Think international heat treatment for Solid Wood Packing Material was meant to eliminate wood attacking pests? Think again.

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OREGON DEPARTMENT OF AGRICULTURE

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Confusion

- Original version:
  - Practically eliminate ("in effect or virtually")

- The ISPM15 heat treatment of 56° C for 30 minutes is not an effective phytosanitary treatment.

- 2009 and Later versions:
  - Significantly reduce = "of important consequence"

- Why does this matter?
  - It allows pests to invade!
  - Efforts are underway to "fix" the SWPM issues
    - With a weak treatment it isn't possible to identify undertreatment or fraud

New Exotic Invertebrate Species Found Established in Oregon 2007 - 2023

Year	No. Species
2007	11
2008	10
2009	14
2010	11
2011	6
2012	10
2013	4
2014	7
2015	25
2016	11
2017	6
2018	13
2019	7
2020	16
2021	11
2022	14
2023	5
	181

An average of
9.4 species/year
or
> 1 every two months!

Since 2007 OR has detected 24 new woodborers

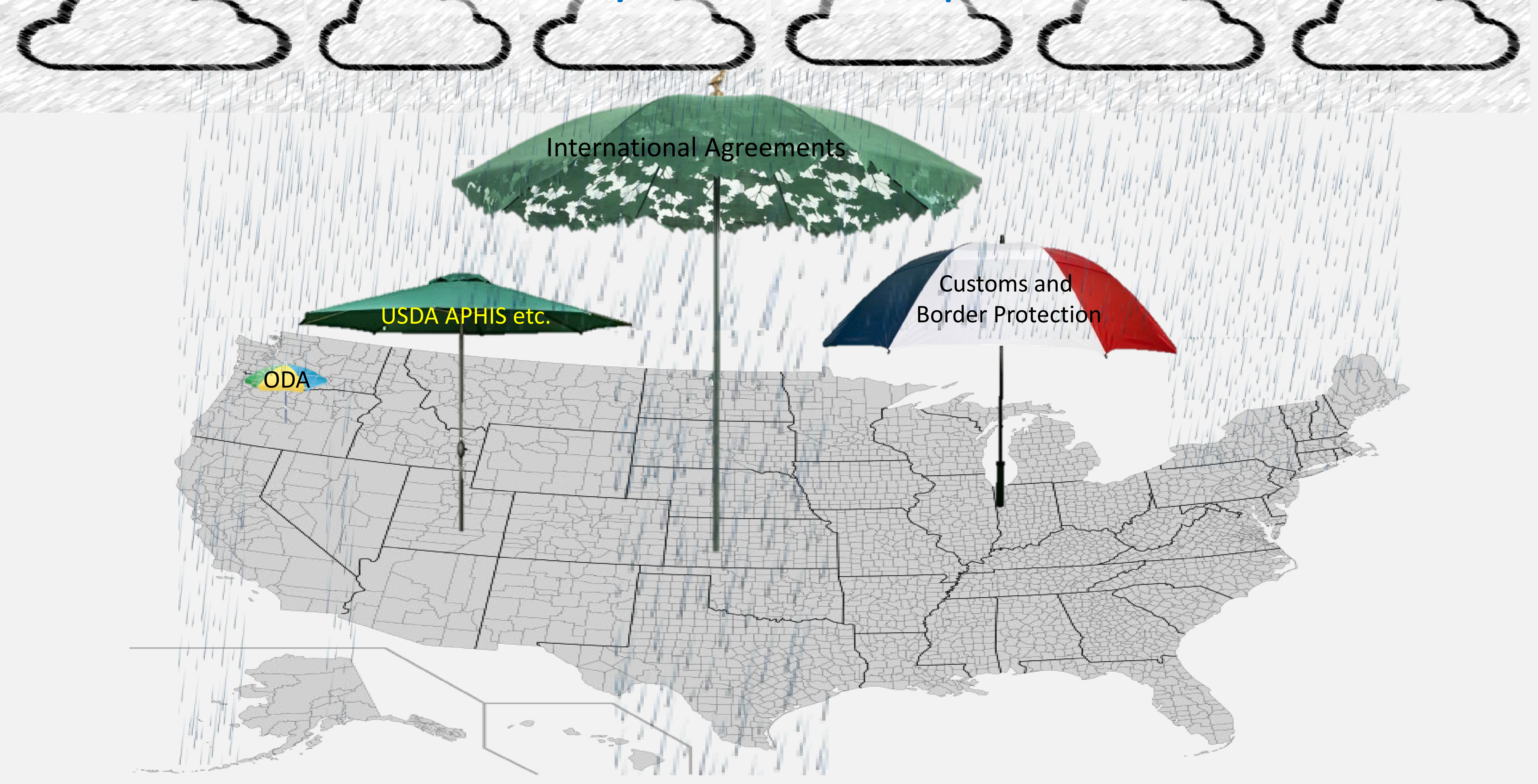
Scientific name	Common name	Origins	Food	Where Found in Oregon	When Collected in Oregon	How Detected	Area New To	Status
Pityophthorus juglandis	Walnut twig beetle	SW U.S., Mexico	Walnut trees	The Dalles	2007	Survey	Oregon/PNW	Established
Tremex columba	pigeon tremex	E. North America	wood borer in broadleaved trees	Portland	2013	Survey	Far western N.A.	Established
Neoclytus caprea (Say)	banded ash borer	E. North America	ash and other hardwoods	Portland industrial area	201[illegible]	Survey	Western N.A.	Unknown
Phymatodes lividus (Rossi)	longhorned beetle	Europe	Larvae bore in dead hardwoods	McMinnville	2015	USDA sample	W. North America	Unknown
Acanthocinus leechi (Dillon)	a longhorned beetle	SW N. America	Pine	Beaverton	2016	Public	Oregon/PNW	unknown
Euwallacea validus	ambrosia beetle	SE US, Asia	broadleaved trees	The Dalles	2016	Survey	Western U.S.	Established
Cyclorhipidion pelliculosum (Eichhoff)	ambrosia beetle	Asia	hardwood trees	Rooster Rock State Park	2017	ODF funnel trap survey	Western N.A.	Established
Trypodendron domesticum	ambrosia beetle	Europe	broadleaved tree wood	Scappoose	2018	ODF funnel trap survey	Oregon	Established
Astyleiopus variegatus	a longhorned beetle	Eastern U.S.	broadleaved tree wood (July)	Umatilla County	2019	Survey	Western N.A.	Unknown
Trichoferus campestris	velvet longhorned beetle	Asia	broadleaved tree wood	Umatilla County	2019	Survey	west of the Rockies	Established
Sternidius alpha	a longhorned beetle	E. North America	broadleaved tree wood	Umatilla County	2020	Survey	west of the Rockies	Unknown
Molorchus bimaculatus bimaculatus	longhorned beetle	eastern N.A.	broadleaved trees and shrubs	The Dalles	2021	Survey	Western N.A.	Unknown
Agrilus difficilis	honey locust borer	eastern N.A.	honeylocust (July trap removal)	Milton-Freewater	2021	Survey	PNW & Oregon	Established
Xyleborus monographus	Mediterranean oak borer	CA, Asia	oak	Marion County	2021	Survey	PNW	Established
Anelaphus m. moestus (LeConte)	longhorned beetle	UT, SW US	walnut, oak, Celtis	Umatilla County nursery	2021	Survey	PNW	Unknown
Ips pertubatus	Northern spruce engraver	Boreal North America	spruce	The Dalles	2022	Survey	Oregon	unknown
Ips grandicollis	eastern 5-spined pine engraver	eastern N.A.	pines	Marion County	2022	Survey	PNW	Unknown
Agrilus planipennis	emerald ash borer	eastern N.A. and Asia	ash	Forest Grove	2022	First detector	west of the Rockies	Established
Synanthedon proxima	willow clear wing moth	E. North America	Salix, Poplar	Umatilla Co.	2022	Survey	Western U.S.	Unknown
Ceratina dalltorreana	small carpenter bee	Europe, Middle east	nectar and pollen	Medford	2022	Survey	Oregon/PNW	Unknown
Callidiellum rufipenne	Japanese cedar longhorned beetle	Japan	Cupressaceae	Portland	2023	iNaturalist	Western N. America	Established
Xylotrechus colonus	Rustic borer	Eastern N. America	Broadleaf trees and pine	Clackamas Co.	2023	Survey	Oregon	Unknown
Anelaphus parallelus	oak twig pruner	eastern N.A.	oak	The Dalles	2024	Survey	Western N.A.	Unknown
Leptostylus transversus	longhorned beetle	eastern N.A.	broadleaf trees	The Dalles	2024	Survey	Western N.A.	Unknown

