## Course Structure

- 10 Mondays
  - Discussion seminar 12-1
  - Labs 3-5
- Contributors
- Independent Reading and Study

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## Your background?

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## Software Requirements

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## Unit Topics

- Three!
  - (Big) data
  - Modelling
  - Meta-analysis
- Read through carefully on LMS (this week)
- Addressed through discussions, readings, labs, assignments and exam

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## Assessments

- Two assignments
- Exam (why???)

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## First discussion topic

- What is big data?
- What kind of big data sets might we find that are relevant to biology, conservation, ecology, restoration, and environment?

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## Labs

- Data wrangling and checking
- Meta-analysis
- Modelling (next week)
- Today – R revision and loops

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## What is a model?

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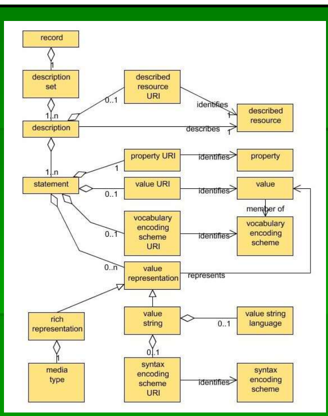


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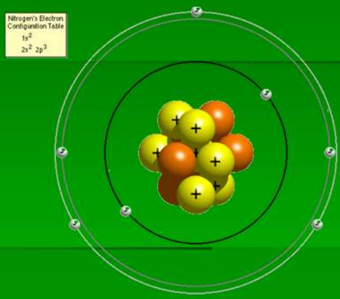


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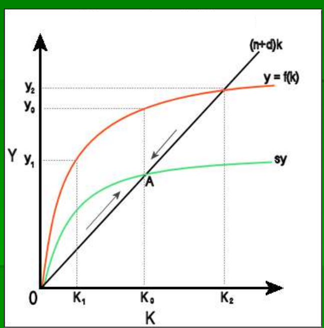


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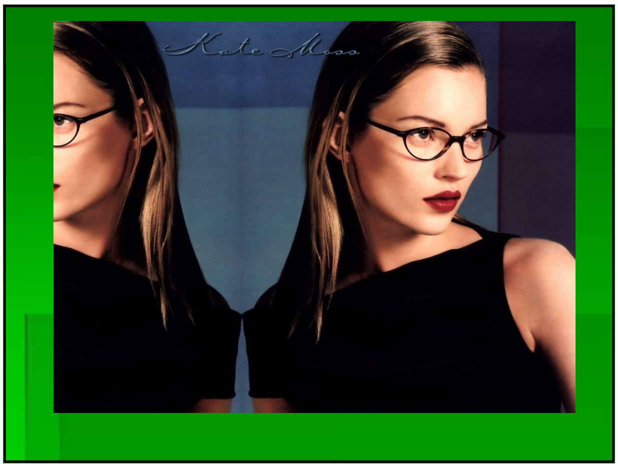


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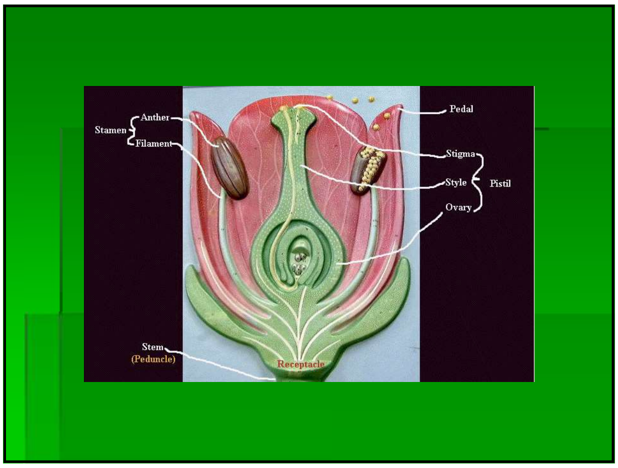


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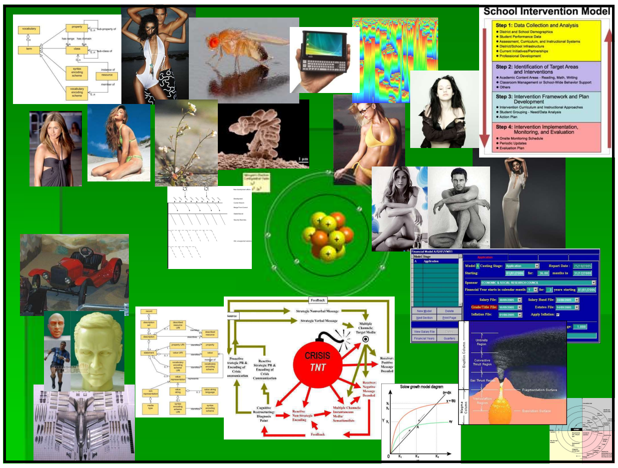


