

Current status of invasions by non-native insects related to woody plants

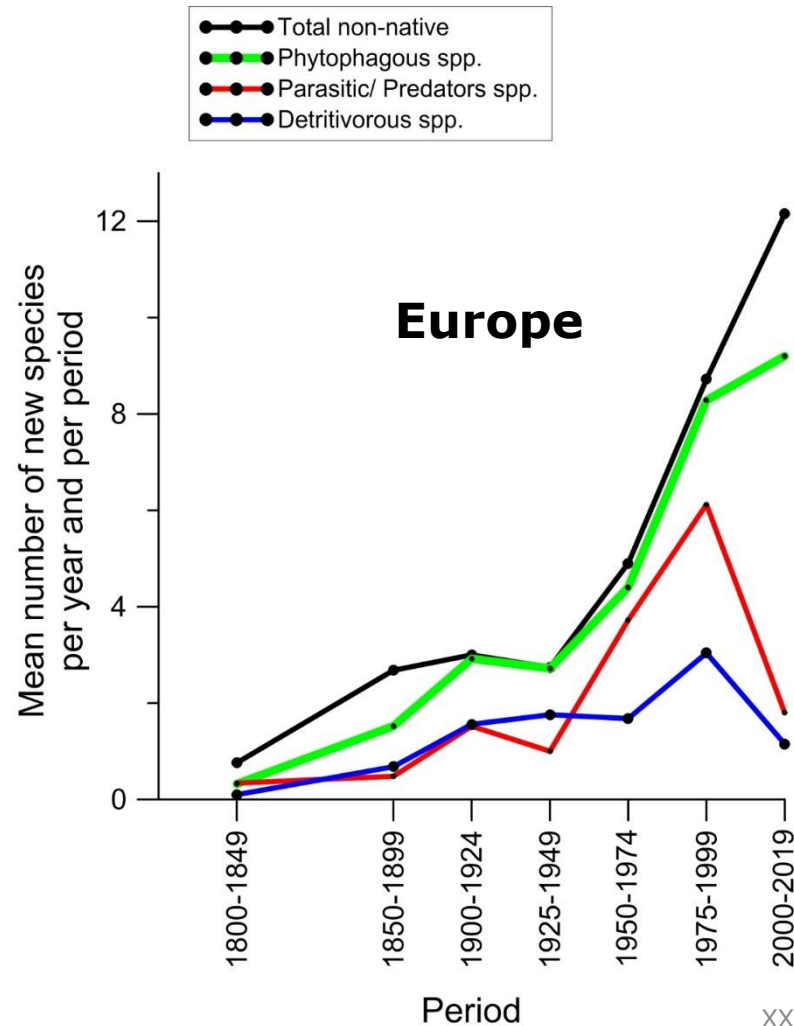
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No saturation in the establishment of non-native insects in Europe *(Seebens et al.2017)*

but
which species are benefiting from globalization ?

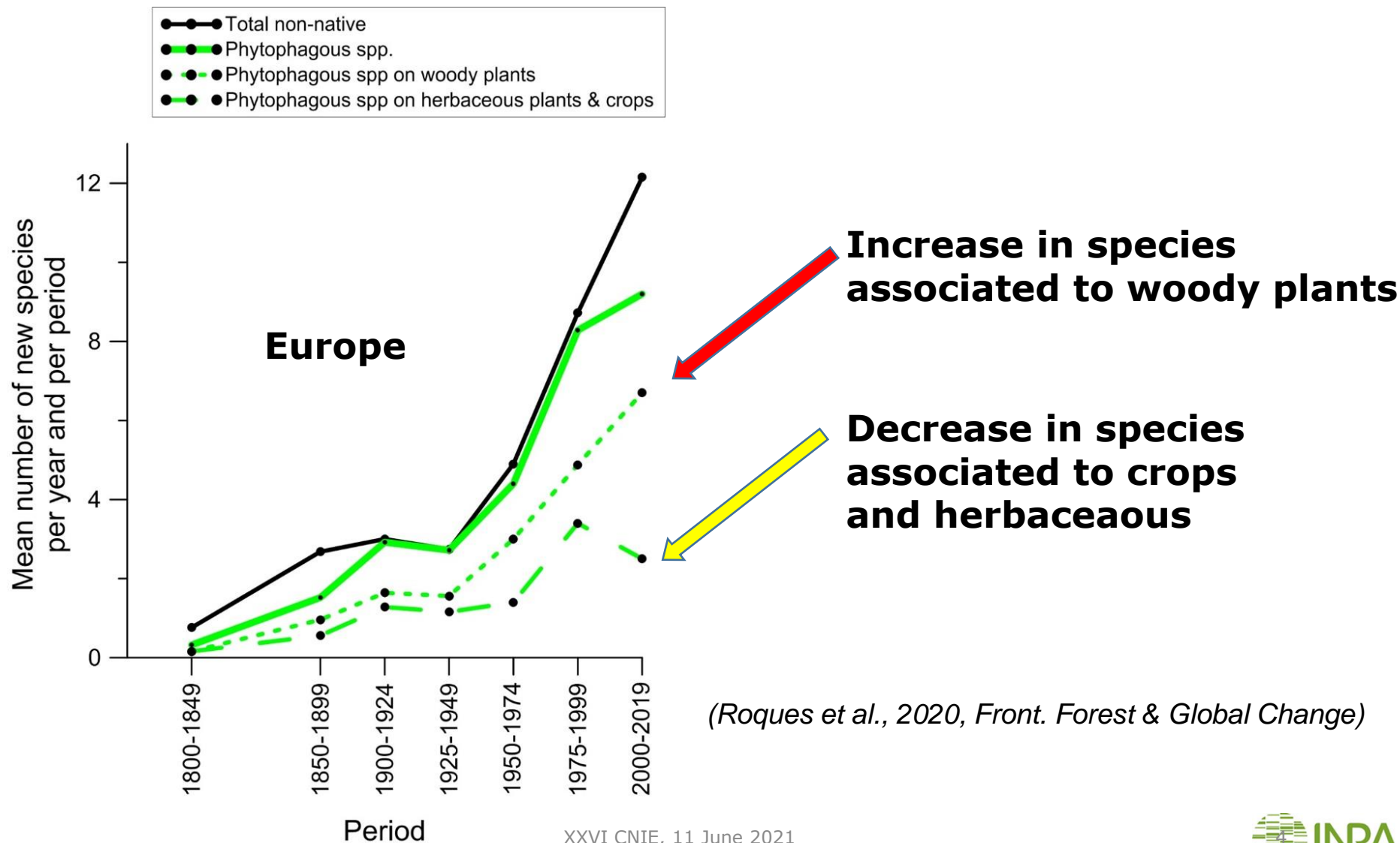


An increasing rate for phytophages whilst other groups declined during the last period

ca. 11.5 new phytophagous species per year since the 2000s (4.5 during 1950-75)

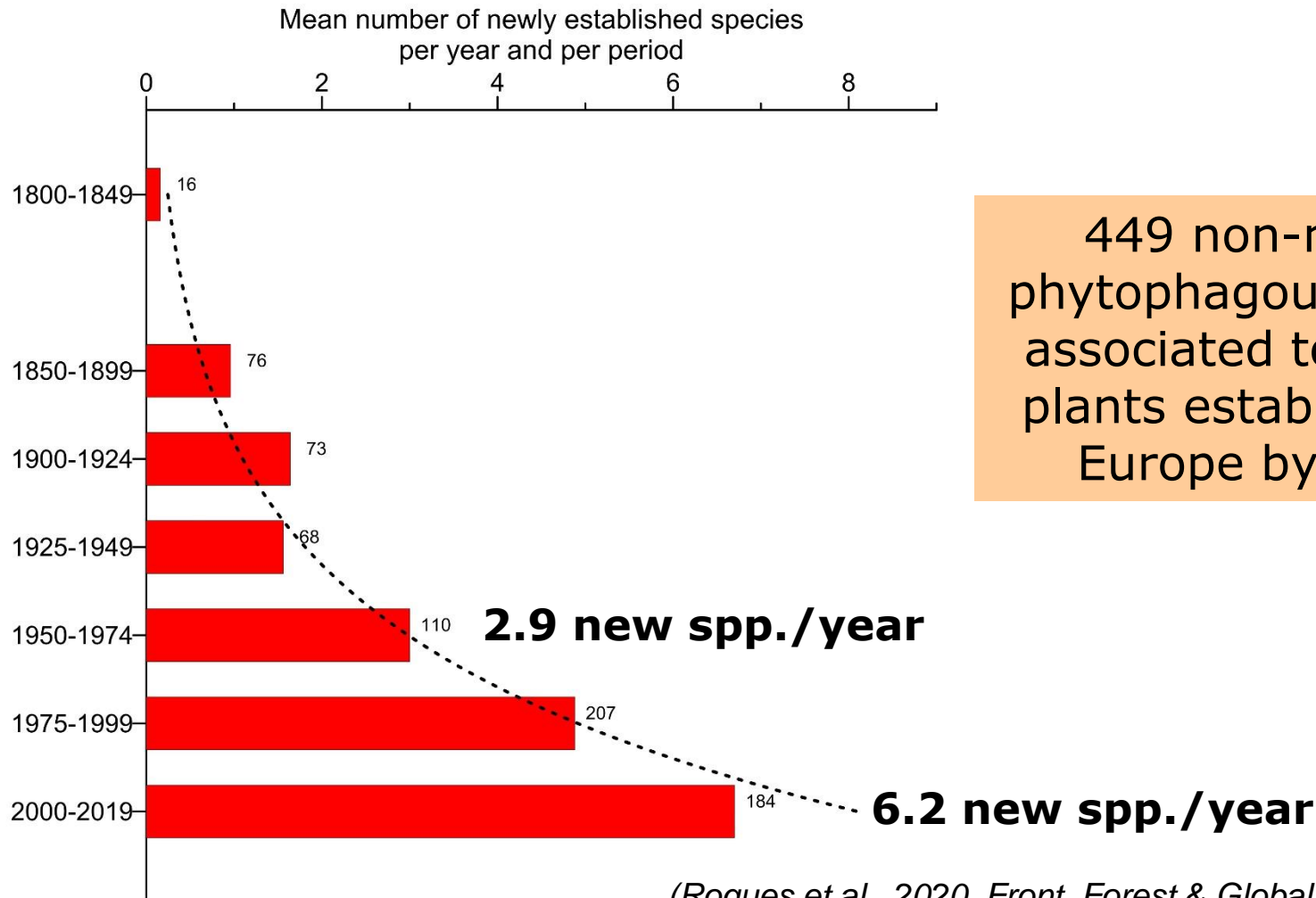
(Roques et al., 2020, Front. Forest & Global Change)

The recent increase in non-native phytophages mostly due to species associated to woody plants



Yearly establishments of non-native insects on woody plants doubled during the last 50 years

