# An approach for modelling bluetongue virus transmission

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# Overview

- We present a description of an approach for modelling the transmission of BTV between animal hosts and insect vectors which can then be used to simulate the spatial pattern of disease spread in Australian livestock

- Our intention is that this logic will be incorporated into the hybrid equation-based and agent-based modelling framework AADIS

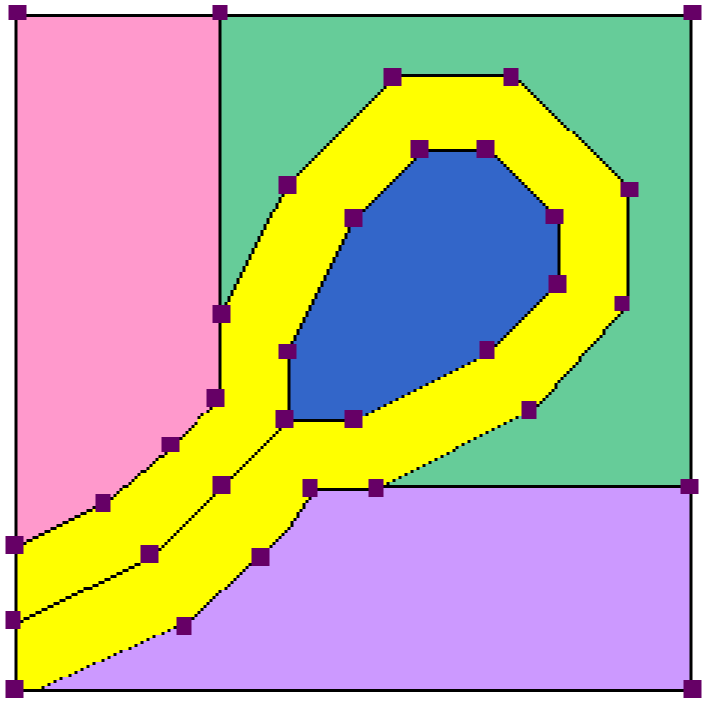
# Methods

- A herd (comprised of susceptible domestic animal species) is defined in AADIS as a single point location (vector format)

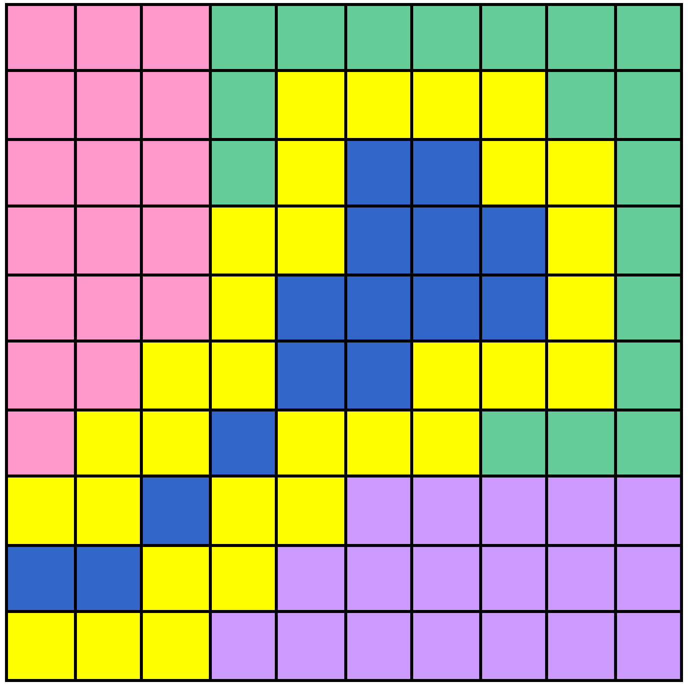
- Attribute data associated with each herd include the number of animals present at that location

- Insect vectors in AADIS are represented spatially in raster format: a regular grid of cells superimposed over the geographic extent of the herd population of interest

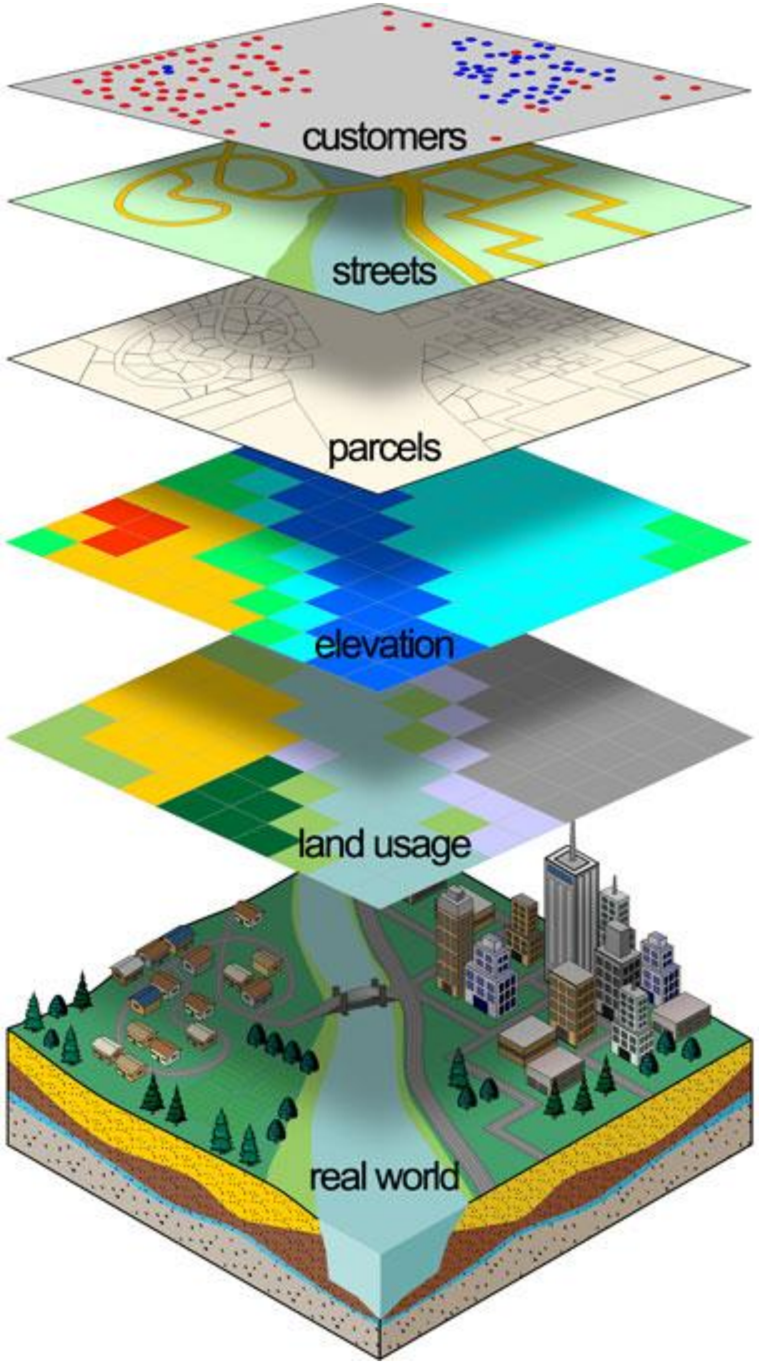
Vector (points, lines, and polygons)



