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Virginie Guyot, Marc Deconchat, Aude Vialatte, Bastien Castagneyrol, Herve Jactel. Tree diversity improves forest resistance to insect defoliators. IUFRO Conference, Sep 2015, Sopot, Poland. 25 p. hal-01608084

**HAL Id: hal-01608084**

**<https://hal.science/hal-01608084>**

Submitted on 5 Jun 2020

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# Tree diversity improves forest resistance to insect defoliators



*Inge van Halder*

**Virginie Guyot, Marc Deconchat, Aude Vialatte (INRA Dynafor, Toulouse)  
Bastien Castagneyrol, Hervé Jactel (INRA Biogeco, Bordeaux)**

**Population Dynamics and Integrated Control of Forest Defoliating Insects  
IUFRO Conference - Sopot – September 28 – October 2, 2015**



# Planted forest health: The need for a global strategy

M. J. Wingfield,<sup>1\*</sup> E. G. Brockerhoff,<sup>2</sup> B. D. Wingfield,<sup>1</sup> B. Slippers<sup>1</sup>

21 AUGUST 2015 • VOL 349 ISSUE 6250

TOOLS FOR DEALING WITH FOREST PESTS	POTENTIAL GLOBAL IMPACT*
Pest research tools	Red
Pest risk assessment	Orange
Pest information database	Red
Pathway risk management	Red
National quarantine	Orange
Surveillance tools	Red
Incursion response/eradication	Yellow
Biological control	Red
Genetic resources/breeding	Orange
Genetic engineering	Orange

\*Yellow = low; Orange = medium; Red = high

# Classical Biological Control

*Introduction* of natural enemies

in order to control pest insects (most often exotic)



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

Biological Control 43 (2008) 172–175

Biological  
Control

[www.elsevier.com/locate/bcon](http://www.elsevier.com/locate/bcon)

Recent advances in conservation biological control  
of arthropods by arthropods

Mattias Jonsson<sup>a,\*</sup>, Steve D. Wratten<sup>a</sup>, Doug A. Landis<sup>b</sup>, Geoff M. Gurr<sup>c</sup>

## Conservation Biological Control

*Manipulating the environment* in order to enhance natural processes  
of biotic regulation

- bottom up = interactions insects – non host plants
- top down = interactions insects – native natural enemies

 ***Manipulation* through change of forest composition**

# Positive relationships between forest diversity and health



**Associational resistance**

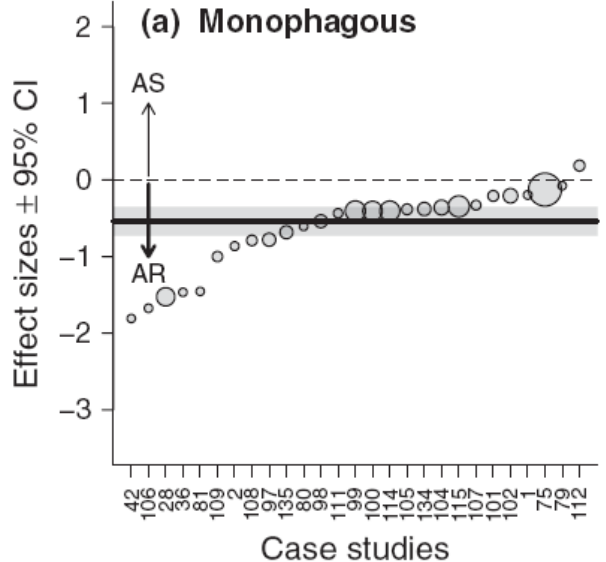
*Ecology Letters*, (2007) 10: 835–848 doi: 10.1111/j.1461-0248.2007.01073.x

**LETTER**

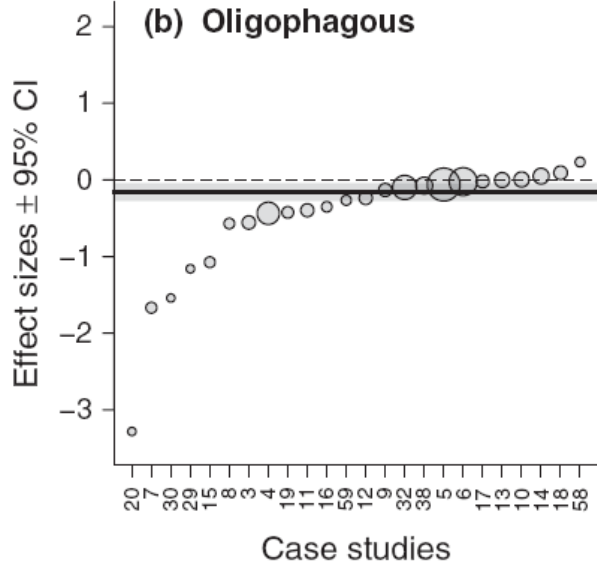
## Tree diversity reduces herbivory by forest insects

Hervé Jactel<sup>1\*</sup> and Eckehard G. Brockerhoff<sup>2</sup>  
<sup>1</sup>INRA, UMR1202 Biodiversity, Genes & Communities,

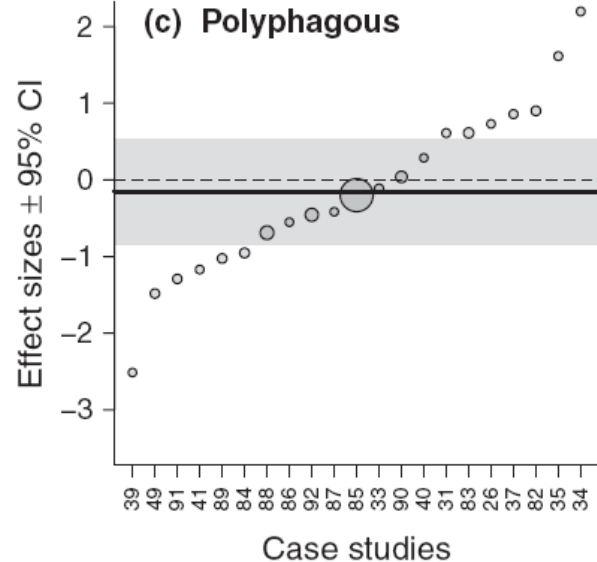
**Abstract**  
 Biodiversity loss from plant communities is often acknowledged to affect primary production but little is known about effects on herbivores. We conducted a meta-analysis of a worldwide data set of 119 studies to compare herbivory in single-species and mixed forests. This showed a significant reduction of herbivory in more diverse



**- 42%**



**- 15%**



**0%**

# Associational resistance in forests

## Limits:

- tested in experimental conditions
- on young trees
- comparisons pure vs. mixed stands (no gradient of diversity)
- focus on particular pest species, mostly native



Oikos 000: 001–012, 2015

doi: 10.1111/oik.02090

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Subject Editor: Ulrich Brose. Editor-in-Chief: Christopher Lortie. Accepted 5 March 2015