Likely related to the recent 'blooming' in ornamental trade

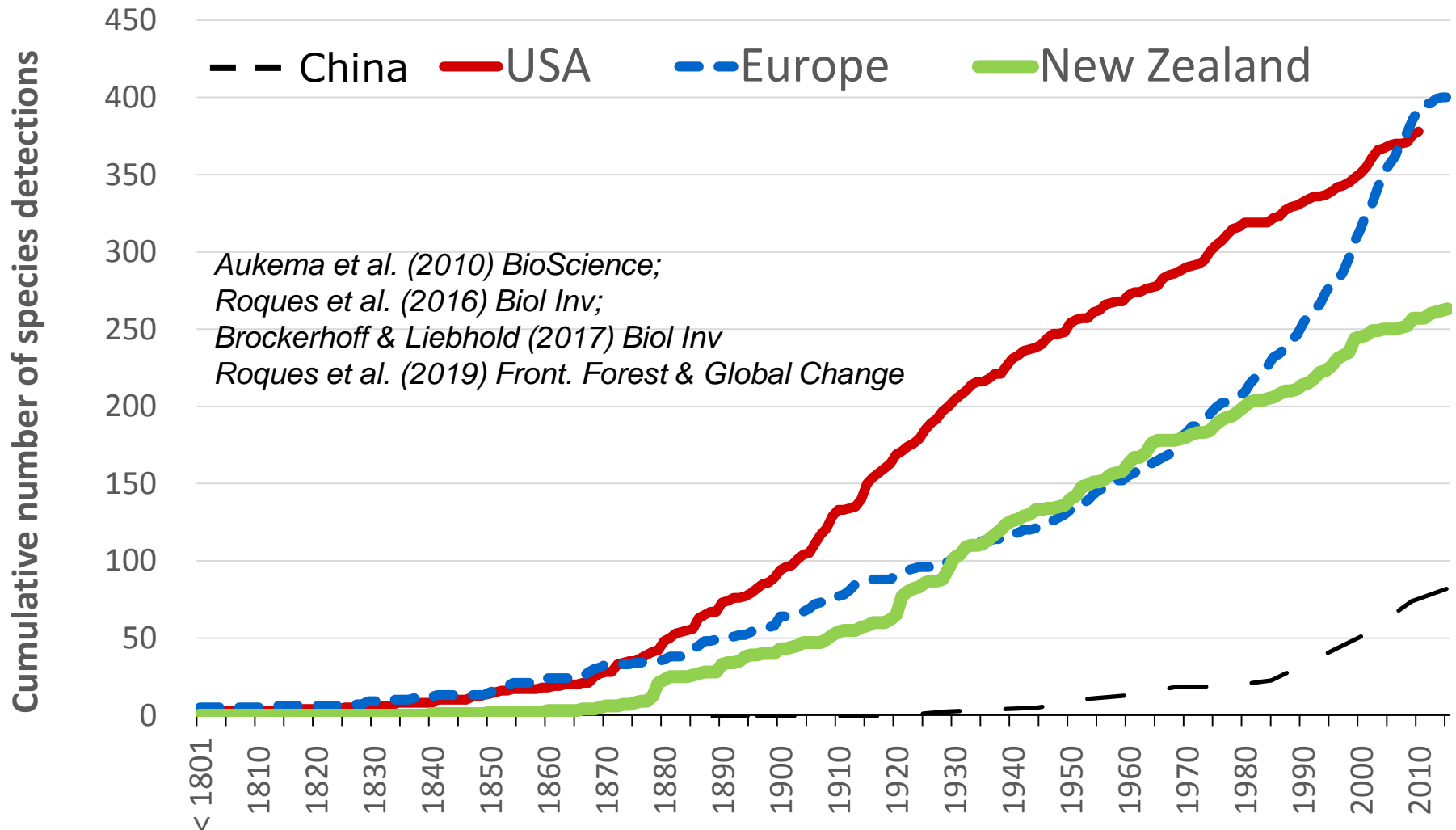


449 non-native
phytophagous insects
associated to woody
plants established in
Europe by 2019

(Roques et al., 2020, *Front. Forest & Global Change*)

Similar increasing trends all over the world

An exponential or a linear increase despite strong differences in border controls



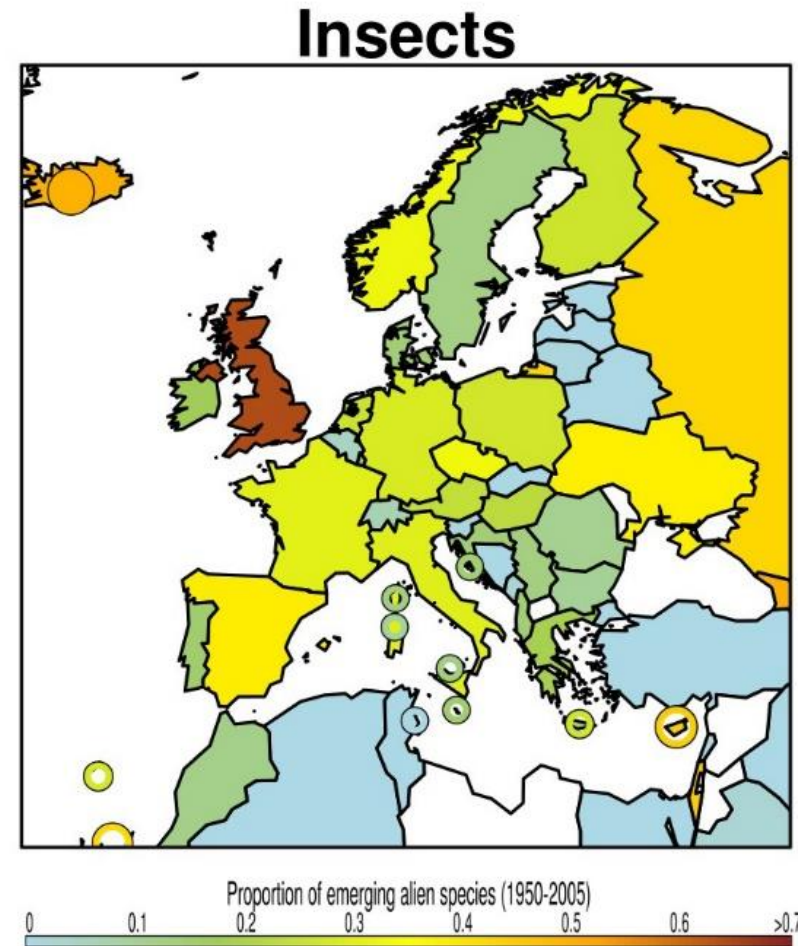
Key problem: recent invaders include a large proportion of « emerging » species

Many recent invaders have never been found elsewhere before they established in a continent other than the native one, eg. for Europe:

- Box tree moth, *Cydalima perspectalis*
- Honeysuckle gall-midge, *Obolodiplosis robiniae*
- Elm zigzag sawfly, *Aproceros leucopoda*
- Palm moth, *Paysandisia archon*
- Conifer Seed bug, *Leptoglossus occidentalis*

EAB- *Agrilus planipennis* and
ALB-*Anoplophora glabripennis* were “emerging”
invaders when first introduced to the USA in the
late 1990s

Same for the red turpentine beetle, *Dendroctonus valens*, when introduced to China



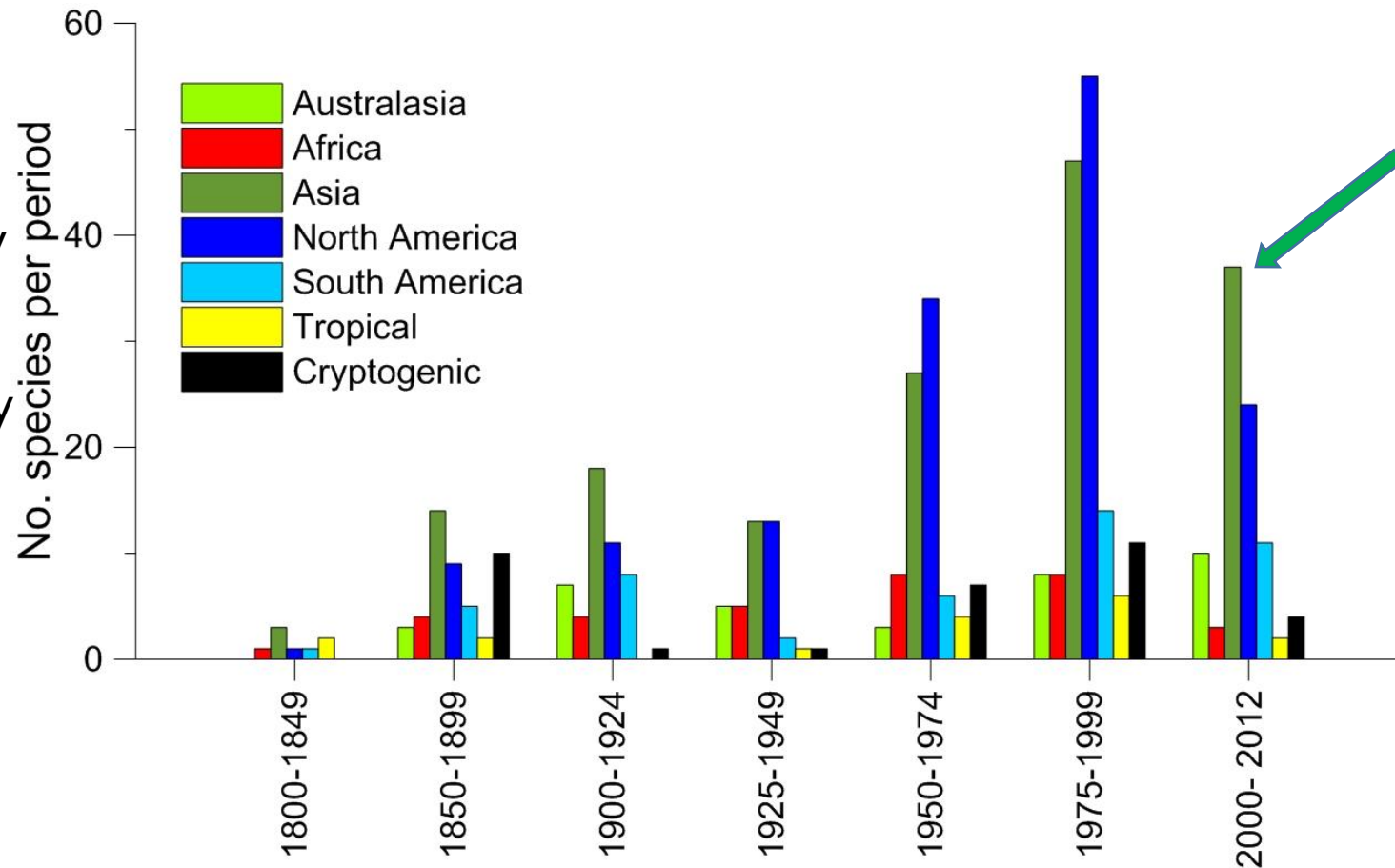
(Seebens et al., PNAS 2018)

Why an increase in « emerging » species ?

