Risk-based surveillance strategies for early detection of *Xylella fastidiosa* in continental France

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Abstract & Highlights

- First cases of *Xylella fastidiosa*: July 2015 in Corsica & October 2015 in PACA.
- **Risk assessment** for the presence of XF in the whole country
  - ❖ South-eastern coast has highest risk, then temperate southern regions. Lower risk elsewhere.
- Design of **surveillance strategies** based on predicted risk
  - ❖ Strategy benchmarking for sampling effort ranging from 100 to 10000 sampling sites
- Comparison of surveillance strategies based on **early-detection probability**
  - ❖ Trade off between sampling in high-risk zones vs. good spatial coverage
- **Marginal effect** of detection probability, per added unit of sampling
  - ❖ It Increases up to 1000 sampling units, after that, the marginal effect decreases rapidly

Introduction

Recent detections of *Xylella fastidiosa* in Corsica and the south-eastern region of Provence-Alpes-Côte d'Azur (PACA) raised the concern about the presence of the disease in the rest of the country. Extensive sampling campaigns on known susceptible host plants have been conducted both in the surroundings of detected foci, following EU quarantine directives, and in other remote area. Although buffer zones have already been established, there is still need to continue surveilling and sampling to get more confidence in the exact delimitation of the infection, which seems to be confined to few coastal areas.

Optimal strategies should balance the need of circumscribing high-risk areas with the need to explore new locations in the attempt to increase the chances of early detection.

Disease status (2013-2019)
- **1288 positive samples**
- **PACA + Corsica**

Materials

We divided metropolitan France with a 8-km grid.
For each grid cell, we computed 100 bioclimatic variables + altitude + land use + presence/absence XF

Most relevant variables :
- Precipitation of driest month
- Precipitation seasonality
- Precipitation of driest and coldest quarters
- Solar radiation in January, August and September
- Median altitude

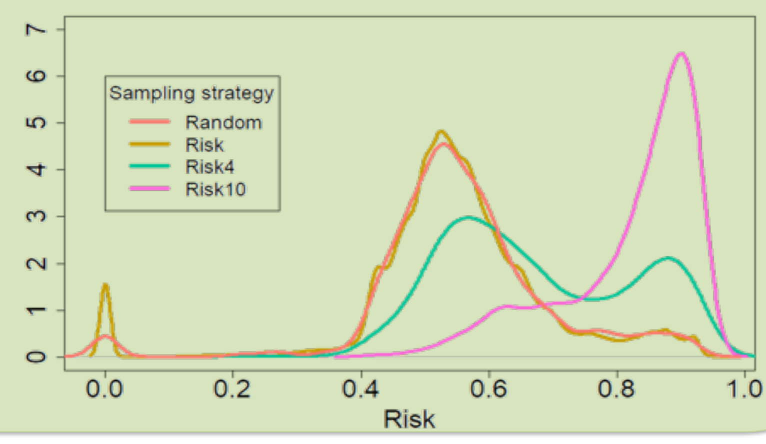
Methods

Step 1 : Variables selection with gain information + PCA.
Step 2 : Production of a risk map with MESS (Multivariate Environmental Similarity Surfaces) with selected variables. Rescale risk between 0 and 1.
Step 3 : Design of 7 risk-based surveillance strategies with increasing number of sampling sites : 100, 500, 1000, 5000 and 10000
Step 4 : Evaluate the efficacy of surveillance
Step 5: Identify best strategies with respect to the number of sampling sites and the trade off between spatial coverage and high-risk