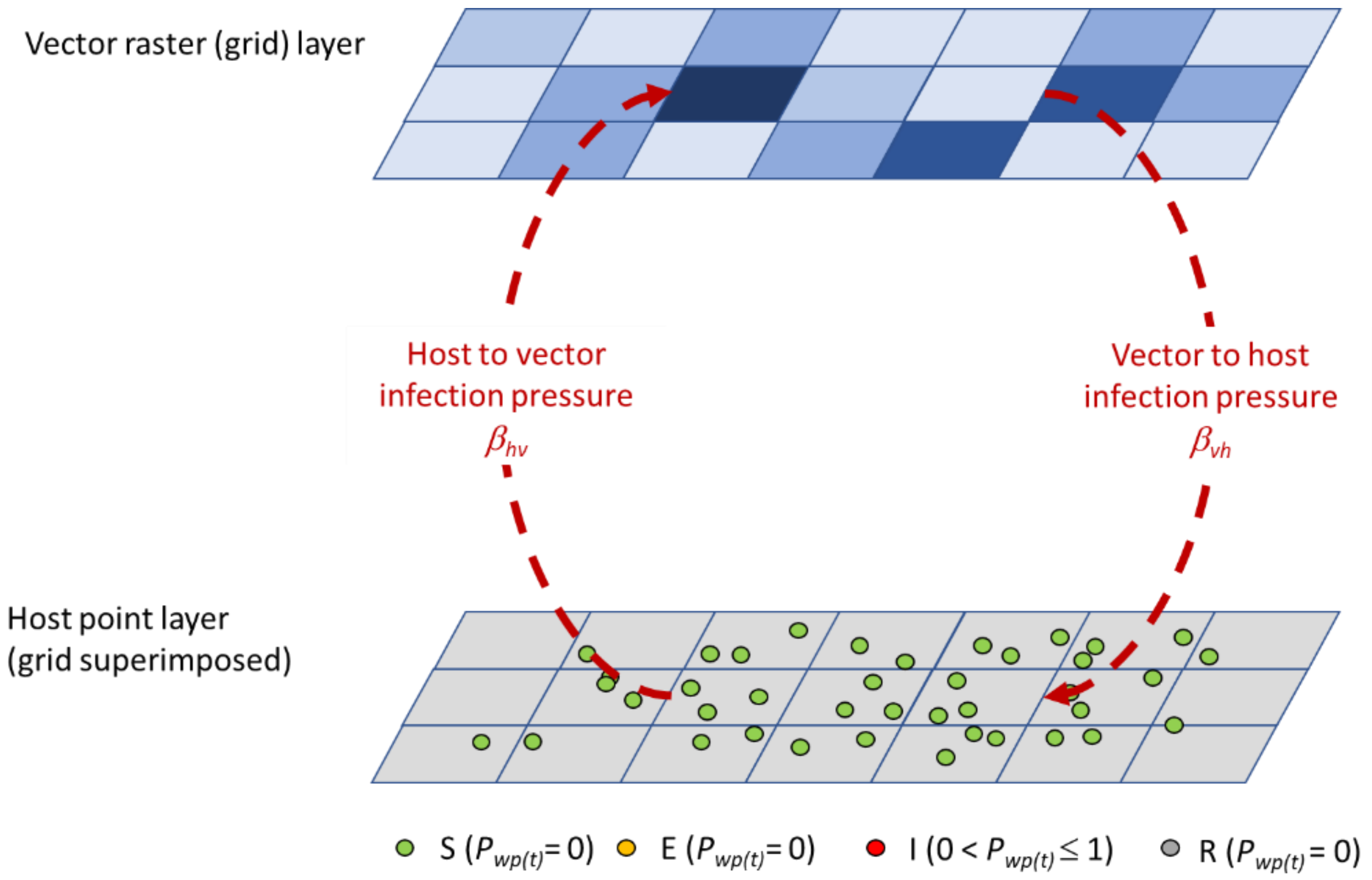
# Raster (arrays of cells /matrix or pixels )



Combinations of raster and vector data.



Interface between herds (represented as spatial point data) and insect vectors (represented as raster data). At time $t = 0$, all animals in all herds are susceptible. S = susceptible; E = exposed; I = infectious; R = recovered; $P_{wp(t)}$ within-herd prevalence at time *t*.

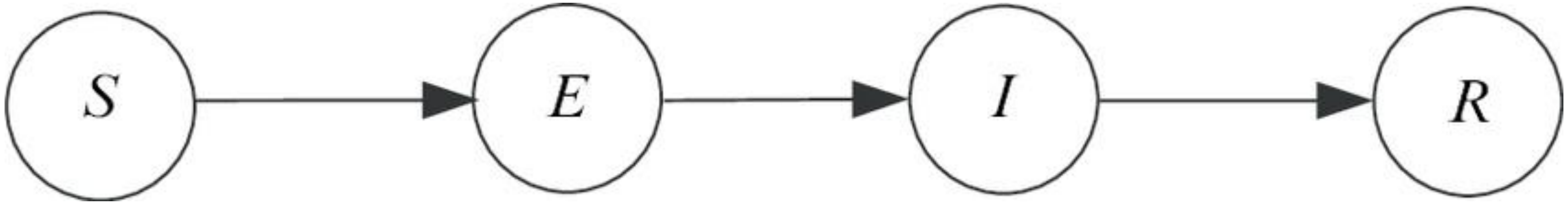


# Methods

- The population of animals within each herd is stratified into compartments (S, E, I and R)

