Tree diversity improves forest resistance to insect defoliators

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

REVIEW

Planted forest health: The need for a global strategy

M. J. Wingfield,[1]* E. G. Brockerhoff,[2] B. D. Wingfield,[1] B. Slippers[1]

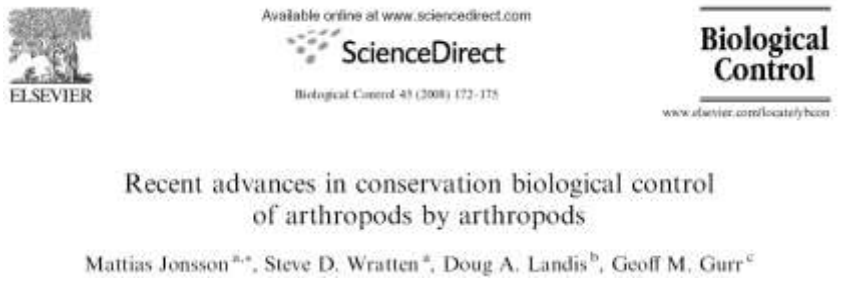
21 AUGUST 2015 • VOL 349 ISSUE 6250

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

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

Classical Biological Control

Introduction of natural enemies
in order to control pest insects (most often exotic)



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

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

LETTER

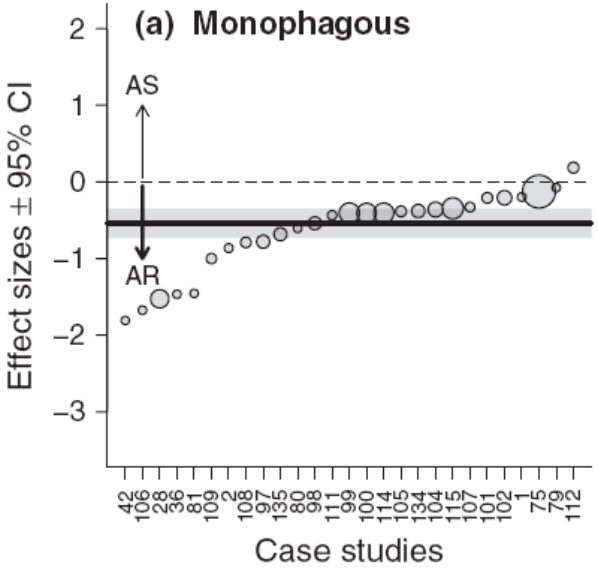
Tree diversity reduces herbivory by forest insects

Hervé Jactel[1]* and Eckehard G. Brockerhoff[2]
[1]*INRA, UMR1202 Biodiversity, Genes & Communities,*

