

# European trees on the precipice of their demise?

A photograph of a large tree with autumn-colored leaves leaning over a body of water, with a forested hillside in the background. The tree's branches are thick and dark, and its leaves are a mix of orange, yellow, and brown. The water is calm and reflects the sky. In the background, there is a line of trees on a hillside under a grey, overcast sky.

Andrew Liebhold

Faculty of Forestry and Wood Science, Czech University of Life Sciences, Prague, Czech Republic

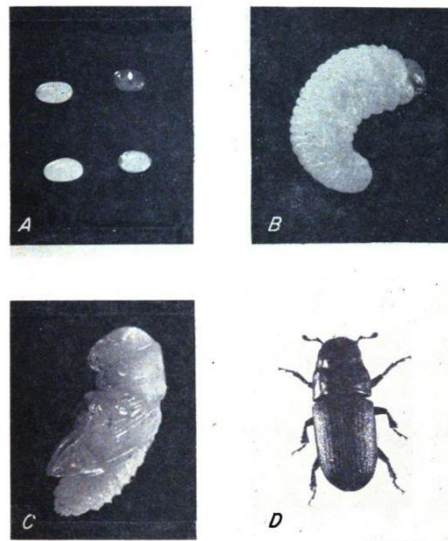
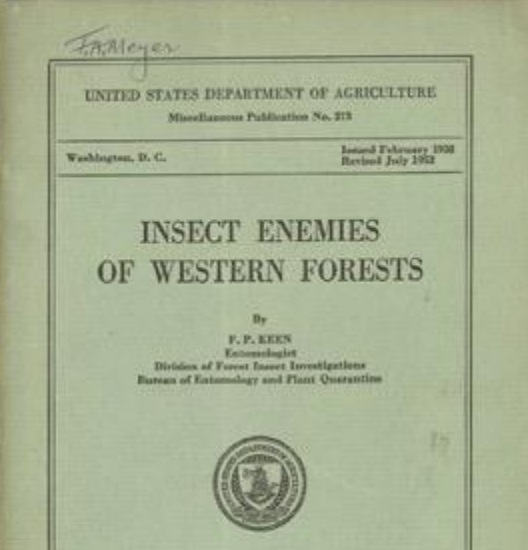
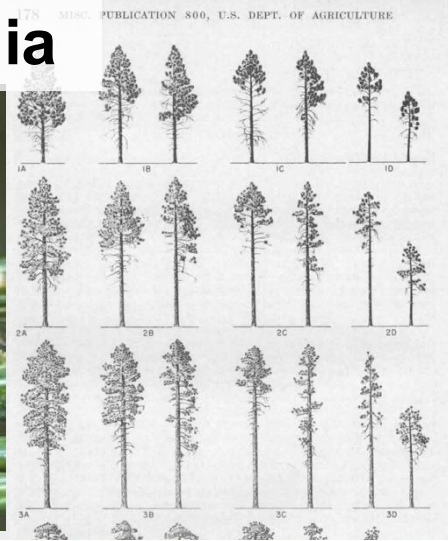
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USA



Prague,  
Czech Republic

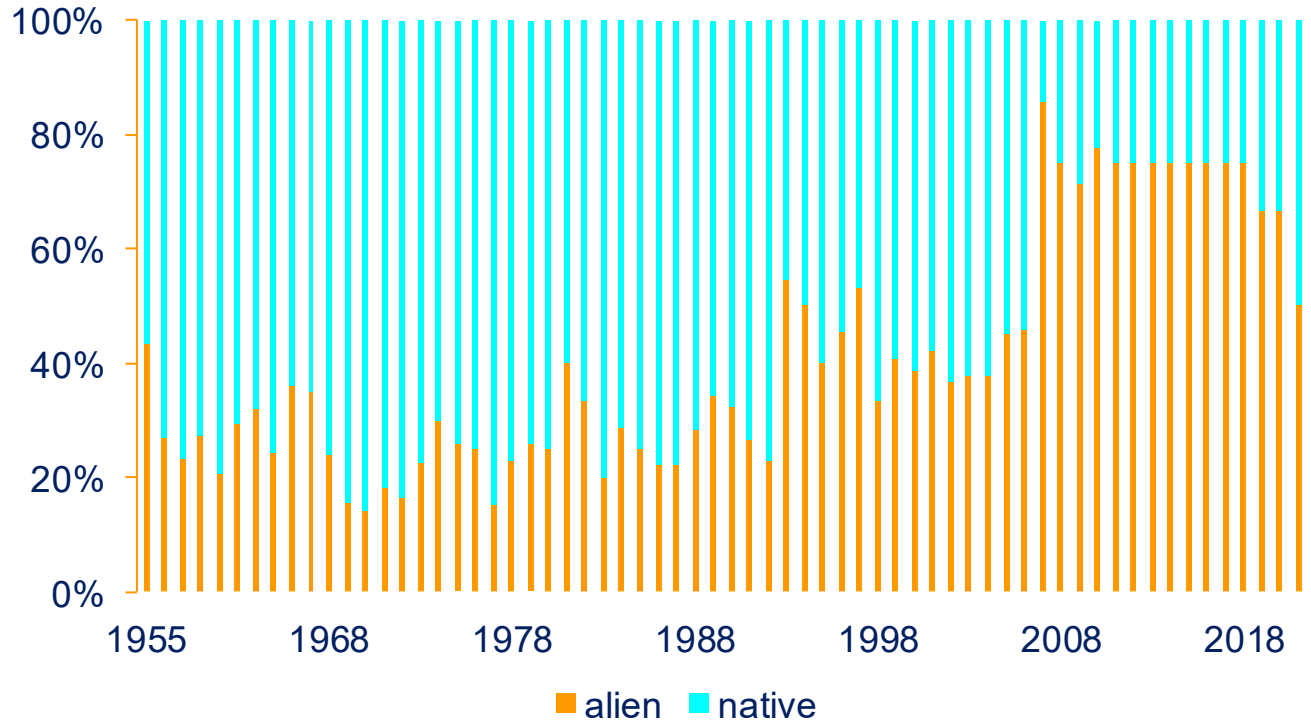
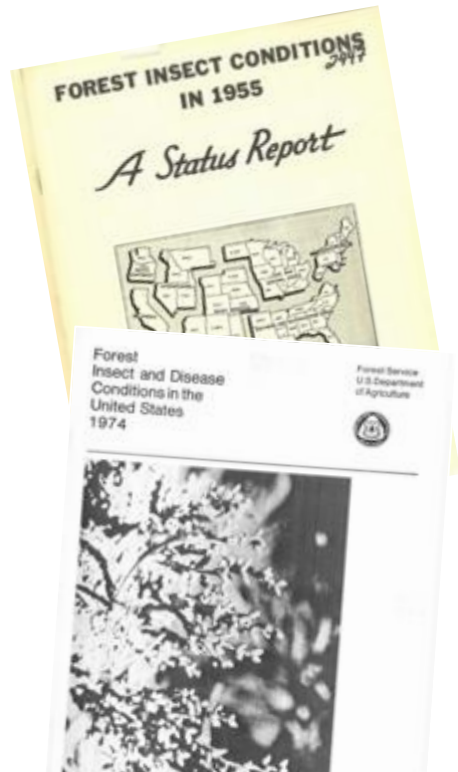


