Developing surveillance strategies for *Xylella fastidiosa* in the Mediterranean region

Alexander Mastin (University of Salford)
Steven White (CEH Wallingford)
Daniel Chapman (CEH Edinburgh)
Stephen Parnell (University of Salford)

University of Salford MANCHESTER
1967-2017 50 YEARS

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

XF ACTORS

efsa European Food Safety Authority

UIB Universitat de les Illes Balears

European Commission

POnTE Pest Organisms Threatening Europe

XF ACTORS

Euphresco

PLAN OF TALK

1) Surveillance for *Xylella fastidiosa* in Apulia, Italy.

2) Optimising surveillance strategies.

3) Applying the method to *X. fastidiosa* in Apulia.

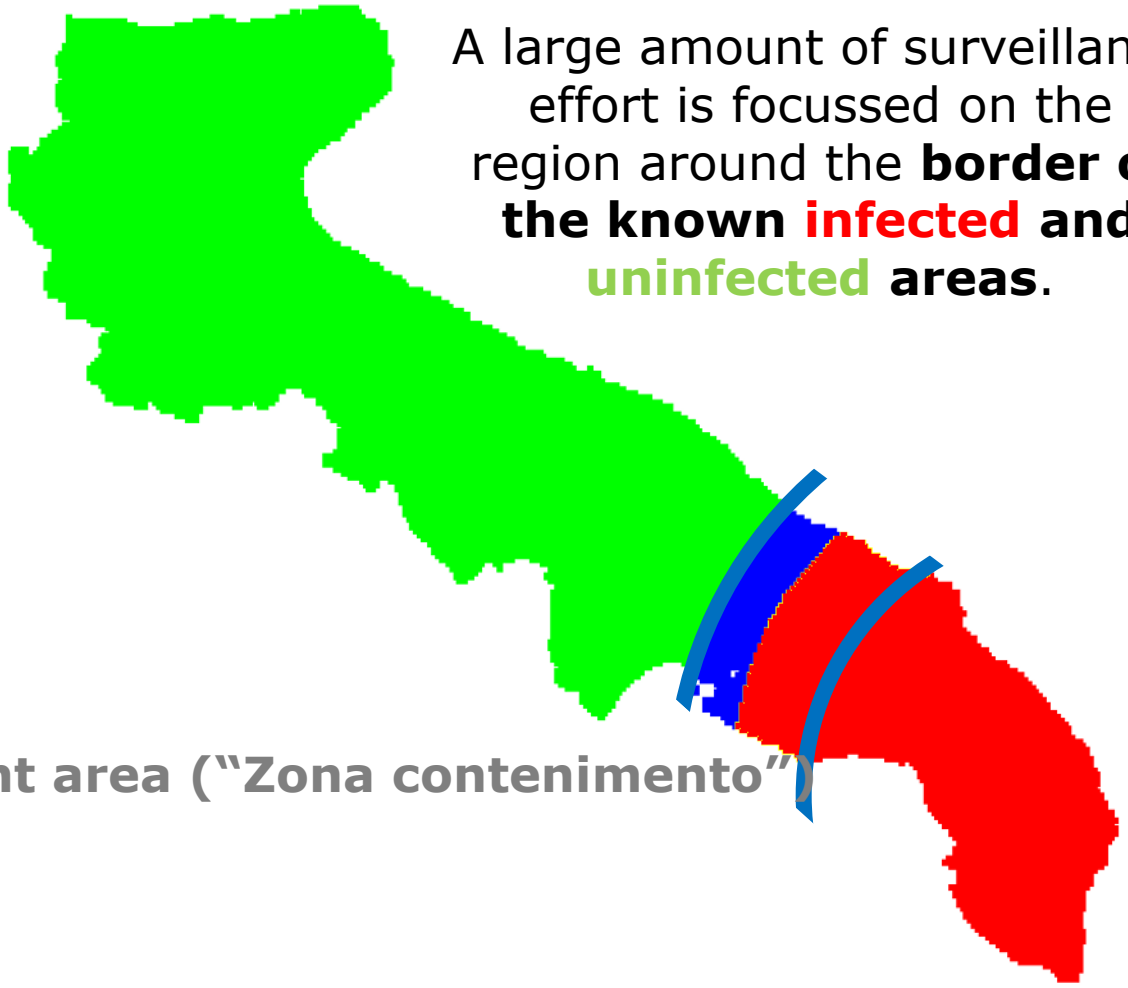
4) Preliminary conclusions.

1) SURVEILLANCE FOR *XYLELLA FASTIDIOSA* IN APULIA, ITALY

XYLELLA FASTIDIOSA IN APULIA

Eradication from southern Apulia is no longer considered possible.
Strona, G., Carstens, C. J., & Beck, P. S. (2017). *Scientific Reports*, *7*.

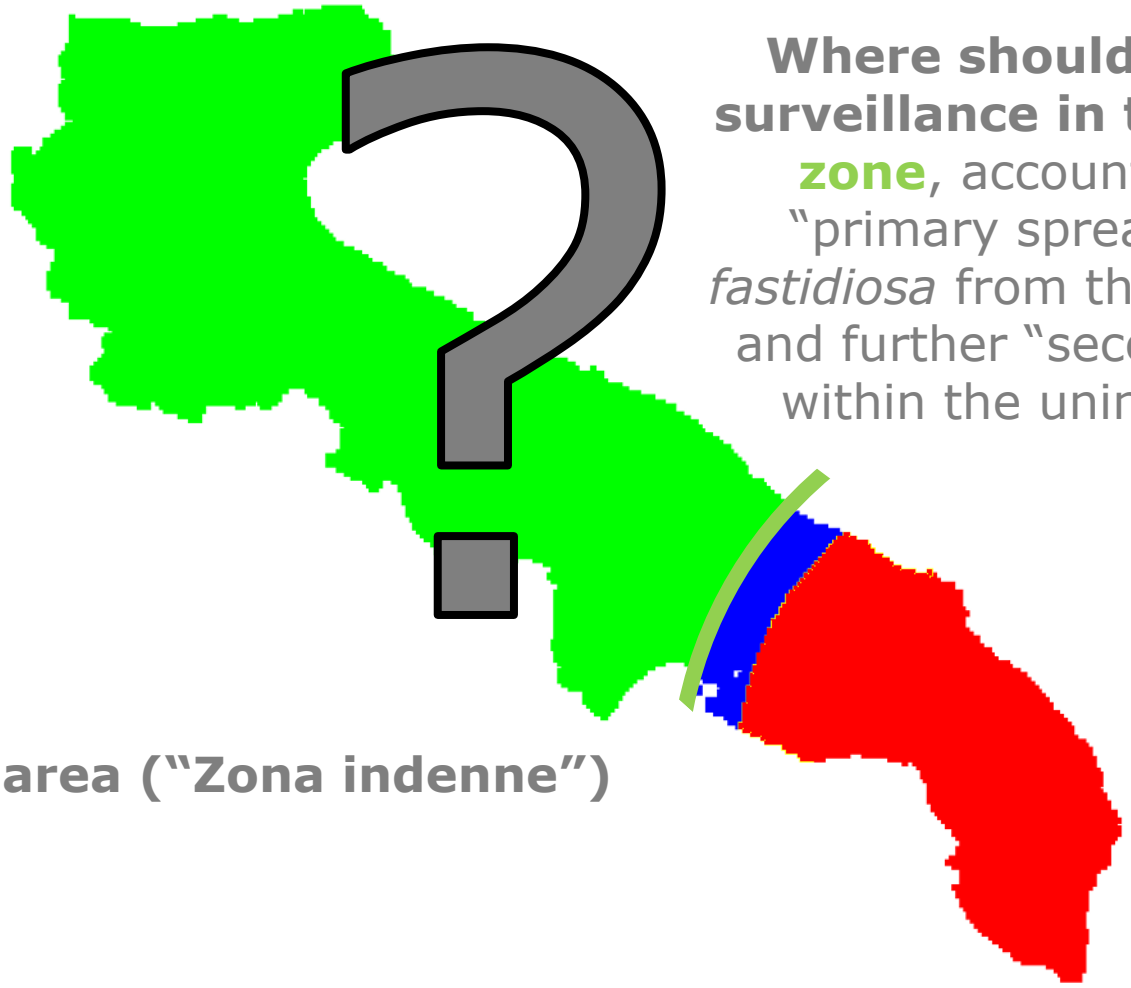
XYLELLA FASTIDIOSA IN APULIA



A large amount of surveillance effort is focussed on the region around the **border of the known infected and uninfected areas**.

Containment area ("Zona contenimento")
30km wide

XYLELLA FASTIDIOSA IN APULIA



Where should we conduct surveillance in the uninfected zone, accounting for both "primary spread" of *Xylella fastidiosa* from the infected zone, and further "secondary spread" within the uninfected zone?