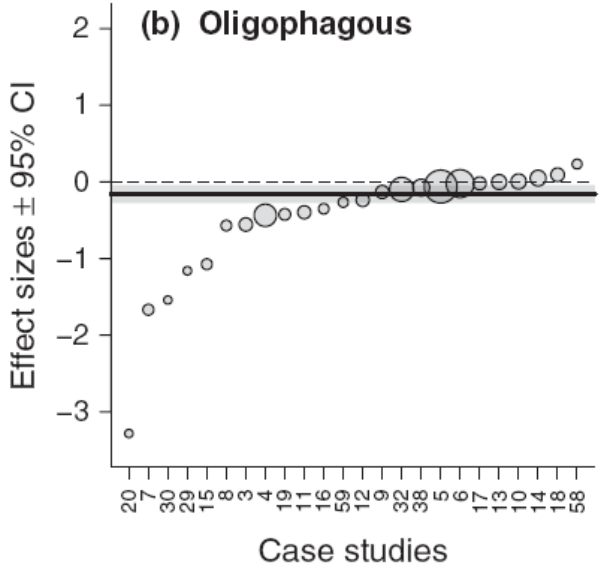
Abstract

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

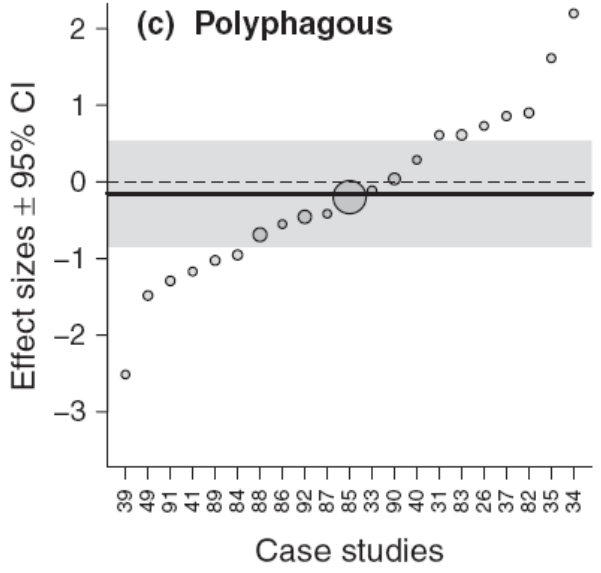
Associational resistance



- 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

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**

Perspectives in Plant Ecology, Evolution and Systematics 15 (2013) 281–291

Contents lists available at ScienceDirect

Perspectives in Plant Ecology, Evolution and Systematics

journal homepage: www.elsevier.com/locate/ppees

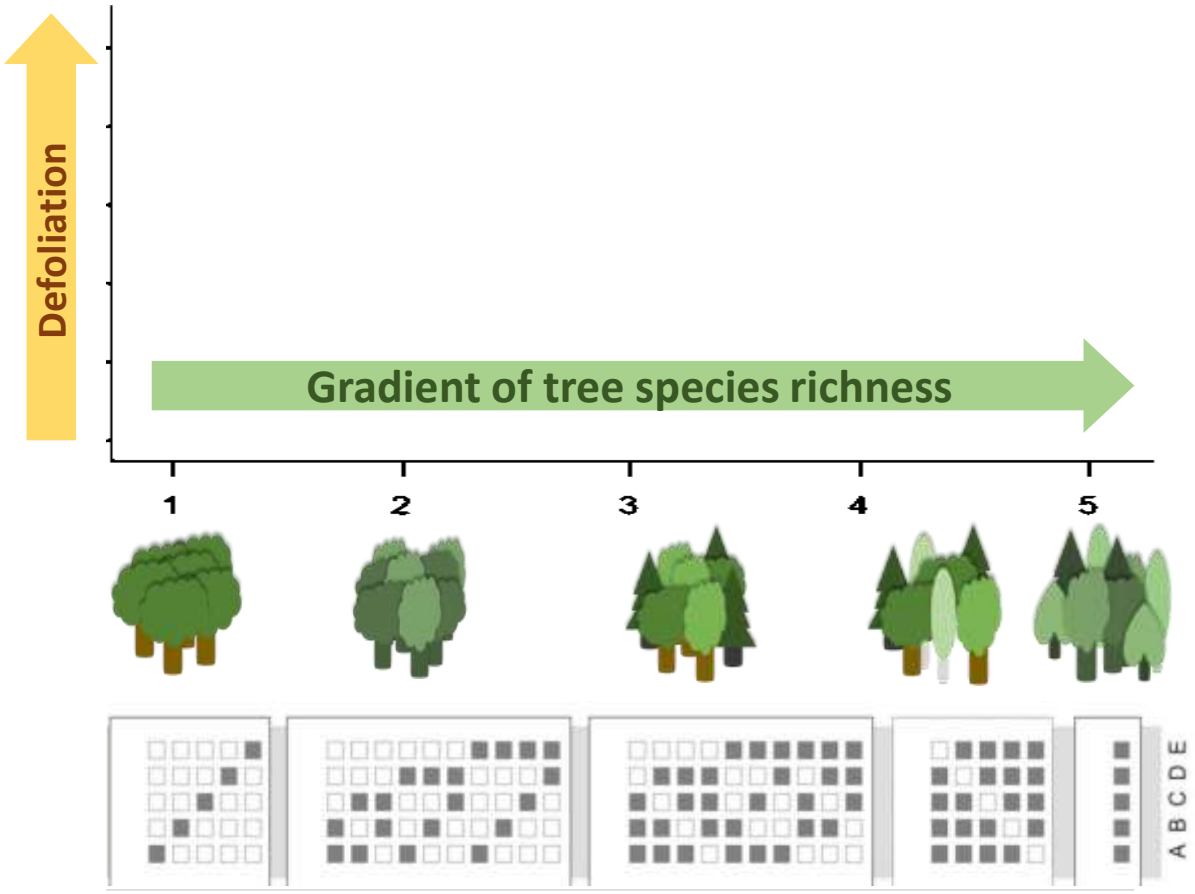
Forum

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

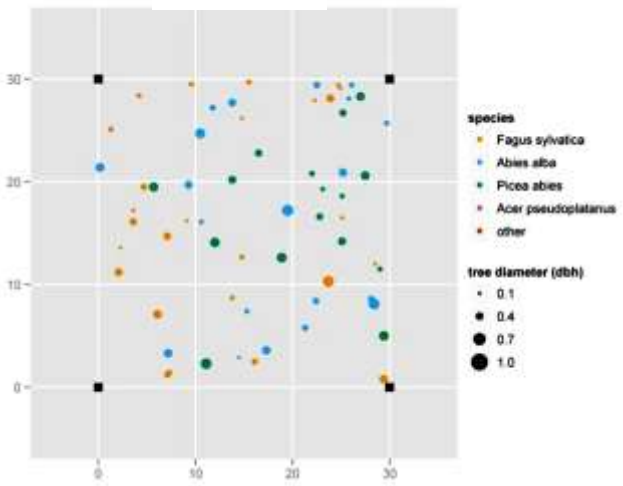
6 exploratory sites in Mediterranean, temperate and boreal forests

