



Microwave Treatment of insect-infested wood

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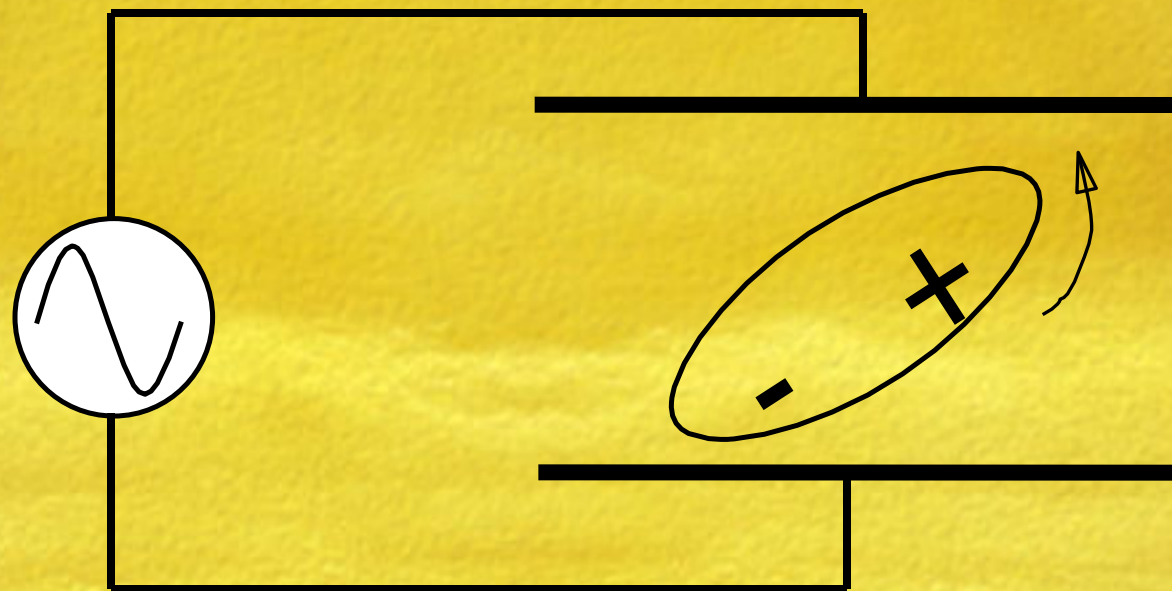
ISPM-15 Regulations

- 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.

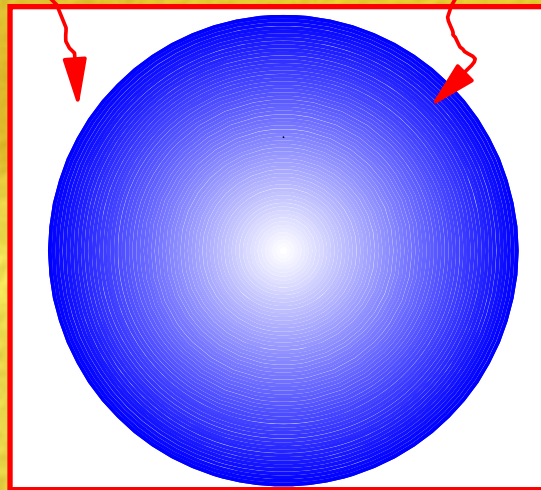
How does MW/RF work?



Ben Wilson, PSC Inc.

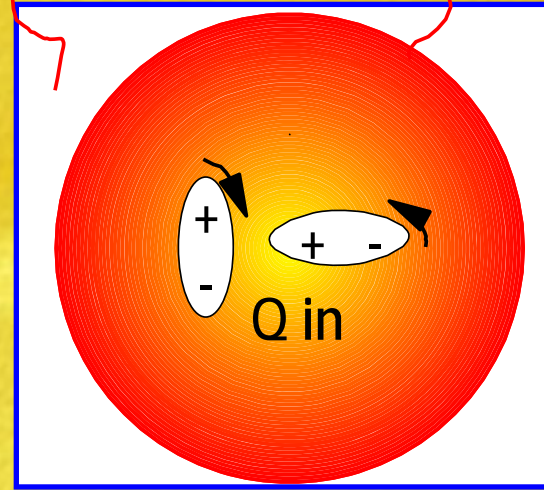
How does MW/RF work?