Arrival of new species pools

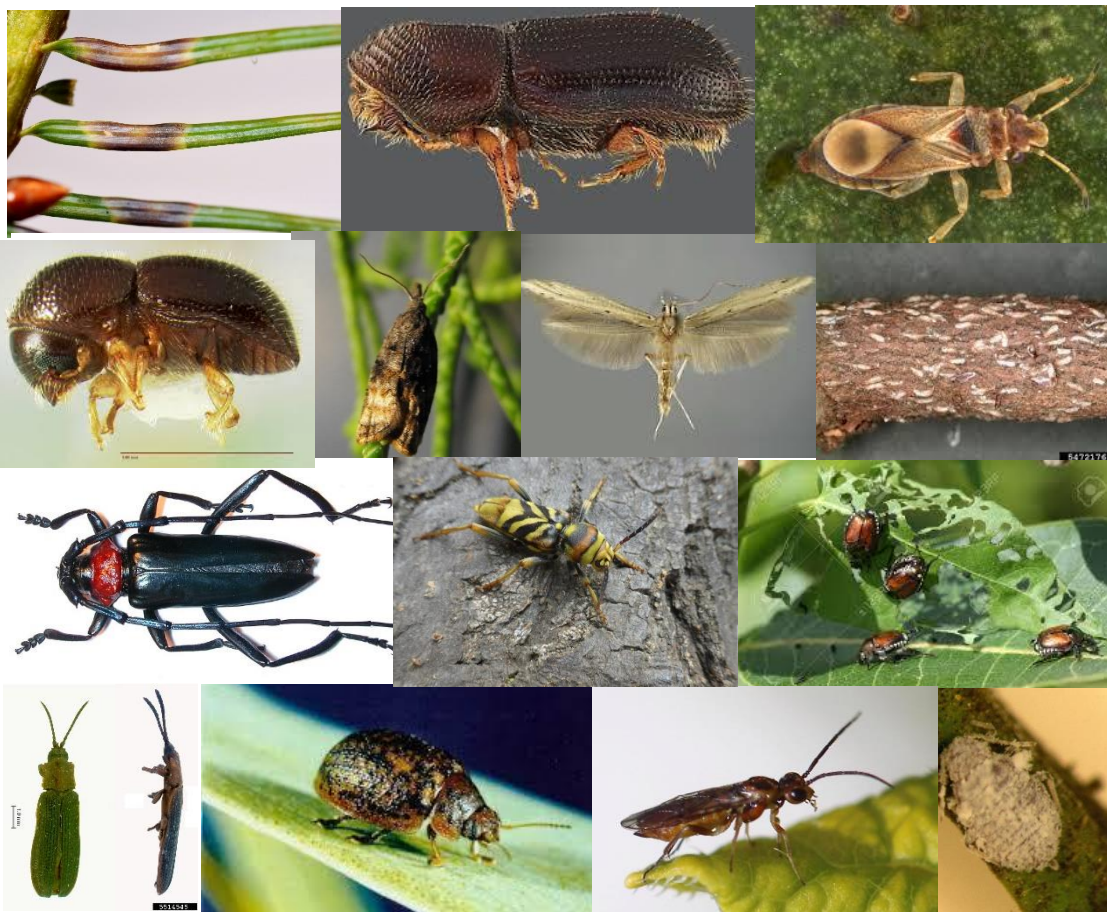
New trade couples and routes: Origin (Donor) x tree species

Asia recently turned dominant as area of primary origin for non-native insects (**37.2%** especially **China- 22.9%**), outcompeting North America (25.8%)



(Roques et al., 2020, *Front. Forest & Global Change*)

Some recent invaders in Europe, witness of the diversity in source pools



Contarinia pseudotsugae
Pityophthorus juglandis
Thaumastocoris peregrinus

Xylosandrus compactus
Platynota stultana
Batrachedra enormis
Lopholeucaspis japonica