Uninfected area ("Zona indenne")

2) OPTIMISING SURVEILLANCE STRATEGIES

XYLELLA FASTIDIOSA IN APULIA

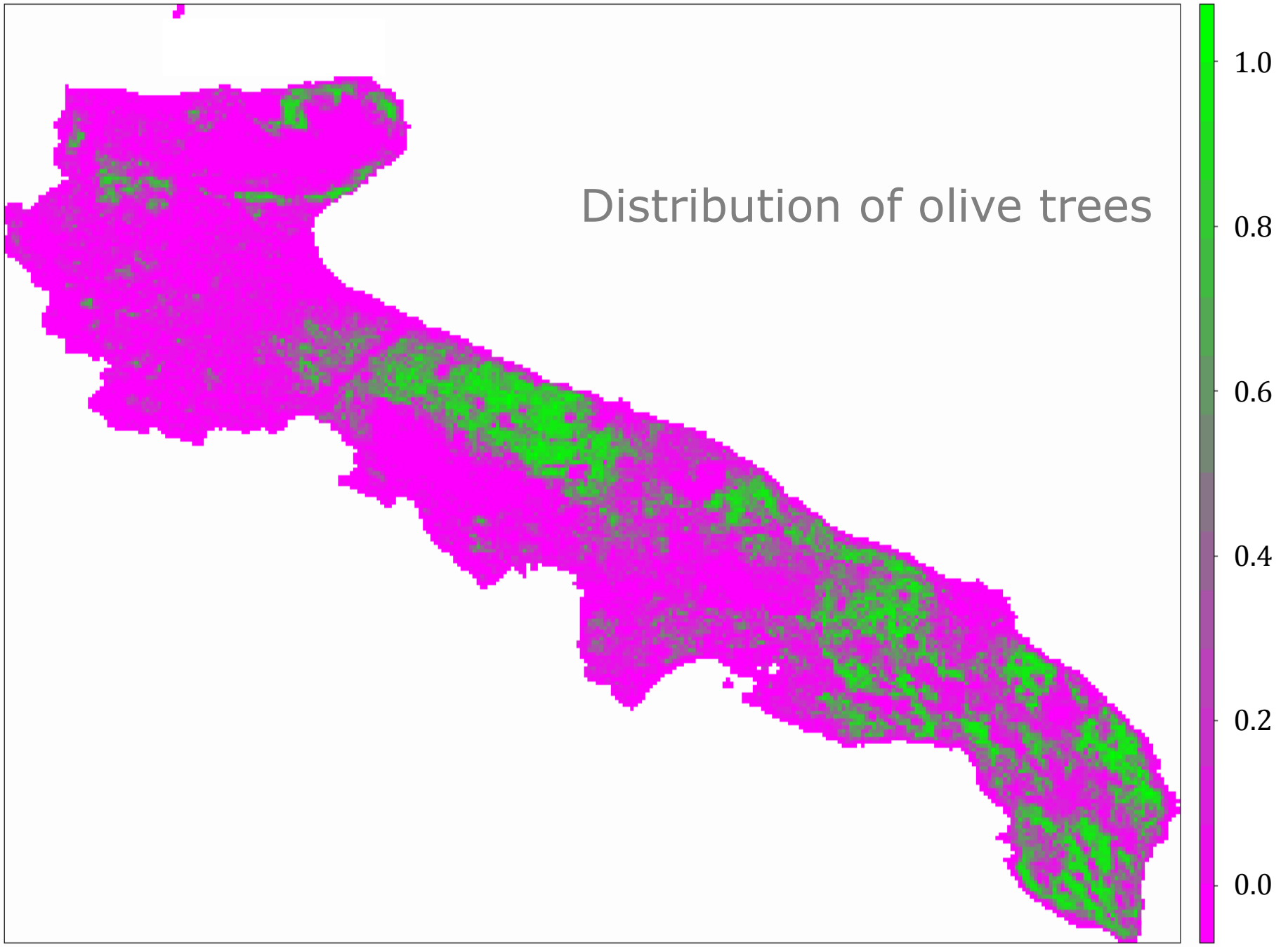
- **Surveillance strategies** are needed to detect **further spread beyond the buffer zone** so that appropriate control and containment measures can be implemented.

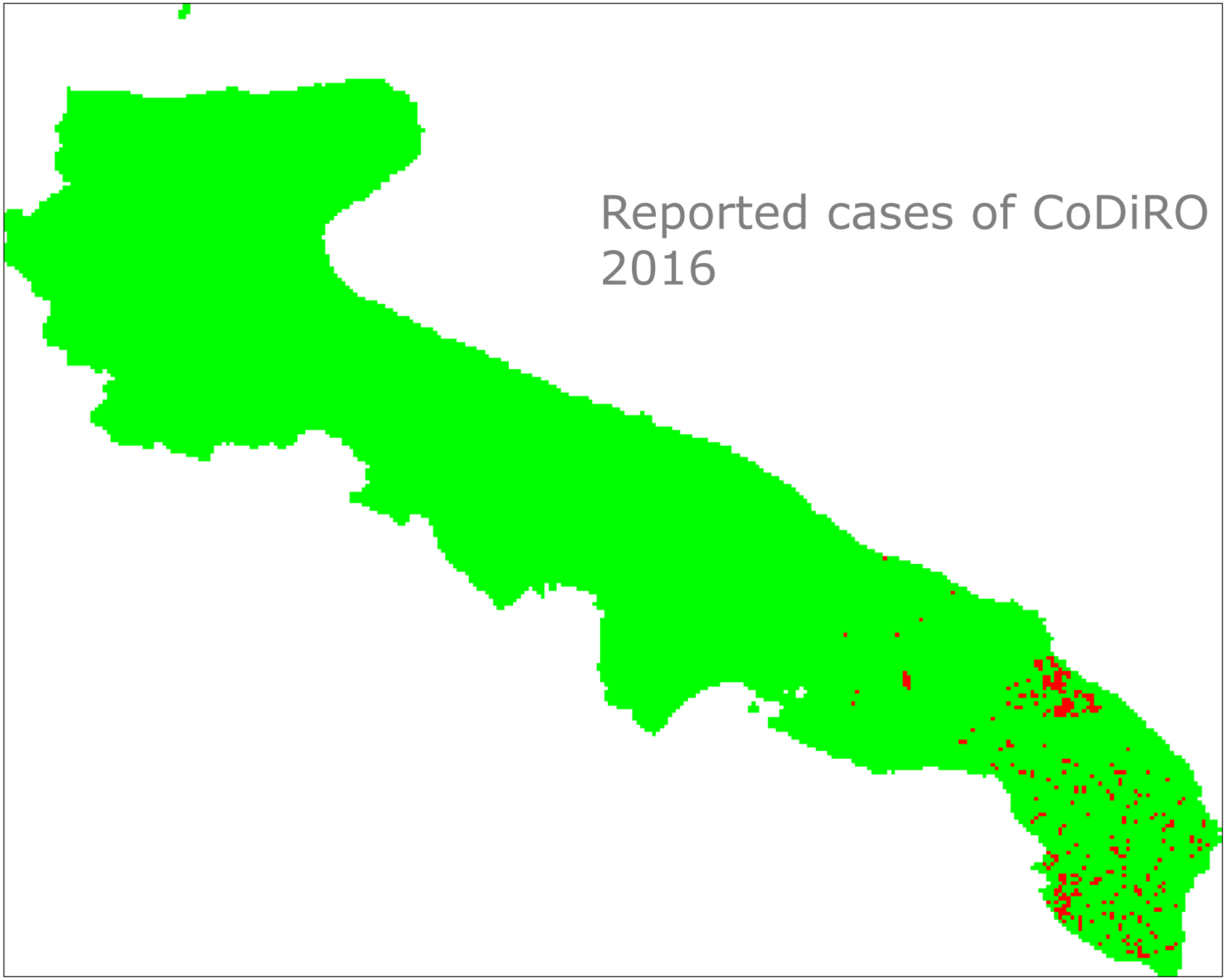
- These measures should account for the **biology of the pathogen**.

MODELLING SPREAD

Used a **grid-based, stochastic model** *(*White, S. M., Bullock, J. M., Hooftman, D. A., & Chapman, D. S. (2017). *Biological Invasions 19(6) 1825-1837)*:

- Deterministic growth in incidence within infected cells
- "Stratified dispersal":
  - Deterministic shorter-distance, "local", spread
  - Stochastic longer-distance "jumps"

