ModAH3
Nantes, France
28 August 2024

Quantifying the influence of wild boar density on African swine fever (ASF) transmission in wild boar populations

Italy, 2022–2023

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ASF in the EU

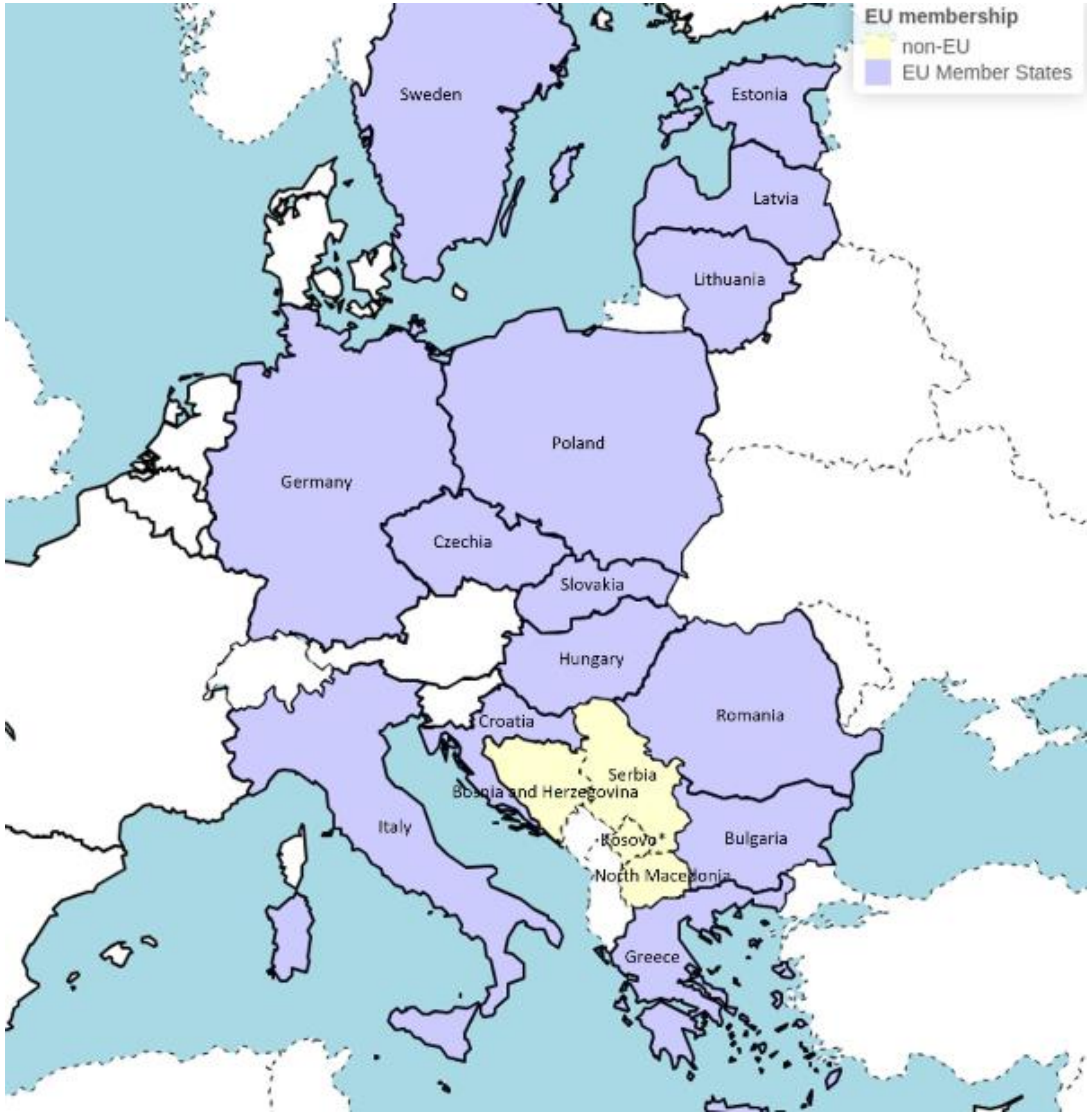
Fatal viral hemorrhagic fever of domestic pigs and wild boar

Approaching endemicity in multiple areas

Wild boar play a central role in sustaining virus circulation

Preventing new outbreaks and gaining control of existing ones critical to control