Species detected but not established

10 species

Scientific name	Common name	Origins	Food	Where Found in Oregon	When Found in Oregon	How Detected	Area New To	Status
Xyloterinus politus	ambrosia beetle	Eastern U.S.	trees	The Dalles	2011	Survey	Western U.S.	Not established
Monarthrum mali	applewood stainer	Eastern U.S.	trees	The Dalles	2012	Survey	Western U.S.	Not established
Tremex fuscicornis	woodwasp	Asia, S. America	broadleaved trees	Portland iron foundry shipment from China	2012	Public	N. America	Not established
Hylotrupes bajulus	old house borer	Europe	seasoned lumber	The Dalles	2013	Survey	Oregon/West	Not established
Monarthrum fasciatum	ambrosia beetle	Eastern U.S.	trees	The Dalles	2014	Survey	Western U.S.	Not established
Xylosandrus crassiusculus	Granulate ambrosia beetle	Eastern U.S.	trees	The Dalles	2015	Survey	Western U.S.	Eradicated
Xylosandrus crassiusculus	Granulate ambrosia beetle	Eastern U.S.	trees	The Dalles	2018	Survey	Western U.S.	Not established
Monochamus urossovii	Black fir sawyer beetle	Eurasia	conifers	Dunnage for iron shipment from Russia port of Portland	2019	Inspection	N. America	Not established
Xylocopa virginica	Eastern carpenter bee	eastern US	nectar and pollen	picnic table from AL	2021	Survey	Western US	Not established
Semanotus sinoauster	longhorned beetle	China	Cupressaceae	Aurora airport	2022	public	W. North America	Not established
Xylobiops parilis	Powderpost beetle	S. CA and MX	Wood and bamboo	Salem	2023	Public	Pacific Northwest	Not established

Potentially Introduced species



In spite of ISPM15, new wood borers keep arriving

- This doesn't include the species intercepted at our ports.