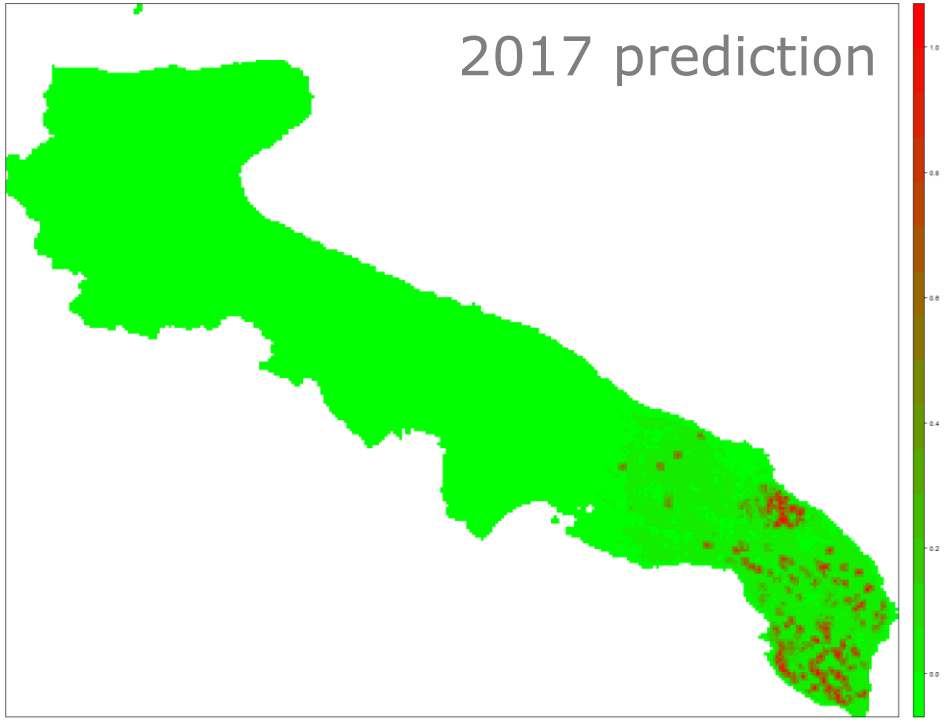

Distribution of olive trees
1.0
0.8
0.6
0.4
0.2
0.0


Reported cases of CoDiRO
2016

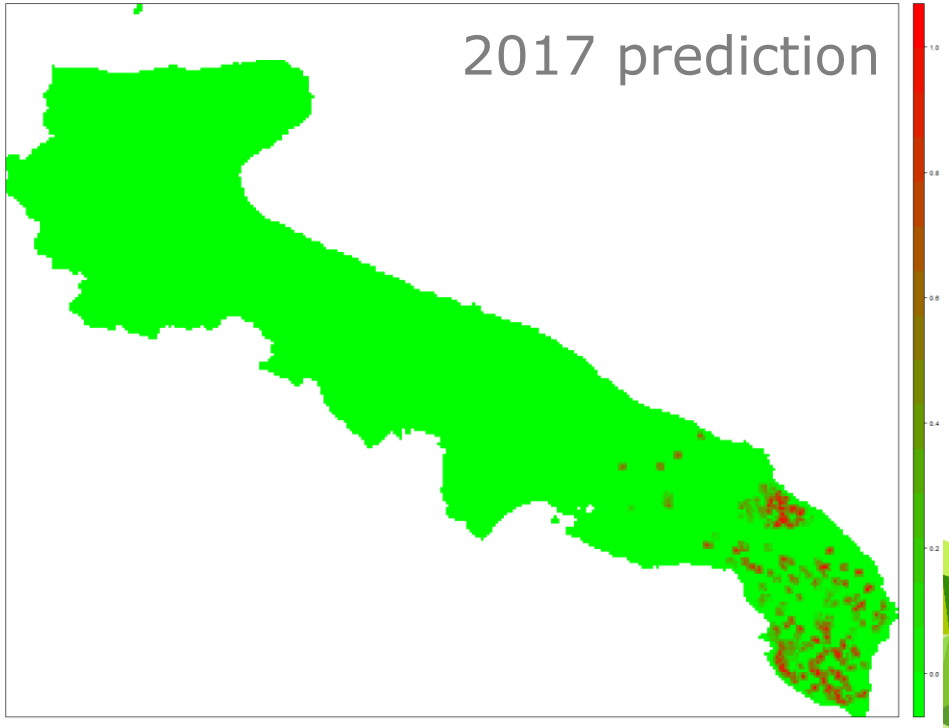
MODELLING LONG DISTANCE SPREAD

Mean incidence of infection (10,000 realisations)

Default parameters
(Gaussian long distance dispersal)



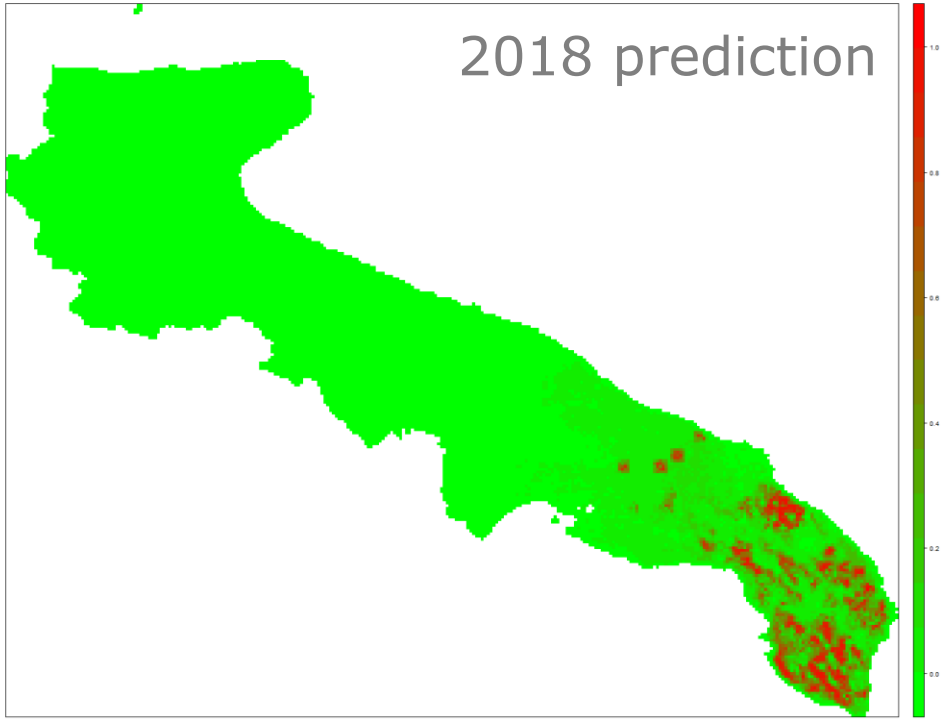
More long range spread
(Uniform long distance dispersal)



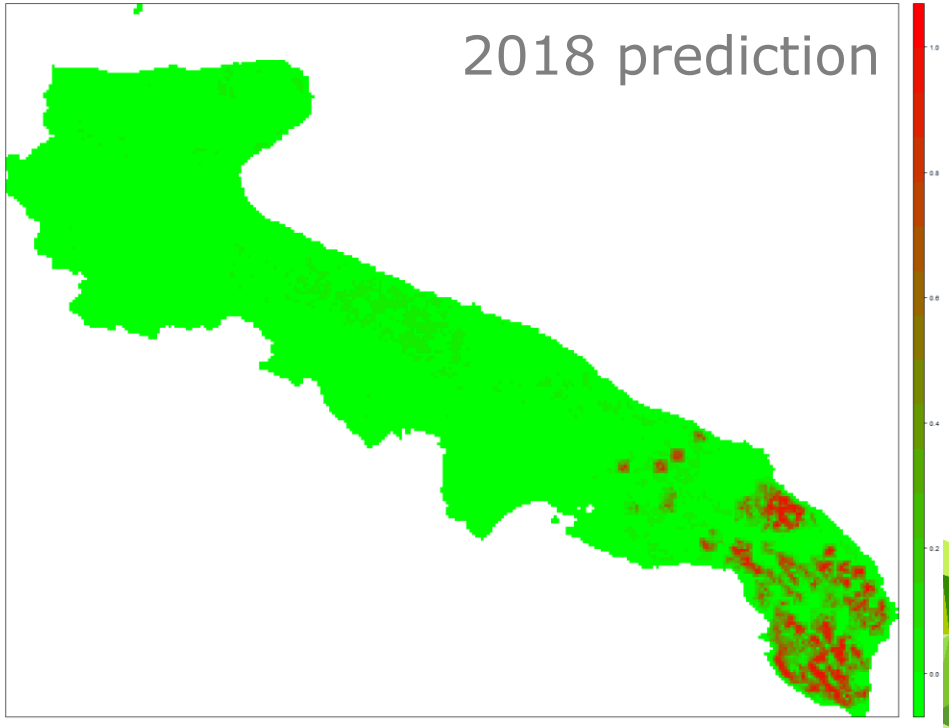
MODELLING SPREAD

Mean incidence of infection (10,000 realisations)

Default parameters
(Gaussian long distance dispersal)



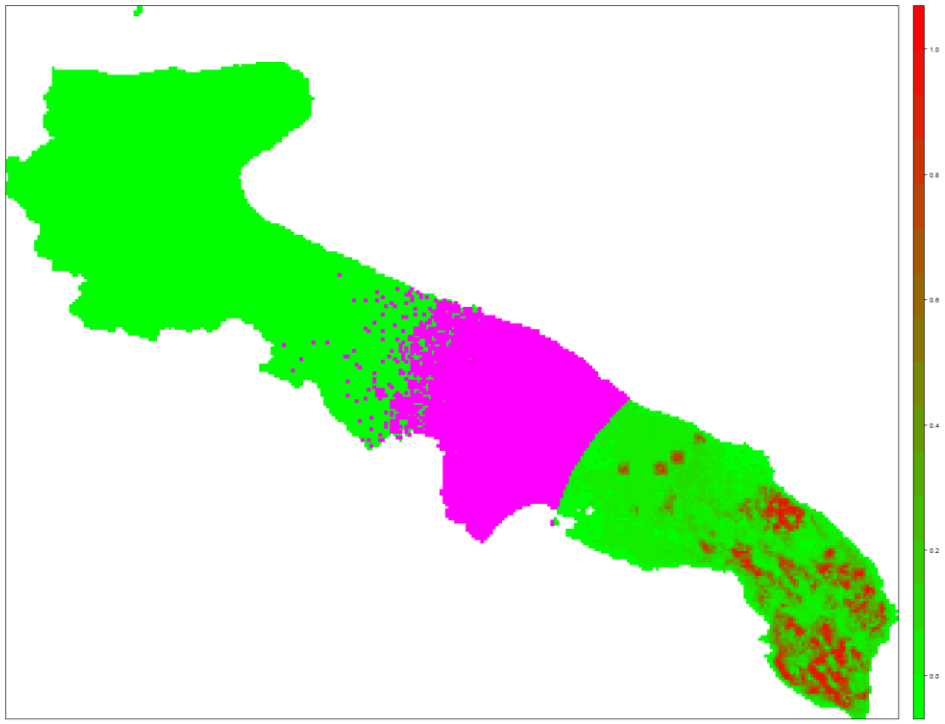
More long range spread
(Uniform long distance dispersal)



