# Excercise 1.
# Implementing a first Application in RePast: A Rabbits Grass Simulation.

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## 1 Implementation

### 1.1 Assumptions

The presence of grass in a cell is a binary variable, i.e. there cannot be more than one grass in a cell. This was chosen because allowing different levels of grass does not change much for the problem.
Once a rabbit gives birth, he gives half his energy to his child (so as to have conservation of the energy).
A rabbit that is blocked by another rabbit does not move but still consumes energy. If there is a new grass under him, he eats it.
The grid is a square (as rectangular grid does not change anything to the rest of the problem).
The energy cost of moving is a constant of value 1.
The energy given by eating the grass in a cell is a constant of value 5.
The starting energy of a rabbit (only used for the rabits generated at step 0) is set to 10 (constant).

### 1.2 Implementation Remarks

A turn happens in the following order:

1. for each rabbit taken in random order + the newborns of this turn in birth order:
   (a) the rabbit tries to move
   (b) he eats grass if there is some under him
   (c) he reproduces if he has enough energy
2. grass is generated
3. rabbits without energy are removed from the simulation

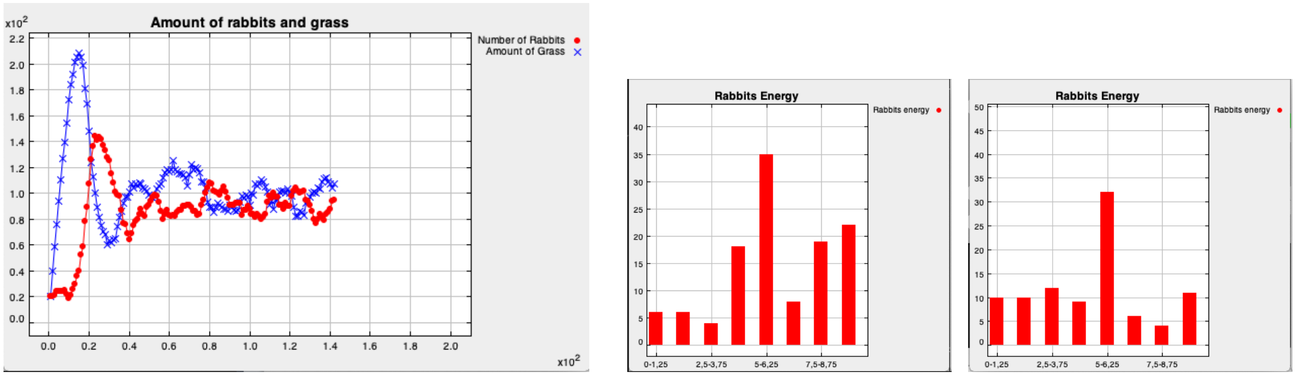
## 2 Results

### 2.1 Experiment 1

#### 2.1.1 Setting

| Name | *birth threshold* | *grass growth rate* | *grid size* | *initial number of rabbits* |
|---|---|---|---|---|
| Value | 10 | 20 | 20 | 20 |

NB: these are the default values for the parameters.




(a) populations graph (b) growing phase histogram (c) shrinking phase histogram

Figure 1: Experiment 1

#### 2.1.2 Observations

As we can see on Figure 1a, there are oscillations between the number of rabbits and the number of grass cells. This is due to the equilibrium between, on one side, the rabbits eating the grass and breeding and on the other side, the grass growing. With this set of parameters, the rabbits breed too quickly/the grass grows too slowly, thus:

1. There are few rabbits and much grass
2. Due to the profusion of food, the rabbits breed intensively and eat much grass
3. The rabbits are too many and have eaten most of the grass, they start to die
4. There are fewer rabbits and the grass starts to grow
5. Go back to 1

We can also see that in the first steps of Figure 1a, there was initially very few grass and the rabbits were initially starving. An extreme case (not represented in an experiment since it's not interesting) would be that all the rabbits die and that the grass would then be free to grow. It is interesting to note that there is no convergence here, the populations keeps oscillating without achieving an equilibrium when the simulation is left running (we tested up to 2000 steps).

The Figure 1b and 1c shows the histograms when the number of rabbits increases and when it decreases. We can see that when the number of rabbits increases, the mass of the histogram is mostly distributed on the right (rabbits with high energy and thus reproducing) and when it decreases, the mass is more distributed on the left (rabbits starving and dying).