Q Heat in



Conventional
Heating

Losses



Dielectric
Heating

Methods for efficacy testing MW of cerambycid adults



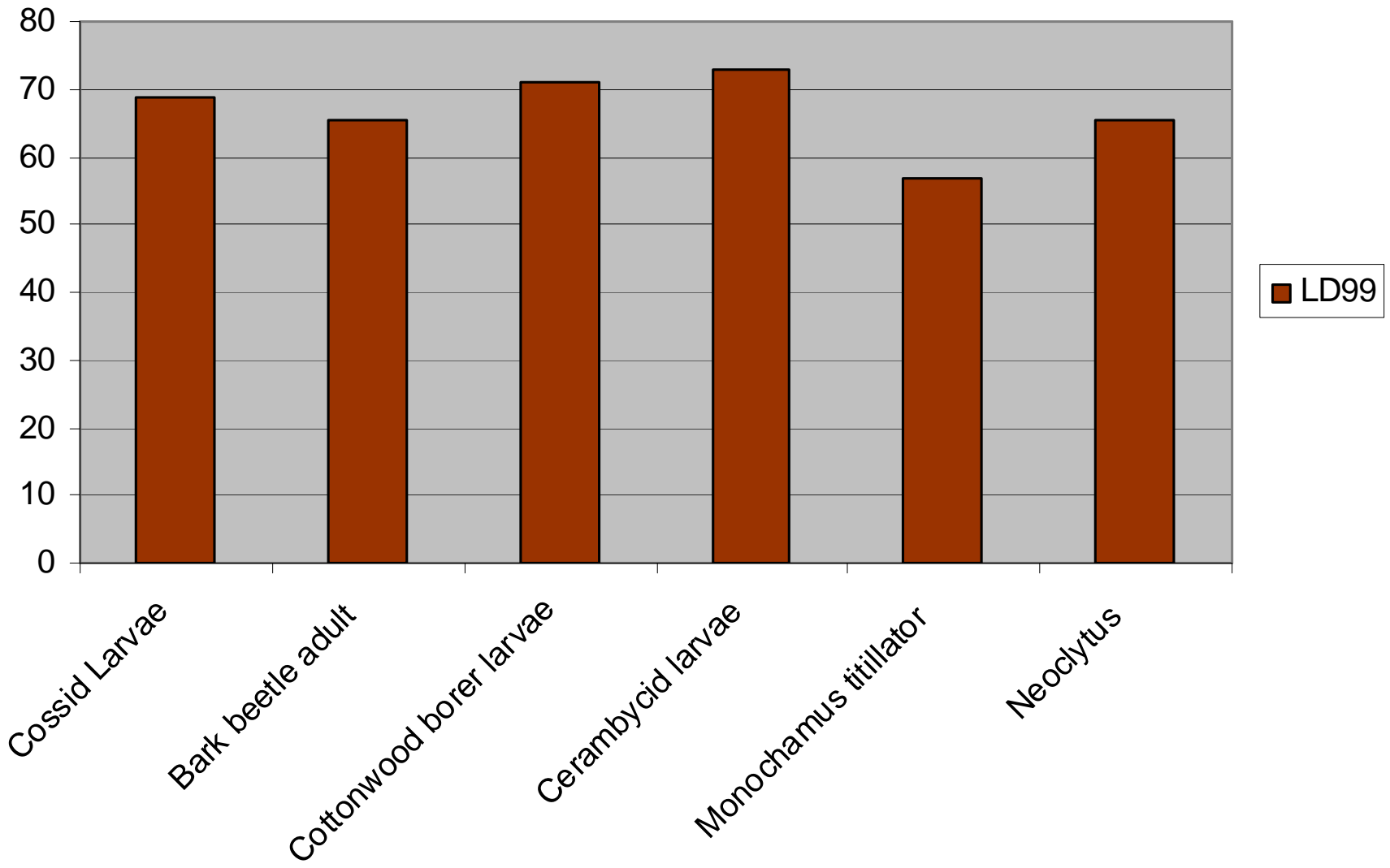
Methods for MW of bark beetle naturally infested pine