Main European tree species

Effects of forest diversity on tree defoliation by insects



30 x 30m



214 forest plots
13 609 trees

3 trees observed/species

1 670 sampled trees

Effects of forest diversity on defoliation

on leaves

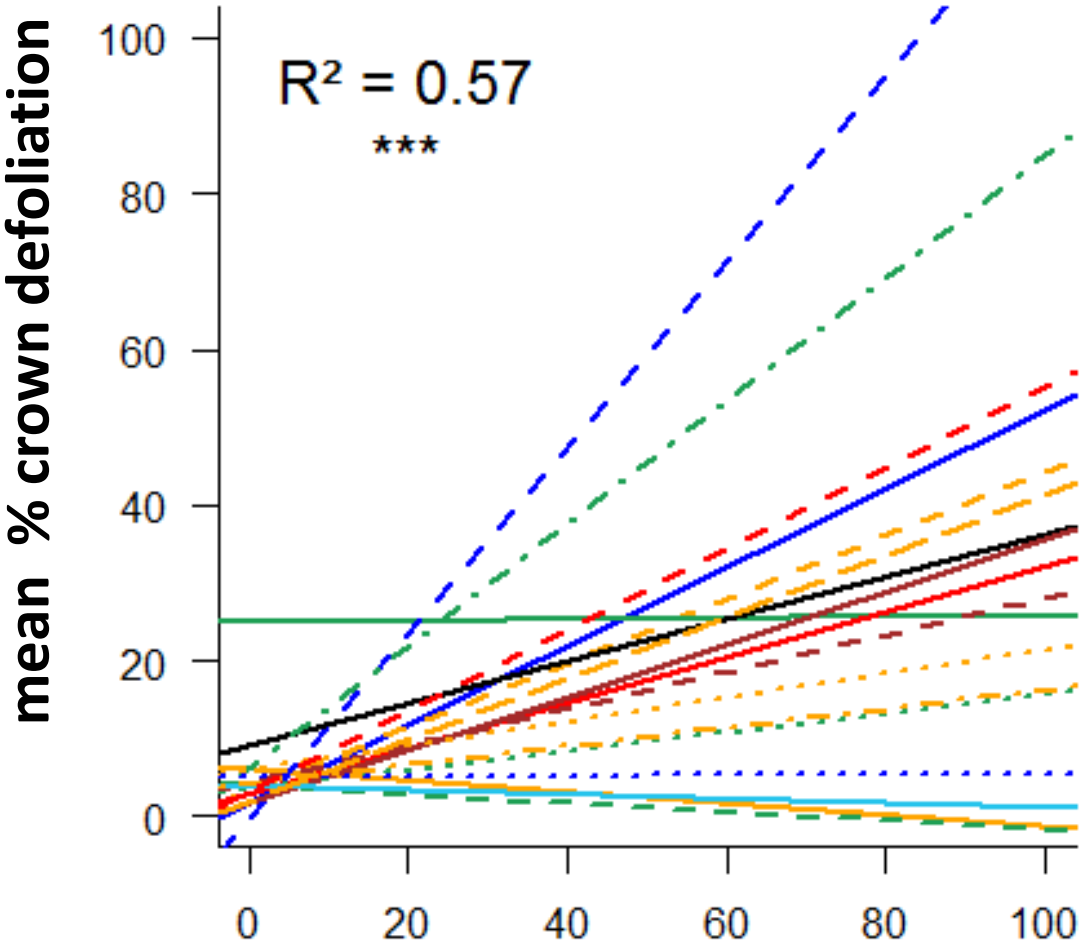
60 - 100/tree = 81 908 leaves

on tree crowns

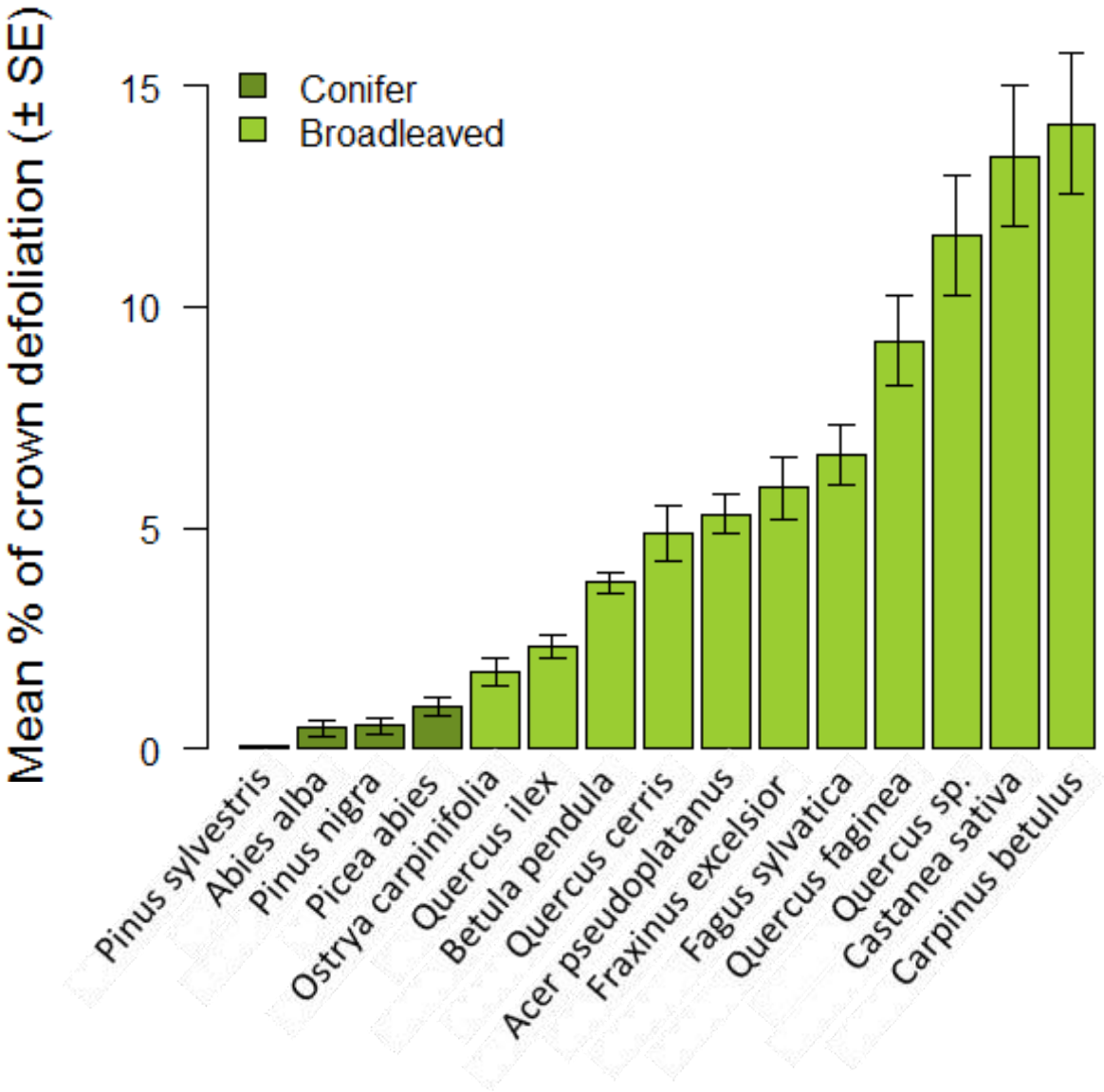
ICP Forest protocol

= 1670 trees

Effects of forest diversity on defoliation



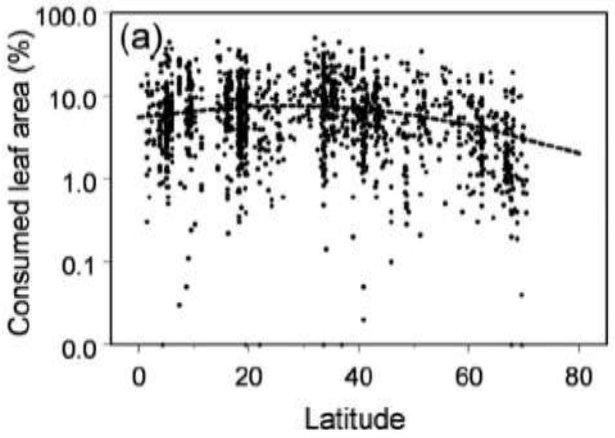
Effects of forest diversity on defoliation



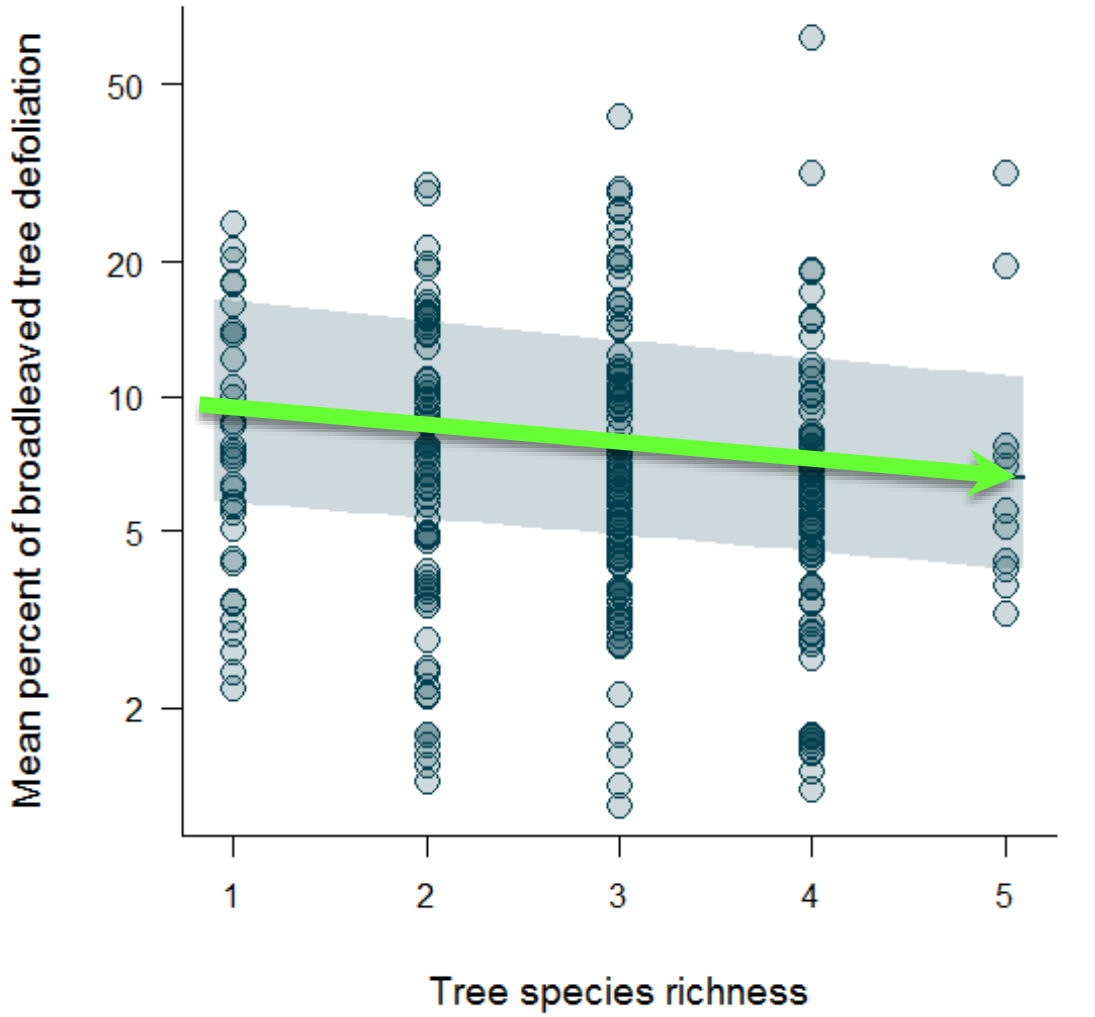
Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2015)