24 Species found in the US since 2006.

Order	Family	Species	Year	Status	Notes
Coleoptera	Scolytinae	*Xyleborinus octiesdentatus*	2008	Established	ambrosia beetle
Coleoptera	Scolytinae	*Dryocoetoides reticulatus*	2009	Established	bark beetle
Coleoptera	Scolytinae	*Cyclorhipidion tenuigraphum*	2009	Established	Ambrosia beetle
Coleoptera	Scolytinae	*Araptus schwarzi*	2010	Established	bark beetle
Coleoptera	Scolytinae	*Xyleborinus artestriatus*	2010	Established	ambrosia beetle
Coleoptera	Scolytinae	*Xylosandrus amputatus*	2010	Established	ambrosia beetle
Coleoptera	Scolytinae	*Trypodendron domesticum*	2010	Established	ambrosia beetle
Coleoptera	Cerambycidae	*Trichoferus campestris*	2010	Established	Velvet longhorn beetle
Coleoptera	Scolytinae	*Xyleborinus andrewesi*	2010	Established	ambrosia beetle
Coleoptera	Buprestidae	*Agrilus smaragdifrons*	2011	Established	Jewel beetle
Coleoptera	Scolytinae	*Ambrosiodmus minor*	2011	Established	ambrosia beetle
Coleoptera	Scolytinae	*Euwallacea interjectus*	2011	Established	Ambrosia beetle
Coleoptera	Scolytinae	*Cyclorhipidion fukiense*	2012	Established	ambrosia beetle
Hymenoptera	Siricidae	*Tremex fuscicornis*	2012	Eradicated	woodwasp
Coleoptera	Scolytinae	*Ambrosiodmus nodulosus*	2013	Established	ambrosia beetle
Coleoptera	Scolytinae	*Euwallacea kuroshio*	2013	Established	ambrosia beetle
Coleoptera	Cerambycidae	*Phymatodes lividus*	2015	Eradicated	Longhorn beetle
Coleoptera	Buprestidae	*Agrilus* spp.	2017	Established	Digirolomo et al 2019
Coleoptera	Scolytinae	*Cyclorhipidion distinguendum*	2017	Established	Ambrosia beetle
Coleoptera	Scolytinae	*Xyleborus monographus*	2018	Established	ambrosia beetle
Coleoptera	Cerambycidae	*Monochamus urossovii*	2019	Destroyed	Black fir sawyer
Coleoptera	Scolytinae	*Ernoporus parvulus*	2021	Established	bark beetle
Coleoptera	Cerambycidae	*Semanotus sinoauster*	2022	Eradicated	Longhorn beetle
Coleoptera	Scolytinae	*Cyclorhipidion japonicum*	2022	Established	Ambrosia beetle

Woodborer invasions worldwide

- Haven’t stopped!
- Insects are regularly found in stamped and documented WPM that has been — or at least appears to have been — treated by heat or fumigation according to ISPM 15 regulations. (Nodar 2021)
- Private companies are voluntarily increasing heat treatments both in time and temperature to avoid rejected shipments (Dorrough 2020).
- There are efforts to mitigate the wood pests (process analysis, etc)
- Cold storage and hammermill

- Having an inadequate treatment makes it impossible to see
  - under treatment
  - Cheating
  - Any problems!
- Undermines confidence in the system
  - Importers can be doing everything right and still fail
  - And be punished!

What do you mean they didn't mean to?

[4] A minimum core temperature of 56° C for a minimum of 30 min. is chosen in consideration of the wide range of pests for which this combination is documented to be lethal and a commercially feasible treatment. Although it is recognized that some pests are known to have a higher thermal tolerance, quarantine pests in this category are managed by NPPOs on a case by case basis.
[5] Certain countries require that the minimum commodity temp should be higher

Guidelines for regulating wood packaging material used in the transport of commodities / 9
ISC draft / November 2001

It is explicitly stated!

2001:

"Although it is recognized that some pests are known to have a higher thermal tolerance, ..."

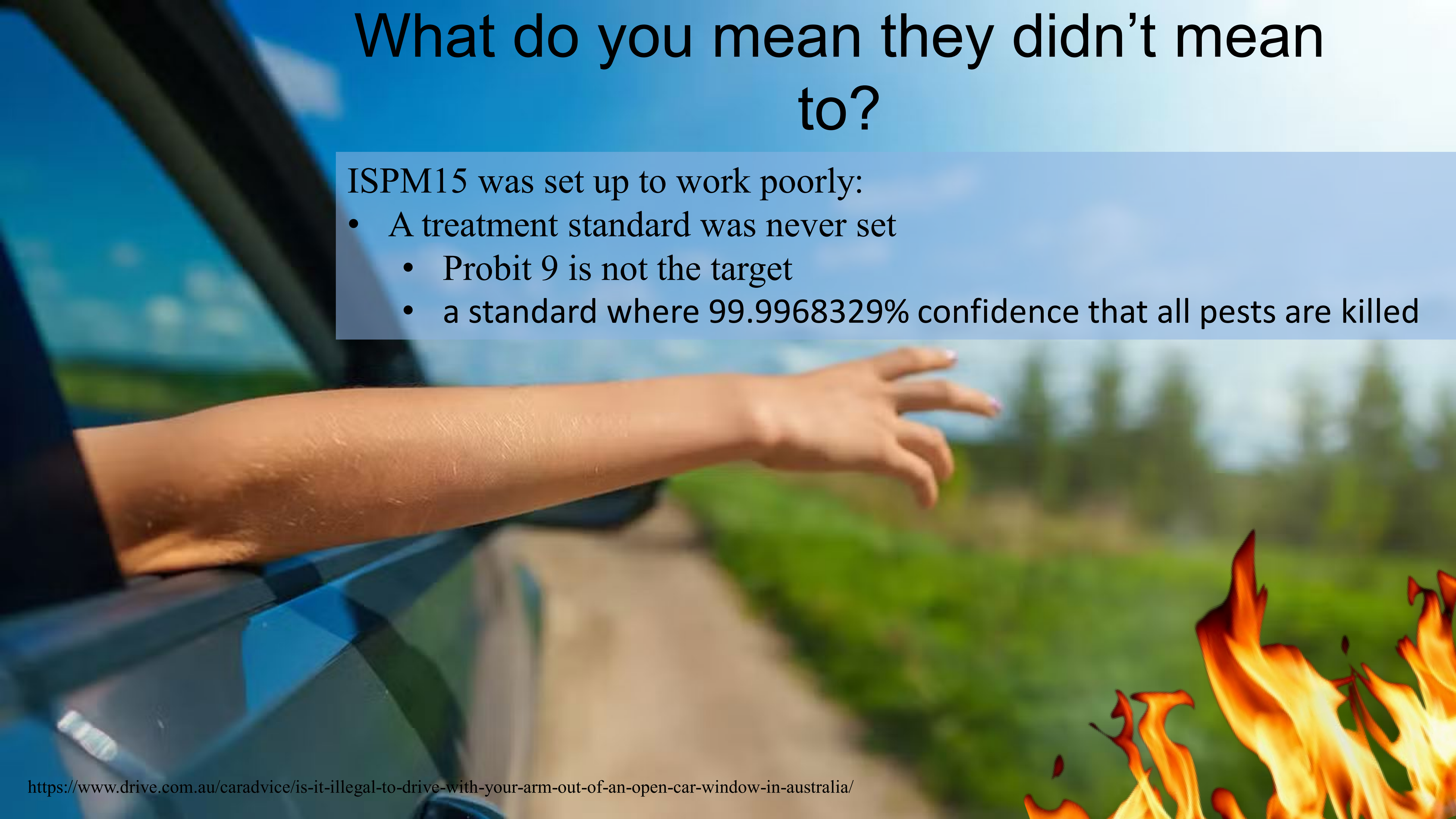
2017:

"The treatments identified in ISPM 15 do not provide absolute protection against all pests of wood. . ."

Since wood packaging material moves through complex and widely dispersed trading patterns, amongst different countries, the addition of country-specific phytosanitary import requirements would result in undesirable complexities in the trade of commodities. The standard balances risk reduction to an internationally recognized acceptable level with least restrictive trade measures. The treatments identified in ISPM 15 do not provide absolute protection against all pests of wood, however, the application of these measures do provide a safer worldwide trading environment in which the majority of risks have been mitigated.

https://www.drive.com.au/caradvice/is-it-illegal-to-drive-with-your-arm-out-of-an-open-car-window-in-australia/

What do you mean they didn't mean to?



ISPM15 was set up to work poorly:

- A treatment standard was never set
  - Probit 9 is not the target
  - a standard where 99.9968329% confidence that all pests are killed

https://www.drive.com.au/caradvice/is-it-illegal-to-drive-with-your-arm-out-of-an-open-car-window-in-australia/

New wood borers keep getting past our international borders

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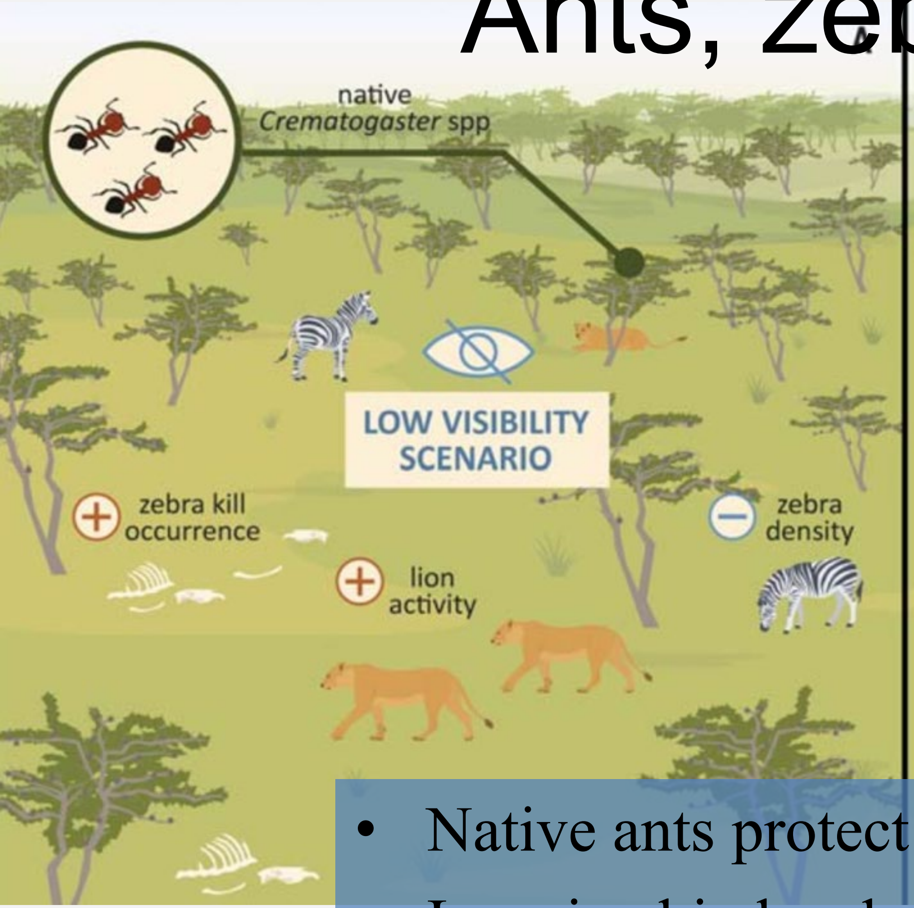
24 Species found in the US since 2006.

