European Food Safety Authority

XF ACTORS

Xylella Fastidiosa Active Containment Through a multidisciplinary-Oriented Research Strategy

3rd European Conference on Xylella fastidiosa and XF-ACTORS final meeting

Effects of dispersal barriers in the demarcated area in Alicante, Spain, for *Xylella fastidiosa*. A non-stationary modelling approach.

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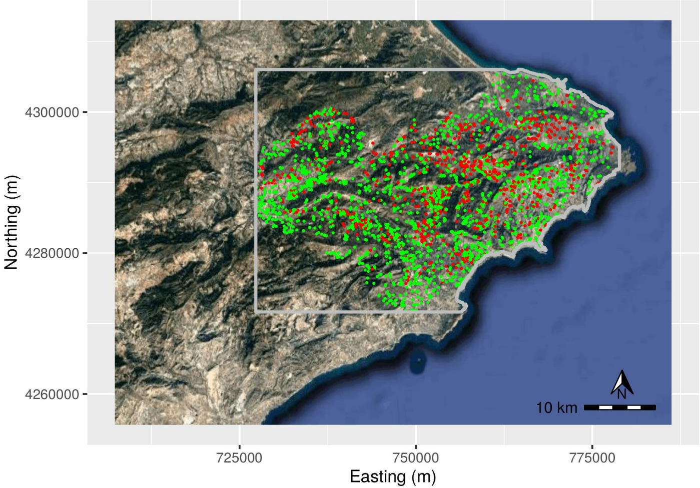
BIOVEXO · CURE XF · EuroXanth COST Action CA16107 · Euphresco · European Research Council · LIFE RESILIENCE

Xylella fastidiosa in Alicante

- First detection in Alicante in 2017 in almond trees.
- *X. fastidiosa* subsp. *multiplex*.
- Delimitation of the Demarcated Area and intensive sampling.

Official surveys for *X. fastidiosa* in Alicante (2018)



- **1151 positives**
- **3054 negatives**

Objective

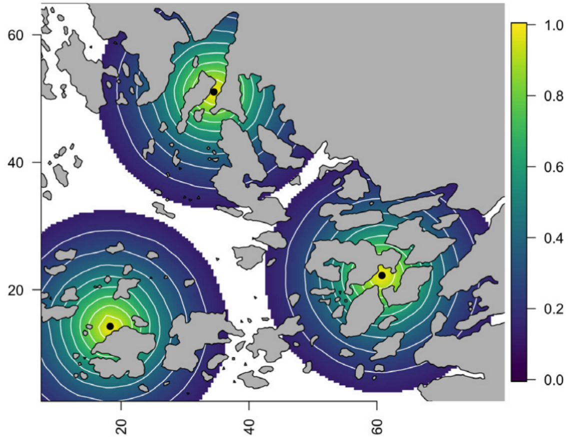
- Analysis of the spatial distribution of *X. fastidiosa* in Alicante and the effect of different types of barriers.
  - Geographic features
  - Control measures

Why spatial?

- Ignoring the **spatial dependence** of the observations can lead to inaccurate results.
- Tobler's first law of geography and foundation of **spatial autocorrelation**: *"everything is related to everything else, but near things are more related than distant things."*

However...

- Spatial models usually asume stationarity and isotropy:
  - Spatial dependence is the same at different points on the map and in all directions
- This is not realistic when there are barriers to the spread of the pathogen.



Bakka et al. (2019)

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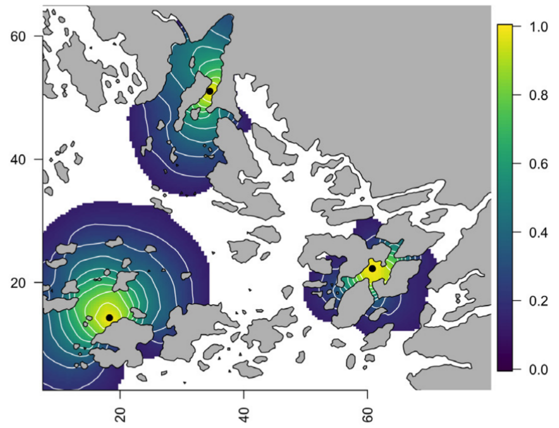
➘ **Non-stationary** (and anisotropic) spatial models



Bakka et al. (2019)

Non-stationary Gaussian models with physical barriers

Haakon Bakka [a,*], Jarno Vanhatalo [b], Janine B. Illian [c], Daniel Simpson [d], Håvard Rue [e]