ASF affected countries, 2023



EFSA. (2024). Epi Analysis of ASF in the EU, 2023

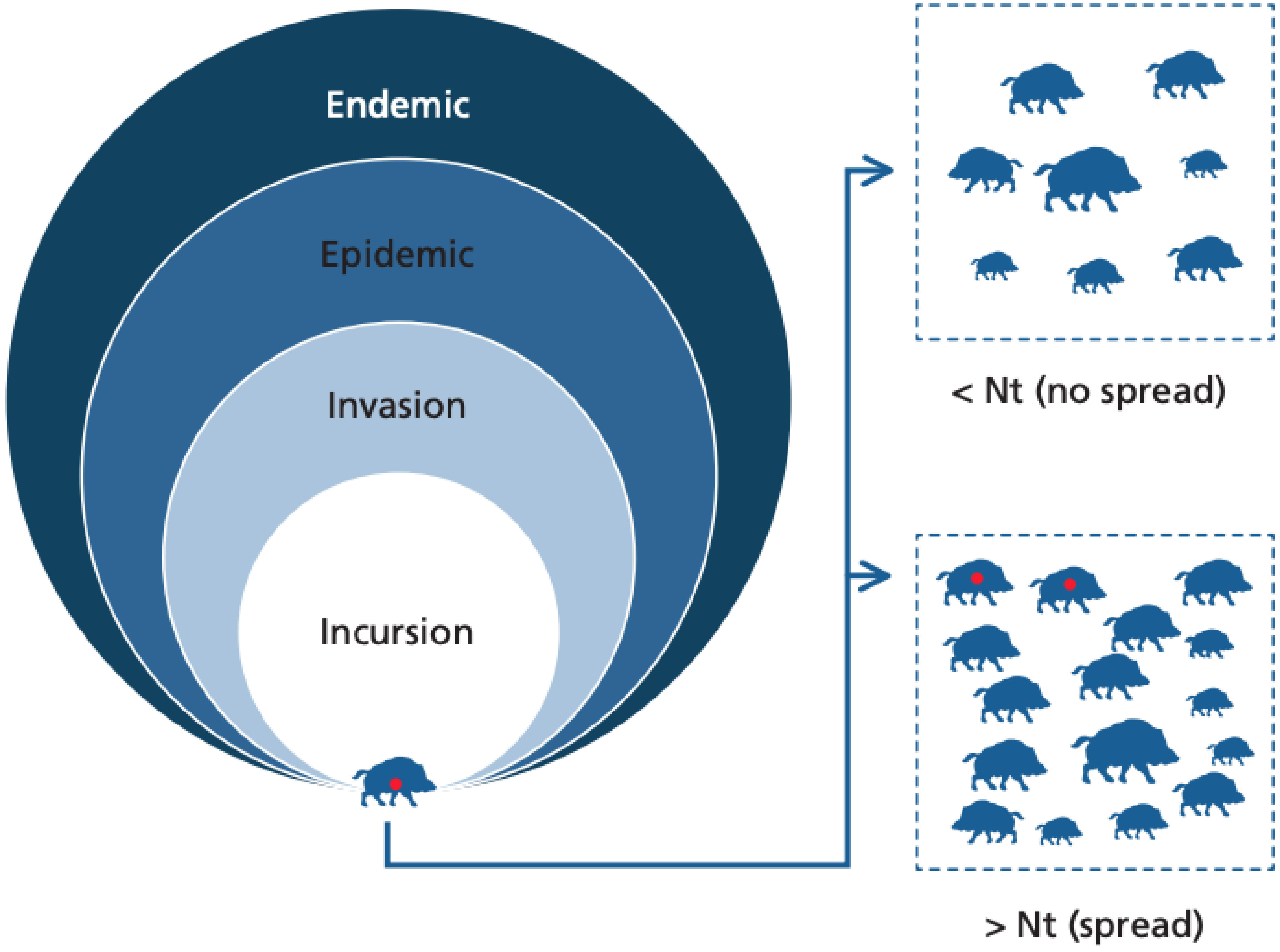
Gaining control

Based on EU strategy of regional compartmentalisation

- Prevent incursions
- Control invasions

Focus on reducing wild boar population density

Target density determined by **host threshold density (N_t)**



wild boar population density → $\rho < N_t$

$$\mathcal{F}(\rho) = ? \therefore N_t = ?$$

Guberti, V., et al. (2019). FAO APHM No. 22

The role of wild boar density

Ideal data needed for investigation

Positive & negative surveillance data

Fine resolution wild boar abundance estimates

Emerging (i.e. not yet endemic) situation

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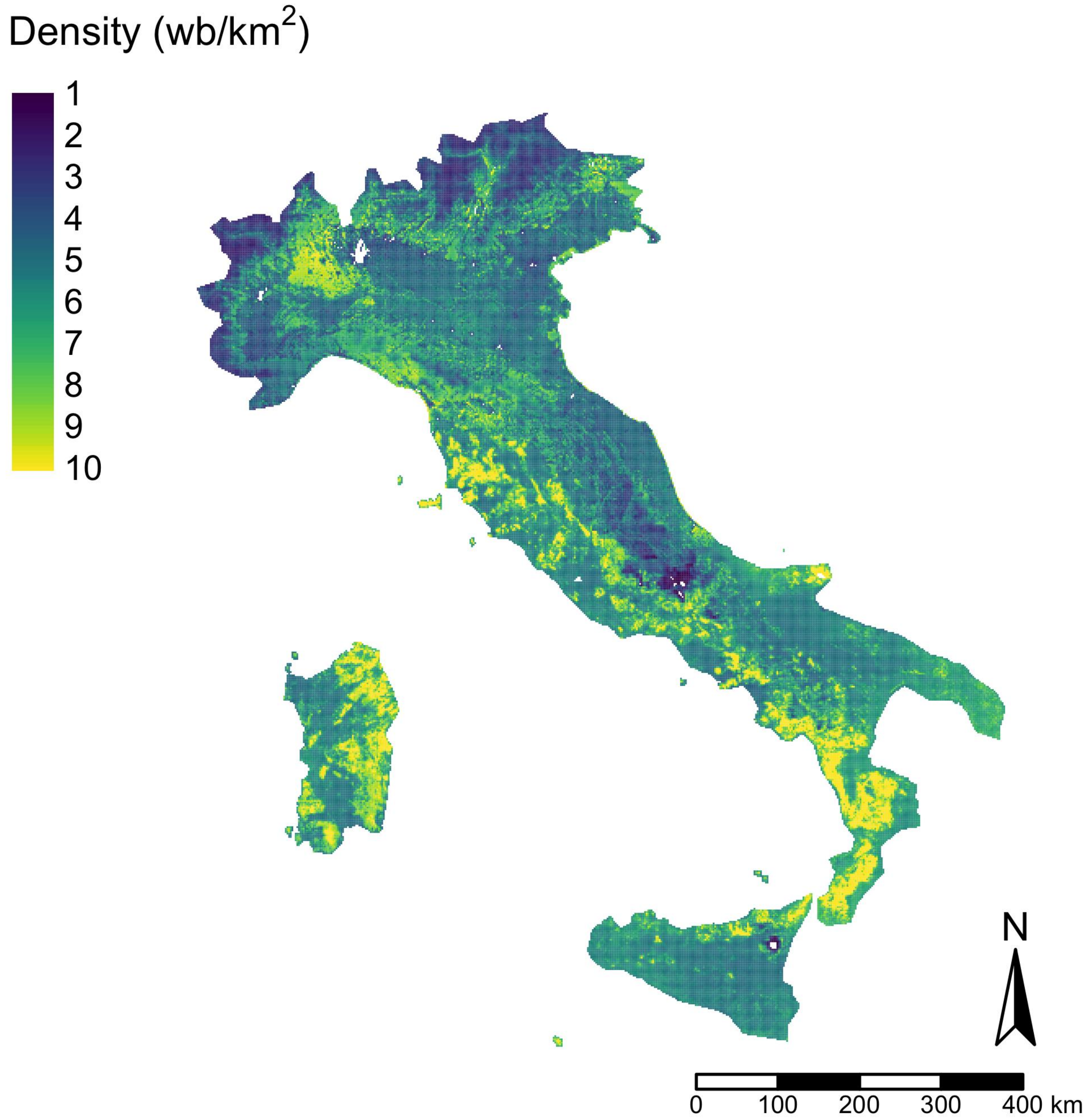


ENETWILD-Consortium. (2024). EFSA Ext. Sci. Rep.

