Risk maps and risk-based surveillance for early detection of Xylella fastidiosa in continental France

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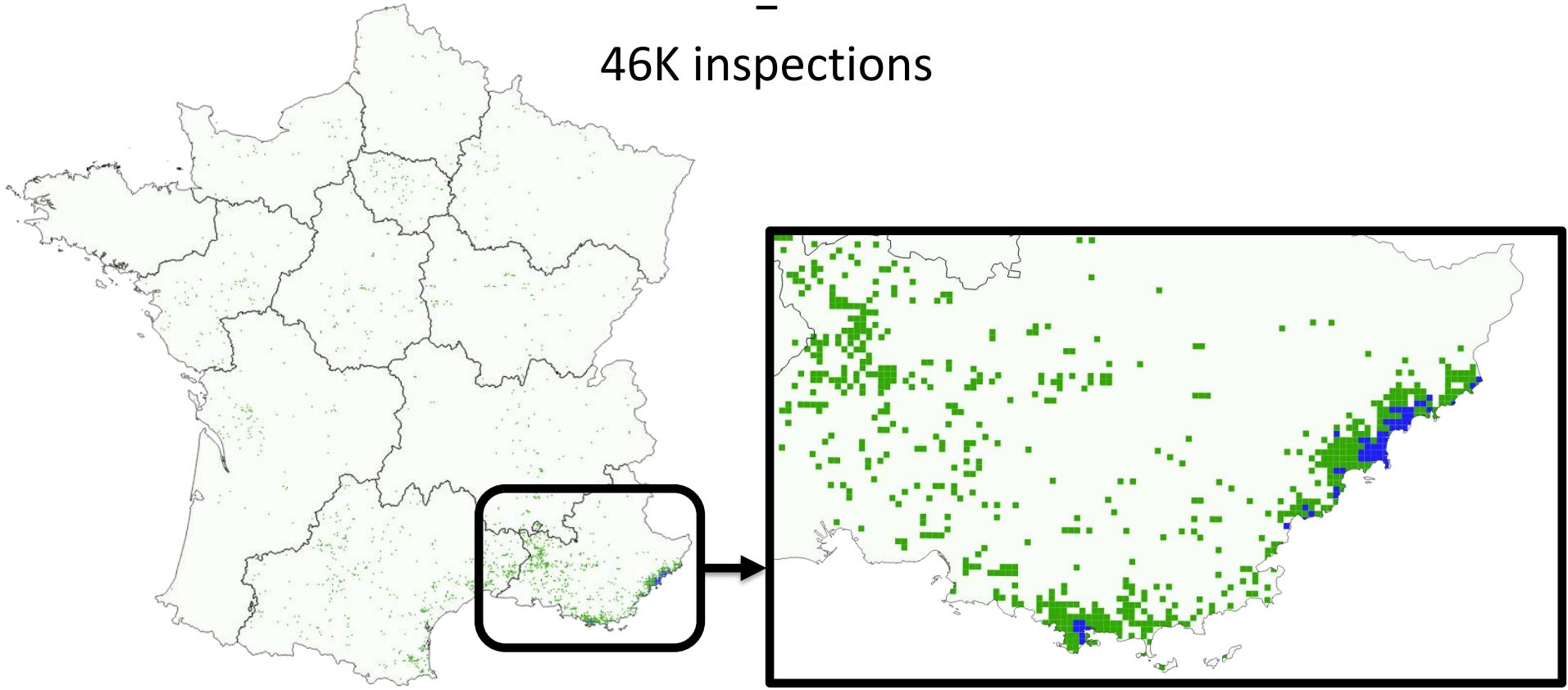
Objectives

Surveillance and early detection

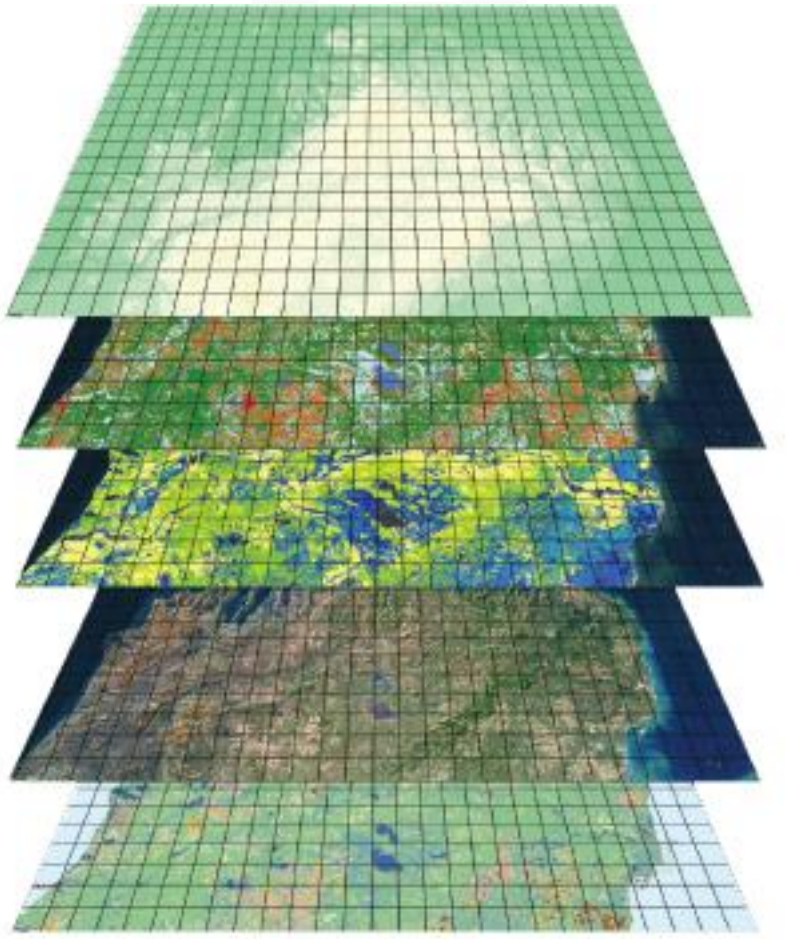
- Production of risk maps for likely appearance of Xf in France
- Design of surveillance and early detection strategies based on risk maps
- Cost-benefit of random surveillance vs. risk-based
- Draw containment and buffer zone as for Apulia, Italy

Surveillance and sampling in France since July 2015

10K in free zone +
36K in delimited zone
=
46K inspections



Data acquisition (on 8-km grid)



12 monthly min temperatures
+
12 monthly max temperatures
+
12 monthly solar radiation
+
12 monthly water vapor pressure
+
19 bioclimatic variable
+
17 land uses
+
4 min, mean, median, max altitudes

