Ecosystems

Cyberentics and models of population dynamics

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Modelling interactions between species

Populations do not exist in isolation.

The dynamics of one population will influence the dynamics of other populations

For example as a result of …..

Predation
Competition
Parasitism
Epidemics

Modelling competition

Many complex models representing competition between organisms

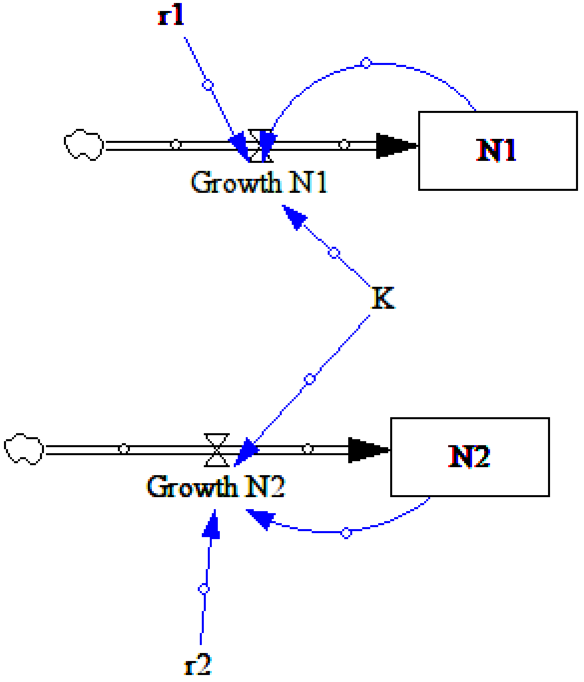
Key question … what enables competing organisms to coexist?

Many explanations involve differential resource use

Simple models imply that competition for a single resource leads to one “winner”

Lotka Volterra competition model

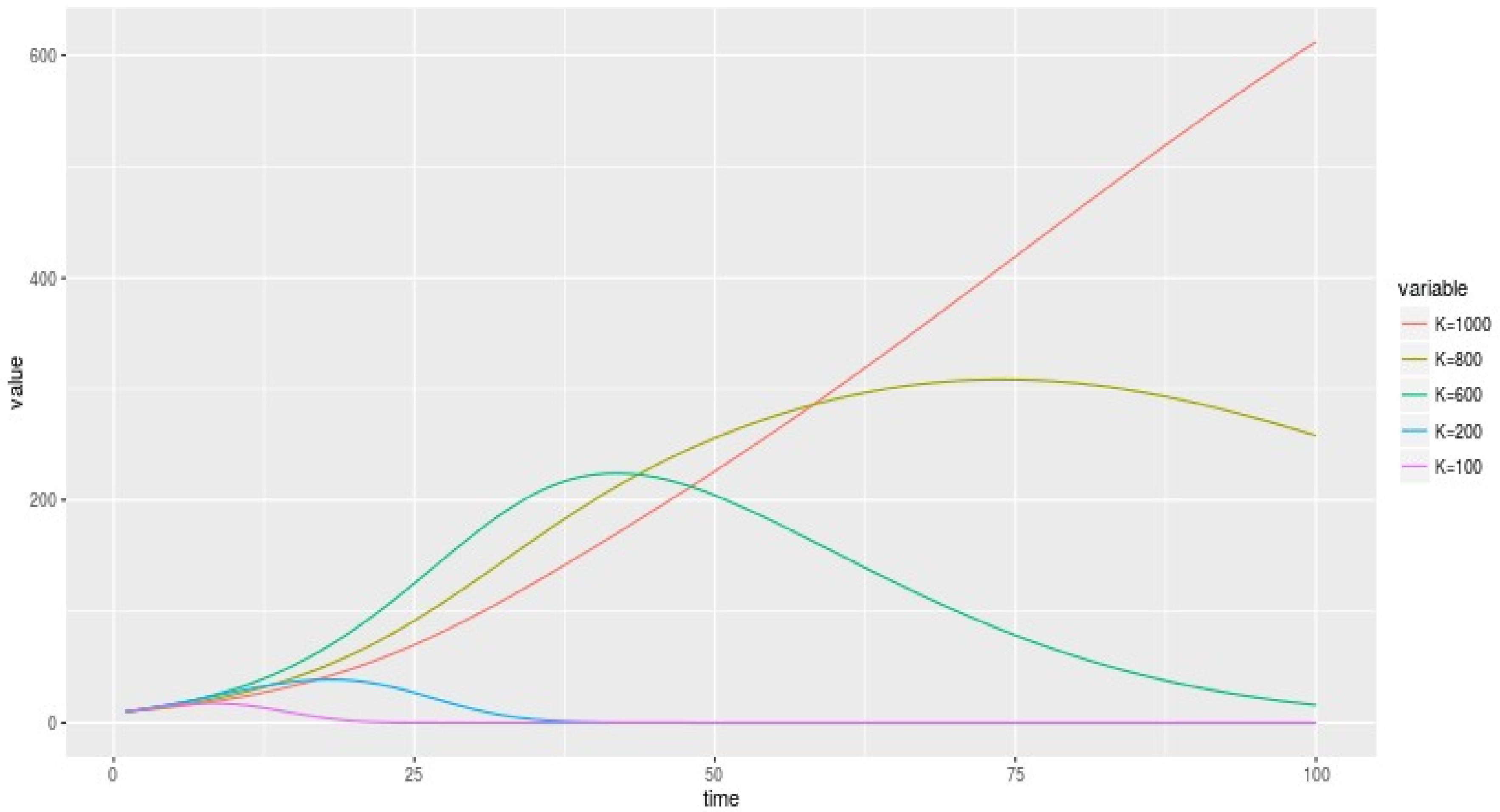
Same equation as the logistic model, but N/K involves the sum of the individuals in all species



