A fine scale agent-based model of the nigerian gerbil (*Gerbillus nigeriae*) invasion in northern Senegal

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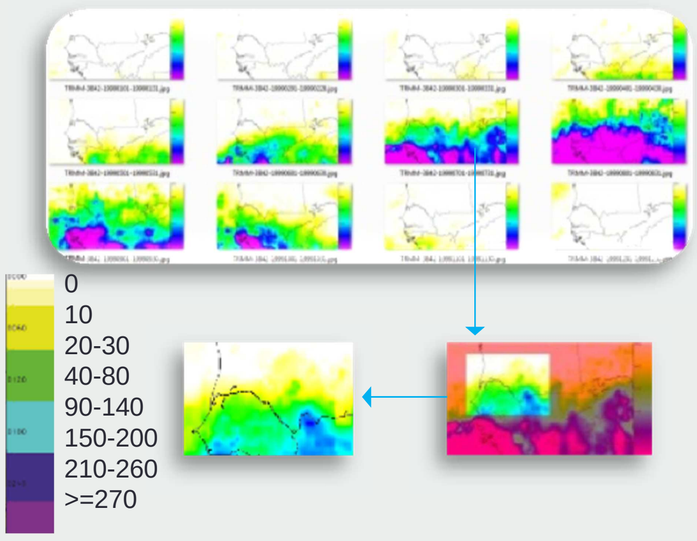
Introduction

Species ranges evolve following environmental changes. This phenomenon accelerated considerably under the increasing influence of global changes. The nigerian gerbil, a major pest of dry crops (millet, sorghum), was first found in the 90's in northern Senegal (Ba et al, 2006), from where it spread rapidly in all the northern, Sahelian, part of the country. To understand the multidimensional aspect of gerbil invasion, we propose a multi-thematic agent-based model, embedded within a general model of bio-ecological coevolution of small rodents and their parasites (Le Fur et al, 2017).

Method

We made use of a mechanistically rich approach (De Angelis and Mooij, 2003) encompassing various divers of the rodents dynamics (**a - e**)

(a) TRMM-3B42 satellite data were used to simulate rain. We proceeded to resampling, reclassifying, digitalization and saving of the numerical matrix obtained.



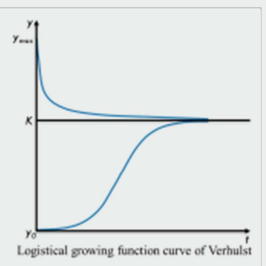
Legend : Rainfall variation after reclassification

(b) The Verhulst logistic function was used to link vegetation growth to rain evolution.

Logistical growing function of Verhulst

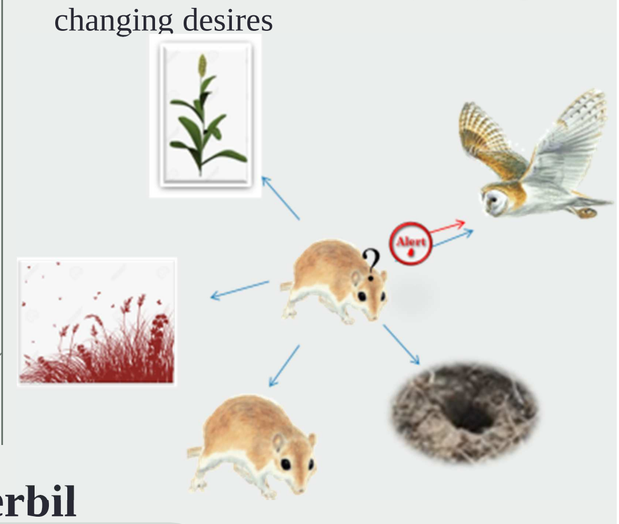
$$\begin{cases} y(0) = y_0 \\ y' = ry\left(1 - \frac{y}{K}\right), r > 0 \text{ et } K > 0 \end{cases}$$

With :
- y : growth at $t \neq 0$
- y_0 : initial growth value ($t = 0$)
- r : growth rate
- K : field carrying capacity