Model

Presence/absence data → Bayesian hierarchical model → **INLA** [Rue et al., 2009] → SPDE [Lindgren et al., 2011]

$$
\begin{aligned}
y_i &\sim \text{Bernoulli}(\pi_i), \;\; i = 1, ..., n, \\
\text{logit}(\pi_i) &= \beta_0 + u_i, \\
\text{P}(\beta_0) &\propto 1, \\
\boldsymbol{u} &\sim N(0, \boldsymbol{Q}^{-1}(r, \sigma_u)), \\
r &\sim \text{PC-prior}(\mu_r, 0.5), \\
\sigma_u &\sim \text{PC-prior}(10, 0.01),
\end{aligned}
$$

- $\boldsymbol{u}$ is the spatial effect.
- r is the range and σ_u is the standard deviation of the spatial effect.
- μ_r was chosen as 50% of the diameter of the study region.

Non-stationarity

- In the **barrier** areas the correlation was eliminated by introducing a different Matérn field, with the same σ_u but **range** (r) **close to zero** [Bakka et al., 2019].

$$
\begin{aligned}
u(s) - \nabla \cdot \frac{r^2}{8} \nabla u(s) &= r\sqrt{\frac{\pi}{2}}\sigma_u W(s), \text{ for } s \in \Omega_n, \\
u(s) - \nabla \cdot \frac{r_b^2}{8} \nabla u(s) &= r_b\sqrt{\frac{\pi}{2}}\sigma_u W(s), \text{ for } s \in \Omega_b
\end{aligned}
$$

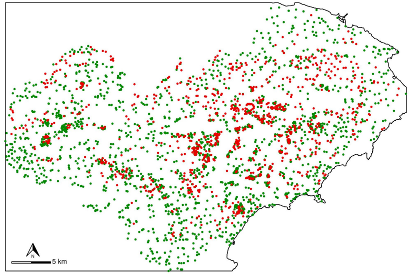
  - Ω_n is the normal area and Ω_b is the barrier area.

- **Barriers** were assumed to be totally **impermeable**:
  - Areas without host plants and through which vectors or plant material cannot pass

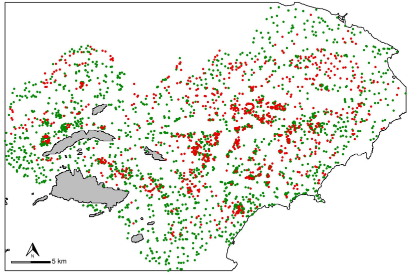
Models

- **Stationary**
  Without barriers
- **Mountain barrier**
  Areas over 1065 m as barriers
- **Continuous barrier**
  Barrier surrounding the infested area
- **Discontinuous barrier**
  Barrier with breaks surrounding the infested area