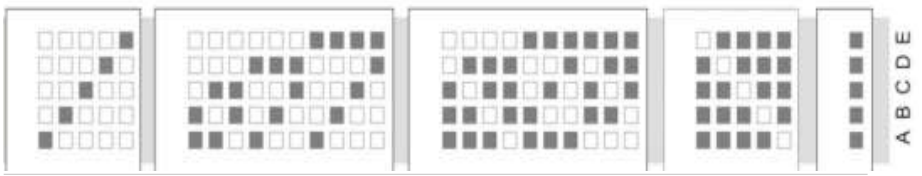
Global patterns in background losses of woody plant foliage to insects

Mikhail V. Kozlov*, Vojtěch Lanta†, 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

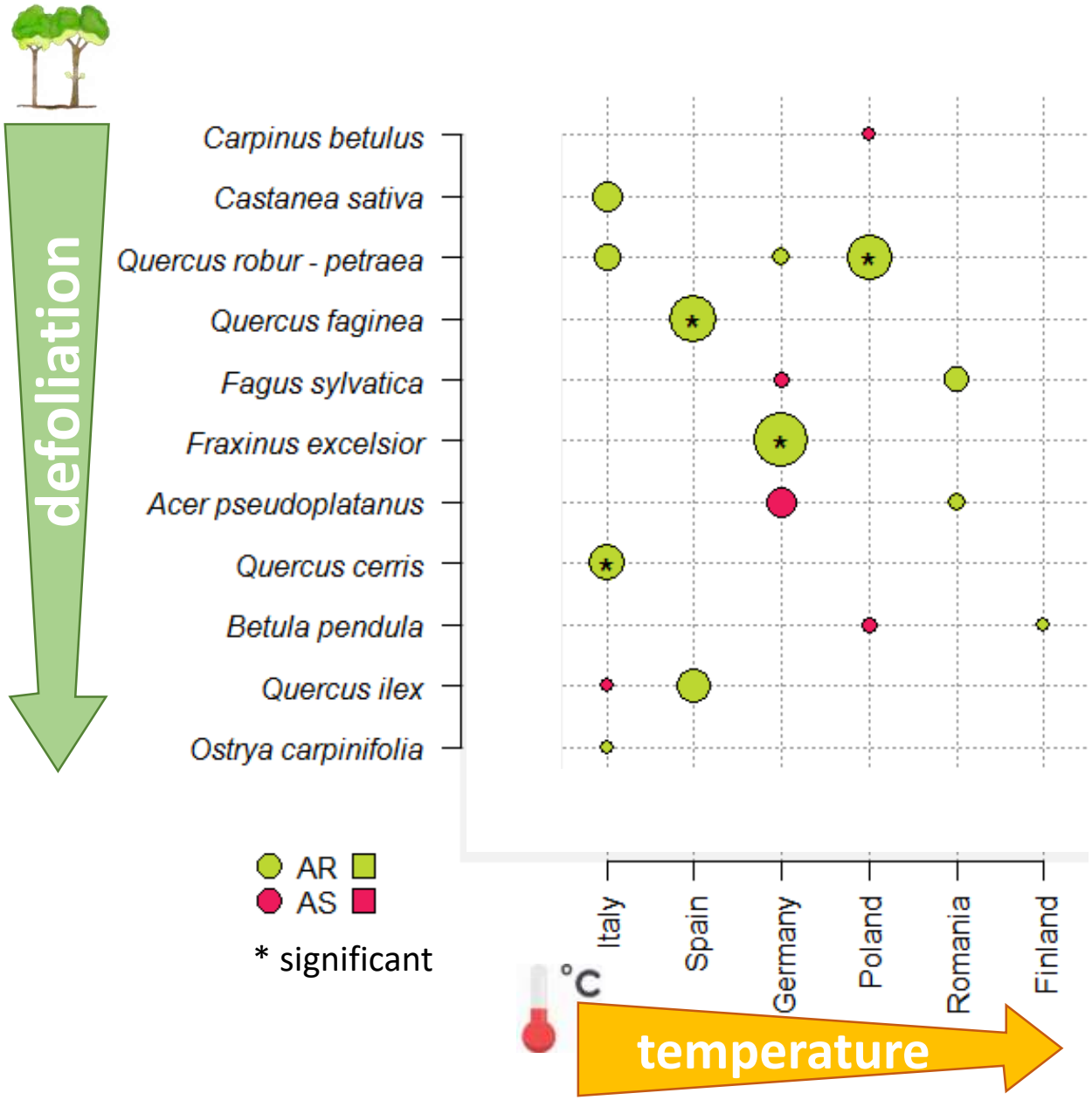
9.6% monocultures

↓

6.6% in mixtures of 5 spp.

