Vers une stratégie générique de surveillance et de gestion des insectes exotiques envahissants en forêt



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INRAE
la science pour la vie, l'humain, la terre

HOMED

Contexte:
des invasions biologiques en augmentation exponentielle

6 nouvelles espèces / an sur les espèces ligneuses en Europe

Ecology of forest insect invasions

E. G. Brockerhoff · A. M. Liebhold

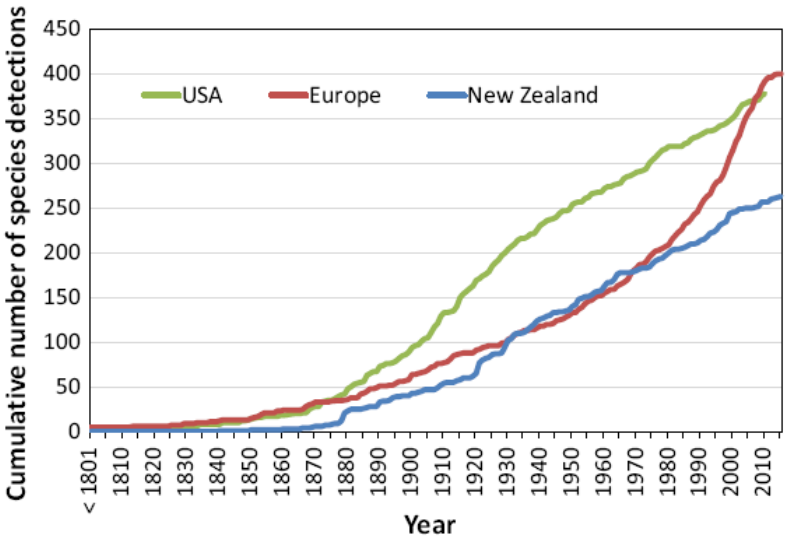
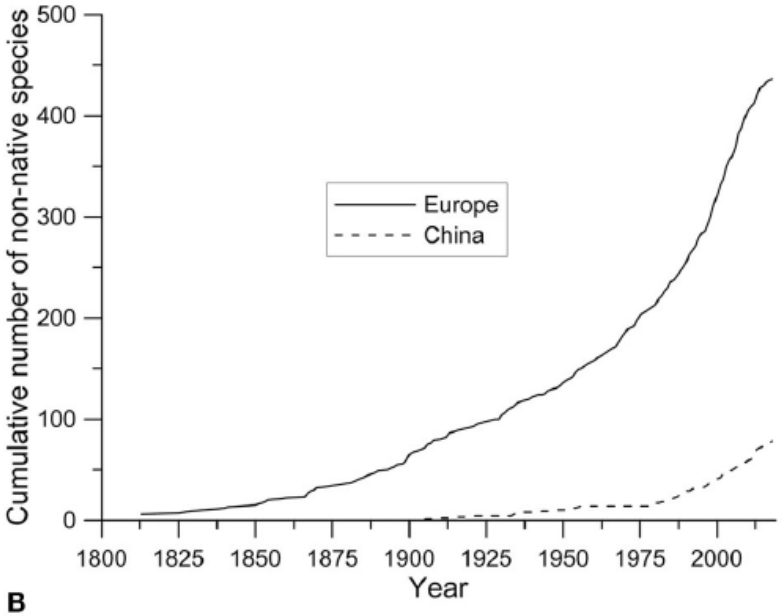


Fig. 1 Cumulative number of detections (i.e., new establishments) of non-native forest insect species over time in the USA, Europe, and New Zealand. Data shown are for non-native



Roques et al. 2020
Frontiers in Forests and Global Change

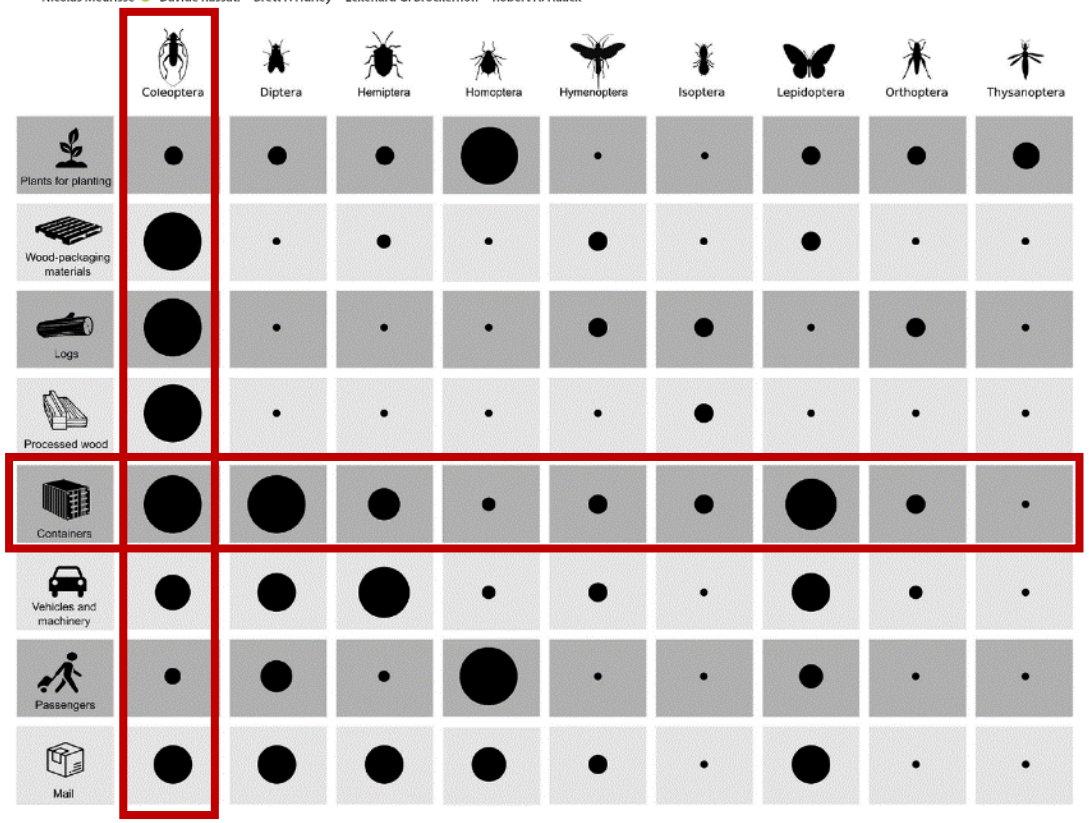
Contexte:
globalisation et commerce mondial

Journal of Pest Science
https://doi.org/10.1007/s10340-018-0990-0

REVIEW

Common pathways by which non-native forest insects move internationally and domestically

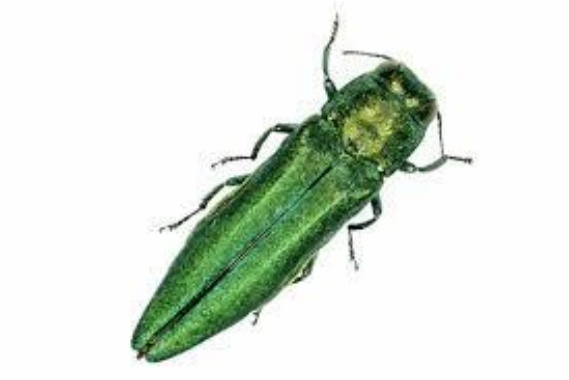
Nicolas Meurisse[1] · Davide Rassati[2] · Brett P. Hurley[3] · Eckehard G. Brockerhoff[4] · Robert A. Haack[5]





RWI/ISL computations based on data provided by 88 ports. December 2018: flash estimate.

Contexte:
coût économique considérable



Agrile du frêne aux USA: 25 milliards $ < 2020



Processionnaire du chêne à Londres: 2 millions £/an



Capricorne asiatique à Gien: 2 millions €/an

Contexte:

EN Official Journal of the European Union

COMMISSION DELEGATED REGULATION (EU) 2019/1702

of 1 August 2019

supplementing Regulation (EU) 2016/2031 of the European Parliament and of the Council by establishing the list of priority pests