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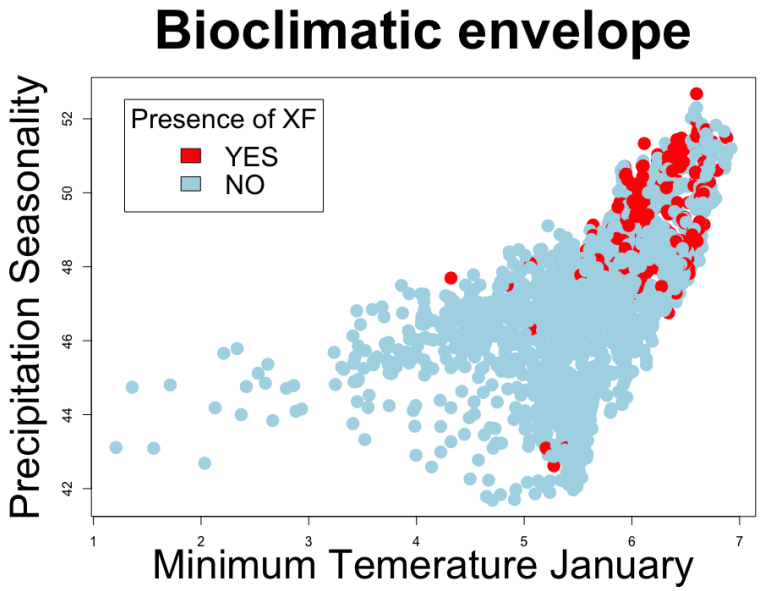
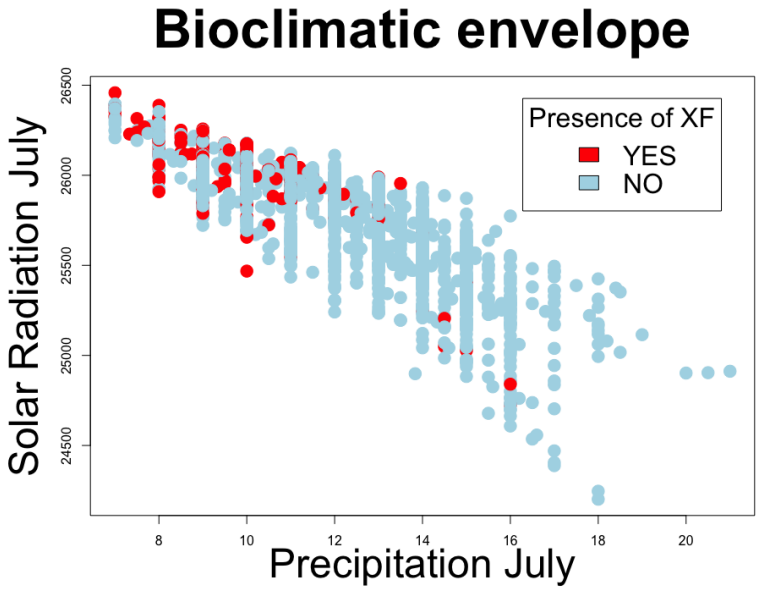
100 variables

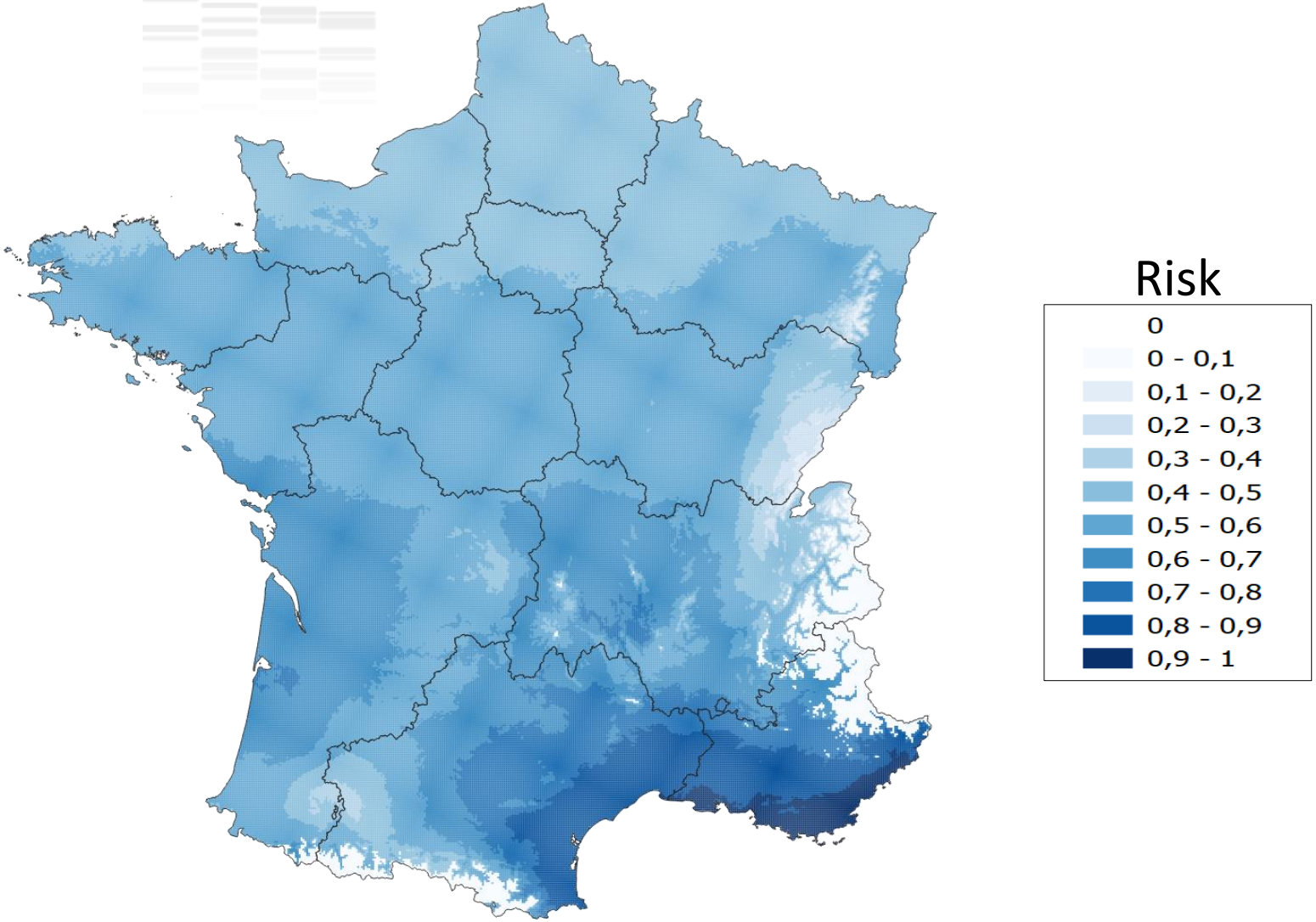
Feature Selection

1. **Water stress** correlates positively with presence of XF
2. **Mild winters** correlate positively with presence of XF
3. **Precipitations in summer** corr. positively with XF
4. **Strong solar radiation** corr. positively with XF





Multivariate Environmental Similarity Surface (MESS)



Elith et al. 2010, Methods in Ecology and Evolution 1.