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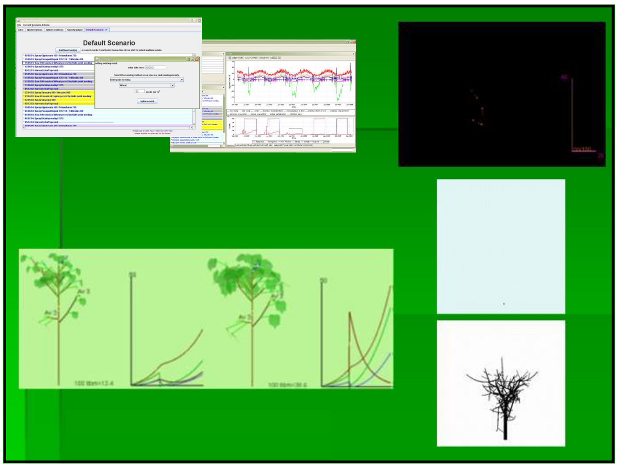


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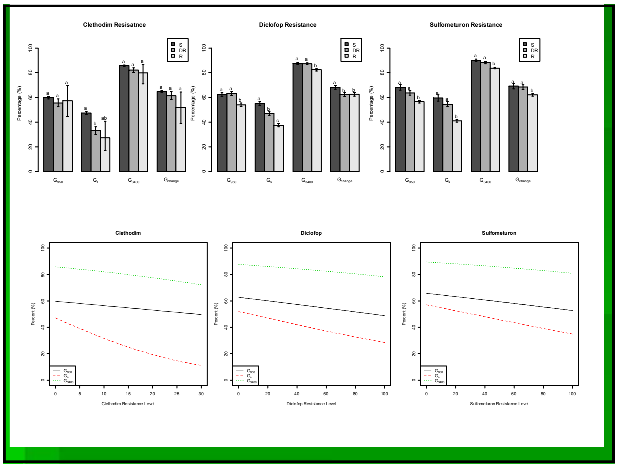


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## So... what is a model?

- Suggestions?

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## A model

- An abstracted or simplified representation of an object, system or concept
- Simplification – leaving stuff out… but what??

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## Modelling Reading

- **Modeling biological systems: principles and applications ****
- **Environmental Modelling: Finding Simplicity in Complexity**
- **Introduction to Practical Linear Programming**
- **Dynamic Models in Biology ***
- **A Biologist's Guide to Mathematical Modeling in Ecology and Evolution ***
- **An introduction to ecological modelling : putting practice into theory**
- **A practical guide to ecological modelling : using R as a simulation platform**

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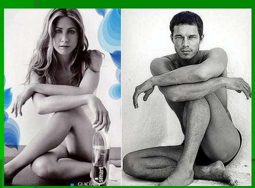

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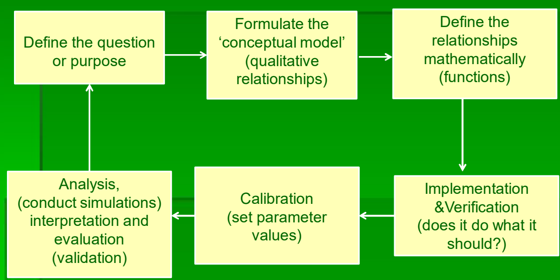
## Modelling Process

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- Model is a verb as well as a noun
- Like many things in life, theory is of limited value


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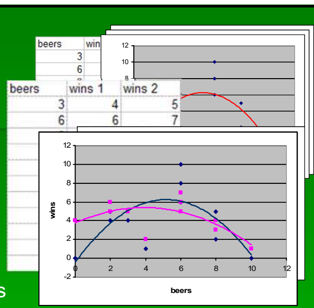
## Why Model?

- To clarify
- To understand
- To compare
- To predict
- To manage
- To educate
- To communicate ideas
- To convince people
- For fun! Creating virtual worlds and playing with them…

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## What is the Modelling Aim?

- Visualisation?
- Communication of results and ideas?
- Part of a larger model?
- Control and management? decision support
- Accurate prediction?
- Theoretical exploration?
- Theoretical Framework for Experimental Investigations


Virtual plant visualisations produced by the Insect-Plant Interactions Program of the CPAI at the University of Queensland using the Virtual Laboratory software developed at the University of Calgary, Canada.