15/20 des OQP sont associés aux arbres



Agrilus anxius



Agrilus planipennis



Popilia japonica



Anoplophora chinensis



Anoplophora glabripennis



Bursaphelunchus xylophilus



Aromia bungii



Dendrolimus sibiricus



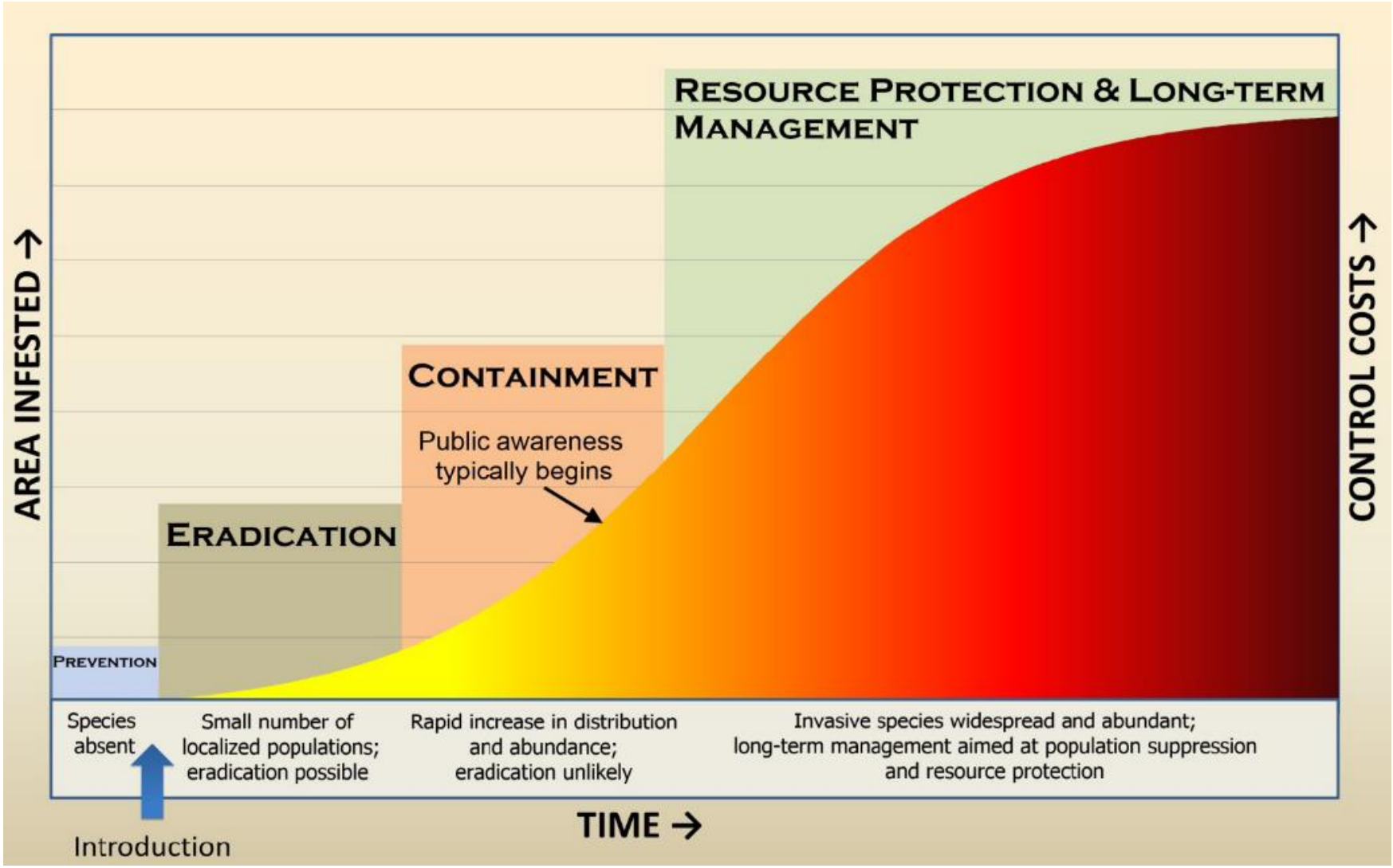
Xyllela fastidiosa

Contexte: « unknown unknowns »

	Knowns	Unknowns
Knowns	**Known Knowns** Things we are aware of and understand.	**Known Unknowns** Things we are aware of but don't understand.
Unknowns	**Unknown Knowns** Things we understand but are not aware of.	**Unknown Unknowns** Things we are neither aware of nor understand.



Contexte:
courbe d'invasion et gestion des EEE



Cahier des charges de la surveillance et de la gestion des ravageurs et pathogènes invasifs en forêt

1. Générique
2. Rapide
3. Efficace / robuste / fiable

Consortium composition: 23 partner organizations

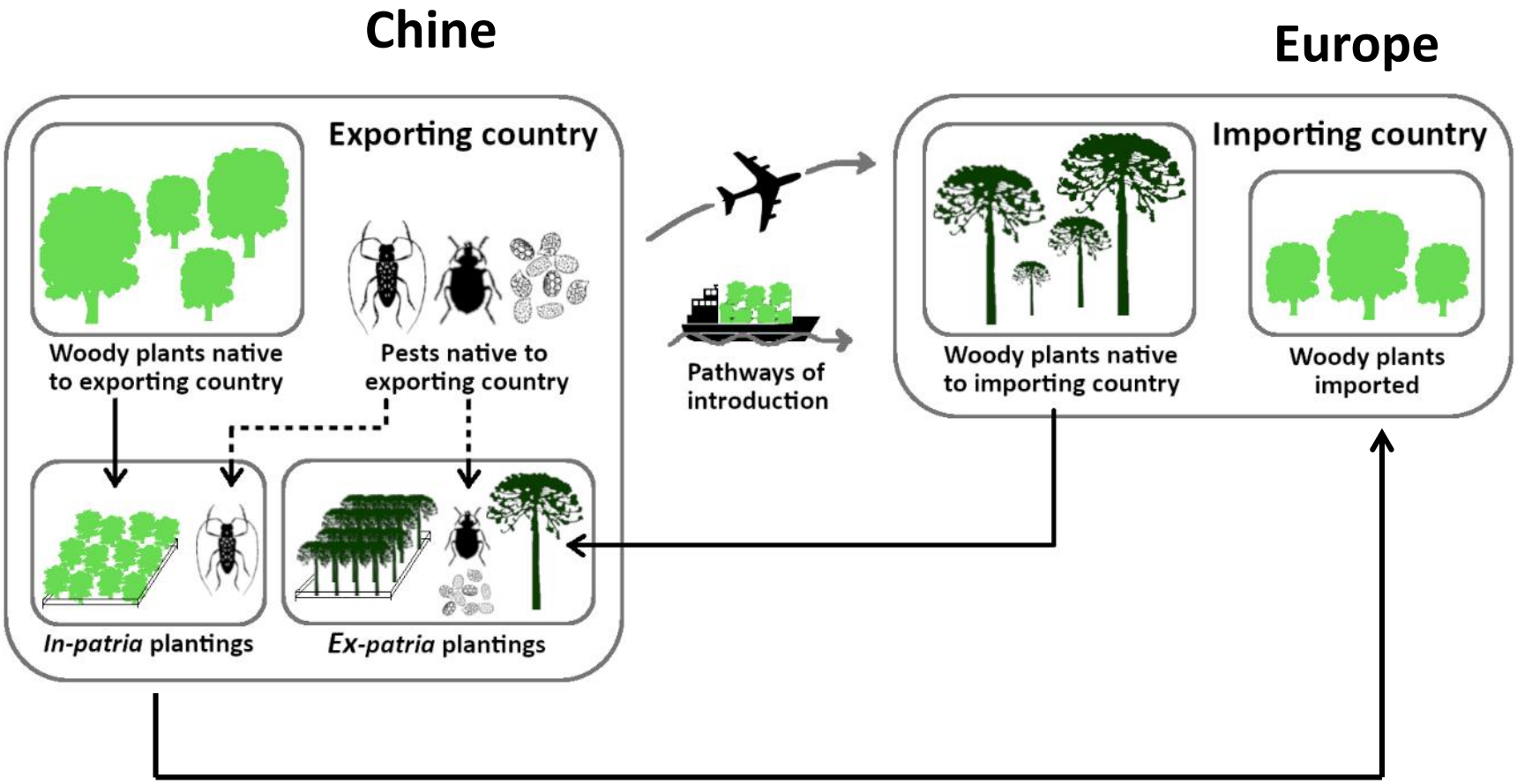
PARTNERS

- National Institute of Agricultural Research (INRA)
- Alliance Forêt Bois ® (AFB)
- CAB International (CABI)
- Institute of Zoology, Chinese Academy of Science (CAS)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- National Research Council (CNR)
- Coventry University (CU)
- Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)
- IEFC
- INRA Transfert (IT)
- School of Agronomy – University of Lisbon (ISA)
- Mendel University in Brno (MENDELU)
- New Zealand Forest Research Institute Limited (SCION)
- Pensoft Publishers (Pensoft)
- Royal Horticultural Society (RHS)
- Swedish University of Agricultural Sciences (SLU)
- Telespazio ® (TPZF)
- The University of Queensland (UQ)
- United States Forest Service (USDA FS)
- University of Padua (UNIPD)
- University of Pretoria (UP)
- Wageningen University (WU)

HOMED

Etape 1: se préparer à l'arrivée d'espèces nouvelles

1.1. Plantations sentinelles pour les « unknown unknows »



Etape 1: se préparer à l'arrivée d'espèces nouvelles

1.2. Arboreta sentinelles pour les « unknown unknows »

Euwallacea fornicatus (PSHB)

European species in which beetles have been observed **in South Africa** to establish galleries and successfully reproduce:

- *Acer pseudoplatanus*
- *Platanus* x *acerifolia*
- *Populus alba*
- *Populus x canescens*
- *Populus nigra*
- *Quercus suber*
- *Quercus robur*



Etape 1: se préparer à l'arrivée d'espèces nouvelles

1.2. Surveiller pendant le transport international



400m long – 23 000 containers

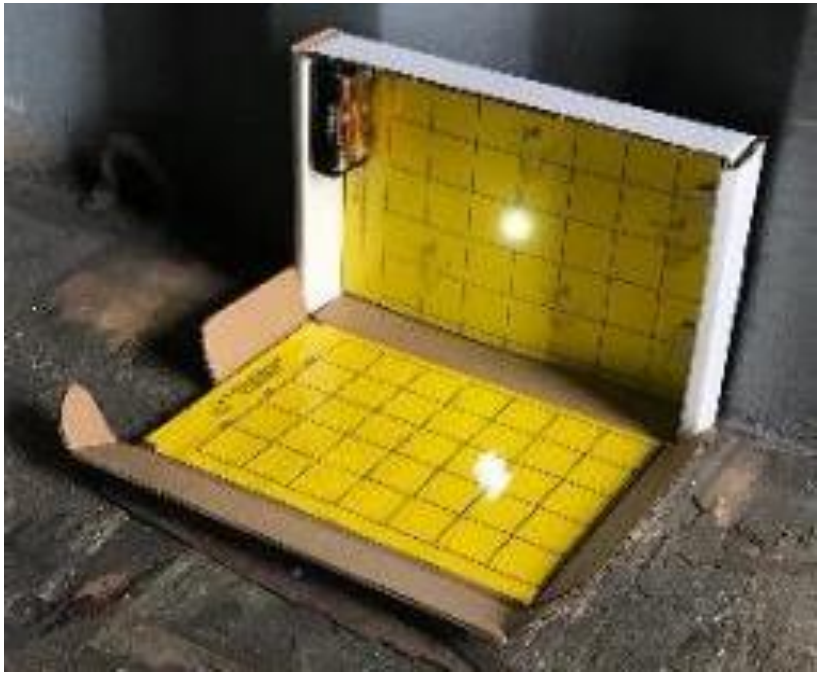
Journal of Economic Entomology, 113(4), 2020, 1718–1724
doi: 10.1093/jee/toaa098
Advance Access Publication Date: 15 May 2020
Research

Commodity Treatment and Quarantine Entomology

Light Traps in Shipping Containers: A New Tool for the Early Detection of Insect Alien Species