Surveillance results

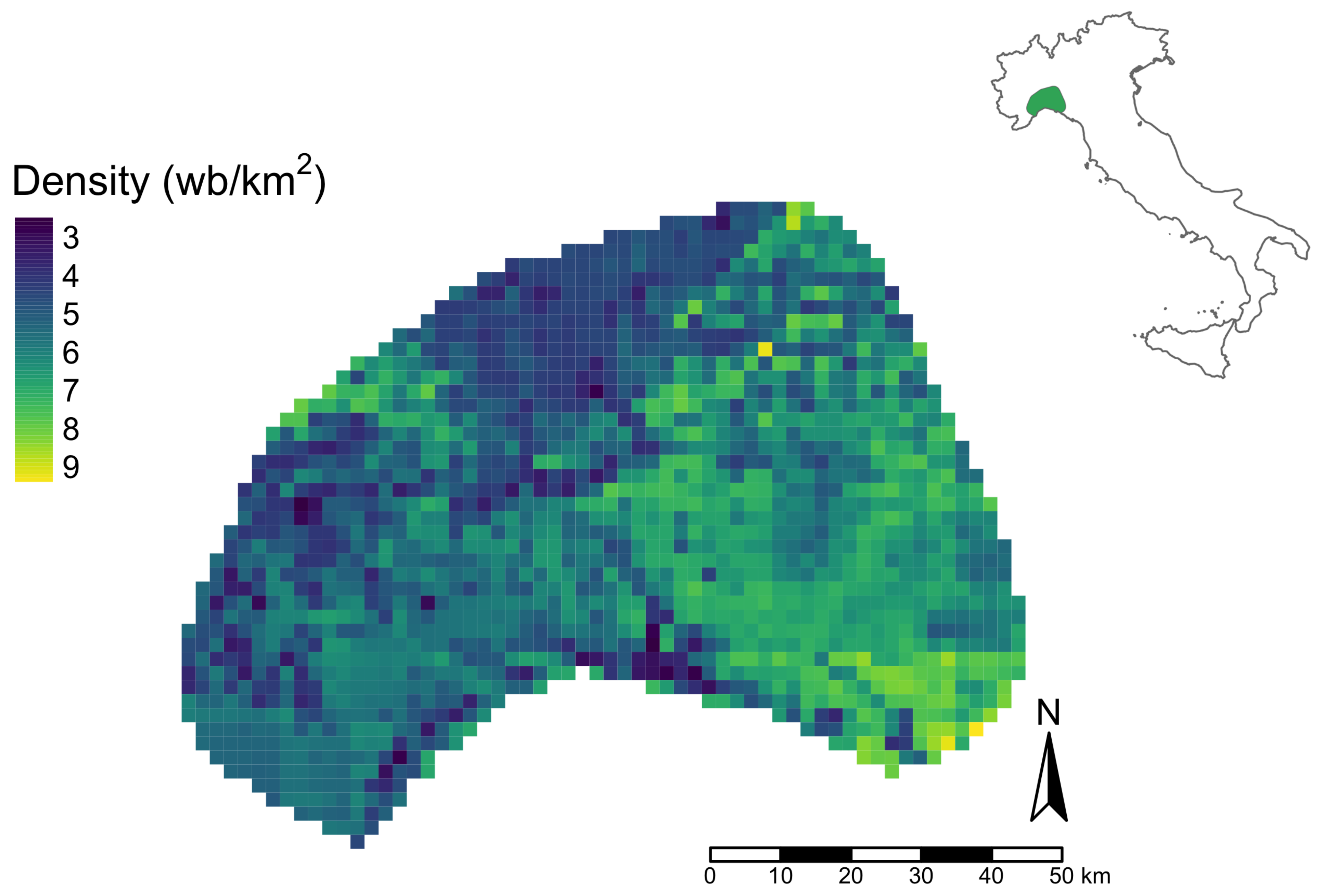
January 2022 – September 2023

7000 km^2 study area

8500+ carcasses tested

10% ASF positive

2 distinct waves in near-continuous radial spread



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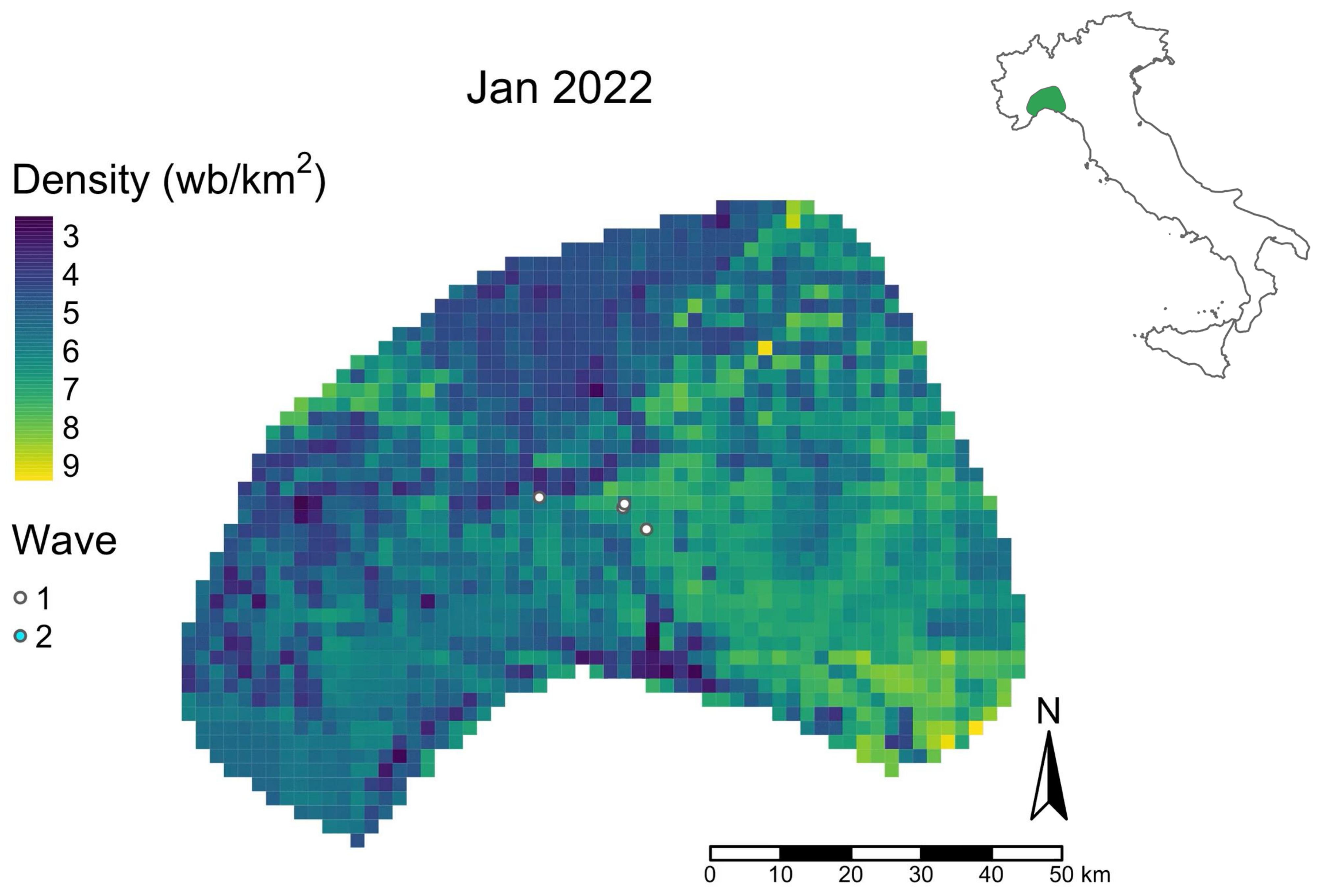
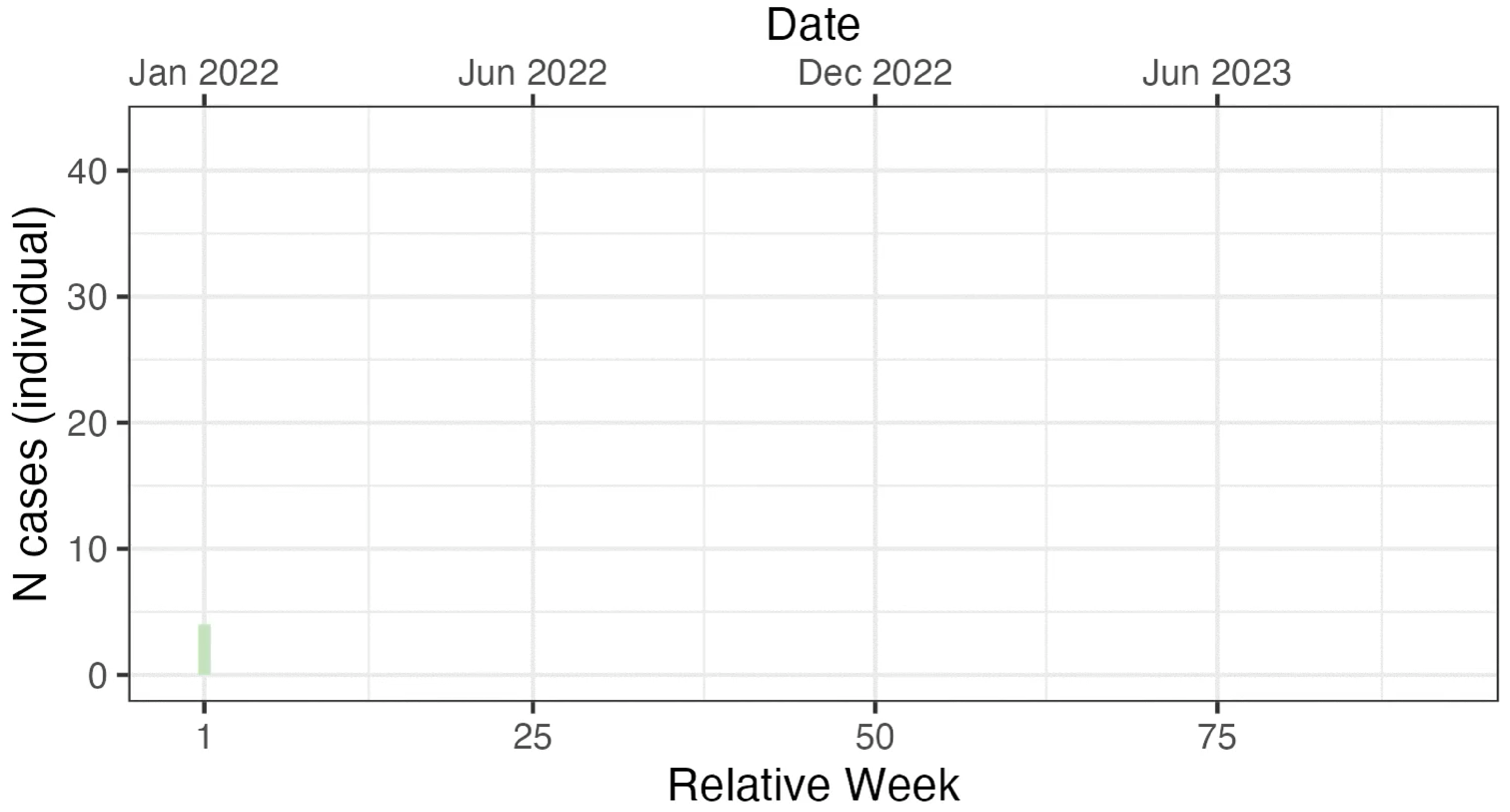




Reconstructing transmission

Model entity

Density-explicit 2 x 2 km cell

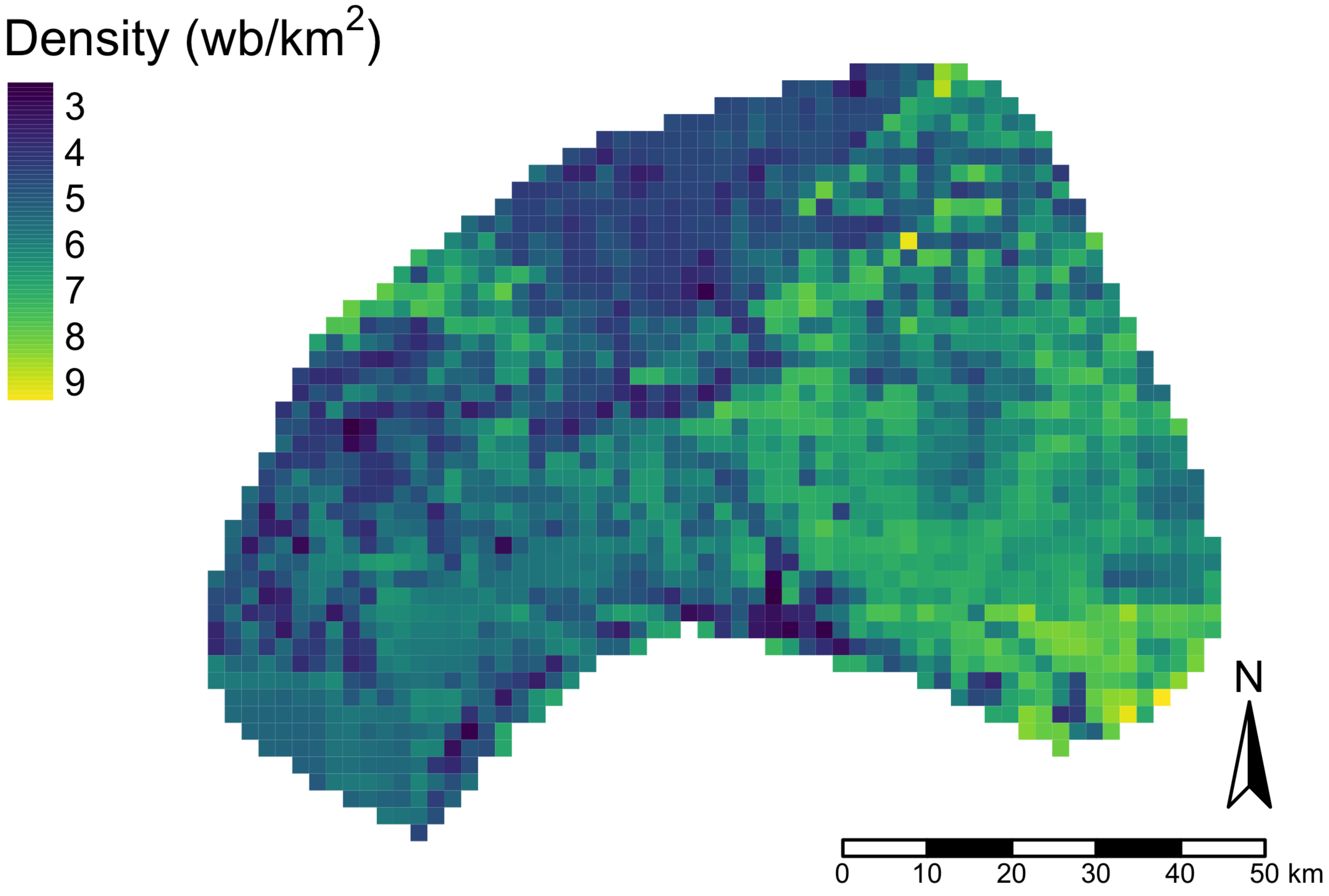
Infectious process

Detection-delay SIR model

Infectious periods (IP)

Estimated per carcass ($IP_{carcass}$)

IP_{cell} defined by continuous overlap of $IP_{carcass}$.



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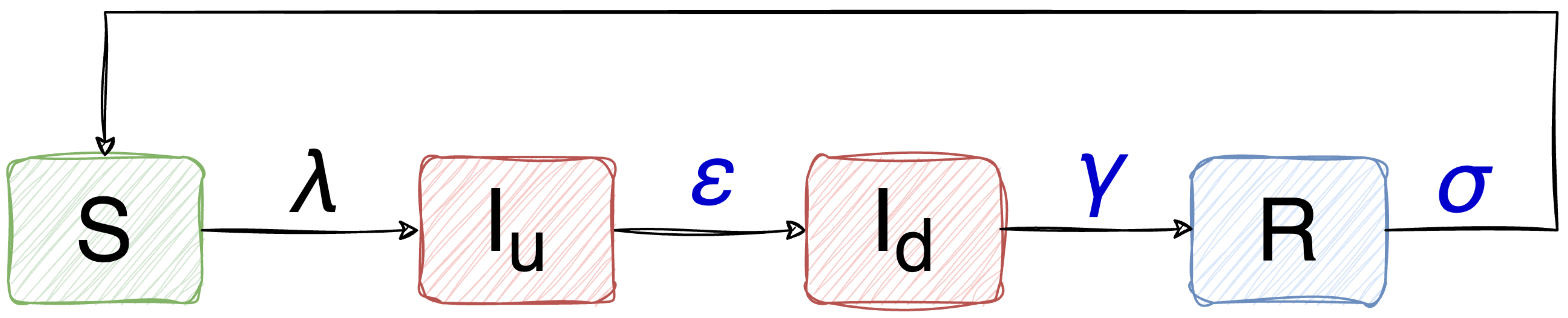