# Native forest insect pests of California

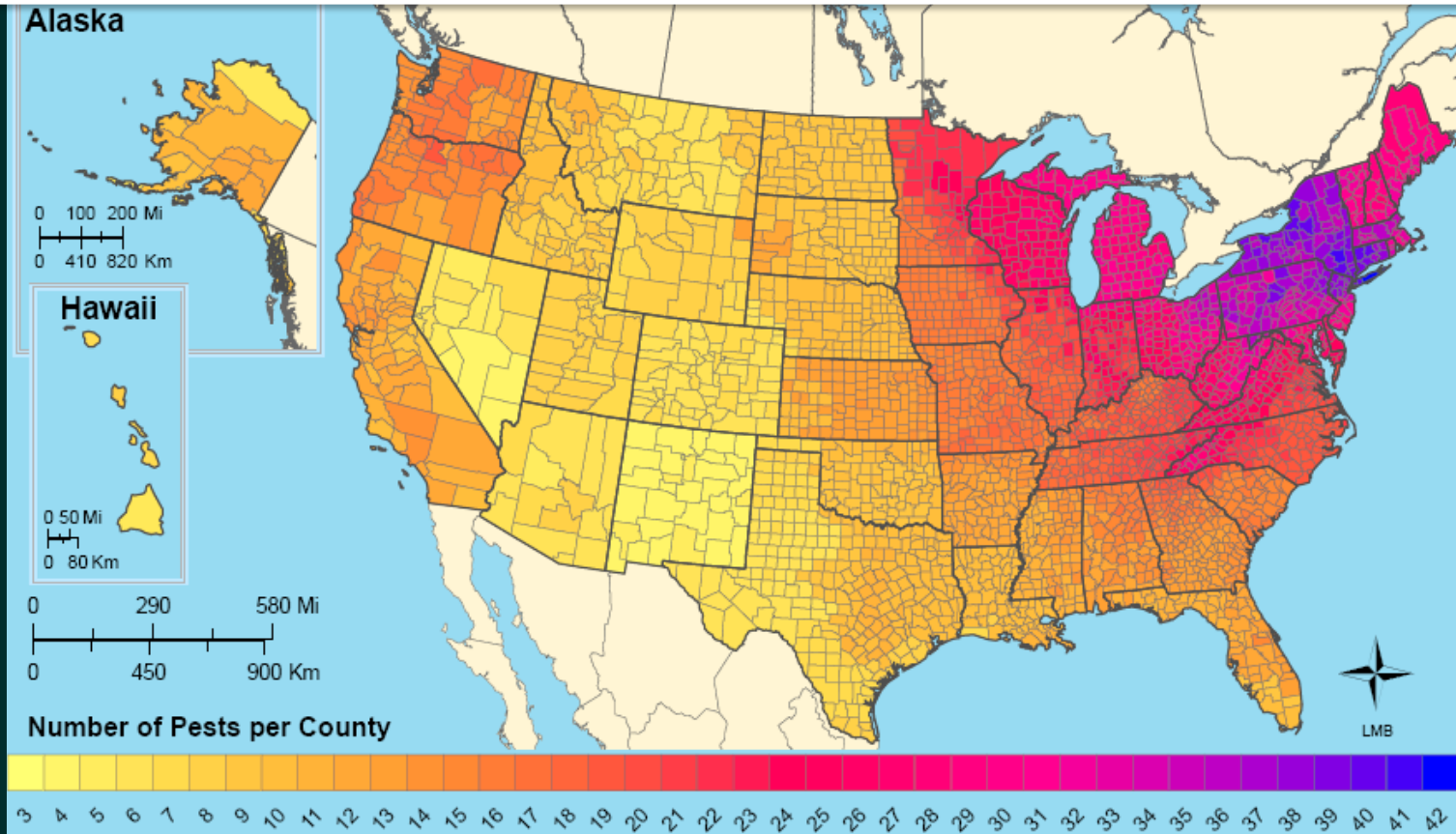


# Increasing importance of non-native insect and diseases

Insect species mentioned in US Forest Service Forest Health Reports  
1955-2020



# Numbers of Damaging Non-native Forest Insects & Diseases



Liebold, A.M., D.G. McCullough, L.M. Blackburn, S.J. Frankel, B. Von Holle and J.E. Aukema. 2013. A highly aggregated geographical distribution of forest pest invasions in the USA. *Diversity and Distributions* 19, 1208–1216.

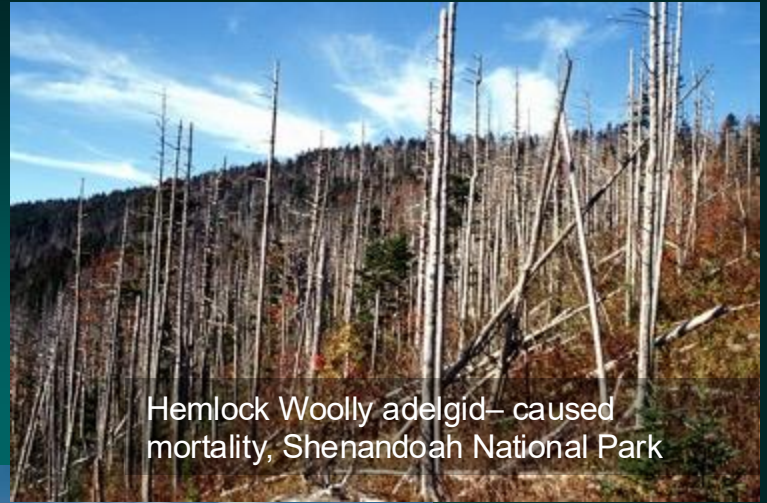


Emerald ash borer-killed trees, Essex Co., Ontario



Balsam woolly adelgid-killed trees, Mt. Mitchell, North Carolina

UGA1748042



Hemlock Woolly adelgid- caused mortality, Shenandoah National Park

## Tree mortality

# Estimation of total tree volume lost annually by all non-native forest insects and diseases in the US

## Biomass losses resulting from insect and disease invasions in US forests

Songlin Fei<sup>1,2</sup>, Randall S. Morin<sup>3</sup>, Christopher M. Oswalt<sup>4</sup>, and Andrew M. Liebhold<sup>5</sup>

<sup>1</sup>Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47906; <sup>2</sup>Northwest Research Station, Forest Service, US Department of Agriculture, Meriden Square, PA 19021; <sup>3</sup>Southern Research Station, Forest Service, US Department of Agriculture, Knoxville, TN 37910; and <sup>4</sup>Northern Research Station, Forest Service, US Department of Agriculture, Morgantown, WV 26505

Edited by Daniel S. Limber<sup>6</sup>, The University of Tennessee, Knoxville, TN, and approved July 16, 2019 (received for review December 4, 2018)

Worldwide, forests are increasingly affected by nonnative insects and diseases, some of which cause substantial tree mortality. Forests in the United States have been invaded by a particularly large number (~450) of tree-feeding pest species. While information exists about the ecological impacts of certain pests, region-wide assessments of the composite ecosystem impacts of all species are limited. Here we analyze 92,978 forest plots distributed across the conterminous United States to estimate biomass loss associated with elevated mortality rates caused by the 75 most damaging nonnative forest pests. We find that these species combined caused an additional (i.e., above background level) tree mortality rate of 5.53 TgC per year. Compensation, in the form of increased growth and recruitment of nonhost species, was not detectable when measured across entire invaded ranges but does occur several decades following pest invasions. In addition, 41.1% of the total live forest biomass in the conterminous United States is at risk of future loss from these 75 pests. These results indicate that forest pest invasions, driven primarily by globalization, represent a huge risk to US forests and have significant impacts on carbon dynamics.

pest invasion | carbon | forest ecosystem | biomass

Forests provide a wide variety of vital ecosystem services, in-

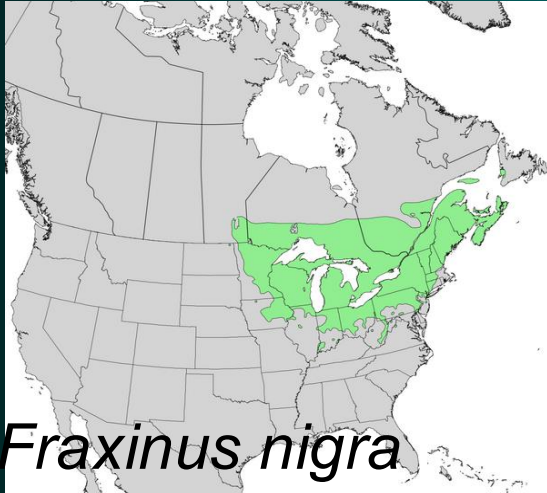
cluding biomass in being converted to dead materials (carbon source) by the 15 species known to have the greatest impacts on tree mortality. We used data from 92,978 field plots sampled by the US Department of Agriculture (USDA) Forest Service Forest Inventory and Analysis (FIA) program to quantify host tree mortality and biomass losses arising from tree mortality associated with invasions of these pests. Our major objectives were to estimate the increased mortality and associated live biomass losses caused by nonnative forest pest invasions, quantify the temporal dynamics of nonnative pest-induced mortality, and quantify the host tree live biomass at risk for impacts from all major nonnative forest pests. The results presented here provide crucial information that can inform policy and management decision making and future carbon dynamics modeling research.