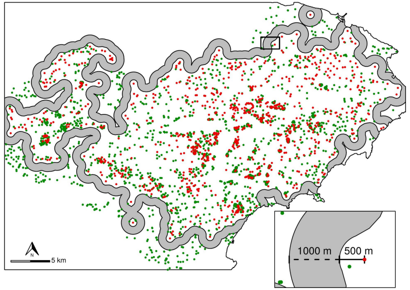
Stationary



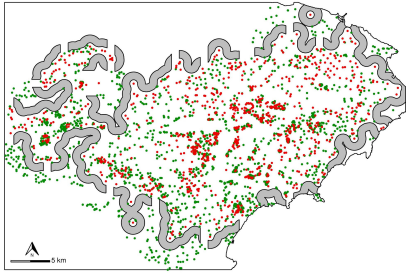
Mountain barrier



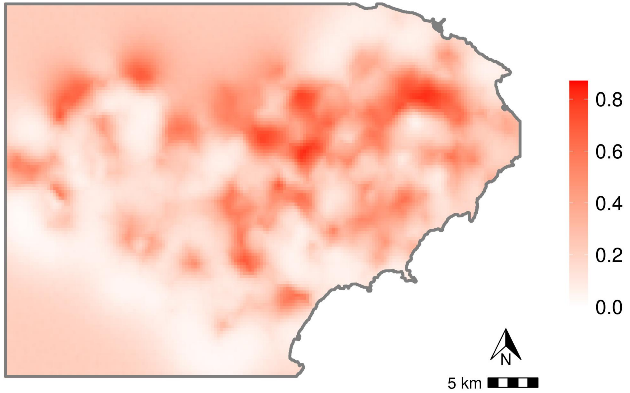
Continuous barrier



Discontinuous barrier

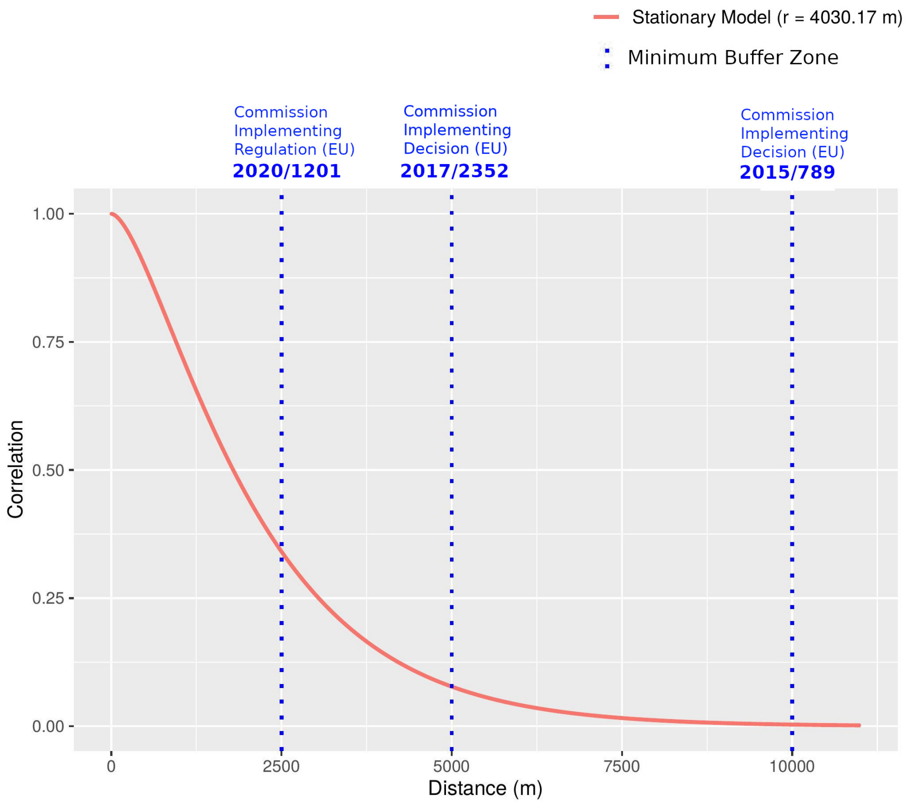


Results: Stationary model

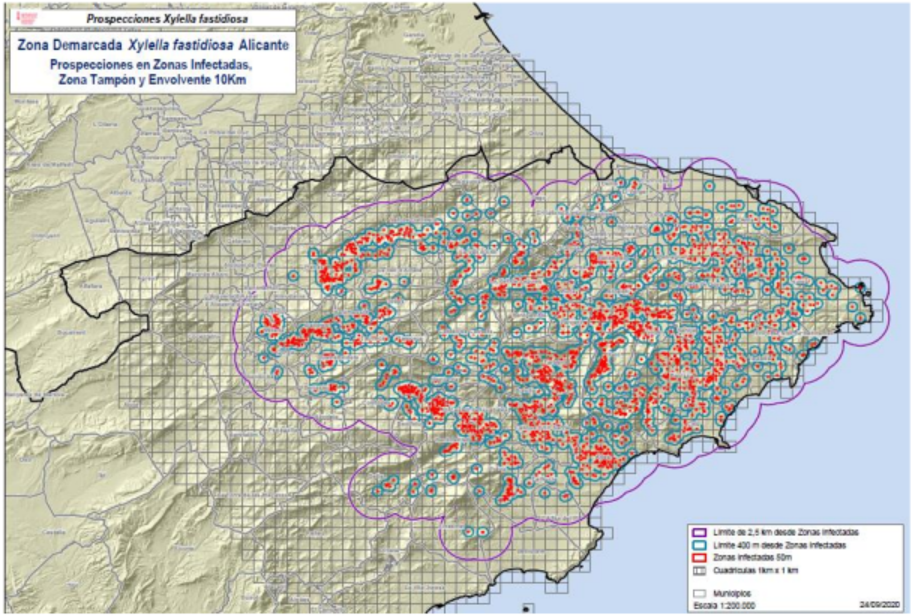


Mean of the predictive posterior distribution of the **probability** of presence

	Mean	(95% CI)
Intercept	-1.68	(-2.21, -1.23)
σ_u	1.52	(1.28, 1.80)
Range (m)	**4030.17**	**(2907.41, 5563.88)**