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## What don't we know…

Inputs → Model → Outputs

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## Models

- Are simplified representations of reality
  - Always based on simplifying assumptions which should be made clear
- Are art as much as science:
  - How much detail needed? (minimum?)
  - Two models of the same thing can be different – but neither wrong or right
  - Should be made with a clear purpose in mind!

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## Relationship of Modelling to Experiment

- Can save time, money, resources
- Can focus expensive experimental effort
- Some experiments are dangerous, impossible, expensive or unpleasant
- Experimentation still very important

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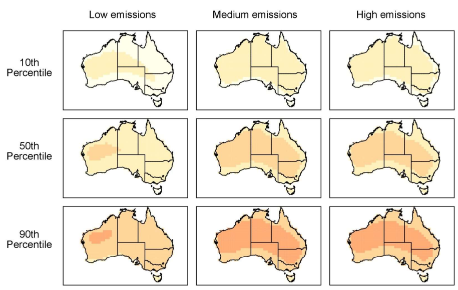


Change in Annual Temperature Predictions for 2030
(climatechangeinaustralia.gov.au)

.3 .6 1 1.5 2 2.5 3 4 5
°C

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Global climate change

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## Formal Models can be:

- Descriptive or explanatory
- Dynamic or static
- Spatial or non-spatial
- Continuous or discrete
- Stochastic or deterministic
- Analytic or simulation
- Bottom-up or top-down

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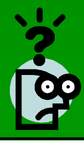
## Analytic or simulation

- Mathematical or Computational
- Complexity
- Modern computing power allows anyone to run complex simulations
- Beware: simulations can get as complex as the real world!



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- Clear purpose
- Simplify as much as possible
- Most important factors and interactions (for your purpose)

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## Modelling Always Involves Trade-offs

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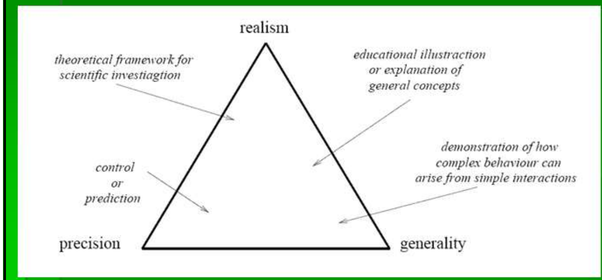


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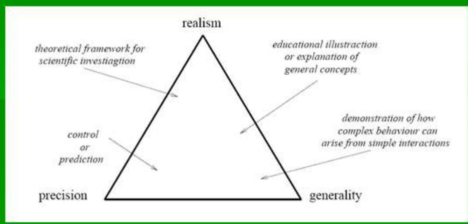
## What to include?

## What to leave out?

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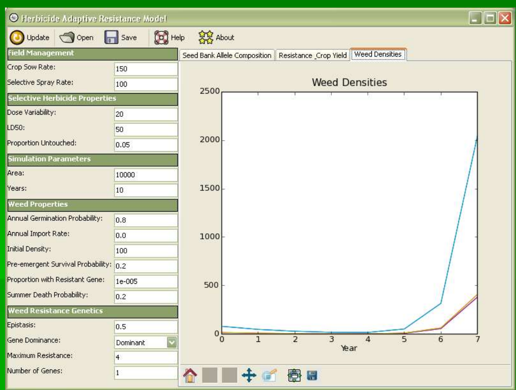


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## What should be included in a model like this?

?

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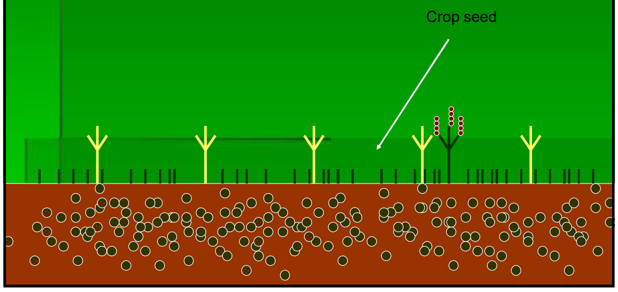
## What's in the Model