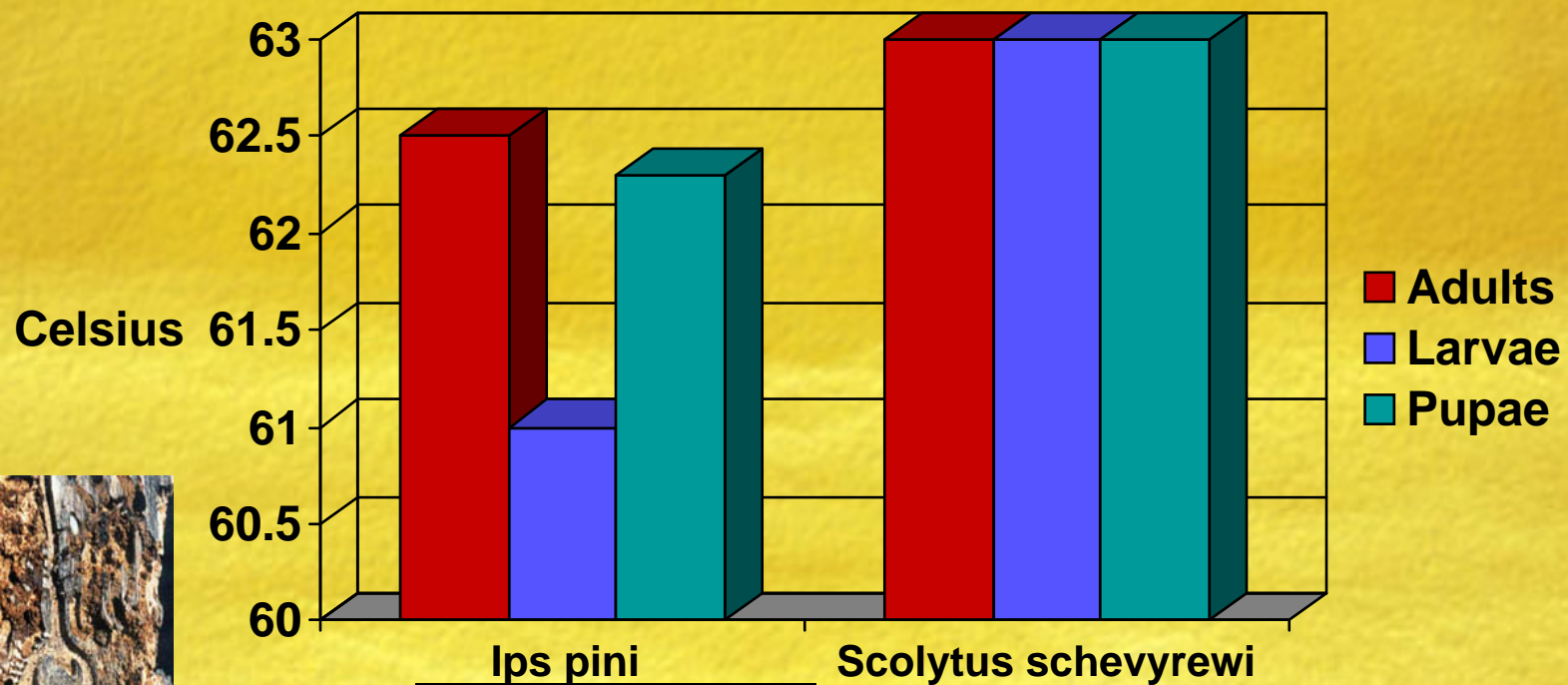
Lethal temperatures

Insect	LD₉₉	95% confidence interval for LD₉₉	Sample size from exp	Standard deviation for LD₉₉	Calculated sample size
Cossid Larvae	68.9	(62.9 114.6)	35	78.0	244
Bark beetle adult	65.3	(60.7, 81.3)	56	39.3	62
Cottonwood borer larvae	71.1	(63.2, 85.4)	104	57.8	134
Cerambycid larvae	72.8	(63.2, 94.5)	116	86.0	285
Monochamus titillator	57.0	(52.7, 131.9)	28	106.9	444
Neoclytus	65.6	(54.067, 183.981)	19	144	801