Stationary Model (r = 4030.17 m)
Minimum Buffer Zone
Commission Implementing Regulation (EU) 2020/1201
Commission Implementing Decision (EU) 2017/2352
Commission Implementing Decision (EU) 2015/789
1.00
0.75
0.50
0.25
0.00
Correlation
0
2500
5000
7500
10000
Distance (m)



Prospecciones Xylella fastidiosa
Zona Demarcada Xylella fastidiosa Alicante
Prospecciones en Zonas Infectadas,
Zona Tampón y Envolvente 10Km
Limite de 2,5 km desde Zonas Infectadas
Limite 400 m desde Zonas Infectadas
Zonas Infectadas 50m
Cuadrículas 1km x 1 km
Municipios
Escala 1:200.000
24/09/2020

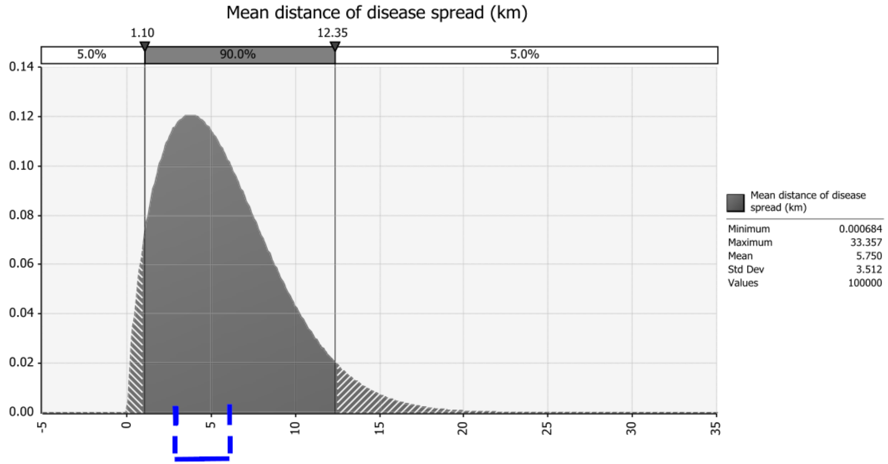
EFSA(2019) expert knowledge elicitation (EKE)

Mean distance of disease spread (km)

Table F.2: Fitted values of the uncertainty distribution on the mean distance of disease spread (km)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert agreement	1.0					3.0		5.0		8.5					12.0
Expert 1	0.5					4.0		8.0		10.0					8.0
Expert 2	1.2					1.5		3.0		6.0					8.0
Expert 3	0.5					2.0		4.0		7.0					15.0
Expert 4	2.0					4.0		7.0		9.0					20.0
Expert 5	2.0					4.0		6.0		8.0					10.0
Expert 6	3.0					3.0		6.0		9.0					15.0
Expert 7	0.5					1.7		3.0		7.0					15.0
Fitted distribution	0.42	0.73	1.10	1.69	2.37	3.07	3.74	5.18	6.85	7.82	9.05	10.57	12.35	13.98	15.10

Fitted distribution: Weibull (1.6840,6.4398), @RISK7.5.



Range 95%CI

- Includes 95%CI of the posterior mean of the range of the stationary model.

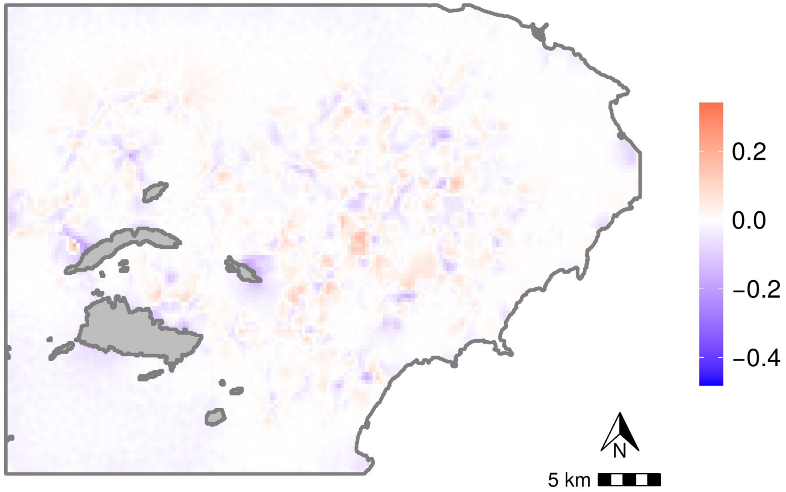
However...

