

Computational Physics Group Project: Ecosystem: predator and prey

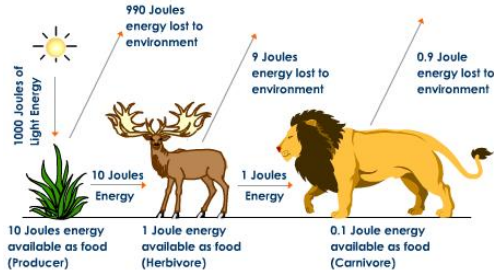
David Hicks
Weiyao Ke
Shagun Maheshwari
Fan Zhang

April 13, 2015

Introduction to eco-system modelling

Implementation of the simulation

Population interaction of predator and prey in eco-system



Progressive Loss of Energy in Food Chain

Figure: default

Population interaction of predator and prey in eco-system

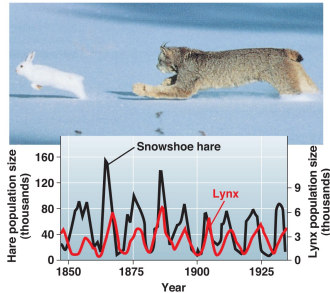


Figure:

<http://www.anselm.edu/homepage/jpitocch/genbi101/ecology1intropops.html>

A simplified determininsitic mode: L-V equation

Simulation of a eco-system with predator and prey

A simulation keep the essential nature of the interaction between and within the species, and predict the evolution of population step by step.

- ▶ Both predator and prey reproduces when they reach the age of reproduction

Simulation of a eco-system with predator and prey

A simulation keep the essential nature of the interaction between and within the species, and predict the evolution of population step by step.

- ▶ Both predator and prey reproduces when they reach the age of reproduction
- ▶ Predator feeds on prey.

Simulation of a eco-system with predator and prey

A simulation keep the essential nature of the interaction between and within the species, and predict the evolution of population step by step.

- ▶ Both predator and prey reproduces when they reach the age of reproduction
- ▶ Predator feeds on prey.
- ▶ Predator and prey will die out if maximum age is reached or starved for enough long time

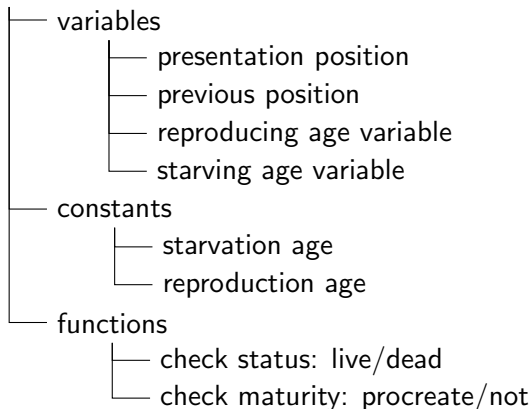
Simulation of a eco-system with predator and prey

A simulation keep the essential nature of the interaction between and within the species, and predict the evolution of population step by step.

- ▶ Both predator and prey reproduces when they reach the age of reproduction
- ▶ Predator feeds on prey.
- ▶ Predator and prey will die out if maximum age is reached or starved for enough long time
- ▶ However, simulation is a random process and change the deterministic nature of LV equation (more realistic).

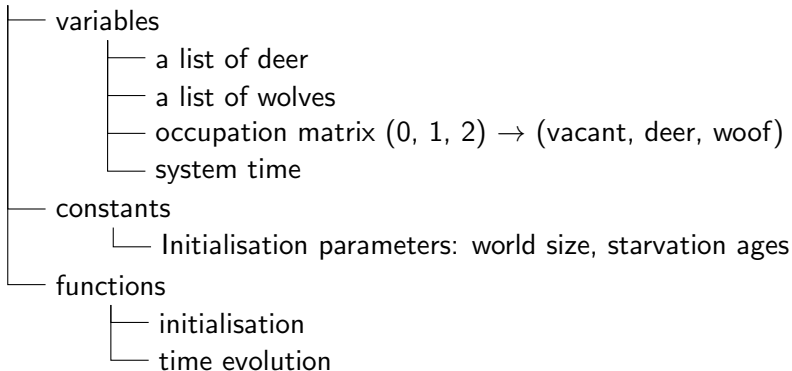
Structural setup

Animal Class → Deer/ Wolf



Structural setup

Eco-system



Initialisation

A sanity simulation requires several constraints on the initialisation of parameters.

- ▶ Reproduction age of predators must be larger than their starvation age. (Or else wolf can sustain themselves ...)

Initialisation

A sanity simulation requires several constraints on the initialisation of parameters.

- ▶ Reproduction age of predators must be larger than their starvation age. (Or else wolf can sustain themselves ...)
- ▶ Starvation age of the deer is extremely large. (Always enough plants!)

time evolution (All things are done serially!)