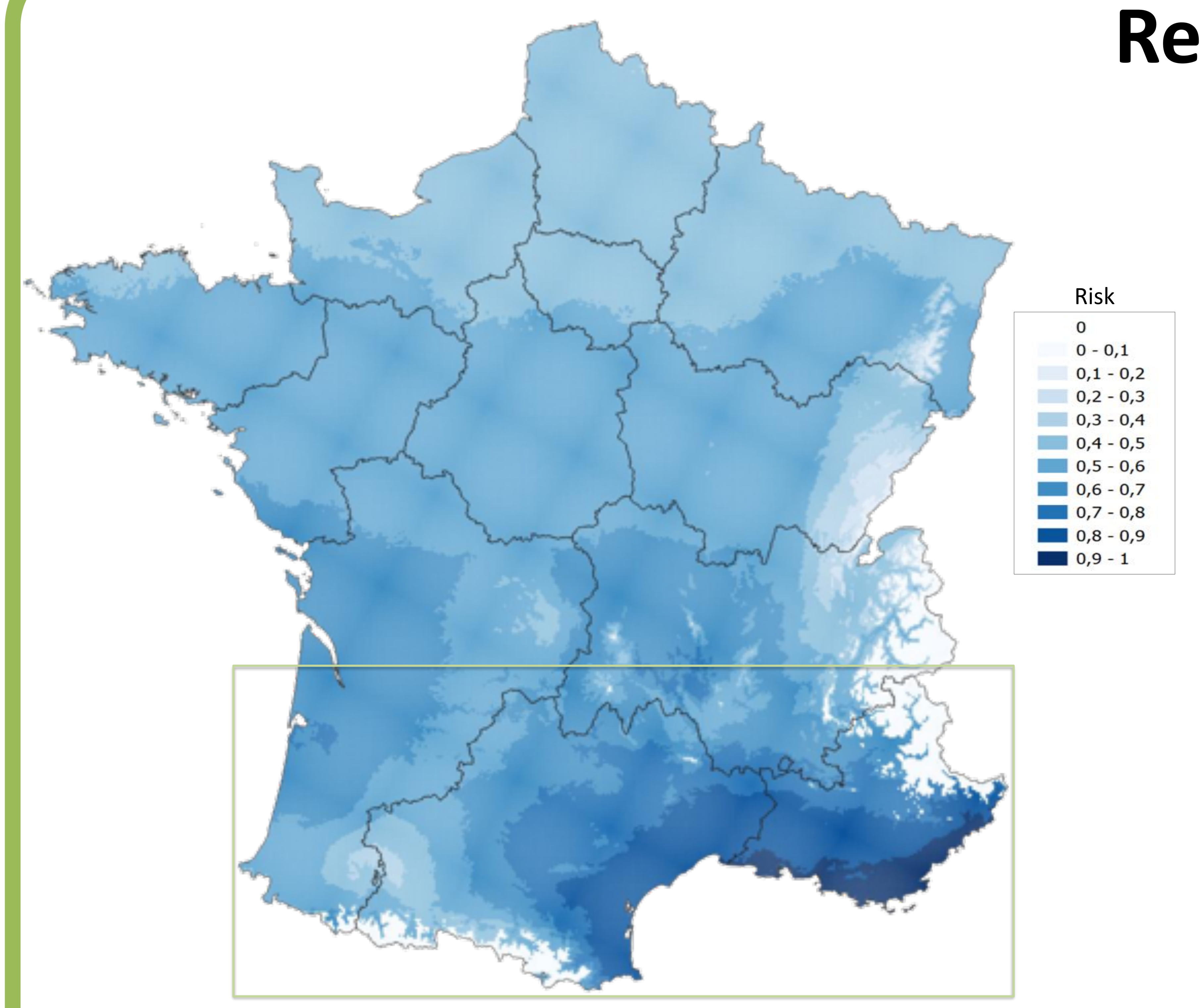
Designing surveillance strategies

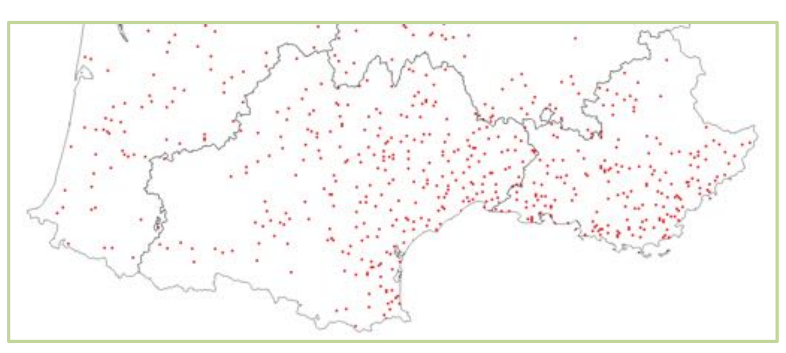
Risk-based surveillance should balance two objectives: being close to high-risk areas and maximize spatial coverage.