## Contrasting effects of tree diversity on young tree growth and resistance to insect herbivores across three biodiversity experiments

Josephine Haase, Bastien Castagneyrol, J. Hans C. Cornelissen, Jaboury Ghazoul, Jens Kattge, Julia Koricheva, Michael Scherer-Lorenzen, Simon Morath and Hervé Jactel

➔ Lack of global pattern



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journal homepage: [www.elsevier.com/locate/ppees](http://www.elsevier.com/locate/ppees)



Forum

A novel comparative research platform designed to determine the functional significance of tree species diversity in European forests



## 6 exploratory sites in Mediterranean, temperate and boreal forests

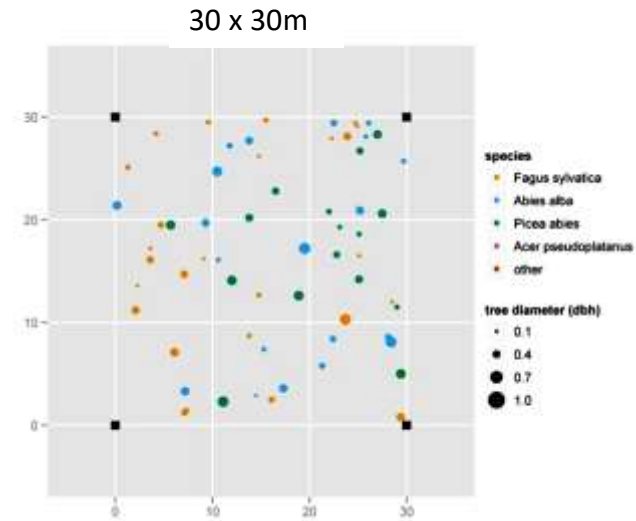
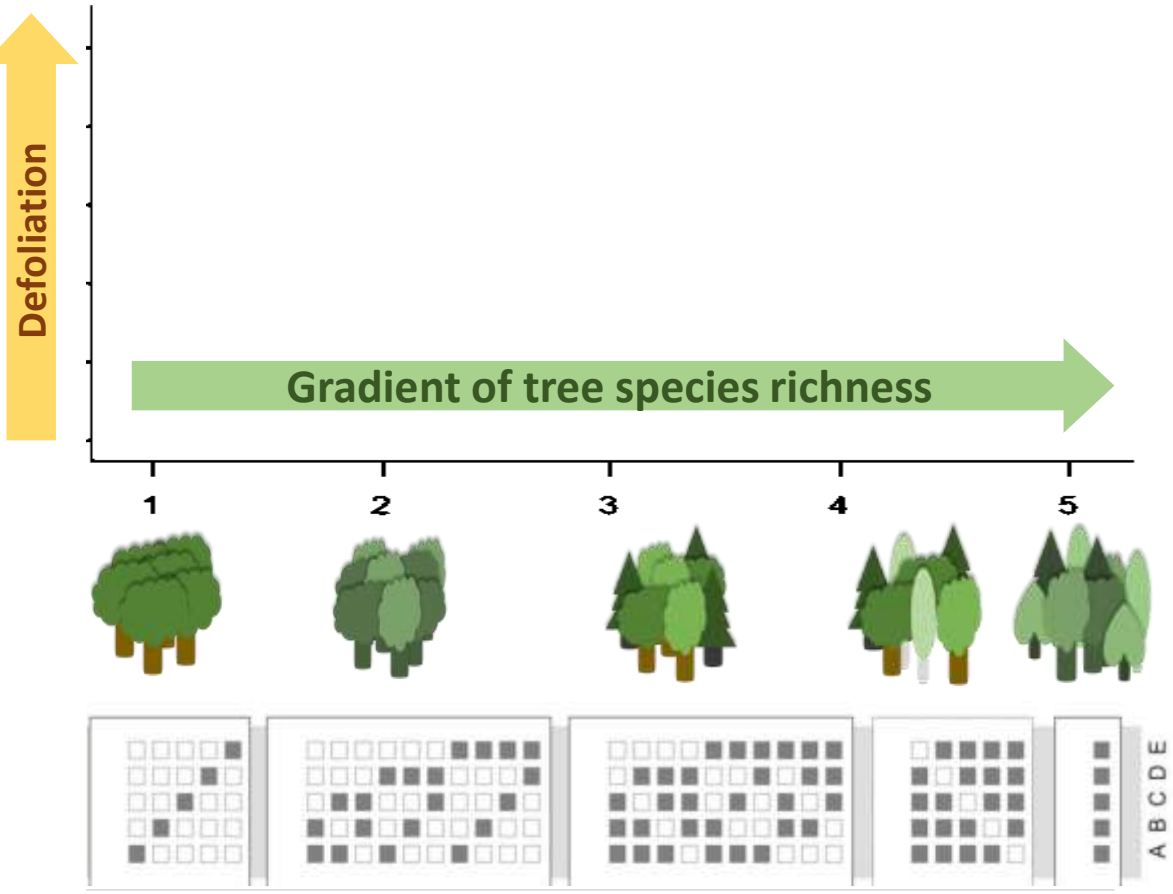