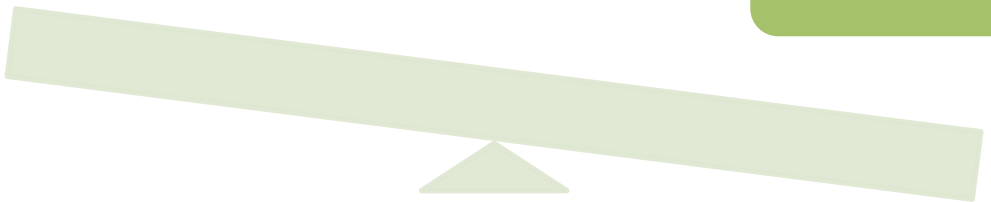
Designing surveillance strategies

Spatial Coverage

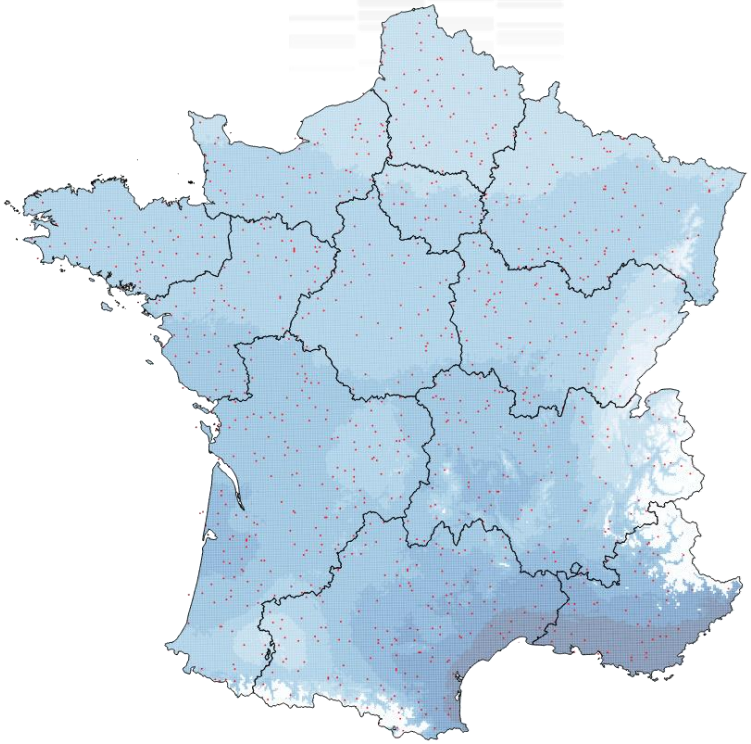
- Health status of all France
- Multiple introductions

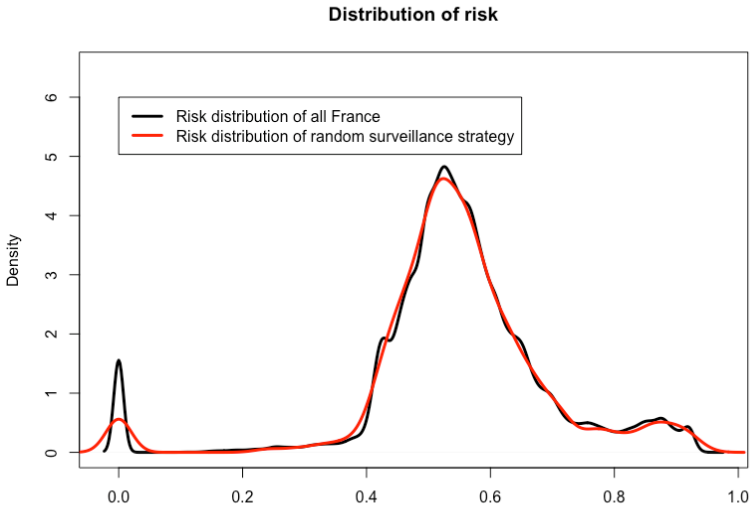
Focus on high risk

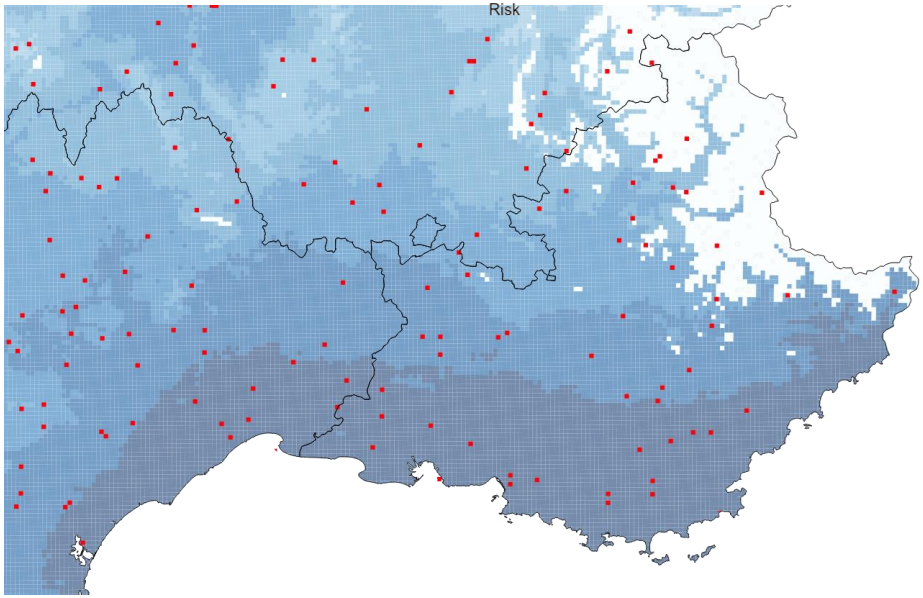
- Delimitate the infected area
- EU Quarantine
- Early detection



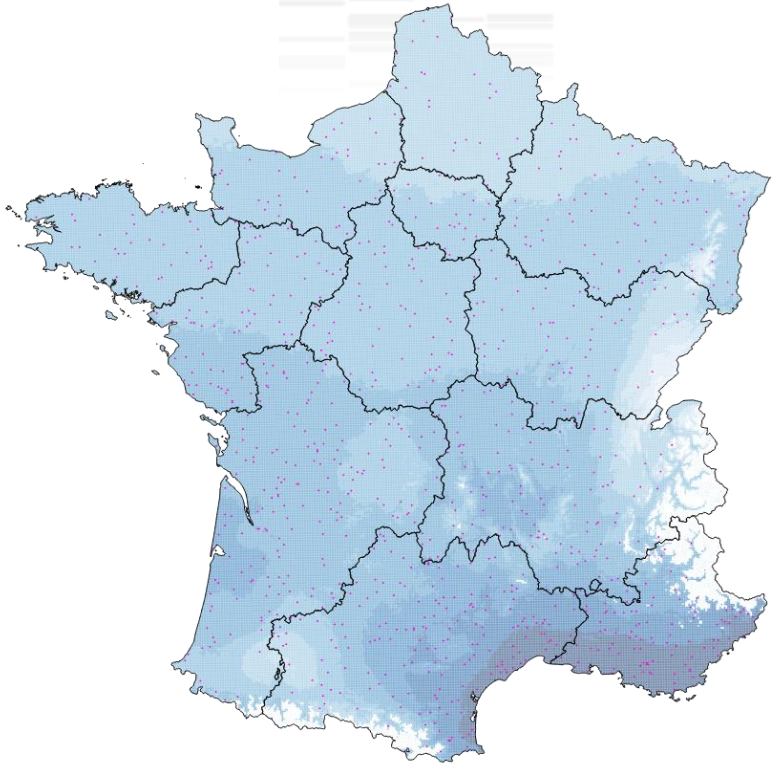
Random strategy: maximum spatial coverage