- Random
- Risk
- Risk2 =Risk^2
- Risk4 =Risk^4
- …
- Risk10 =Risk^{10}

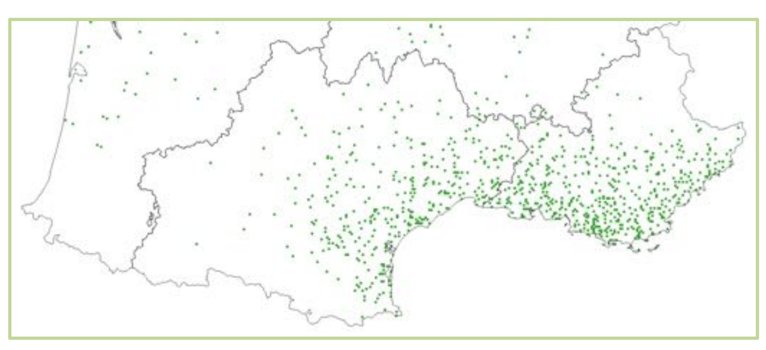


Results





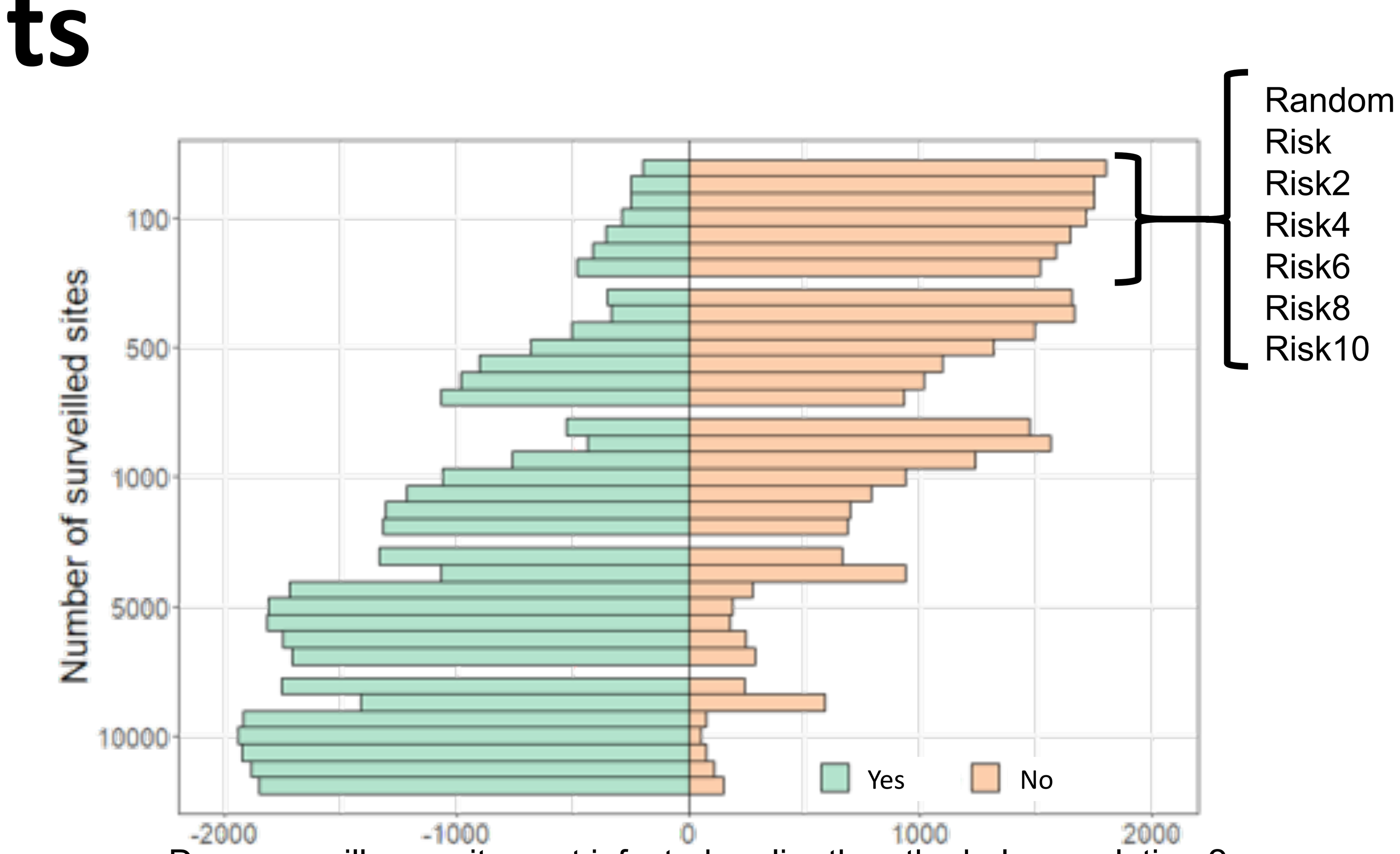
Strategy Risk4 (425 more points to the North)



Strategy Risk10 (100 more points to the North)

