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

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1 Implementation

1.1 Assumptions

1.1.1 Assumptions for the Implementation of grass and of its growth

There can be either 1 or 0 unit of grass per cell. At each simulation tick *GrassGrowthRate* (default 50) units of grass are added to empty cells **if possible**. This value is user defined and modifiable throughout the simulation.

1.1.2 Assumptions for the Implementation of the movement of Rabbits and of collisions

At each tick each alive rabbit tries to move to a random cell picked among the 4 cells adjacent to it's location. If it tries to move to a cell where another rabbit is present, **if the cell is empty it moves to it, if it is already occupied it doesn't move for this turn**. Regardless of whether it actually moved or not the rabbit loses 1 energy unit per tick.

1.1.3 Assumptions for the Implementation of feeding, energy and reproduction

Each rabbit has an energy value $e \in [0, 20]$ this value drops by a unit of 1 every turn. At each tick, rabbits "eat" grass after moving (in the new cell they moved to if they succeeded in moving). If there exists a unit of grass on the cell it's on the energy of the rabbit "eats" it (clearing the cell of grass) and the rabbit's energy increases by a value *GrassEnergy* (default 5) that is user-set and editable throughout the simulation. At each tick (before movement and feeding) if a rabbit has an energy value $e \geq$ *BirthThreshold* it gives birth (this means if a rabbit has gathered enough energy through eating it will give birth at the start of the next turn). *BirthThreshold* (default 20) is user set and editable throughout the simulation.

1.1.4 Assumptions for the Implementation of birth and death

When giving birth, **the parent rabbit gives a random proportion of it's energy to it's child**, meaning it losses some random amount of it's energy. The child inherits the exact amount of energy the parent lost when giving birth and appears on a random empty cell on the grid (the cell can have grass but no rabbit). The repartition of energy between parent and child is the following : $e_{parent} + e_{child} = e_{parent\ before\ birth}$. At each tick, after movement, feeding, and reproduction rabbits whose energy is ≤ 0, die: they are removed from the simulation.

1.1.5 Assumptions for the initialization of the simulation

The model is initialized with a user-set number of grass cells and rabbits. Initial rabbits are given a random amount of energy $e \in [0, 20]$.

1.2 Implementation Remarks

In our model implementation energy is stored as a *double* value. The way the placement of new grass units and rabbits is handled is by picking a random position repeatedly until an empty cell is found, this operation can be repeated a finite number of times to avoid infinite loops in the case where no cell is free. This solution runs the risk of not finding a free spot in edge cases when there may actually be one but has the advantage of being relatively computationally inexpensive (in the most common case) compared to going through every single free cell every time. An alternative solution could be the storage of a separate list of every free cell but such an implementation would be quite memory-intensive for large size simulations.

2 Results

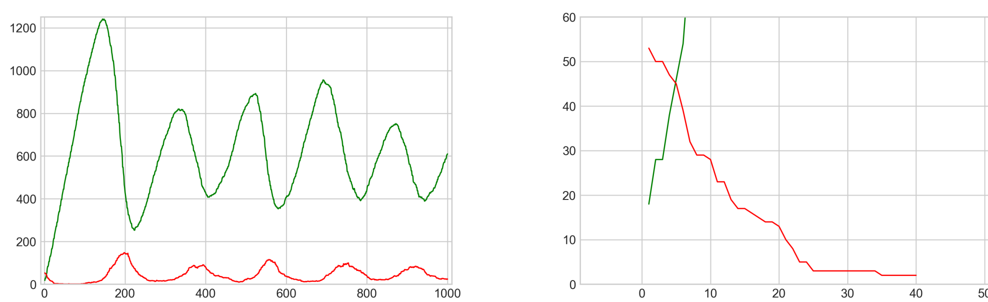

Figure 1: **Left :** An typical example of Lotka-Volterra solution. **Right :** An example of population crash.

2.1 Experiment 1 : reference run

2.1.1 Setting

Default run : this will be our reference run. We will study the evaluation the simulation properties around those reference parameters.

2.1.2 Observations

We observe that the default run (Figure 2, left) converges in around 100 ticks to a stable regime where the prey and predator populations (number of individuals) oscillate around equilibrium values. This is consistent with how typical solutions of Lokta-Volterra equations should behave (tuning the parameters allows for a textbook solution example as seen in Figure 1, left).

2.2 Reaction of the simulation to variation in parameters

We will now describe the way the model behaves in reaction to various parameters. First, let's observe that since the populations converge towards an equilibrium, as long as the initial populations of grass is sufficiently high so that the rabbit population does not die off (this particular case can be seen in the

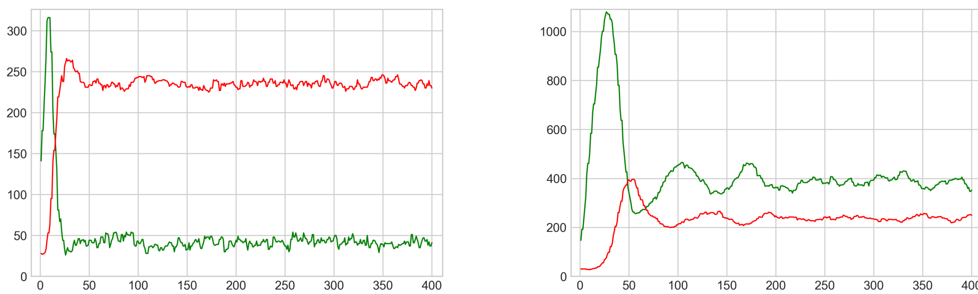

Figure 2: **Left :** Lineplots of the rabbits (in red) and grass (in green) populations over the first 400 ticks of the reference simulation. **Right :** Equivalent lineplots for a simulation on a larger grid, we see that the oscillations are of a lower frequency.

Figure 1, right), the initial populations values only have an influence on the transient response of the system, not on the stable state it converges to.

The grass growth rate is highly correlated with a high rabbit-to-grass population ratio, but saturates for high values (Figure 3, right). The grass energy behaves similarly (although it saturates for different reasons). The birth threshold of rabbits has an optimal value (around 15) for a maximum rabbit-to-grass population ratio, this ratio gets lower for higher and lower values.

Finally a higher grid-size correlates to a higher grass-to-rabbit population ratio (Figure 3, left) as well (and perhaps more interestingly) to a lower oscillation frequency in the stable mode (Figure 2, right).

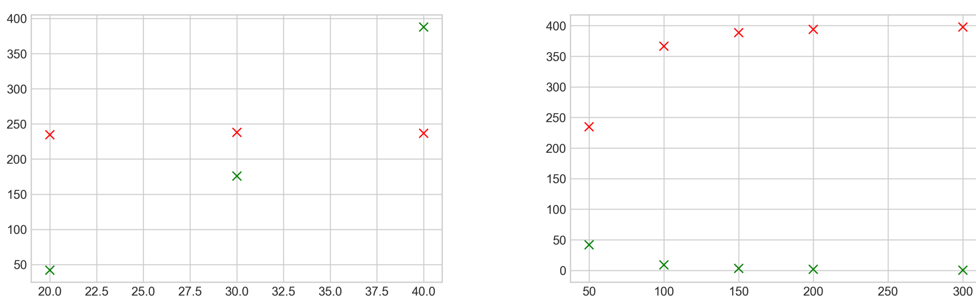

Figure 3: **Left :** Evolution of rabbit (red) and grass (green) population equilibriums as grid size changes (each point pair here is a simulation). **Right :** Similar plot for the evolution of rabbit (red) and grass (green) population equilibriums as the grass growth rate changes.