### Results

Among the 83 nonnative pests recognized to cause reportable damage in the conterminous United States, 16 species (19%) are wood- and phloem-boring insects, 28 (34%) are foliage-feeding insects, 25 (30%) are sap-feeding insects, and 14 (17%) are tree pathogens. (Dataset S1 presents the entire list.) Species reviewed were from Asia (35%), Eurasia (29%), Europe (29%), or Australia (7%). We identified 15 species (9 pathogens, 4 sap-feeders, 1 wood-borer, and 1 foliage-feeder) that cause sub-

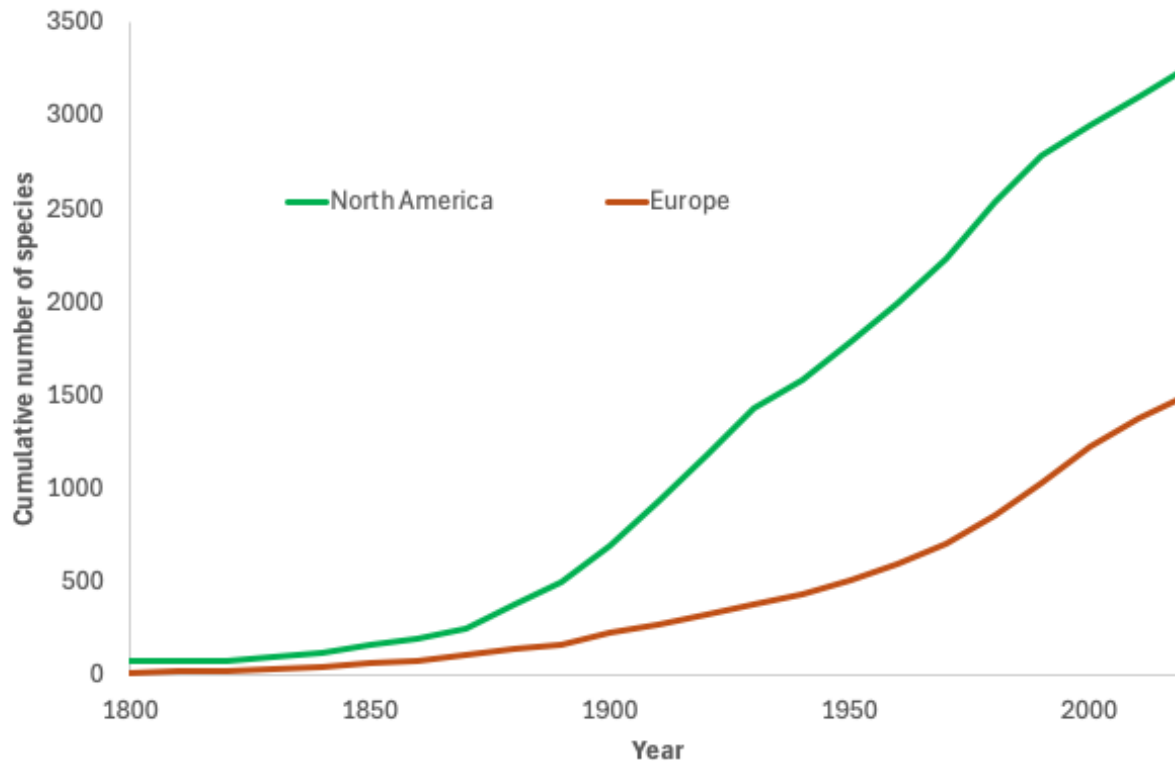
Pest Species	Annual Loss (TgC/yr)
Dutch elm disease	2.386
Emerald ash borer	1.813
Beech bark disease	1.121
Hemlock woolly adelgid	0.103
Laurel wilt disease	0.049
Butternut canker	0.042
Red pine scale	0.007
Port Orford cedar root disease	0.003
Chestnut blight	0.002
Balsam woolly adelgid	—
Dogwood anthracnose	—
Green spruce aphid	—
Spongy moth	—
<b>TOTAL</b>	<b>5.53</b>

# Emerald ash borer invasion destroys indigenous North American basket-making tradition



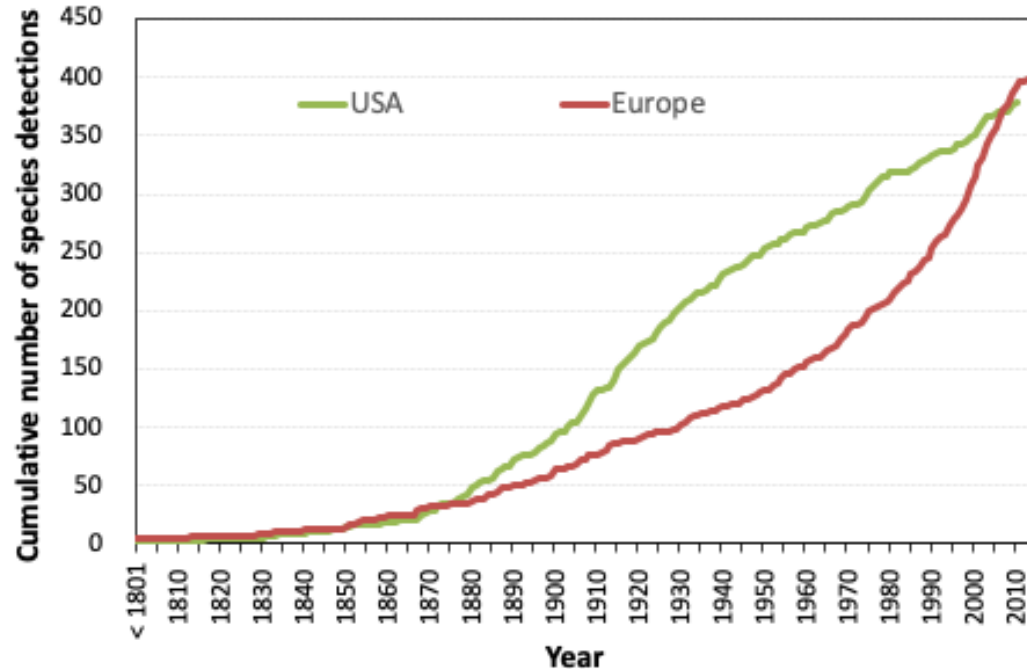
*Fraxinus nigra*

# Total number of non-native insect species: Europe is late but catching up



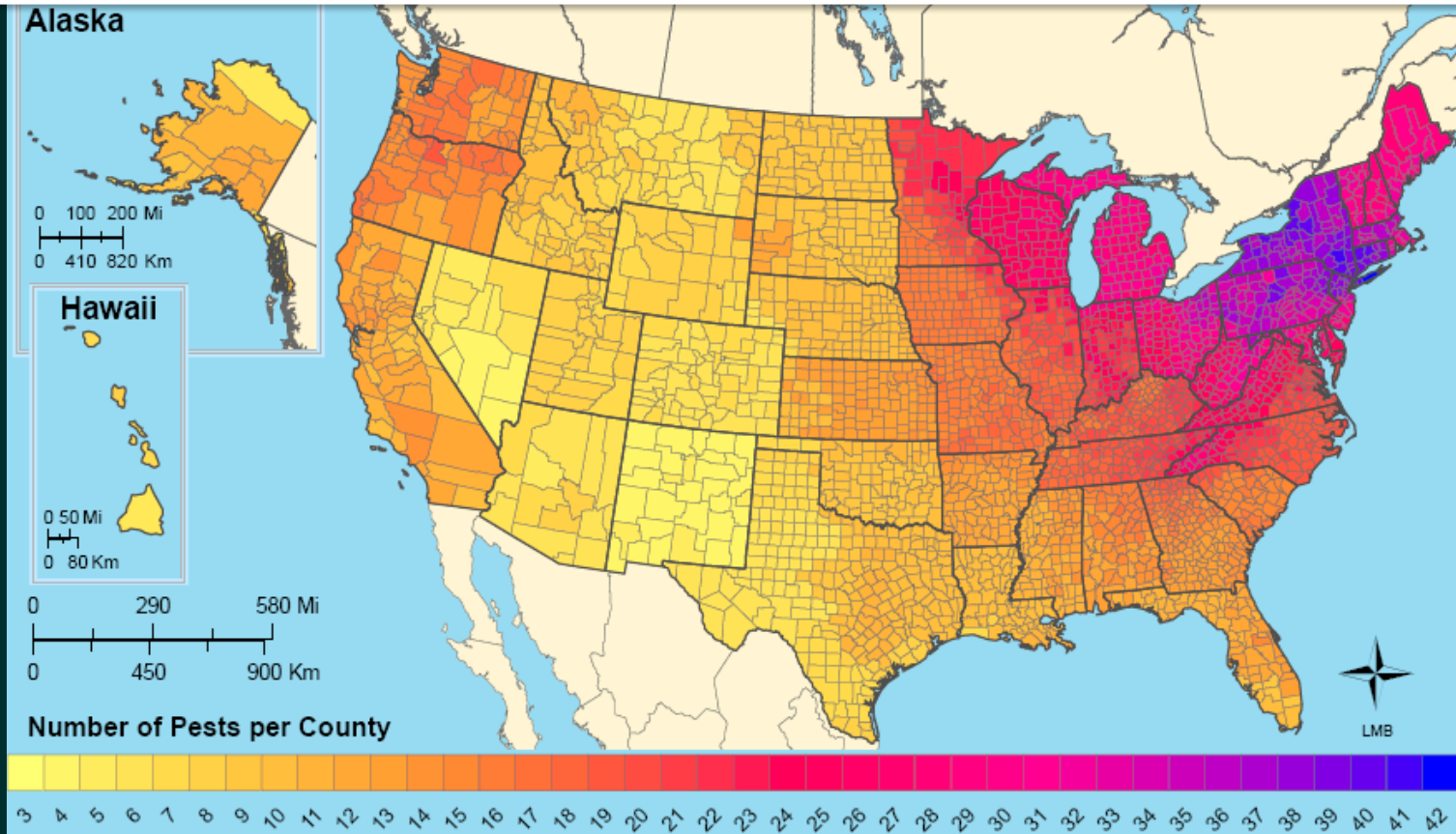
Turner, R., Blake, R., Mally, R., & Liebhold, A. M. (2024). International Non-native Insect Establishment Data (0.2.1) [Data set]. Zenodo. <https://doi.org/10.5281/zenodo.11519262>