- Animals move between these compartments over time

- Insect vectors move from S to E to I (there is no R)



# Methods

- An SEIR model defines the transition of animal hosts and insect vectors from one compartment to another in weekly time steps

- For each simulation week $\beta_{vh}$ equals the infection pressure exerted by the insect vector raster layer on the animal host population

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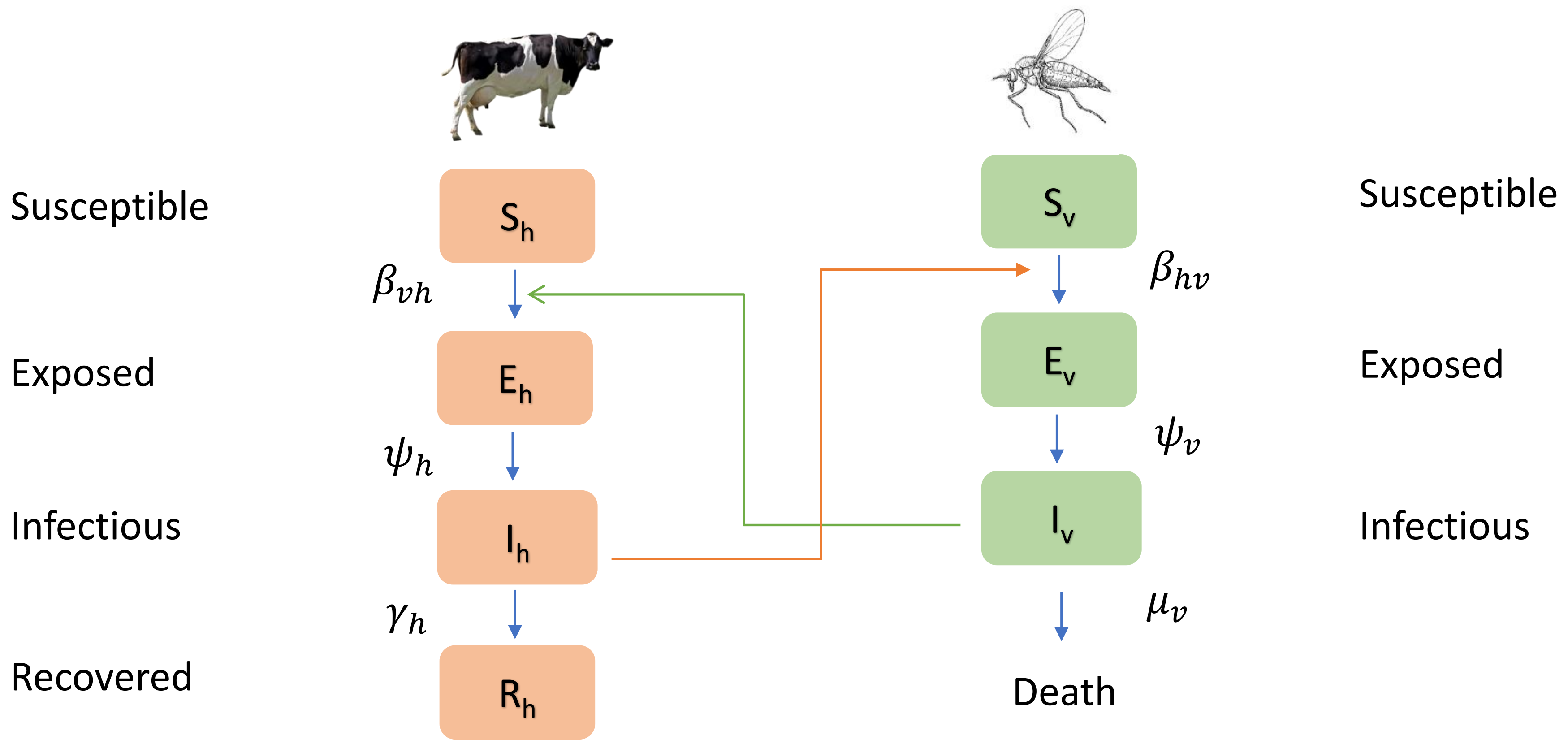
Diagram showing the states for animal hosts and insect vectors and the parameters regulating the transition of host-vectors from one state to another.