Main European tree species





# Effects of forest diversity on tree defoliation by insects



214 forest plots  
13 609 trees

3 trees observed/species

1 670 sampled trees



# Effects of forest diversity on defoliation

on leaves

60 - 100/tree = 81 908 leaves

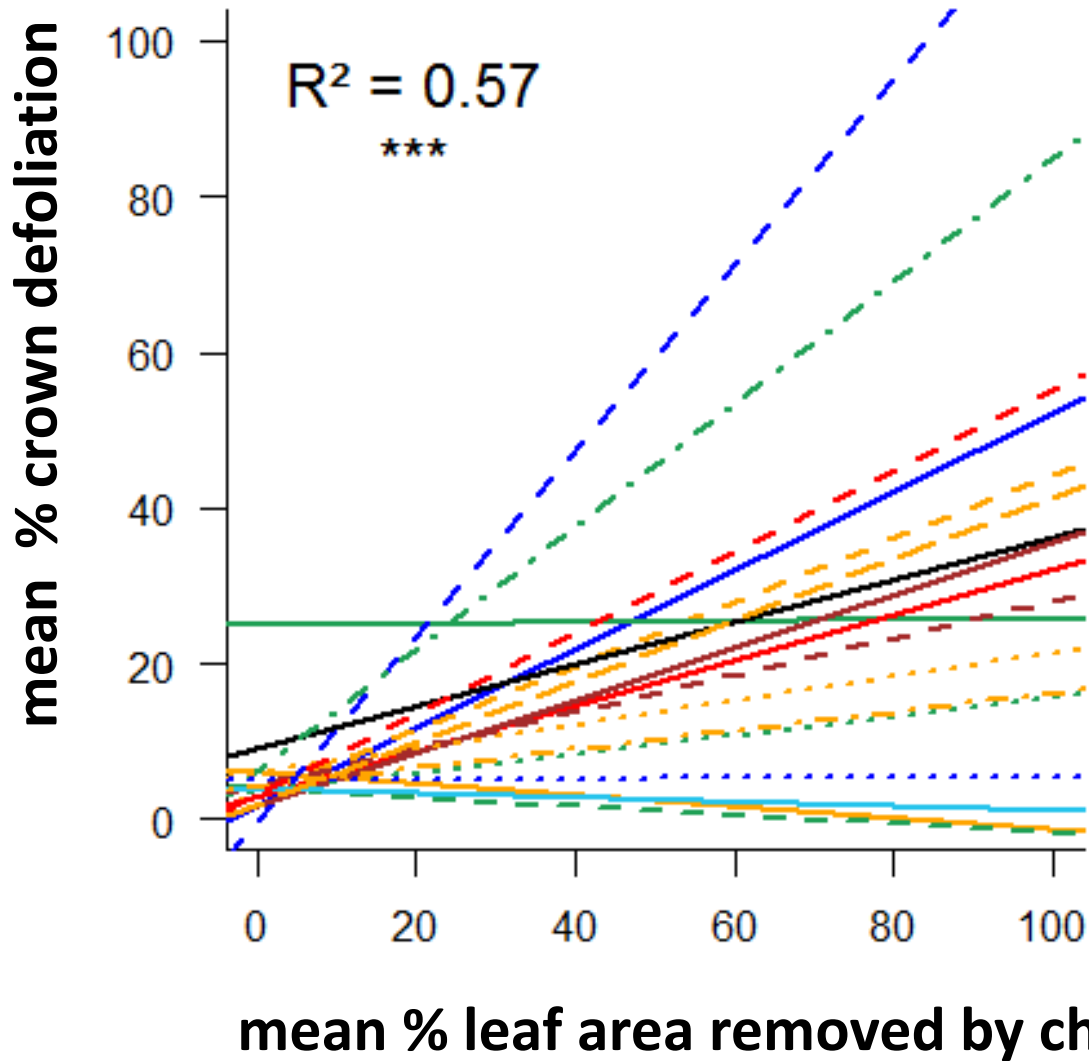


on tree crowns

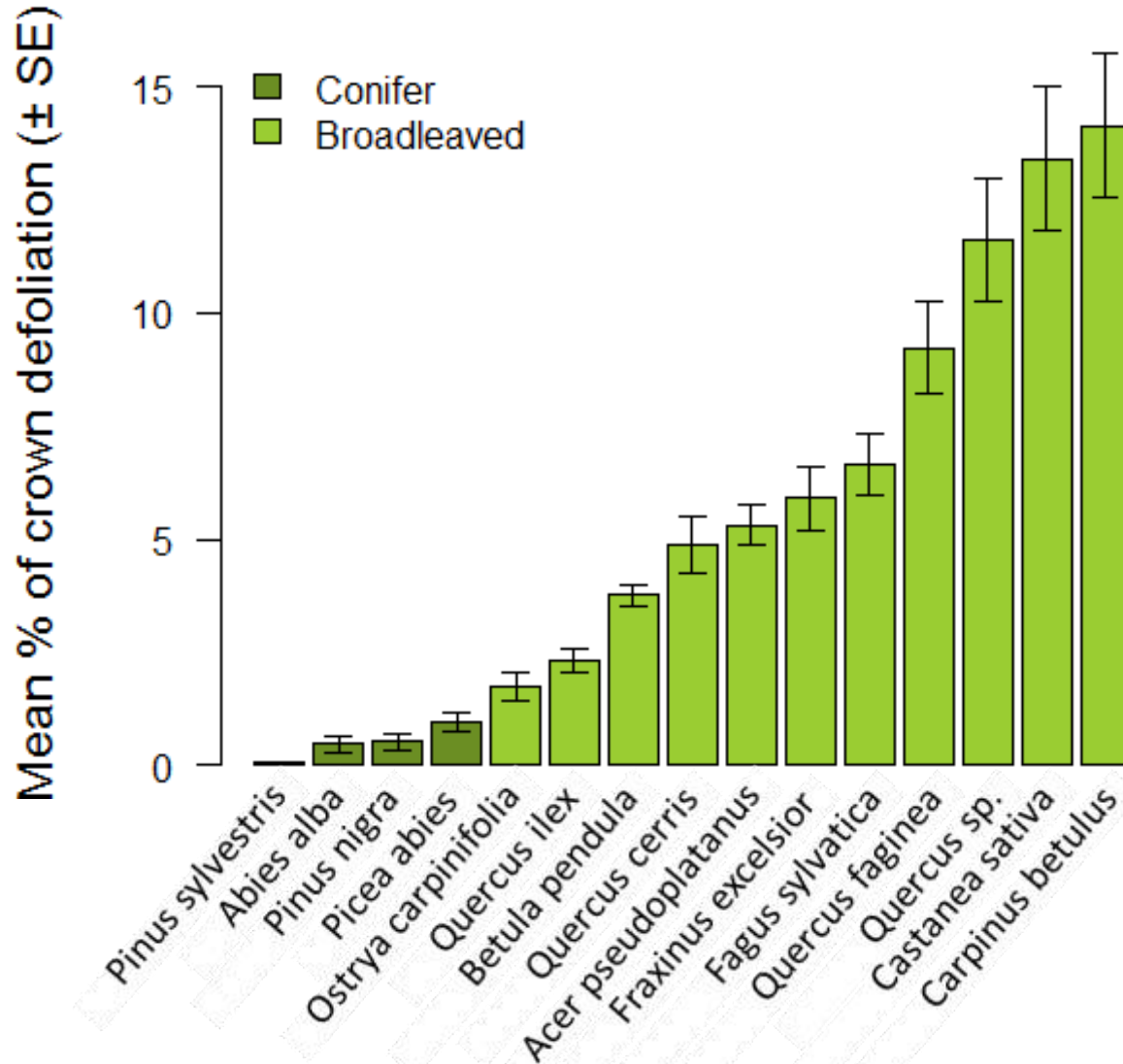
ICP Forest protocol  
= 1670 trees



# Effects of forest diversity on defoliation



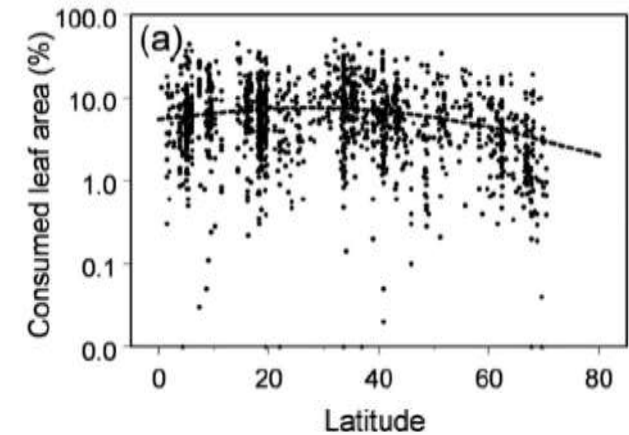
# Effects of forest diversity on defoliation