# Number of non-native forest insects: Europe was late but has caught up

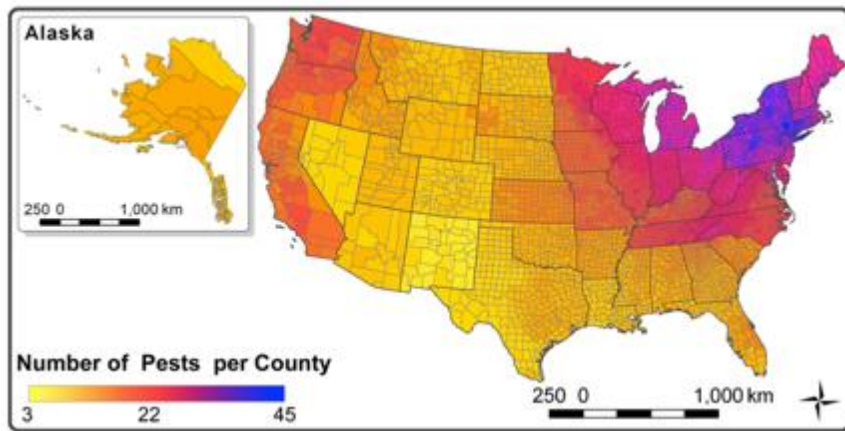


Brockhoff, E. G., & Liebhold, A. M. (2017). Ecology of forest insect invasions. *Biological Invasions*, 19(11), 3141-3159.

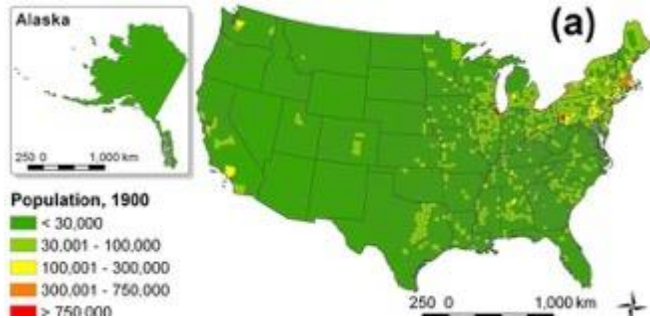
# Numbers of Damaging Non-native Forest Insects & Diseases



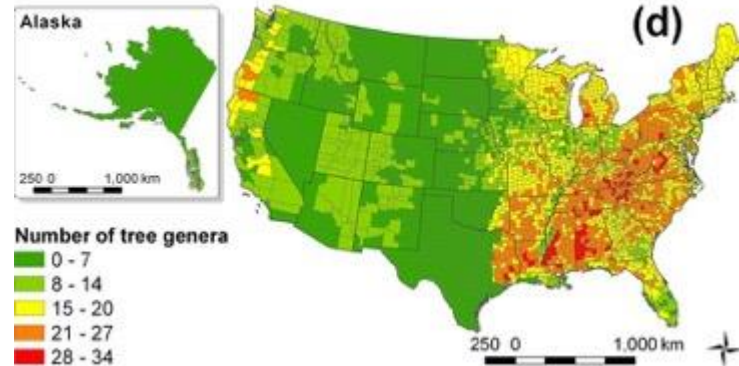
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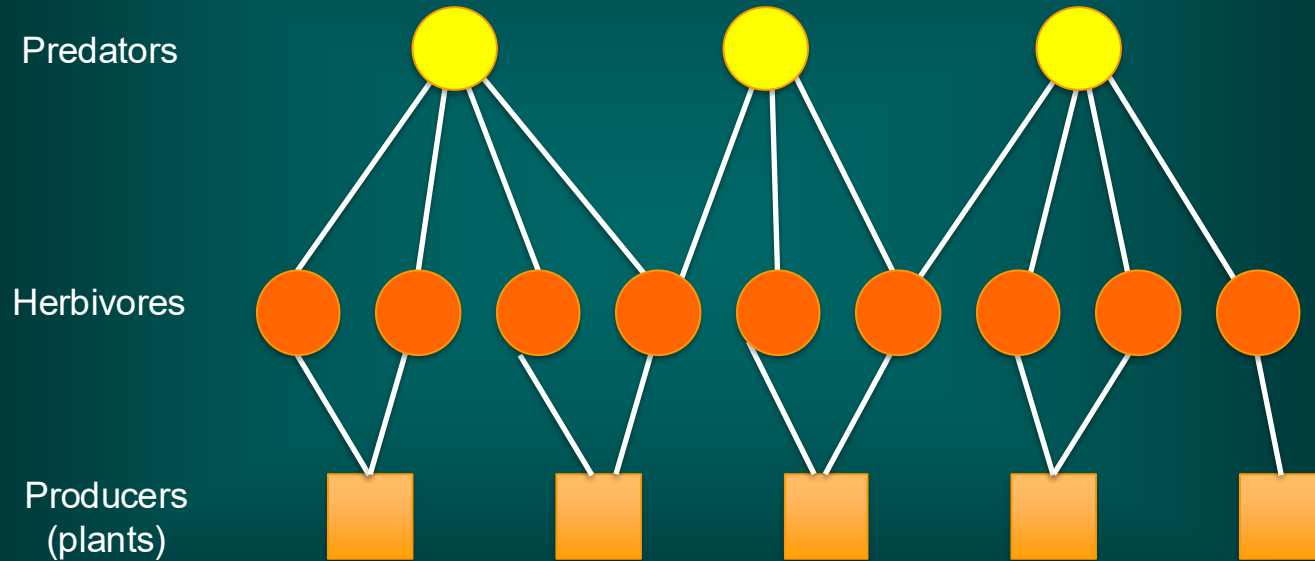
propagule pressure



invasibility

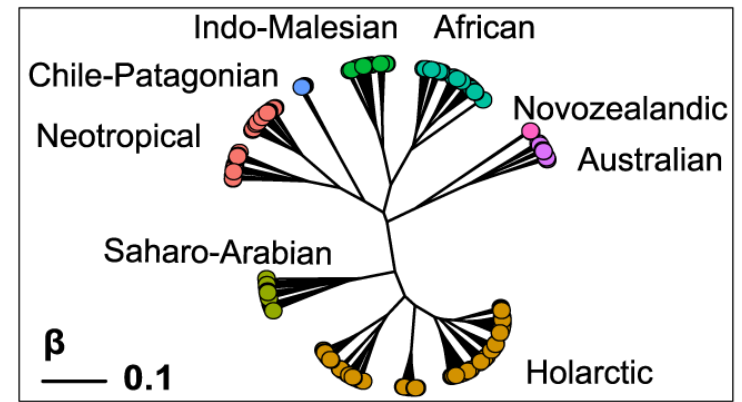


# Insect Assemblages Dominated by Herbivores

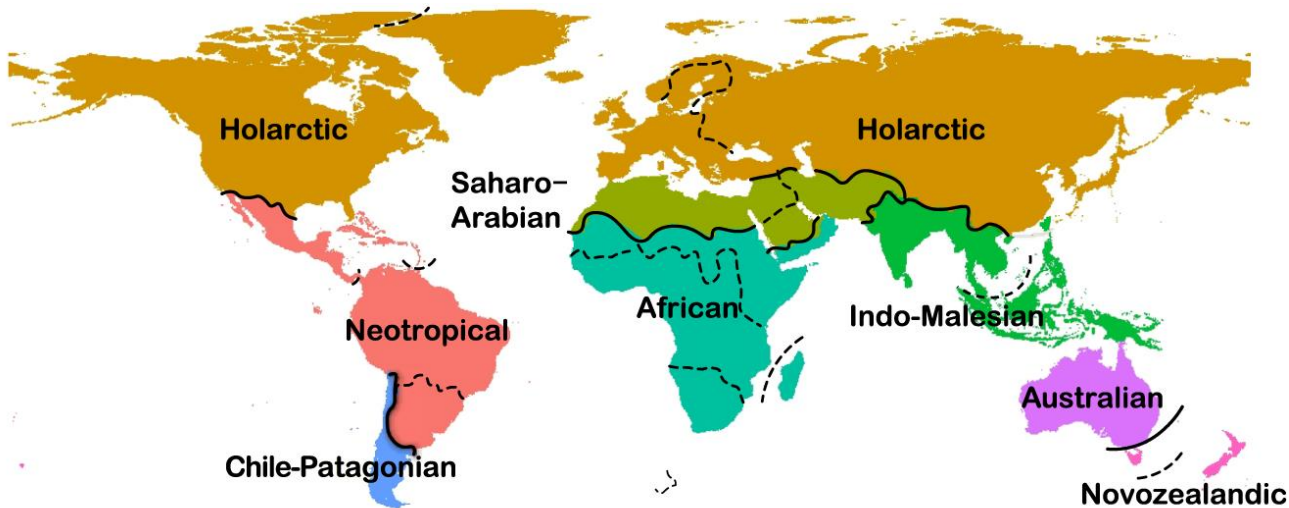


# Geographical barriers compartmentalized the historical radiation of plant diversity into floristic realms

Liu et al.. *Nature Communications*, 14(1), 2990.