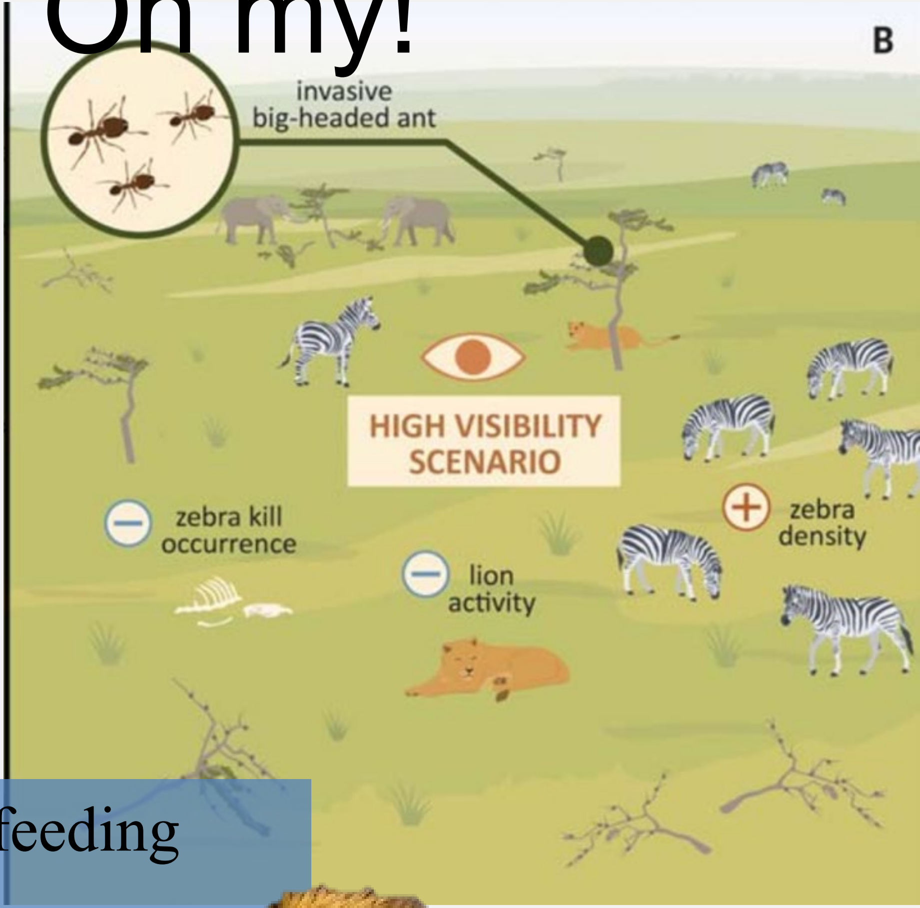
How much impact can a little bug have?

How about an ant?

Ants, zebras and lions, Oh my!



Kamaru *et al* 2024



- Native ants protect *Acacia* trees from elephant feeding
- Invasive big headed ants kill the native ants
- Elephants destroy the trees
- Lions have less cover
- Fewer zebras caught
- Lions eat?

Legacy Species: A "Gift" From One Generation To The Next

Ecological crisis

- Invasive species represent an ecological crisis almost completely ignored
  - Altering ecosystems- forever
  - Adding stressors to trees- forever
  - Making it difficult for native species to survive and fulfill their roles- forever

Customs and Border Protection

- Less than 2% of shipments are inspected
- Under the guidance of USDA APHIS

- **Inspection rates must be increased!**

http://cryptotimes.org/bitcoin/cryptocurrency-hits-high-seas-ukrainian-shipping-company-accepts-bitcoin/

Haack *et al* 2014

- **estimated that 13,000 containers arrive in the US each year with live wood pests**

- This ignores pests that don’t bore into wood.

Doesn't the data support 56/30?

- NO
- 4 studies (of 8 studies) demonstrated treatment inadequacy
  - Survival ranged from near zero to 38.9%.

Author	year	species	life stage	harvest time	temp C	Time (minutes)	% survival
Myers et al	2009	Emerald ash borer	larvae	winter	58.6	60	1.3
Myers et al	2009	Emerald ash borer	larvae	winter	59.2	30	13.8
Myers et al	2009	Emerald ash borer	larvae	winter	57	30	28.1
Myers et al	2009	Emerald ash borer	larvae	winter	58.5	30	35.3
Goebel et al	2010	Emerald ash borer	larvae/pupae	winter	56	38	>0
Goebel et al	2010	Emerald ash borer	larvae/pupae	winter	56	66	>0
Haack and Petrice	2022	Agrilus bilineatus		winter	56.5	30	0.6
Haack and Petrice	2022	Agrilus bilineatus		winter	57.9	30	0.9
Haack and Petrice	2022	Agrilus sulcicollis		winter	56.9	30	1.7
Haack and Petrice	2022	Agrilus sulcicollis		winter	57.5	30	1.7
Haack and Petrice	2022	Agrilus sulcicollis		winter	58.7	30	0.3
Haack and Petrice	2022	Ips		summer	56.4	30	38.9
Haack and Petrice	2022	Ips		summer	57.4	30	14.3
Haack and Petrice	2022	Ips		summer	58.8	30	25
Haack and Petrice	2022	Cerambycidae		summer	56.4	30	14.3
Haack and Petrice	2022	Cerambycidae		summer	57.4	30	9.1

In fact, failure has been demonstrated 60/30 and above

Author	year	species	life stage	harvest time	temp C	Time (minutes)	% survival
Myers et al	2009	Emerald ash borer	larvae	winter	64.3	30	2.3
Myers et al	2009	Emerald ash borer	larvae	winter	63.9	30	14.0
Nzokou et al	2000	Emerald ash borer	larvae/pupae	winter	60	30	>0

We're working with an ineffective mitigation method.