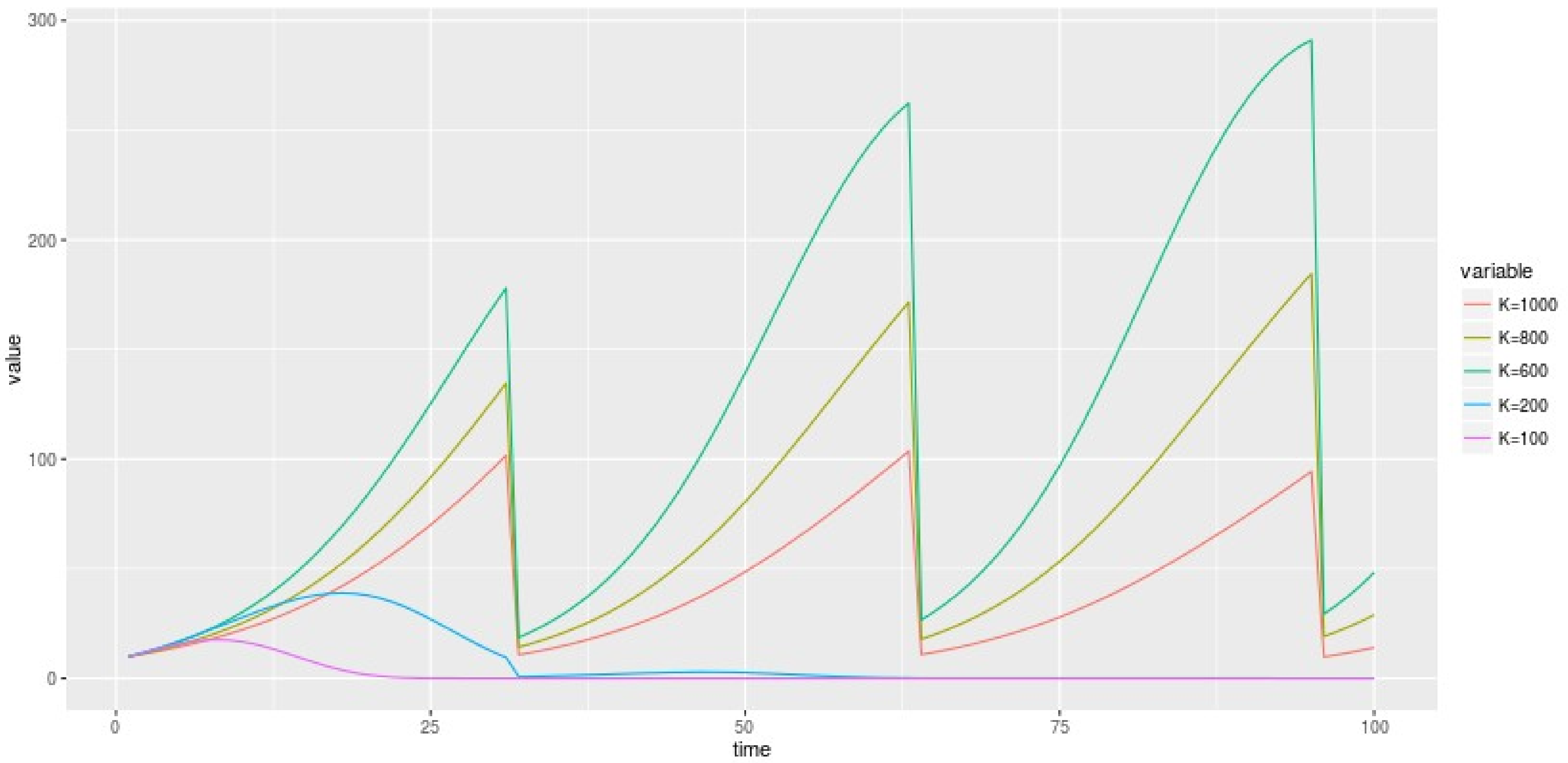
Play with a model which includes disturbance

https://dgolicher.shinyapps.io/Lotka_Volterra/

Without disturbance



With disturbance



Predator prey models

Predators obtain food through the mortality of prey species

Predator populations will increase when prey is abundant and decrease when prey is scarce