Matteo Marchioro,[1,] Andrea Battisti,[] and Massimo Faccoli

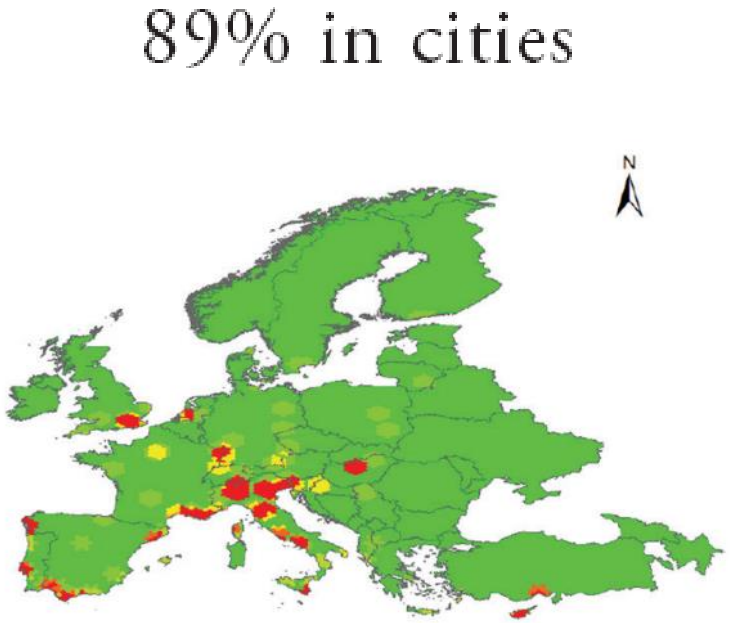


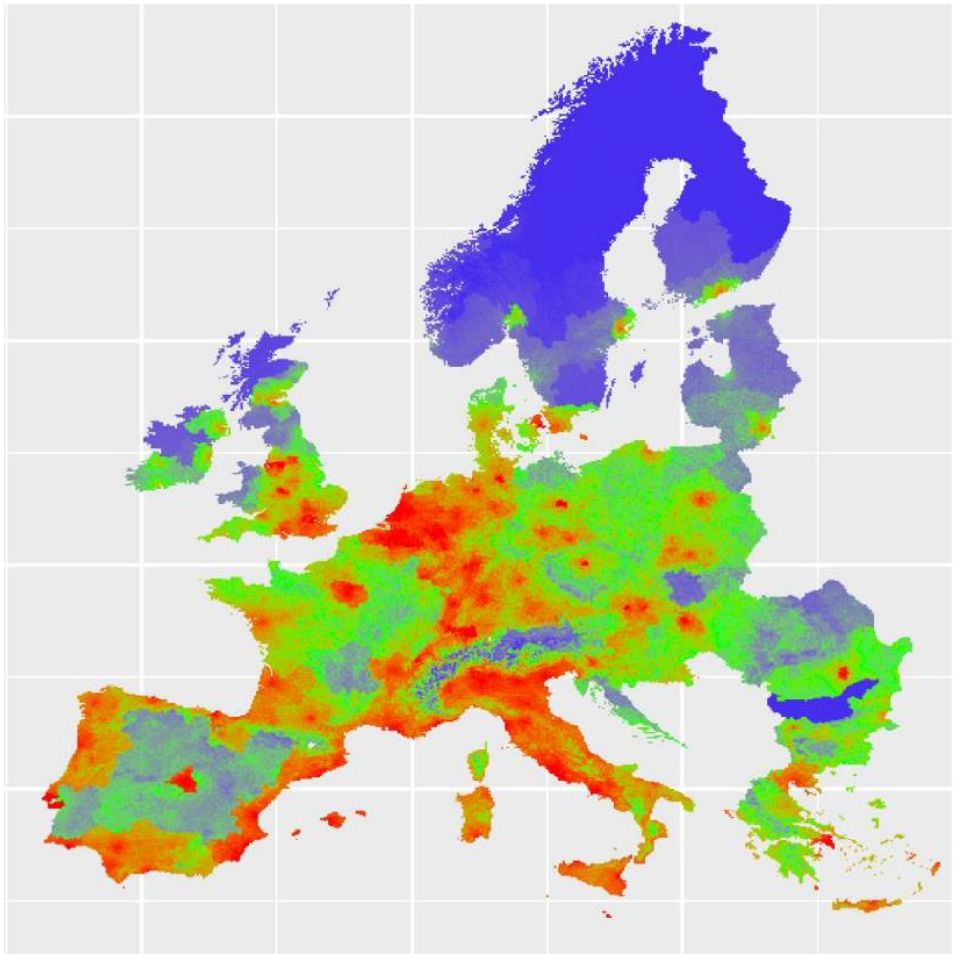


TransTrap ™

Etape 2: détecter rapidement l'arrivée

2.1. Où concentrer la détection





Etape 2: détecter rapidement l'arrivée

2.2. Comment détecter

Pièges « génériques »
avec mélange d'attractifs







Dans les (aéro)ports et des forêts voisines

Etape 2: détecter rapidement l'arrivée

2.2. Comment détecter

18 espèces coléoptères, 3 nouvelles pour l'Europe
250 spécimens de *Monochamus galloprovincialis* interceptés à Roissy CDG et port de Marseille!





Xylotrechus altaicus
Larix- Siberia

Uraecha angusta
Camphor tree- China

Xyleborus affinis
Euplatypus parallelus & E. hintzi
Africa



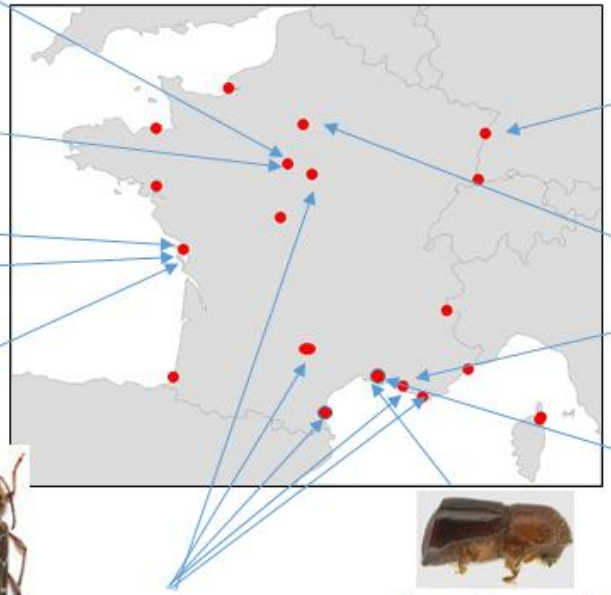




Cordylomera spinicornis
Gabon



Xylotrechus stebbingi-
Deciduous- China



Amasa resecta
Eucalypts- Australasia



Trichoferus campestris- China





Monochamus galloprovincialis-
European native but PWN vector

Etape 2: détecter rapidement l'arrivée

2.3. Comment identifier

LAMP

ORIGINAL ARTICLE Open Access

Real-time loop-mediated isothermal amplification: an early-warning tool for quarantine plant pathogen detection

Chiara Aglietti[1,2], Nicola Luchi[1*], Alessia Lucia Pepori[1], Paola Bartolini[3], Francesco Pecori[1], Aida Raio[1], Paolo Capretti[2] and Alberto Santini[1]

Reports

BioTechniques

Real-time loop-mediated isothermal amplification assay for rapid detection of *Fusarium circinatum*

Dagmar Stehlíková[1,2], Nicola Luchi[*,2], Chiara Aglietti[2,3], Alessia Lucia Pepori[2], Julio Javier Diez[4] & Alberto Santini[2]

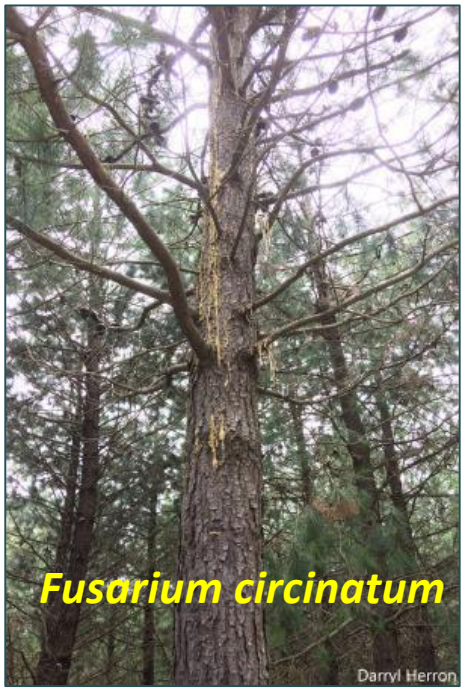
[1]University of South Bohemia Faculty of Agriculture, Biotechnological Centre Na Sadkach 1780 CZ-37005 Ceske Budejovice, Czech Republic; [2]Institute for Sustainable Plant Protection, National Research Council (IPSP-CNR), Via Madonna del Piano 10, 50019, Sesto Fiorentino (Firenze), Italy; [3]Department of Agriculture, Food, Environment & Forestry (DAGRI), University of Florence, Piazzale delle Cascine 28, 50144, Firenze, Italy; [4]Universidad de Valladolid Escuela Técnica Superior de Ingenierías Agrarias, Campus Yutera Edificio E, despacho 204. 34071, Palencia, Spain; *Author for correspondence: nicola.luchi@ipsp.cnr.it

BioTechniques 69: 00–00 (July 2020) 10.2144/btn-2019-0168
First draft submitted: 16 December 2019; Accepted for publication: 16 March 2020; Published online: 27 April 2020