Aromia bungii
Xylotrechus chinensis
Popilia japonica

Octodonta nipae
Trachymela sloanei
Nematus lipovskyi
Neophyllaphis podocarpi

The « emerging » species



Contarinia pseudotsugae
Pityophthorus juglandis



Platynota stultana
Batrachedra enormis
Lopholeucaspis japonica

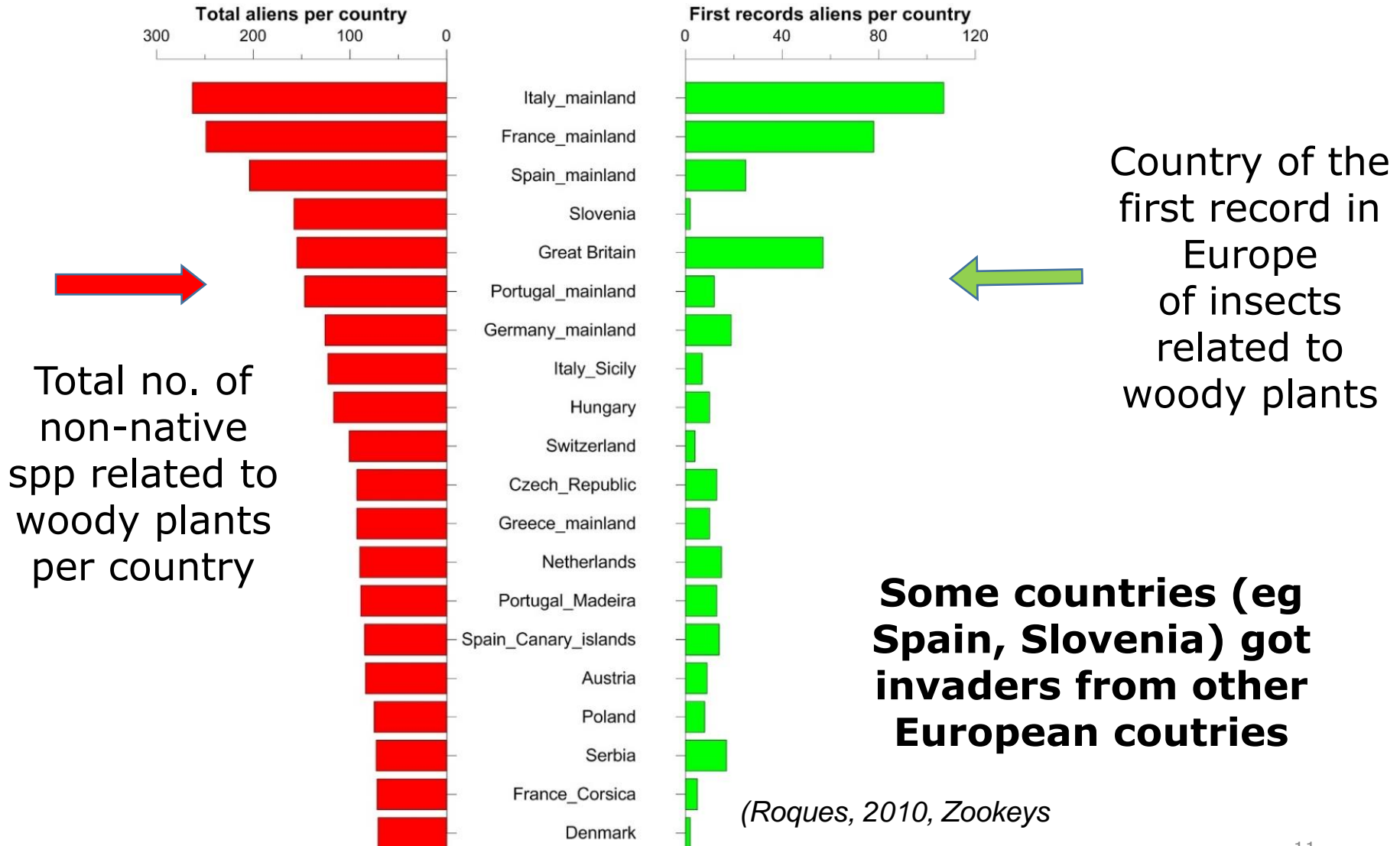


Aromia bungii
Xylotrechus chinensis

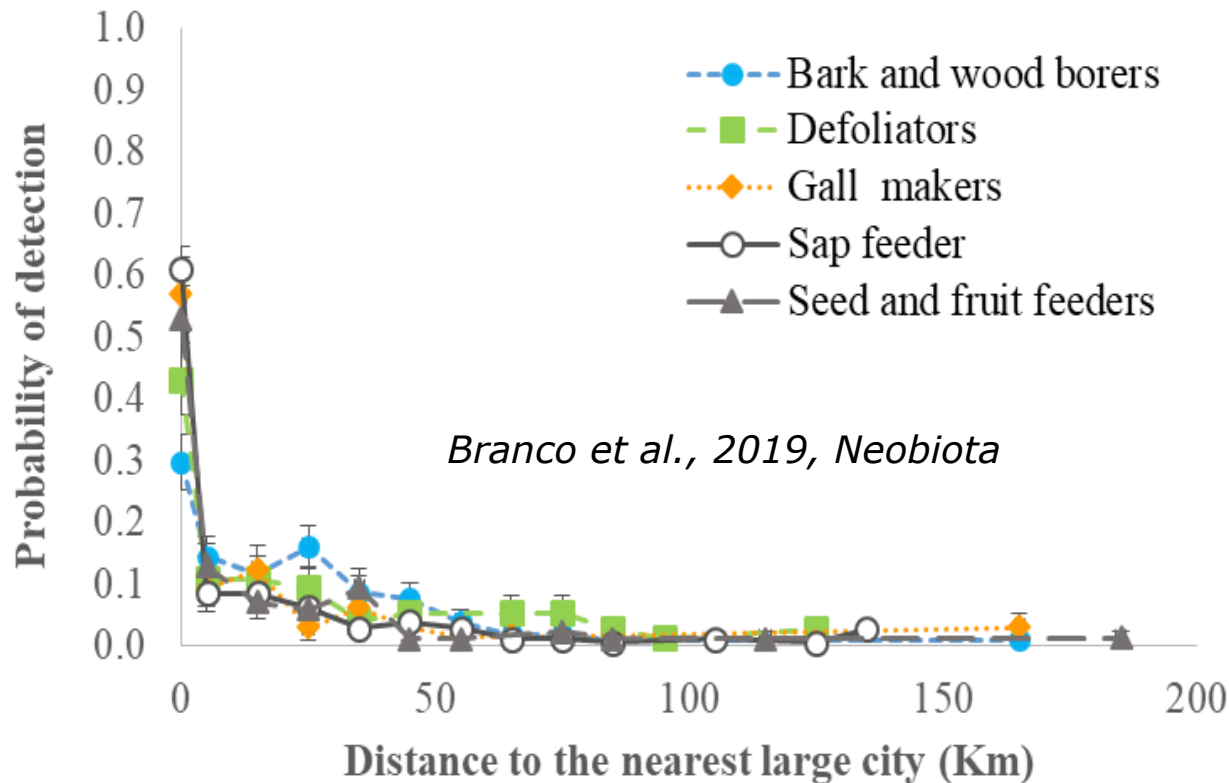


Octodonta nipae
Trachymela sloanei
Nematus lipovskyi
Neophyllaphis podocarpi

Continental Italy and France, the doors of entry



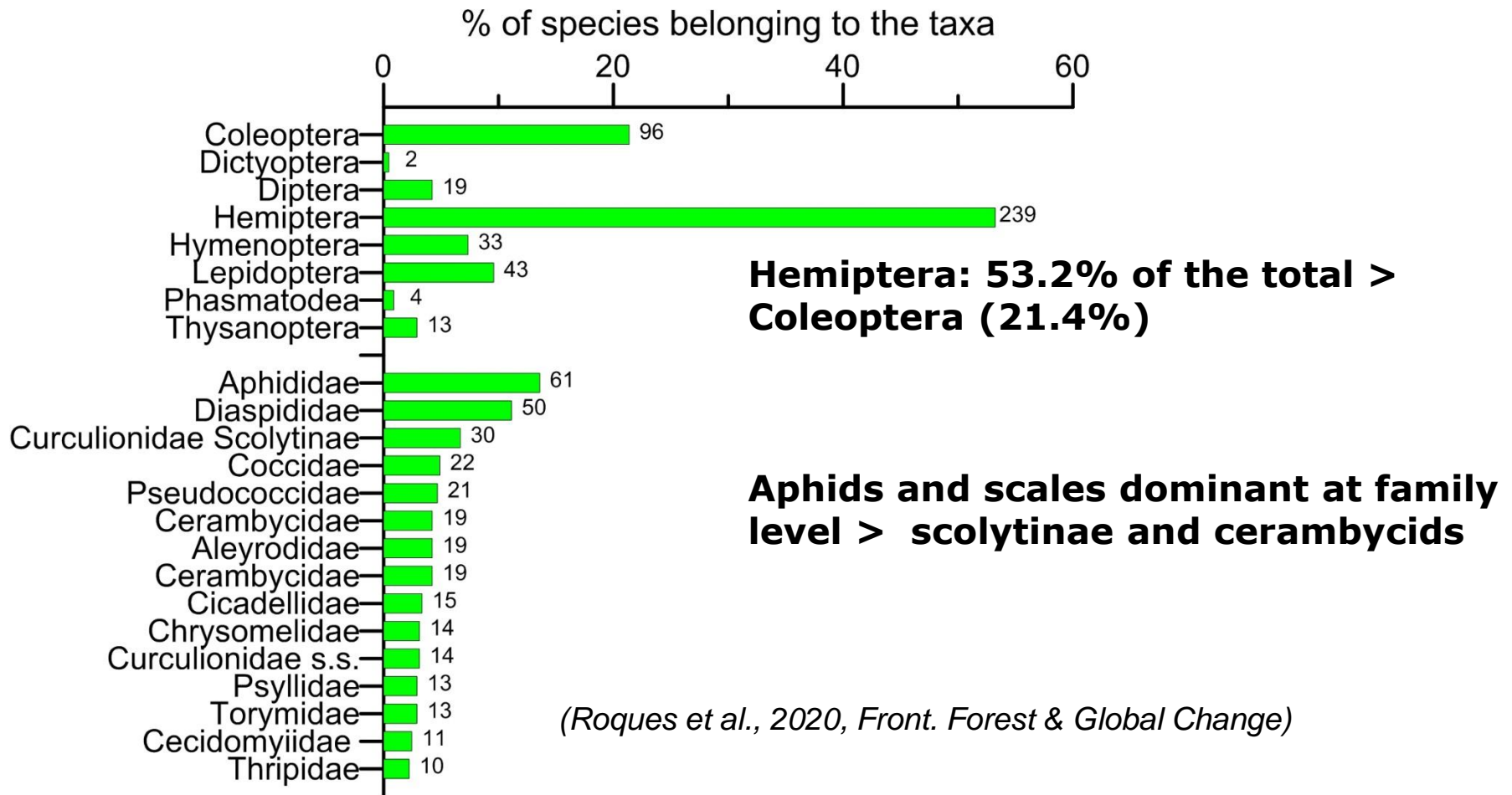
Urban trees, main facilitators for the establishment of non-native forest pests



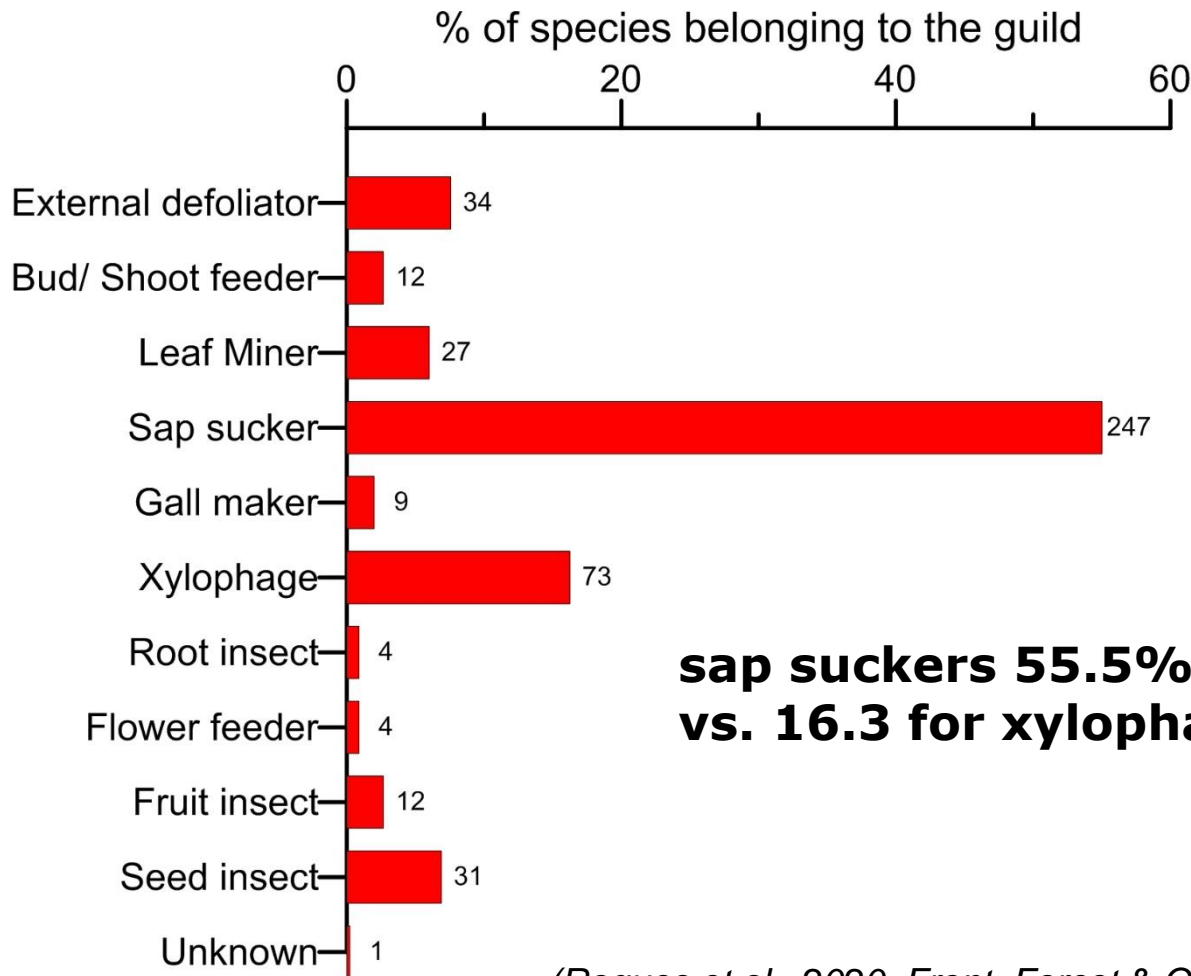
- **89% of first records in urban/suburban areas** (public parks, street trees, university campus, arboreta, zoos, and botanical gardens).
- **7% in forests** far from cities.
- Probability of occurrence decreased sharply with distance from the city.
- Detection in urban areas **higher for sap feeders, gall makers, and seed/fruit feeders (>90%)** than for bark and wood borers (**81%**).

Cities should thus be intensely surveyed

Hemiptera largely dominating the non-native entomofauna related to woody plants



As a result predominance of sap-suckers at guild level

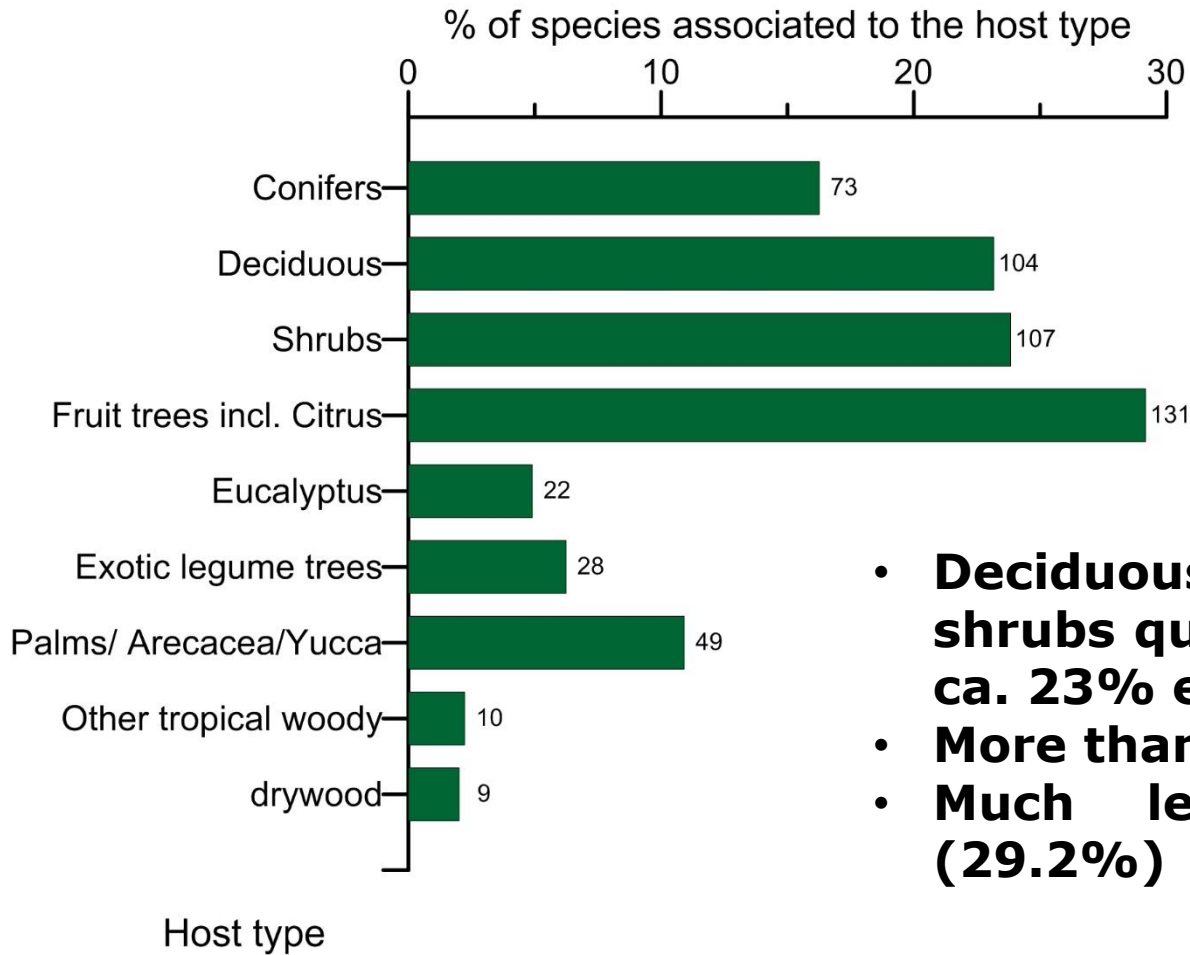


**sap suckers 55.5% of the total spp
vs. 16.3 for xylophagous insects**

(Roques et al., 2020, Front. Forest & Global Change)