## The infection pressure

Animal host layer → Insect vector layer

A measure of insect vector activity, dependent on temperature

$$\beta_{hv} = d_h \times P_h \times f_v(temp) \times e_{hv}$$

Density of the animal host population

The prevalence of infection in the animal host population

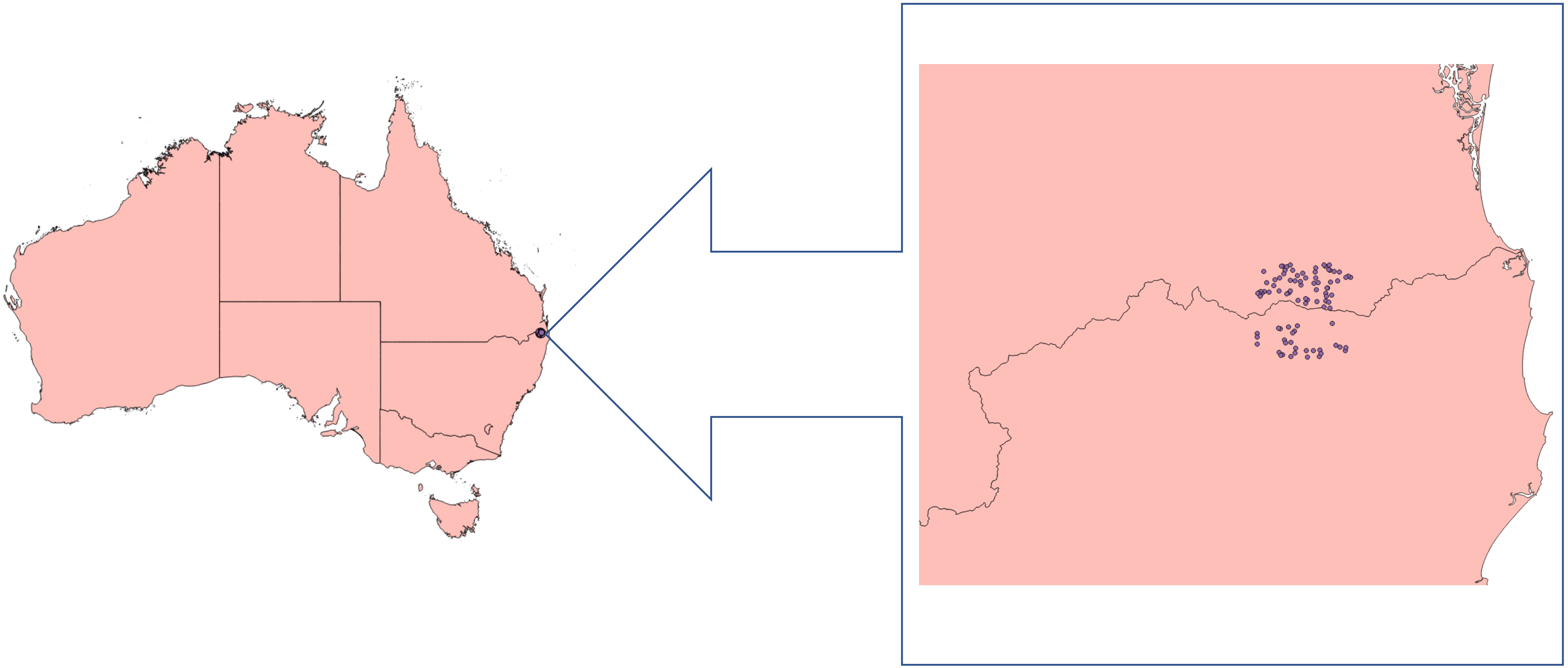
A measure of the effectiveness of contact between susceptible hosts and insect vectors

**The infection pressure** Insect vector layer ➡ Animal host layer

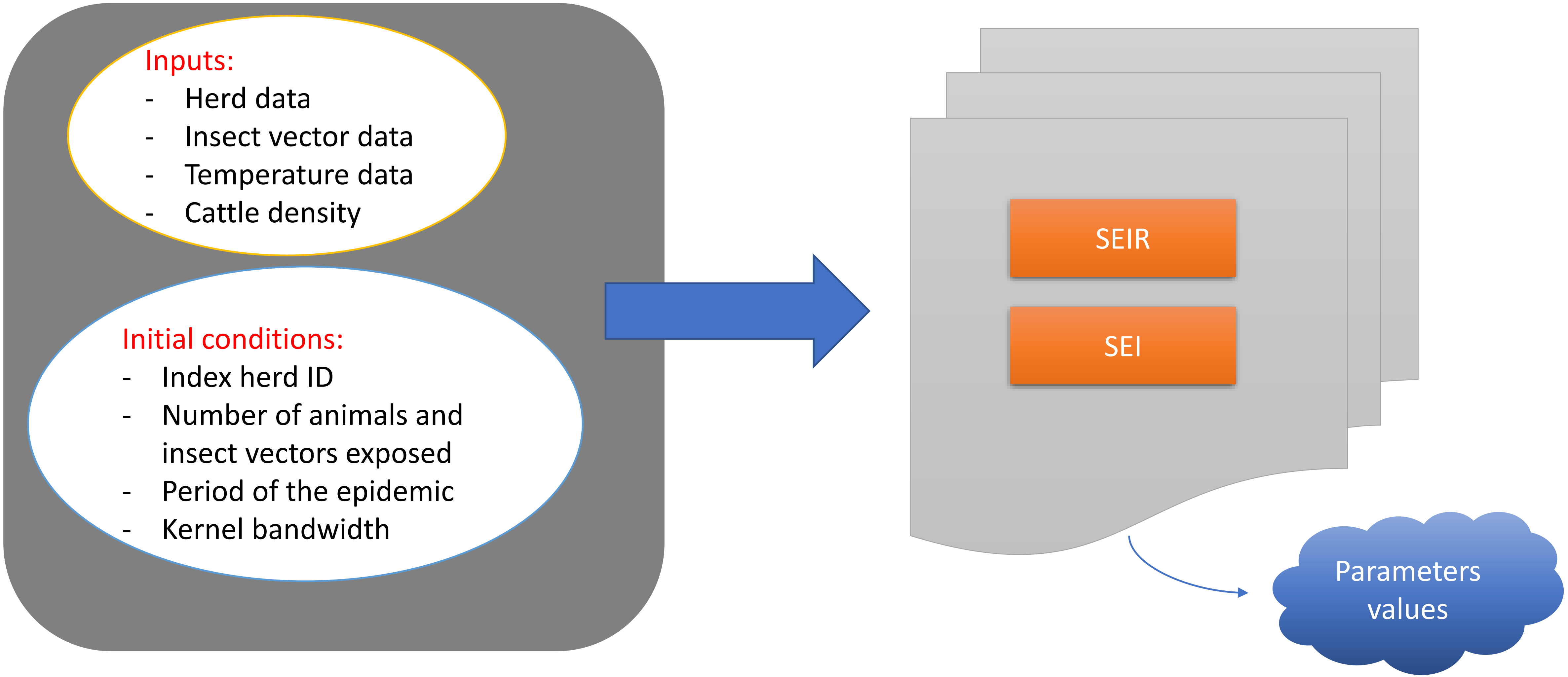
$$\beta_{vh} = d_v \times P_v \times f_v(temp) \times e_{vh}$$