Failure is assured!

EFSA. 2011. Scientific Opinion: Scientific Opinion on a technical file submitted by the US Authorities to support a request to list a new option among the EU import requirements for wood of *Agrilus planipennis* host plants. 9(7): 2185

Verdict: 60/60 is inadequate for EAB

Goebel, P.C., M. S. Bumgardner, D.A. Herms, and A. Sabula. 2010. Failure to Phytosanitize Ash Firewood Infested with Emerald Ash Borer in a Small Dry Kiln Using ISPM-15 Standards. Commodity Treatment and Quarantine Entomology. 103(3):597-602

Verdict: 56/30 is inadequate for EAB

Haack, R.A. and T.R. Petrice. 2022. Mortality of Bark- and Wood-boring Beetles (Coleoptera: Buprestidae, Cerambycidae, and Curculionidae) in Naturally Infested Heat-treated Ash, Birch, Oak, and Pine Bolts. Journal of Economic Entomology. 12pp.

Verdict: unclear but suggests 60/30

Mayfield, A.E., S.W. Fraedrich, A. Taylor, P. Merten, and S.W. Myers. 2014. Efficacy of Heat Treatment for the Thousand Cankers Disease Vector and Pathogen in Small Black Walnut Logs. Commodity Treatment and Quarantine Entomology. 107(1): 174-184

Verdict: 56/30 is adequate to eliminate *Pityophthorus juglandis* and thousand cankers disease

McCullough, D.G., T.M. Poland, D. Cappaert, E.L. Clark, I. Fraser, V. Mastro, S. Smith, and C. Pell. 2007. Effects of Chipping, Grinding, and Heat on Survival of Emerald Ash Borer, Agrilus planipennis (Coleoptera: Buprestidae), in Chips. Forest Entomology. 100(4): 1304-1315

Verdict: 60/120 is adequate to eliminate EAB and 55/120 is inadequate

Myers, S.W., I. Fraser, and V.C. Mastro. 2009. Evaluation of Heat Treatment Schedules for Emerald Ash Borer (Coleoptera: Buprestidae). Commodity Treatment and Quarantine Entomology. 102(6): 2048-2055

Verdict: 60/60 or 70/30 would be adequate for EAB

Myers, S.W. and S.M. Bailey. 2011. Evaluation of a Heat Treatment Schedule for the Asian Longhorned Beetle, Anoplophora glabripennis (Coleoptera: Cerambycidae) Forests Products Journal. 61(1): 46-49

Verdict: 56/30 is adequate for ALB

Nzokou, P., S. Tourtellot, and D.P. Kamdem. 2008. Kiln and microwave heat treatment of logs infested by the emerald ash borer (Agrilus planipennis Fairmaire) (Coleoptera: Buprestidae). Forest Products Journal. 58(7/8): 68-72

Verdict: 55/30 and 60/30 inadequate for EAB; 65/30 adequate

Ostaff, D. and M.Y. Cech. 1978. Heat sterilization of spruce-pine-fir lumber containing sawyer beetle larvae (Coleoptera: Cerambycidae, Monochamus sp.). Eastern Forest Products Laboratory Report OPX200E. 9pp

Verdict: “60.0ºC (140ºF) for 2 h should be the mínimum schedule used.”

Interception data

Scolytine (bark and ambrosia beetles) and Platypodinae (ambrosia beetles) interception data.

- From 2007 to 2022 there have been 5,532 detections
- Nearly 345 detections per year.
- Inspecting less than 2% of shipments
- Does that mean we're missing 16,905 in the other 98%?

Impact of Inadequate Treatment

- In Haack and Petrice (2022), the lowest rate of survival in 56/30 was for *Agrilus sulcicollis* at 0.3%.
- In that part of the experiment, there were 9 pieces of wood.
- In Haack *et al* (2022), the infestation rate in SWPM from 2010 to 2020 was 0.22%

Made from 11 pieces of wood!

X 10

Low estimate of number of containers

X 20,000,000

=

1 out of 4 containers has an infested piece. = 5,000,000

5,000,000 infested pieces of wood enter the US.

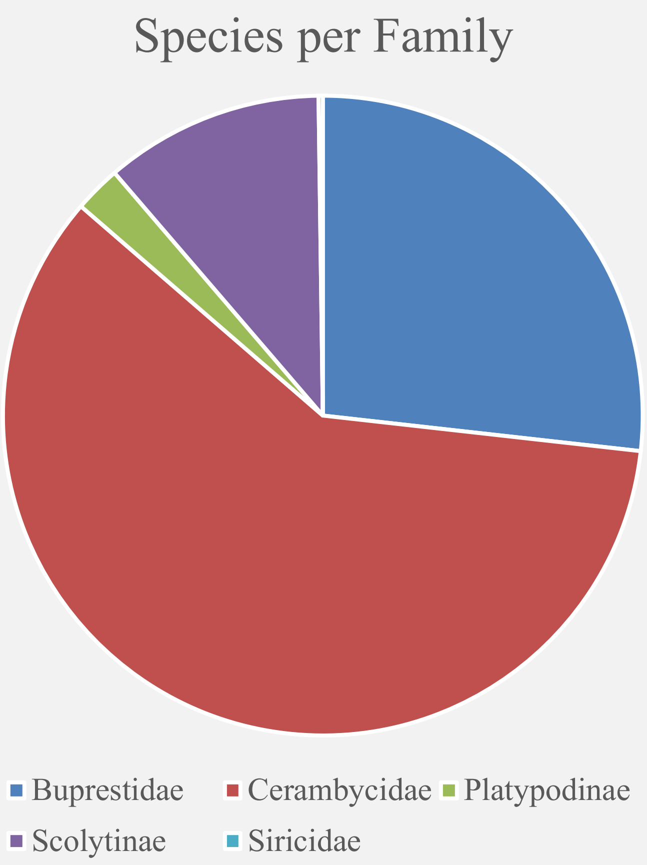
- 1 in 4 containers has an infested piece of wood in a pallet
- A 20 foot container can hold 10 pallets