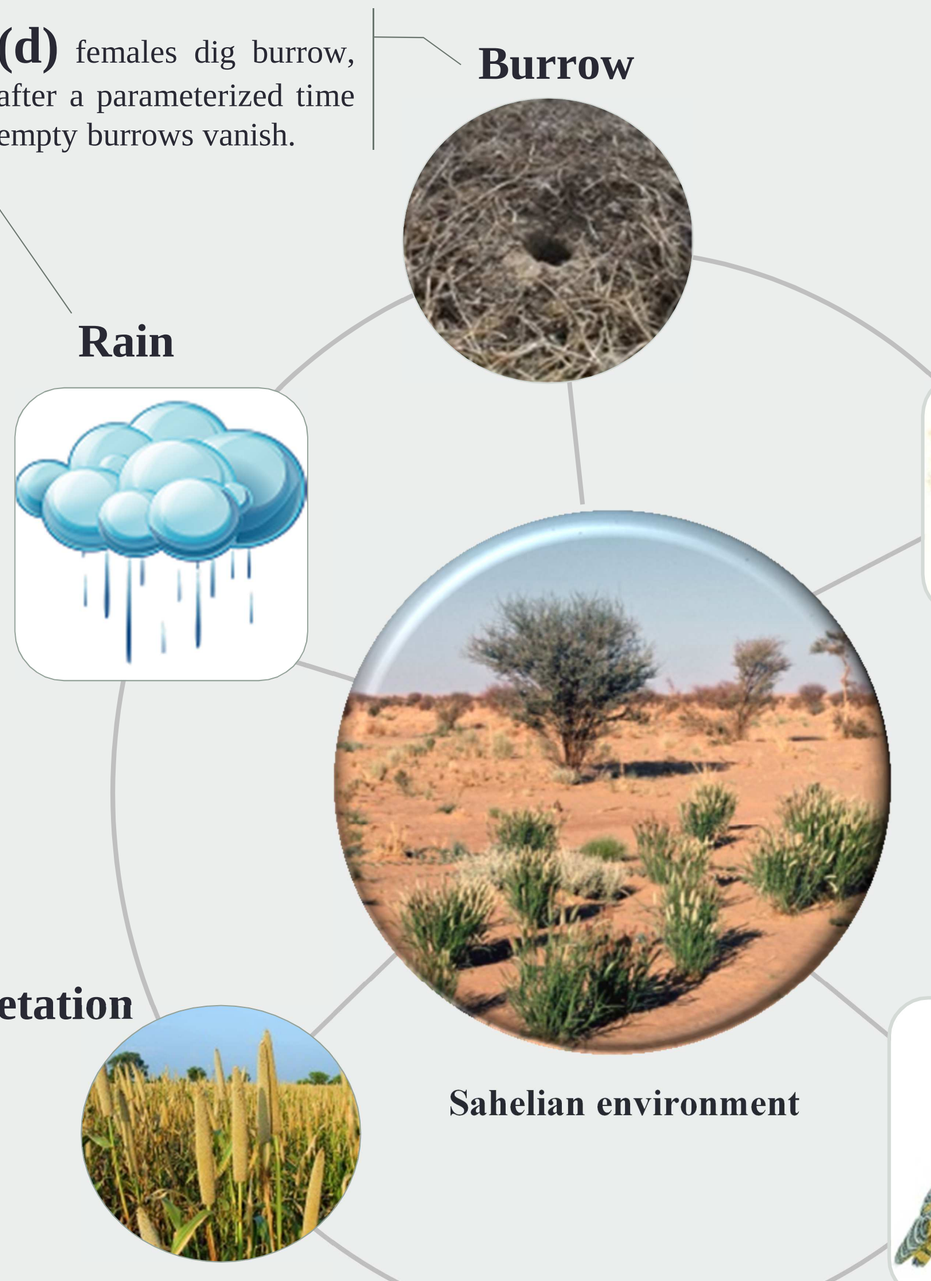
Analytical solution f(t) : $f(t) = K\frac{1}{1+\left(\frac{K}{y_0}-1\right)e^{-rt}}$

(c) Agents process to "perception / deliberation / action" (PDE) given changing desires

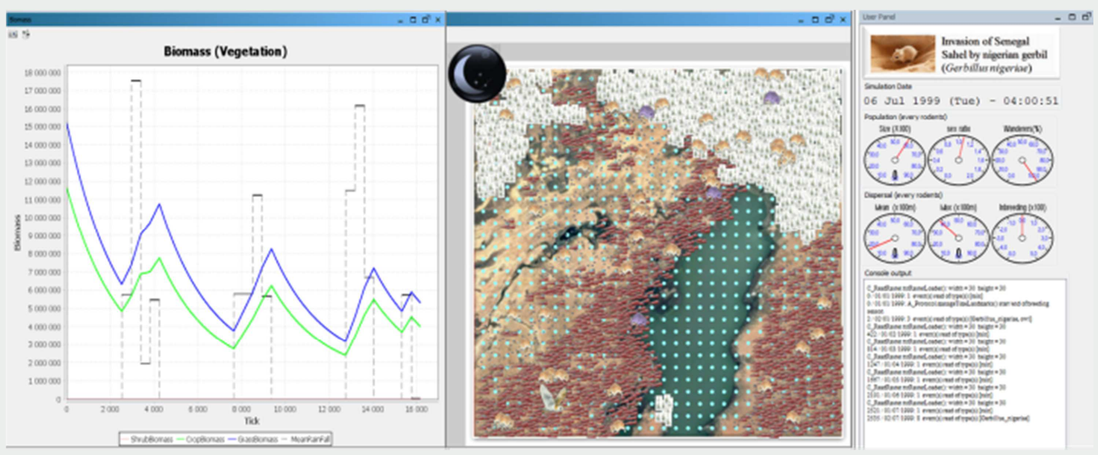


(d) females dig burrow, after a parameterized time empty burrows vanish.

(e) Predator: nest in trees, wander at night in search of gerbils



Result: model overview



Caption:
- Grass biomass curve
- Crop biomass curve
- Rainfall curve
- Crop
- Grass
- Rain
- sexually receptive gerbil
- Gerbil
- Barn owl

Figure 1 : Snapshot during a simulation;
- ***Left:*** Crop, grass biomass and rainfall dynamics;
- ***Middle:*** gerbil and barn owl population evolving in their dynamic environment (sahelian area around « Lac de Guiers ») characterized by a diversified vegetation (grass, tree, crop and shrub);
- ***Right:*** multi thematic control of the population dynamics.

Time step : 1hour; resolution : 1px = 100m

Discussion

- ✓ The complexity of the model obtained lies in its multi-thematic dimension.
- ✓ The model supports running at different time scales. This proved valuable to better understand the model potential, limitation and functioning.
- ✓ The simulation model is close to observed patterns with consideration of circadian rhythms.

Conclusion

- ✓ The model emulates a sahelian environment. This permits to test a set of ecological questions such as rodents' dispersal in the context of the gerbils' invasion of Senegal.
- ✓ Forthcoming works include sensitivity analyses to better understand the model's validity range potential, other developments, such as including energy costs, are also considered.

References

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