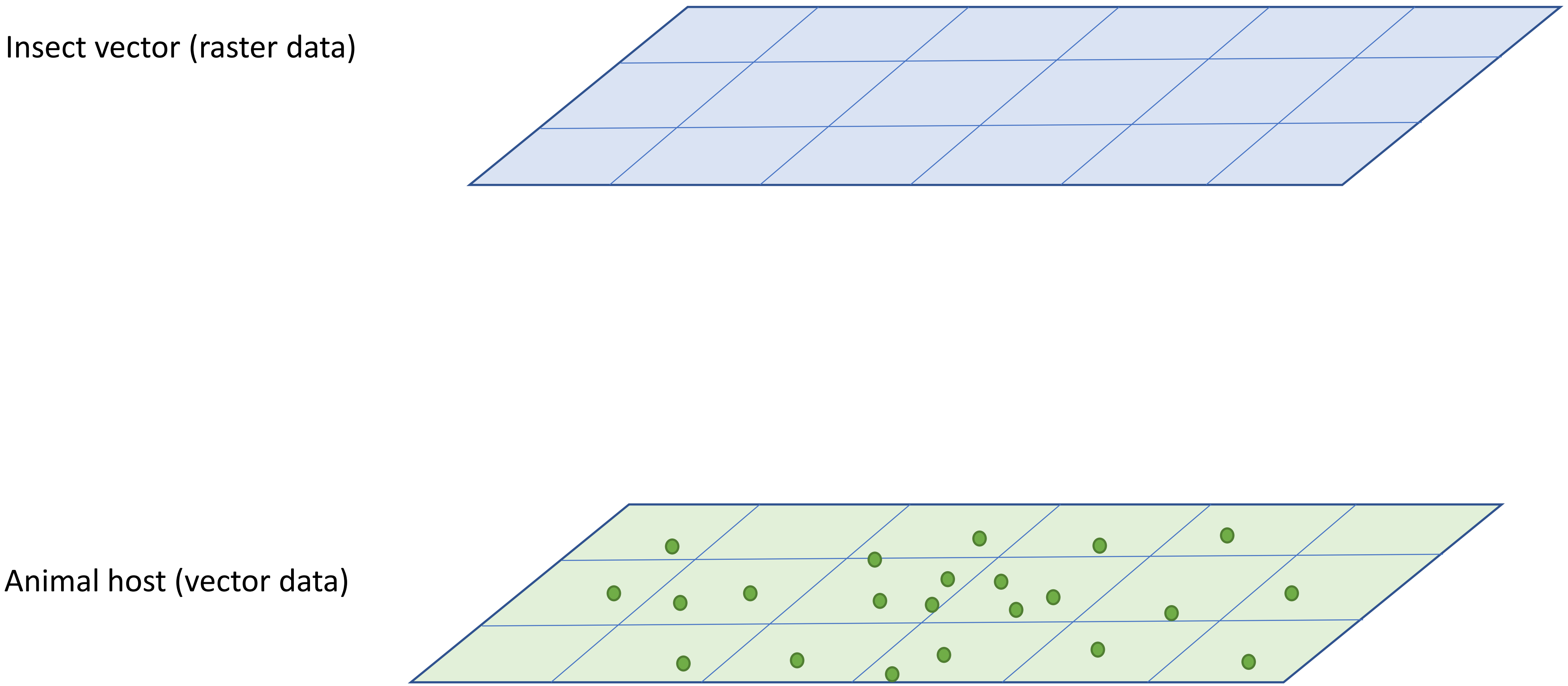
- $d_v$: Density of the insect vector population
- $P_v$: The prevalence of infection in the insect vector population
- $f_v(temp)$: A measure of insect vector activity, dependent on temperature
- $e_{vh}$: A measure of the effectiveness of contact between insect vectors and animal hosts

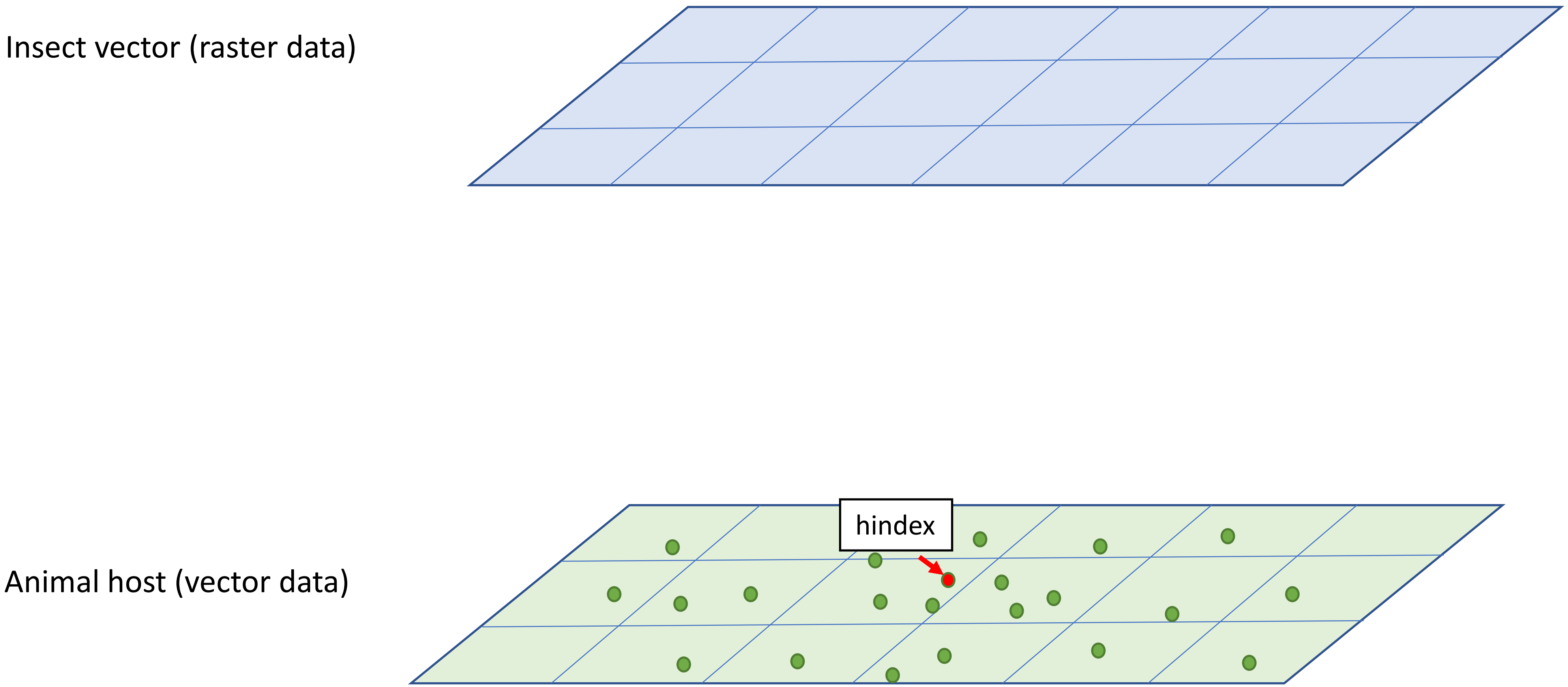
# Local study area to test BTV transmission model.