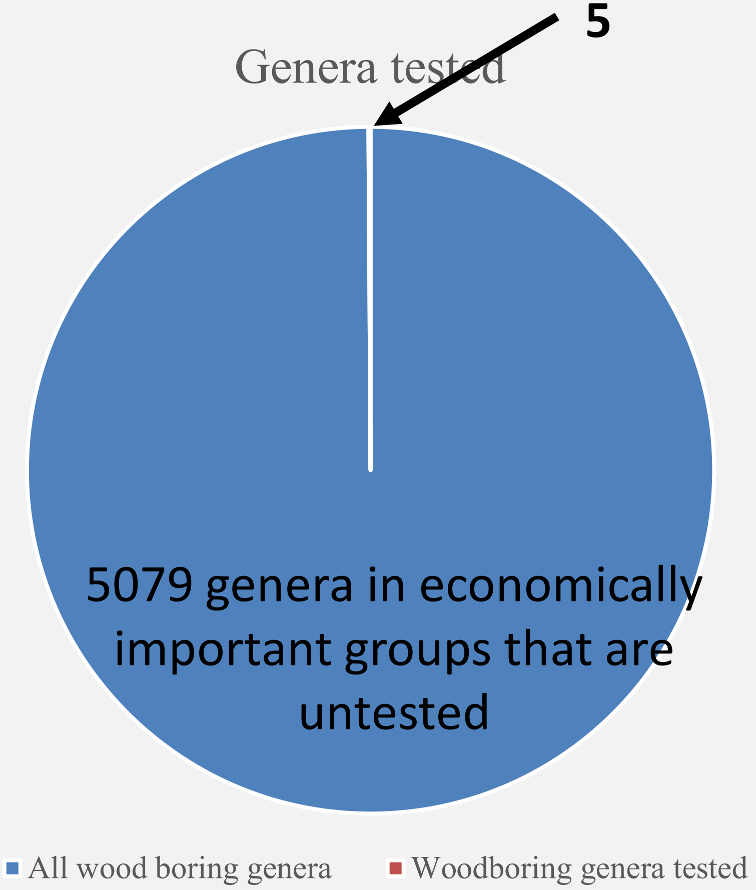
https://en.wikipedia.org/wiki/Intermodal_container

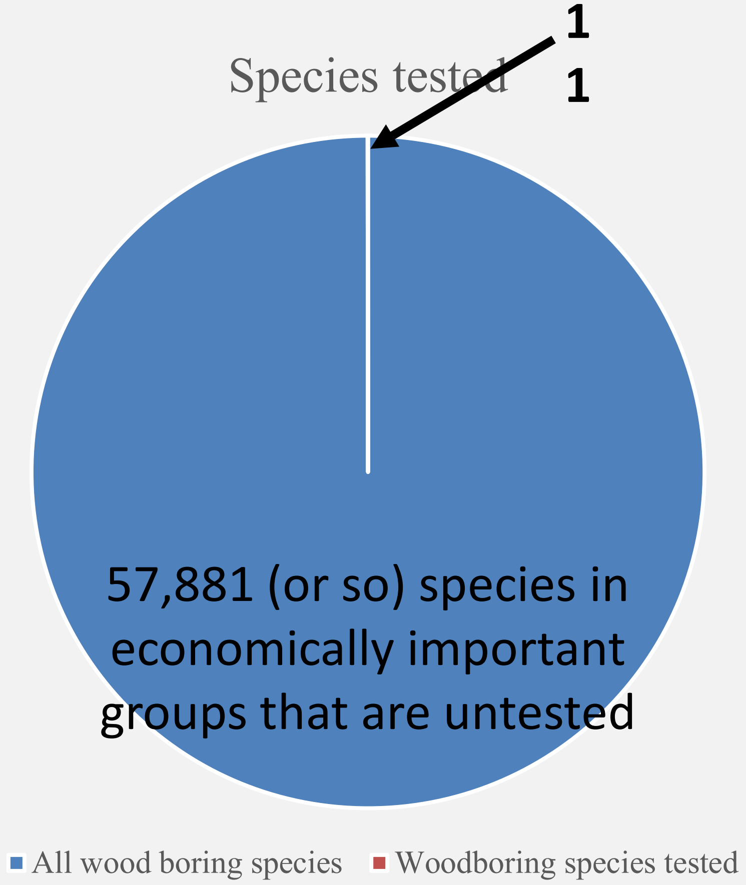
Probit-9 and ISPM 15

- regulatory standard where we have 99.9968329% confidence in 100% mortality of a pest after treatment.
- Treatments at 56/30 **do not** meet the Probit 9 level of confidence
- Myers *et al* (2009) extrapolated their data to estimate Probit 9 for emerald ash borer. They found it would require
  - 73.5 ° /30 or 61.4 ° /60.
- Extrapolating from existing data could give us a meaningful place to start

So Few Species Tested!







Species per Family: 57,892 (or so) species are found in these economically important woodborer groups worldwide.

Why haven’t experts spoken out?