Comments

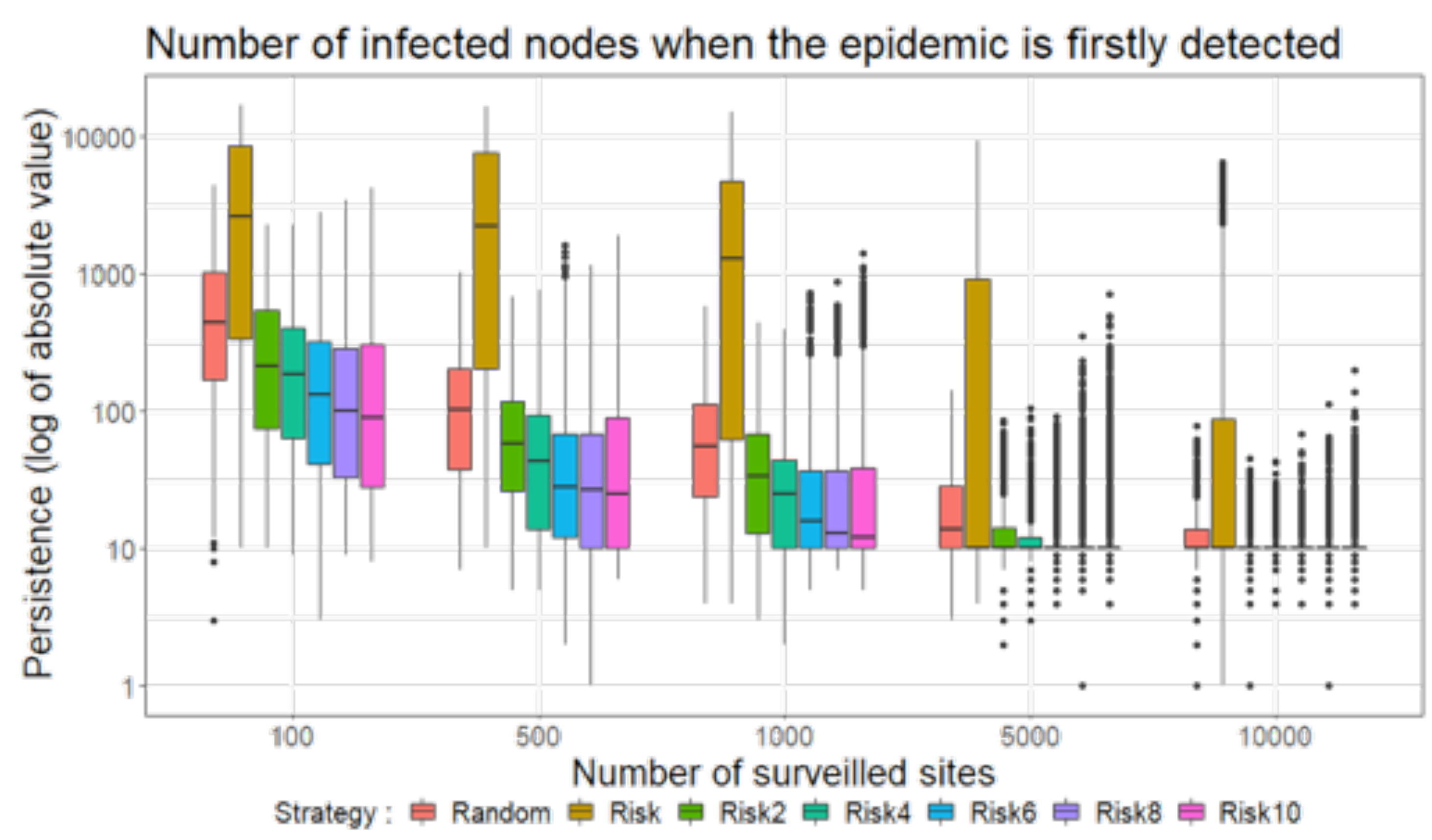
Quantitative result: with less than 1000 sampling sites, it is difficult to achieve early detection, irrespectively of the surveillance strategy
Qualitative result: Trade off between complete spatial coverage (Random strategy) and high-risk strategy (Risk 10). Risk4 and Risk6 perform better once we sample more than 1000 sites.



Does surveillance sites get infected earlier than the hole population ?

Explanation

Green bars account for the number of times in which the persistence of the epidemic on the surveillance sites reached 0.01% before reaching the same threshold on the whole population. Red bars represent the opposite situation.



Explanation

Boxplots represent the empirical distribution of the number of sites that were already infected when the first detection happened on the surveillance sites.

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