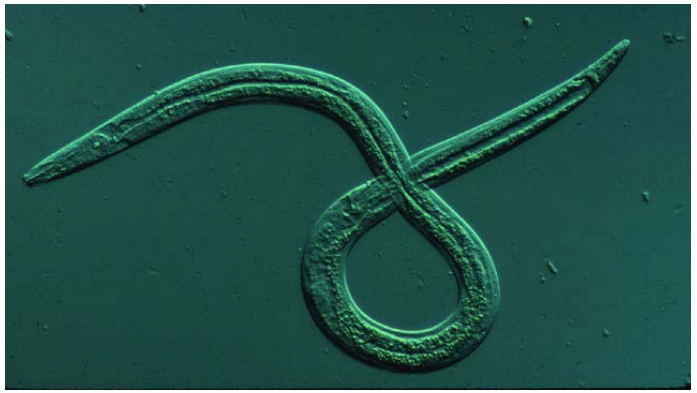


Pine wood nematode

PWN

Bursaphelunchus xylophilus

Insect vector

Pine sawyer beetle (PSB)

Monochamus galloprovincialis

E. Sousa, P. Naves, L. Bonifacio, J. Casado, J.C. Samalens, T. Ferreira
E. Mauri, C. Orazio, H. Jactel

EFIATLANTIC

TELESPAZIO a LEONARDO and THALES company

Tragsatec Grupo Tragsa

iniav

INSTITUTO SUPERIOR DE AGRONOMIA Universidade de Lisboa

INRA SCIENCE & IMPACT

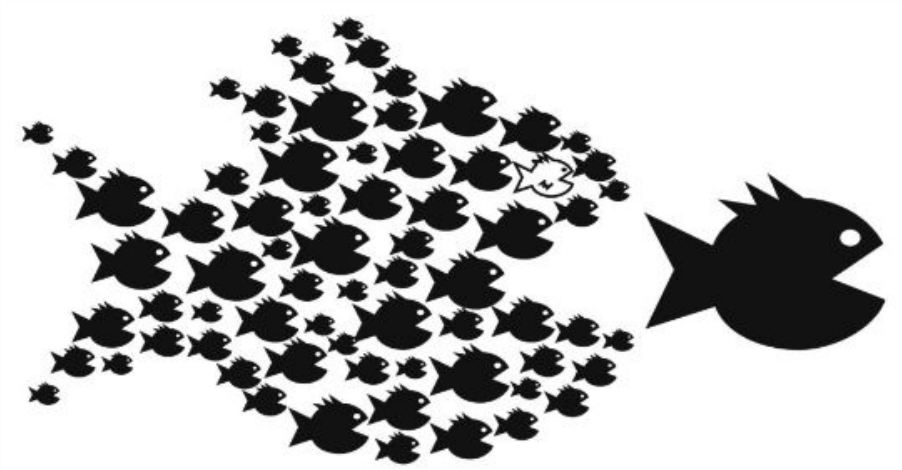
Process of collective action

- **Objective**: Defining research priorities to improve PWN risk management

- **Method**: Dialogue between scientists and tree health managers

  - Stakeholders' needs and expectations
  - Scientist's knowledge and vision
  - Transboundary cooperation

  through interviews and workshops



Research priority for PWN risk management

- **Early warning detection in areas at risk**

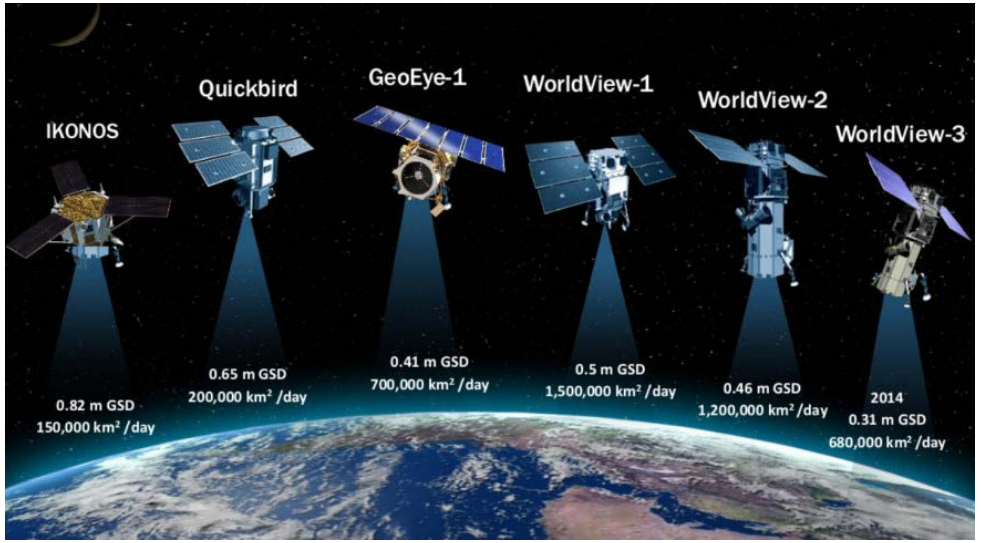
- **2 methods to be improved**:

1. Field detection of symptomatic trees
   - Official method (EU regulation)
   - Often few and isolated
   - Non-specific symptoms

2. Pheromone trapping of insect vectors
   - Recommended by EU regulation
   - Where ? Defining priority areas of deployment
   - How many (cost)? Optimizing the density of traps

1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.1. Use of satellite images



Pros

- Cover large areas
- Easy to program and obtain
- Large array of satellites
  w. various image resolution and colors

Cons

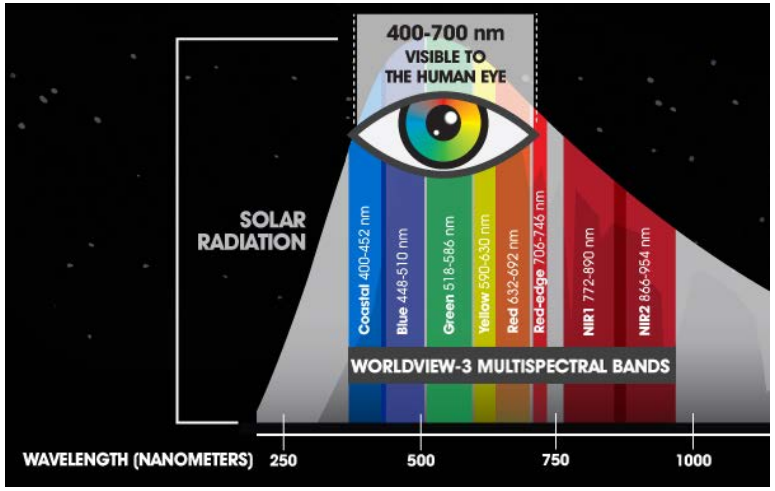
- Size of the pixel > individual tree crown area
- Weather conditions
- Image cost