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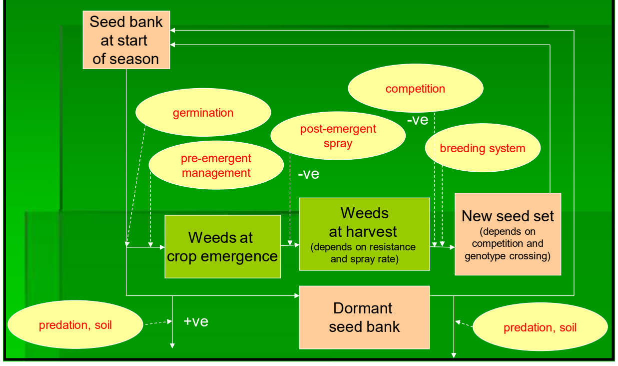
## Model Dynamics

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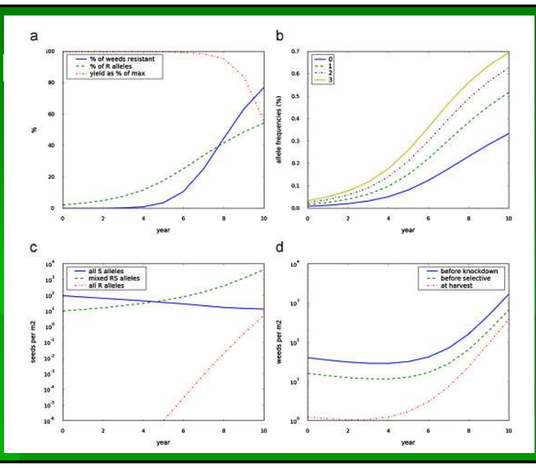


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## Draw a ‘conceptual model’

- Wallabies eat grass
- Wallabies increase in number faster if there is more grass, slower if not enough
- Fertilizer helps grass grow, but poisons some wallabies
- People like seeing wallabies

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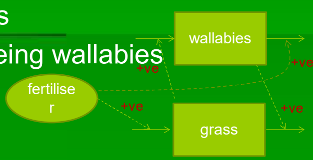


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Consider the following description of Operation Cat Drop, quoted from Hawken et al. (1999):

> *[In Borneo, in the 1950s, m]any Dayak villagers had malaria, and the World Health Organization had a solution that was simple and direct. Spraying DDT seemed to work: mosquitoes died, and malaria declined. But then an expanding web of side effects . . . started to appear. The roofs of people's houses began to collapse, because the DDT had killed tiny parasitic wasps that had previously controlled thatch-eating caterpillars. The colonial government issued sheet-metal replacement roofs, but people could not sleep when tropical rains turned the tin roofs into drums. Meanwhile, the DDT-poisoned bugs were being eaten by geckoes, which were eaten by cats. The DDT invisibly built up in the food chain and began to kill the cats. Without the cats, the rats multiplied. The World Health Organization, threatened by potential outbreaks of typhus and sylvatic plague, which it had itself created, was obliged to parachute fourteen thousand live cats into Borneo. Thus occurred Operation Cat Drop, one of the odder missions of the British Royal Air Force.*

Draw a Forrester diagram of this system. Include as state variables the biomass of the main ecological components (e.g., malaria, mosquitoes, wasps, geckoes, cats, etc) and levels of DDT; use driving variables for WHO interventions; and an auxiliary variable representing *Dayakan Happiness*.

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In the SW deserts of North America, ants, birds, small mammals, and plants interact to create a complex foodweb. The primary interactions are as follows. Ants and small mammals compete for seeds produced by two kinds of plants: small-seeded and large-seeded plants. Within limits, both granivores can consume both sizes of seeds, but, understandably, ants favor small seeds and mammals prefer large seeds. Consumption of seeds reduces the population growth rates of the plants. Birds also consume large seeds, but are more effective at times when the amount of bare ground is high (or, the amount of plants is low). Neither birds nor small mammals eat ants. The two types of plants compete for space.

Draw a Forrester diagram for the population dynamics of these five groups for a model that simulates a period of 20 years at one-month intervals. Assume that both plant types produce seeds in the fall, but that there is a seed pool available to granivores during other months.

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## Reading for next fortnight

- Haefner, Chapters

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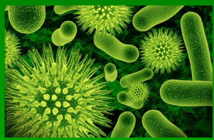
## Today's Lab: Population Dynamics

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## Loops

```
for (x in 1:n){
      do some things
}
```

```
for (fruit in c('apples','pears','guavas')){
      for (i in 1:3) print (fruit)
}
```


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## Indexing

- fruits <- c('apples','pears','guavas')
- fruits[2]
- fruits[2:3]
- which(fruits=='apples')
- x=1
- for (t in 2:n) x[t]=2*x[t-1]

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