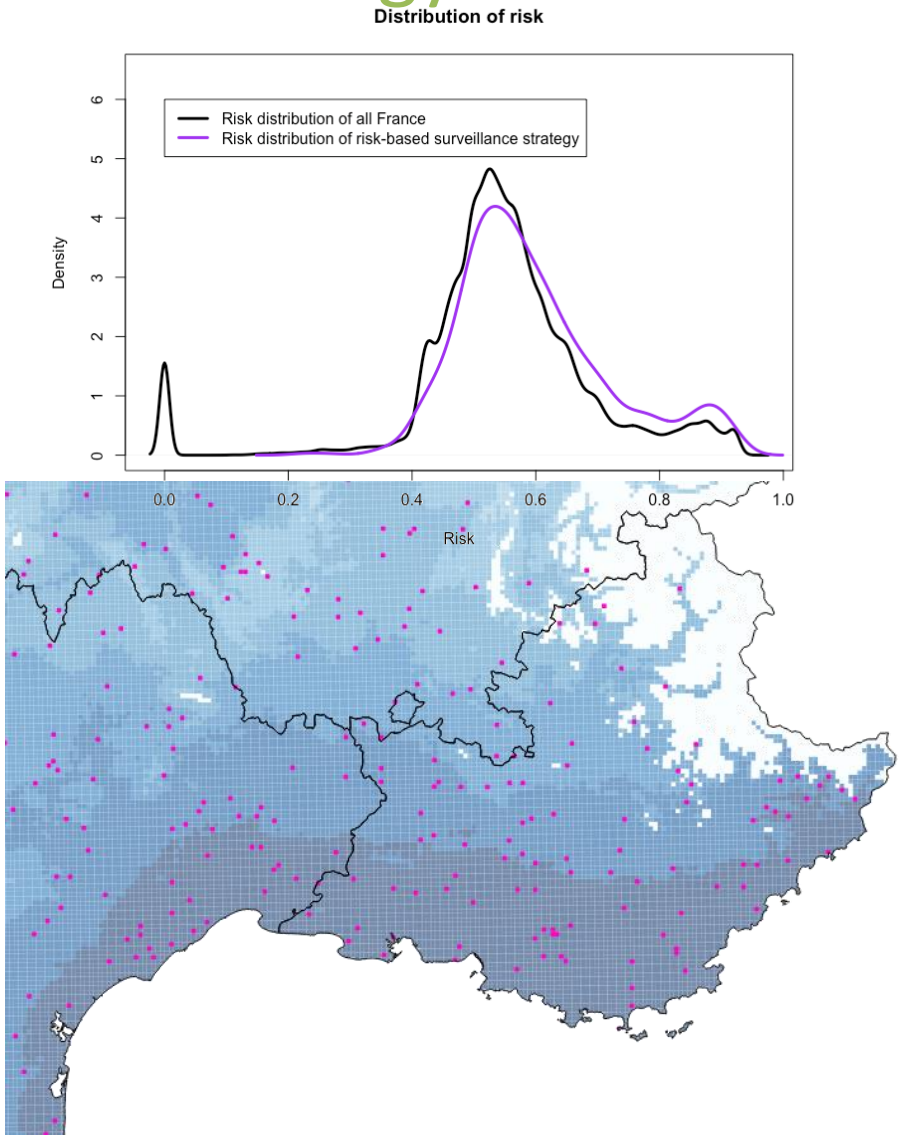




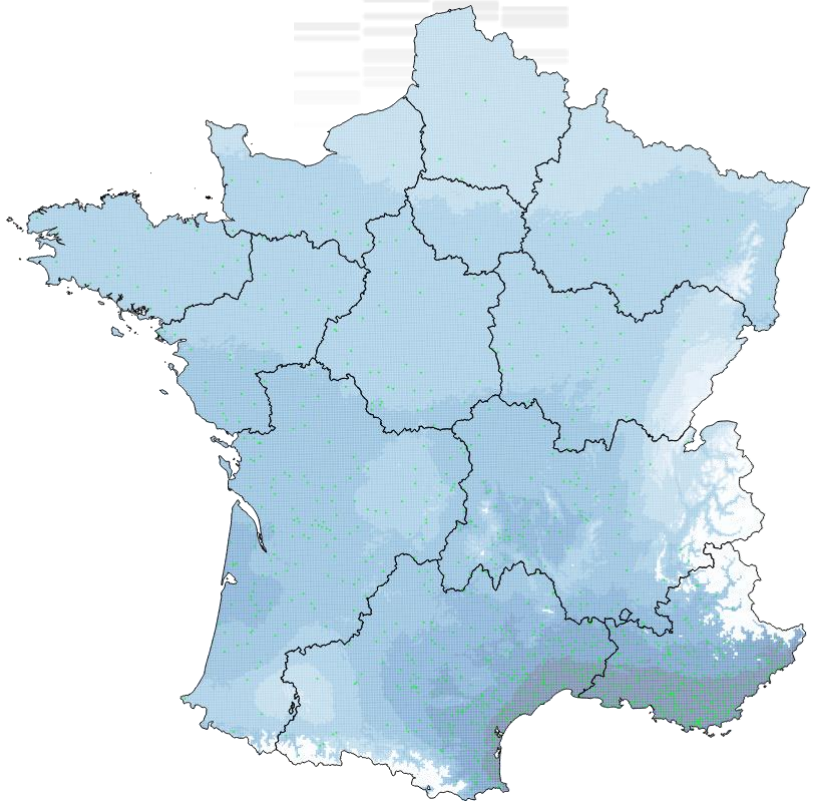


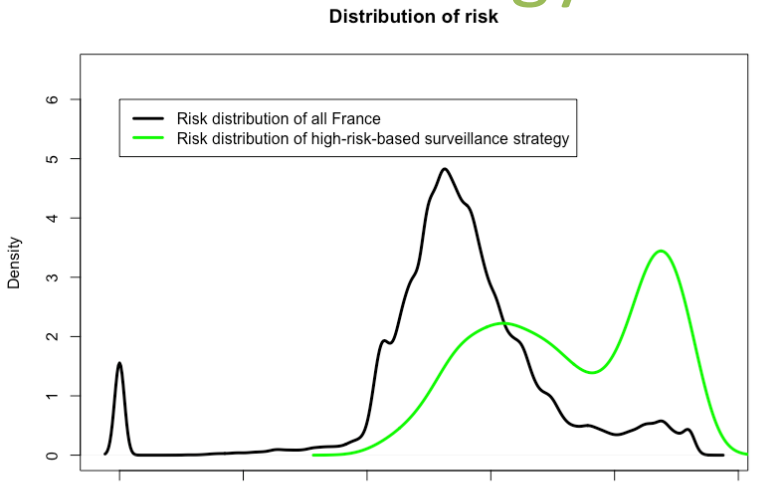
Risk-based strategy

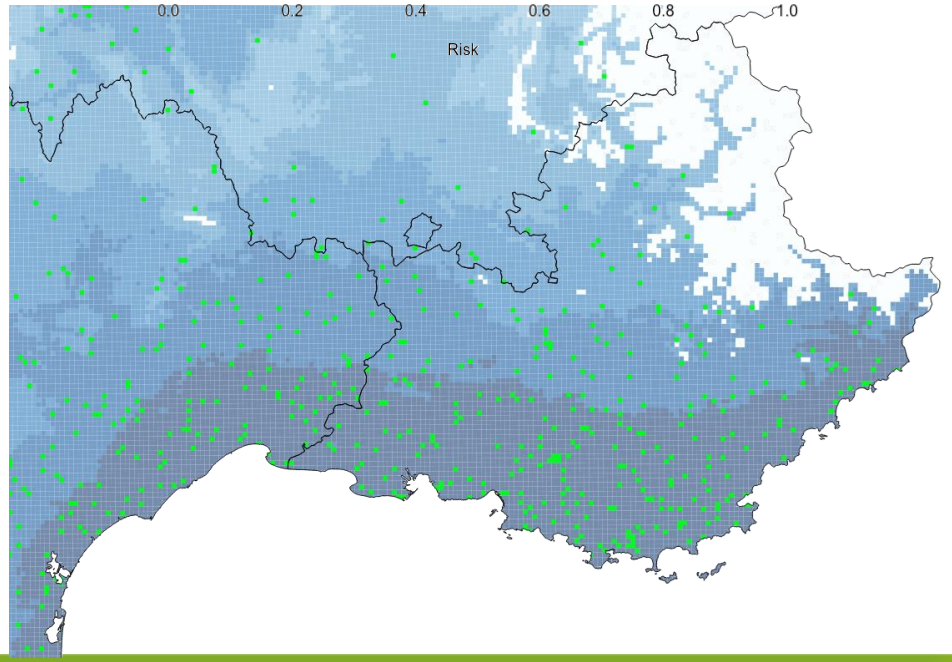




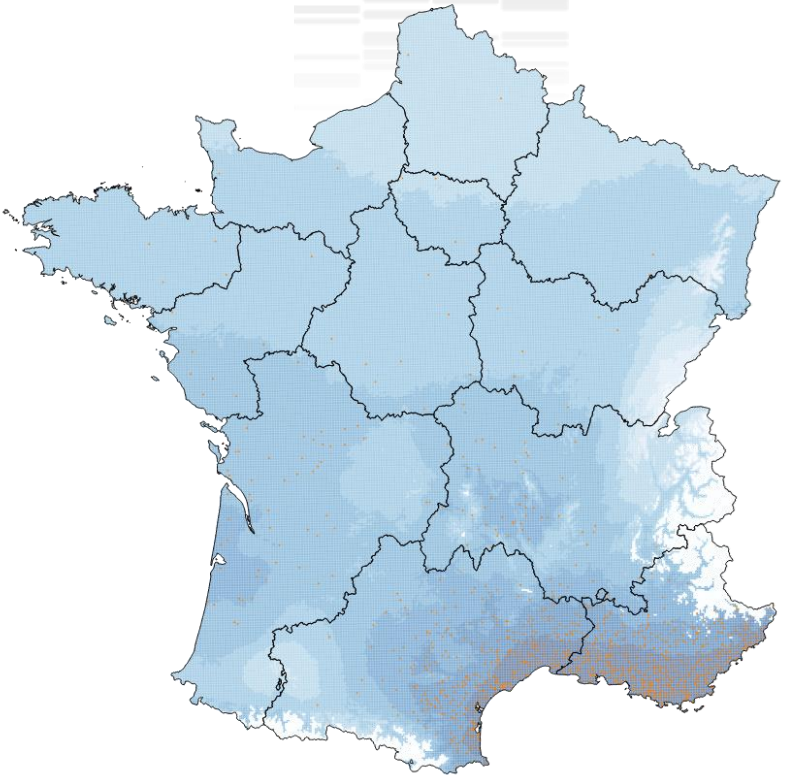