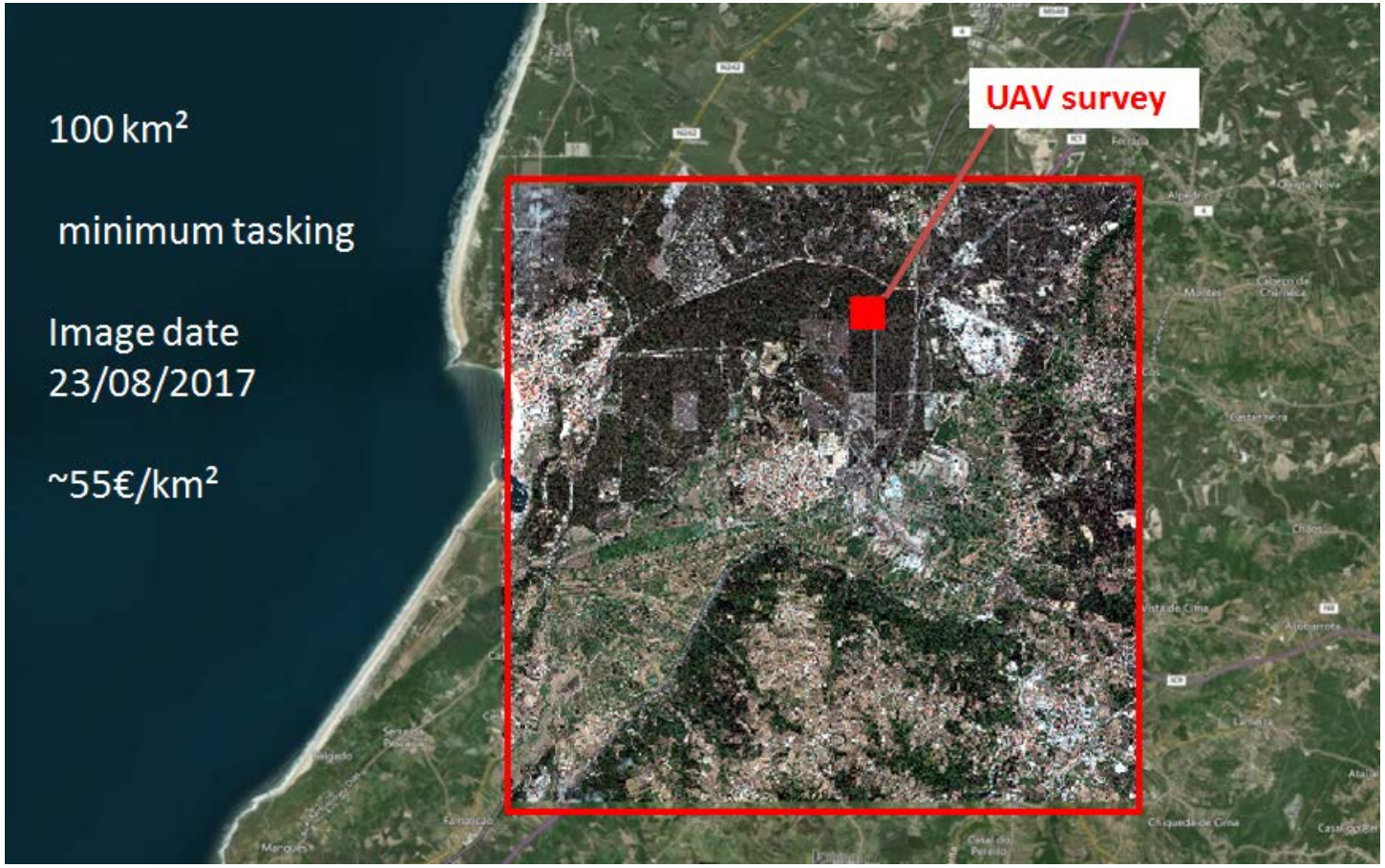
1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.1. Use of satellite images

Experiment

Nazaré Pine Forest
WorldView satellite
Very high resolution image (31cm)