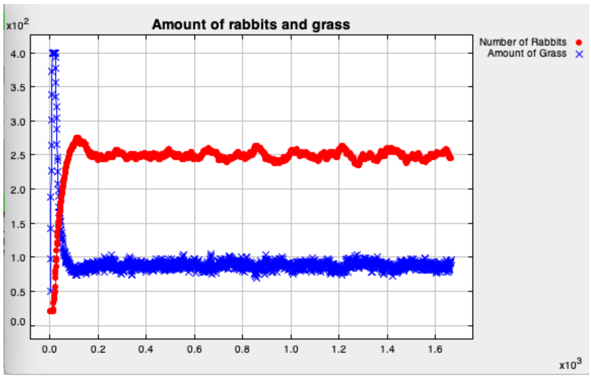
### 2.2 Experiment 2

#### 2.2.1 Setting

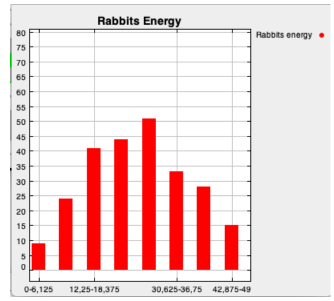
| Name | *birth threshold* | *grass growth rate* | *grid size* | *initial number of rabbits* |
|---|---|---|---|---|
| Value | 50 | 50 | 20 | 20 |

#### 2.2.2 Observations

As we can see on Figure 2a, the populations (approximately) stabilize to a constant number of rabbits (250) and number of grass (90). This is due to the fact that since the birth threshold and the grass growth rate are higher, the rabbits do not breed excessively with respect to the amount of grass anymore and an equilibrium can be achieved. We can also notice that the average amount of grass has not changed much from the previous experiment although we multiplied the grass growth rate by a factor of 2.5. This




(a) populations graph




(b) steady phase histogram

Figure 2: Experiment 2

shows the regulation effect of the rabbits. The energy histogram (2b) has more weights on the center (with respect to Figures 1b and 1c) which indicates a better birth/deaths balance. Note that due to the change of *birth threshold*, the scale of the X-axis is not the same but it does not invalidates the comparison. Changing only *birth threshold* and only *grass growth rate* were tried as well, they both lead to a stabilization of the graph.

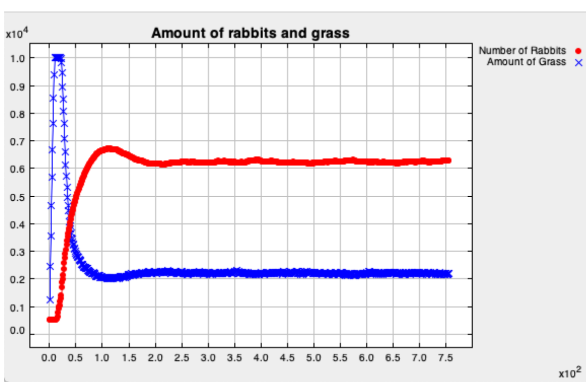
## 2.3 Experiment 3

### 2.3.1 Setting

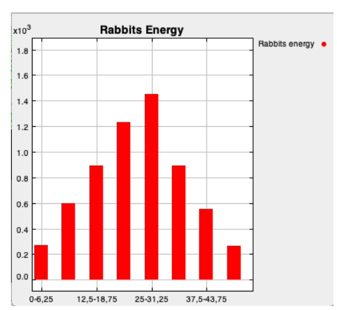
| Name | *birth threshold* | *grass growth rate* | *grid size* | *initial number of rabbits* |
|---|---|---|---|---|
| Value | 50 | 1250 | 100 | 500 |

NB: *grass growth rate* and *initial number of rabbits* were kept the same as in Experiment 2 relatively to the number of cells.

### 2.3.2 Observations




(a) populations graph




(b) steady phase histogram

Figure 3: Experiment 3

We tried to modify the size of the grid and we saw from that experiment that the equilibrium was a bit smoother. This makes sense since we reduced the impact of noise by increasing the size of the experiment. There is no notable difference between the histograms (especially since the histograms changes from timestep to timestep inside of the same simulation).