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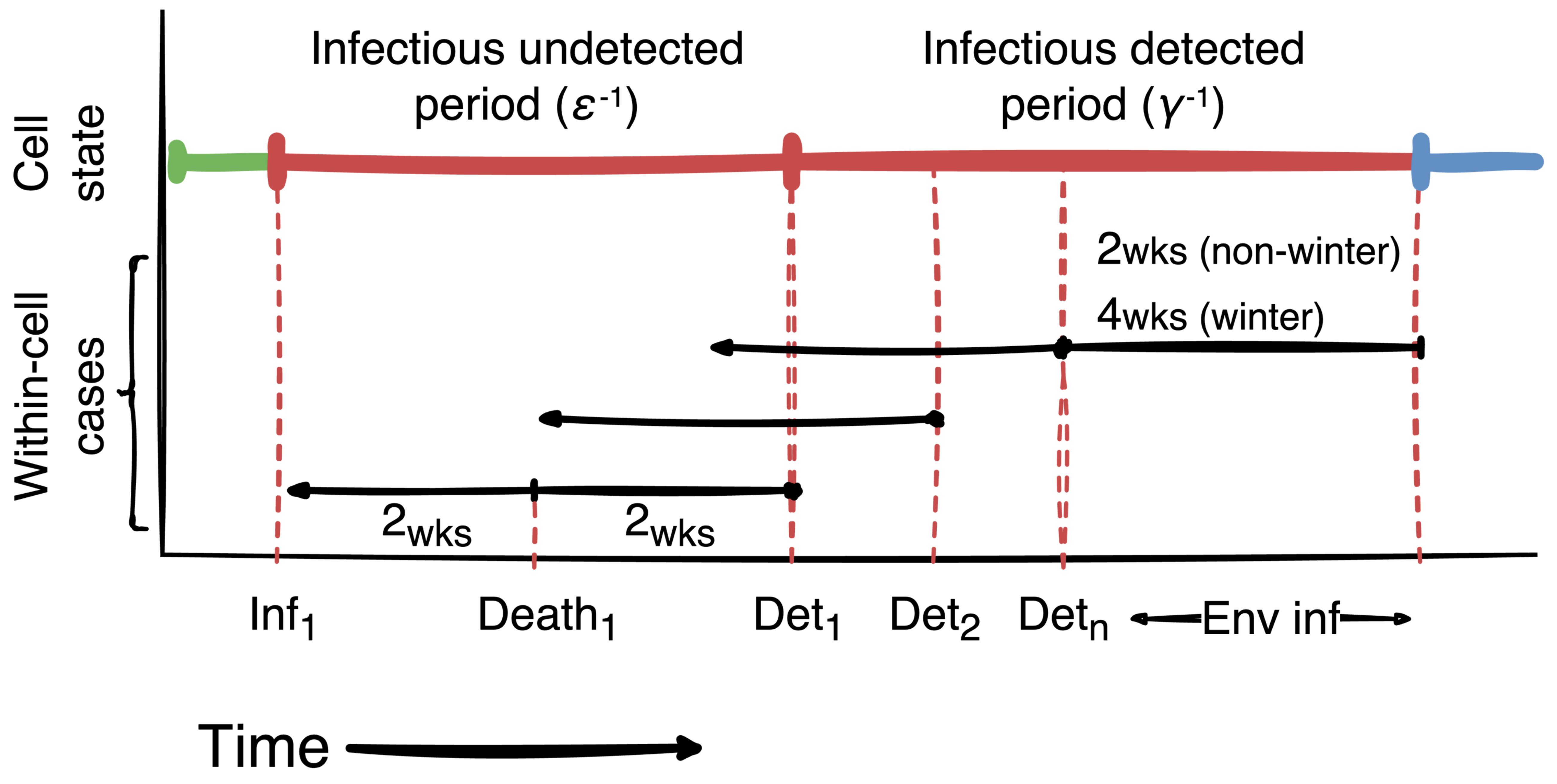


Reconstructing transmission

Detection rates

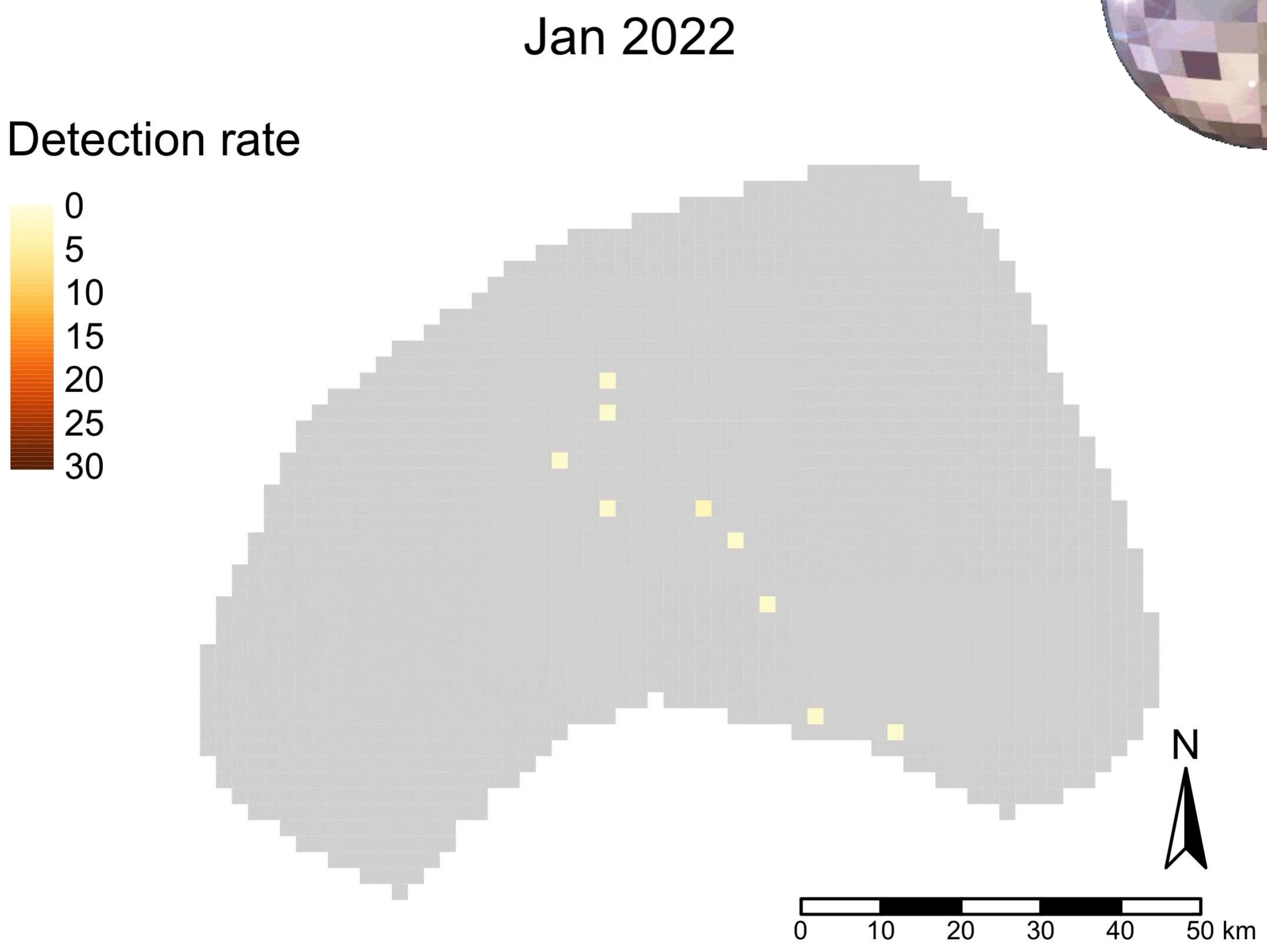
Weekly probability of detection per cell

Recovery rates

Seasonal (winter/non-winter)

Re-susceptibility

Fixed from waves in epi curve



$\mathcal{F}$ (n carcasses tested & mean prevalence at first detection)

Reconstructing transmission

Detection rates

Weekly probability of detection per cell

Recovery rates

Seasonal (winter/non-winter)

Re-susceptibility

Fixed from waves in epi curve

Season	Definition	Weeks	Value
Winter	Mean weekly temp ≤ 5ºC	49–6	0.095
Non-winter	Mean weekly temp > 5ºC	7–48	0.14

Reconstructing transmission

Detection rates

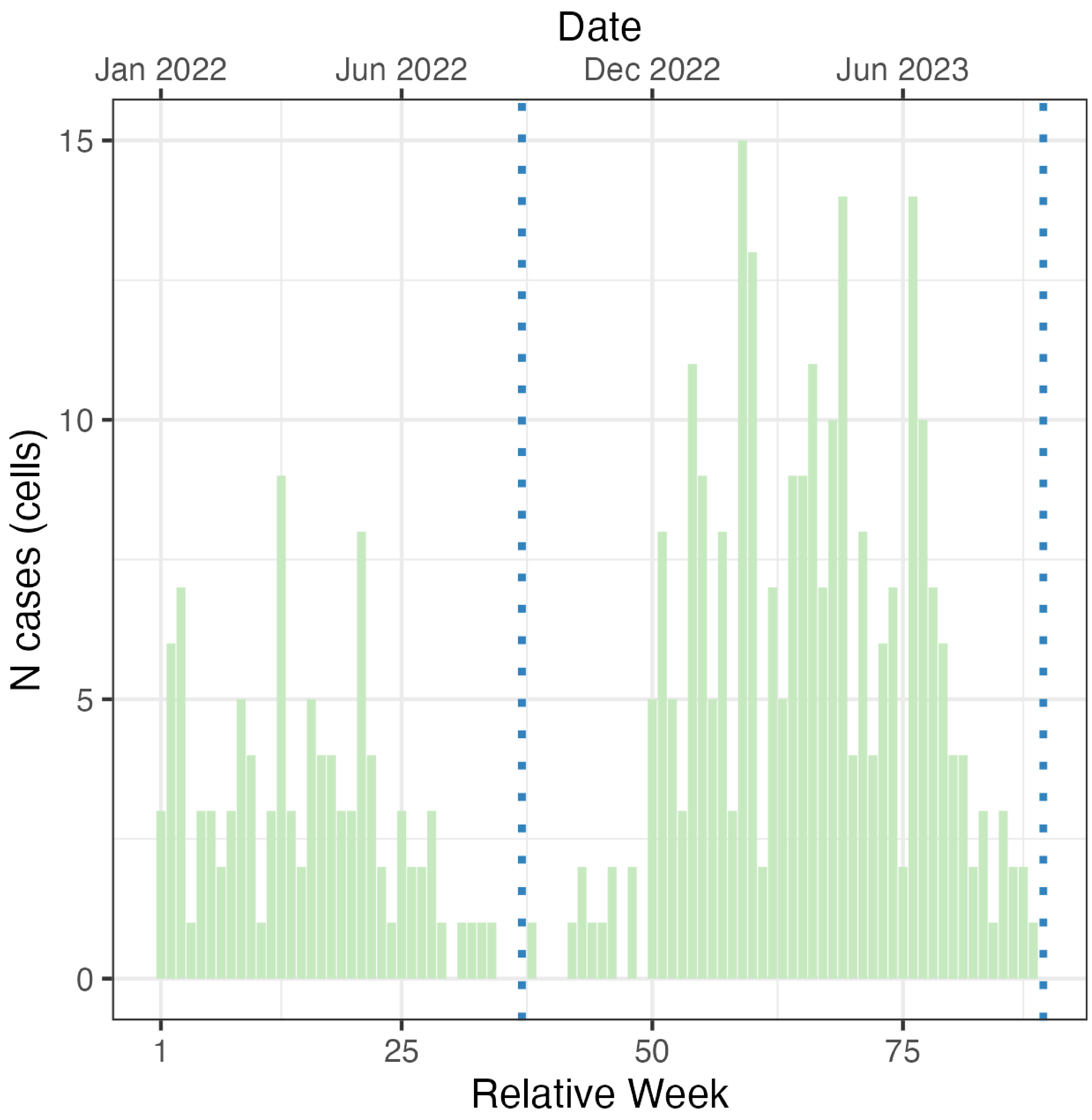
Weekly probability of detection per cell