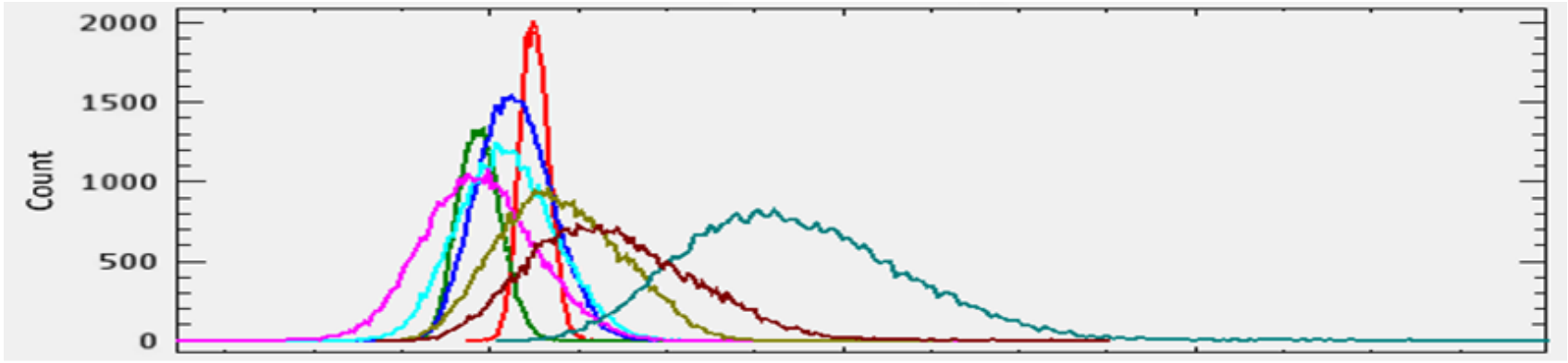


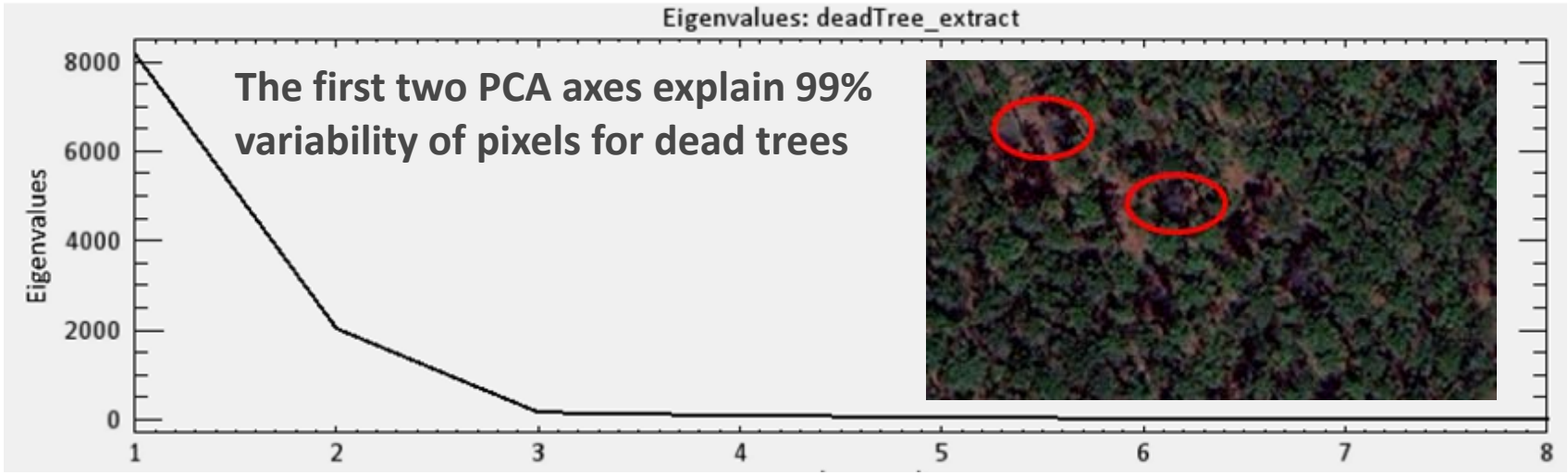
1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.1. Use of satellite images

Experiment

Identification of specific spectral combination (PCA) for symptomatic trees observed in the field in August

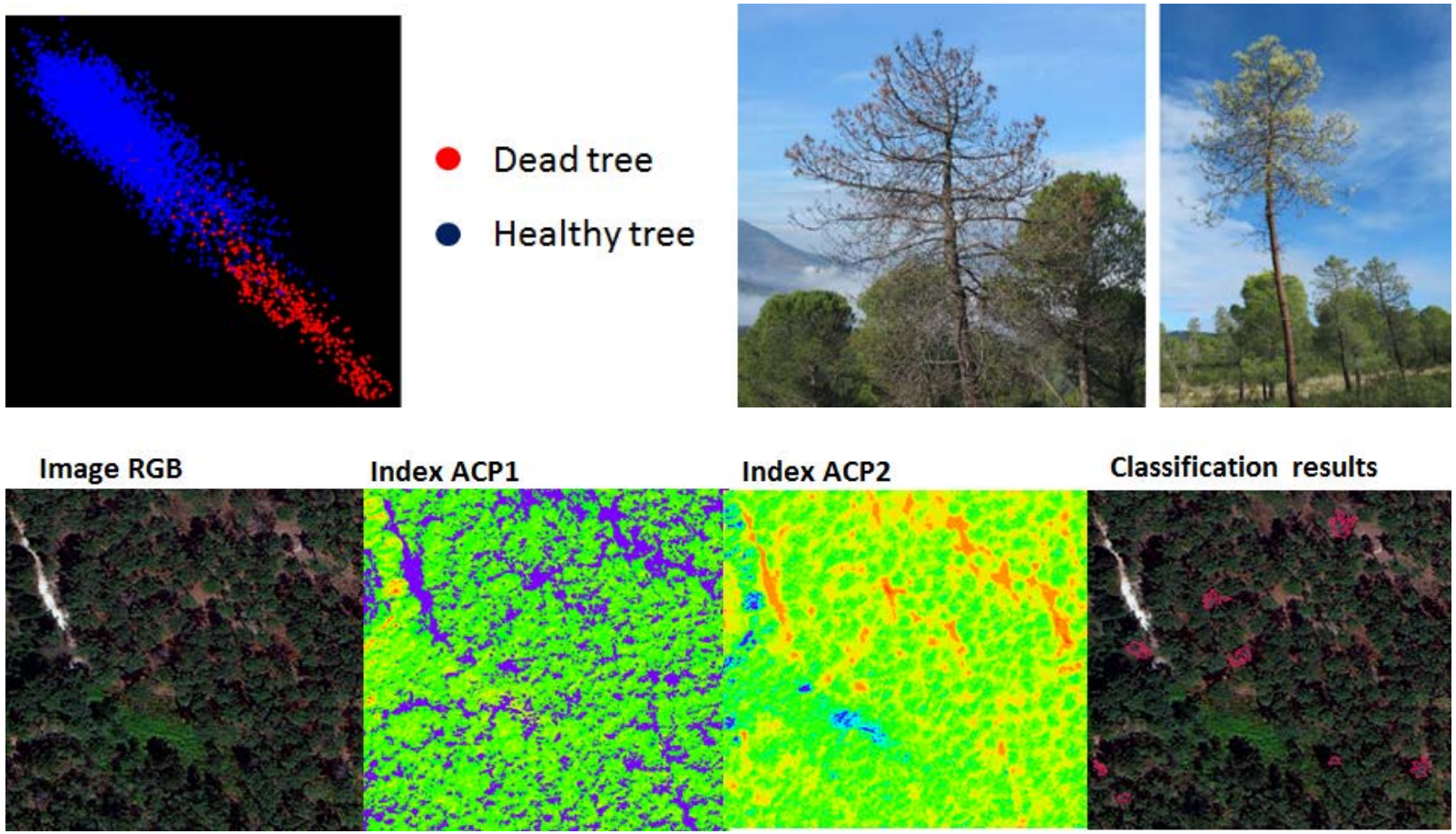




1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

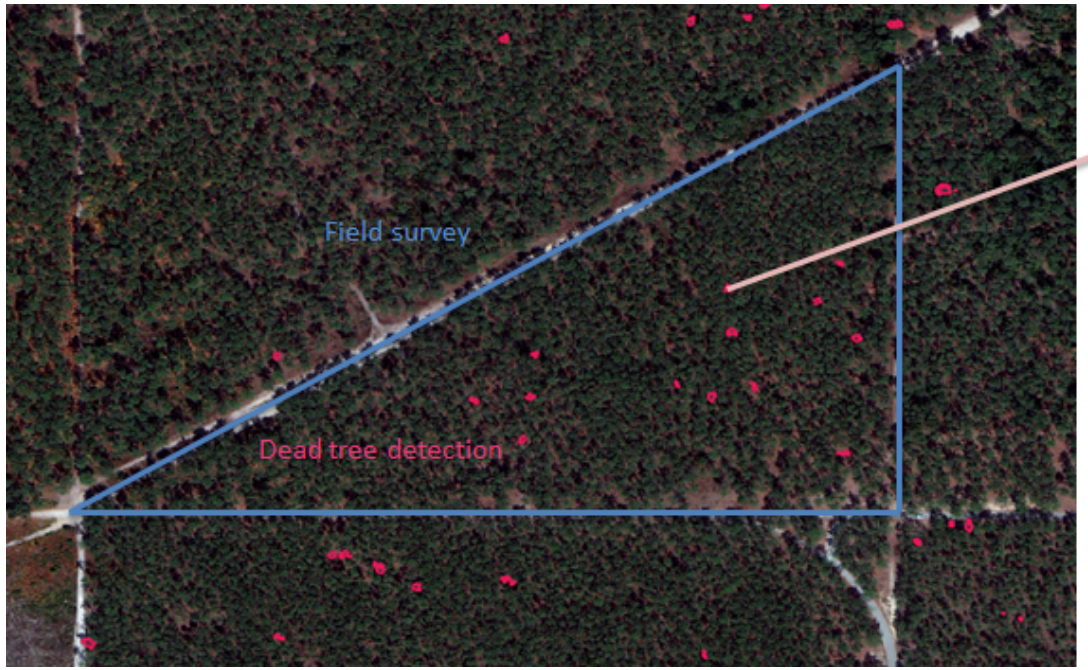
1.1. Use of satellite images

Experiment



1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.1. Use of satellite images