# BTV prototype



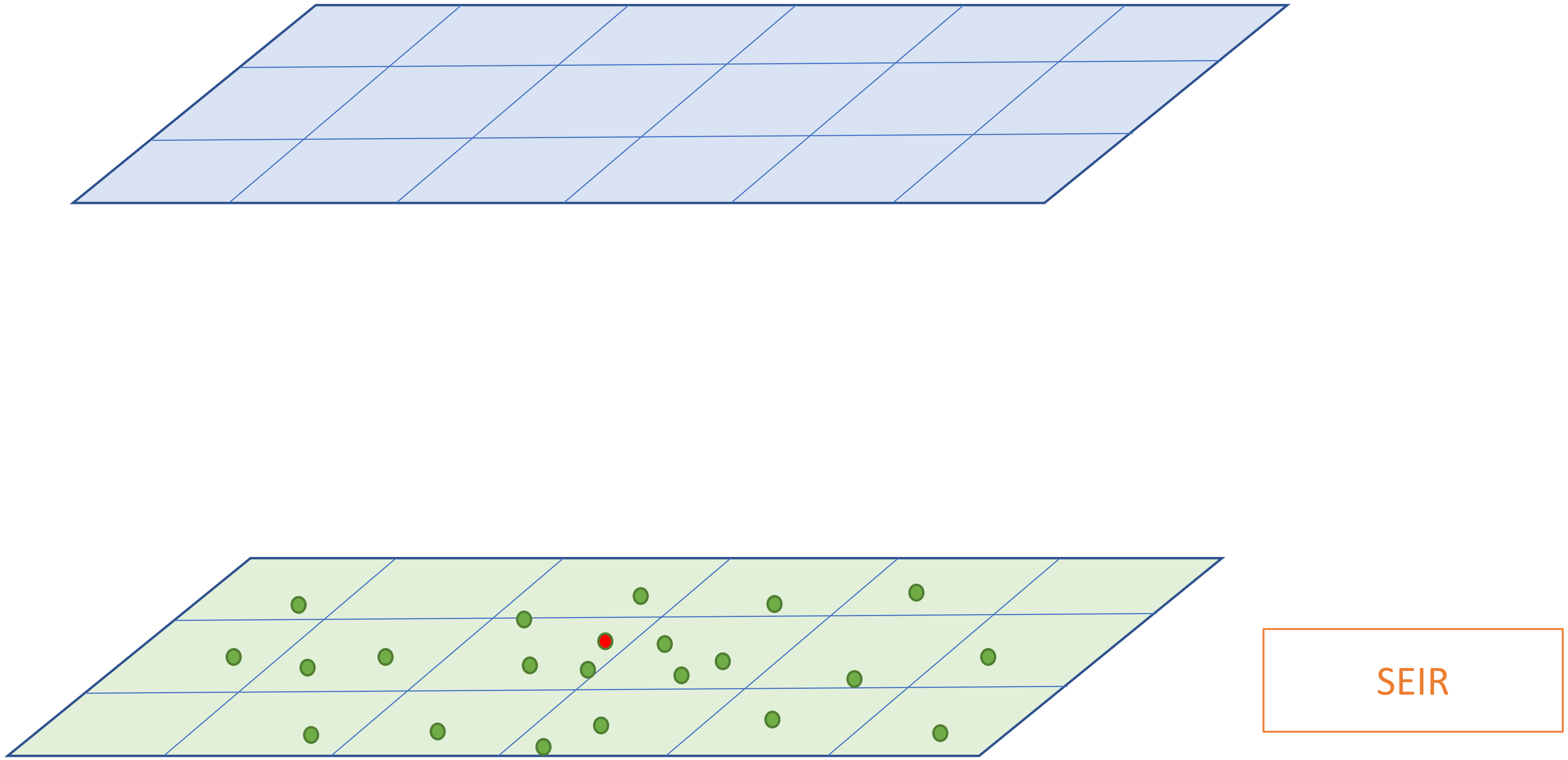

Insect vector (raster data)
Animal host (vector data)