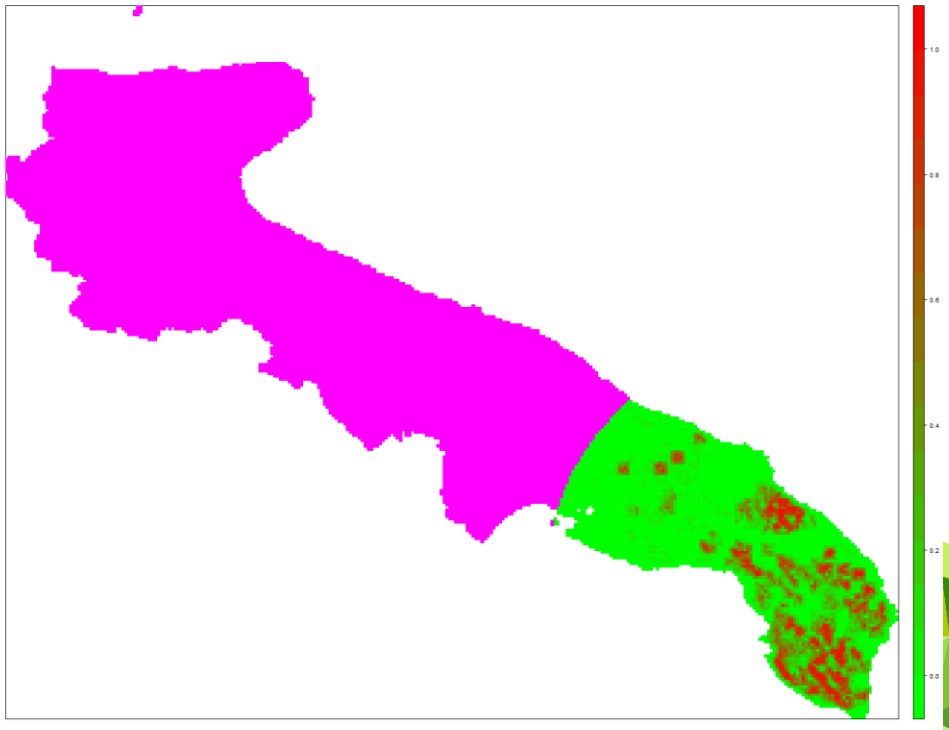
MODELLING SPREAD

Area of Apulian uninfected zone with **at least one predicted incursion** (from 10,000 model realisations, over two years) in the absence of any control/surveillance measures.

Default parameters



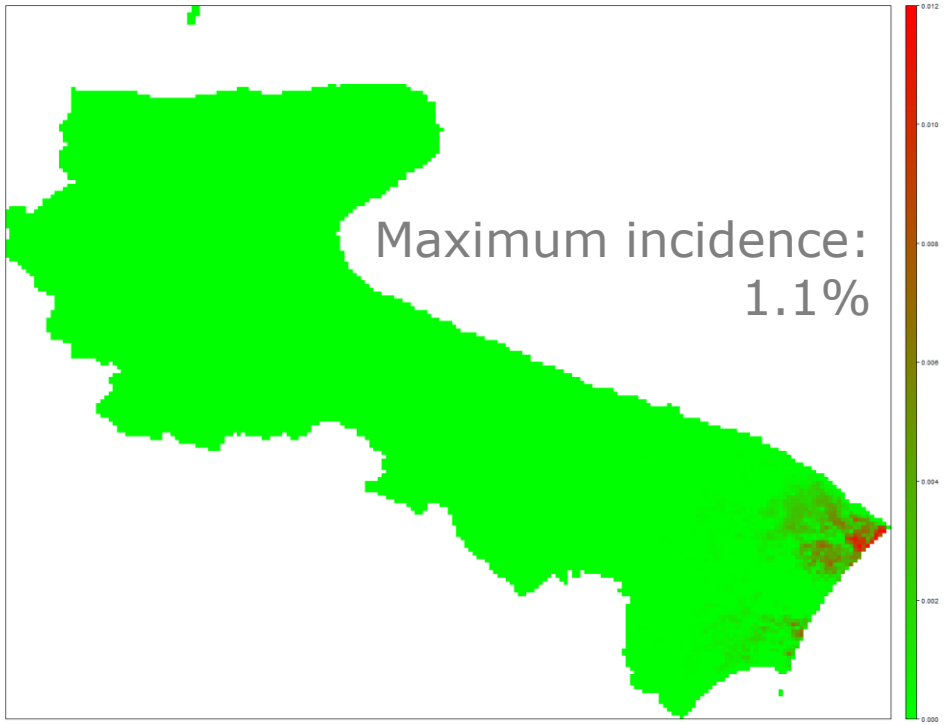
More long range spread



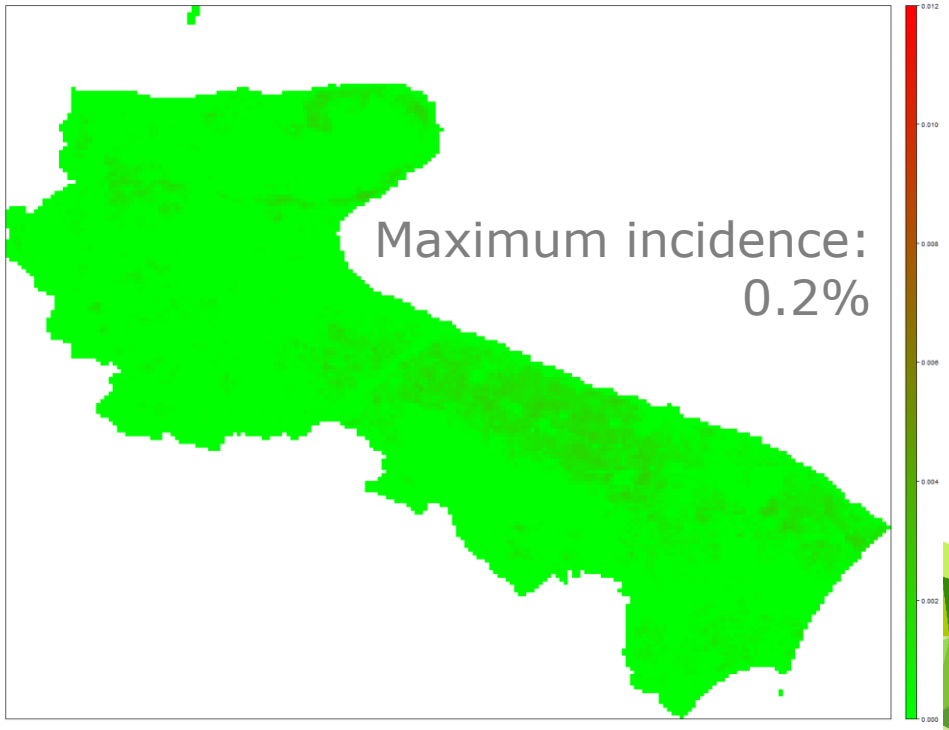
MODELLING SPREAD

Mean incidence in the uninfected zone
(10,000 model realisations).

Gaussian spread



Uniform spread



OPTIMISING SURVEILLANCE

- We want our surveillance strategy to **minimise the probability of <u>failing</u> to detect infection**.

- We can calculate this probability when we inspect:
  - N locations
  - x trees per location

  When the incidence in each location is p_n

$$P(\text{no det}) = \prod_{n=1}^{N} (1 - p_n)^x$$

OPTIMISING SURVEILLANCE

- We want our surveillance strategy to **minimise the probability of <u>failing</u> to detect infection**.

- We can calculate this probability when we inspect:
  - N locations
  - x trees per location

  When the incidence in each location is p_n

$$P(\text{no det}) = \prod_{n=1}^{N} (1 - p_n)^x$$

Probability of **<u>not</u>** selecting an infected tree, **if we took one sample from site n**

OPTIMISING SURVEILLANCE

- We want our surveillance strategy to **minimise the probability of <u>failing</u> to detect infection**.

- We can calculate this probability when we inspect:
  - N locations
  - x trees per location

  When the incidence in each location is p_n

$$P(\text{no det}) = \prod_{n=1}^{N} (1 - p_n)^x$$

Probability of not selecting **<u>any</u>** infected trees, **when we sample x trees from site n**

OPTIMISING SURVEILLANCE

- We want our surveillance strategy to **minimise the probability of <u>failing</u> to detect infection**.

- We can calculate this probability when we inspect:
  - N locations
  - x trees per location

  When the incidence in each location is p_n

$$P(\text{no det}) = \prod_{n=1}^{N} (1 - p_n)^x$$

Probability of not selecting any infected trees, **when we sample all N sites, with x trees from each**

OPTIMISING SURVEILLANCE

- *X. fastidiosa* CoDiRO is characterised predominantly by "secondary spread" (i.e. **within** olive groves)

- To account for this, we used two consecutive years' incidence predictions (p_{n_1} and p_{n_2}):

$$P(\text{no det}) = \prod_{n=1}^{N} (1 - p_{n_1})^x (1 - p_{n_2})^x$$

OPTIMISING SURVEILLANCE

- *X. fastidiosa* CoDiRO is characterised predominantly by "secondary spread" (i.e. **within** olive groves)

- To account for this, we used two consecutive years' incidence predictions (p_{n_1} and p_{n_2}):

$$P(\text{no det}) = \prod_{n=1}^{N} \left(1 - p_{n_1}\right)^x \left(1 - p_{n_2}\right)^x$$