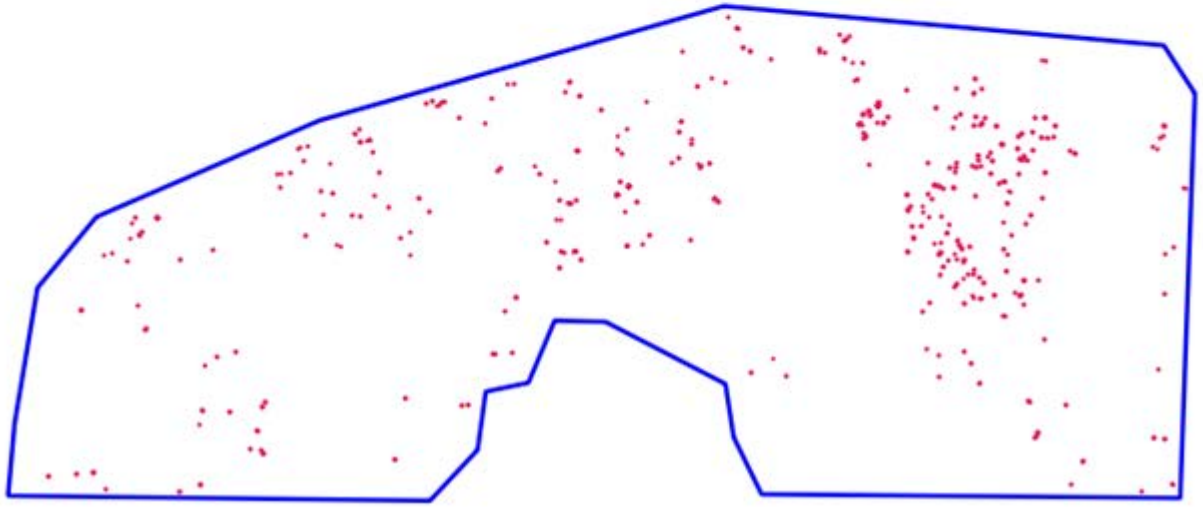
Observation	Defoliation	Date of wood sample	PWN presence
canopy partially reddish	2	17-nov	Negative
all canopy brown	3	17-nov	Negative
dead with few needles attached	4	17-nov	Positive
dead with few needles attached	2	17-nov	Positive
dead with few needles attached	4	17-nov	Positive
dead with few needles attached	4	17-nov	Positive
dead with few needles attached	3	17-nov	Positive
all canopy brown	3	17-nov	Positive
all canopy brown	3	17-nov	Positive
canopy partially reddish	2	17-nov	Positive
dead with few needles attached	3	17-nov	Positive
dead with few needles attached	3	17-nov	Positive
all canopy brown	3	17-nov	Positive
canopy partially reddish	2	17-nov	Positive
dead with few needles attached	4	17-nov	Positive
dead with few needles attached	4	17-nov	Positive
dead with few needles attached	4	17-nov	Positive
dead with few needles attached	4	17-nov	Negative
all canopy brown	3	17-nov	Positive
dead with few needles attached	4	17-nov	Positive
all canopy brown	3	17-nov	Positive
all canopy brown	3	17-nov	Positive
all canopy brown	3	17-nov	Positive
all canopy brown	3	17-nov	Positive
dead with few needles attached	4	17-nov	Positive

- **The 13 dead trees detected on August satellite images were also inventoried in the field in November**
- **Obviously, no difference were found between dead trees damaged or not by PWN**
- **No particular spectral signature could be identified for the early detection of PWN symptoms**
- **No omission and no over detection of isolated dead trees -> promising results**

1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.1. Use of satellite images

437 isolated dead trees
could be further mapped
at larger scale (ca. 1500ha)



1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.2. Use of drone (UAV) images

Pros

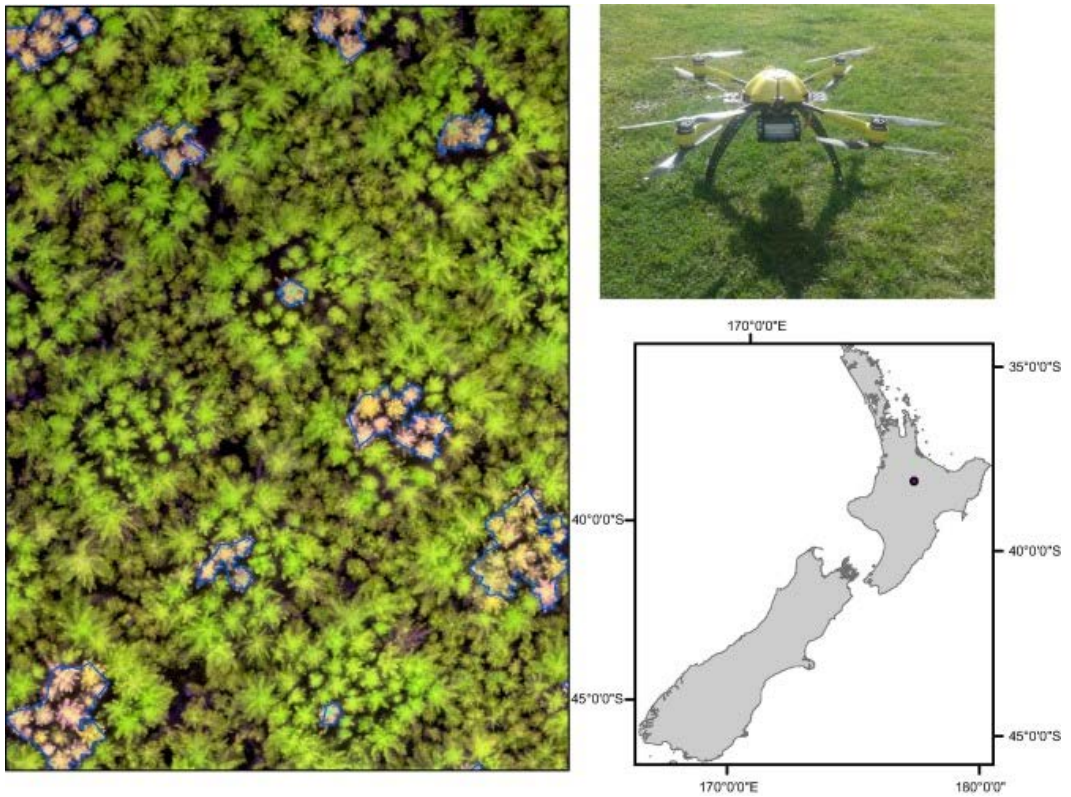
- Accuracy (small pixels)
- Hovering flights
- Embarked multi/hyperspectral cameras