Feeding guild

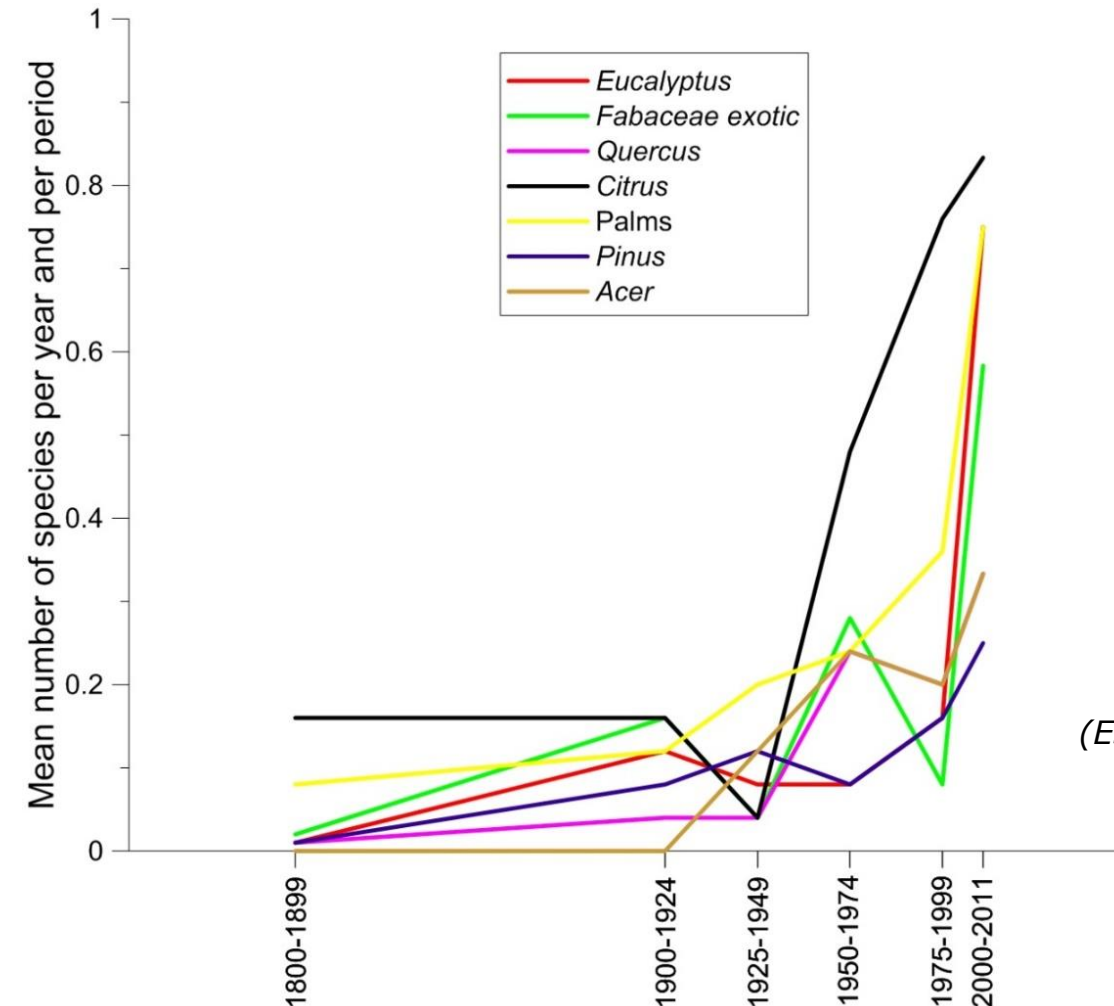
More broadleaved colonized than conifers



- **Deciduous trees and ornamental shrubs quite equally colonized by ca. 23% each**
- **More than conifers (16.3%)**
- **Much less than fruit trees (29.2%)**

(Roques et al., 2020, Front. Forest & Global Change)

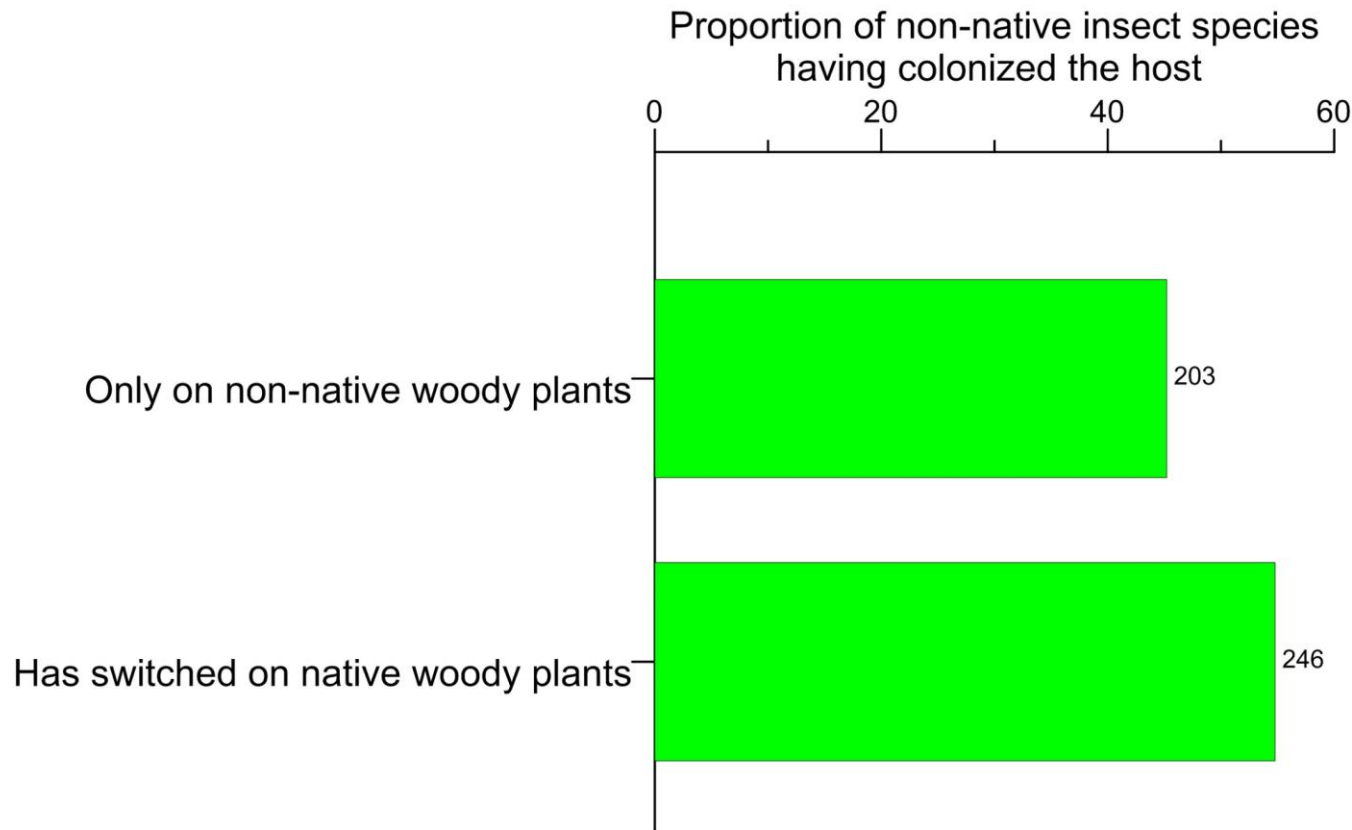
The colonization of exotic trees by non-native insects is increasing faster than that of natives trees



**Climate change ?
Change in trade because
increase in use of exotics?
Both ?**

(Eschen, Roques & Santini, 2014, Div & Dist.)

Switch on native trees still limited 45% of the non-native insects remain stucked to exotic trees planted in Europe



(Roques et al., 2020, Front. Forest & Global Change)

Invader presence and damage in forests still limited unlike urban areas

□ Most «important» invaders still stuck to urban ornamentals

- *Anoplophora* spp. on broadleaved and citrus
- Aphids spp. on all kinds of trees and shrubs
- Scales spp. on all kinds of trees and shrubs
- *Rhynchophorus* on palms,
- *Paysandisia* on palms

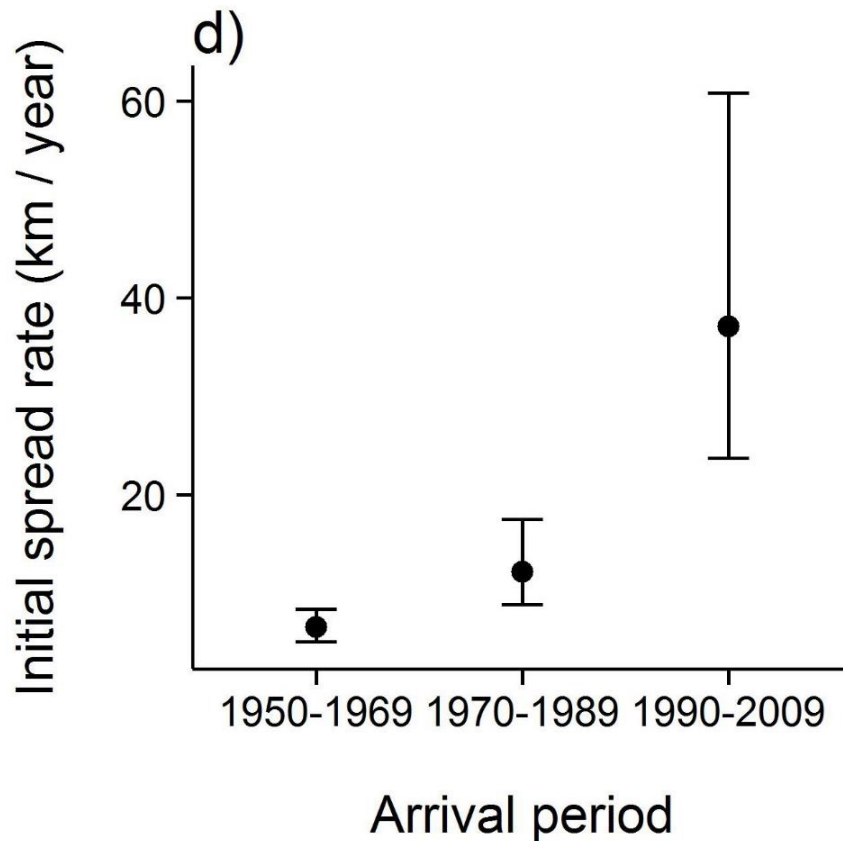
□ A few species already impacting native forests:

- *Dryocosmus* gall wasp on chestnut forests
- *Cydalima perspectalis* on box tree stands
- *Agrilus planipennis* on Ash but only Russia and Ukraine yet
- *Leptoglossus* on conifer regeneration
- *Aproceros* zig-zag sawfly on elm foliage
- *Xylosandrus* spp.