+ Lecanosticta acicola, Dothistroma pini & septosporum

Etape 2: détecter rapidement l'arrivée

2.3. Comment identifier



Multi-lure trap



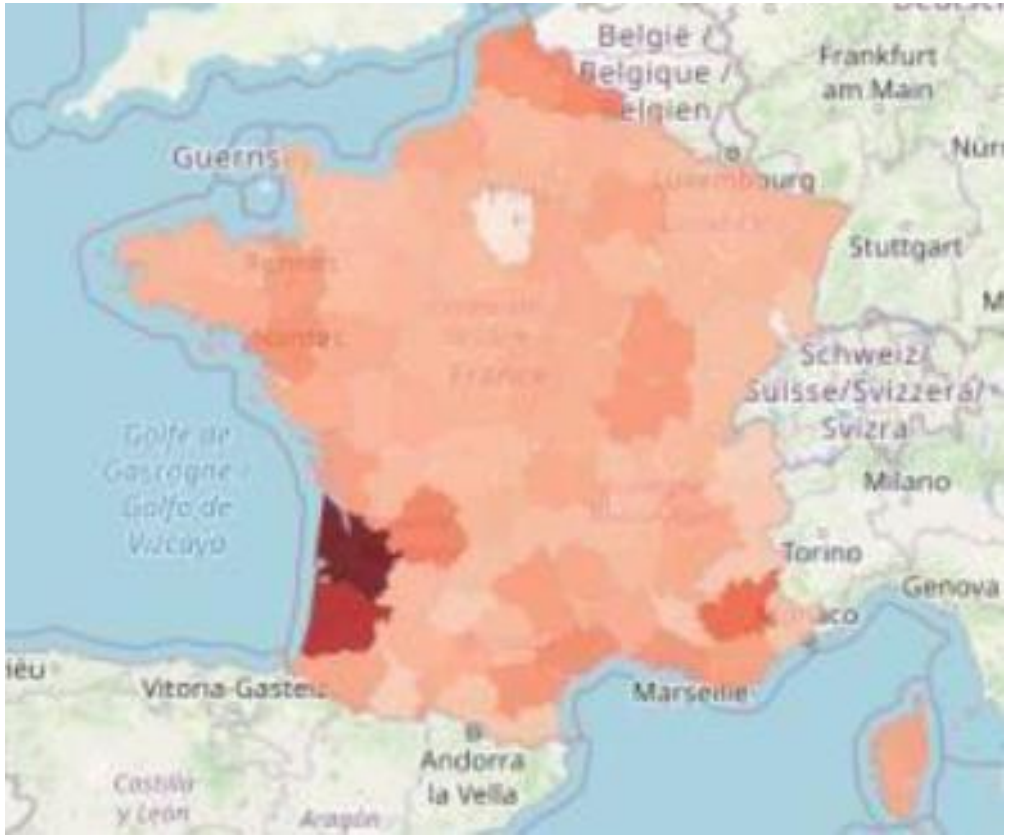
Barcodes of 293 Cerambycidae species

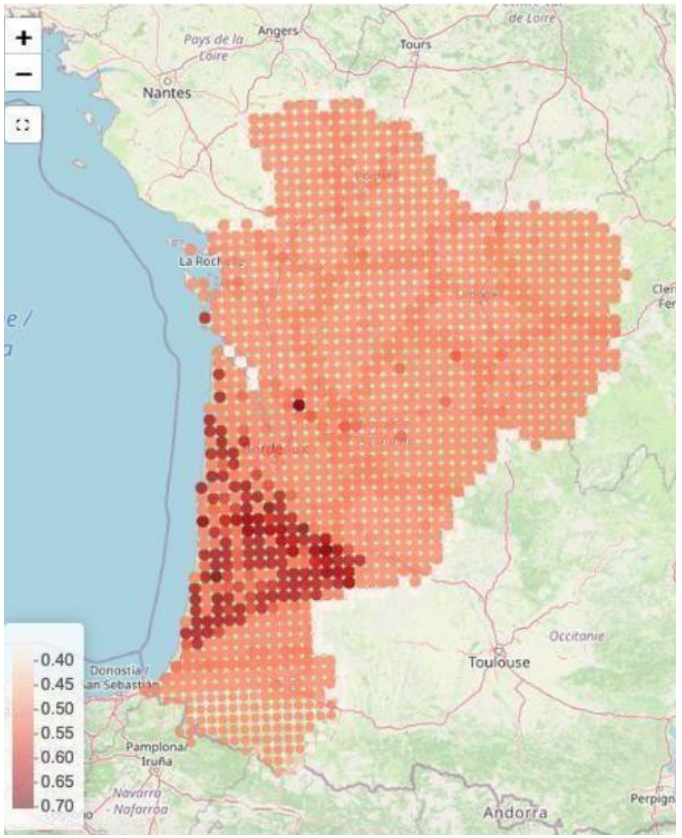
The MinION has been <u>able to differentiate closely related species</u> such as :

- *Xylotrechus stebbingi / chinensis / undulatus*
- *Arhopalus rusticus / ferus*
- *Monochamus galloprovincialis / sutor*
- *Leiopus femoratus / linnei*
- *Plagionotus detritus / arcuatus*

Etape 3: surveiller l'établissement

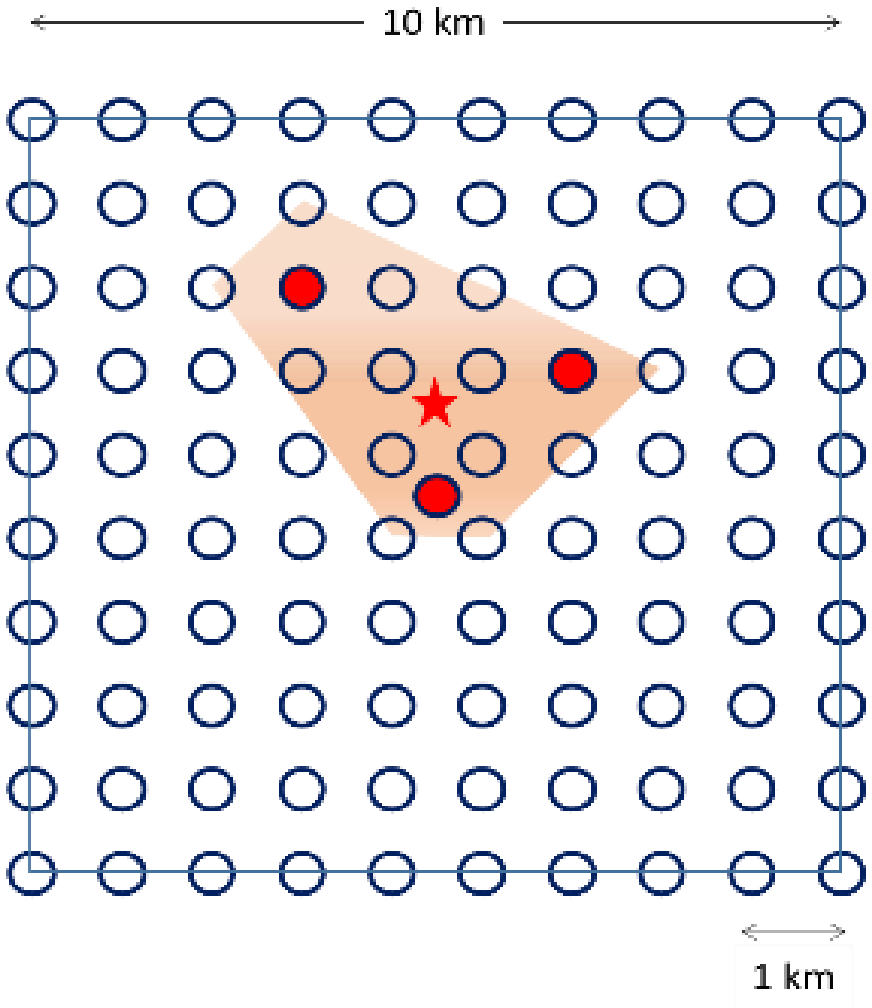
3.1. Surveiller dans les zones à risques





Etape 3: surveiller l'établissement

3.2. Surveiller avec un réseau de pièges + barycentrage



$$X_B = \frac{\sum_{i=1}^{n} x_i . w_i}{\sum_{i=1}^{n} w_i}$$

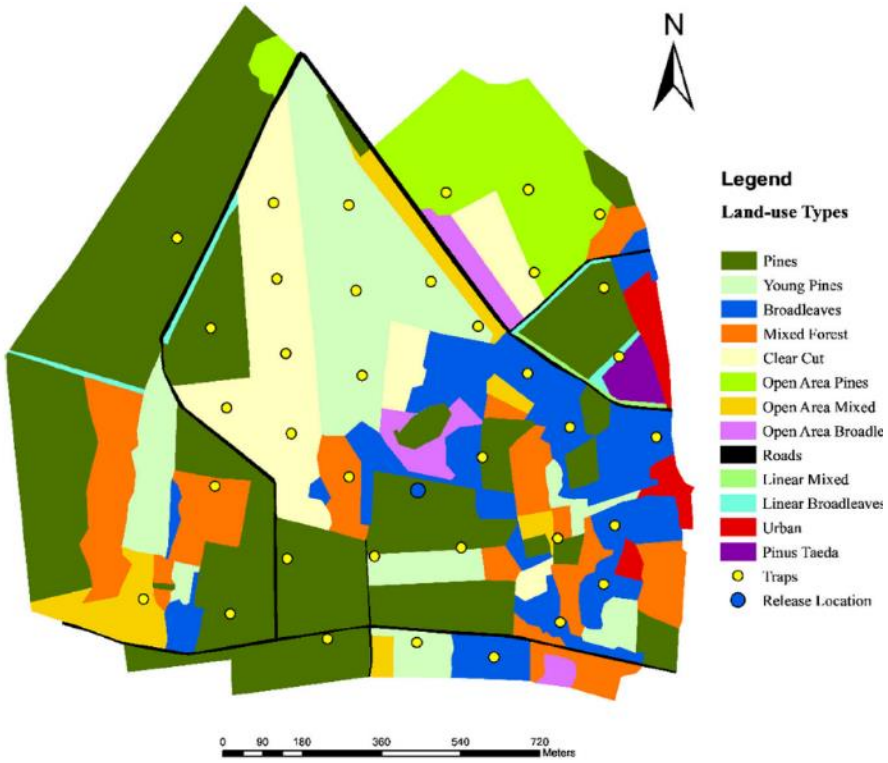
$$Y_B = \frac{\sum_{i=1}^{n} y_i . w_i}{\sum_{i=1}^{n} w_i}$$