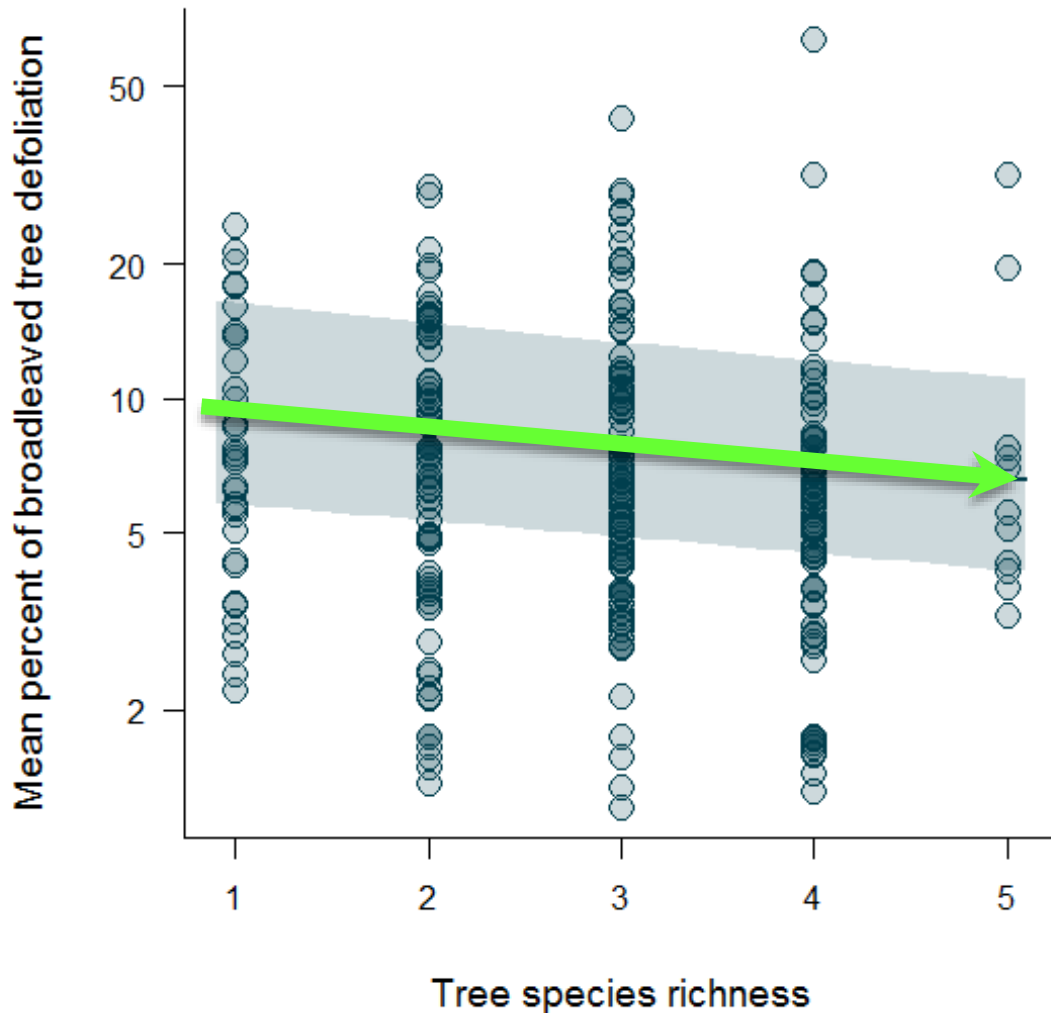
*Global Ecology and Biogeography*, (Global Ecol. Biogeogr.) (2015)

## Global patterns in background losses of woody plant foliage to insects

Mikhail V. Kozlov\*, Vojtěch Lanta<sup>†</sup>, Vitali Zverev and Elena L. Zvereva



# Effects of forest diversity on defoliation in broadleaves



11 broadleaves species

$$F_{1,328} = 16.01, P < 0.001$$

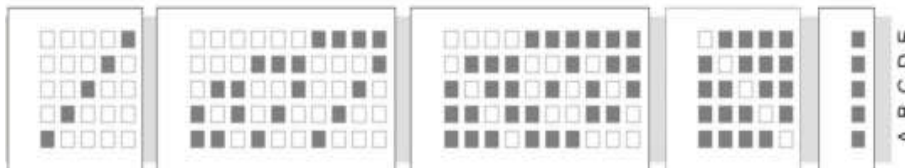
Associational  
resistance

9.6% monocultures



6.6% in mixtures of 5 spp.

large variability



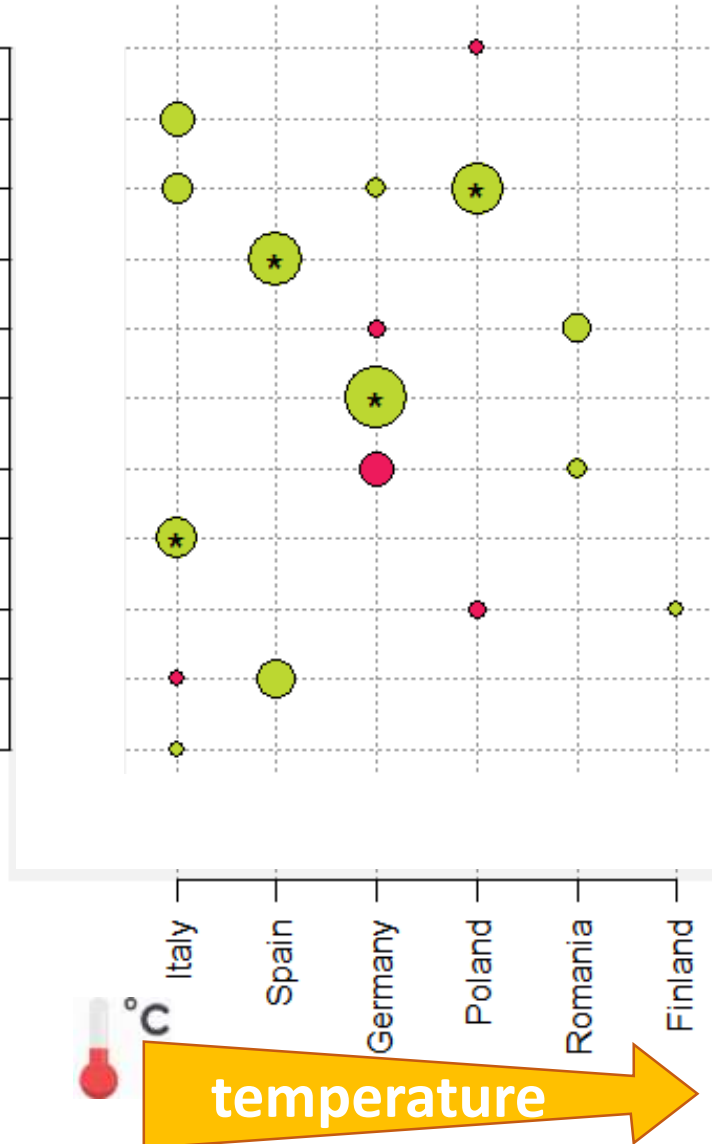
# Effects of forest diversity on defoliation in broadleaves