UPGMA clustering based on phylogenetic beta diversity

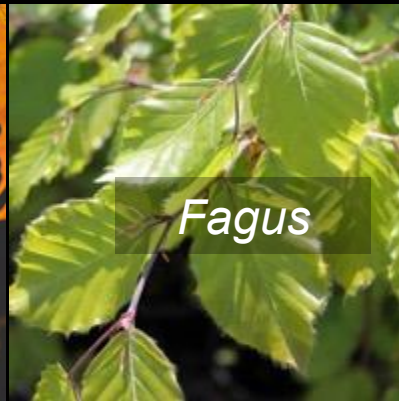




*Quercus*



*Acer*



*Fagus*



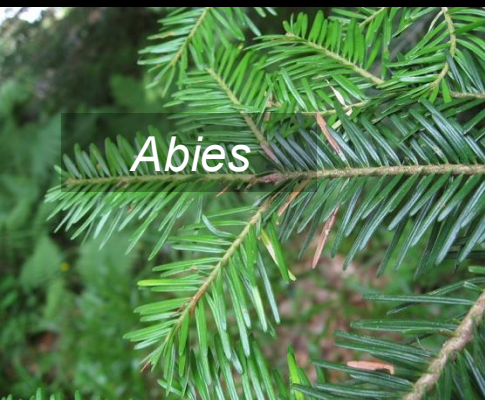
*Fraxinus*



*Pinus*



*Picea*

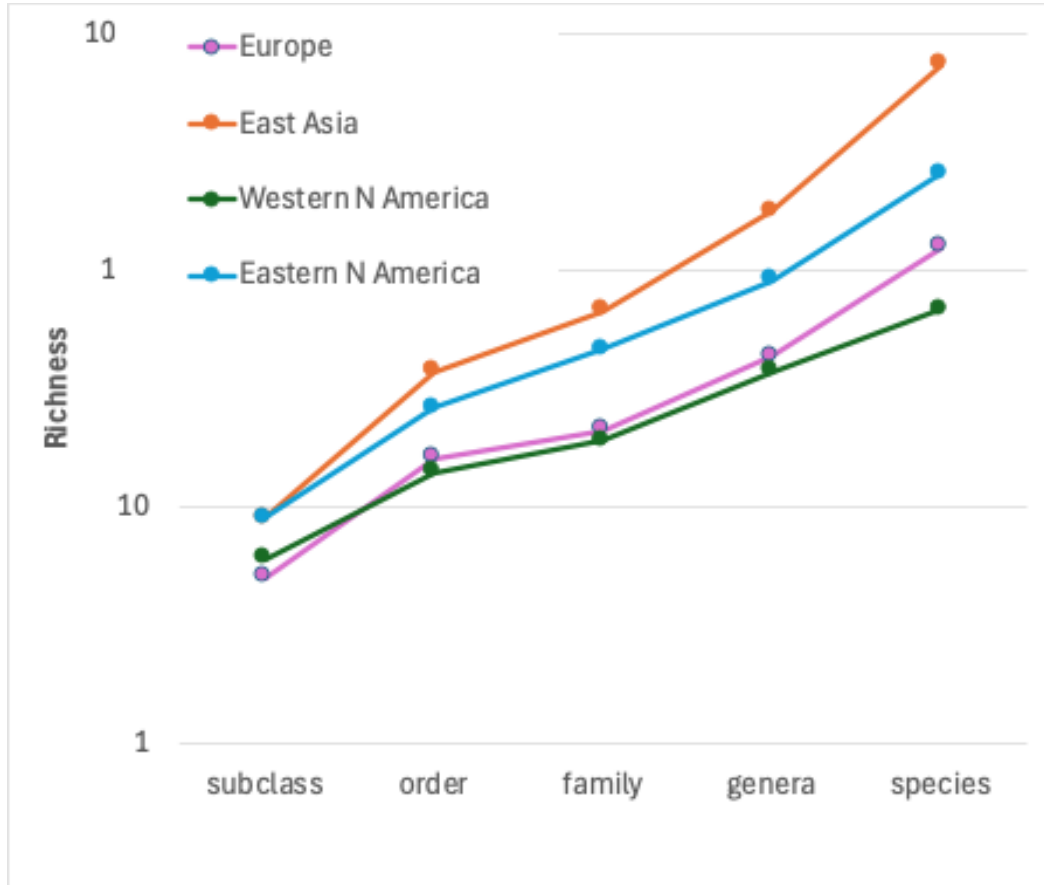


*Abies*



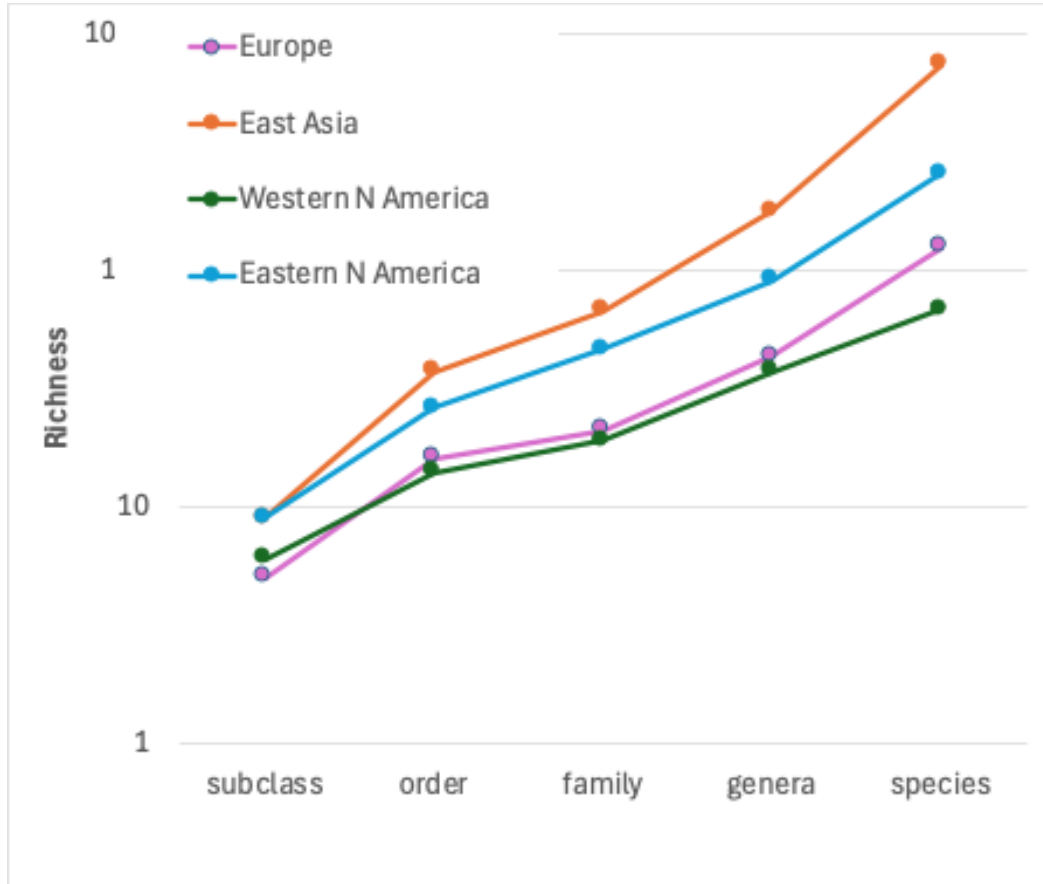
*Larix*

# Europe has low tree diversity



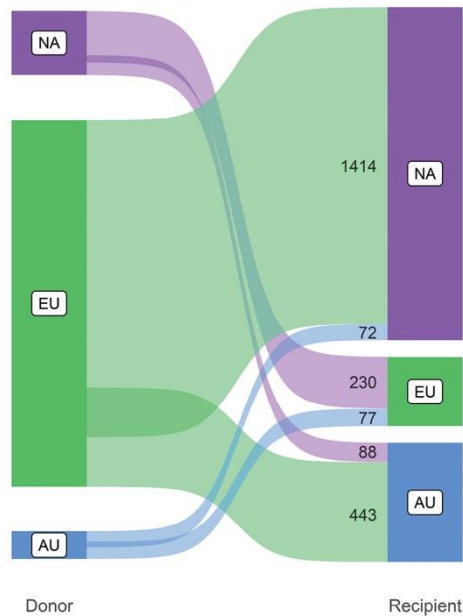
Latham, R. E., & Ricklefs, R. E. (1993). Continental comparisons of temperate-zone tree species diversity. In: Ricklefs and Schluter (eds). 1993. Species Diversity in Ecological Communities: Historical and Geographical Perspectives. U. Chicago Press

