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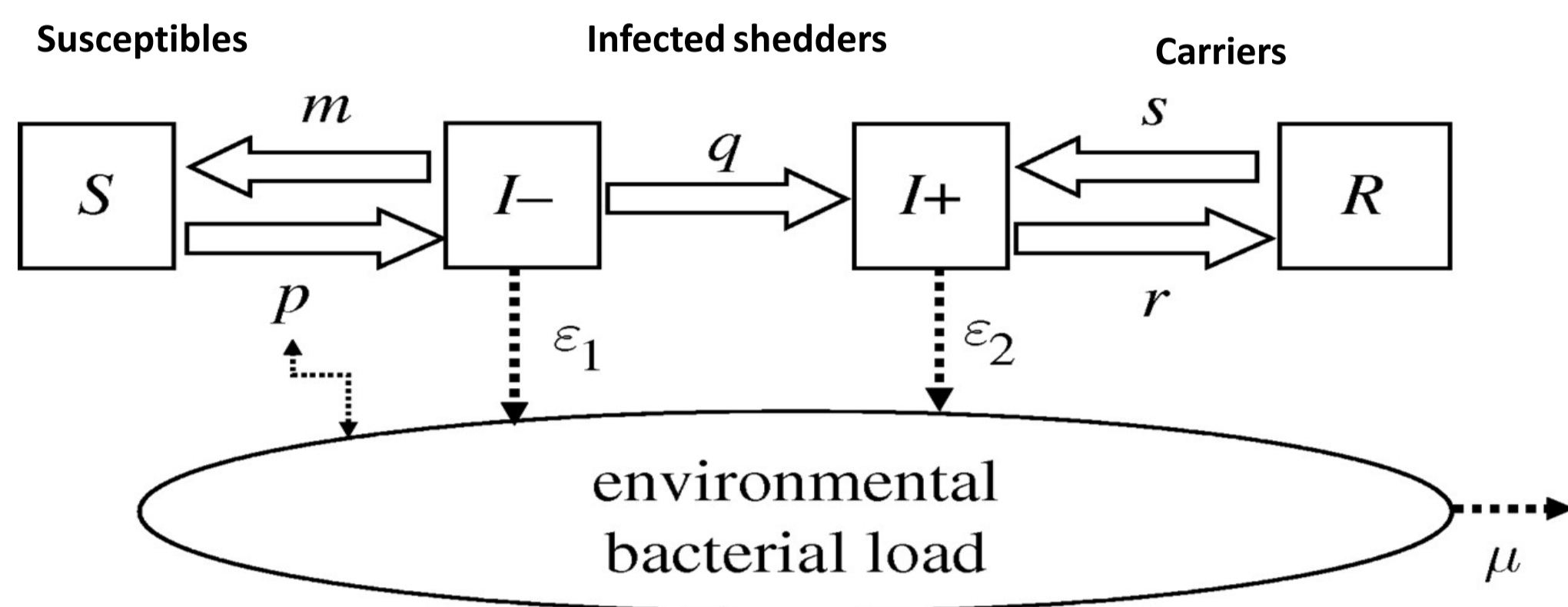
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Q fever is one of the most important zoonotic diseases in Europe caused by the bacterium *Coxiella burnetii*. Previous modeling studies described the disease dynamics in a dairy cattle herd. In order to simulate transmission between herds, we extend this model by including airborne dispersion modeling to understand the spread of the disease on a regional scale.

## INTRA-HERD MODEL



$$p = 1 - e^{-\text{environmental load}}$$

Courcou A et al. Proc. R. Soc. B 2010;277:2857-2865

- Compartmental deterministic model in discrete-time
- Four health states: S: susceptible, I-: shedder without antibodies, I+: shedder with antibodies, C: non-shedder with antibodies, E: environment
- Intra-herd dynamics as described in previously.
- Animals infected by inhalation of the contaminated aerosols

## DISPERSION MODEL

- One dimensional Gaussian Dispersion model
- Ground level dispersion of the particles
- Bacterial plume reaching  $C(x,y,0,t) = \frac{Q(t-x/u)}{2\pi\sigma_x(x)\sigma_y(x)} e^{-\frac{y^2}{2\sigma_y^2(x)}}$
- Flat terrain with no geographical wind barriers
- No settling of infectious particles during the transport