Prey populations may increase when predation pressure is reduced

Lotka Volterra model

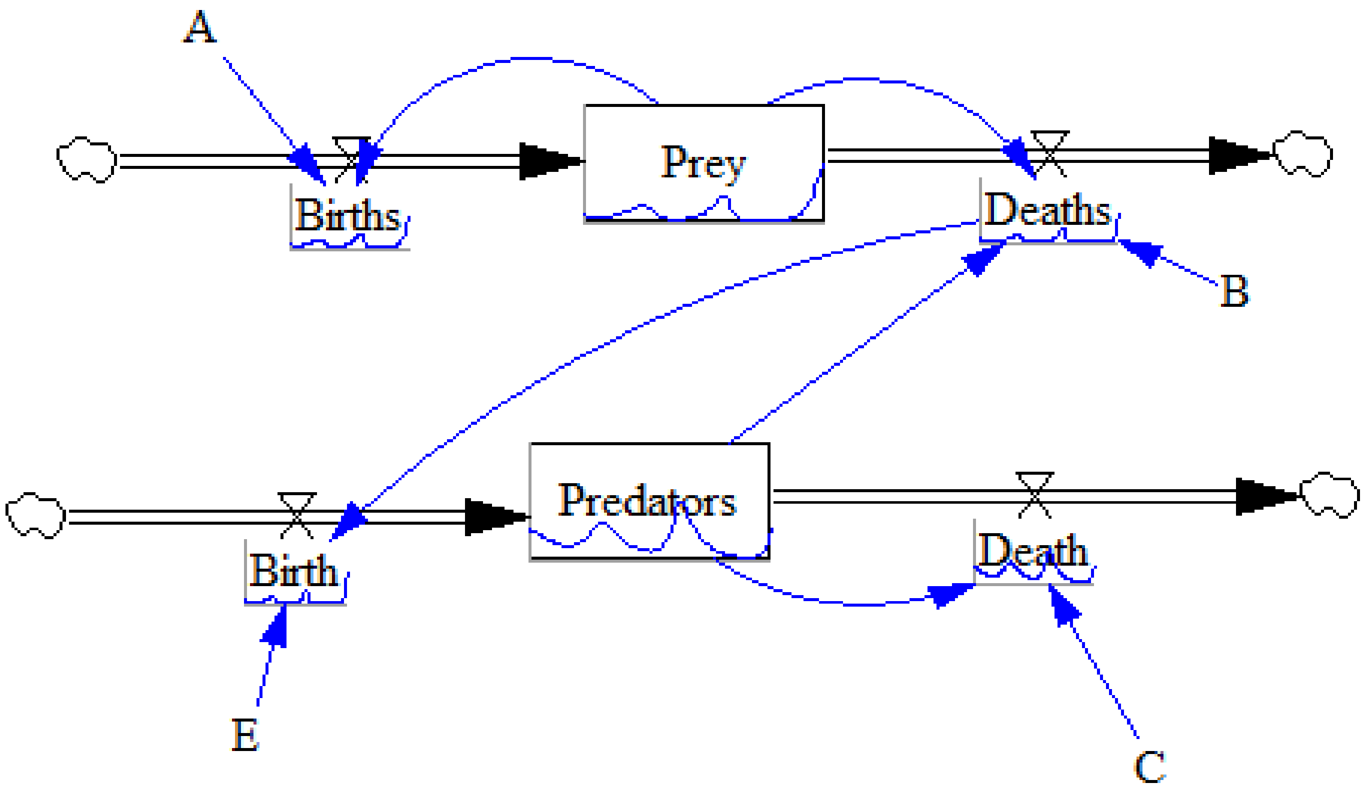
A = the natural growth rate of prey in the absence of predation,

B = the natural death rate of predators in the absence of food

C = the death rate per encounter of prey due to predation,

E = the efficiency of turning prey into predators.

Lotka Volterra model



$$\frac{dN}{dt} = AN - BNP$$

$$\frac{dP}{dt} = EBNP - CP$$

What does this imply?

- If BNP (predator induced mortality) is greater than AN (prey birth rate) the prey population will fall
- Predator induced mortality is a function of the number of predators.

$$\frac{dN}{dt} = AN - BNP$$

$$\frac{dP}{dt} = EBNP - CP$$

What does this imply?

- If EBNP (predator birth rate) is greater than CP (predator death rate) the predator population will increase
- Predator birth rate is a function of the number of prey.