Recovery rates

Seasonal (winter/non-winter)

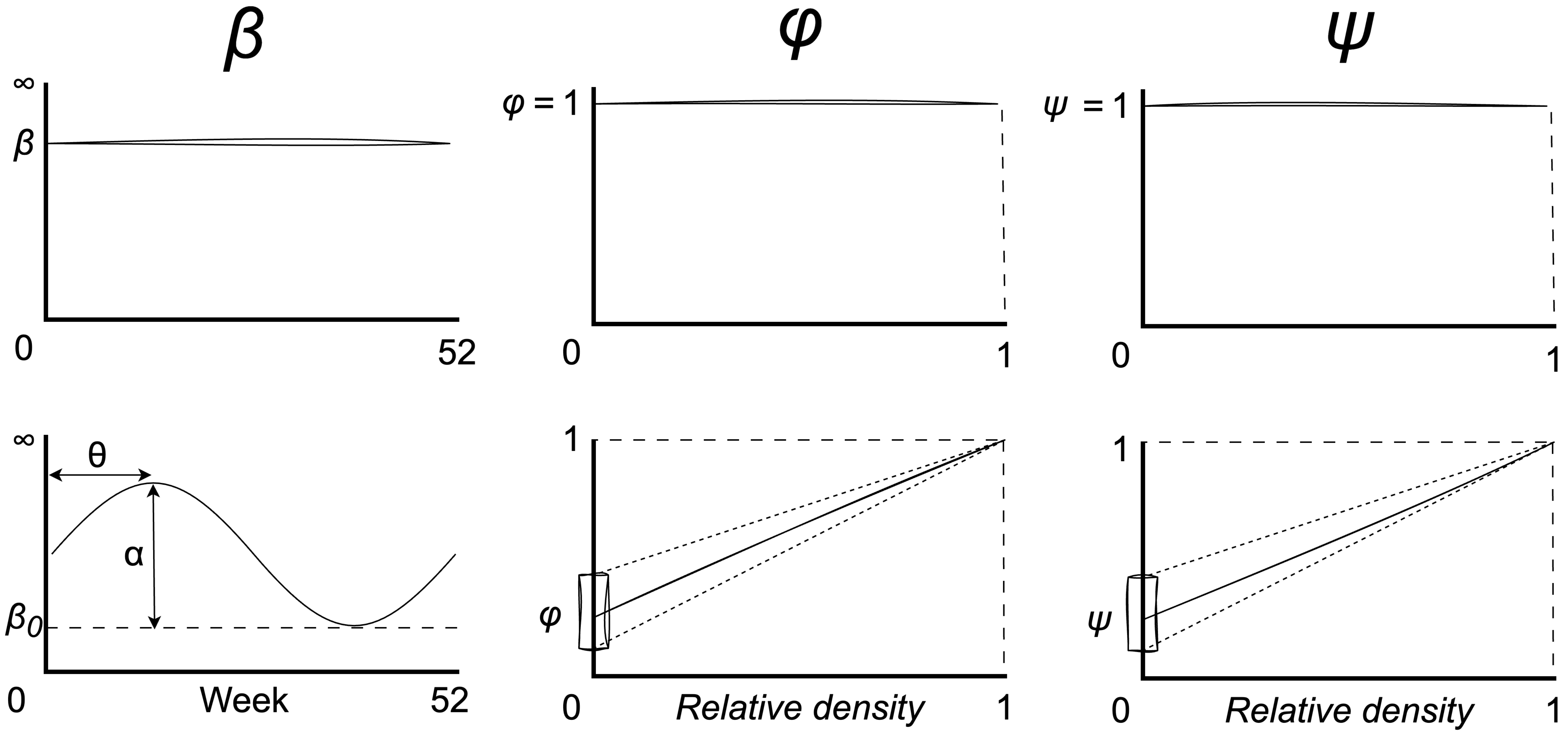
Re-susceptibility

Fixed from waves in epi curve



Simulating infection

$$\lambda_j = \varphi_j \sum_{i \in I} \psi_i \cdot \beta_t$$



Model Selection

8 models fit by APMC

Variant of sequential Monte Carlo approximate Bayesian computation (ABC-SMC)