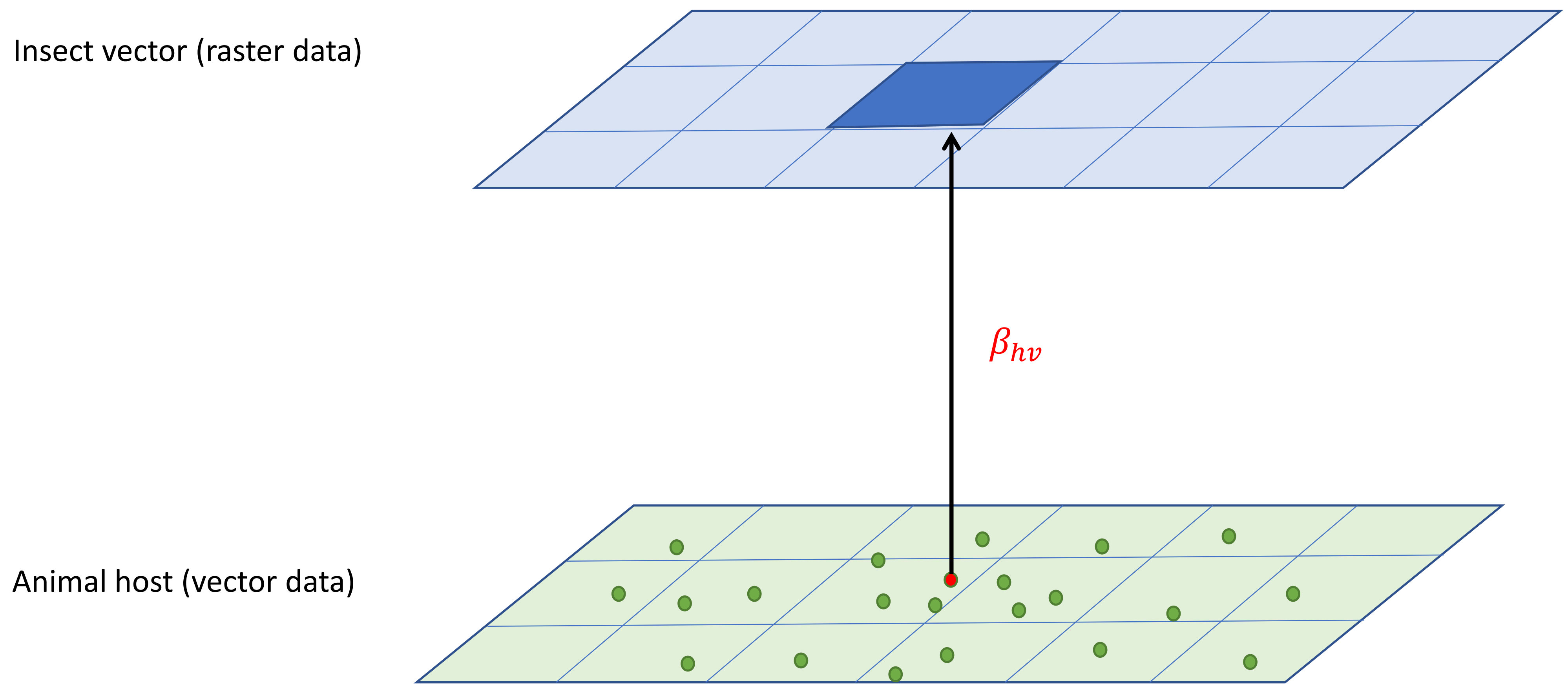

Week 1: Select the first infected herd. Set the number of animals exposed in the first infected herd.

Insect vector (raster data)

Animal host (vector data)

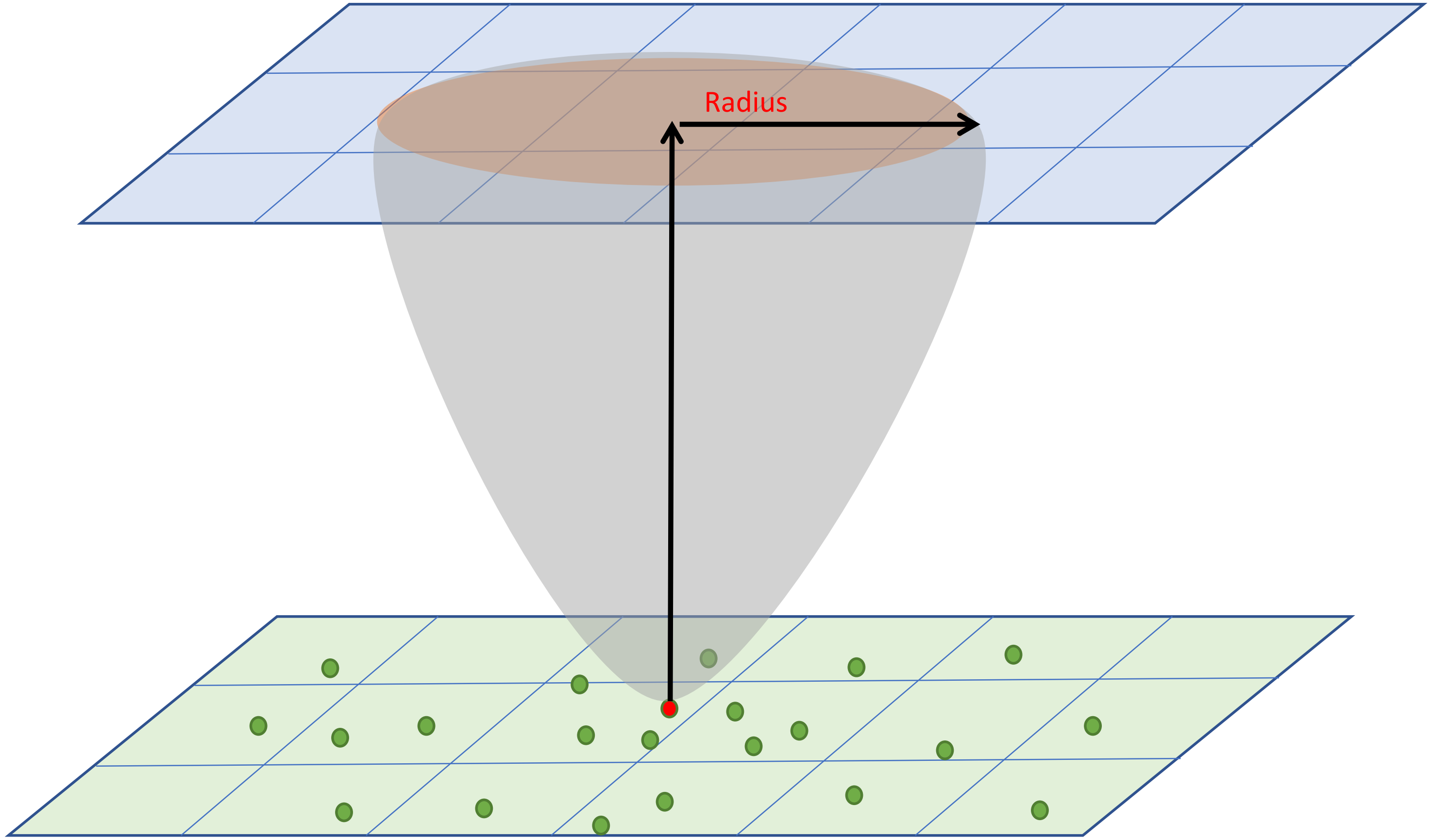



Week 1: Run SEIR in the animal host population. Calculate $\beta_{hv} = d_h \times P_h \times f_v(temp) \times e_{hv}$.