$$\frac{dN}{dt} = AN - BNP$$

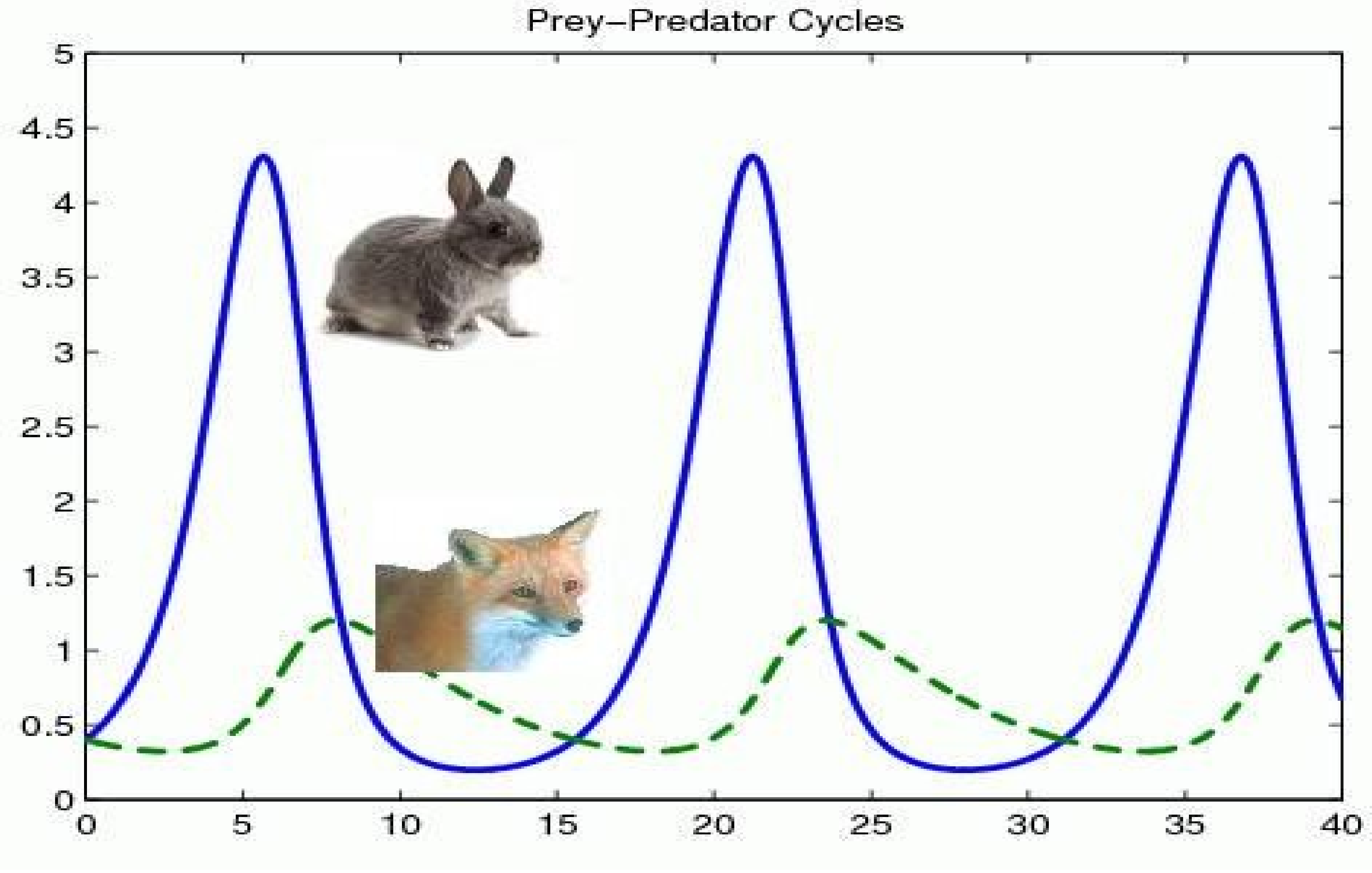
$$\frac{dP}{dt} = EBNP - CP$$

Model assumptions

- All prey mortality is due to predation
- Predators only eat one form of prey
- Predator mortality rate is a constant
- Lack of prey leads to reduced reproduction of predators but not reduced mortality (directly)