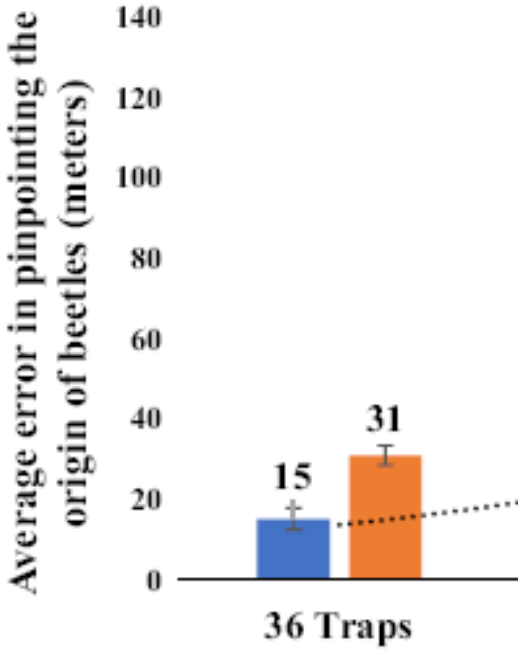
Etape 3: surveiller l'établissement

3.2. Surveiller avec un réseau de pièges + barycentrage

Modelling *Monochamus galloprovincialis* dispersal trajectories across a heterogeneous landscape to optimize monitoring by trapping networks

Pedro Nunes · Manuela Branco · Inge Van Halder · Hervé Jactel

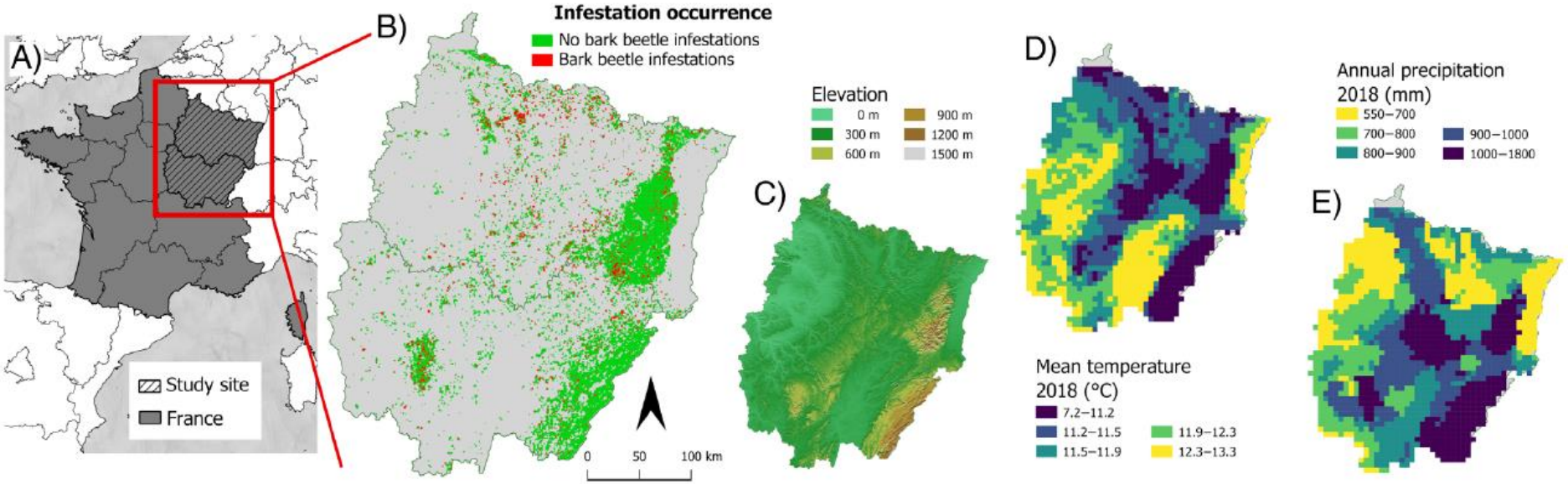




Etape 3: surveiller l'établissement

3.3. Surveiller les mortalités d'arbres par télédétection

Images aériennes (ex. Sentinel 2) + analyses d'image (IA) + analyse des trajectoires spatio-temporelles = alerte & diagnostic



Précision 95%

Etape 3: surveiller l'établissement

3.3. Surveiller la propagation des maladies par piégeage de spores



Etape 4: surveiller la propagation

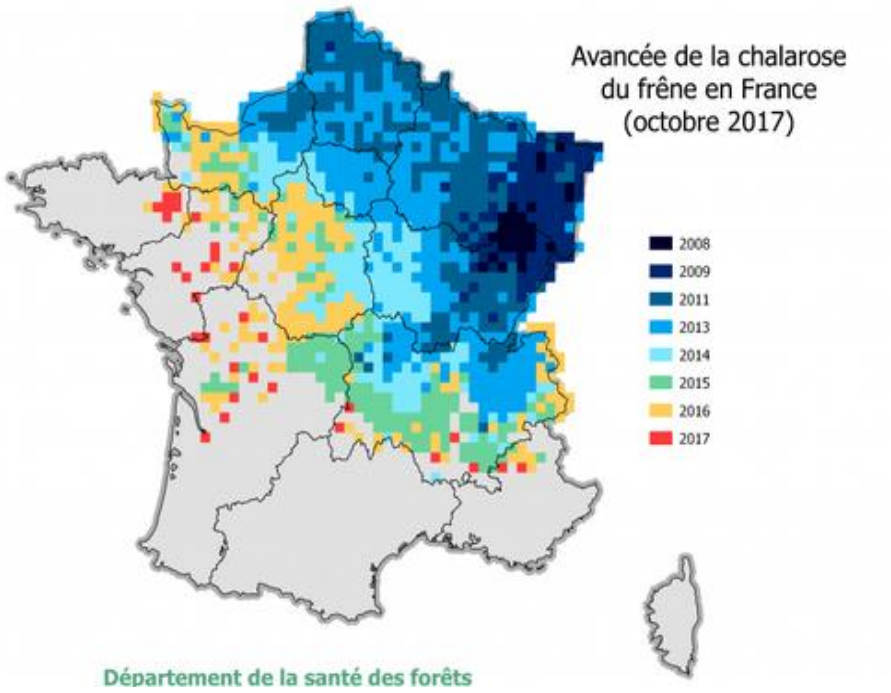
4.1. Surveiller la propagation des maladies par piégeage de spores

ORIGINAL ARTICLE

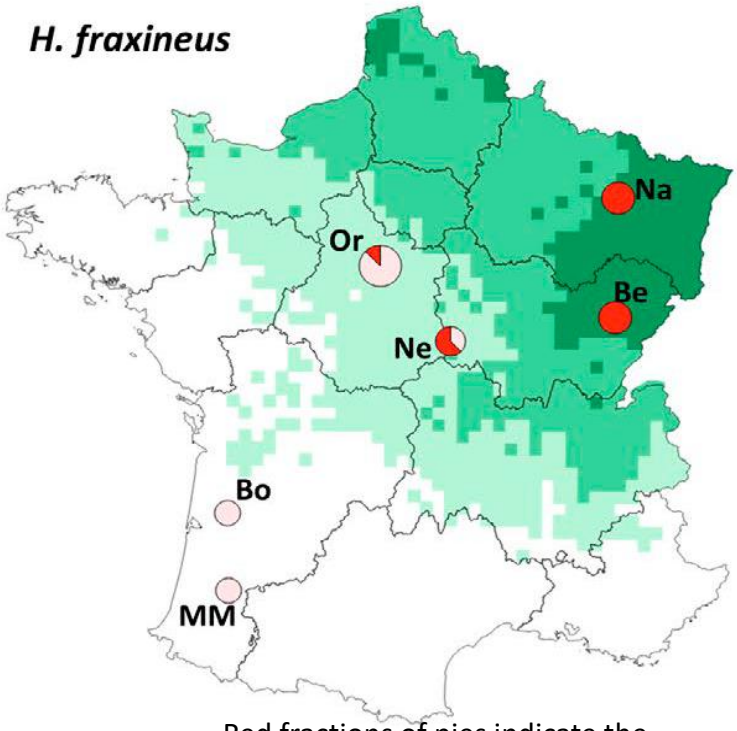
Plant Pathology WILEY

Combining permanent aerobiological networks and molecular analyses for large-scale surveillance of forest fungal pathogens: A proof-of-concept

Jaime Aguayo[1] | Claude Husson[2,3] | Emilie Chancerel[4,5] | Olivier Fabreguettes[4,5] | Anne Chandelier[6] | Céline Fourrier-Jeandel[1] | Nadine Dupuy[7] | Cyril Dutech[4,5] | Renaud Ioos[1] | Cécile Robin[4,5] | Michel Thibaudon[7] | Benoit Marçais[3,8] | Marie-Laure Desprez-Loustau[4,5]



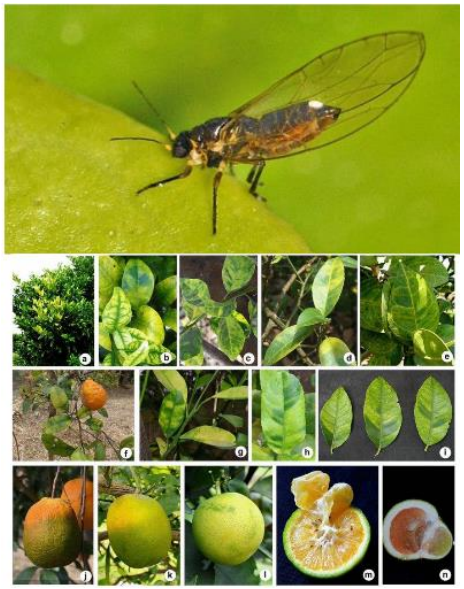
Hymenoscyphus fraxineus
Chalarose du frêne



Red fractions of pies indicate the frequency of detection in pollen (spore) traps

Etape 4: surveiller la propagation

4.2. Prédire la propagation des invasions par modélisation



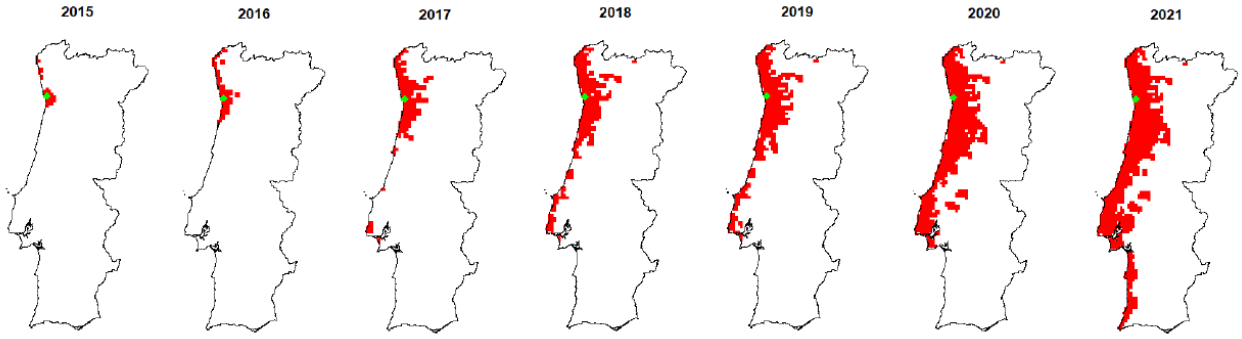
Trioza erytreae (Del Guercio)