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# Asymmetry in numbers of insect invasions between Europe and N America



## Invasion of North American Forests by European Phytophagous Insects

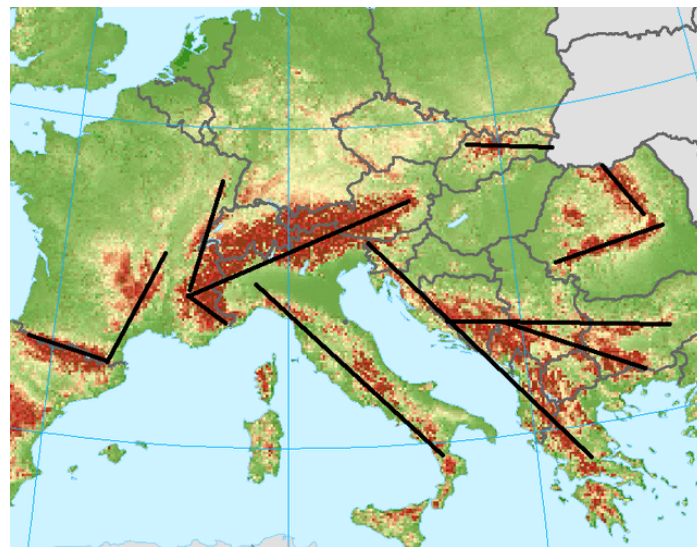
*Legacy of the European crucible?*

Pekka Niemelä and William J. Mattson

Over the last 500 years, nearly 2000 insects and 2000 weedy plants have invaded North America (Kim and McPherson 1993,

European biota may be much better competitors,

similarities in forest and faunal composition between North America and Europe predispose the two continents to successful interchange of

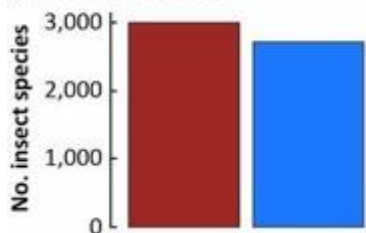


Isitt, R., Liebhold, A.M., Turner, R.M., Battisti, A., Bertelsmeier, C., Blake, R., Brockerhoff, E.G., Heard, S.B., Krokene, P., Okland, B. and Nahrung, H.F., 2024. Asymmetrical insect invasions between three world regions. *NeoBiota*, 90, pp.35-51.

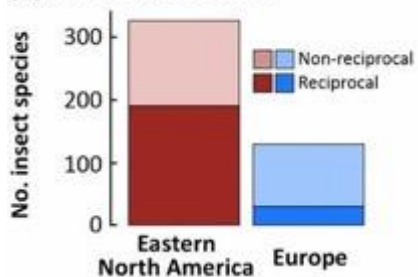
# Asymmetry in numbers of insect invasions between Europe and N America