- Carpinus betulus*
- Castanea sativa*
- Quercus robur - petraea*
- Quercus faginea*
- Fagus sylvatica*
- Fraxinus excelsior*
- Acer pseudoplatanus*
- Quercus cerris*
- Betula pendula*
- Quercus ilex*
- Ostrya carpinifolia*

- AR ■
- AS ■

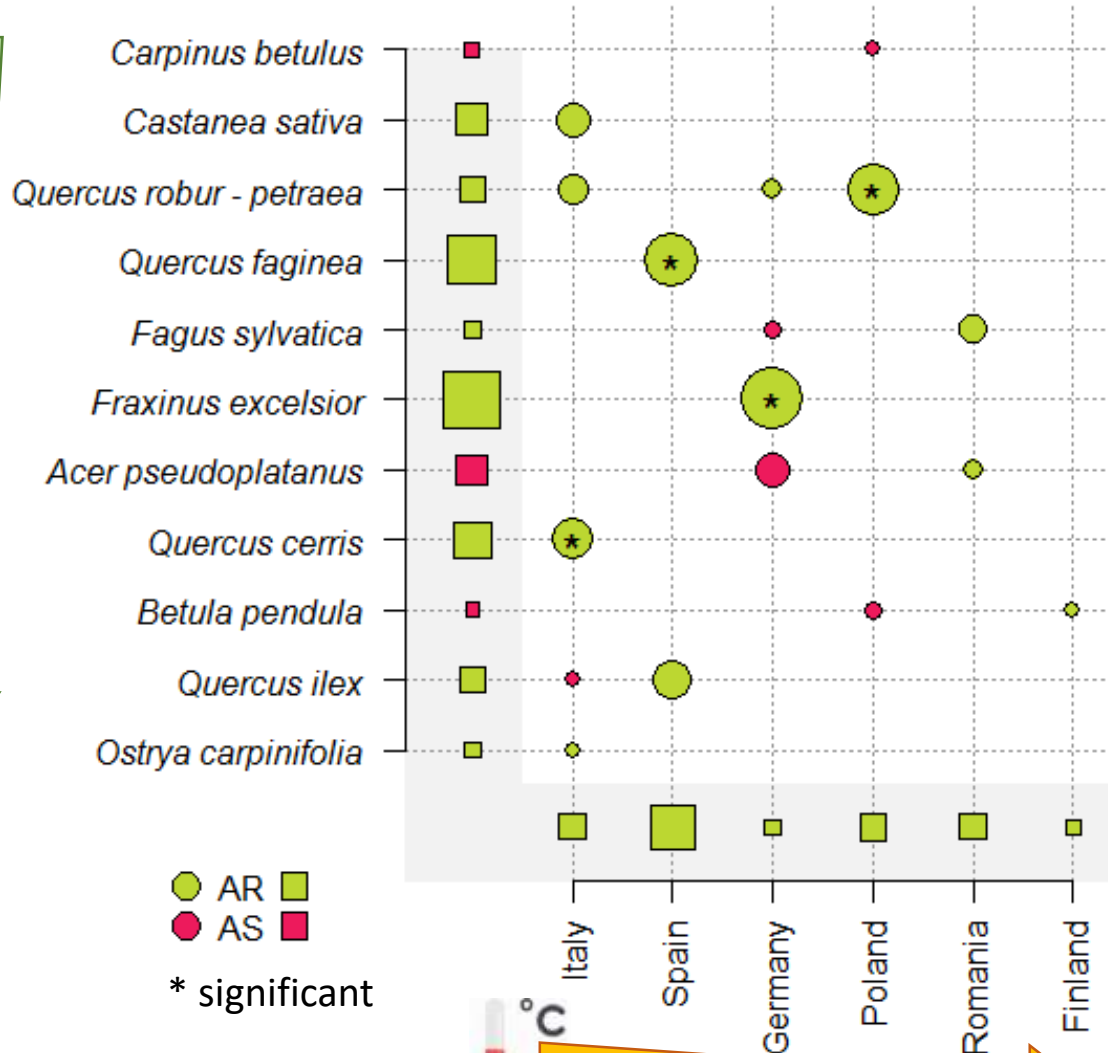
\* significant



# Effects of forest diversity on defoliation in broadleaves



## Majority of broadleaved tree species with AR



No effect of latitude

● AR    ■  
 ● AS    ■  
 \* significant





# A focus on chestnut forests in Italy



Asian chestnut gall wasp  
ACGW  
*Dryocosmus kuriphilus*



# A focus on chestnut forests in Italy



↘ 80%

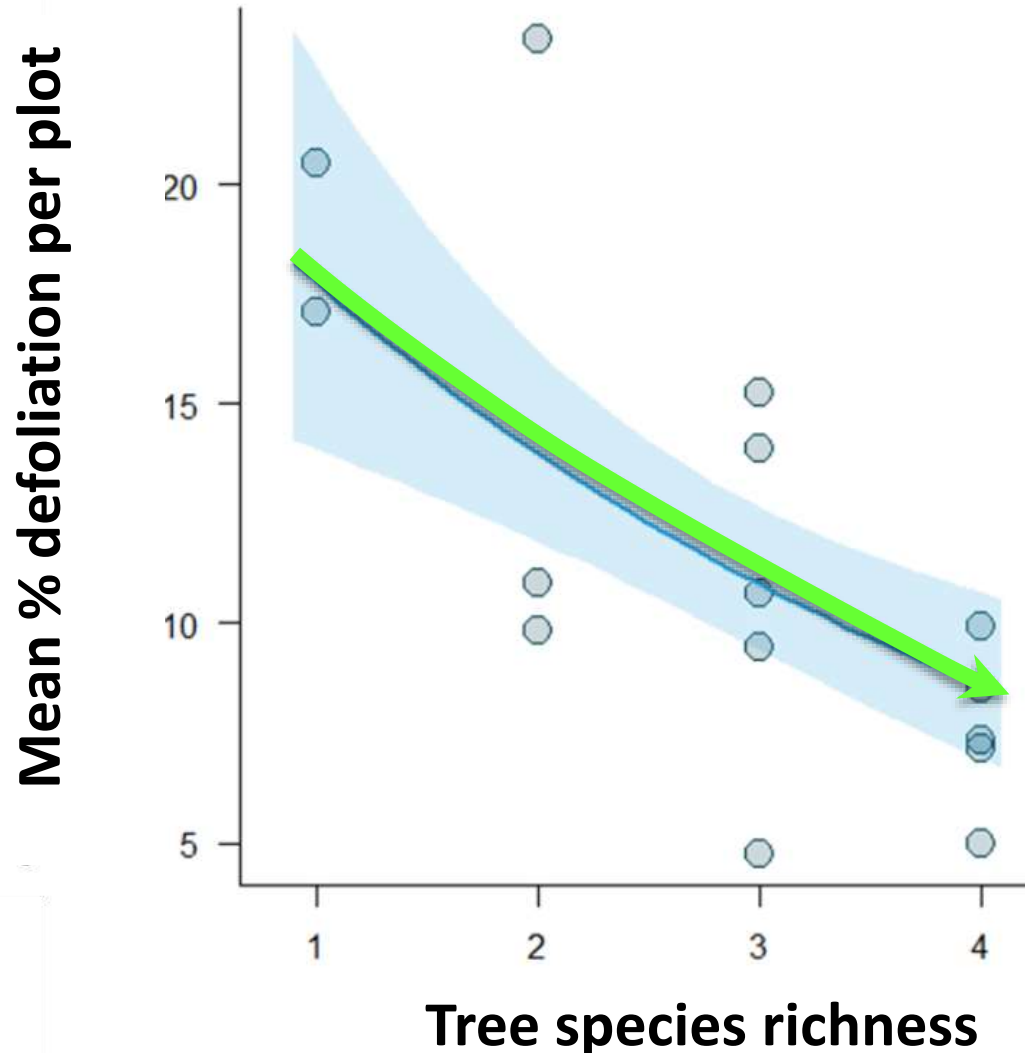
*Agricultural and Forest Entomology* (2013), DOI: 10.1111/afe.12036