Where,

Q = Concentration of bacteria at source

$\sigma_y^2$  &  $\sigma_x^2$  = standard deviations of diffusion

u = wind velocity

Standard deviation of lateral diffusion is calculated as below

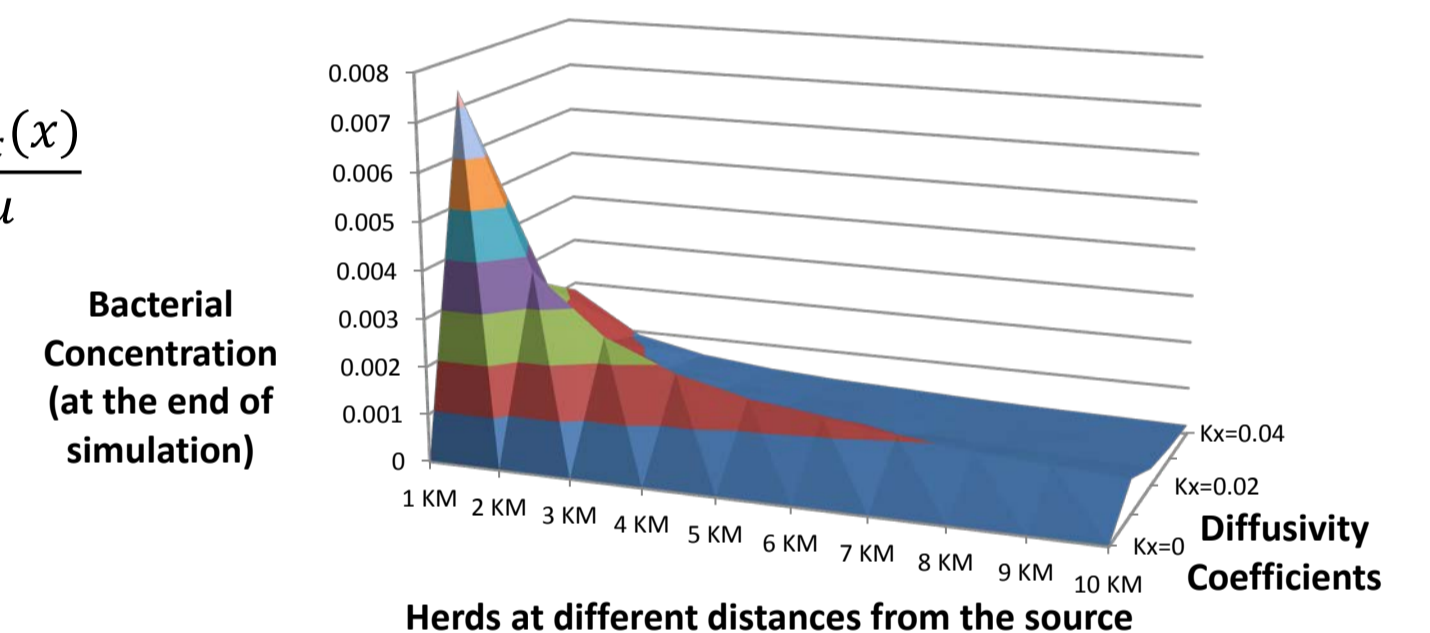
$$\sigma_y^2 = \frac{2K_y(x)}{u} \quad \sigma_x^2 = \frac{2K_x(x)}{u}$$

Where,  $K_y(x)$  &  $K_x(x)$  are coefficients of eddy diffusivity

The bacterial plume generated was found to be highly sensitive to lower values of diffusivity coefficients at smaller distances from the source