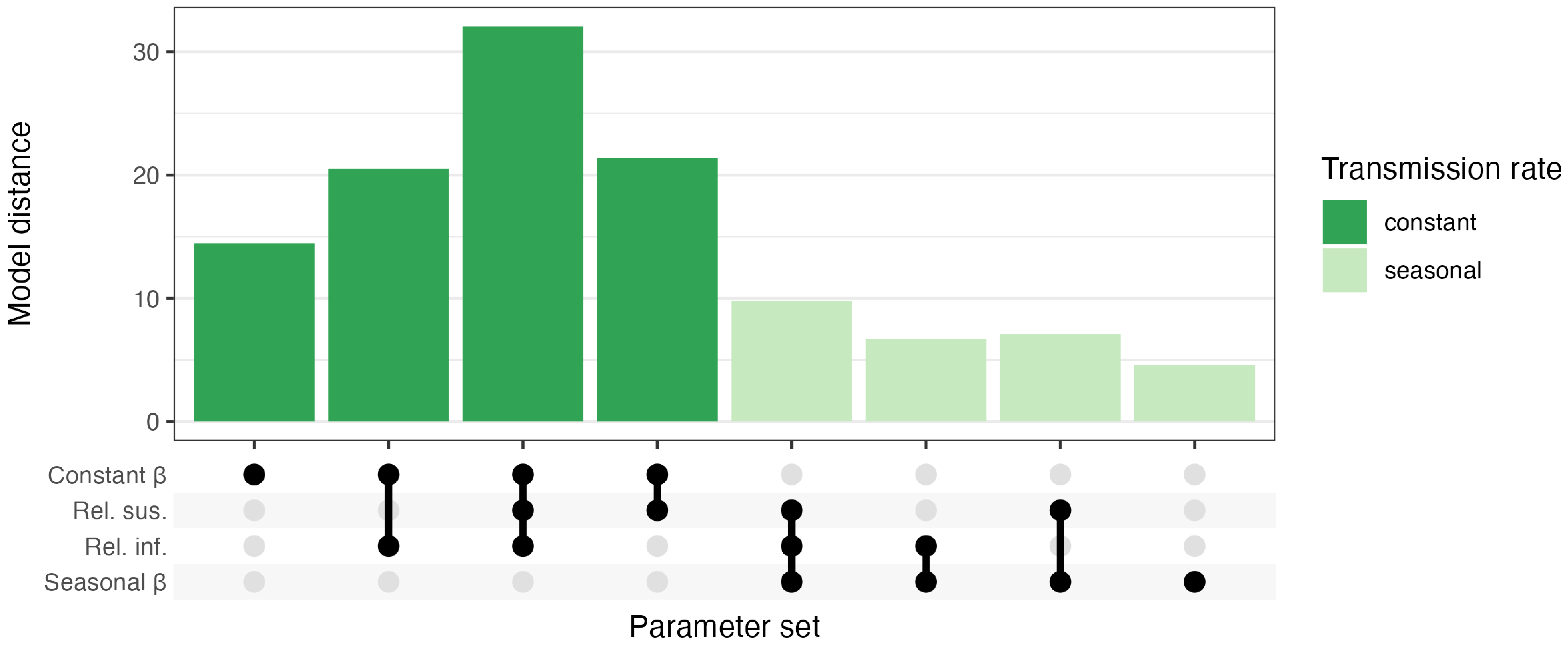
Summary statistics

Incidence, area of spread, total wild boar density of detected cells

Best performing model

Nearest distance to observed summary statistics

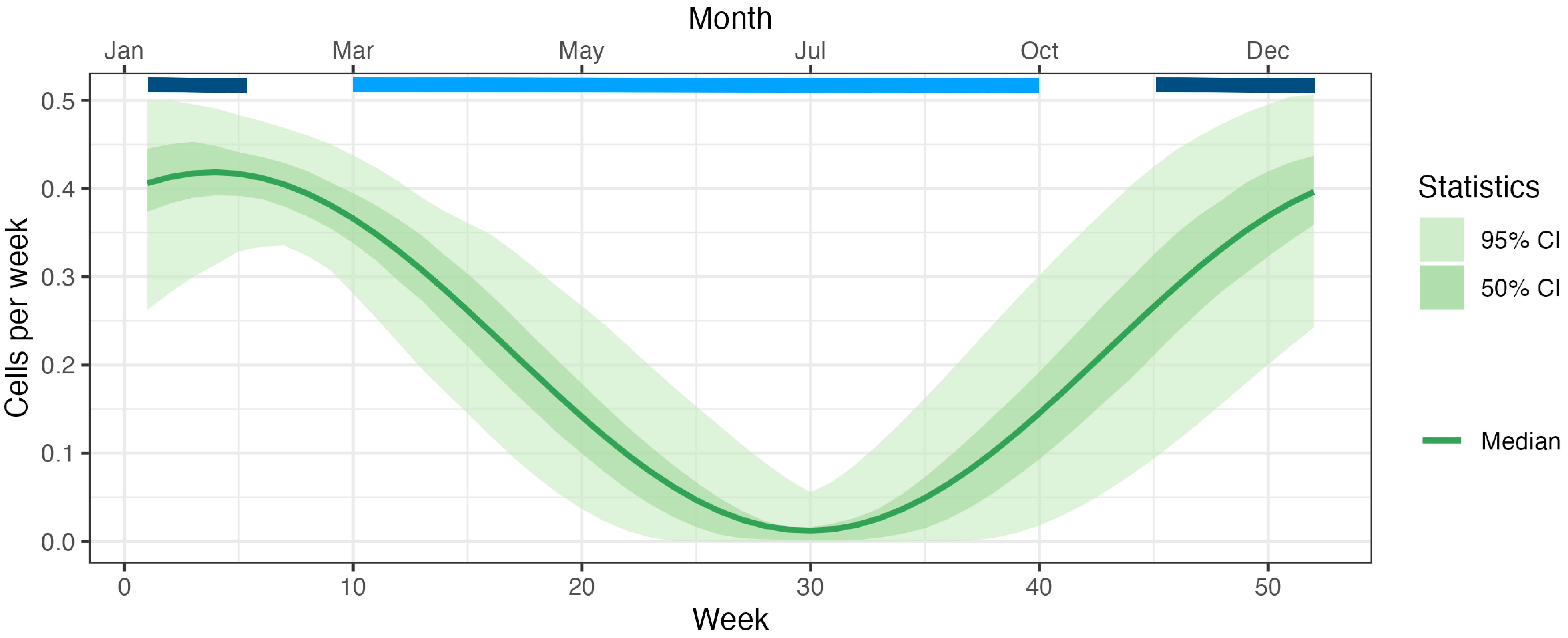
Model Selection



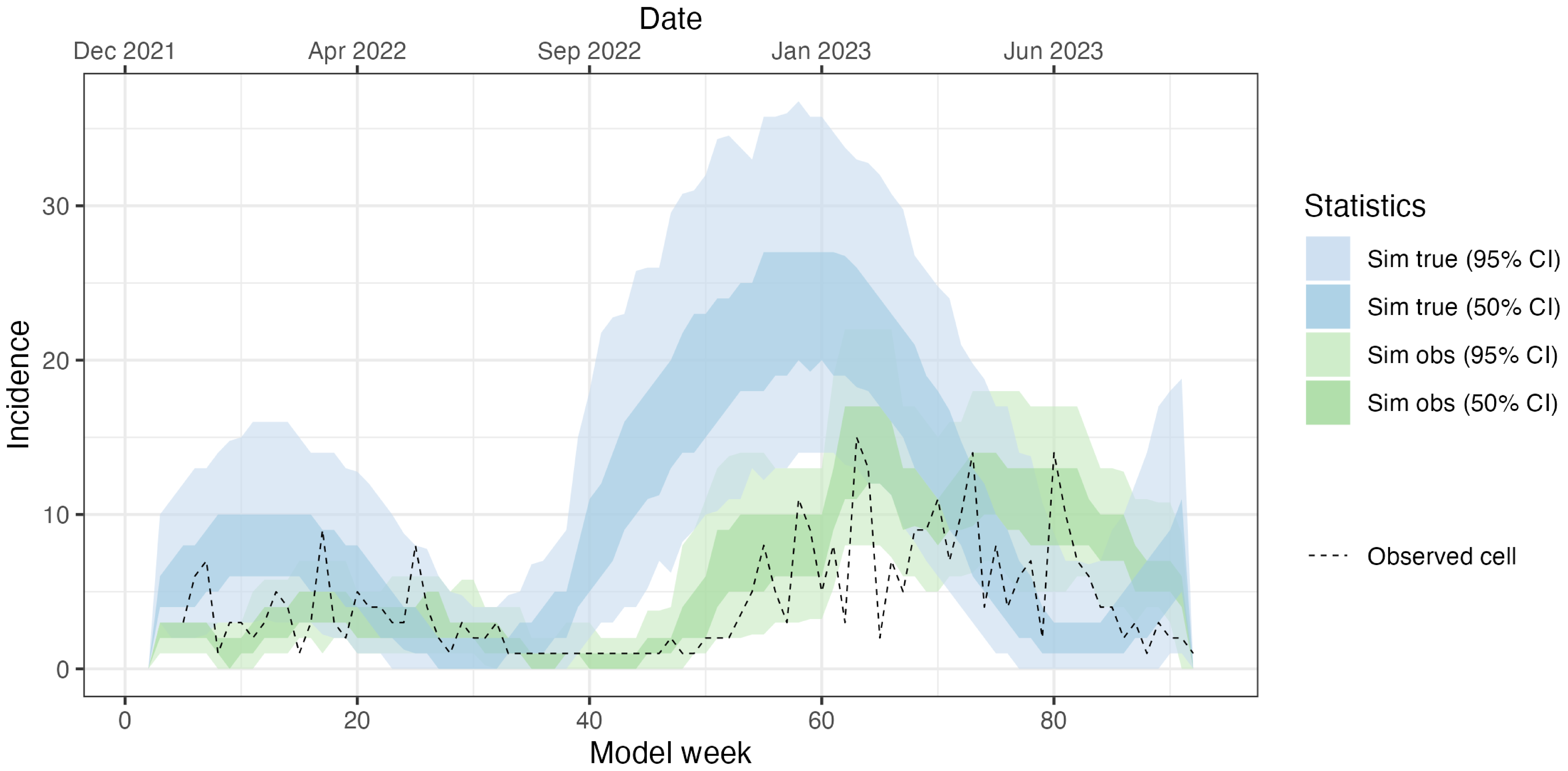
Transmission pattern

Farrowing season

Mating season



Observed dynamics

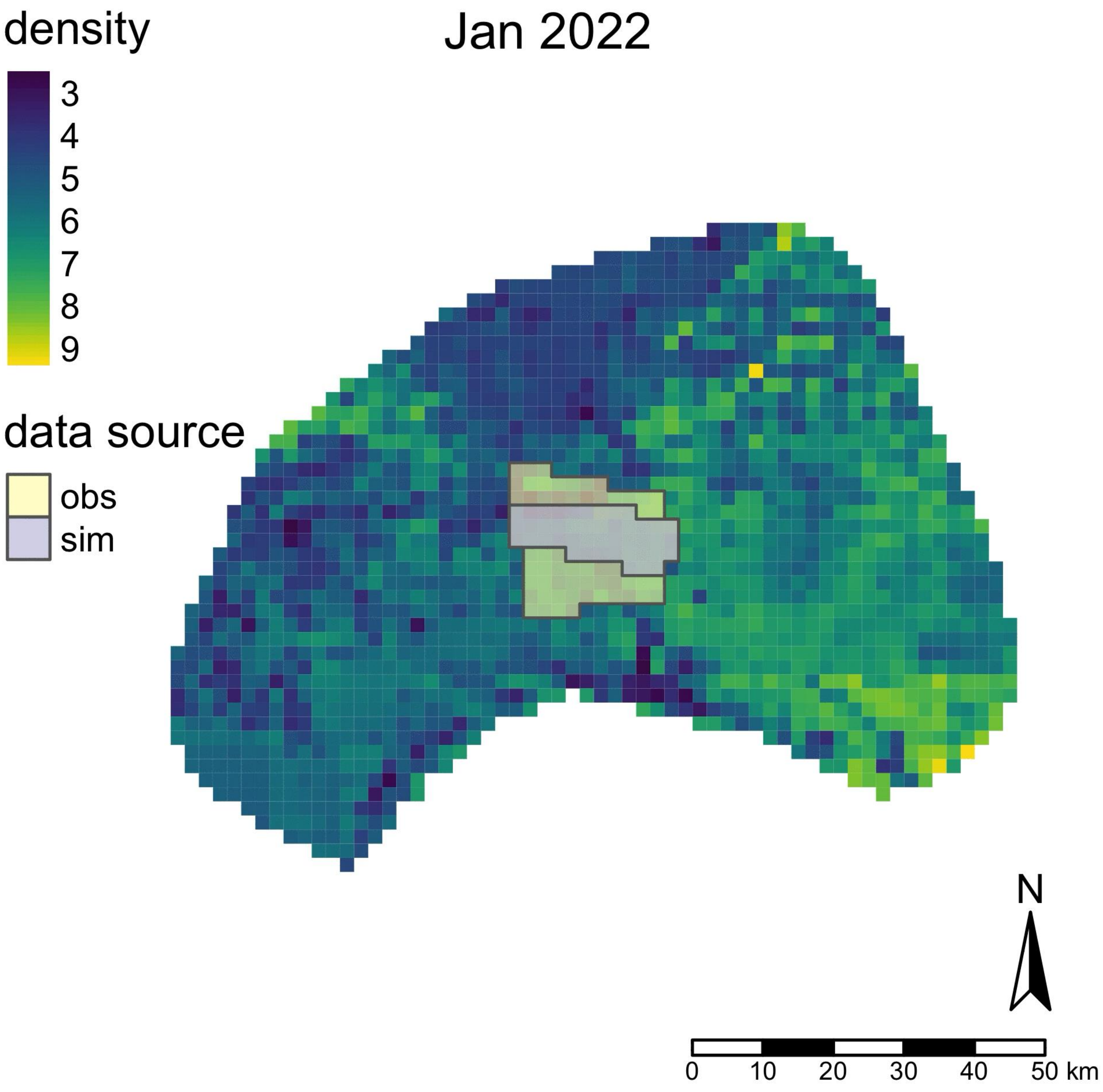


Density effect

Null-model best-fitting

∴ No constant density effect

Wave-specific effect?



Density effect

Null-model best-fitting

∴ No constant density effect

Wave-specific effect?