Cons

- Cover small areas
- Weather conditions
- Experienced pilots

Assessing very high resolution UAV imagery for monitoring forest health during a simulated disease outbreak

Jonathan P. Dash [a,*], Michael S. Watt [b], Grant D. Pearse [a], Marie Heaphy [a], Heidi S. Dungey [a]



1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.2. Use of drone (UAV) images

Experiment

Site

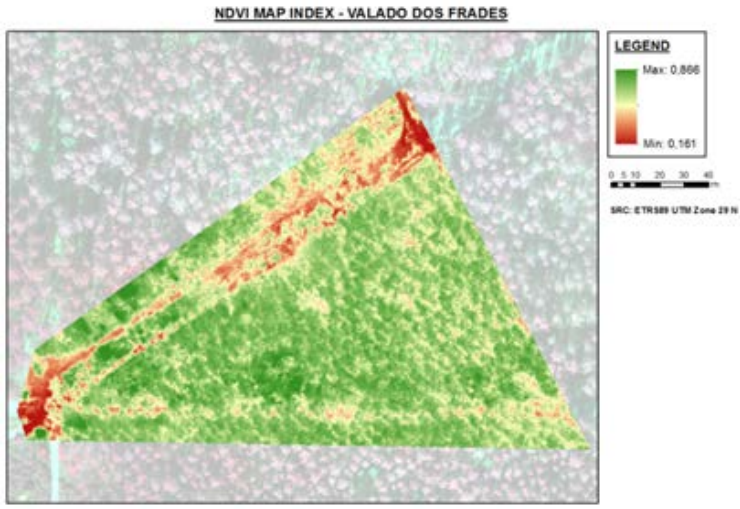
Mata Nacional Vimeiro. Valado dos Frades
Area: 6 ha Pinus pinaster
Age: 49-67 years, height 25 m

Remote sensing (December 2017): TRAGSATEC

Platform: eBee drone
Multispectral camera red-edge (IR)
Vegetation index, Individual crown segregation

Field survey (December 2017): INIAV

Symptomatic trees
Presence of PWN (at the lab)



1. **Aerial survey** of pine forests for early warming detection of PWN infected trees

1.2. Use of drone (UAV) images

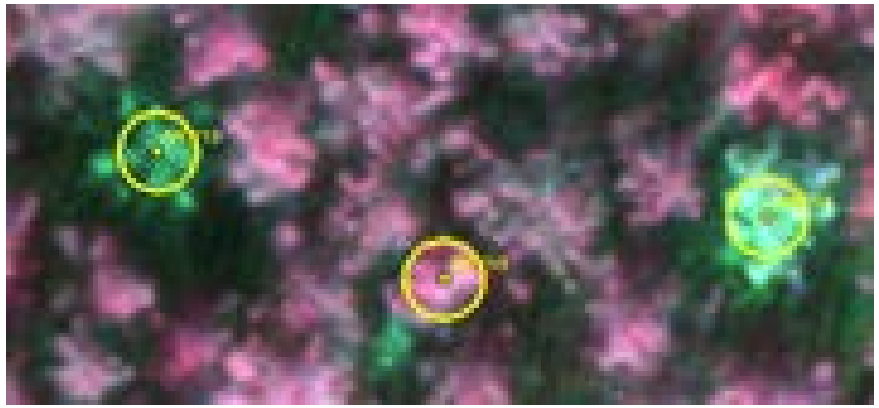
Experiment

20 trees: 9 asymptomatic
+ 11 symptomatic (9 PWN infected)
10 trees to build the model
10 trees to test the prediction

Model

cct in chlorophyll_a as predictor of tree physiological status
< 1mg/g chloro_a as threshold for decay
cct chloro_a estimated with red edge absorption RE
Logistic regression: infected vs. not infected = f(RE)

Model testing:
100% true positive symptomatic
100% true negative asymptomatic



2. **Field survey** of insect vectors with **pheromone traps** for early warming detection of PWN establishment

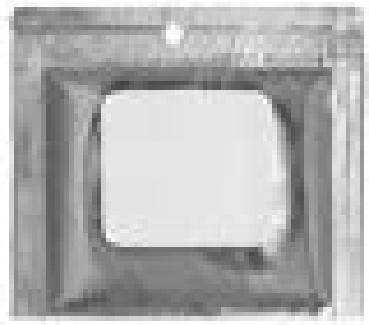
2.1. Current strategy

Standardized pheromone trapping system

SEDQ Healthy crops in our hands

FABRICANTE Y PROVEEDOR:
SEDQ
Sociedad Española
de Desarrollos Químicos S.L.

Galloprotect Pack
Use in mass trapping of the pine sawyer
Monochamus galloprovincialis



JOURNAL OF APPLIED ENTOMOLOGY
J. Appl. Entomol.

ORIGINAL CONTRIBUTION

Combining pheromone and kairomones for effective trapping of the pine sawyer beetle *Monochamus galloprovincialis*

G. Álvarez[1], D. Gallego[2], D. R. Hall[3], H. Jactel[4,5] & J. A. Pajares[1]

Agricultural and Forest Entomology

A novel, easy method for estimating pheromone trap attraction range – Application to the pine sawyer beetle, Monochamus galloprovincialis

Herve Jactel [1*], Luis Bonifacio [2], Inge van Halder [1], Fabrice Vétillard [1], Christelle Robinet [3], Guillaume David [1,4]

Effective attraction radius = 100m

2. **Field survey** of insect vectors with **pheromone traps** for early warming detection of PWN establishment

2.1. Current strategy

Focus on areas at risk:

Burnt or wind damaged forests

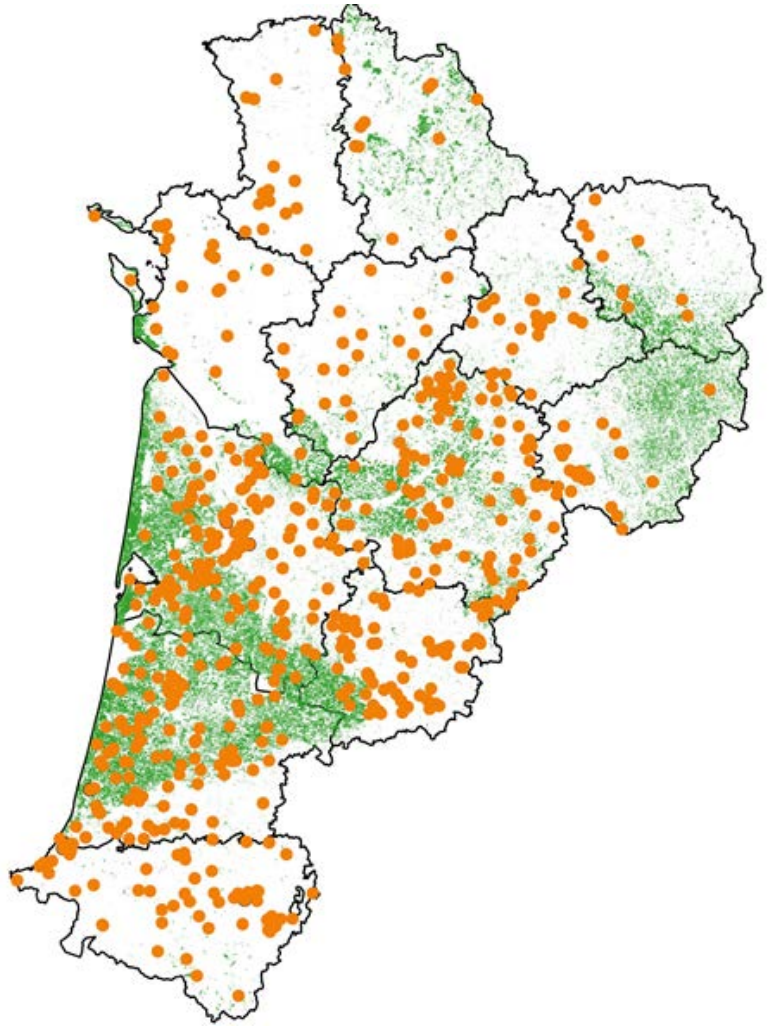
Along main roads, wood truck parks, ports

wood factories, sawmills, warehouses…

But only 20 traps for Aquitaine, to cover

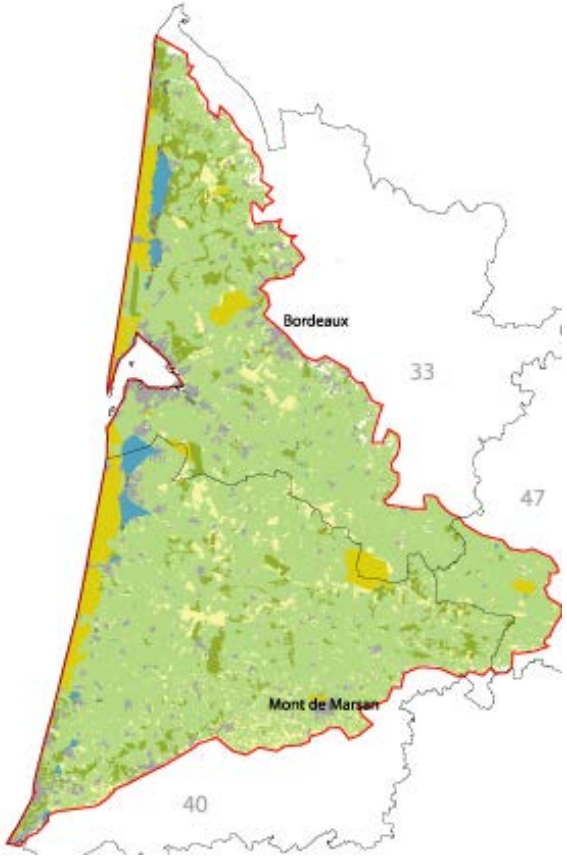
1 million ha (1 trap / 50 000 ha, r=12km)

with permutations

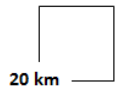


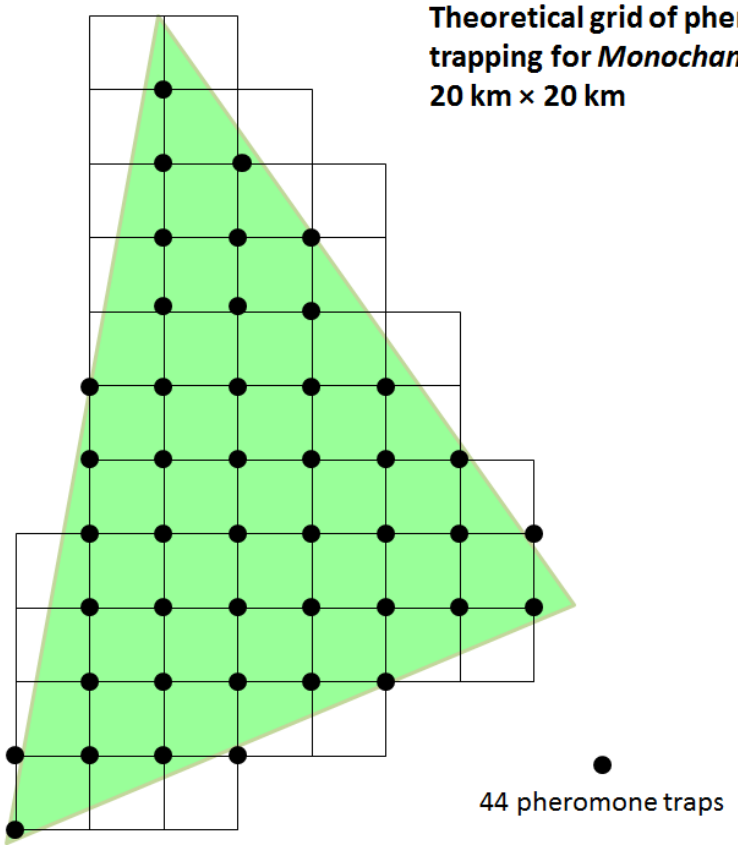
2. **Field survey** of insect vectors with **pheromone traps** for early warming detection of PWN establishment

2.2. Improved strategy: systematic grid of traps



Aquitaine forest
200 km NS – 120 km EO



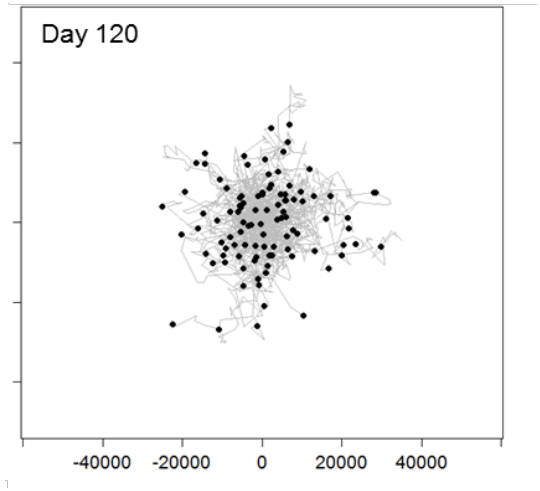


2. **Field survey** of insect vectors with **pheromone traps** for early warming detection of PWN establishment