**Invasion by the chestnut gall wasp in Italy causes significant yield loss in *Castanea sativa* nut production**

Andrea Battisti\*, Isadora Benvegnù\*†, Fernanda Colombari\* and Robert A. Haack‡

# Effect of tree diversity on resistance to ACGW

100% chestnuts damaged

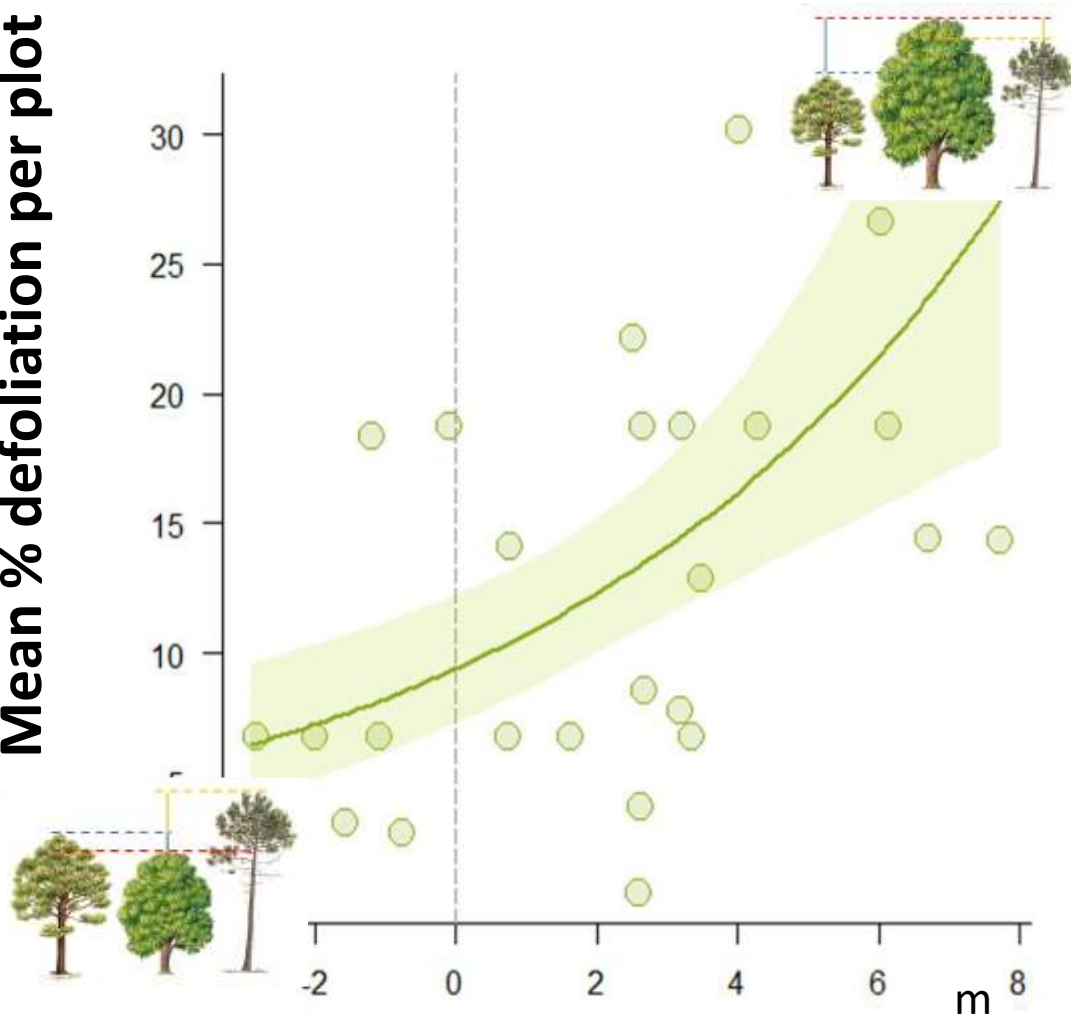


**Associational  
resistance  
(-50%)**

**Citation:** Guyot V, Castagneyrol B, Vialatte A, Deconchat M, Selvi F, Bussotti F, et al. (2015) Tree Diversity Limits the Impact of an Invasive Forest Pest. PLoS ONE 10(9): e0136469. doi:10.1371/journal.