- EKE was conducted under specific assumptions
- Extrapolation to Alicante is not straightforward

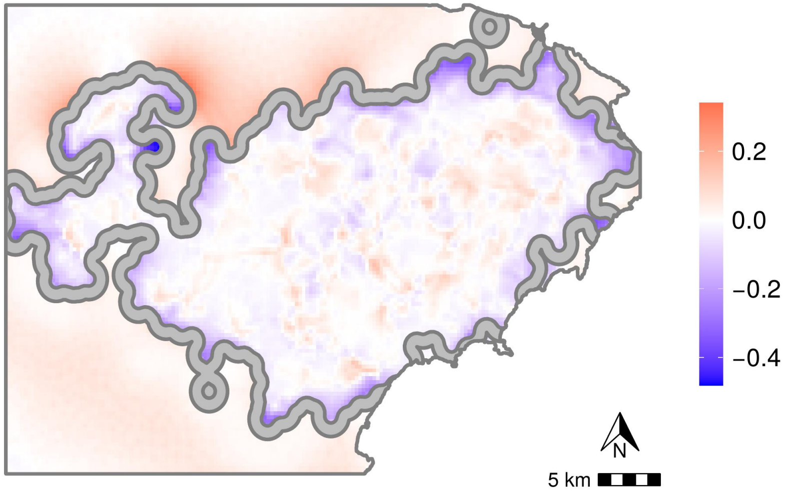
Results: Non-stationary models

Difference of the mean of the predictive posterior distribution with the stationary model

Stationary VS. Mountain barrier



Stationary VS. Continuous barrier

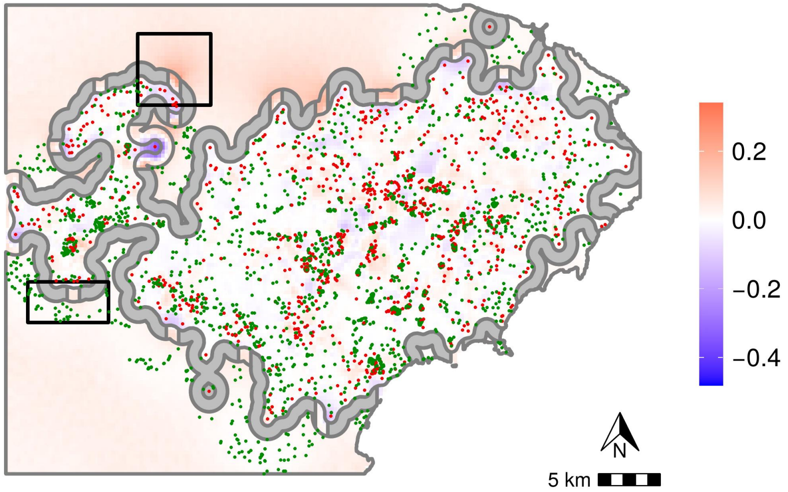


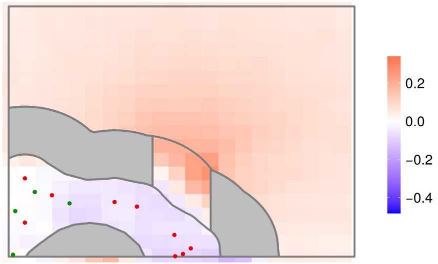
Red areas → higher probability in the **stationary** model

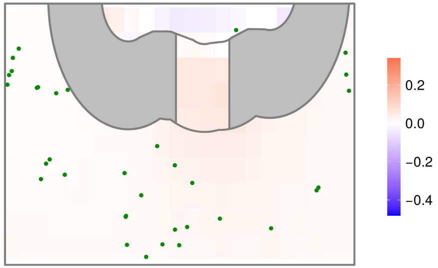
Results: Non-stationary models

Difference of the mean of the predictive posterior distribution between the perimeter barriers

Discontinuous barrier VS. Continuous barrier







Red areas → higher probability in the **discontinuous** barrier model

Conclusions

- The **spatial range** obtained was used as a reference to establish the buffer zone surrounding the infested area in Alicante.
- This methodology can be **extrapolated** to other study areas, adapting it to the corresponding data.
- **Non-stationary** models have allowed us to take into account elements that can hinder the spread of the pathogen.
- **Perimeter barriers** that simulate control measures have reduced the probability of *Xf* presence in the external area.
- The results can assist to **prioritize** the areas where control measures should be implemented first
  - Areas with lower sampling intensity and therefore more uncertainty.

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Barrier effects on the spatial distribution of *Xylella fastidiosa* in Alicante, Spain

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Thank you!

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