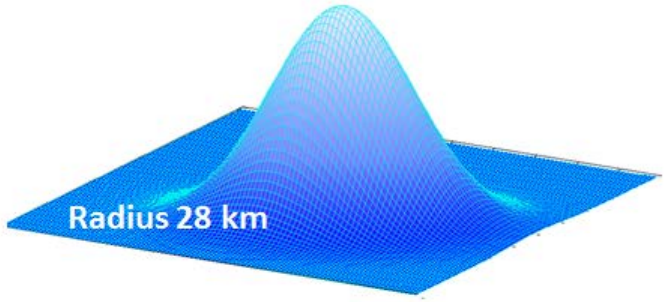
2.2. Improved strategy: systematic grid of traps

Modelling the distances travelled by insects based on flight mill and mark-release-recapture experiments. (submitted)

Christelle Robinet[a*], Guillaume David[b,c], Hervé Jactel[b]

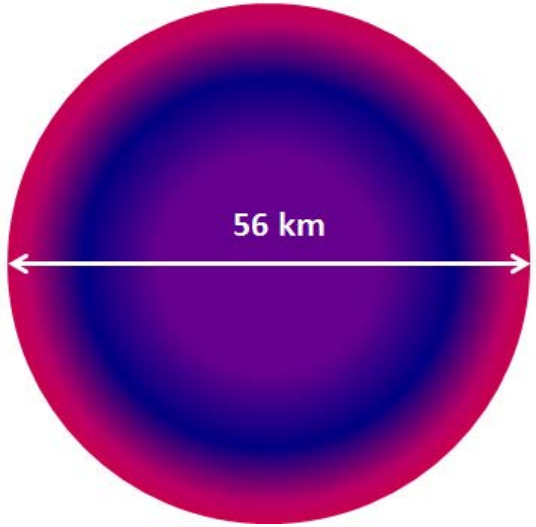


Mean dispersal distance = 13 km



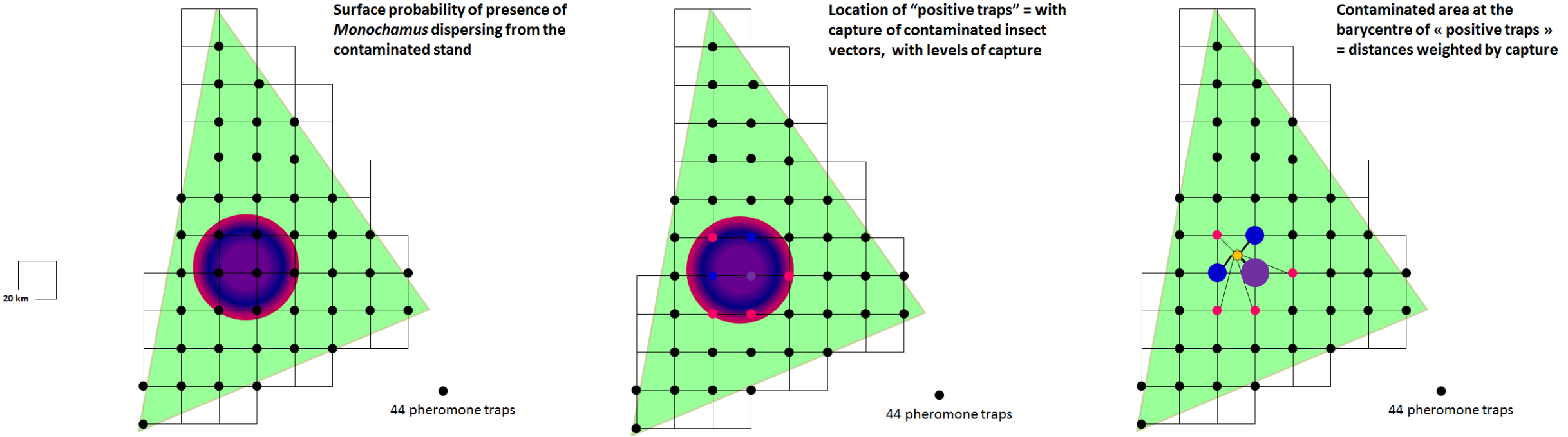
3D representation of frequency distribution of flying distances from the contaminated area

2D representation of frequency distribution of flying distances from the contaminated area



2. **Field survey** of insect vectors with **pheromone traps** for early warming detection of PWN establishment

2.2. Improved strategy: systematic grid of traps



2. **Field survey** of insect vectors with **pheromone traps** for early warming detection of PWN establishment

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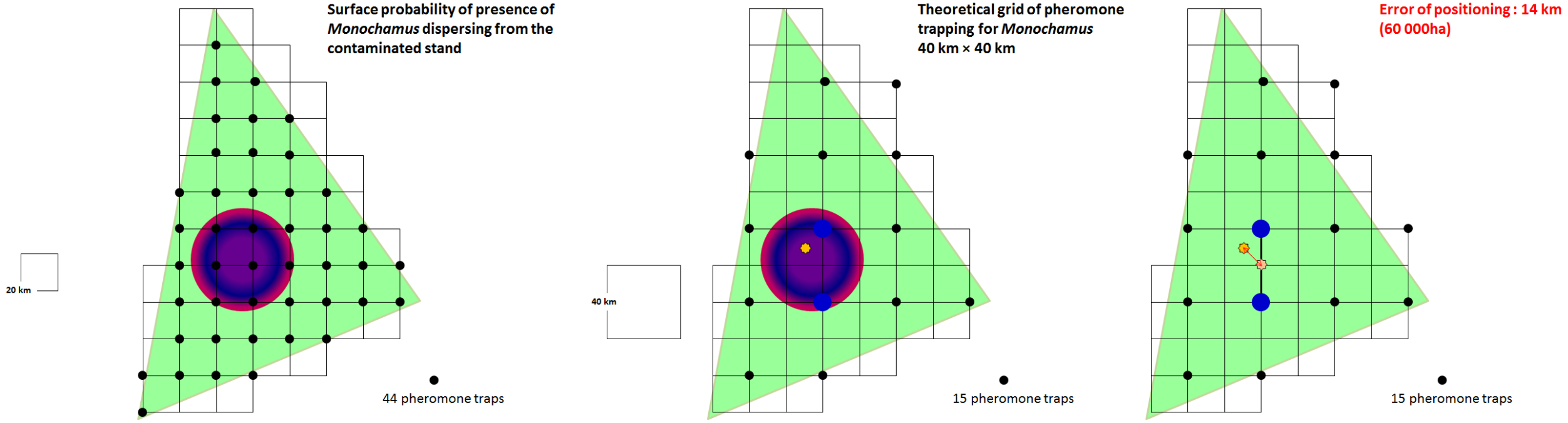