# Effect of tree diversity on resistance to ACGW

Mean % defoliation per plot



Tree apparency

# Conclusions

## *Global pattern of associational resistance in European forests*

= lower defoliation in mixed forests

1. large array of 11 main broadleaved species
2. in mature forests
3. irrespective of the insect species
4. incl. alien invasive pest
5. across tree diversity gradient ( $\neq$  pure vs. mixed)
6. crown defoliation = relevant to forest productivity

# Conclusions

## *Mechanisms remain to be addressed*

1. Diversity causes resource dilution
  - reduced abundance of host trees
2. Diversity reduces “host apparency”
  - reduced physical detectability of host
  - interference with host finding by non-host odours
3. Diversity enhances activity of natural enemies of pests
  - more insect predators, parasitoids, insectivorous birds

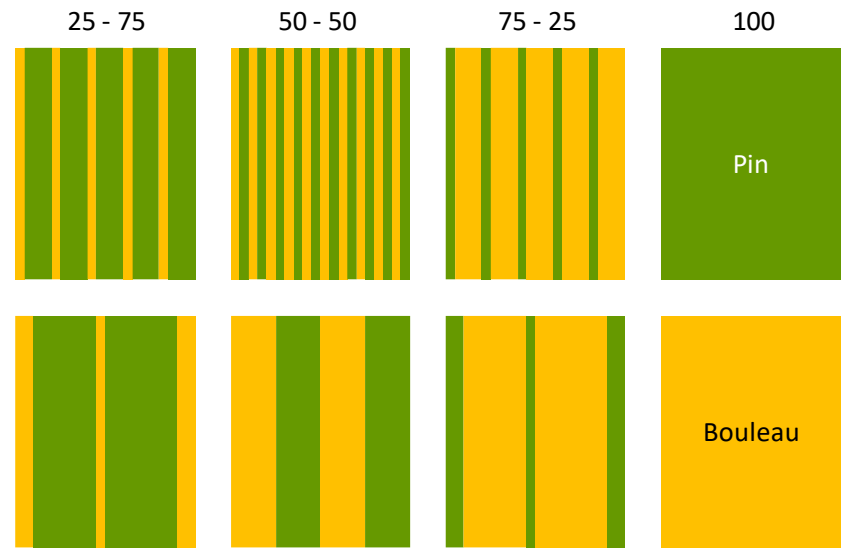
# Conclusions

2 avenues for implementation in forestry



**1. Heterospecific hedgerows**

**2. Two-species plantations**

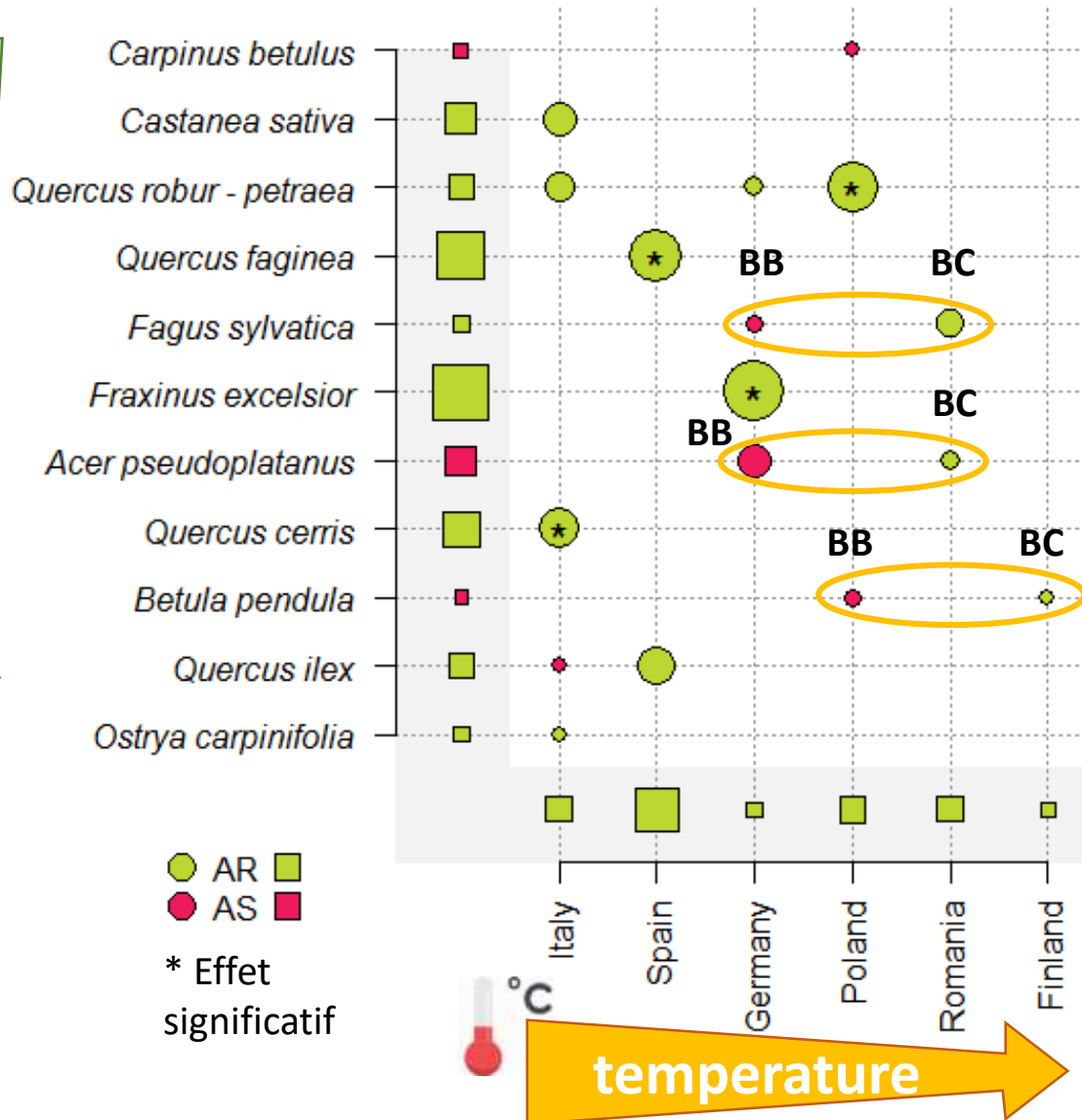




*Thank you for attention !*

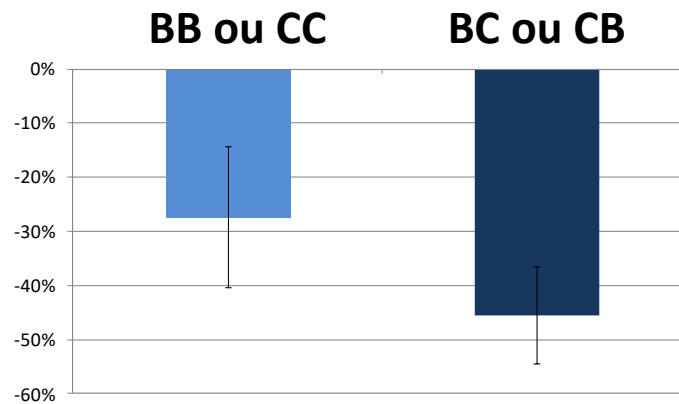
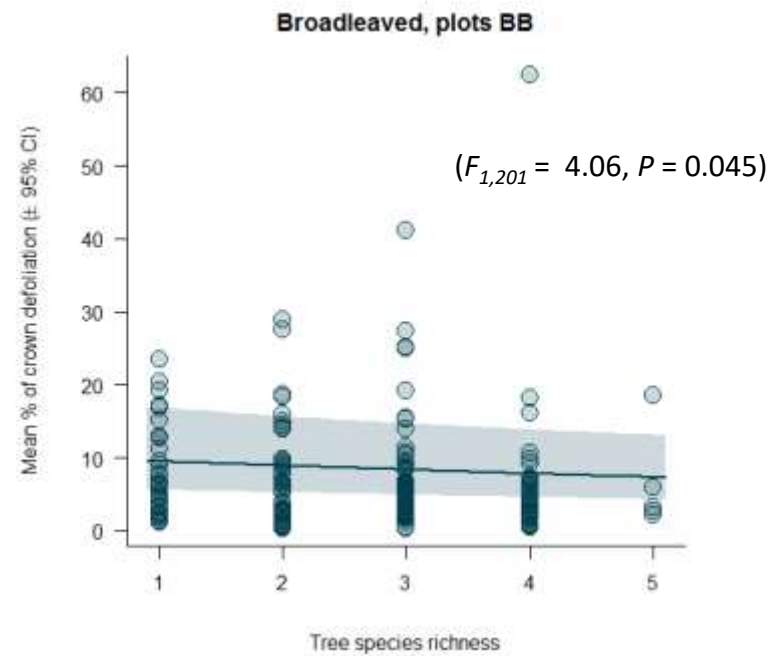
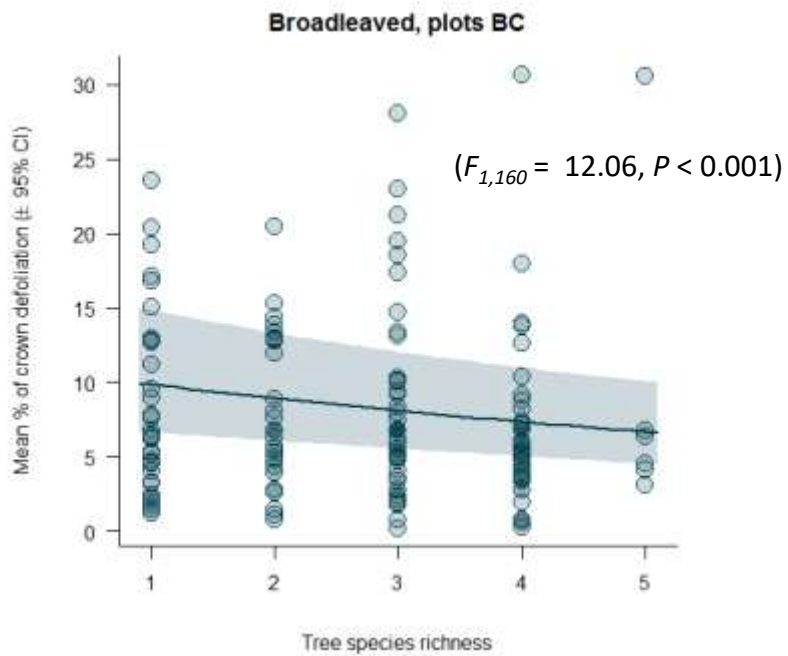


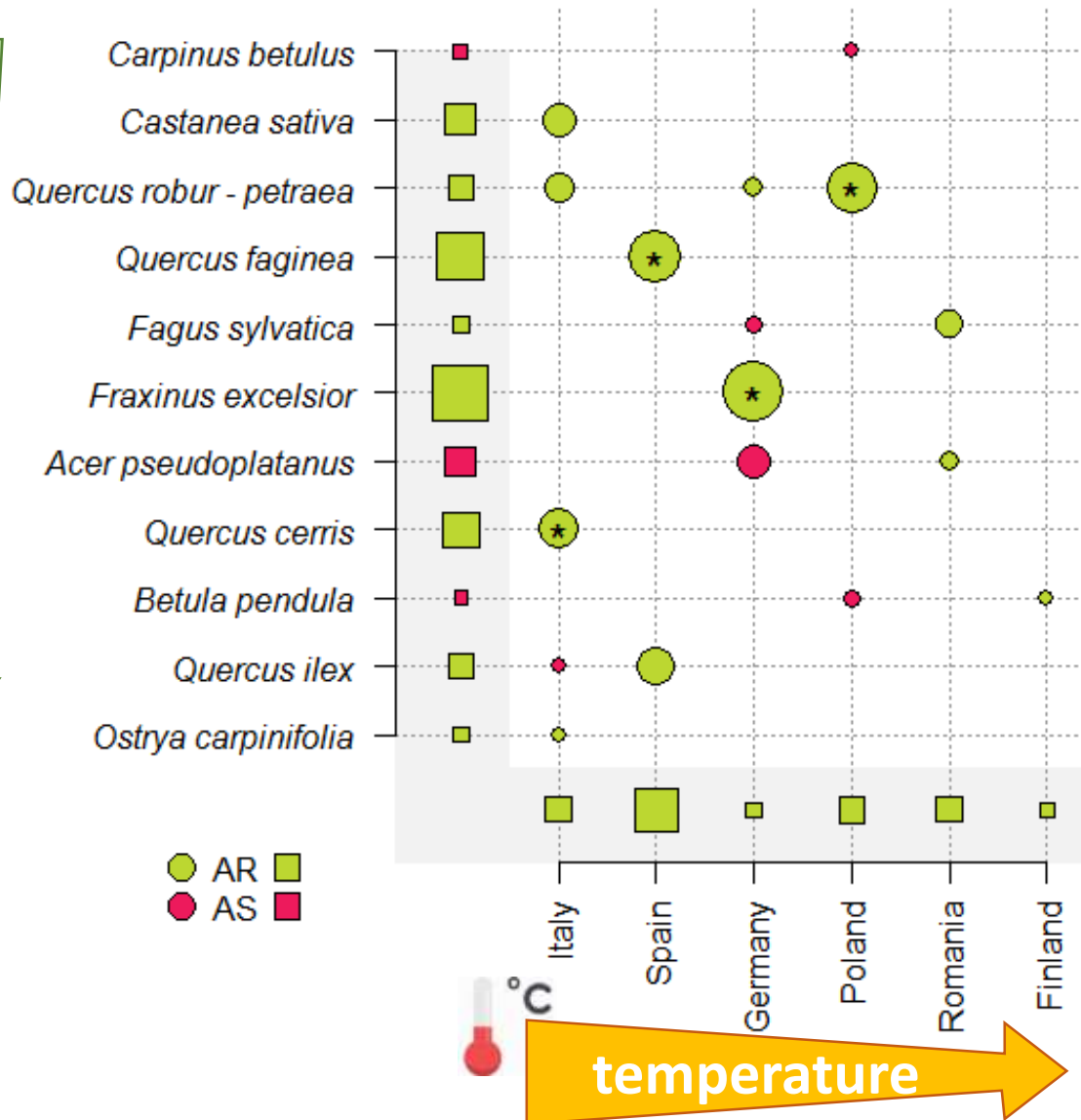




SA in  
Broadleaved-  
Broadleaved

RA in  
Broadleaved -  
Conifers





**AR** in oaks

**AS** in pioneer species