$K_y(x) = K_x(x) = 0.03$  were used in current simulations

Sensitivity analysis for Diffusivity coefficient

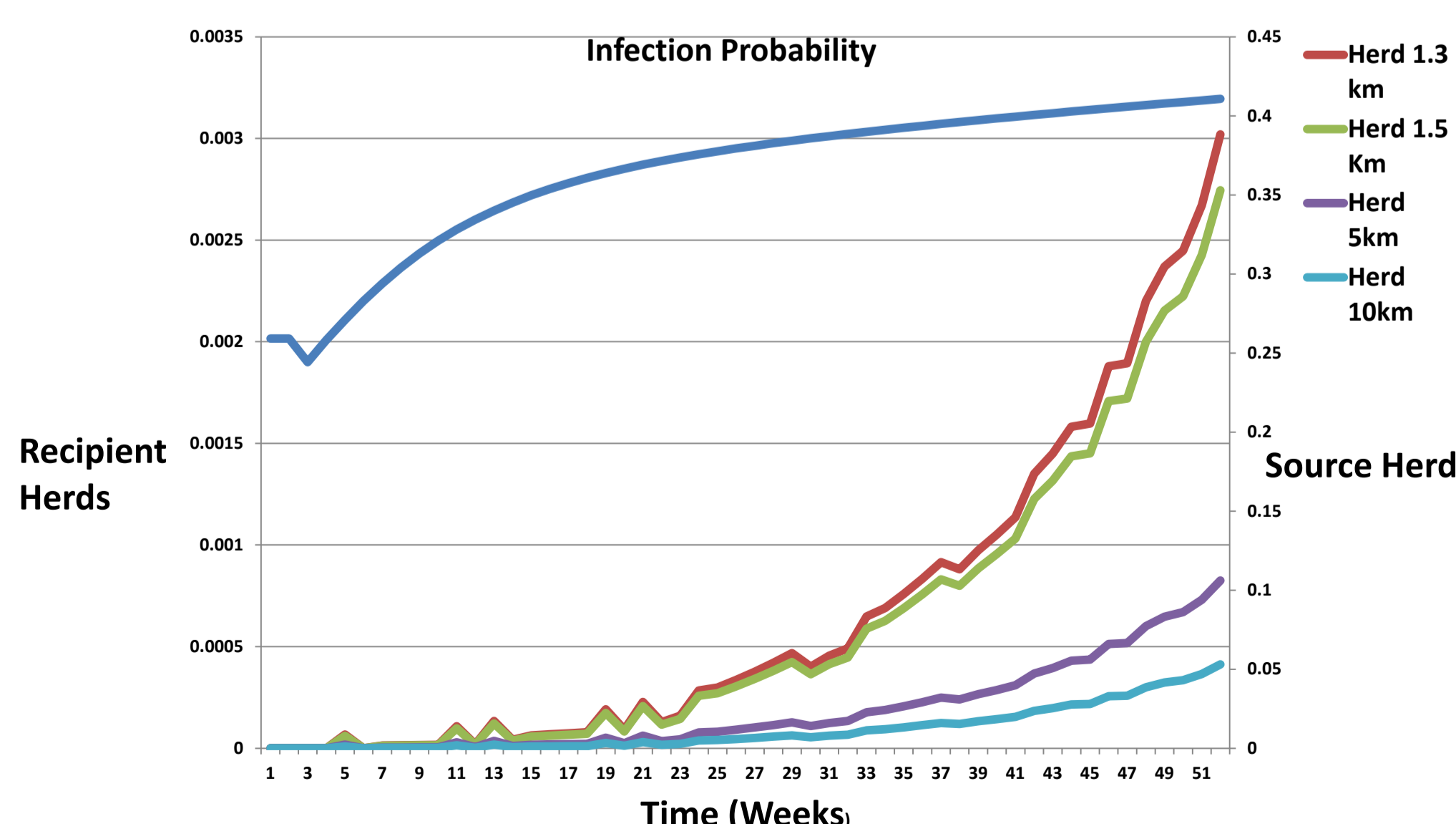


Sematimba A et al. Plos ONE 2012; 7(2): e31114.