□ Other species impact exotic trees in plantation forests:

- *Adelges* on Douglas-fir foliage
- *Psyllidae*, *Eulophidae*, *Gonipterus* weevils on eucalypt foliage
- *Phoracantha* spp. on eucalypt trunks

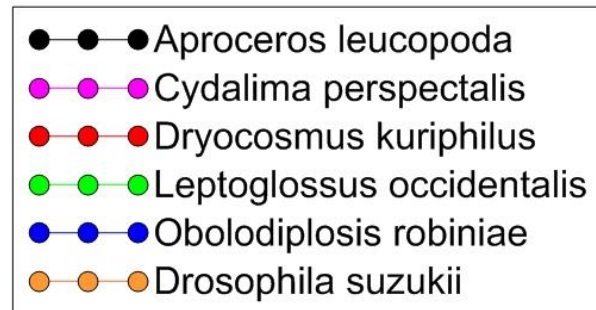
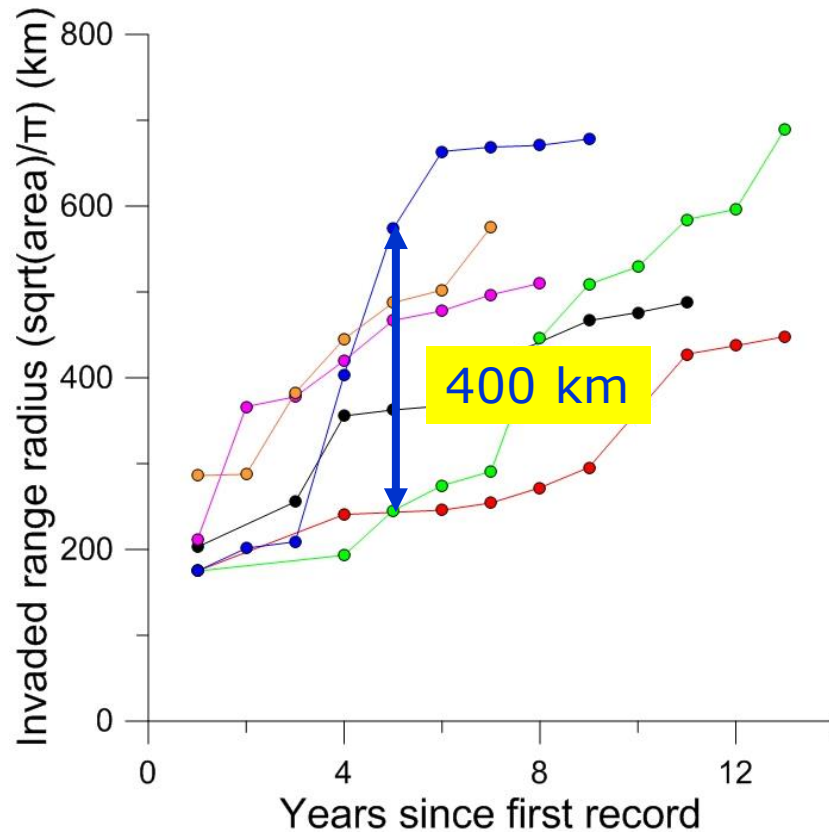
Once established, a much faster spread across Europe after 1989



Comparative initial spread of the species first recorded after 1950

(Roques et al., 2016 Biol. Inv)

A number of species related to woody plants invaded the whole of Europe in < 15 years



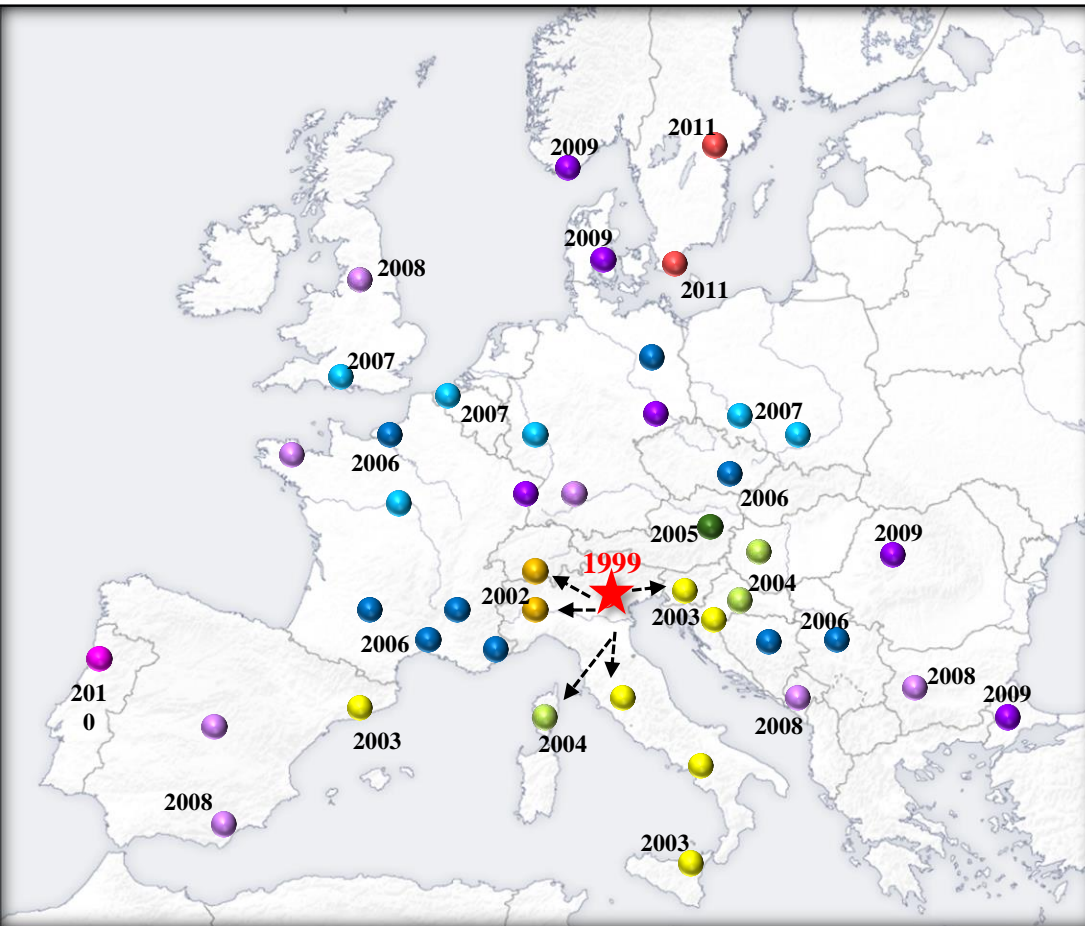
Impossible to relate yearly long-distance jumps to natural dispersal for many species

➡ Human mediation

(Roques et al., 2016)

Examples of very fast spread across Europe

The American conifer seed bug first recorded in 1999

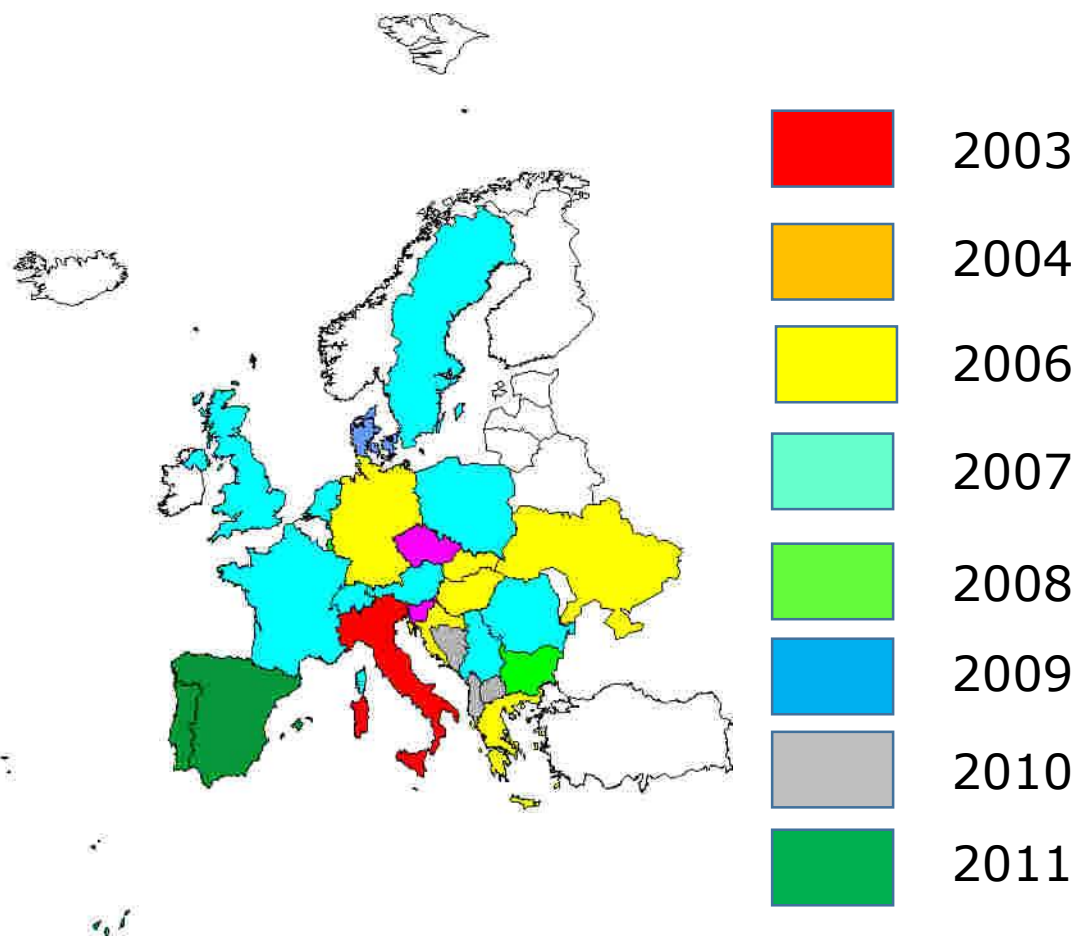


Leptoglossus occidentalis
(North America)