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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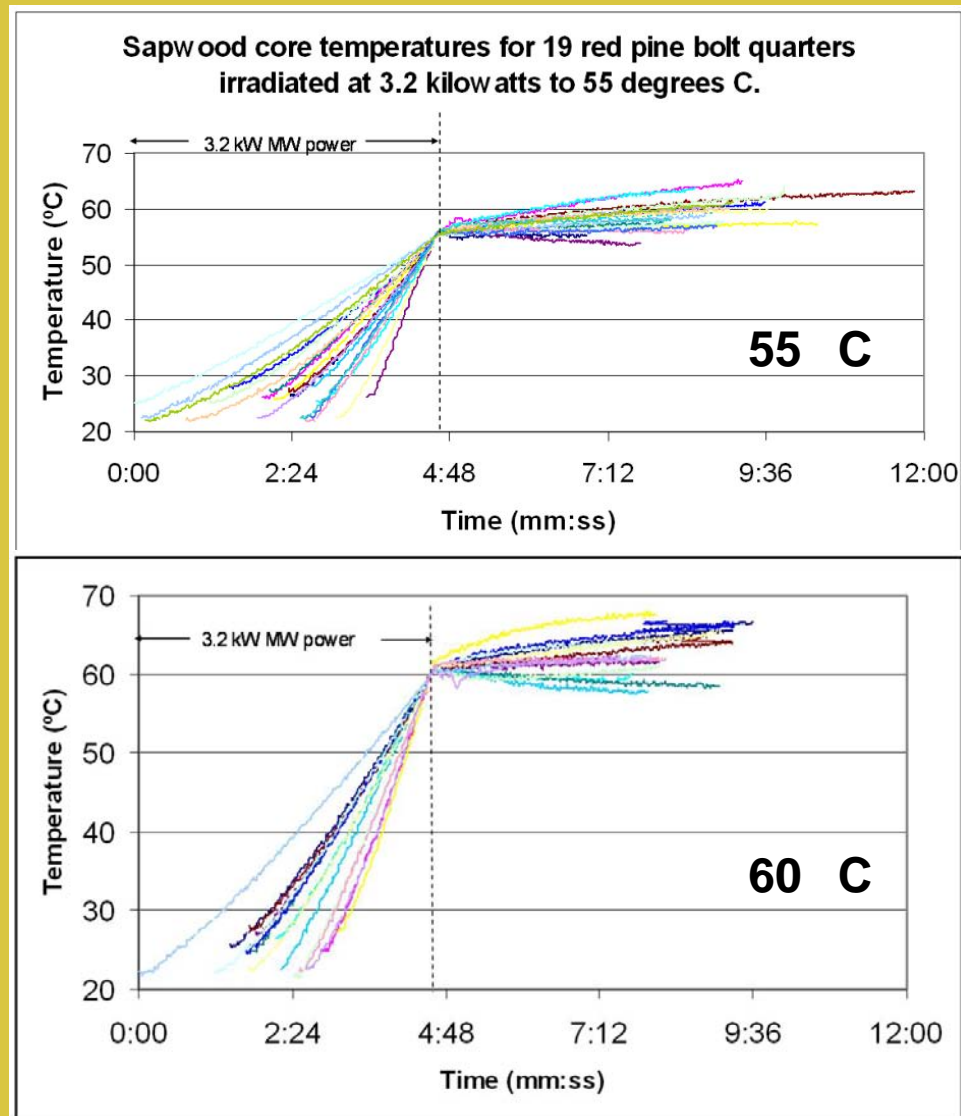
In line tunnel testing

- 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 $\geq 62^{\circ}\text{C}$