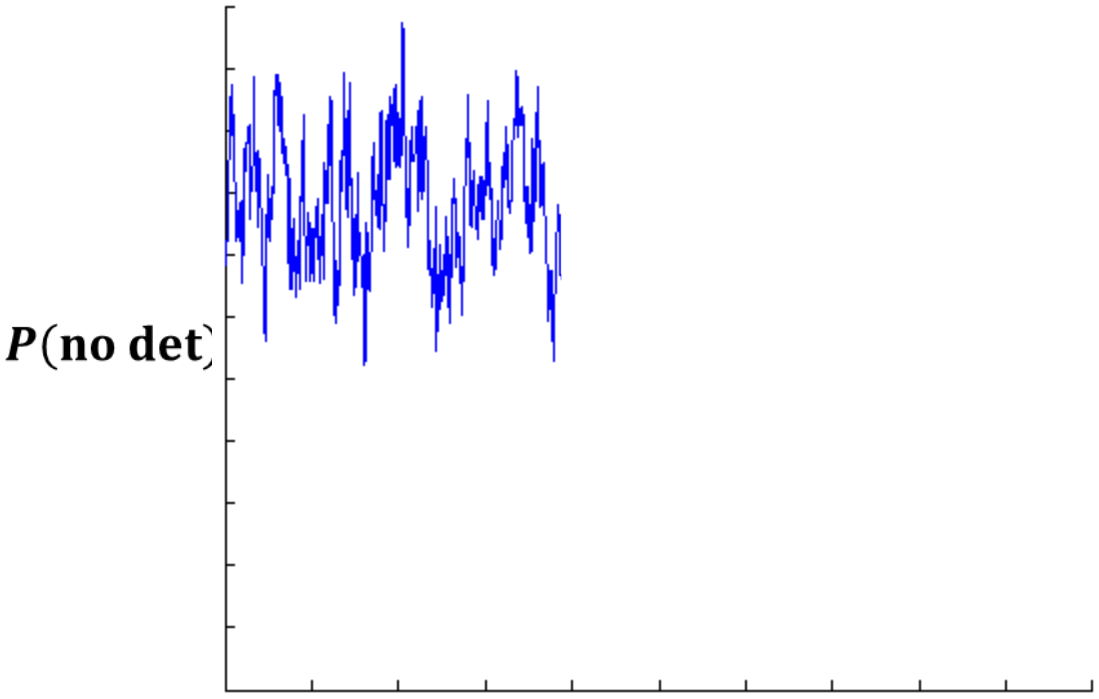
Probability of not selecting any infected trees **in either year 1 or 2**, **when we sample all N sites, with x trees from each**

OPTIMISING SURVEILLANCE

- For **any** set of N sites, we can estimate the probability of failing to detect infection.
- We need a way of finding the combination of sites which **minimises** this probability.
- However, the number of combinations of sites is too great to evaluate all possible combinations.
- We can use **algorithmic optimisation routines** (such as **simulated annealing**) to identify the best combination without having to evaluate all combinations.

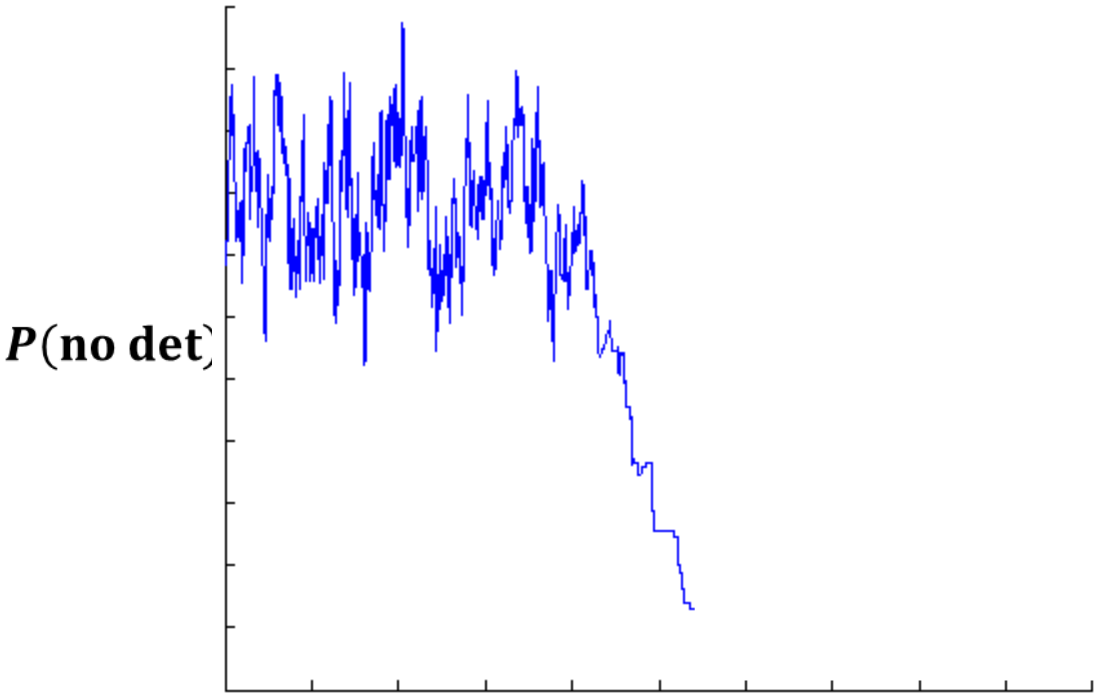
SIMULATED ANNEALING

Exploring the parameter space



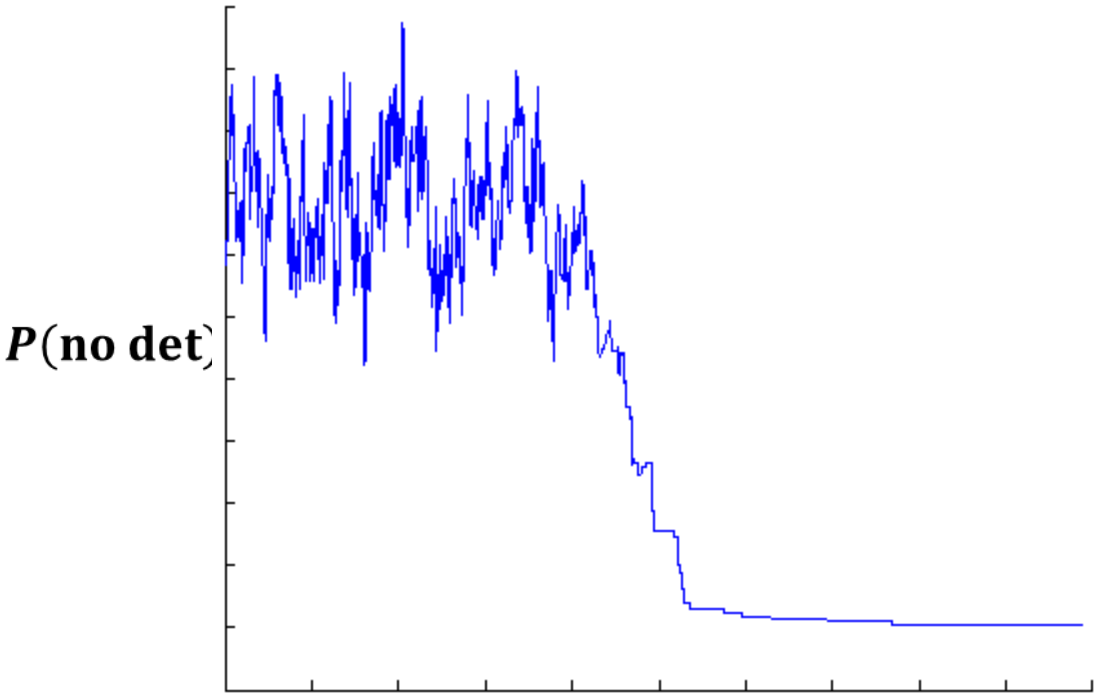
SIMULATED ANNEALING

Rejecting poor selections



SIMULATED ANNEALING

Identifying optimal locations



SIMULATED ANNEALING

- We used simulated annealing to identify **which locations should be sampled in order to minimise the probability that we fail to detect infection.**

- We assumed that an average of **1 tree per hectare** was inspected (100 trees per km^2 grid cell).

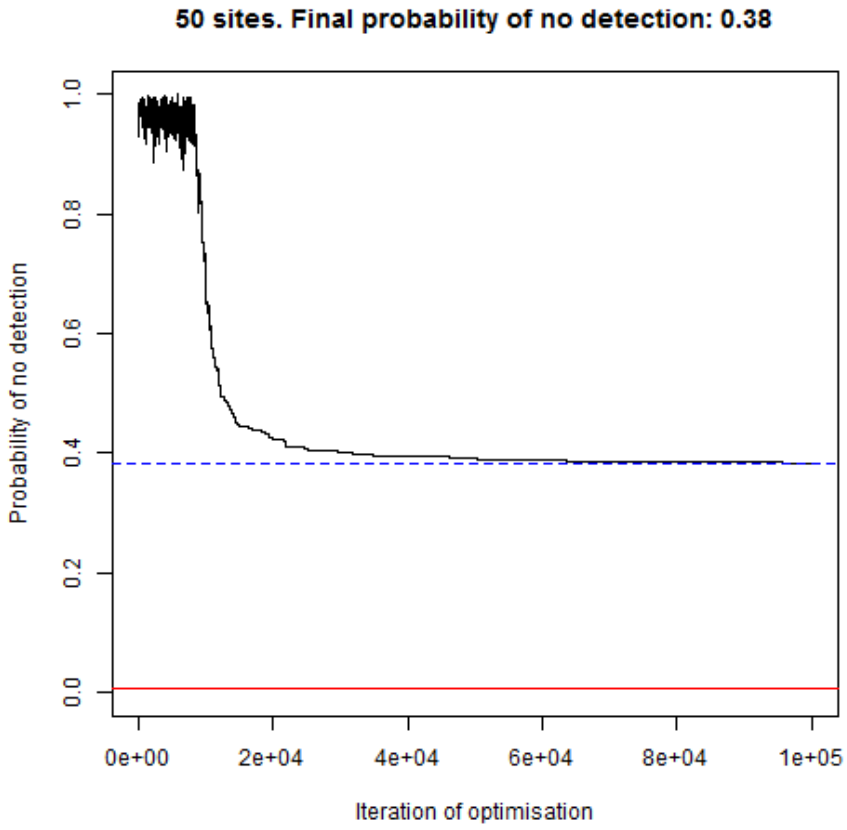
- We repeated this approach for **different numbers of sample locations** – from 50 to 500.