Moderate-risk-based strategy

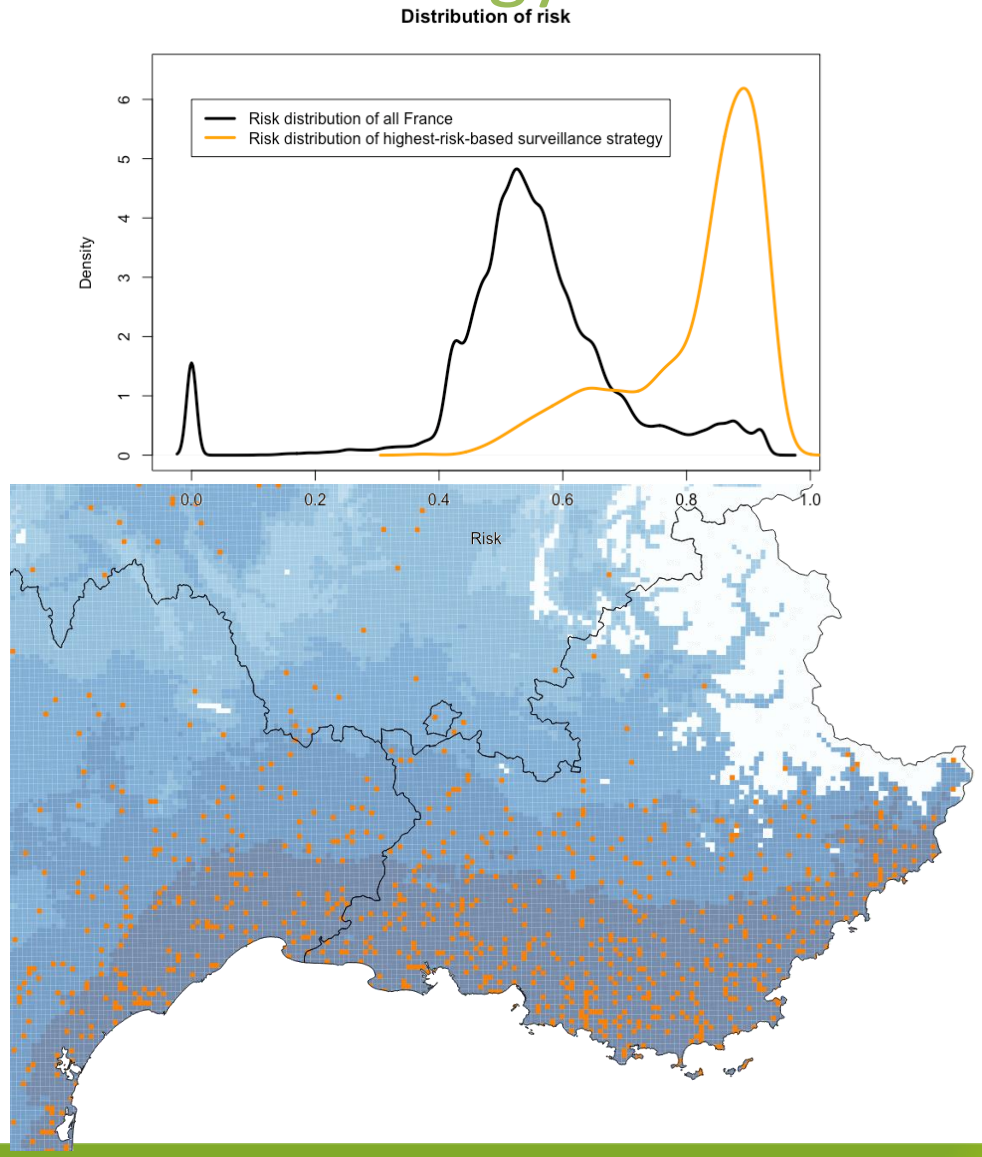






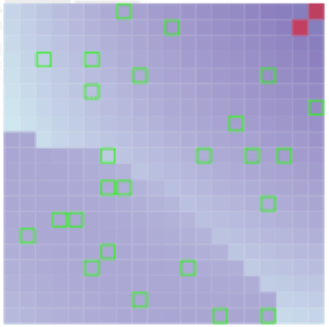
High-risk-based strategy

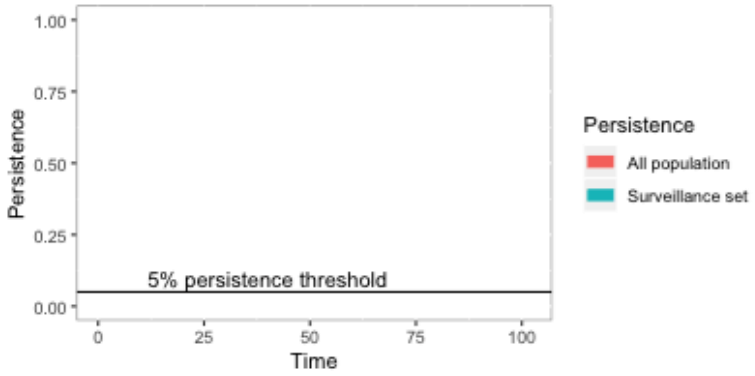




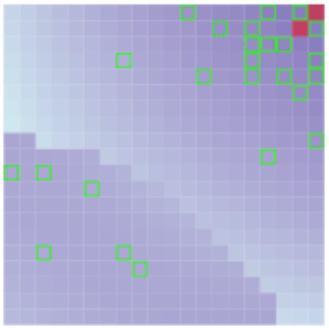
Evaluating surveillance strategies