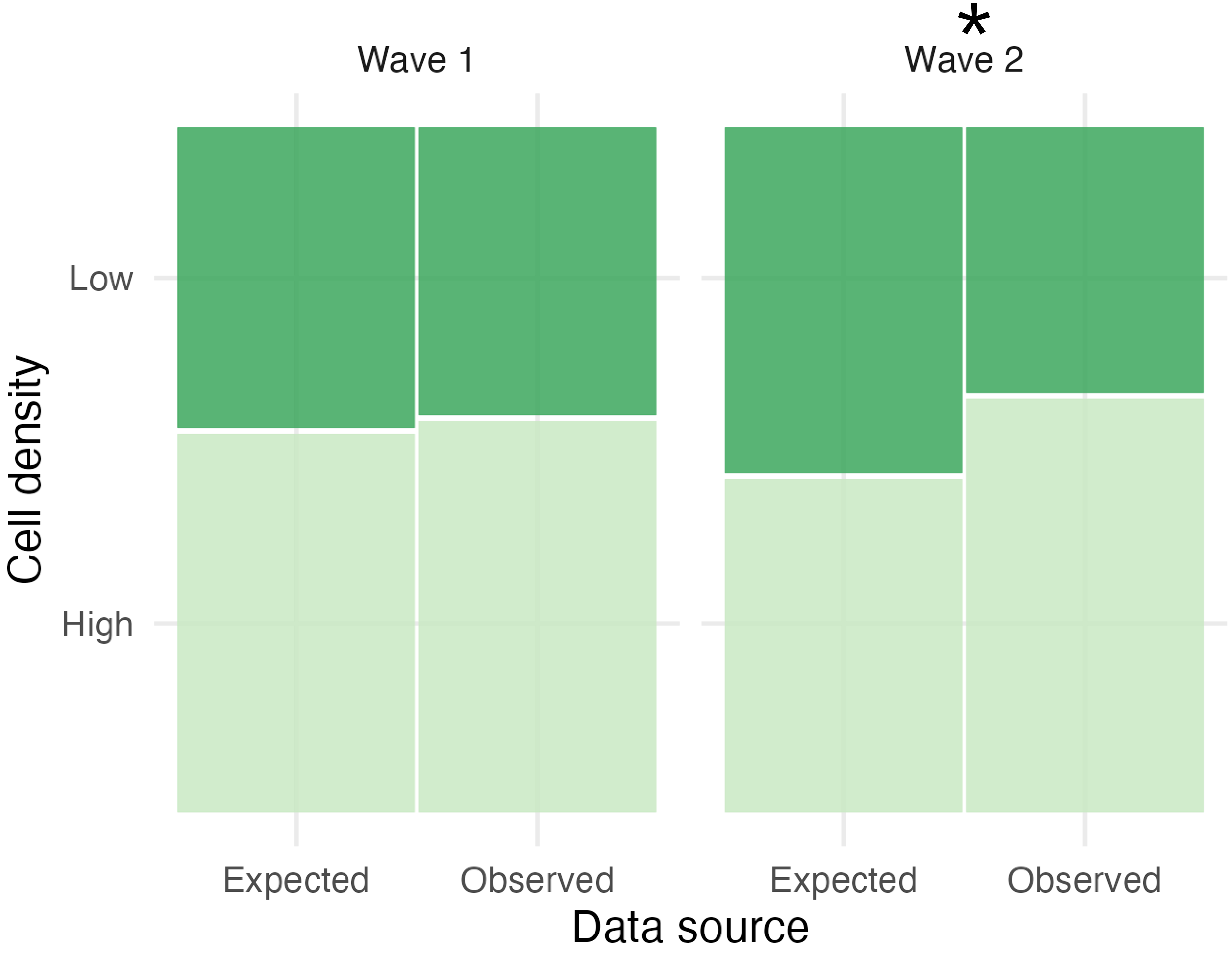
Compare difference in proportion of cells belonging to each density class by wave

Why wave specific effect?

Lack of power

Difference in control measures between time periods

Truly no impact of density during the invasion period



Perspectives

Take-home message

Constant influence of density on ASF spread not observed in Italy

Wave-specific effect of density supported for second wave

Next steps

Include new wave-three data to examine density effect

Fit model with wave-specific parameters for density (e.g. $\varphi_1, \varphi_2, \varphi_3$)

Apply model to contrasting situations (e.g. Sweden, Belgium)

Thank you for your attention

Special thanks to **Lina MUR** & **Eleonora CATTANEO** from EFSA

and the **ENETWild Consortium**

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https://xkcd.com/1838/

HPAI MODELLING CHALLENGE

Surveillance stats

- 8500+ carcasses tested
  - 25% found dead
  - 65% hunted
- 10% ASF positive
  - 85% found dead
- Minority dead non-symptomatic, road/predator killed

Assumptions

Exponentially-distributed detection and recovery rates

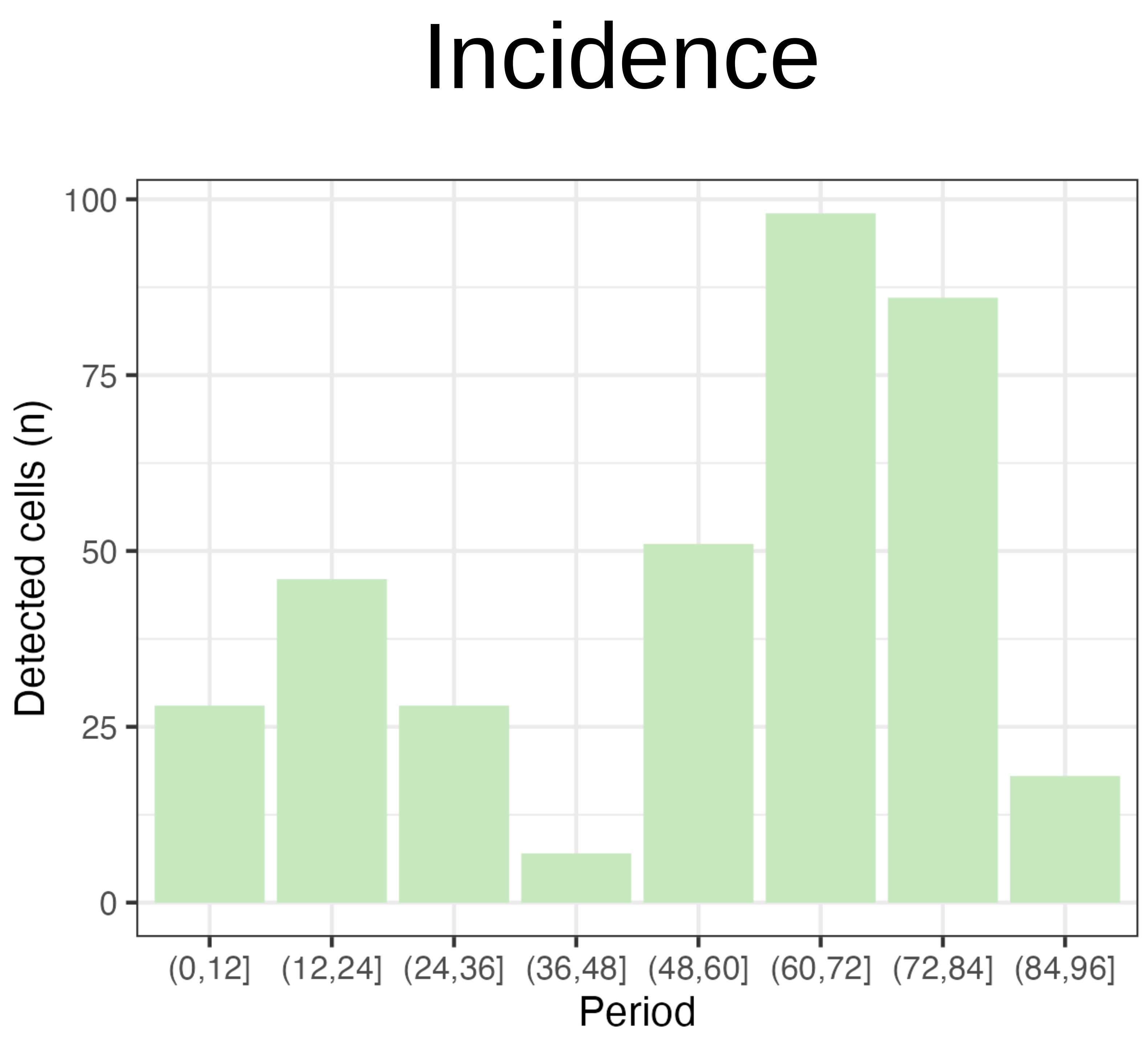
Fixed parameters informing infectious periods