- They have!
- 2011: a European Food Safety Authority Scientific Opinion determined that 60/60 was inadequate as a phytosanitary measure against emerald ash borer
- 2012: The European Food Safety Authority evaluated a proposal from the US (USDA) to increase treatment to 71.1/60. They determined that there was inadequate data
- 2023: National Plant Board requested USDA APHIS work to raise the treatment time and temperature

There seems to be a lot of effort to fix the woodborer invader problem

While simultaneously ignoring the fact that the primary treatment, the 56/30 heat treatment, is only partially effective.

Why don’t we correct the heat treatment?!

But we can’t increase the treatment: Facilities can’t do it!

China interim rule

- Signed 1998
- In response to ALB
  - But also pine shoot borer and EAB
  - 71.1 °C for 75 minutes!
  - 98% compliance!

https://www.kiln-direct.com

But we can't increase the treatment: Climate change!!! Carbon release

- by spreading a wood degrading fungus, effects on erosion, soil characteristics: *Ambrosiodmus minor*

- And *Flavodon subulatus*

- Found in 2011
- Deregulated in 2021

What we need to do

1. **Increase the temperatures and time required for heat treatment** of solid wood packing material to control most insects and pathogens.
    - We can use existing data to extrapolate
    - The best is 71.1/75, but 60/60 is pretty good

2. **Increase inspections of imports,** specifically of those with live woody plants and SWPM.

Thanks!

Josh Vlach
Entomologist

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References

Annila, E. 1969. Influence of temperature upon the development and voltinism of *Ips typographus* L. (Coleoptera, Scolytidae). Ann. Zool. Fennici. 6: 161-208.

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Haack, R.A. and T.R. Petrice. 2022. Mortality of Bark- and Wood-boring Beetles (Coleoptera: Buprestidae, Cerambycidae, and Curculionidae) in Naturally Infested Heat-treated Ash, Birch, Oak, and Pine Bolts. Journal of Economic Entomology. 12pp.
Verdict: Unclear, but appears to be suggesting 60/30

Hulcr, J., J. Skelton, A.J. Johnson, Y. Li, M.A. Jusino. 2018. Invasion of an inconspicuous ambrosia beetle and fungus may alter wood decay in Southeastern North America. Peer J Preprints. 6:e27334v1 https://doi.org/10.7287/peerj.preprints.27334v1

Kasson, M.T., K.L.Wickert, C.M. Stauder, A.M. Macias, M.C. Berger, D.R. Simmons, D.P.G. Short, D.B. DeVallance, and J. Hulcr. 2016. Mutualism with aggressive wood-degrading *Flavodon ambrosius* (Polyporales) facilitates niche expansion and communal social structure in *Ambrosiophilus* ambrosia beetles. Fungal Ecology. 23: 86-96

Mayfield, A.E., S.W. Fraedrich, A. Taylor, P. Merten, and S.W. Myers. 2014. Efficacy of Heat Treatment for the Thousand Cankers Disease Vector and Pathogen in Small Black Walnut Logs. Commodity Treatment and Quarantine Entomology. 107(1): 174-184
Verdict: 56/30 is adequate to eliminate *Pityophthorus juglandis* and thousand cankers disease

McCullough, D.G., T.M. Poland, D. Cappaert, E.L. Clark, I. Fraser, V. Mastro, S. Smith, and C. Pell. 2007. Effects of Chipping, Grinding, and Heat on Survival of Emerald Ash Borer, Agrilus planipennis (Coleoptera: Buprestidae), in Chips. Forest Entomology. 100(4): 1304-1315
Verdict: 60/120 is adequate to eliminate EAB and 55/120 is inadequate

Myers, S.W., I. Fraser, and V.C. Mastro. 2009. Evaluation of Heat Treatment Schedules for Emerald Ash Borer (Coleoptera: Buprestidae). Commodity Treatment and Quarantine Entomology. 102(6): 2048-2055
Verdict: 60/60 or 70/30 would be adequate for EAB

Myers, S.W. and S.M. Bailey. 2011. Evaluation of a Heat Treatment Schedule for the Asian Longhorned Beetle, Anoplophora glabripennis (Coleoptera: Cerambycidae) Forests Products Journal. 61(1): 46-49
Verdict: 56/30 is adequate for ALB

Noseworthy, M. K., L.M. Humble, T. Souque, E. John, J. Roberts, E. Allen, C. Lloyd. 2022. Determination of specific lethal heat treatment parameters for pests associated with wood products using the Humble water bath. Journal of Pest Science. 96:1187-1197

Nzokou, P., S. Tourtellot, and D.P. Kamdem. 2008. Kiln and microwave heat treatment of logs infested by the emerald ash borer (Agrilus planipennis Fairmaire) (Coleoptera: Buprestidae). Forest Products Journal. 58(7/8): 68-72
Verdict: 55 and 60 inadequate for EAB

Ostaff, D. and M.Y. Cech. 1978. Heat sterilization of spruce-pine-fir lumber containing sawyer beetle larvae (Coleoptera: Cerambycidae, Monochamus sp.). Eastern Forest Products Laboratory Report OPX200E. 9pp
Verdict: "60.0ºC (140ºF) for 2 h should be the mínimum schedule used."

Wu, Y., N.F. Trepanowski, J. J. Molongoski, P. F. Reagel, S. W. Lingafelter, H. Nadel, S.W. Myers, & A. M. Ray. 2017. Identification of wood-boring beetles (Cerambycidae and Buprestidae) intercepted in trade associated solid wood packaging material using DNA barcoding and morphology. Scientific Reports. P. 1-12