Results

Classic model produces cycles



Classic textbook data: Snowshoe hare and Lynx

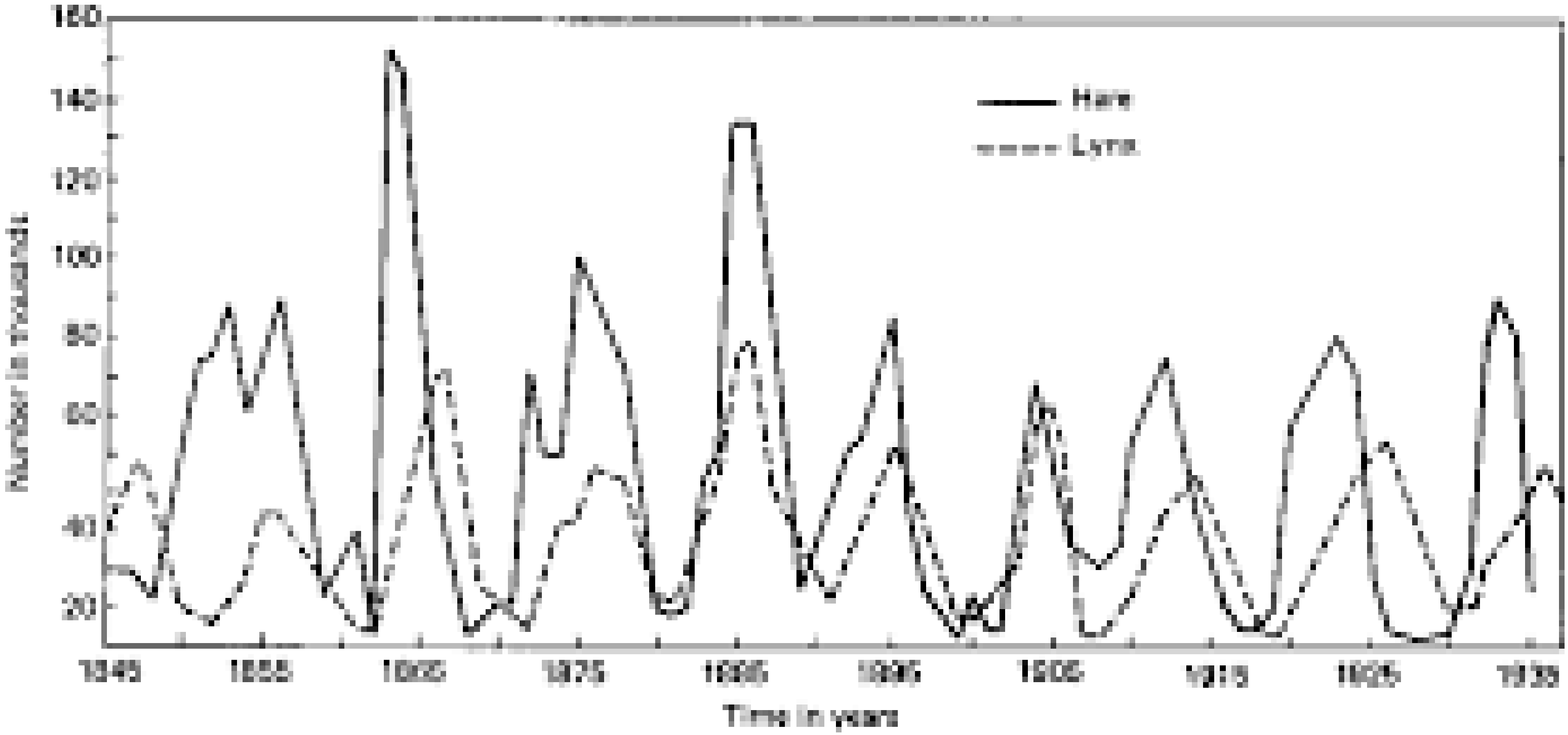
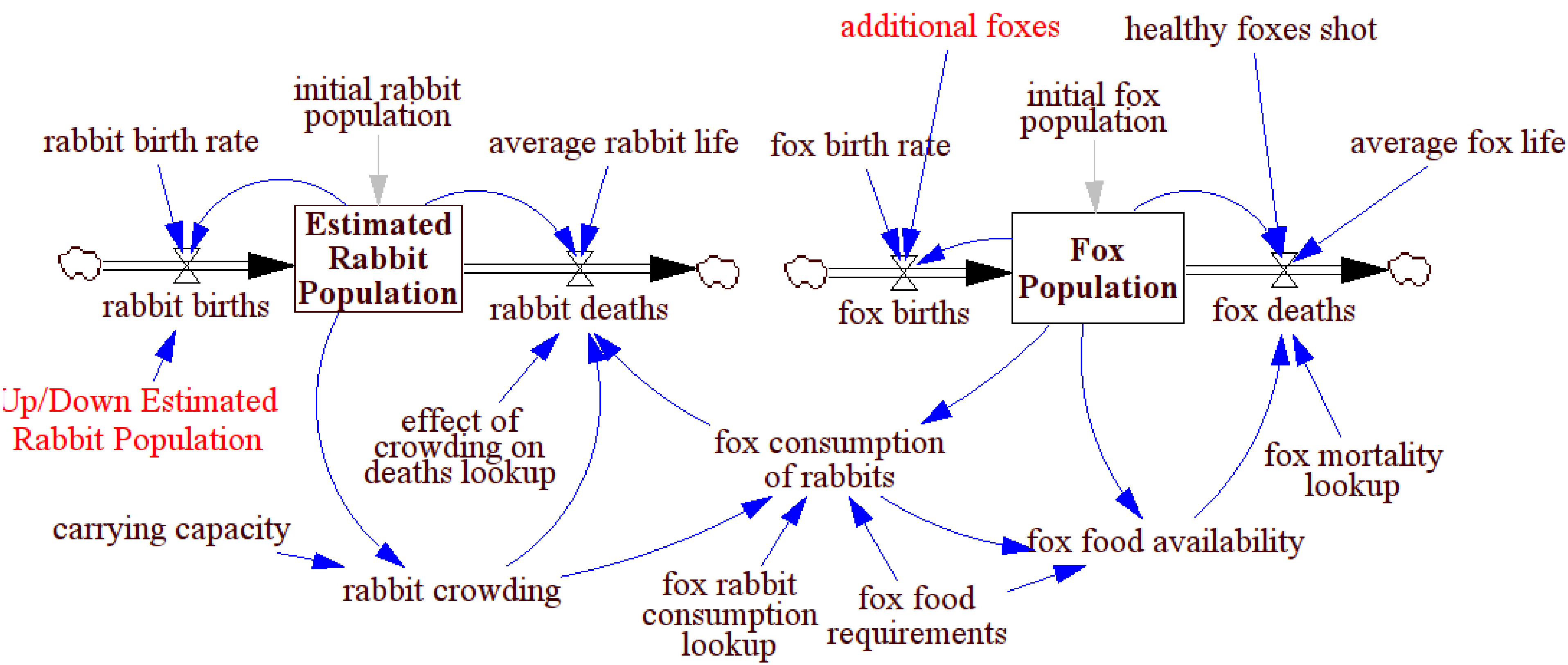


Figure 9-3. Changes in the abundance of the lynx and the snowshoe hare, as indicated by the number of pelts received by the Hudson's Bay Company. This is a classic case of cyclic oscillation in population density. (Redrawn from MacLulich 1937.)