(Lesieur, 2015)

The American Honeysuckle gall midge first recorded in 2003

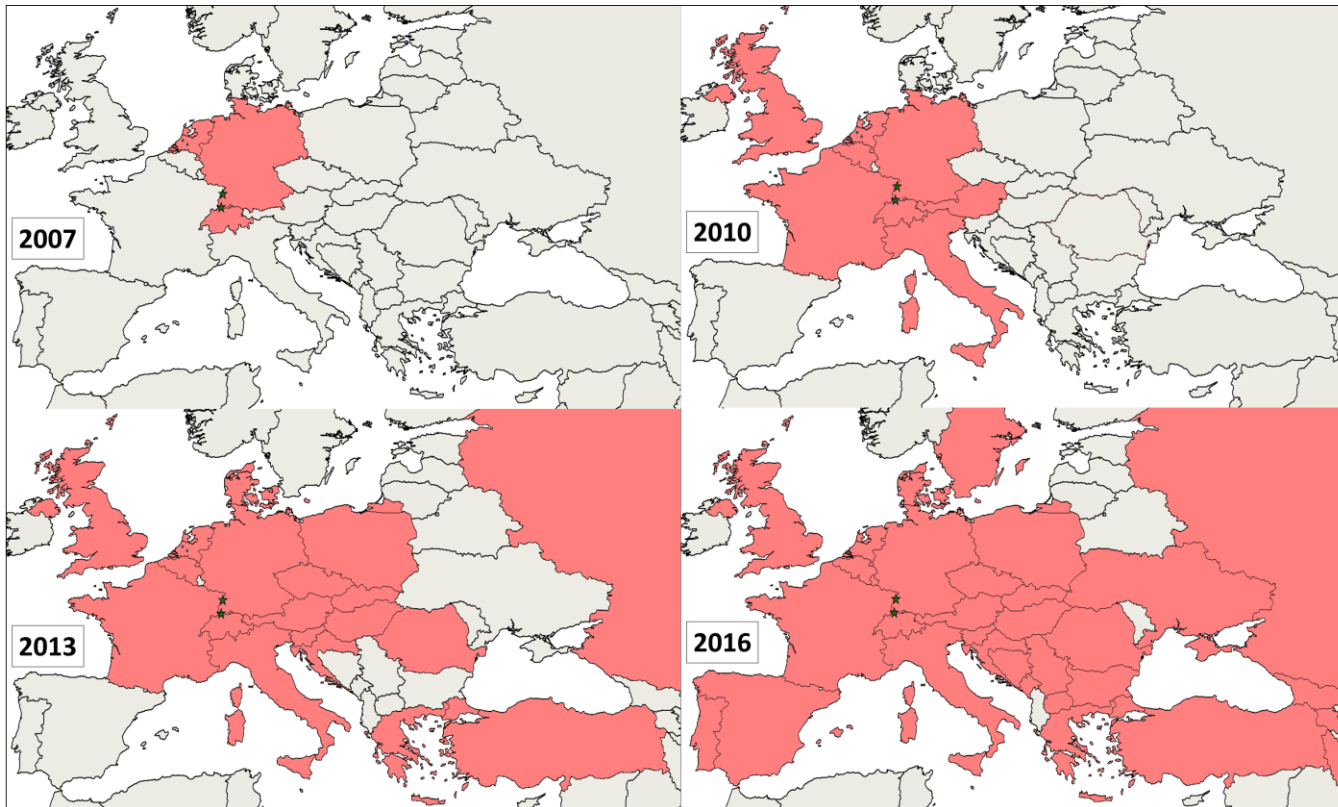


Obolodiplosis robiniae (North America)



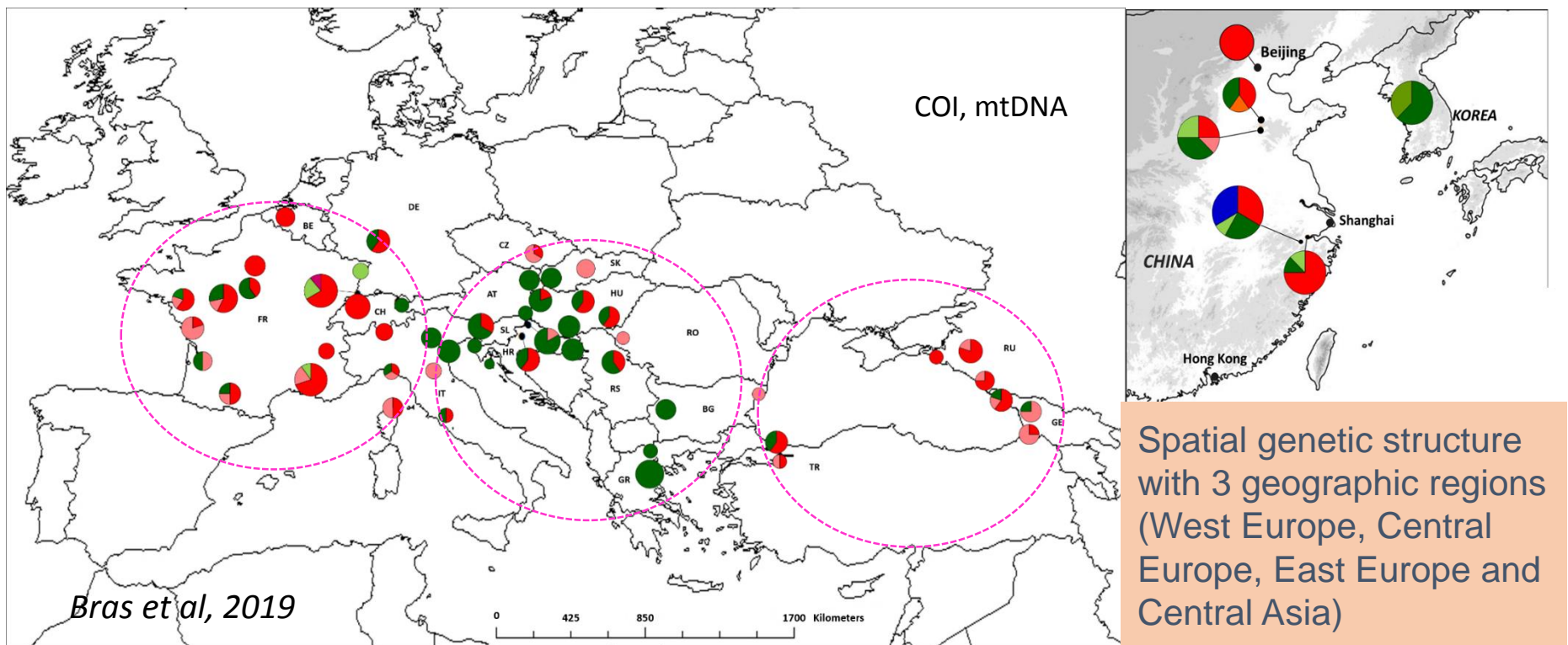
The Asian box tree moth first recorded in 2006

*Cydalima
perspectalis*
(China)



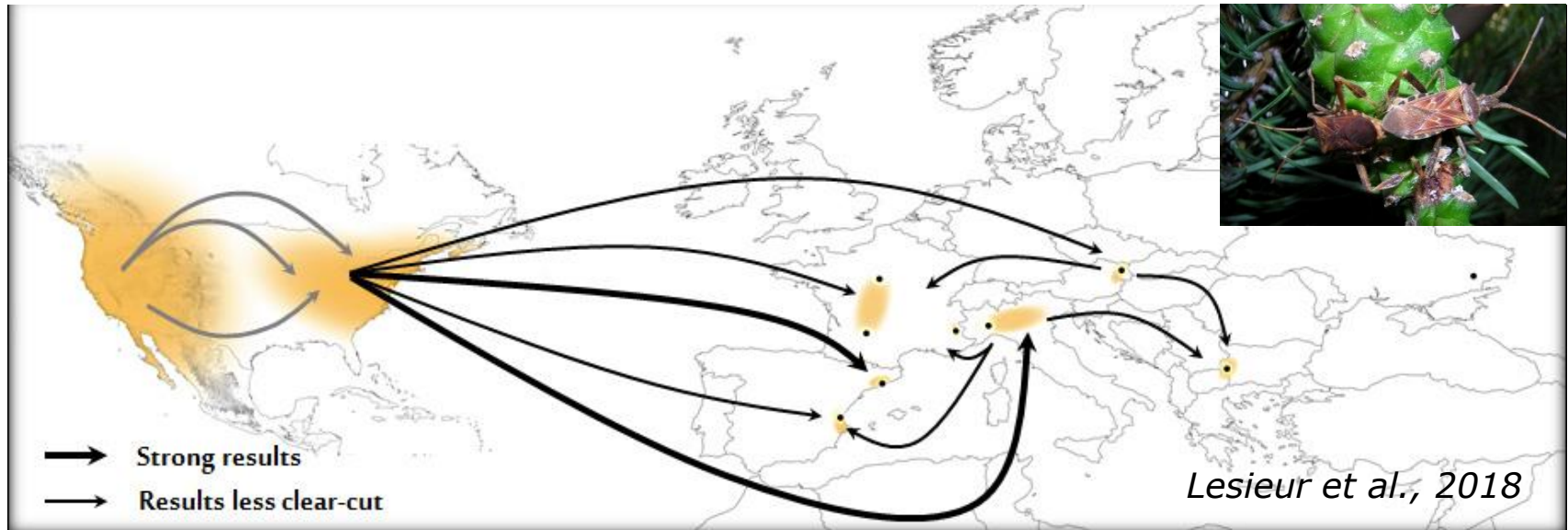
Genetic studies allowed to infer a complex invasion history in some species