Vector of the Citrus Greening disease or Huanglongbing

The **worst** citrus disease worldwide

Disease caused by the *Candidatus Liberibacter* bacteria

First detected in January 2015 in Portugal in Porto



Etape 4: surveiller la propagation

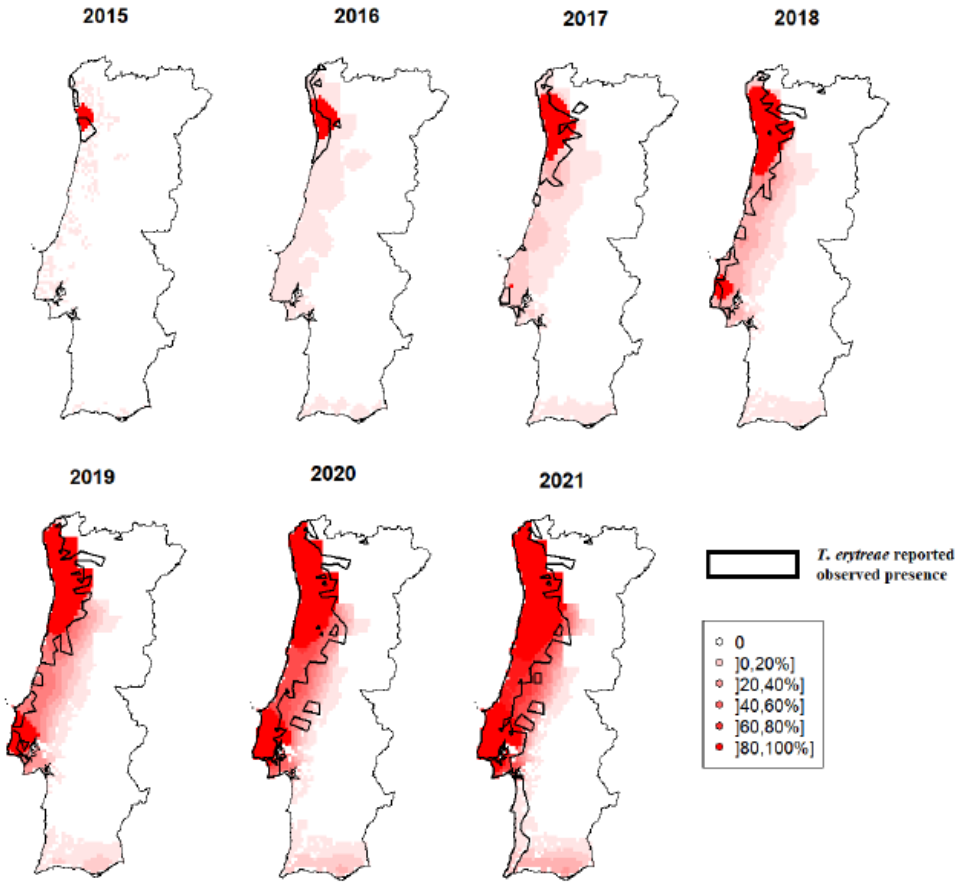
4.2. Prédire par modélisation

Model Validation using reported data

- Including human long-distance dispersal improved model performance significantly
  (e.g. model 5 F1-Score = 0.583 vs model 29 F1-Score = 0.801)
- Including the estimated urban citrus trees improved model performance significantly

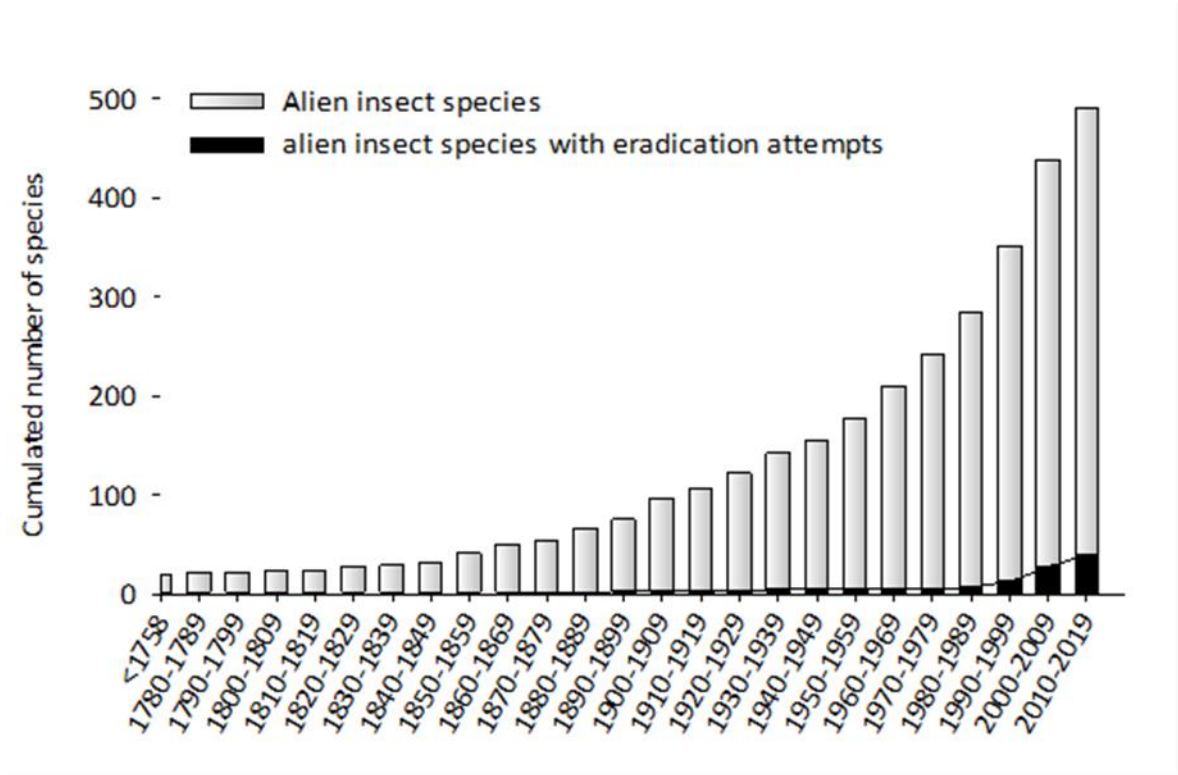
Best model had a F1-Score = 0.803

Spread rate used: 6km/year



Etape 5: essayer d’éradiquer

Revue des tentatives d'éradication des ravageurs et pathogènes exotiques des ligneux en Europe depuis 1945

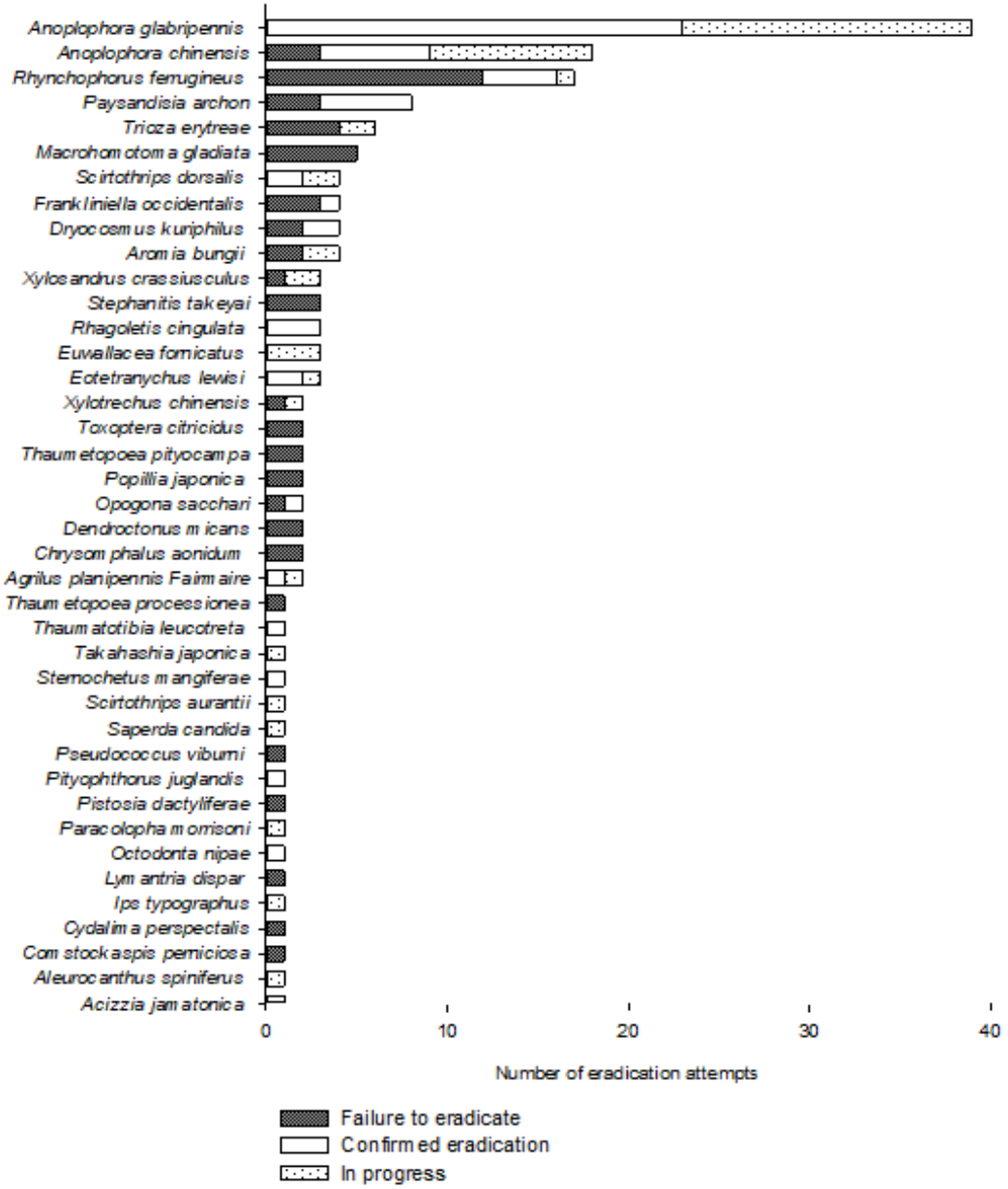


Etape 5: essayer d'éradiquer

Revue des tentatives d'éradication

50% de succès

- **Le plus tôt possible**
- **Petites surfaces**
- **Suppression arbres hôtes**
- **Effet Allee**