What does the model not include?

More complexity can be built into models



Models of epidemics

- The SIR model

  Kermack and McKendrick

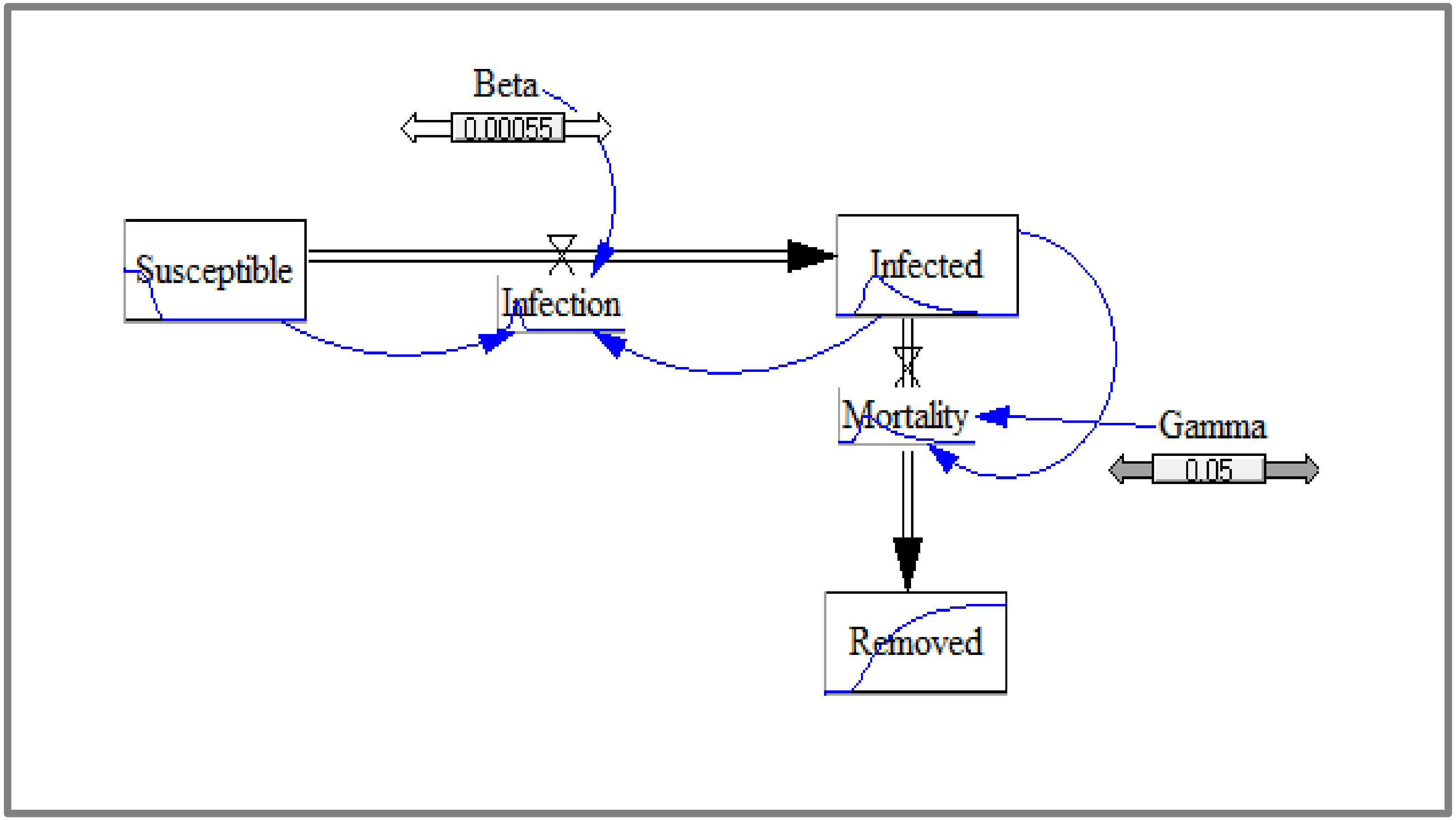
  - Susceptible
  - Infected
  - Removed