## Insect species per region

(a) Native richness

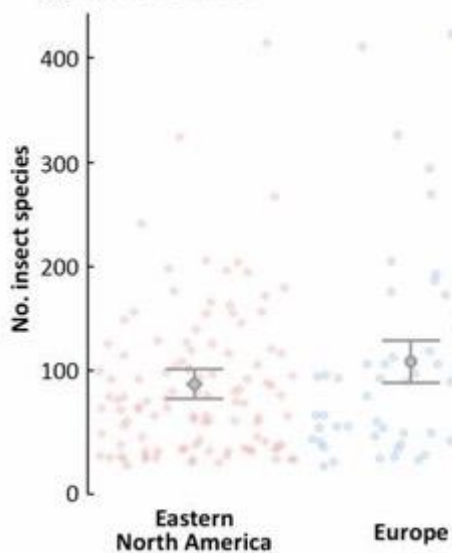


(b) Non-native richness

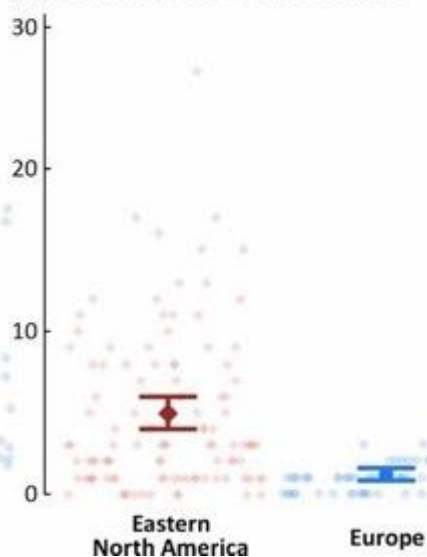


## Insect species per tree species

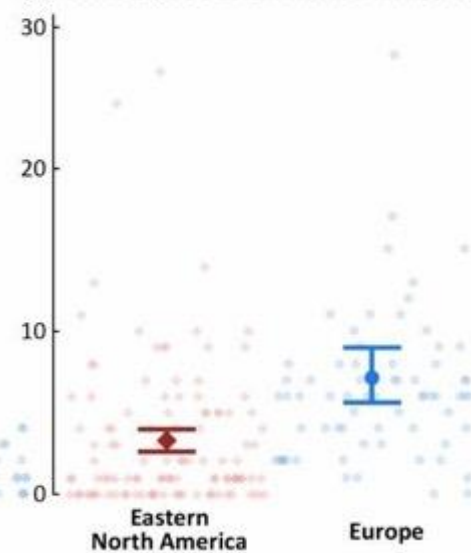
(c) Native richness



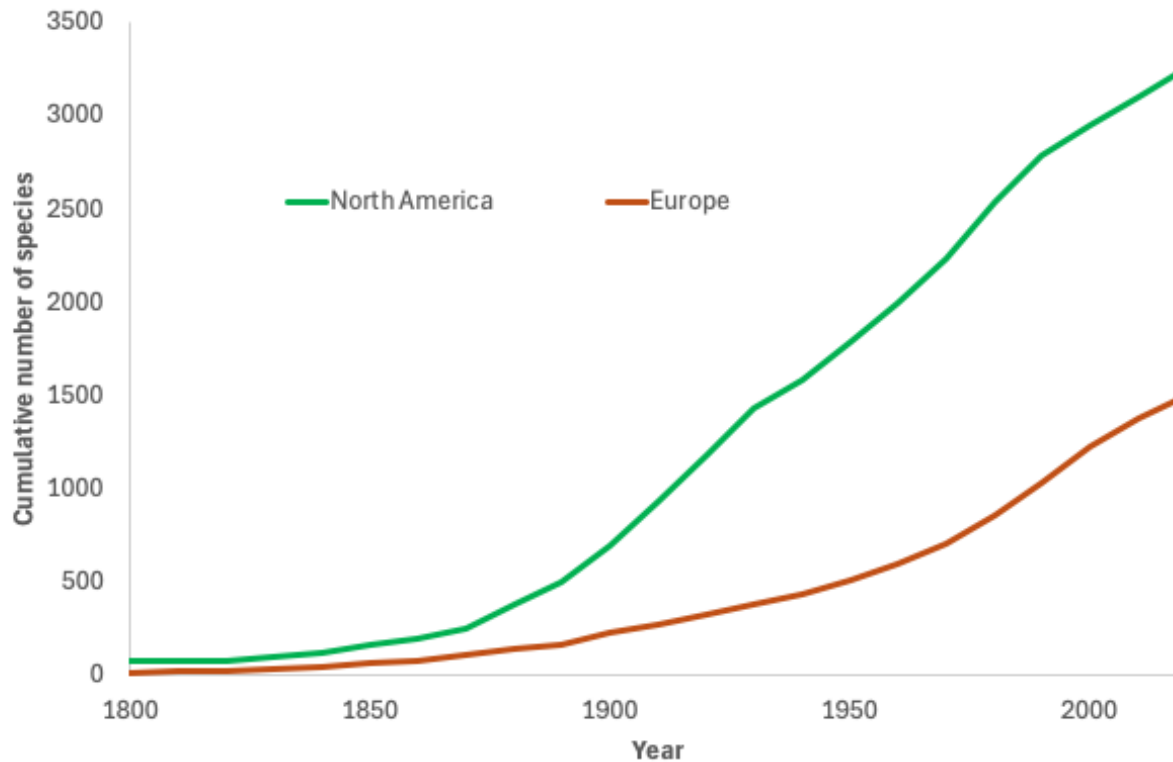
(d) Reciprocal non-native richness



(e) Non-reciprocal non-native richness



# Total number of non-native insect species: Europe is late but catching up



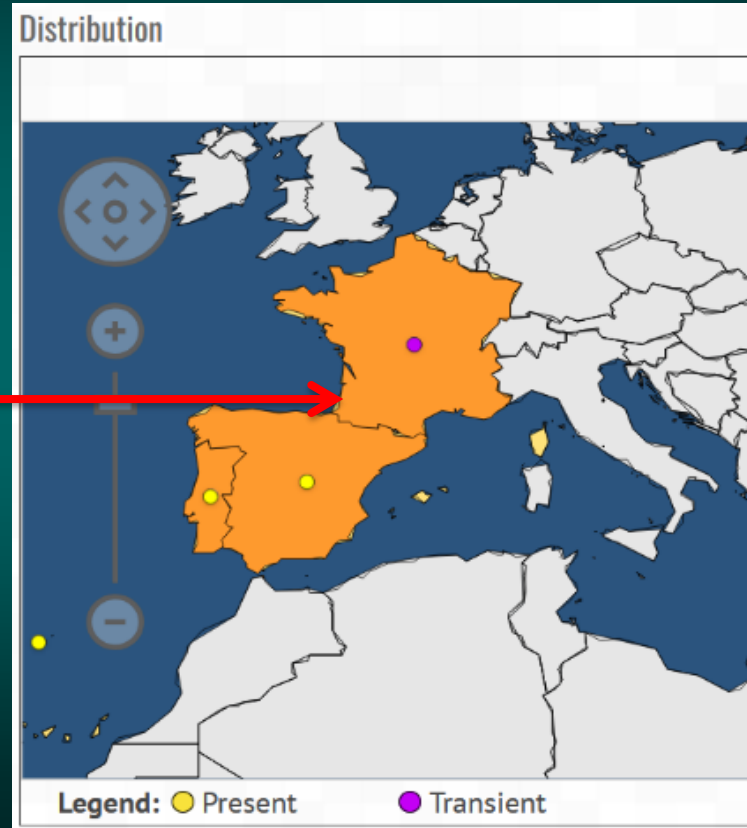
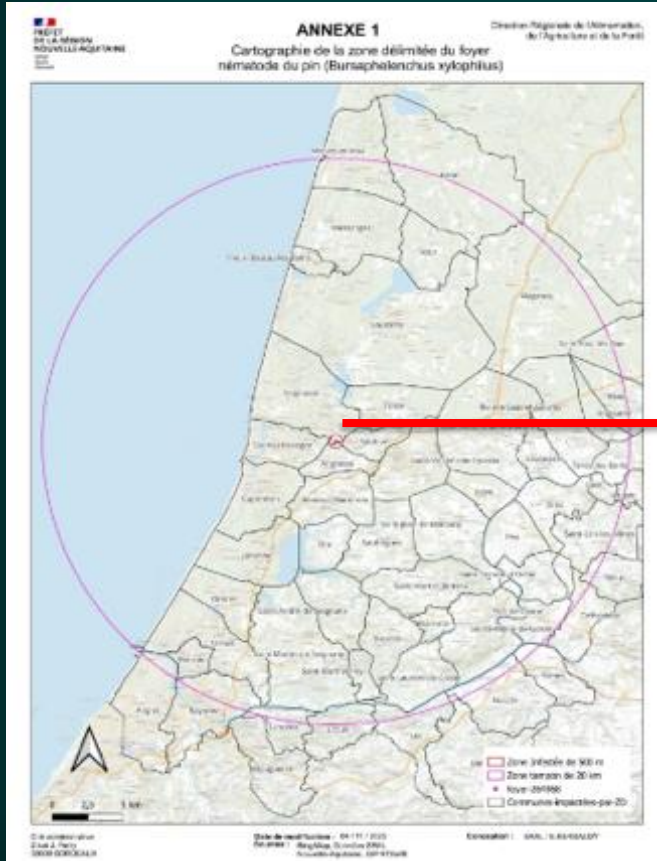
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# New serious forest insect and tree pathogen invasions in Europe

- Emerald ash borer
- Pine wilt disease
- Ash dieback



# Location of the first occurrence of pinewood nematode in France (November 2025) Landes de Gascogne (slides courtesy of Herve Jactel)

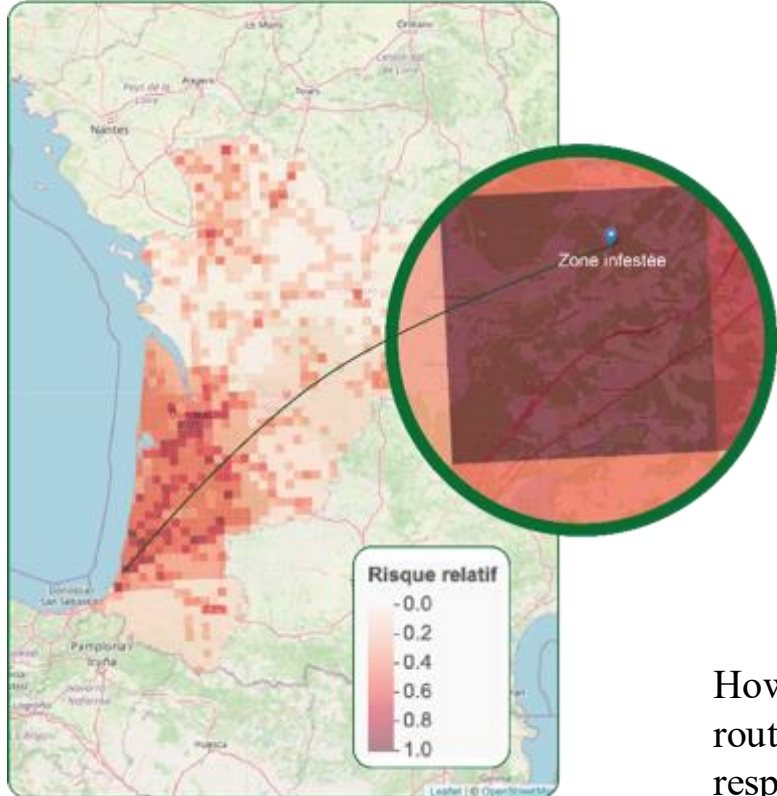


Drone images of trees affected by the pinewood nematode  
(*Bursaphelenchus xylophilus*)



Looking for *Monochamus galloprovincialis* larvae in pinewood infected trees





Risque entrée - hôte maximal (1) de la région.

The PWN was detected precisely in the grid cell where the highest risk of introduction had been predicted

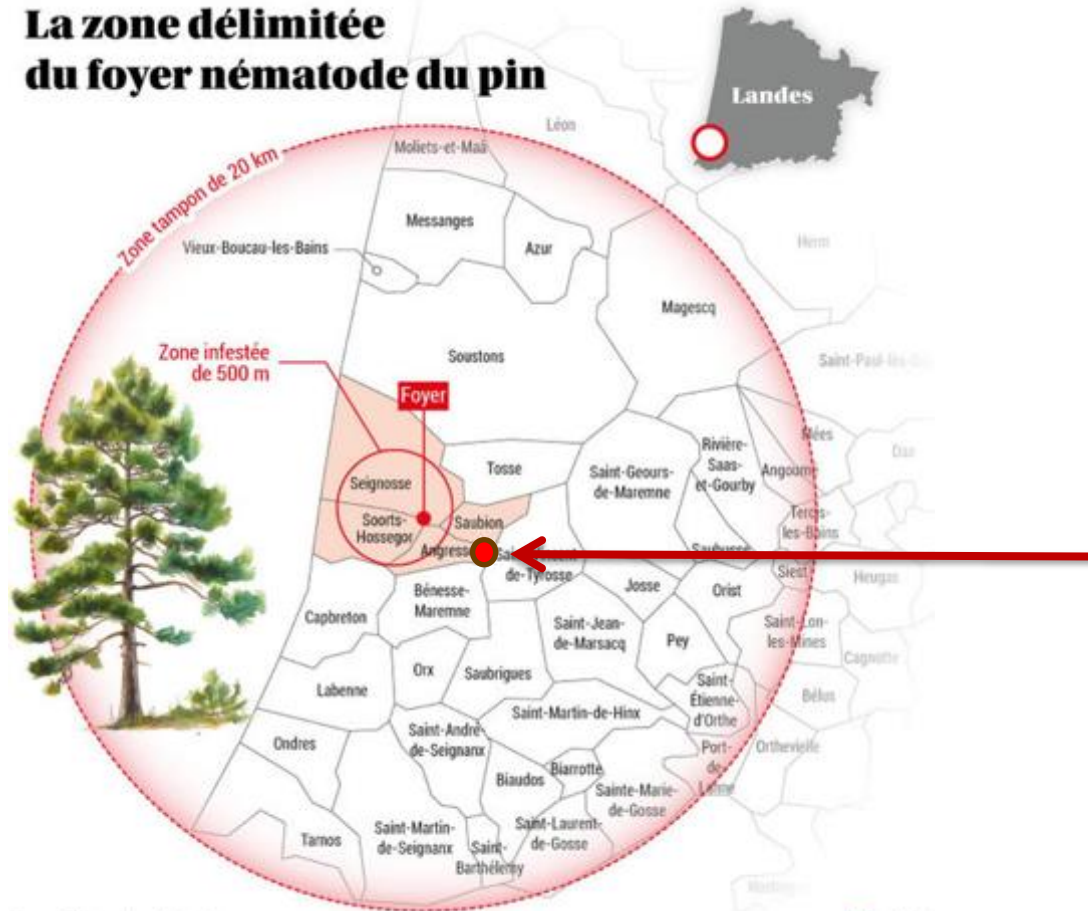
However, the detection was carried out as part of a routine procedure, the sampling effort by the authorities responsible for forest monitoring had not been adjusted to the predicted level of risk ...