Etape 6: lutter pour limiter le dégâts

6.1. Lutte biologique « classique »

NeoBiota 65: 169–191 (2021)
doi: 10.3897/neobiota.65.66276
https://neobiota.pensoft.net

RESEARCH ARTICLE

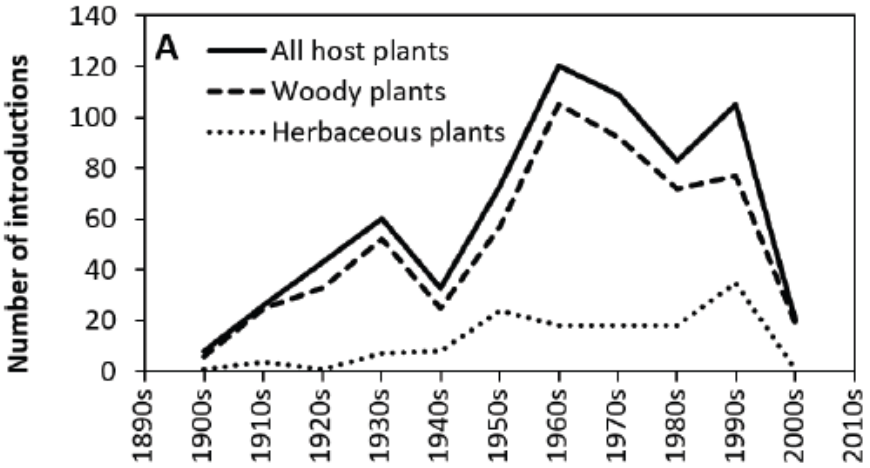
A peer-reviewed open-access journal
NeoBiota
Advancing research on alien species and biological invasions

Classical biological control against insect pests in Europe, North Africa, and the Middle East: What influences its success?

M. Lukas Seehausen[1], Catarina Afonso[2], Hervé Jactel[3], Marc Kenis[1]

Entre 1890 et 2010:
780 introductions d'ennemis naturels

32% d'installation réussie
18% avec impact significatif
11% avec contrôle complet



Meilleure efficacité avec:
- **Parasitoïdes**
- **Introductions répétées**
- **Ravageurs cibles à 1 génération**

Etape 6: lutter pour limiter le dégâts

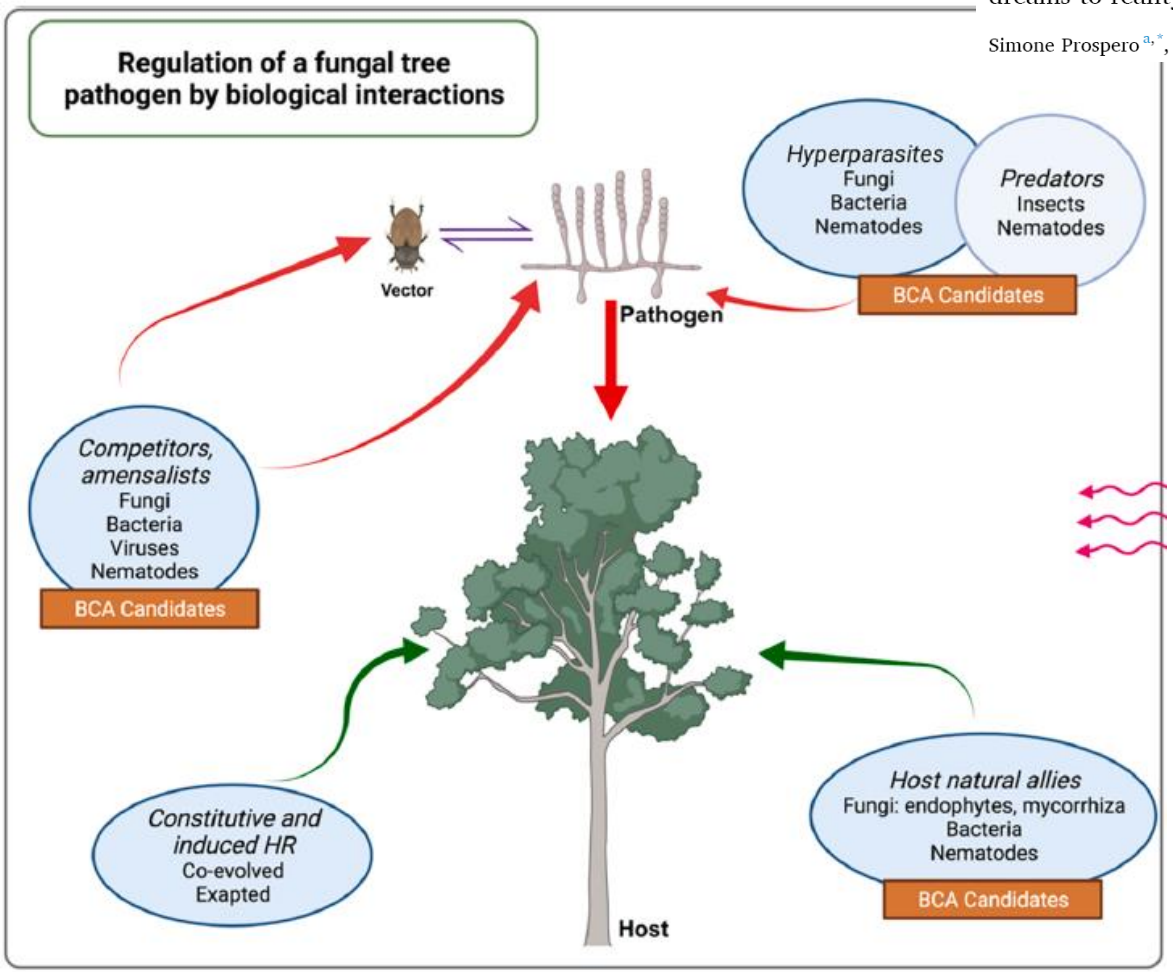
6.1. Lutte biologique « classique »

Forest Ecology and Management

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

Biological control of emerging forest diseases: How can we move from dreams to reality?

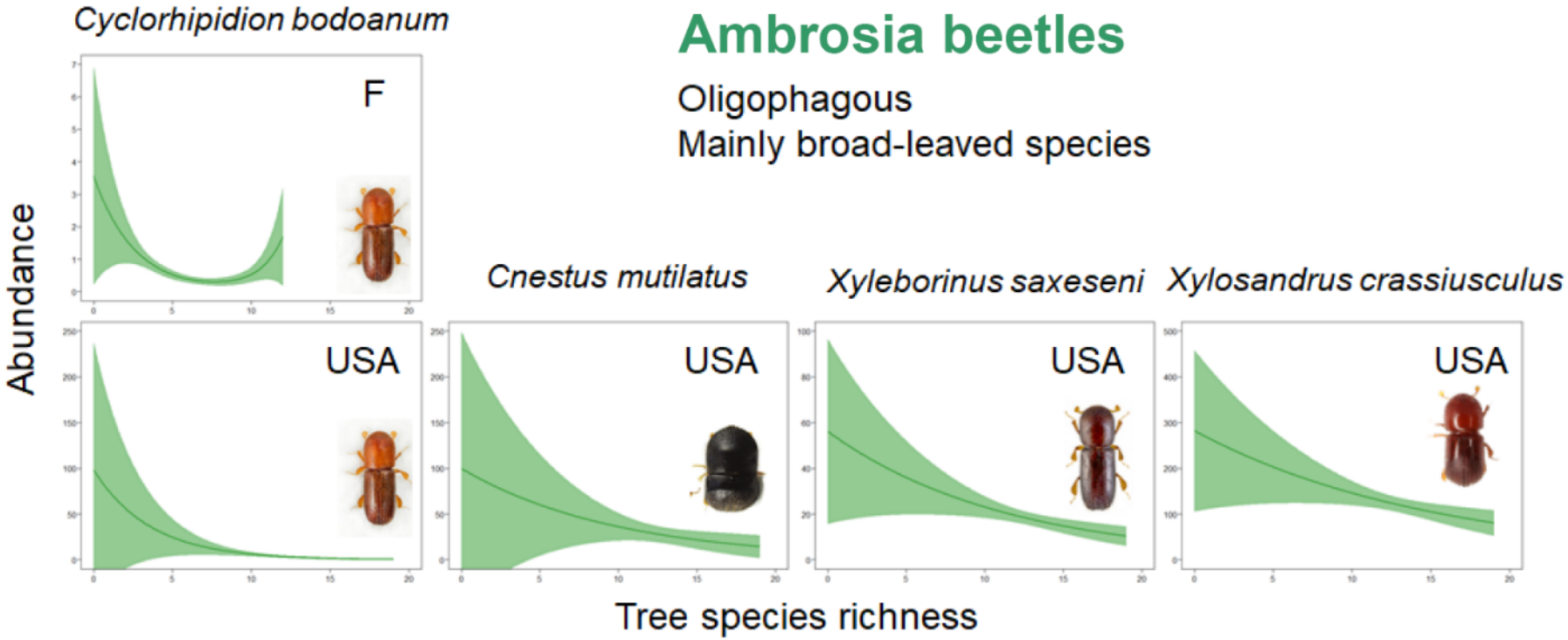
Simone Prospero [a,*], Leticia Botella [b,c], Alberto Santini [d], Cécile Robin [e]