- ▶ Step1: loop over wolves and deer and increase ages by 1; then check if they are alive. Only live animals are kept in list for operations below.

time evolution (All things are done serially!)

- ▶ Step1: loop over wolves and deer and increase ages by 1; then check if they are alive. Only live animals are kept in list for operations below.
- ▶ Step2: loop over wolves and check neighbours. If deer nearby, capture a random one and move to that position. If no deer but vacancies around, move to a random location. If a mature wolf's present location differs from previous location, deposits a new-born at its previous location.

time evolution (All things are done serially!)

- ▶ Step1: loop over wolves and deer and increase ages by 1; then check if they are alive. Only live animals are kept in list for operations below.
- ▶ Step2: loop over wolves and check neighbours. If deer nearby, capture a random one and move to that position. If no deer but vacancies around, move to a random location. If a mature wolf's present location differs from previous location, deposits a new-born at its previous location.
- ▶ Step3: loop over deer and delete those whose location are now occupied by wolves (via the occupation matrix)

time evolution (All things are done serially!)

- ▶ Step1: loop over wolves and deer and increase ages by 1; then check if they are alive. Only live animals are kept in list for operations below.
- ▶ Step2: loop over wolves and check neighbours. If deer nearby, capture a random one and move to that position. If no deer but vacancies around, move to a random location. If a mature wolf's present location differs from previous location, deposits a new-born at its previous location.
- ▶ Step3: loop over deer and delete those whose location are now occupied by wolves (via the occupation matrix)
- ▶ Step4: loop over deer and check neighbours. If vacancies around, move to a random location. If a mature deer's present location differs from previous location, deposits a new-born at its previous location.

time evolution (All things are done serially!)

- ▶ Step1: loop over wolves and deer and increase ages by 1; then check if they are alive. Only live animals are kept in list for operations below.
- ▶ Step2: loop over wolves and check neighbours. If deer nearby, capture a random one and move to that position. If no deer but vacancies around, move to a random location. If a mature wolf's present location differs from previous location, deposits a new-born at its previous location.
- ▶ Step3: loop over deer and delete those whose location are now occupied by wolves (via the occupation matrix)
- ▶ Step4: loop over deer and check neighbours. If vacancies around, move to a random location. If a mature deer's present location differs from previous location, deposits a new-born at its previous location.
- ▶ Step5: go back to Step1 and increase system time by 1

parameter scanning

Parameter Search

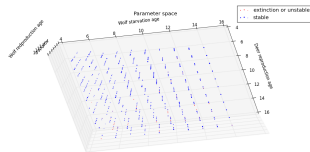
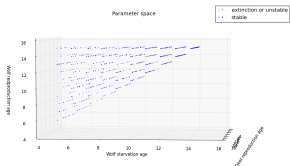
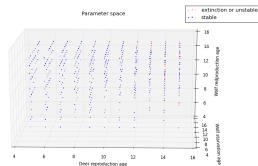
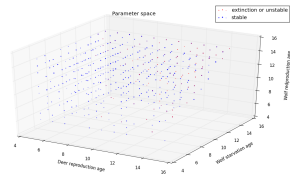
5 parameters to test (5-D parameter space)

- ▶ **Initial population of deer**
- ▶ **Initial population of wolves**
- ▶ Reproduction age of deer
- ▶ Reproduction age of wolf
- ▶ Starvation "age" of wolf

Reduce to 4 dimensions (4-D)

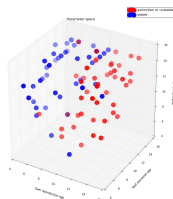
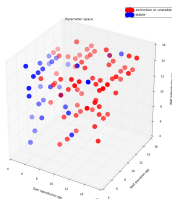
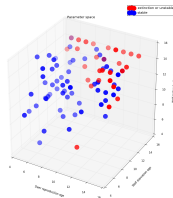
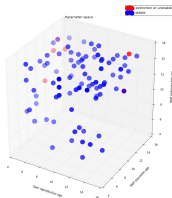
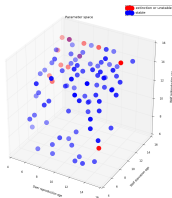
- ▶ **Ratio of initial populations : Size of point**
- ▶ Reproduction age of deer : x-axis
- ▶ Reproduction age of wolf : y-axis
- ▶ Starvation "age" of wolf : z-axis

Results of Full Parameter Search



Results of Restricted Parameter Search

Fix initial population ratios



Ecosystem at Equilibrium

Parameters used:

- ▶ Initial number of deer: 2,500
- ▶ Initial number of wolves: 250
- ▶ Deer reproduction rate: 5
- ▶ Wolf reproduction rate: 14
- ▶ Wolf starvation rate: 11

Animation Time!