 30.714 \text{ (intercept)} + 0 \text{ (estimate for RF)} + 0.776 * \text{low\_surface\_T} \\ + 0.262 * \text{hi\_surface\_T} - 0.145 * \text{MC} - 0.006 * \text{wtSVratio}$$

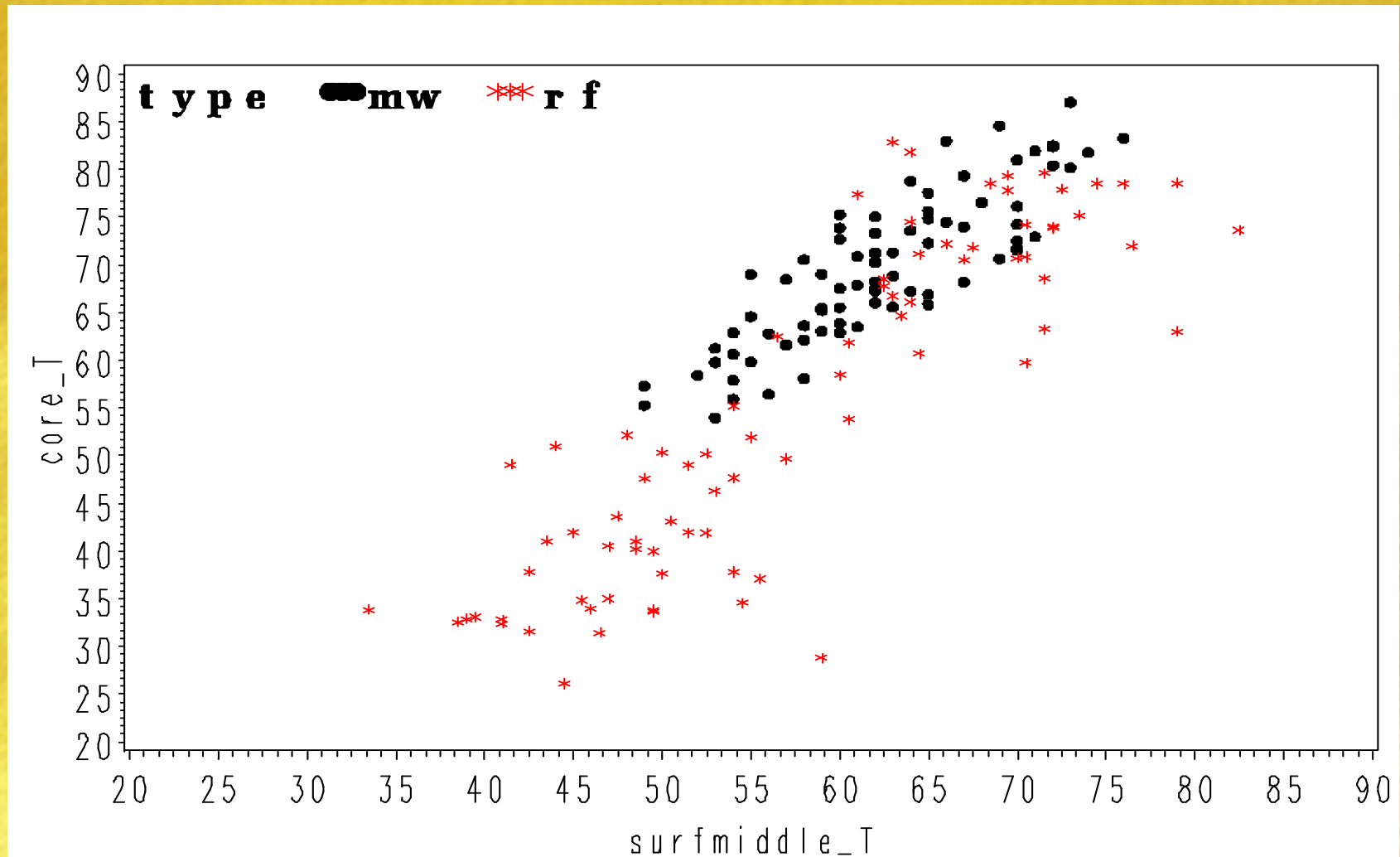
$$R^2 = 0.756$$

# Surface to cambium temp

$$\text{Cambium\_T} = -2.49 + 0.67 * \text{low\_surface\_T} + 0.49 * \text{hi\_surface\_T}$$

with  $R^2=0.88$

# Core Temp vs. surface middle Temp by heating type



# Other wood pests tested by MW or RF


- Coleoptera
  - ⊙ Anobiidae (Burdette et *al.* 1975)
  - ⊙ Cerambycidae (Fleming et *al.*, 2004 and 2005)
  - ⊙ Curculionidae (white pine weevil)
- Isoptera : Dampwood termites
- Pinewood nematode (Fleming et *al.*, 2005)
- Sapstain fungi (RF, Tubajika et *al.*, 2007)
- Asian longhorned beetle (larvae and pupae)
- Emerald ash borer (RF & MW in progress)
- *Sirex noctilio* (RF in progress)

# Conclusions

- Microwave irradiation of wood is as (or more) effective against pests as current ISPM-15 approved methods (conventional heat or MB)
- ISPM-15 requirement of 56°C for at least 30 minutes is not applicable to MW or RF
- Fitting data to the best model is necessary to estimate temperature required to reach 100% mortality with 95% confidence



# Goals for 2008

- ✓ Verify lethal temperature models with naturally infested wood
  - ✓ Test more PWN and wood-boring insects to narrow the confidence interval
  - ✓ Efficacy of MW/RF of emerald ash borer infested roundwood in progress
  - ✓ Develop data set to demonstrate RF efficacy is comparable to MW followed by formal submission of RF by US NPPO as alternative treatment under ISPM-28
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# Thanks to...

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