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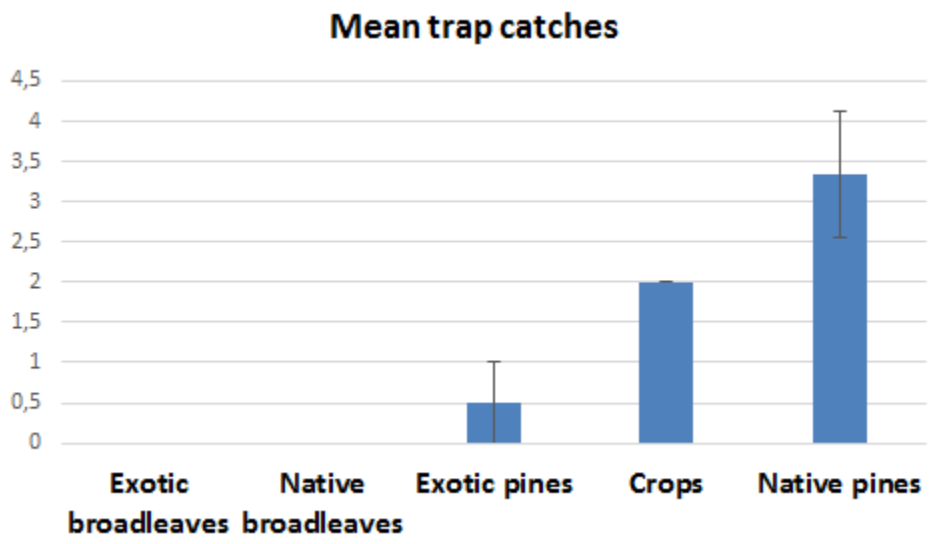
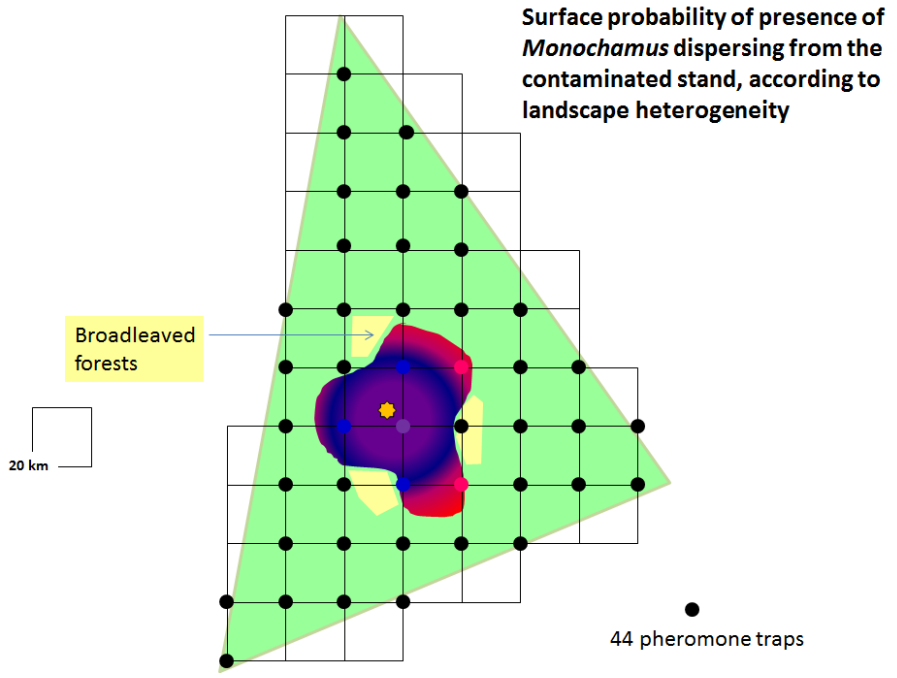


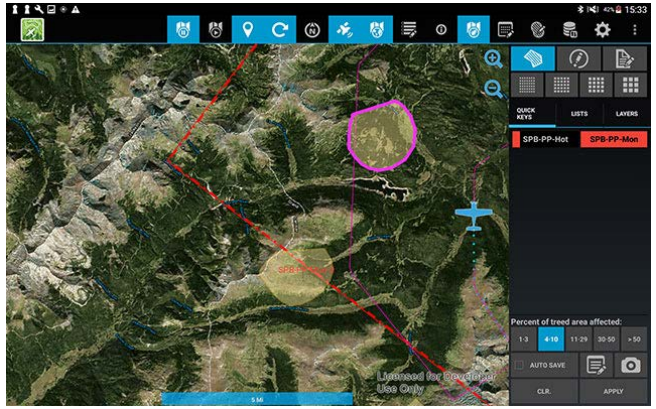


Next steps in PWN risk management

- **Remote sensing of PWN infected trees**
  - Confirm the prediction model with drone hyperspectral images
  - Test more accurate satellite images

  - **Investigate aircraft or helicopter sketch mapping of PWN symptomatic trees**

Digital Mobile Sketch Mapping (DMSM)



  - **Develop automatic image analyses to identify spatiotemporal patterns of PWN induced tree decline**

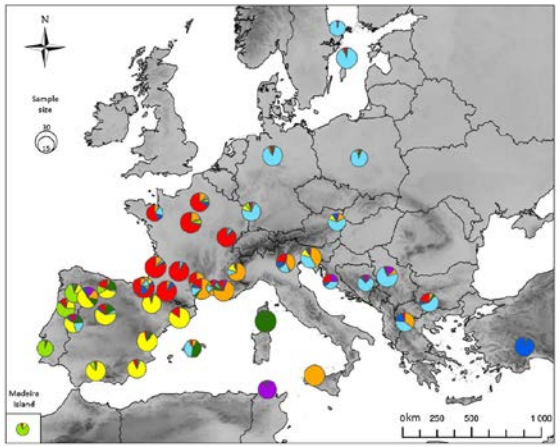
Next steps in PWN risk management

- **Pheromone trapping of the insect vector**
  - Refine the individual-based dispersal model of *Monochamus*, in realistic landscapes
  - Apply the model to optimize a systematic grid of traps
  - Discuss with tree health managers about implementation of systematic grid of traps (pre vs. post detection in risk areas)

  - **Develop DNA bar coding for identifying the geographical origin of trapped beetles**

Phylogeography of *Monochamus galloprovincialis*, the European vector of the pinewood nematode

Julien Haran[1,2,3] · Jérôme Rousselet[1] · David Tellez[1,2] · Alain Roques[1] · Géraldine Roux[1,2]



A big thank to our associated partners!

Region	Organisation	Contact person	Associated partners
Portugal	INIAV	Edmundo Sousa	Altri Florestal Instituto da Conservação da Naturesa e das Florestas RAIZ - Instituto de Investigação da Floresta e Papel
Castilla y Leáon	TRAGSATEC	Jorge Casado	Junta de Castilla y León Empresa de Transformación Agraria
Aquitaine	INRA	Hervé Jactel	Caisse de Prévoyance et de Protection des Forêts du Sud-Ouest Direction régionale de l'alimentation, de l'agriculture et de la forêt Association Régionale de Défense des Forêts Contre l'Incendie