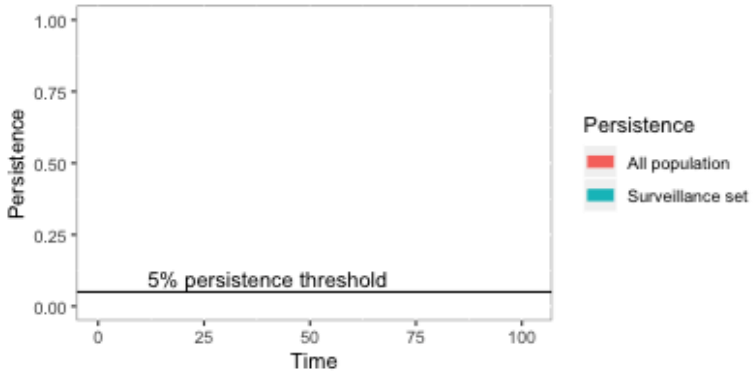
Random strategy



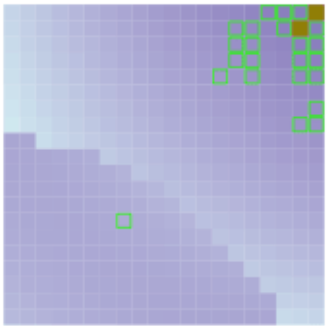


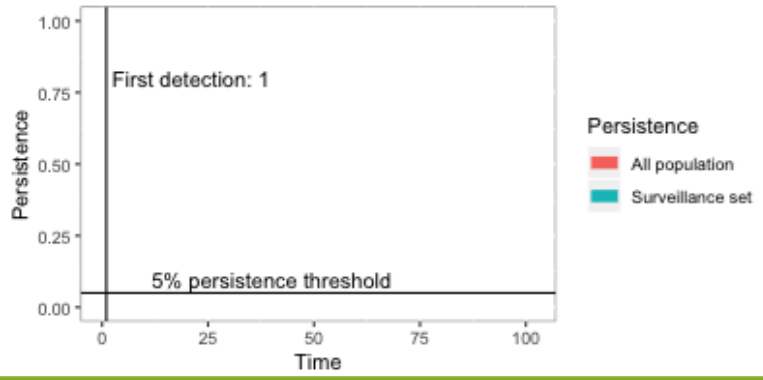
Risk-based strategy



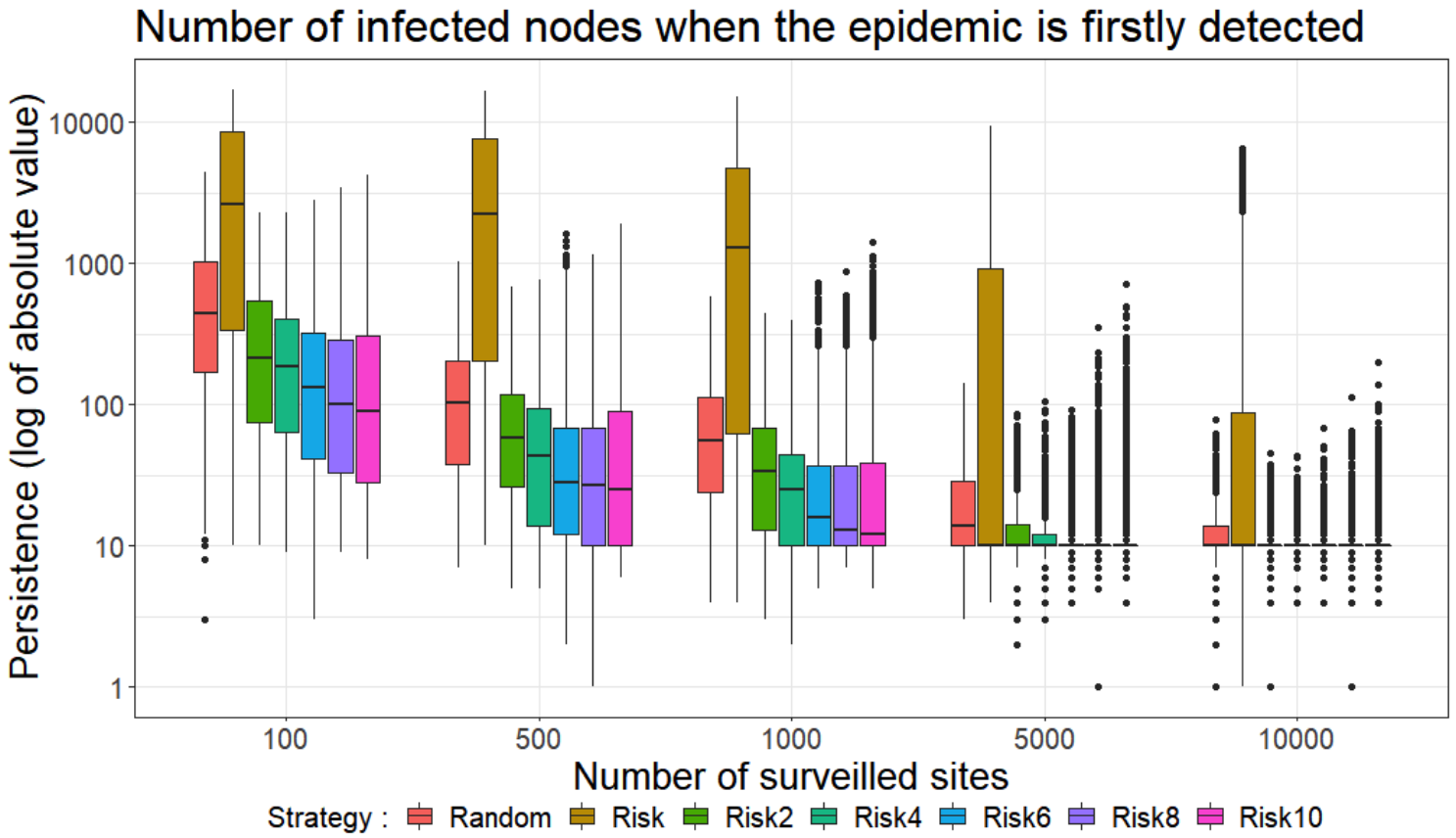


High-risk-based strategy