Etape 6: lutter pour limiter le dégâts

6.2. Lutte par « conservation de la biodiversité »

Scolytes mycétophages spécialistes moins abondants dans les forêts mélangées



Etape 6: lutter pour limiter le dégâts

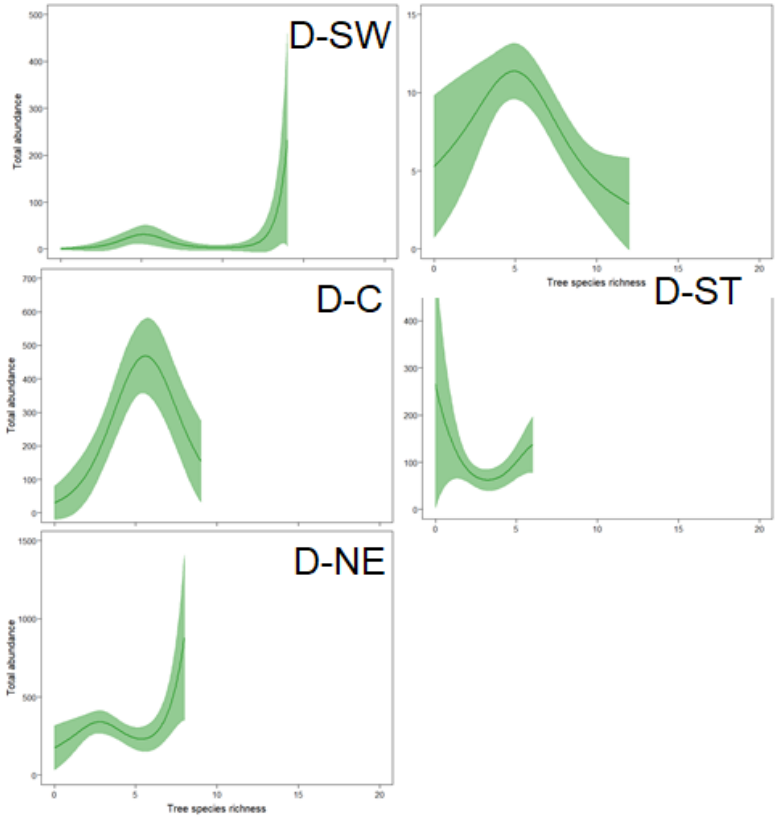
6.2. Lutte par « conservation de la biodiversité »

Scolytes exotiques polyphages

Xylosandrus germanus



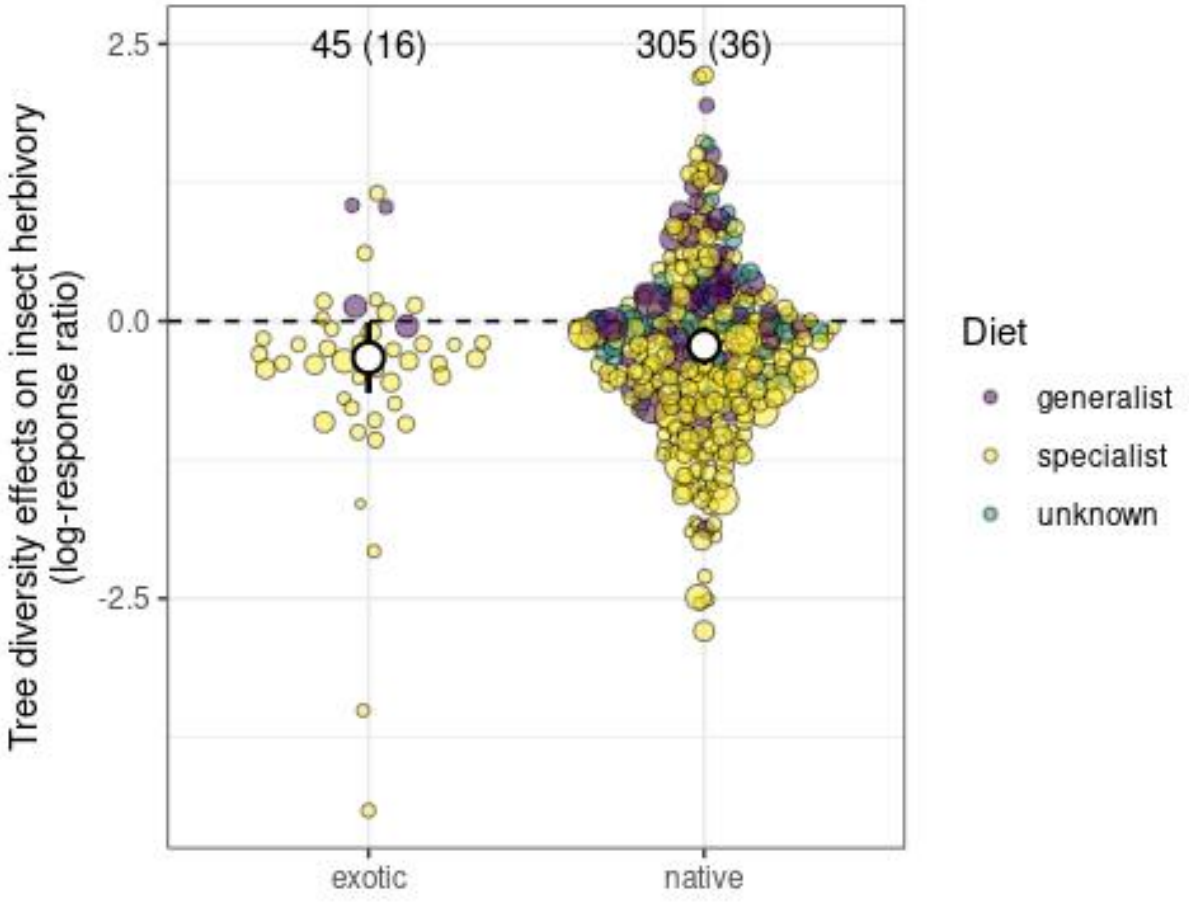
Polyphagous
broad-leaved and conifers



Etape 6: lutter pour limiter le dégâts

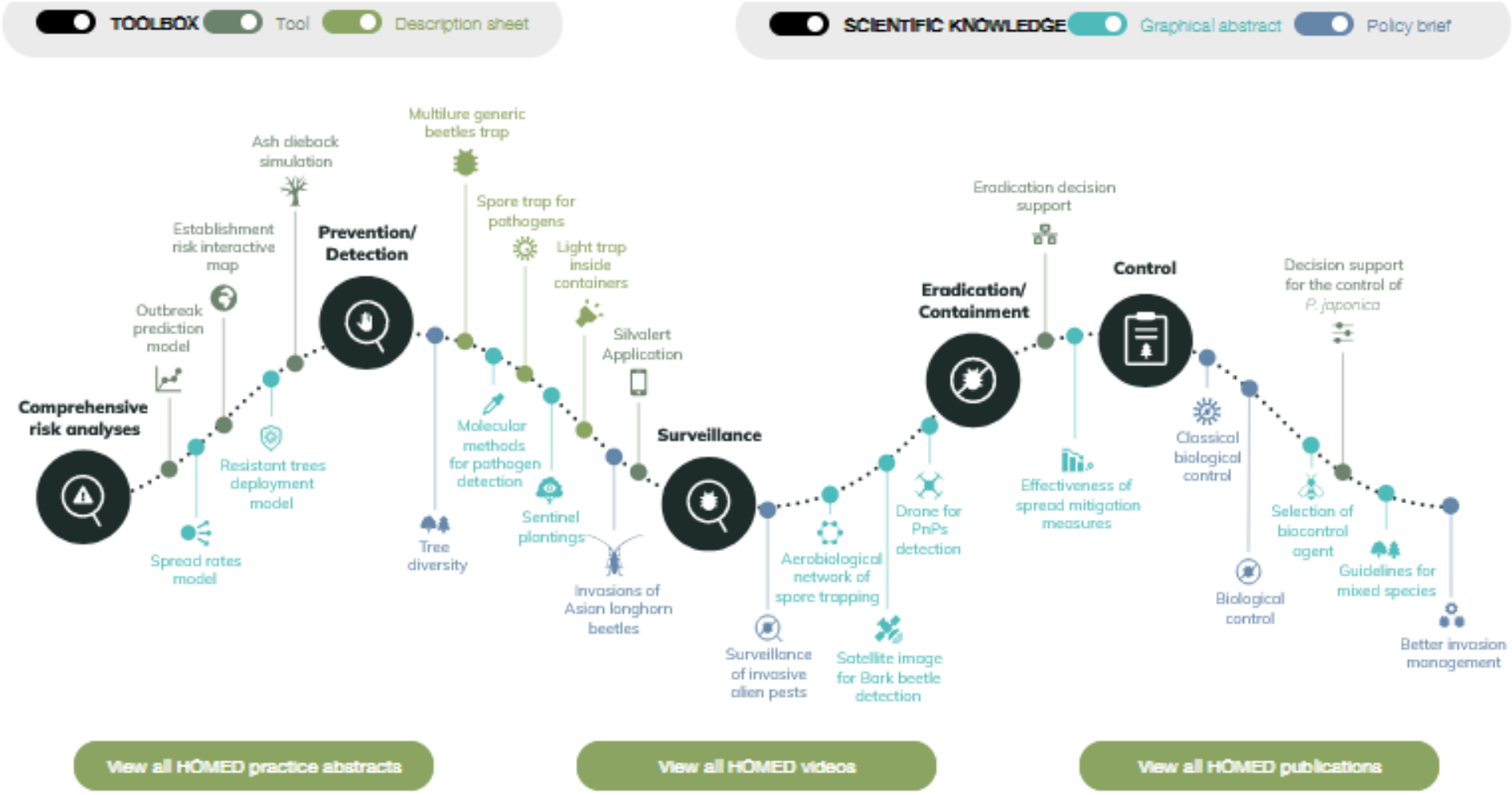
6.2. Lutte par « conservation de la biodiversité »

Pityogenes juglandi
Phyllonorycter issikii
Matsucoccus feytaudi
Lymantria dispar
Leptoglossus occidentalis
Dryocosmus kuriphilus
Drosophila suzukii
Dreyfusia nordmannianae
Cydalima perspectalis
Ctenarytaina eucalypti
Corythucha arcuata
Contarinia pseudotusgae
Agrilus planipennis



- 32% **- 20%**

https://homed-project.eu/knowledge-hub



Merci pour votre attention