APPLYING THE METHOD TO *X. FASTIDIOSA* IN APULIA: PRELIMINARY RESULTS

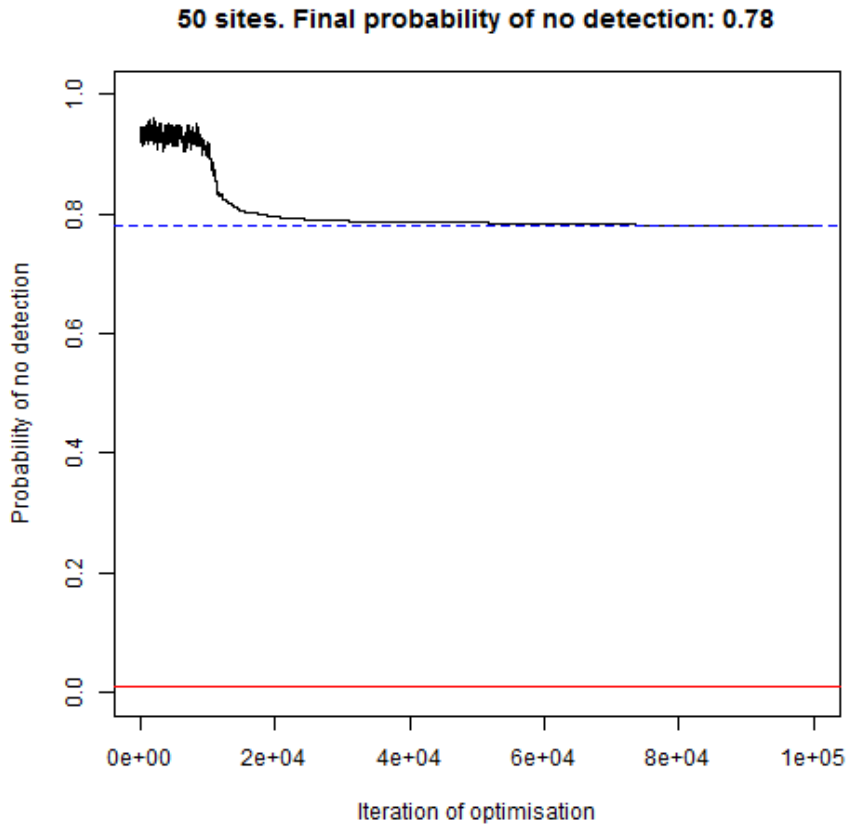
PRELIMINARY RESULTS

Probability of no detection when sampling 100 trees in each of a specified number of sites:

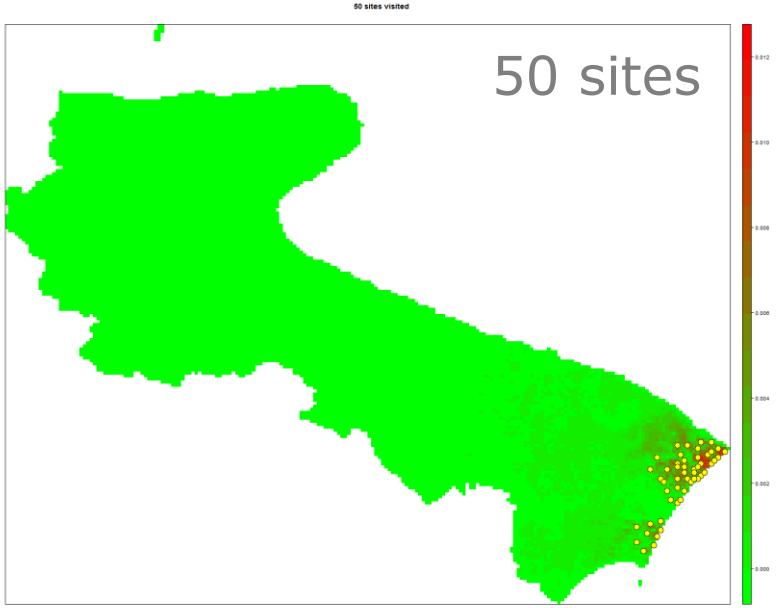
Default parameters

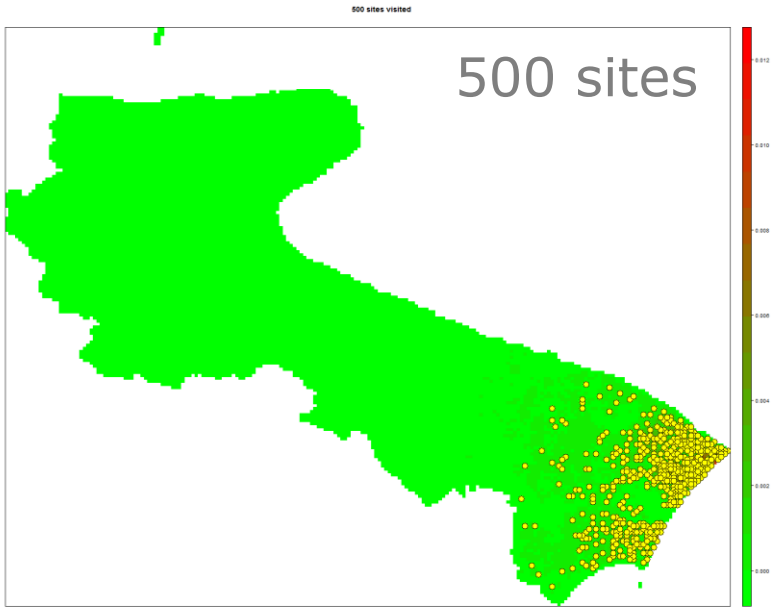


More long range spread

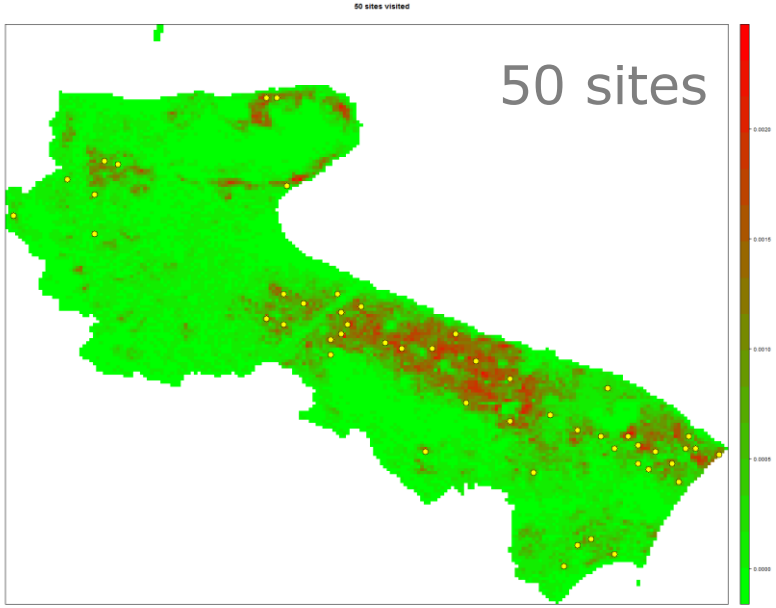


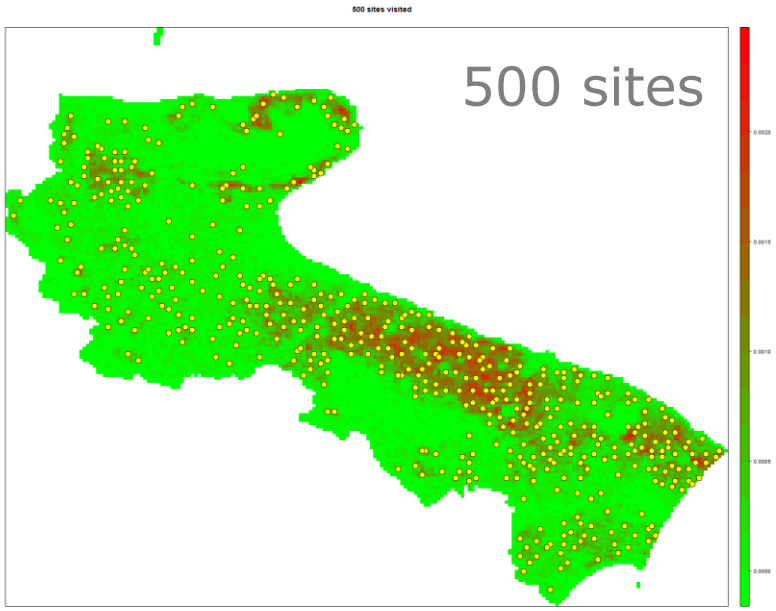
Default parameters





More long range spread

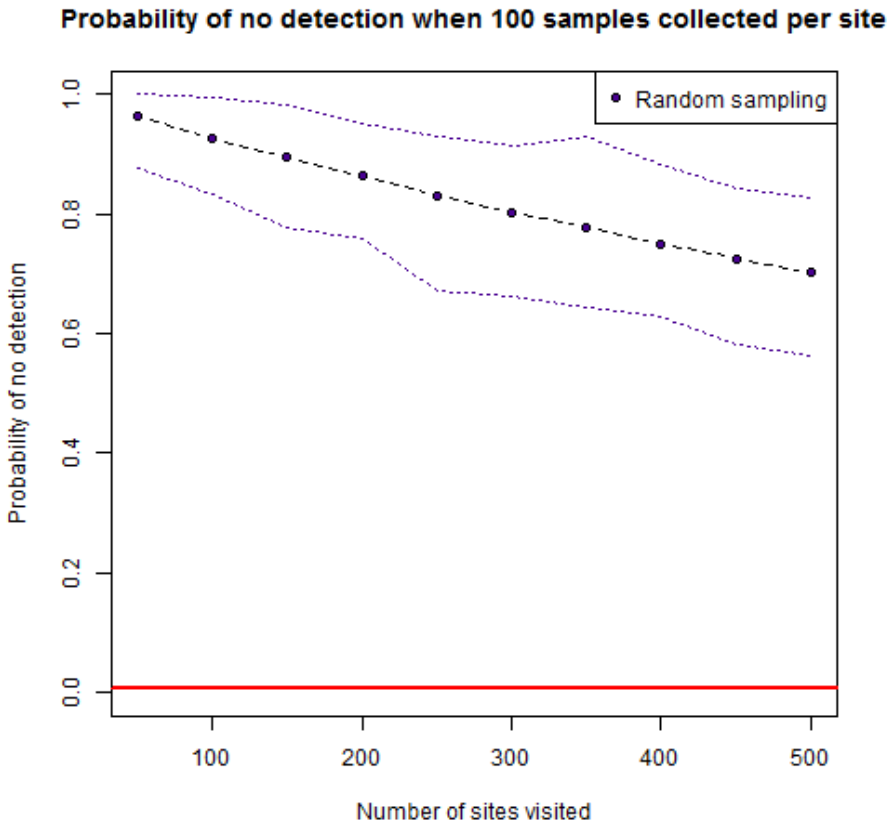




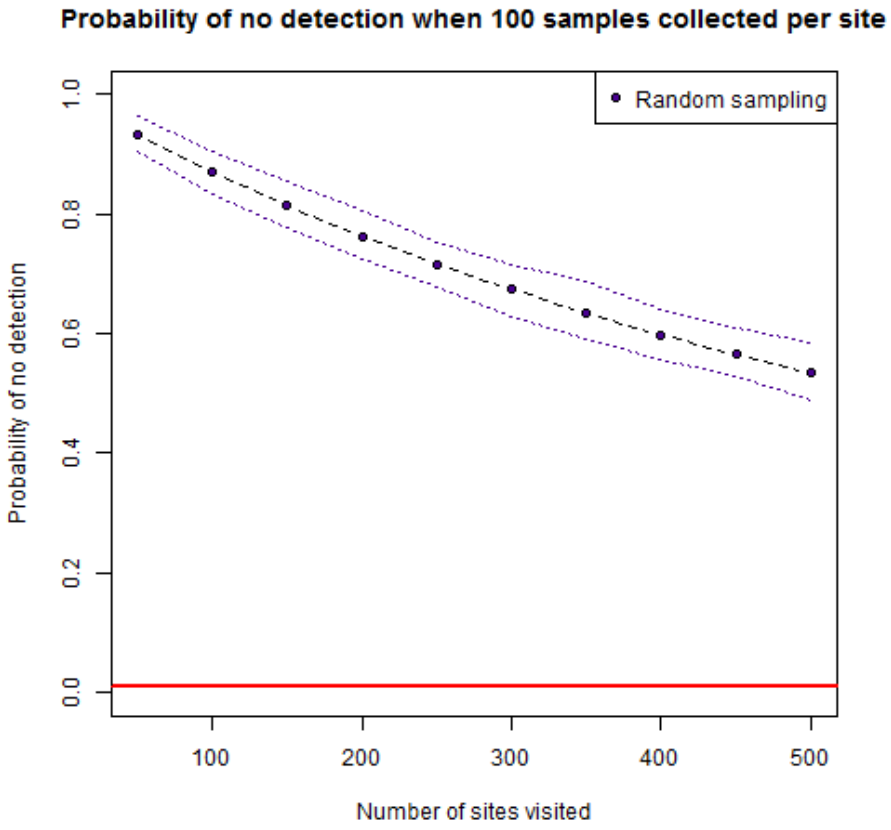
PRELIMINARY RESULTS

Probability of no detection when visiting a specified number of sites **randomly** from the population:

Default parameters



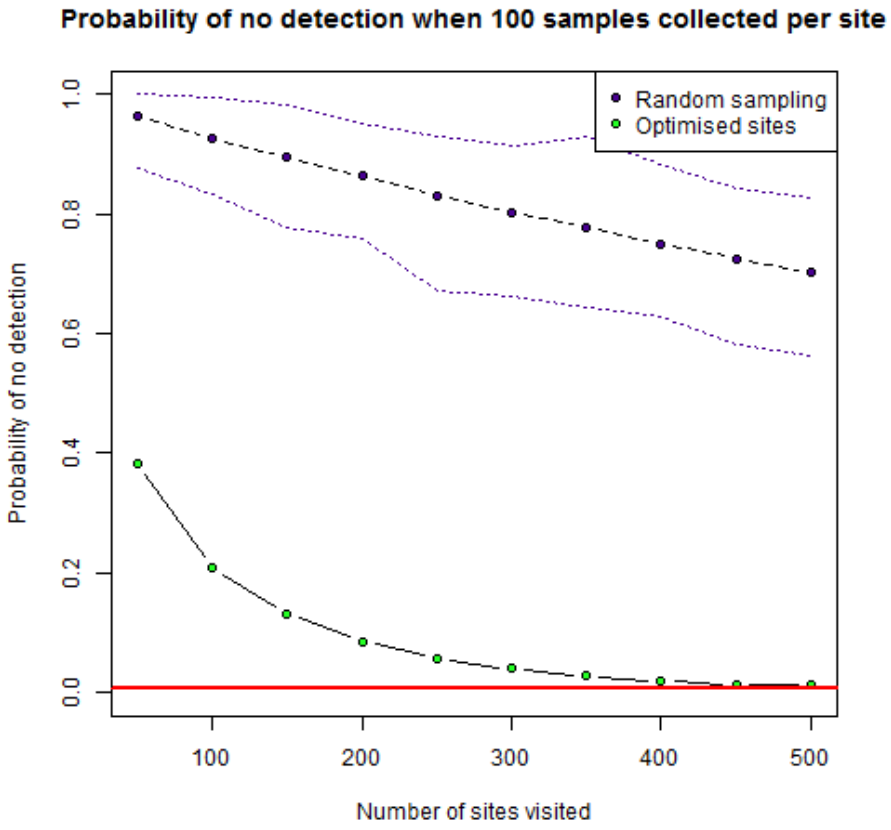
More long range spread



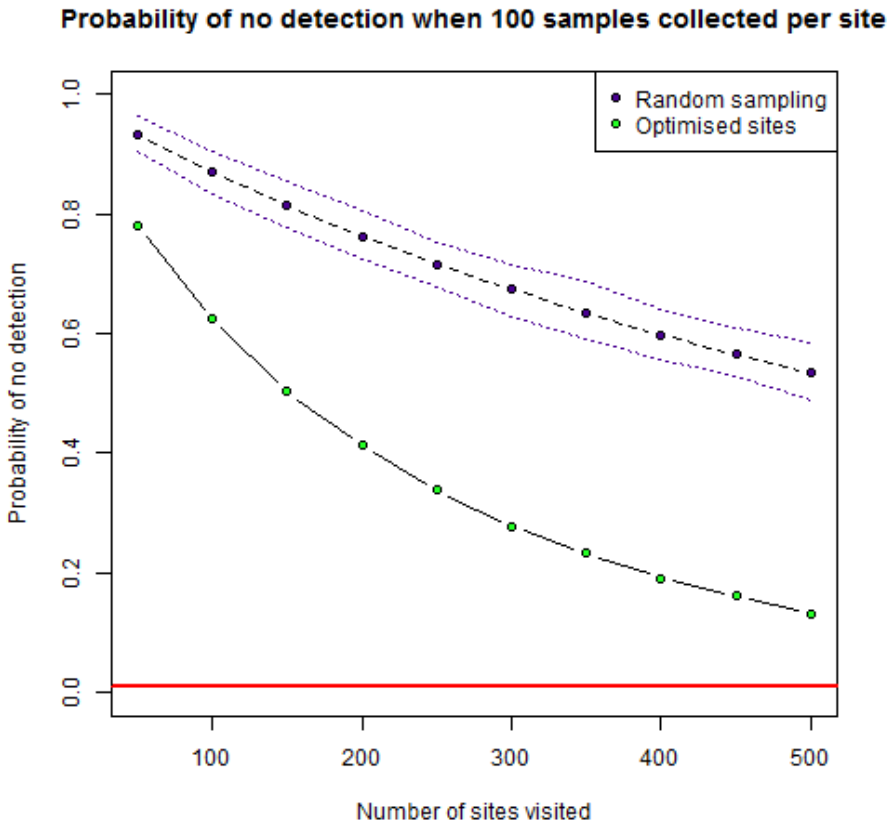
PRELIMINARY RESULTS

Probability of no detection when visiting the specified number of **optimal sites**:

Default parameters



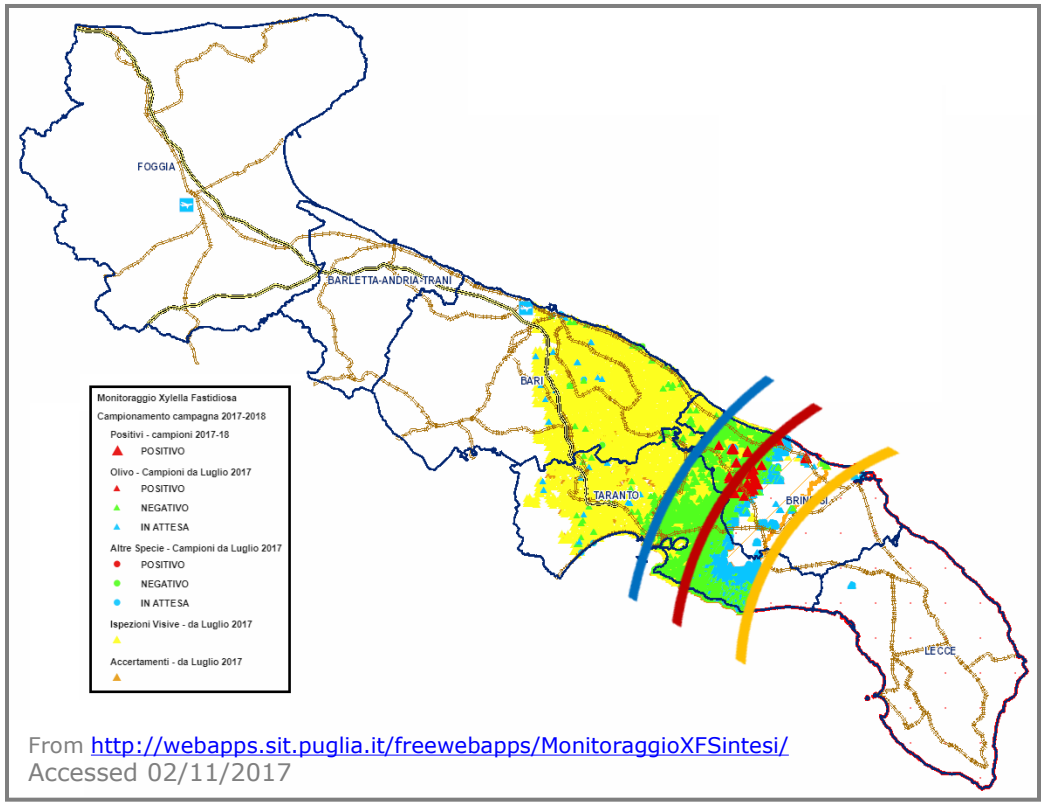
More long range spread



PRELIMINARY CONCLUSIONS

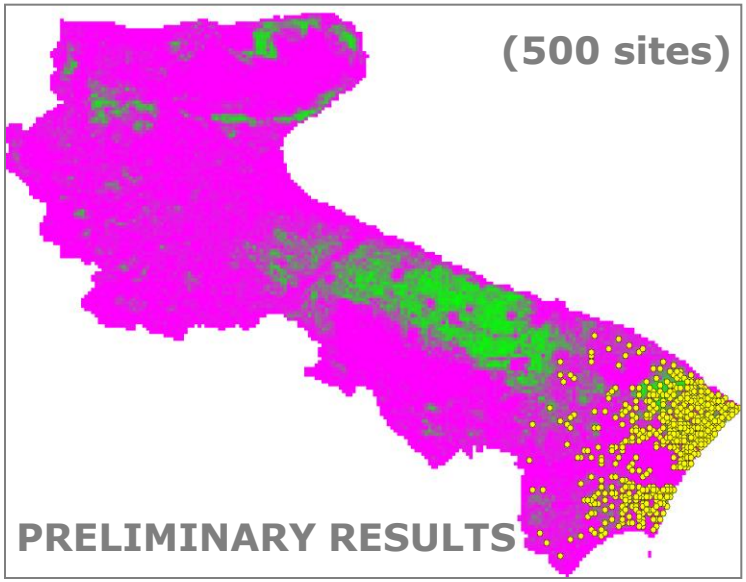
SURVEILLANCE COMPARISON: DEFAULT PARAMETERS

Actual surveillance, 2017



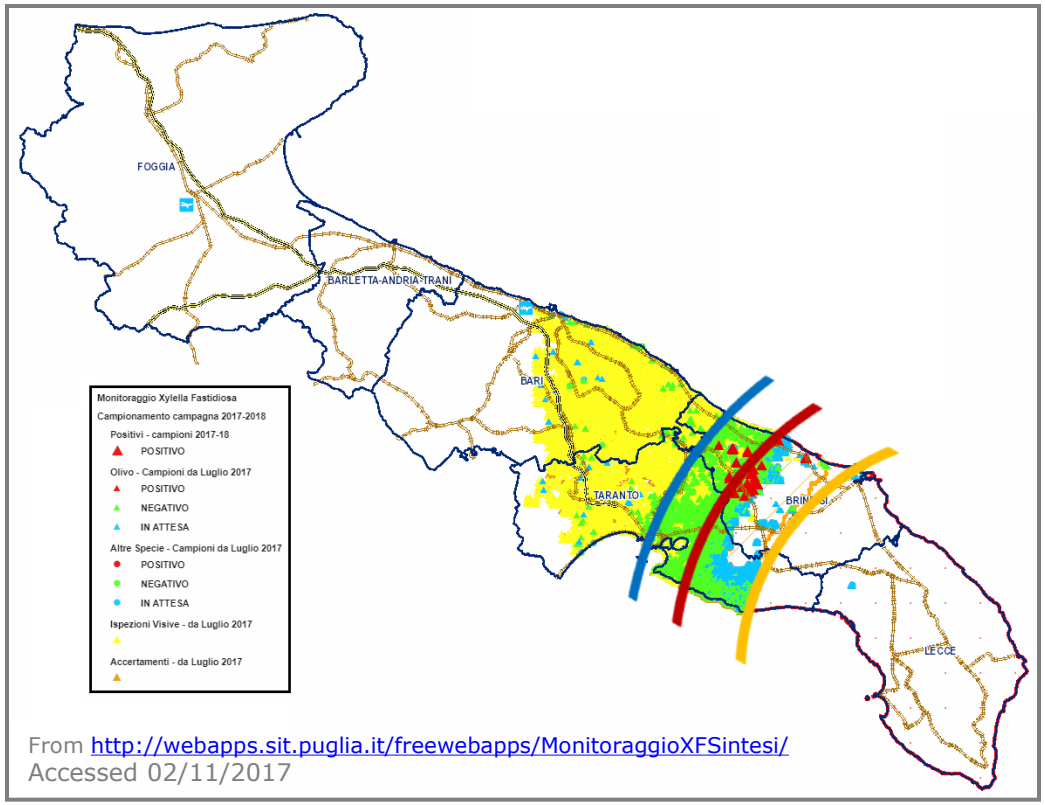
From http://webapps.sit.puglia.it/freewebapps/MonitoraggioXFSintesi/
Accessed 02/11/2017

Optimal surveillance



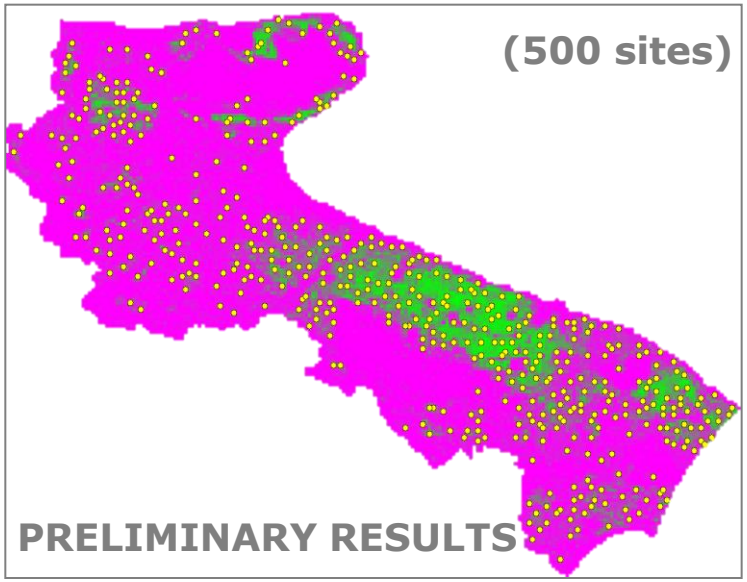
SURVEILLANCE COMPARISON: LONG DISTANCE SPREAD

Actual surveillance, 2017



From http://webapps.sit.puglia.it/freewebapps/MonitoraggioXFSintesi/
Accessed 02/11/2017

Optimal surveillance



PRELIMINARY CONCLUSIONS

- **Simulation models** of *Xylella fastidiosa* spread can be used to identify **where best to conduct surveillance** in the uninfected zone of Apulia.

- The best place to conduct surveillance depends on the **nature of pathogen spread** from the infected zone – and may not always be close to the buffer zone boundary.

- Correctly **characterising this long-distance spread is crucial**, this is now the focus of work with the CEH to improve upon our current (provisional) findings.

Thank you!

European Commission

Horizon 2020
European Union funding
for Research & Innovation

XF ACTORS

University of Salford MANCHESTER
1967-2017 50 YEARS

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Steven White (CEH Wallingford)

Daniel Chapman (CEH Edinburgh)

Stephen Parnell (University of Salford)

This project is funded by the European Commission as part of the Horizon 2020 program

(SFS-09-2016, XF-ACTORS, grant agreement 727987)