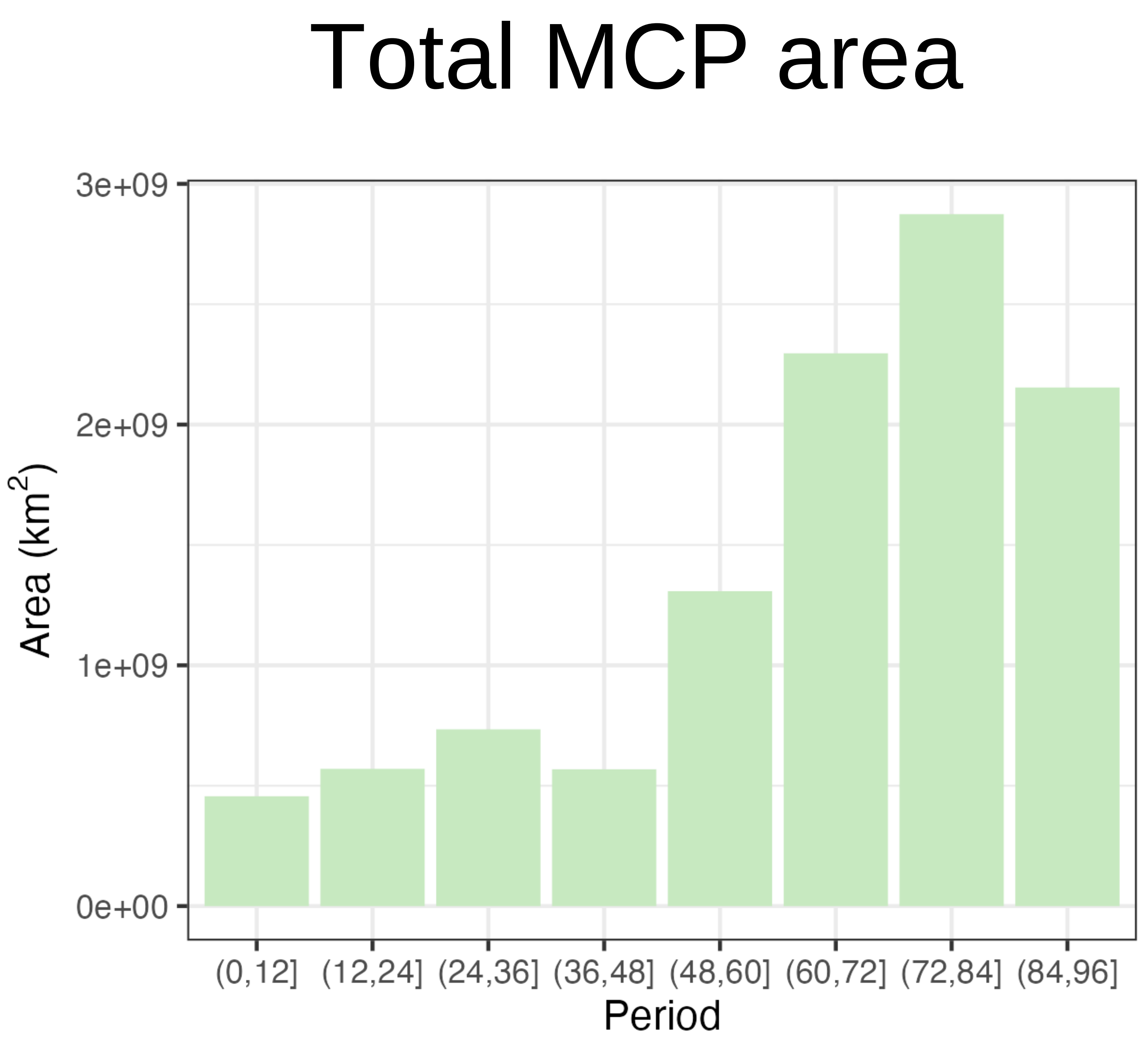
Constant detection delay for all carcasses

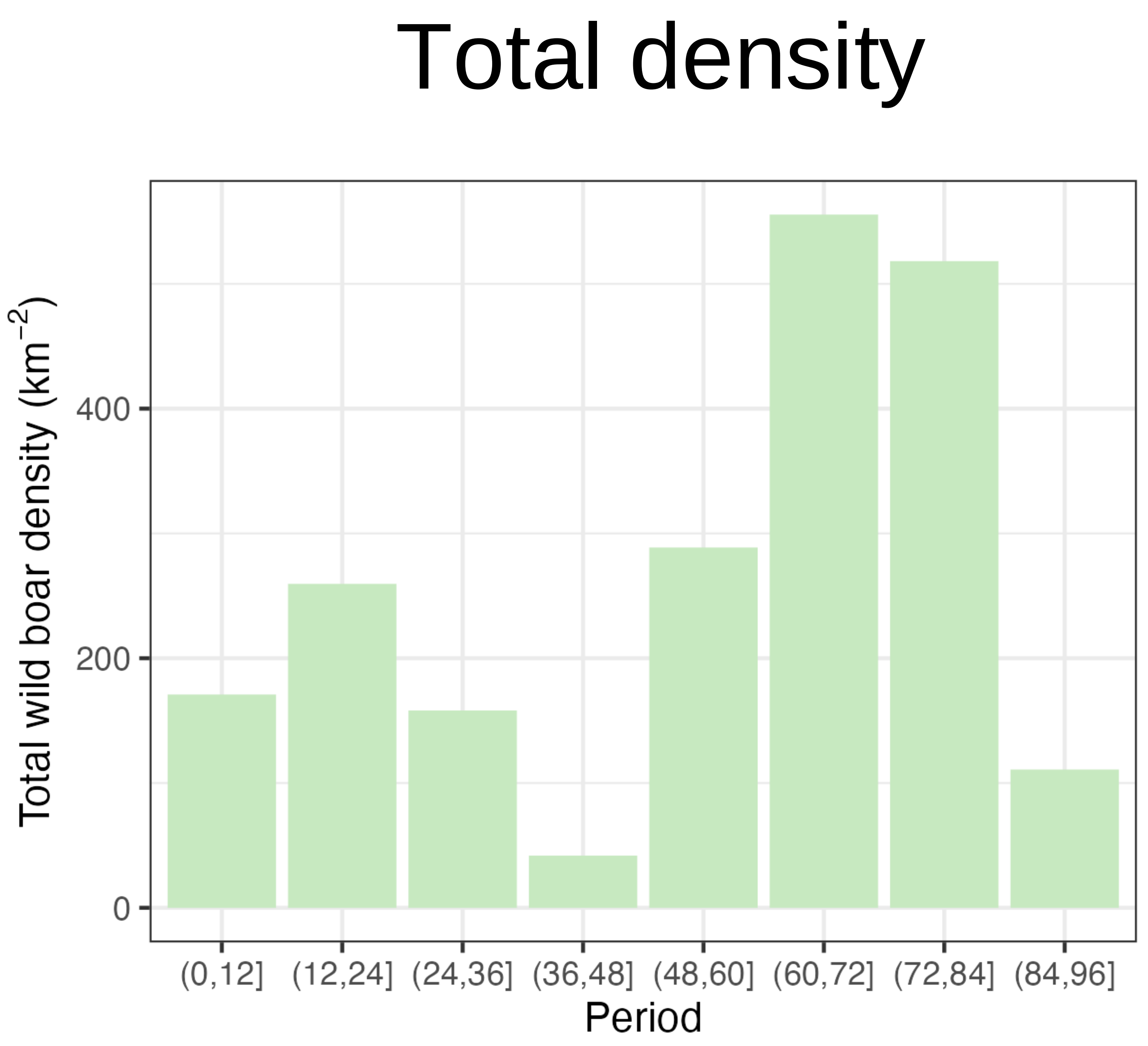
Cell recovery dependent on detection

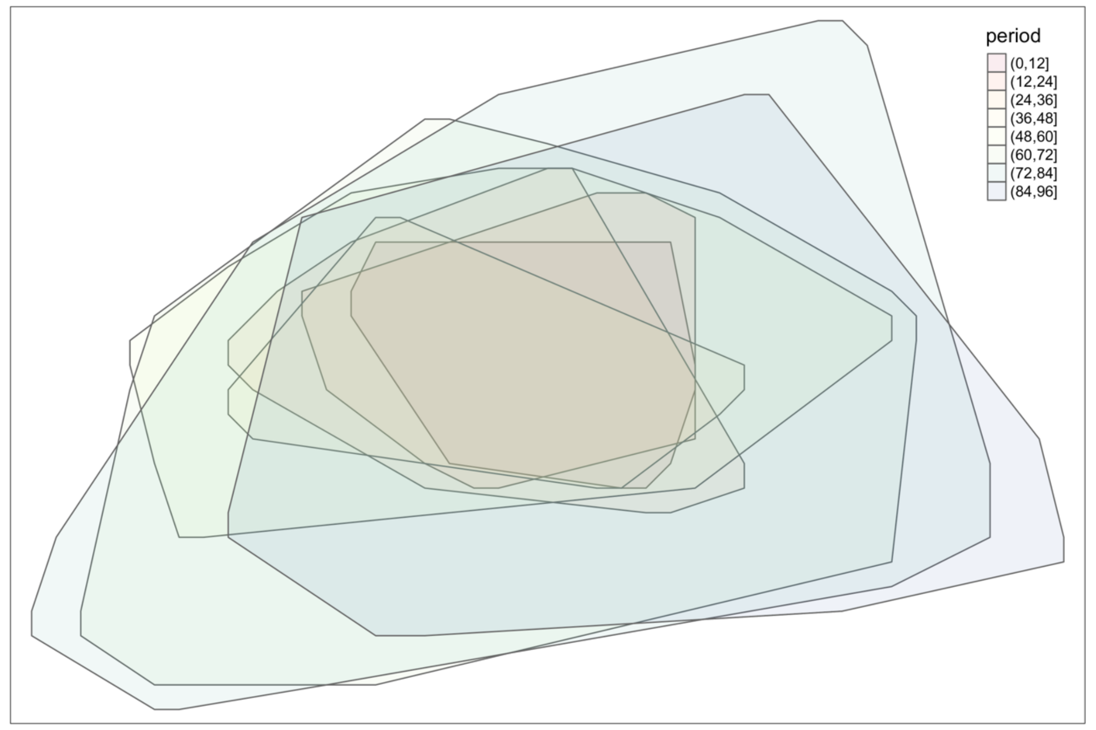
Par	Value	Source
Case fatality interval	2 weeks	In-vivo experimentation (Pietschmann et al., 2015)
Detection delay	2 weeks	Field experience in South Korea (J.S. Lim, personal comm)
Winter cold period (median < 5° C)	Weeks 1–6, 49–52 of year	Weekly provincial temperature data from EFSA
Carcass infectiousness persistence	4 weeks (non-winter) 6 weeks (winter)	In-vivo experimentation (Fischer et al., 2020; Guberti et al., 2022)
Mean prevalence at first detection	0.78	Observed data
Re-susceptibility transition	38th week of year (~mid September)	Observed data

Summary statistics









Detection rate

Detection probability

$$P_{i,t} = 1 - (1 - \pi_{det})^{n_{i,t}}$$

Detection rate

$$\epsilon_{i,t} = -ln(1 - P_{i,t})$$

Parameter	Definition
$P_{i,t}$	Probability of detection per cell per week
π_{det}	Mean prevalence at first detection (~75%)
$n_{i,t}$	Number of tested carcasses
$\varepsilon_{i,t}$	Detection rate per cell per week

Distance (km)	Weeks	Mean prev
2	4	0.93
	2	0.93
	6	0.92
4	2	0.84
	4	0.84
	6	0.82
6	2	0.81
	4	0.78
	6	0.76
8	2	0.75
	4	0.71
	6	0.70
10	2	0.67
	4	0.65
	6	0.63

Detection probability

Simulated detection probability congruent with observed detections