large variability

Effects of forest diversity on defoliation in broadleaves



Effects of forest diversity on defoliation in broadleaves

defoliation

Majority of broadleaved tree species with AR

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

Italy
Spain
Germany
Poland
Romania
Finland

°C

temperature

No effect of latitude

A focus on chestnut forests in Italy

Asian chestnut gall wasp
ACGW
Dryocosmus kuriphilus

A focus on chestnut forests in Italy

↘ 80%

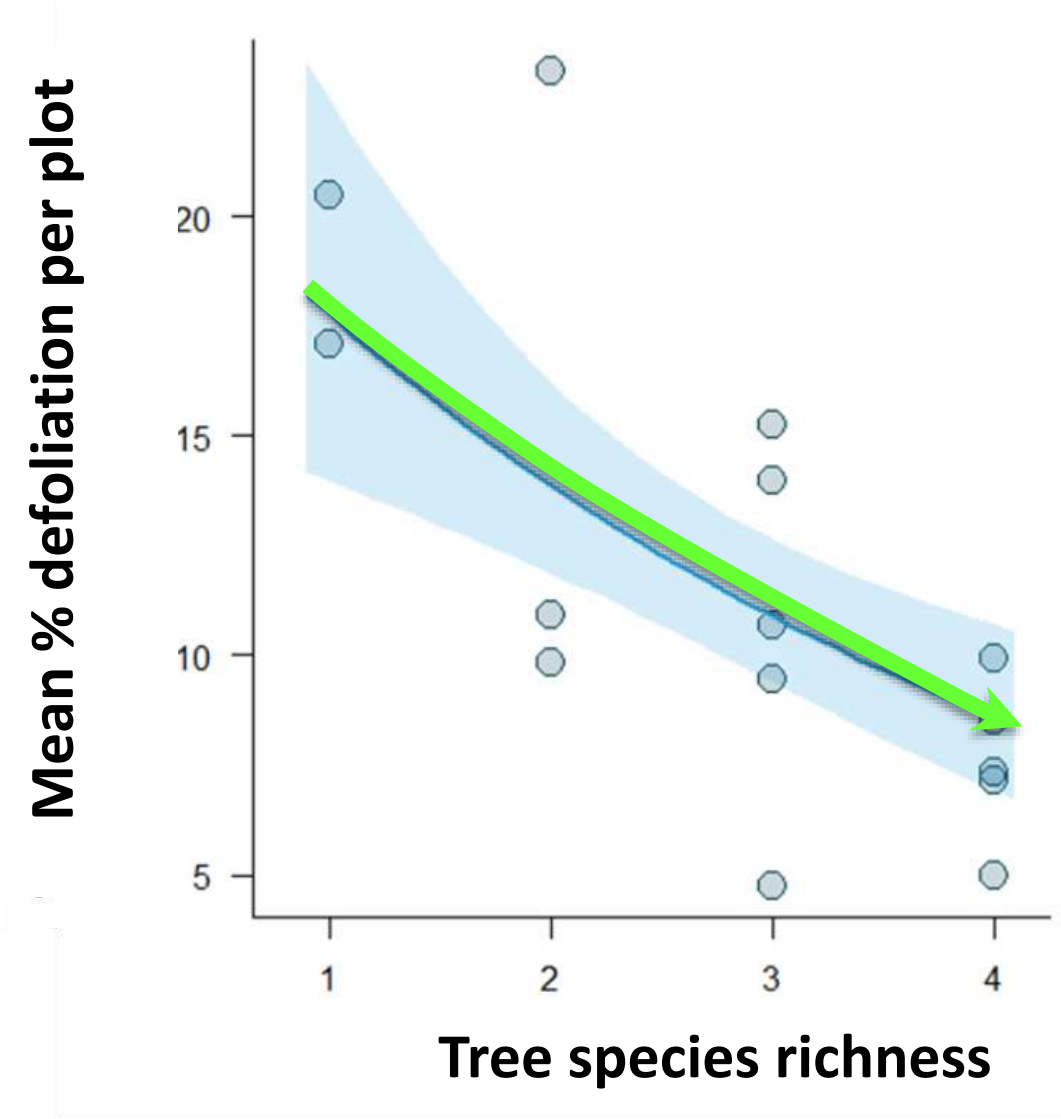
Agricultural and Forest Entomology (2013), DOI: 10.1111/afe.12036