## SIMULATIONS

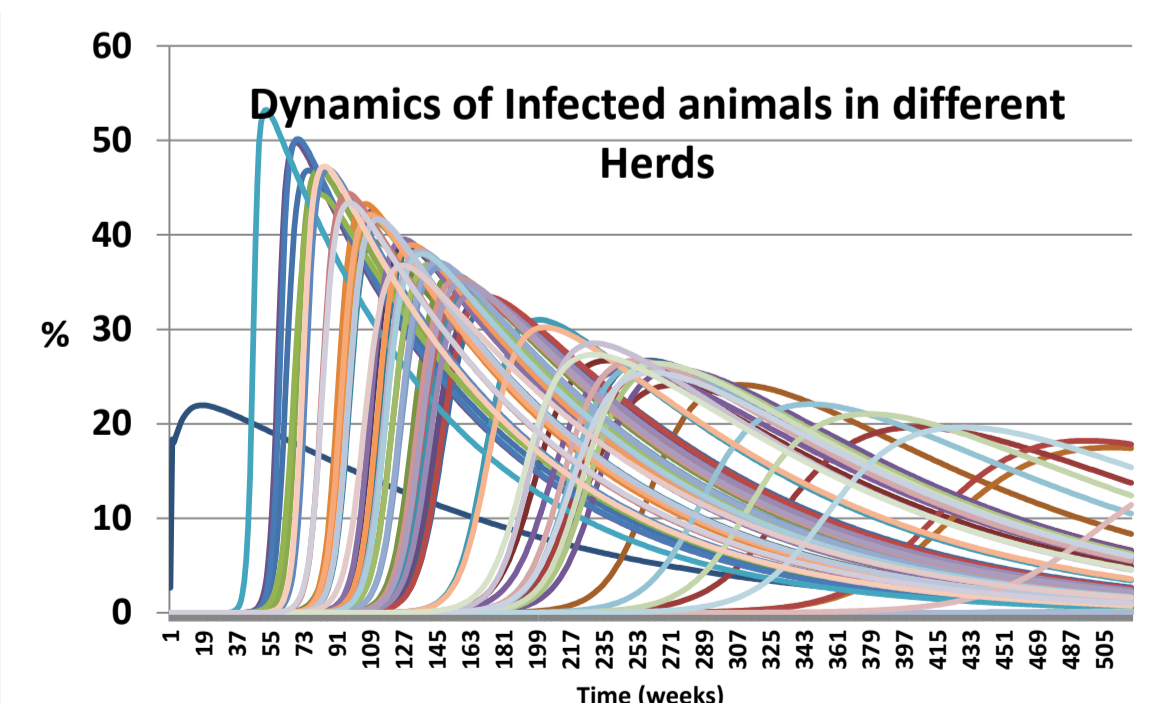
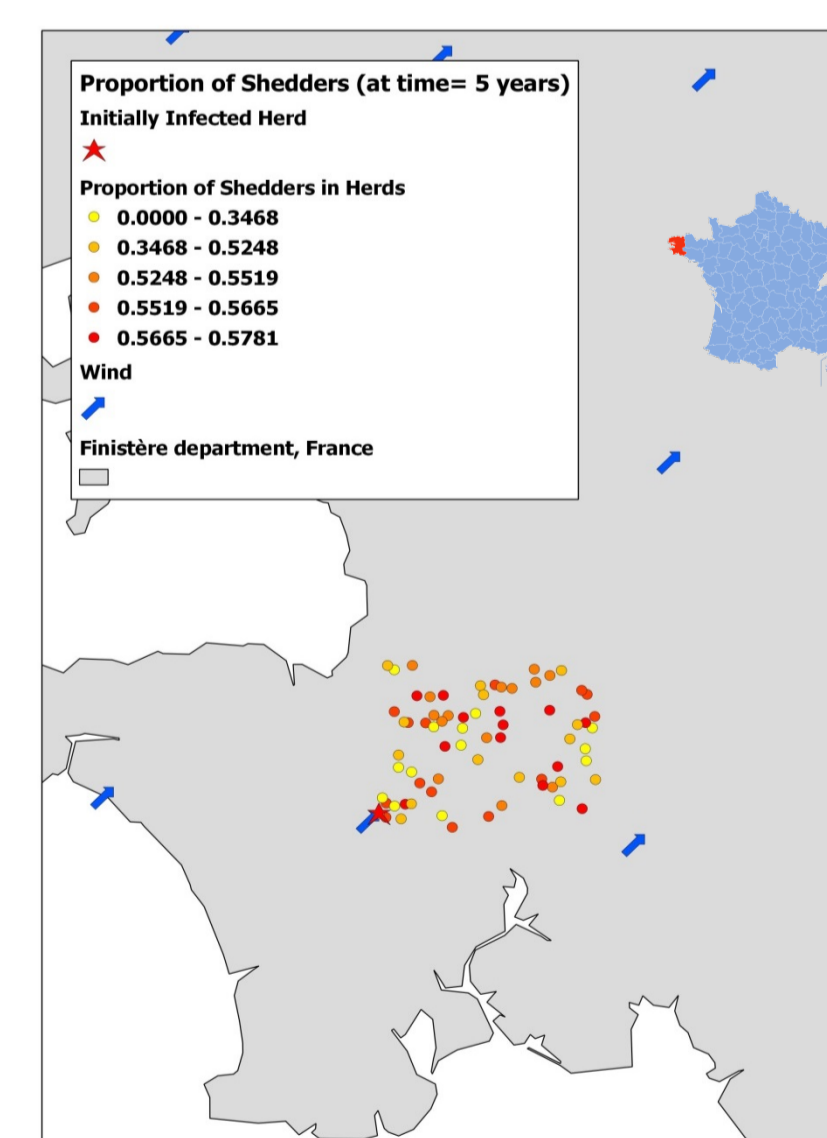
### Modeling Scenario 'A'

- 5 cattle dairy herds, 1 source herd and 4 completely susceptible herds
- Situated at 1.3, 1.5, 5 and 10 kms from the source herd
- Source herd is endemically infected herd, steady state as in [1].
- All herds can produce plume once they are infected
- All herds are on the same latitude



### Modeling Scenario 'B'

- 70 dairy cattle herds in a single meteorological grid located in the department of Finistère in France.
- 1 source herd at the beginning of the simulation
- Simulation of the windborne spread over one year and varying wind velocities



Analysis for possible parameters influencing transmission such as distance, wind velocities, direction and herd size will be done

## DISCUSSION

- Inclusion of wind-borne dispersion of bacteria allows simulation of plausible patterns of disease spread at the regional level
- The proposed framework will be used to quantify the relative role of wind borne and animal movements related infections and to assess different local controls and preventive strategies (ongoing work)