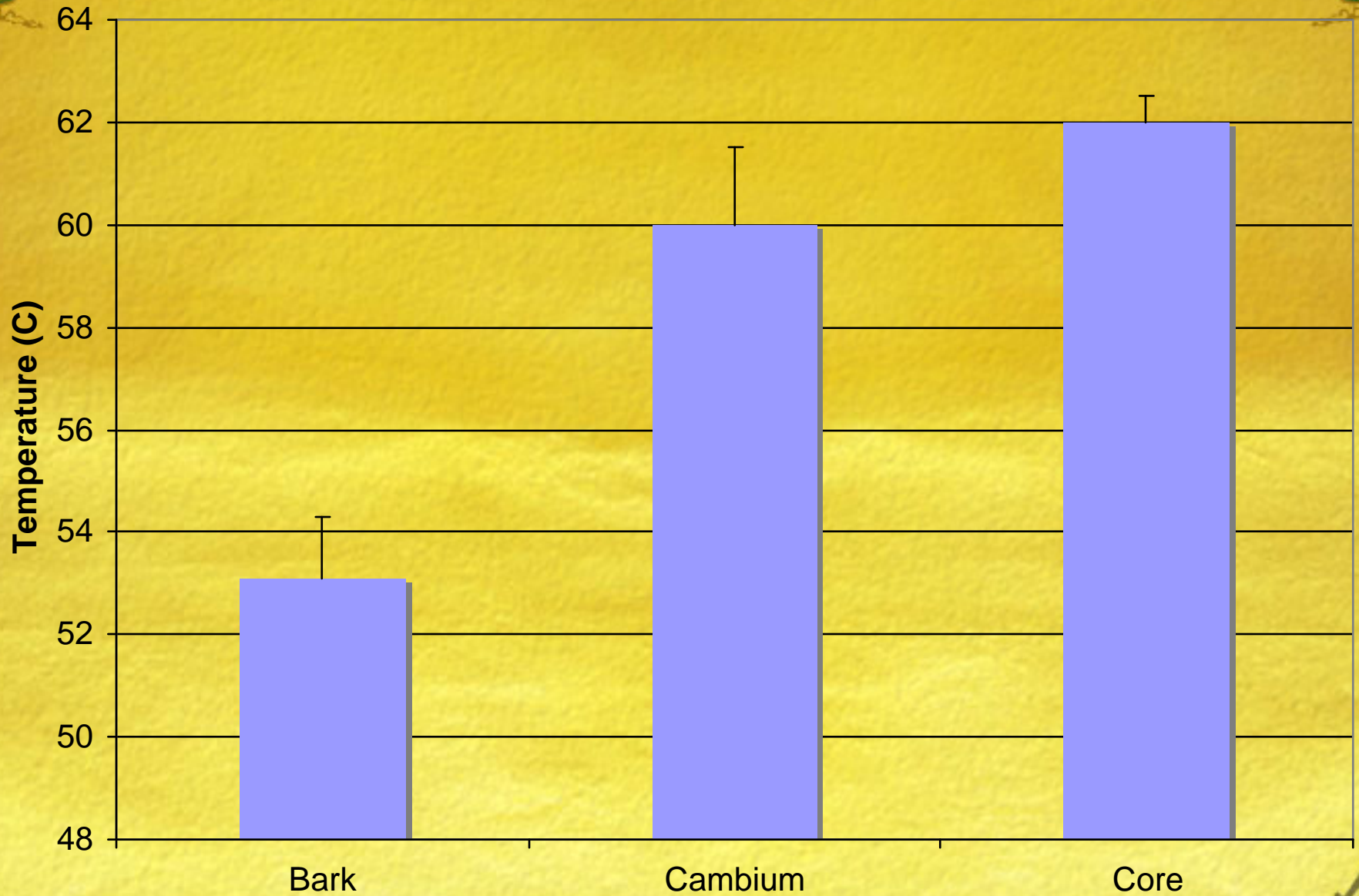


Fleming et al. 2005.