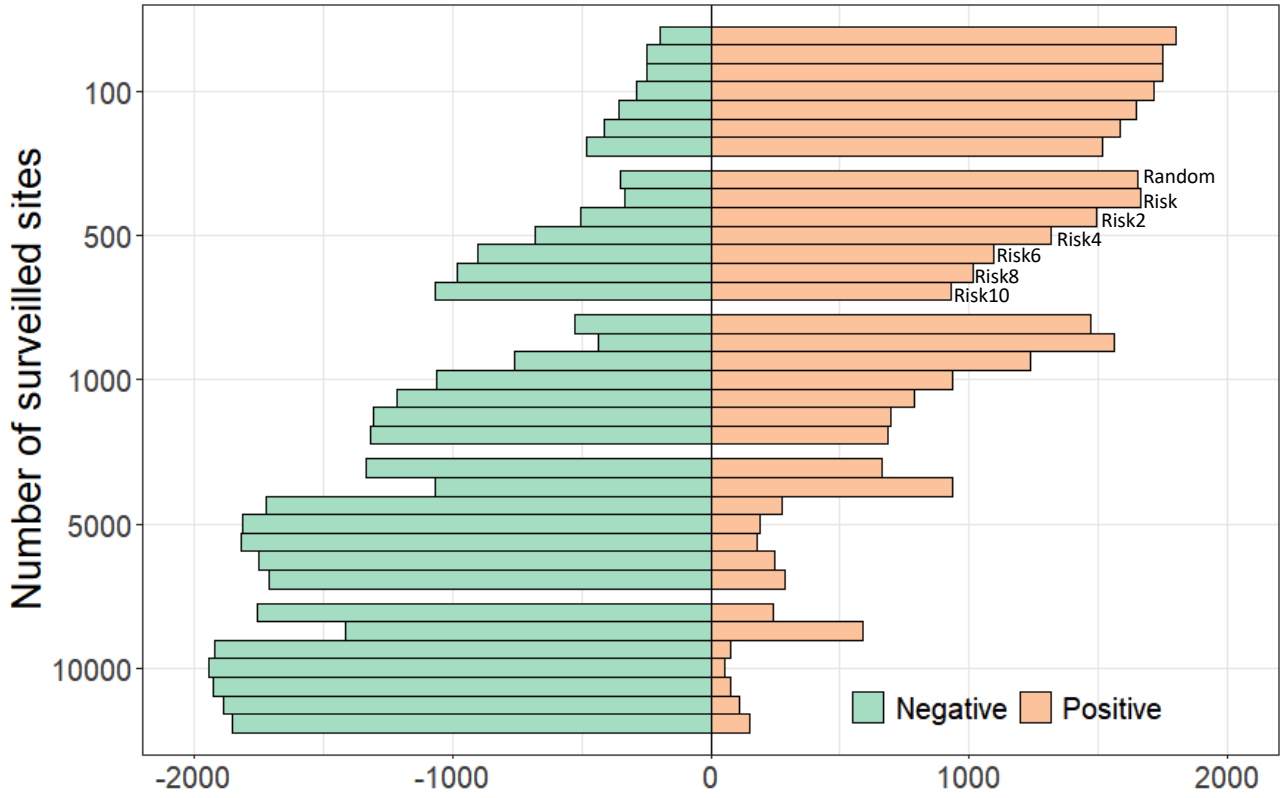


Results: Time of first detection



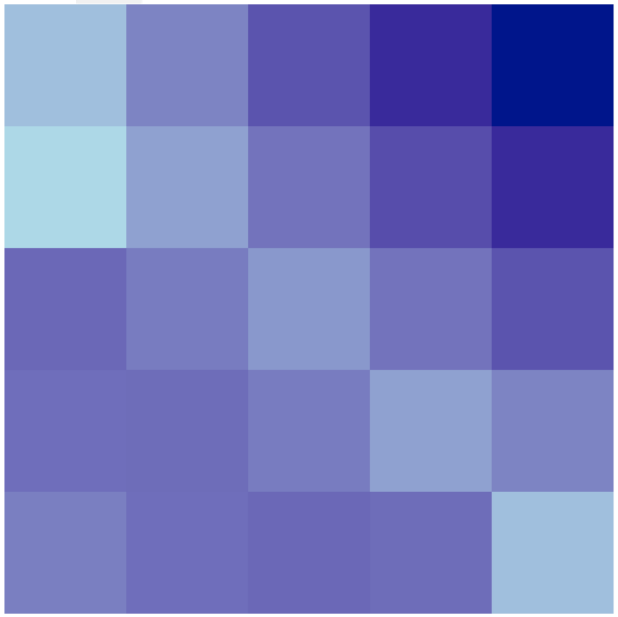
Boxplots represent the average persistence of the epidemic on the whole population at the time of first detection