$$\frac{dS}{dt} = -\beta SI$$

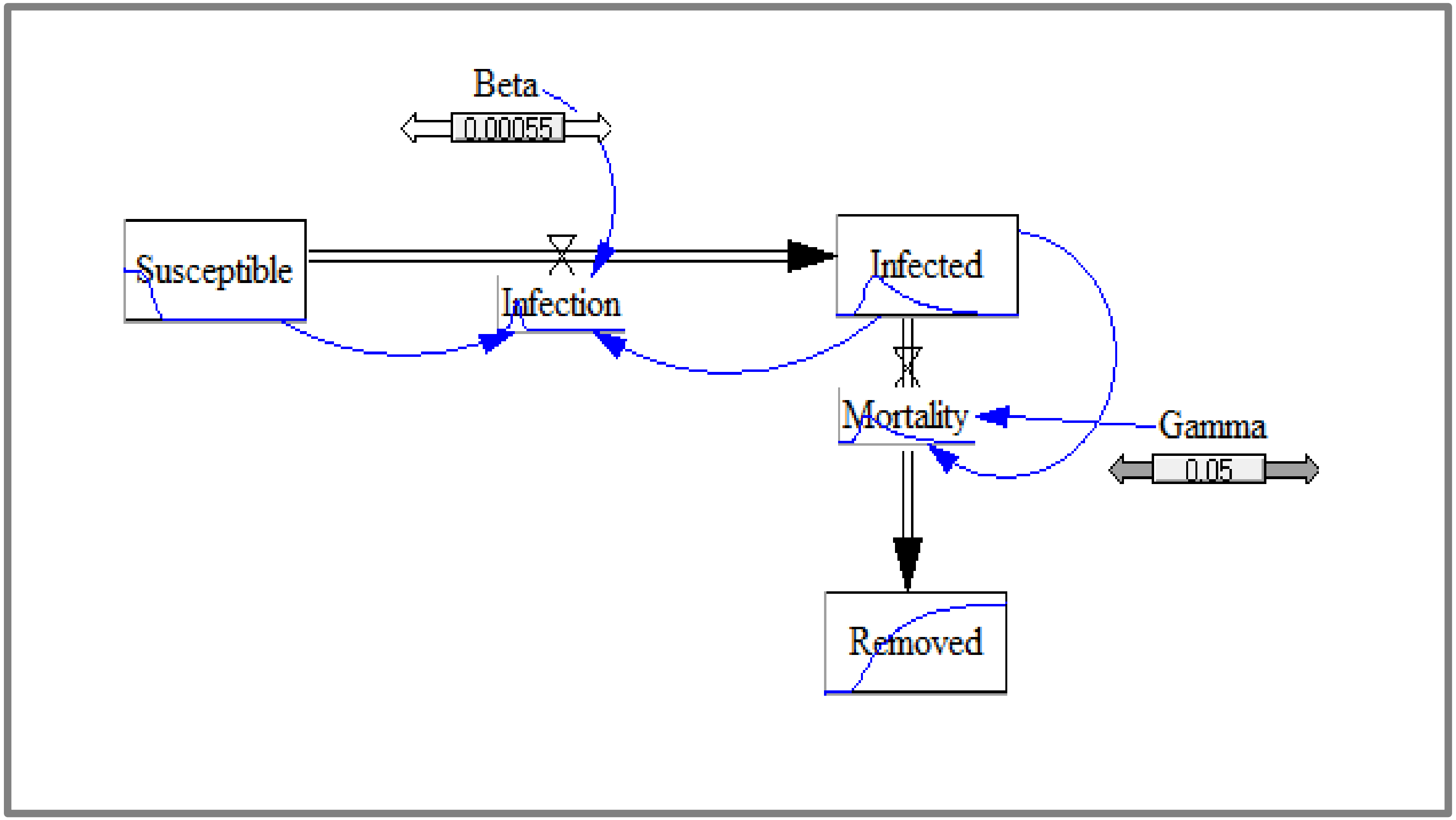
$$\frac{dI}{dt} = \beta SI - \gamma I$$

$$\frac{dR}{dt} = \gamma I$$

SIR model


Beta
0.00055
Susceptible
Infection
Infected
Mortality
Gamma
0.05
Removed

SIR model



Beta
0.00055
Susceptible
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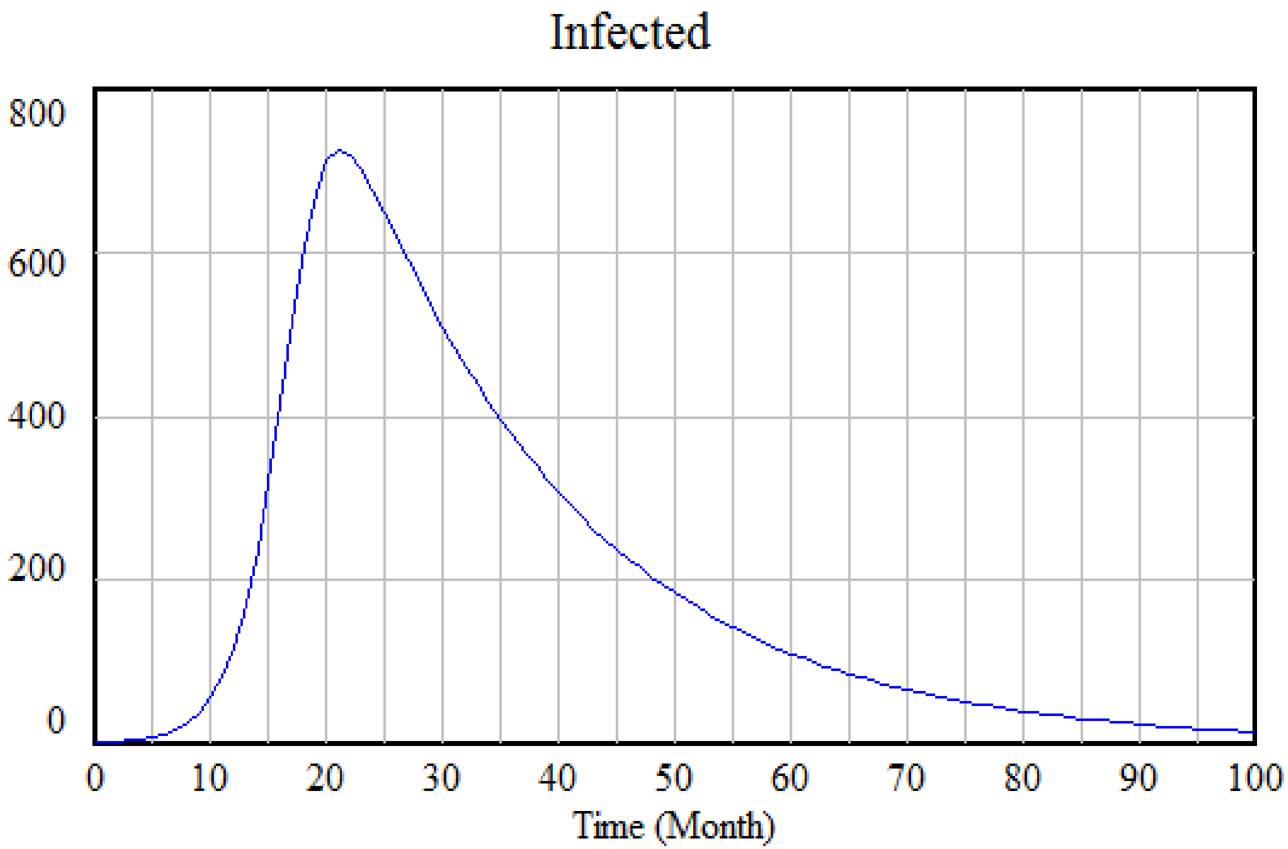