Temperature increases or remains stable for several minutes after oven off



Temperatures in red pine



β_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

$$\text{Core_T} = 30.714 \text{ (intercept)} + 0 \text{ (estimate for RF)} + 0.776 * \text{low_surface_T} \\ + 0.262 * \text{hi_surface_T} - 0.145 * \text{MC} - 0.006 * \text{wtSVratio}$$

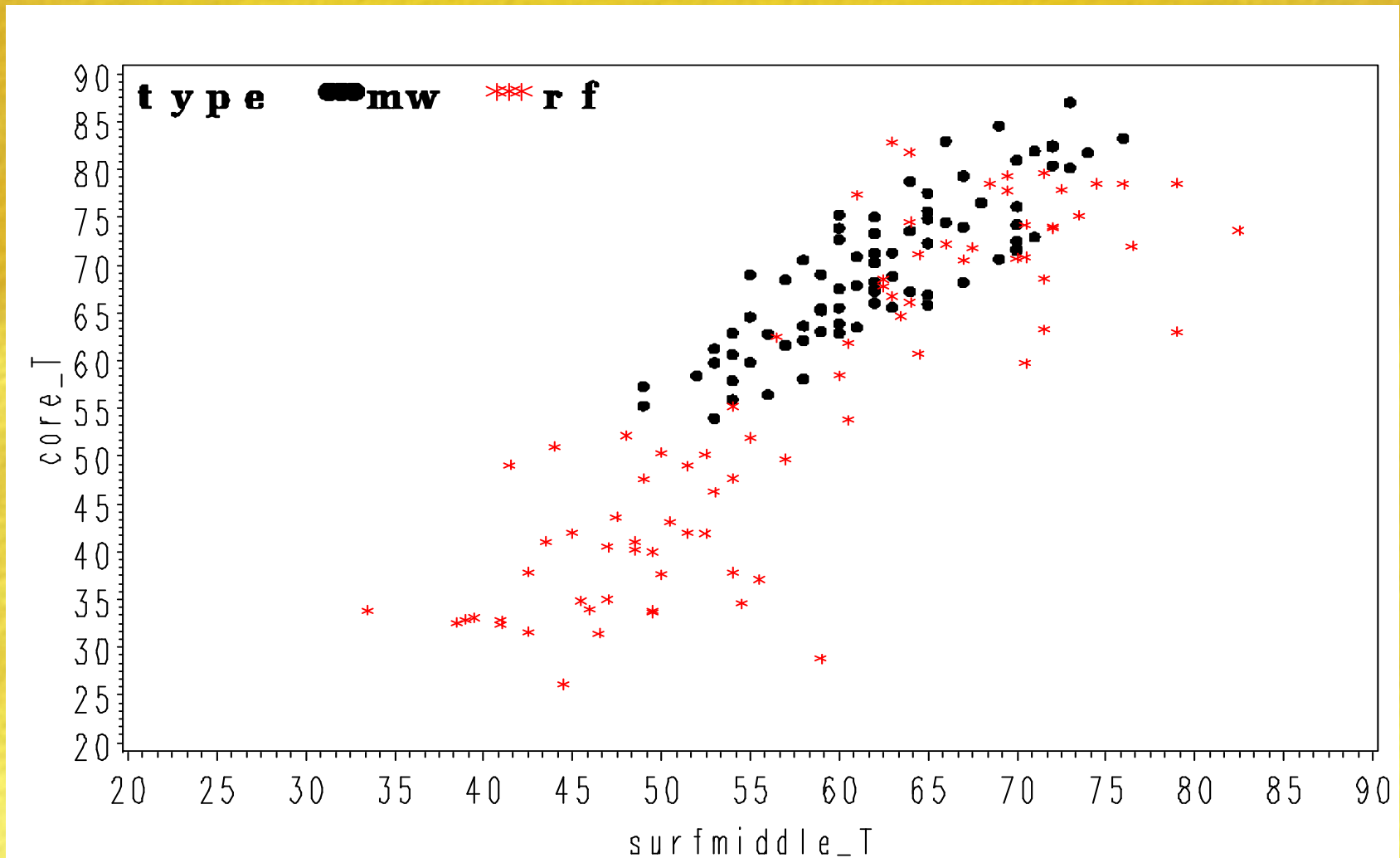
$$R^2 = 0.756$$

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...

- Jeff Kimmel, Scott Geib
- Ben Wilson (PSC, Inc.)
- Emitech (Italy)
- Ron Mack (APHIS)
- Bob Haack & Therese Poland (USFS)
- Ivich Frasier & Vic Mastro (APHIS)
- Funding: USDA Methyl Bromide Transitions
- Previous funding: USDA, APHIS