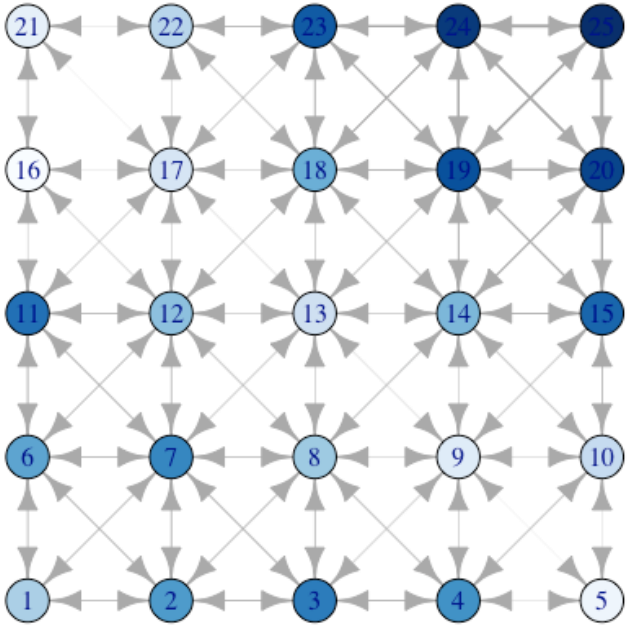
Results: 0.01% persistence threshold



Boxplots represent the average persistence of the epidemic on the whole population at the time of first detection

From risk map to contact network





Cells of the grid become nodes of the network:

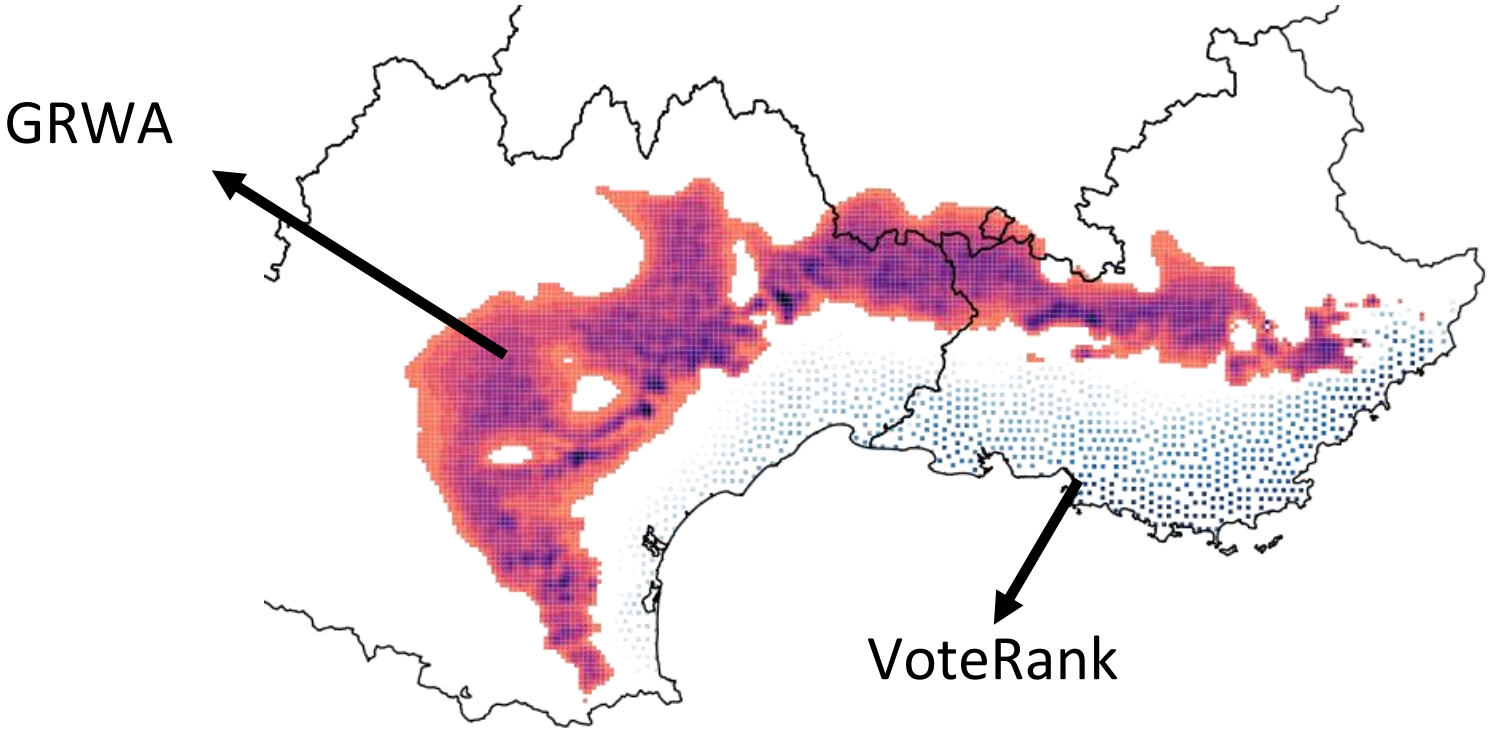
- 8 nearest neighbours
- Link between node weighted according to risk

$$w_{ij} = r_i * r_j$$

Use nodes metrics to define surveillance strategies

Generalized Random Walk Accessibility[a]: accessibility of a node from all other nodes, weighted by the inverse of the factorial of the walk length

VoteRank[b]: modified version of PageRank algorithm



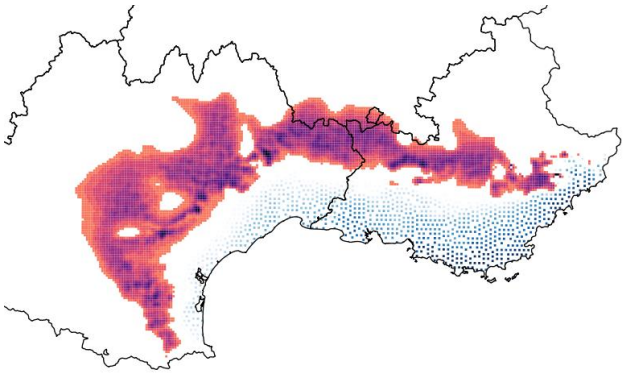
[a]de Arruda et al. (2014). Physics Reviews E, 90.
[b]Zhang et al. (2016!. Scientific Reports, 6.

Future works

1. **Network metrics** to design new surveillance strategies

2. **Simulate adaptive strategies** in order to account for the oversampling effort close to identified foci

3. Define **buffer and containment** zone as for the case of Apulia and test if different sampling strategies should be used in different zones



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