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

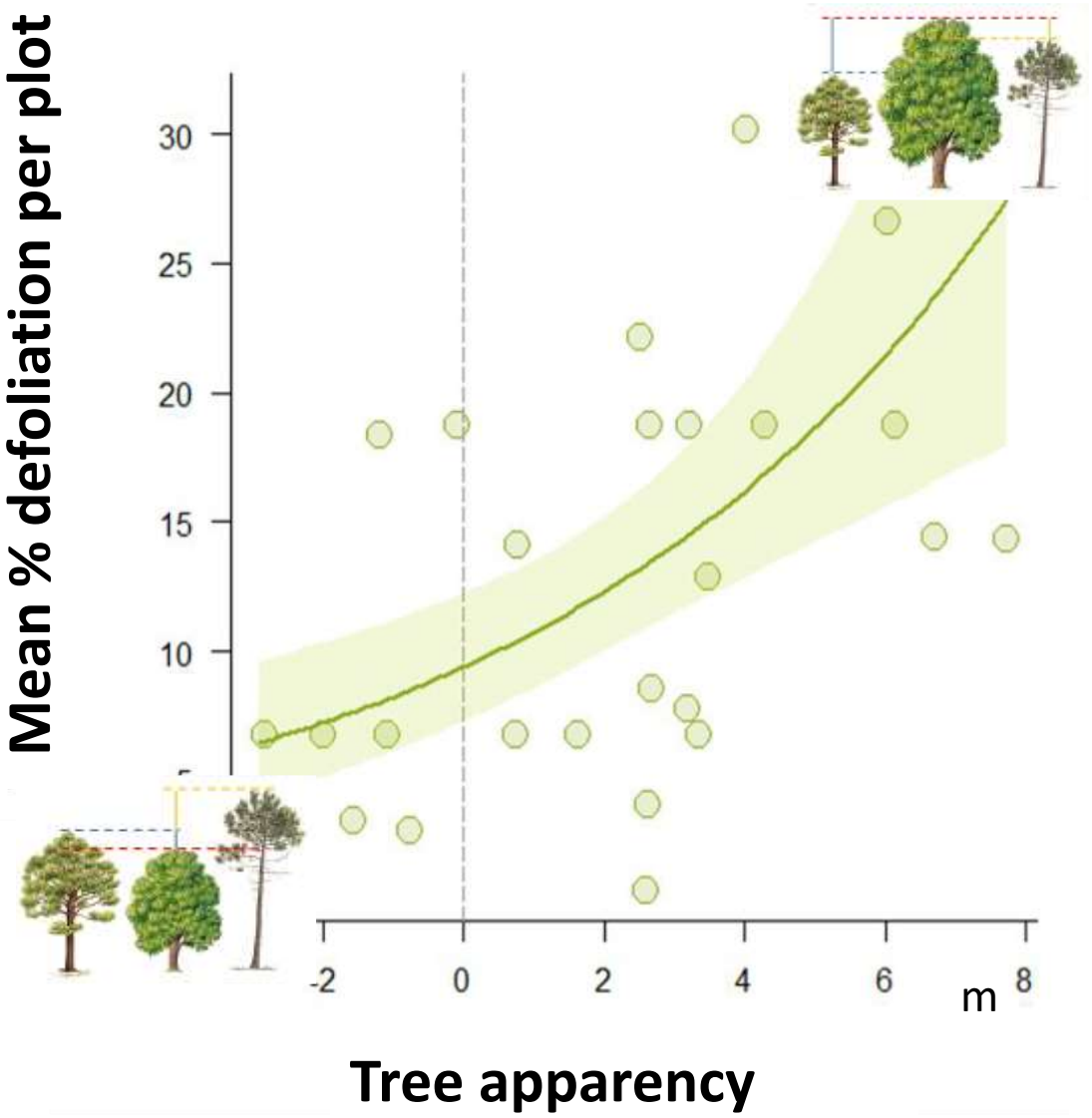
100% chestnuts damaged



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



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 (≠ pure vs. mixed)
6. crown defoliation = relevant to forest productivity

Conclusions

Mechanisms remain to be addressed

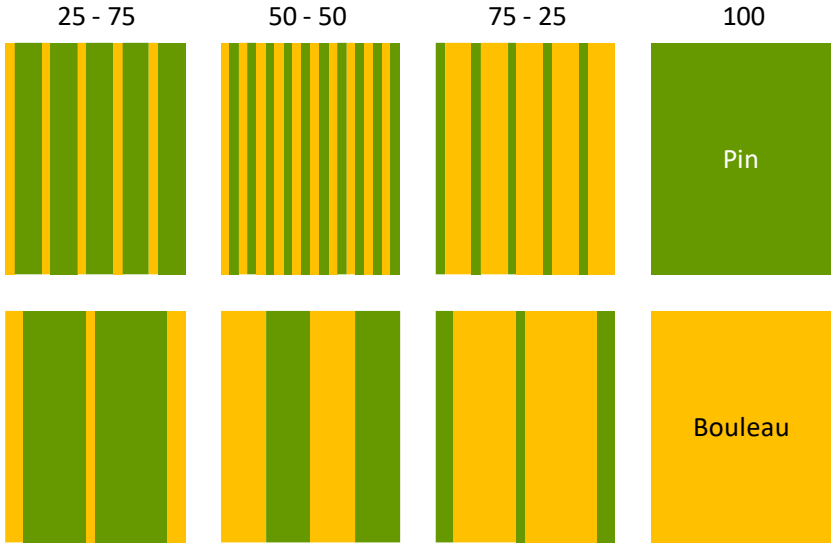
1. Diversity causes *resource dilution*
   - reduced abundance of host trees
2. Diversity reduces "*host apparency*"
   - reduced physical detectability of host
   - interference with host finding by non-host odours
3. Diversity enhances *activity of natural enemies* of pests
   - more insect predators,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

Conclusions

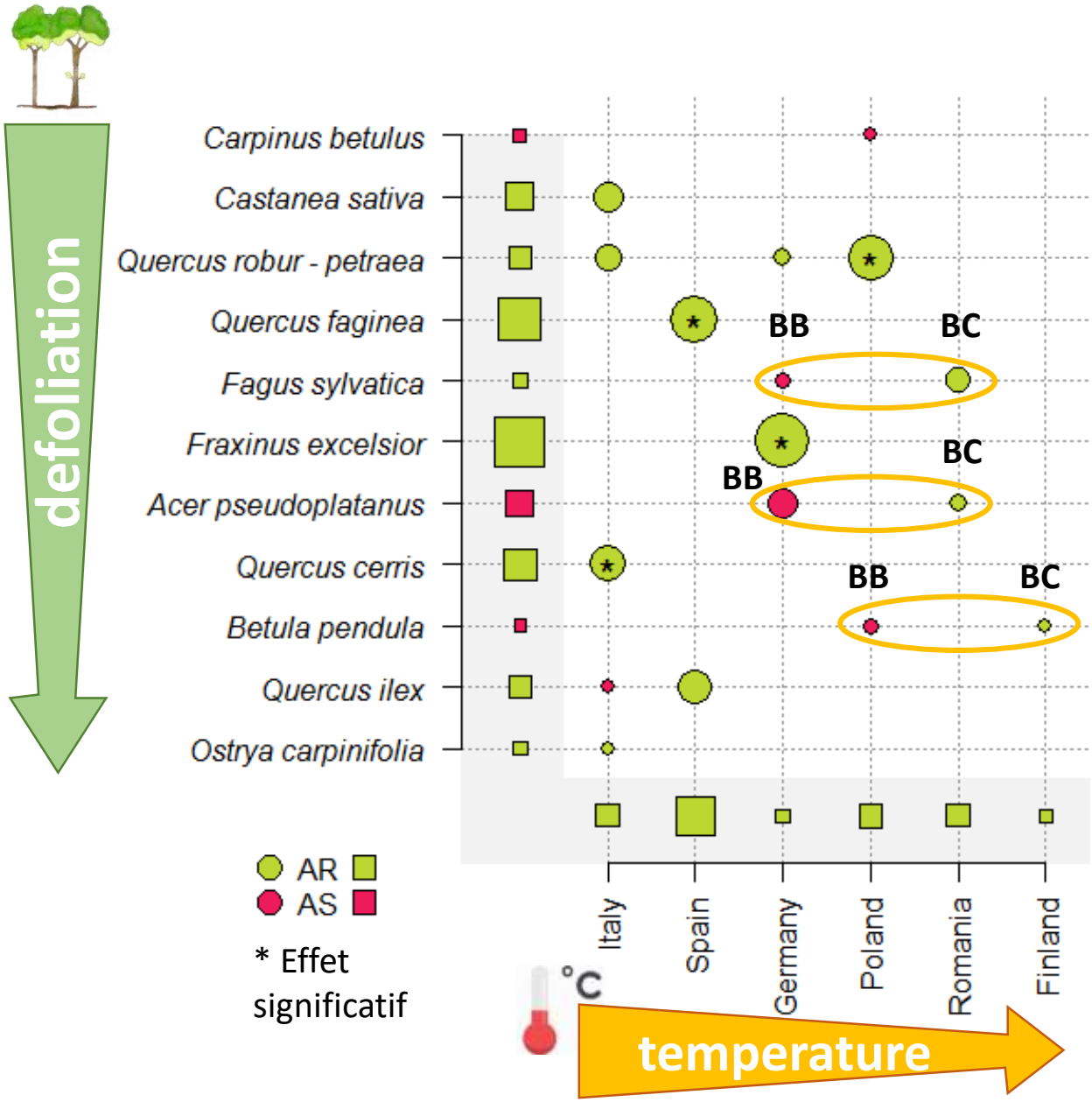
2 avenues for implementation in forestry