Box tree moth and key role of ornamental trade



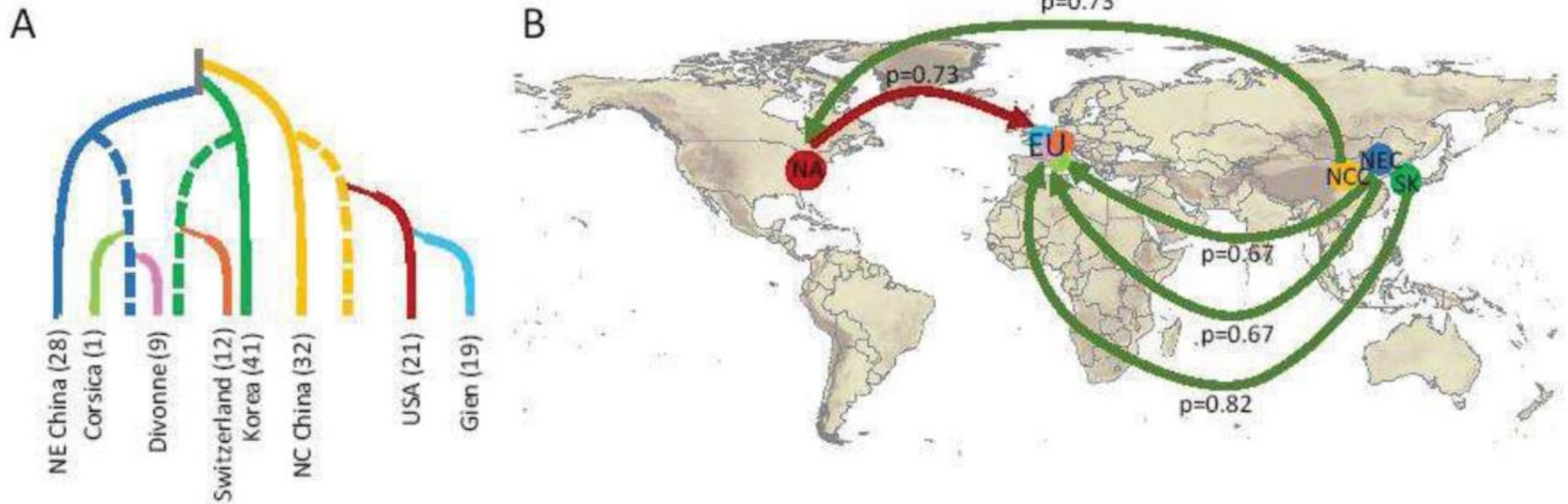
- ❑ Multiple introductions from Eastern China with ornamental trade
- ❑ Human-mediated dispersal with ornamental trade across Europe: Bridgehead effects from NL, Germany and Italy
- ❑ Local active dispersal by moth flight

Leptoglossus bugs: bridgehead and multiple introductions followed by long-range, human-mediated, dispersal combined with short-range natural dispersal



- ❑ Multiple independent introductions, at least 2 in Italy and Spain, probably much more : NW France, Spain, ...
- ❑ Bridgehead effects: primary invasive populations in eNA served as source for subsequent invasions in Europe... and not wNA
- ❑ Movements within Europe: flight+ hitchhiking + human-mediated transport= new bridgeheads

The Asian longhorned beetle, *Anoplophora glabripennis*

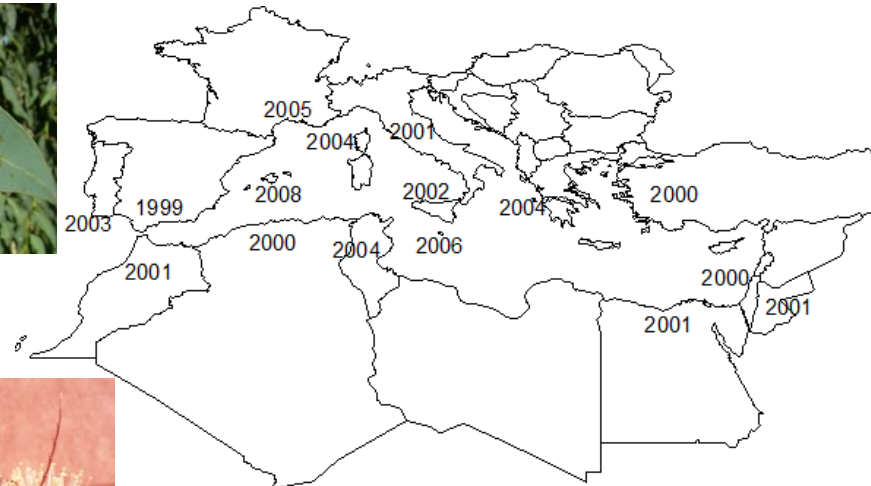


**Multiple introductions and
bridgehead USA/Gien**

Javal et al., Mol. Ecol. 2019

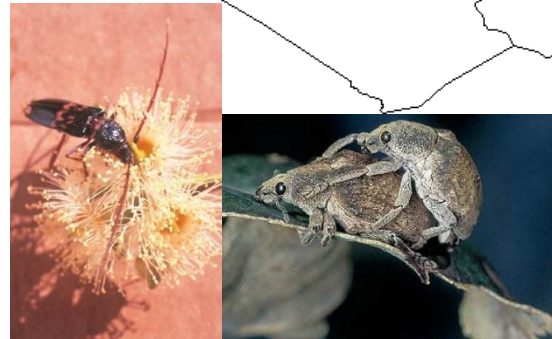
Faster spread associated to ornamental trade especially obvious for recently-arrived species associated with eucalypts and palms

- ❑ foliage feeders and gall-makers (*Leptocybe invasa*, *Ophelimus maskelli*, *Glycaspis brimblecombei*, ...) colonized most of the Mediterranean in <10 years



vs.

- ❑ a much slower colonization rate by *Phoracanta* spp. (arrival 1969 and 1992) and *Gonipterus* spp. (arrival 1975 and 1991)

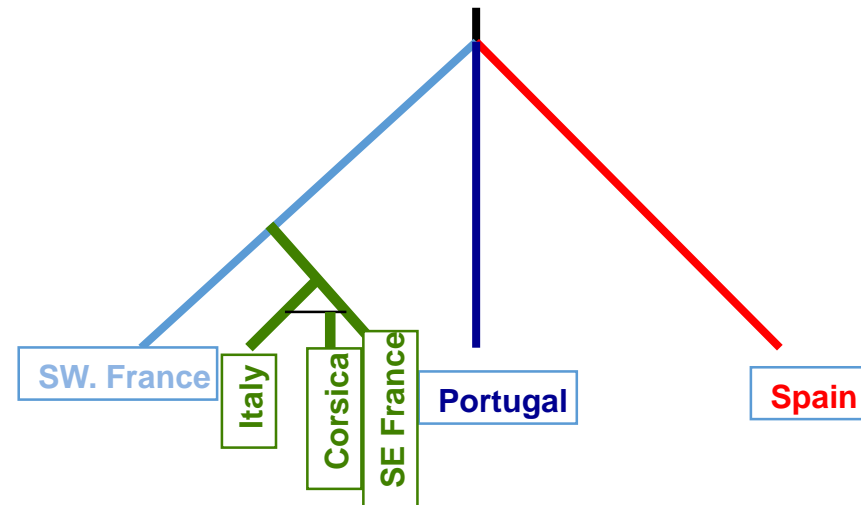
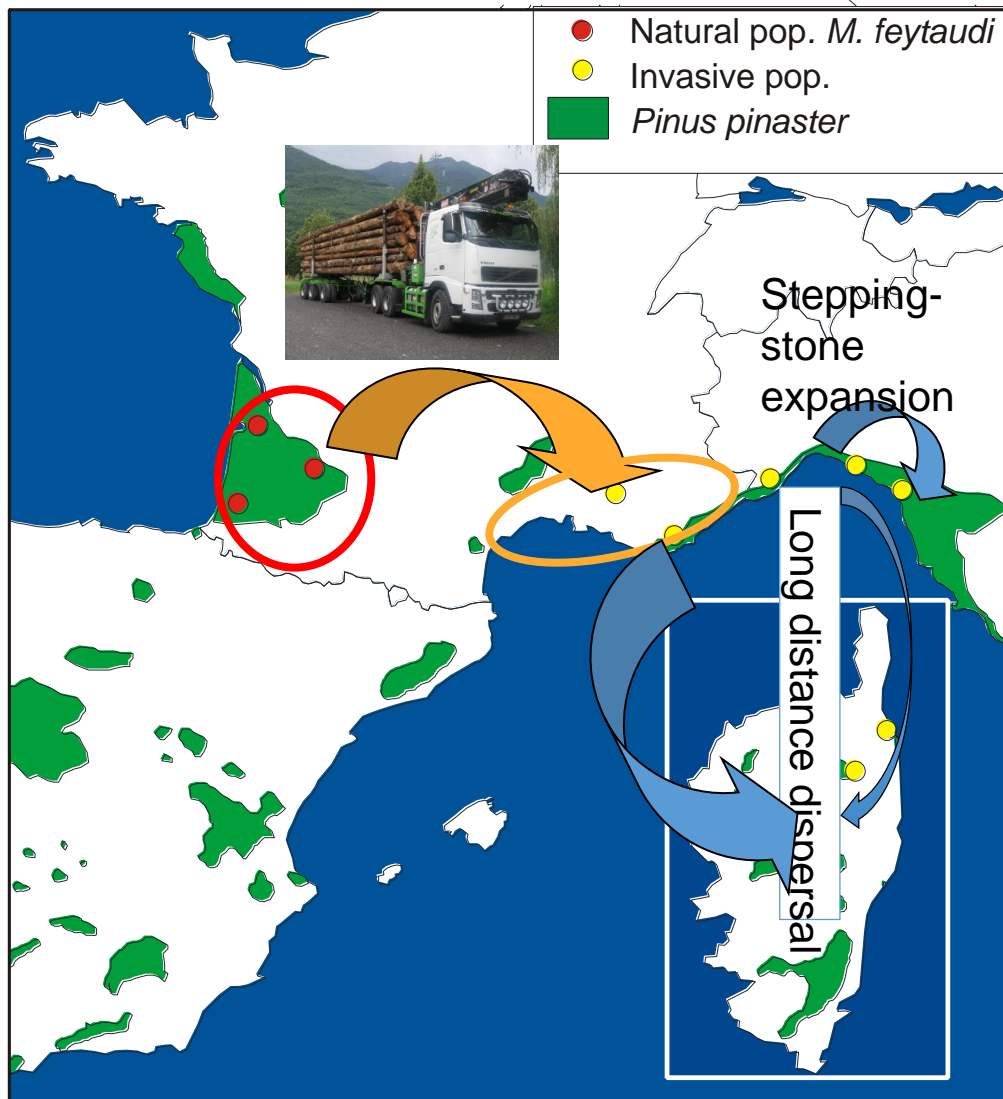


Direct trade of Eucalypts and Eucalypt wood with Australia limited:
Exchanges of ornamental plants for planting and/or cut foliage likely responsible for the jumps from one Mediterranean country to the others (Hurley et al., 2016)

Invaders within Europe

The pine scale, *Matsucoccus feytaudi*

Human mediation, natural dispersal and bridgehead



Kerdelhué et al. 2014

Take- home messages

- Insect invasions are accelerating with globalization without any evidence of saturation
- The establishment of emerging invaders is increasing with new trade routes and pathways resulting in promoting new species pools
- Urban trees act as facilitators for the establishment of exotic forest pests, and survey of cities should be a priority
- Once established, the non-native insects tend to spread faster than before in relation with the large development of trade of plants for planting between countries
- Most species still remain in urban areas, and quite a half did not switch from their exotic host to a native one
- Damage in forests due to invaders is still limited with noticeable exceptions
- However, it may correspond to the necessary time lag to adapt and we may face larger damage in the future
- In many cases, we are facing multiple introductions from native areas as well as bridgehead process from already-invaded regions



Thank your for your attention !