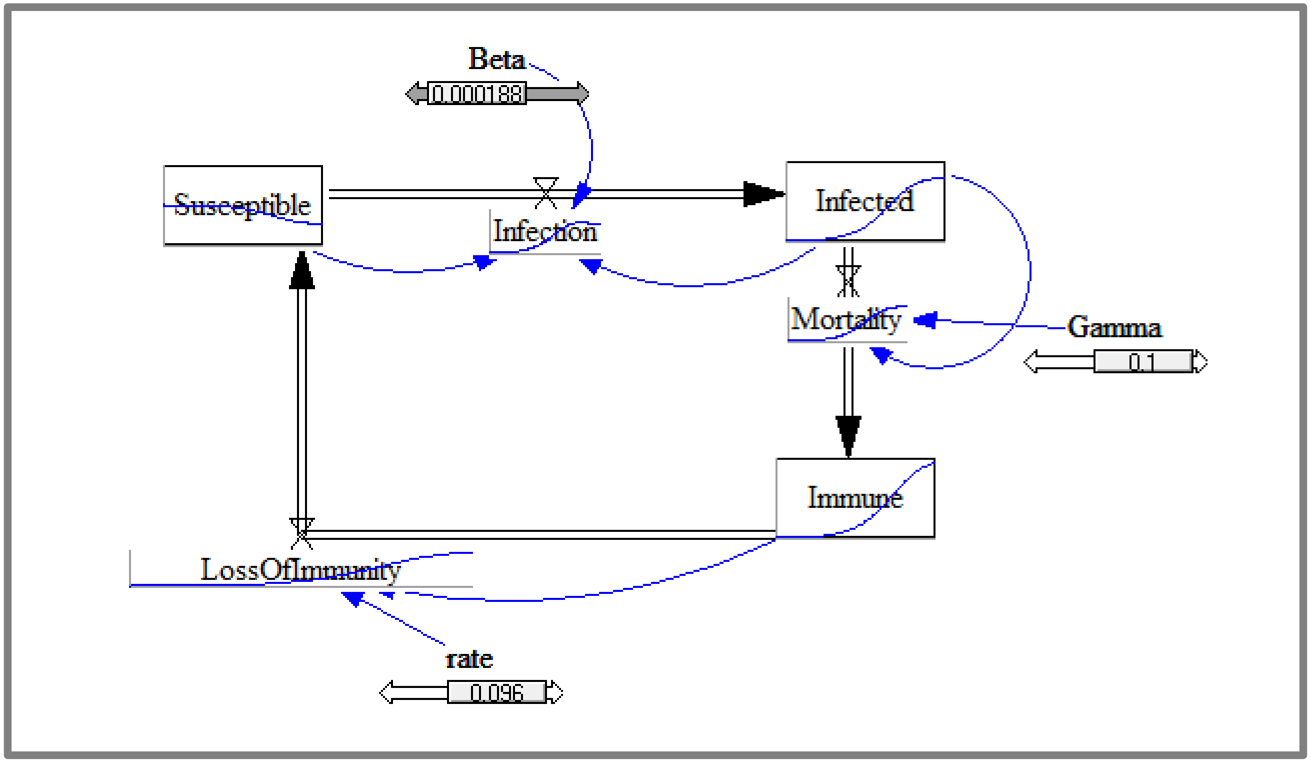
The SIR model



Extensions to the model

- SIRS model
- Immunity can be lost



Further reading

Details of all these models are included in all introductory Ecology textbooks

Some treatments are mathematically complex

Look into criticisms of simple models and extensions to include more realistic assumptions linked to concepts taught on this course