Eradication operation: clear-cutting of 61 hectares of forest (within a 500m radius of the infected area)



5 infected trees  
~15,000 trees felled

# La zone délimitée du foyer nématode du pin



A second outbreak was discovered in March 2026, 3 km from the first

# New serious forest insect and tree pathogen invasions in Europe

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# Spread of emerald ash borer in US



Discovered in Michigan in 2002

8/1/2024, 7:20:38 AM

EAB Known Infested Counties

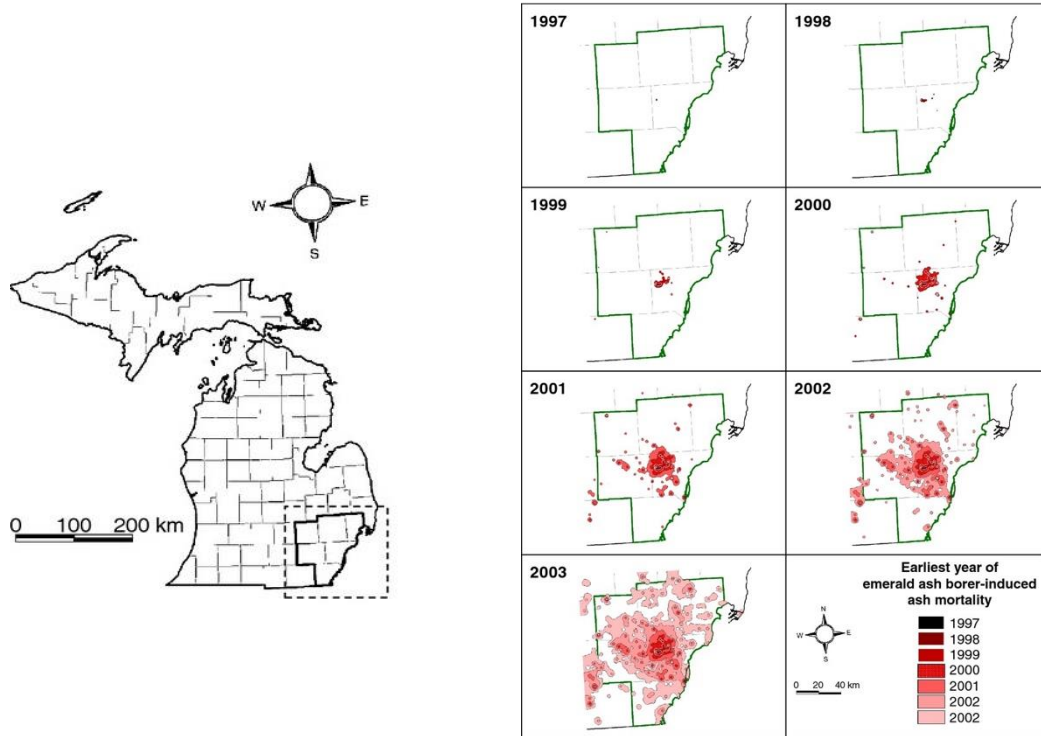


1:18,489,298



Esri, TomTom, Garmin, FAD, NOAA, USGS, EPA, USFWS, Esri, USGS

# Emerald ash borer had probably been established for 10-15 years when it was discovered in Michigan



Siegert, N. W., McCullough, D. G., Liebhold, A. M., & Telewski, F. W. (2014). Dendrochronological reconstruction of the epicentre and early spread of emerald ash borer in North America. *Diversity and distributions*, 20(7), 847-858.

# Tree mortality in natural forests in North America



# Tree mortality in urban forests in North America



# There is a lot of urban ash in Europe



THE SKY IS  
FALLING!!  
THE SKY IS  
FALLING!!



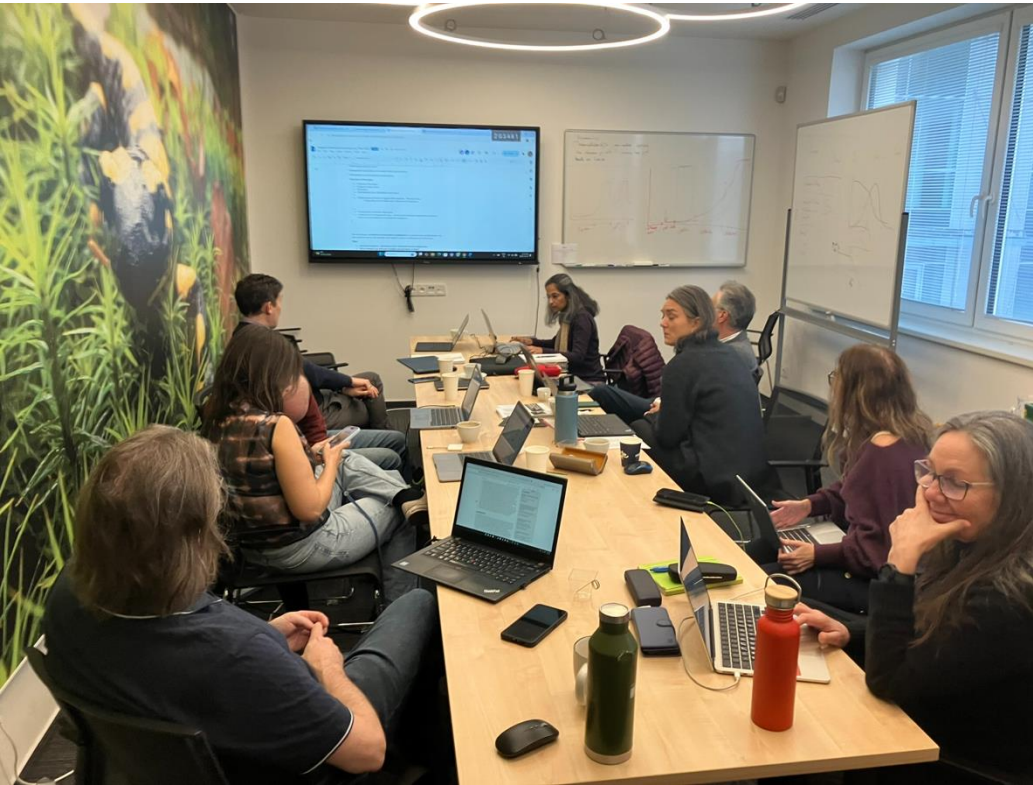


## **Forest Invasion Synthesis Centre, Prague**

**(a socio-ecological synthesis center that addresses the problem of biological invasions in forests)**



## FISC Working Group Meetings



### Current working group topics

- Determinants of tree growth in native and non-native ranges: Global patterns and mechanisms
- Biogeographic analysis of historical forest insect invasions and host associations
- Synthesis: transient invasion impacts
- Synthesis: role of hybridization during invasions

Union

## 2026 Call for FISC Working Group Proposals:

- **Synthetic working groups** – these groups typically focus on synthesizing existing knowledge in a new way, typically resulting in a review paper, policy brief or similar outputs. FISC typically supports a single 4-5 day meeting for such groups.
- **Data analysis working groups** – these groups typically assemble existing data and perform analyses targeting specific research questions. FISC typically supports two 4-5 day meetings held at FISC 6-12 months apart.

**Deadline for submitting pre-proposals: 15 June 2026**