1. **Heterospecific hedgerows**

2. **Two-species plantations**

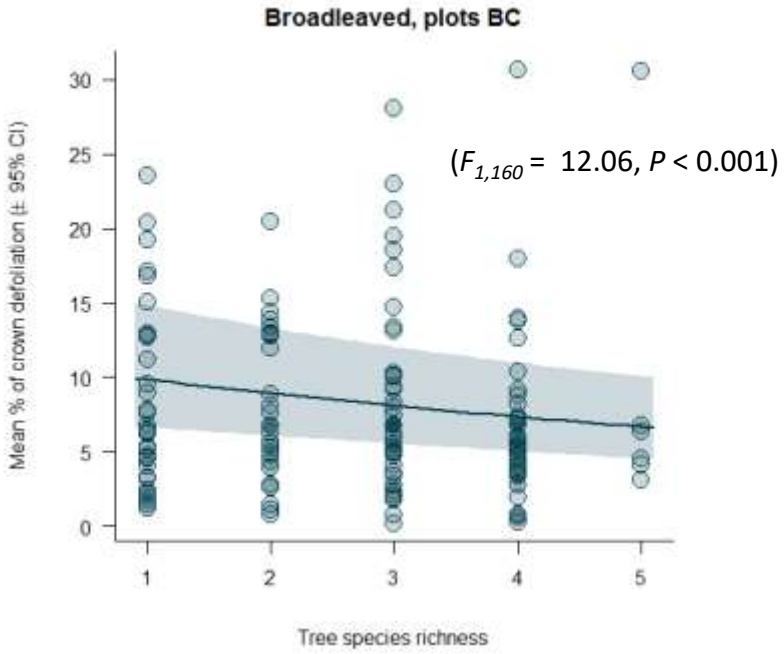


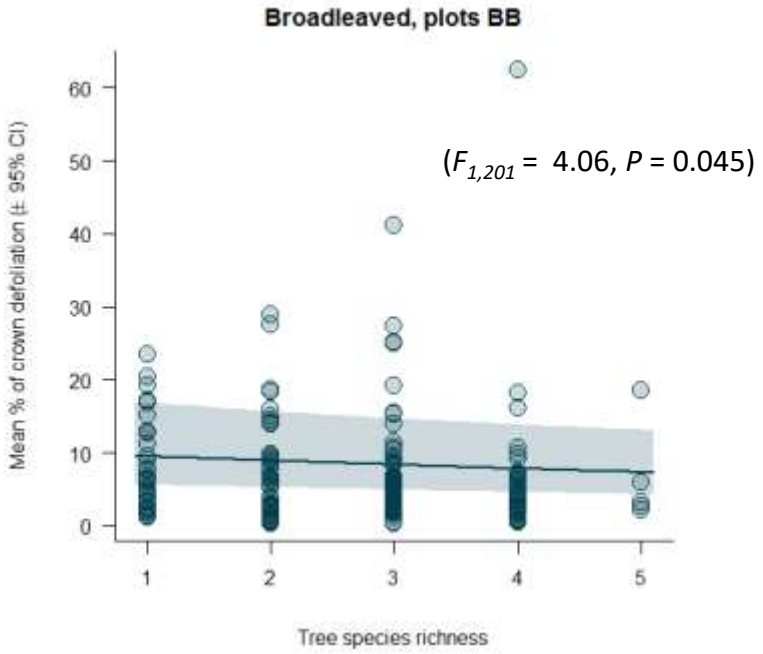

Thank you for attention !
Inge van Halder

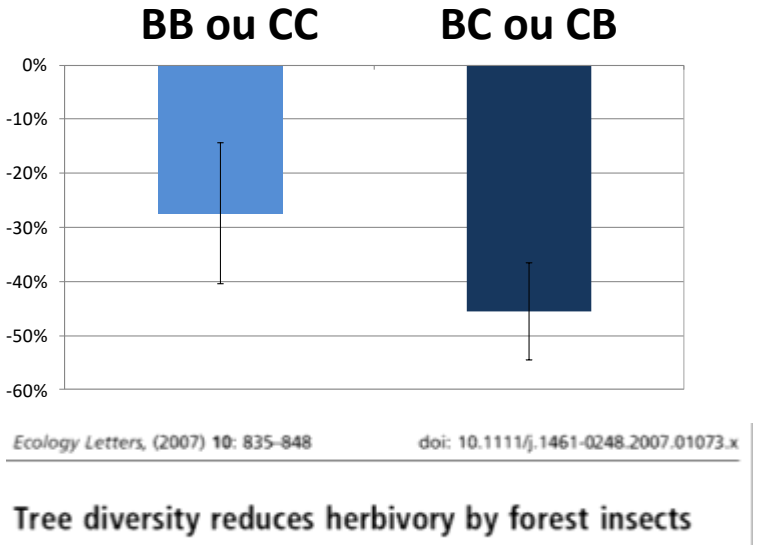


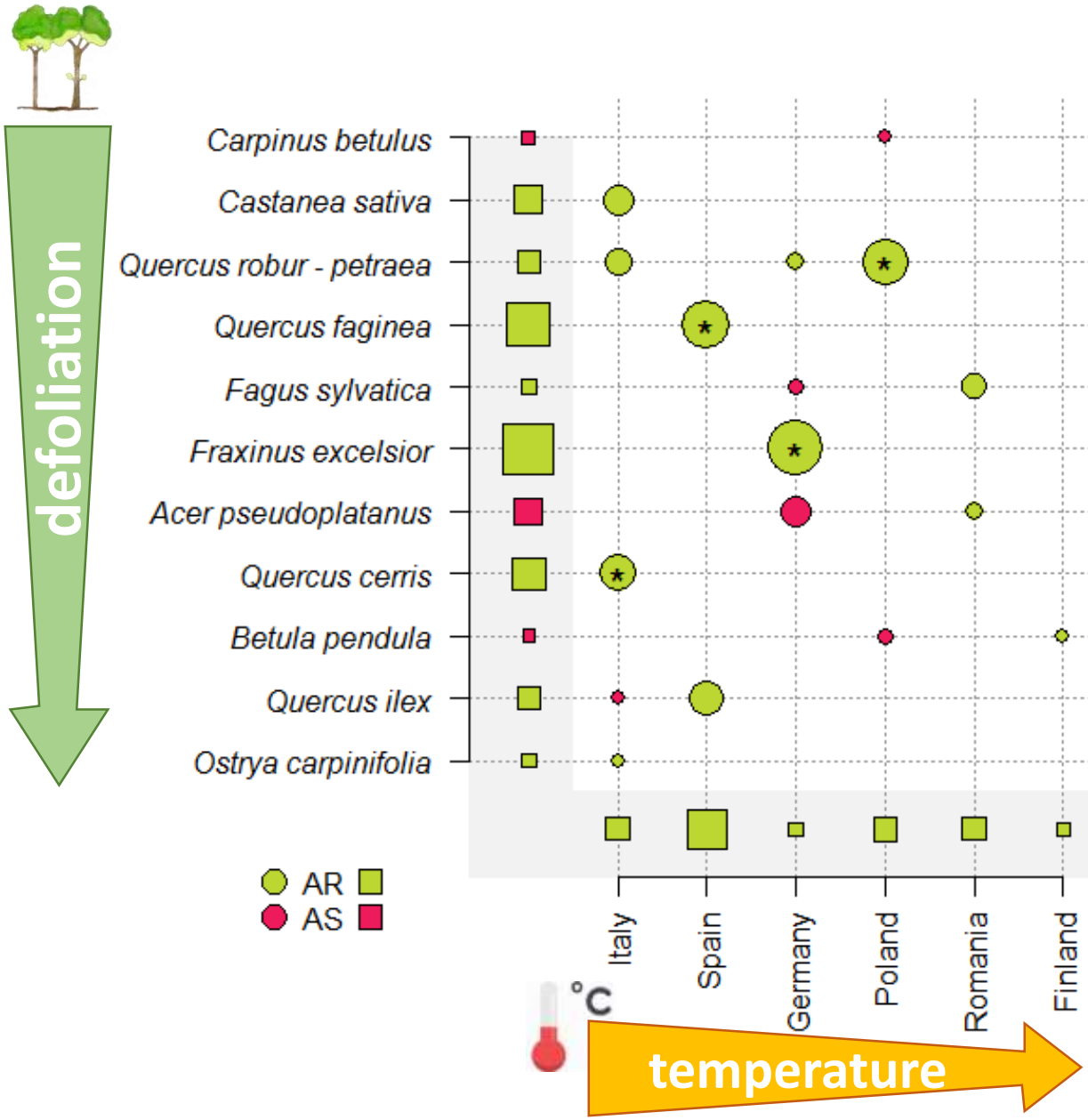
SA in Broadleaved-Broadleaved

RA in Broadleaved - Conifers


Broadleaved, plots BC
Mean % of crown defoliation (± 95% CI)
Tree species richness
($F_{1,160}$ = 12.06, P < 0.001)

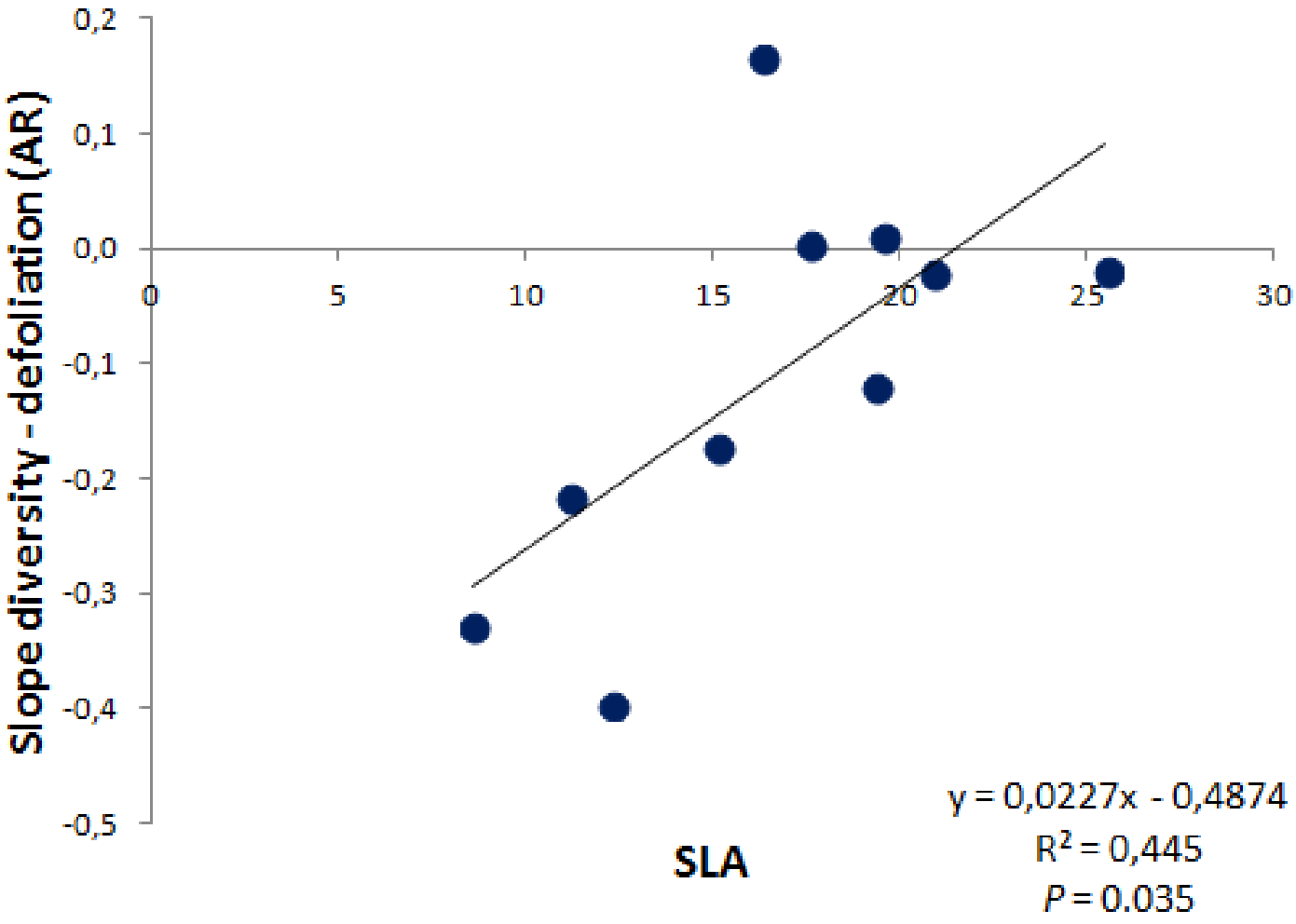

Broadleaved, plots BB
Mean % of crown defoliation (± 95% CI)
Tree species richness
($F_{1,201}$ = 4.06, P = 0.045)


BB ou CC
BC ou CB
0%
-10%
-20%
-30%
-40%
-50%
-60%
Ecology Letters, (2007) 10: 835-848
doi: 10.1111/j.1461-0248.2007.01073.x
Tree diversity reduces herbivory by forest insects



AR in oaks

AS in pioneer species


Slope diversity - defoliation (AR)
0,2
0,1
0,0
-0,1
-0,2
-0,3
-0,4
-0,5
0
5
10
15
20
25
30
SLA
y = 0,0227x - 0,4874
R² = 0,445
P = 0.035