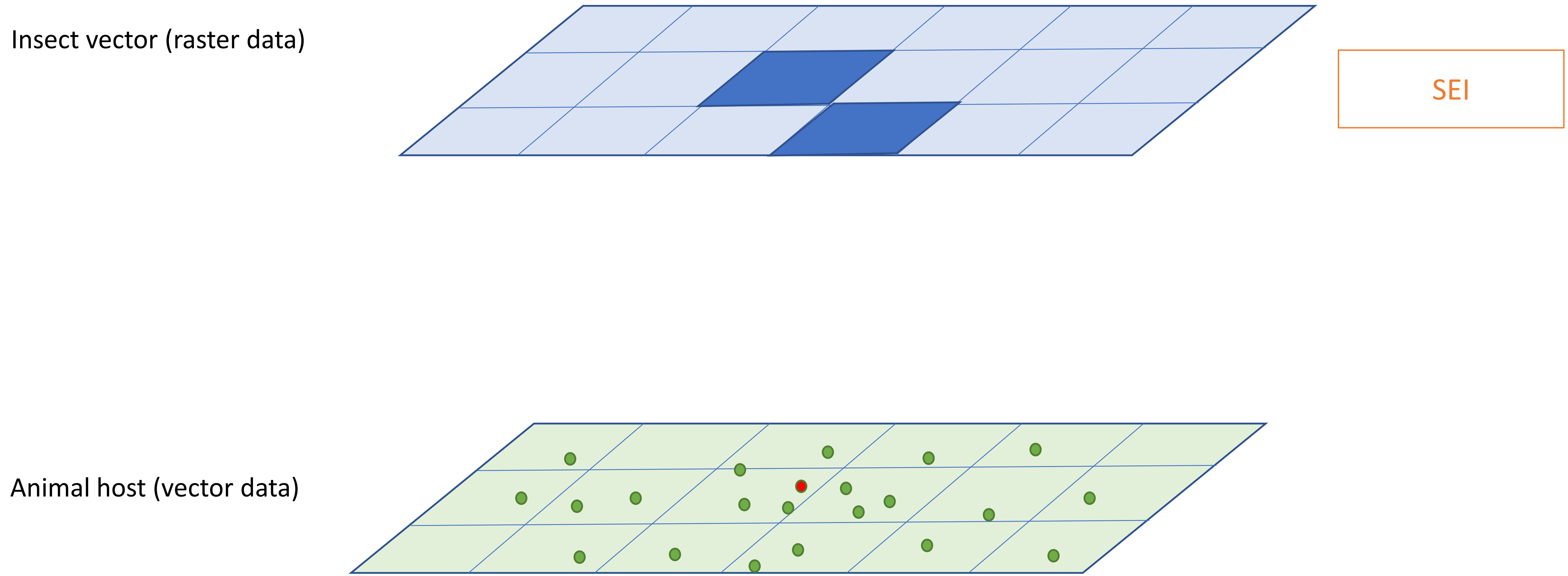

Week 1: Identify insect vector raster cell corresponding to infected animal host point location.

Insect vector (raster data)

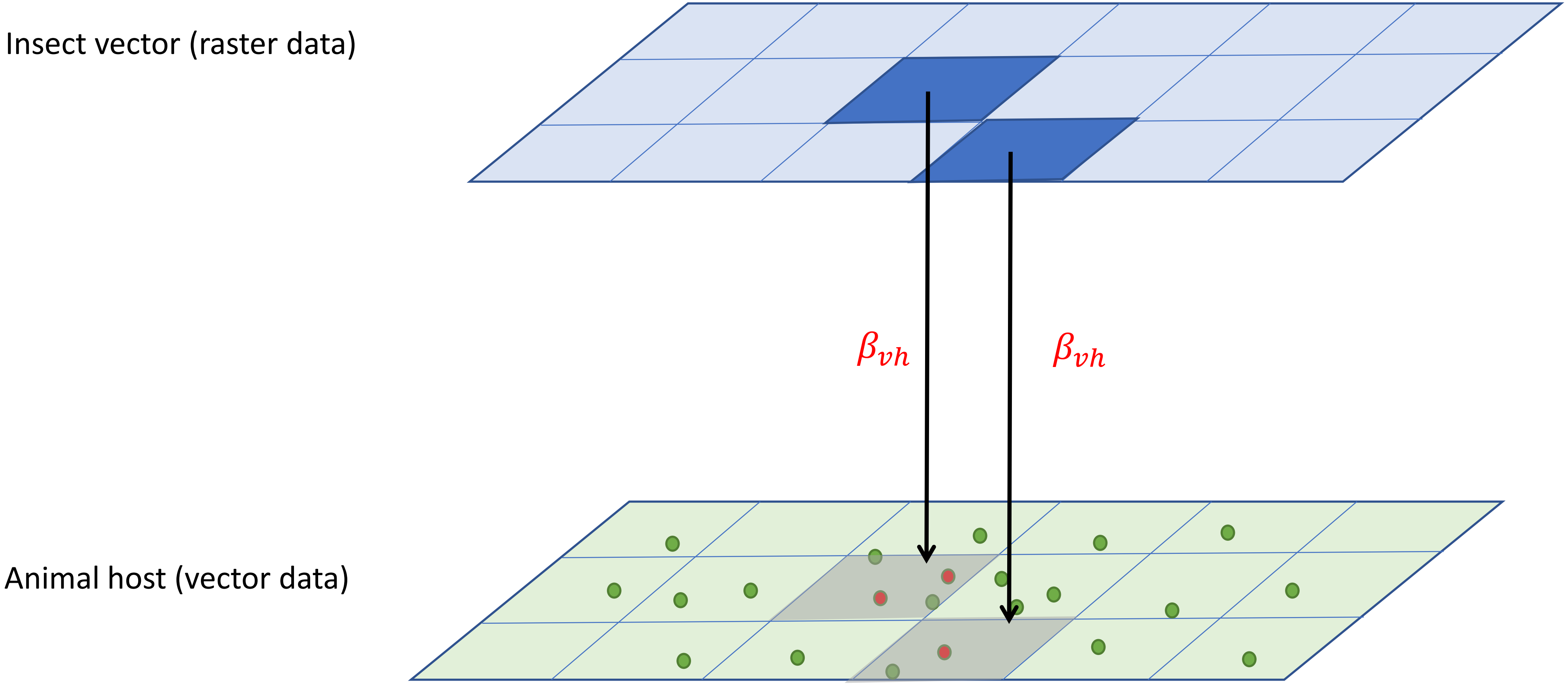



Animal host (vector data)

Week 1: Define transmission kernel. Probability of transmission to adjacent raster cells proportional to the area of each raster cell occupied by the kernel.




Week 1: Run the SEI model in the insect vector population.




Week 1: Select animal host (herd locations) to receive infection based on $\beta_{vh} = d_v \times P_v \times f_v(temp) \times e_{vh}$.