Fine-scale agent based simulation of nigerian gerbils (*Gerbillus nigeriae*) within their habitat in sahelian Senegal

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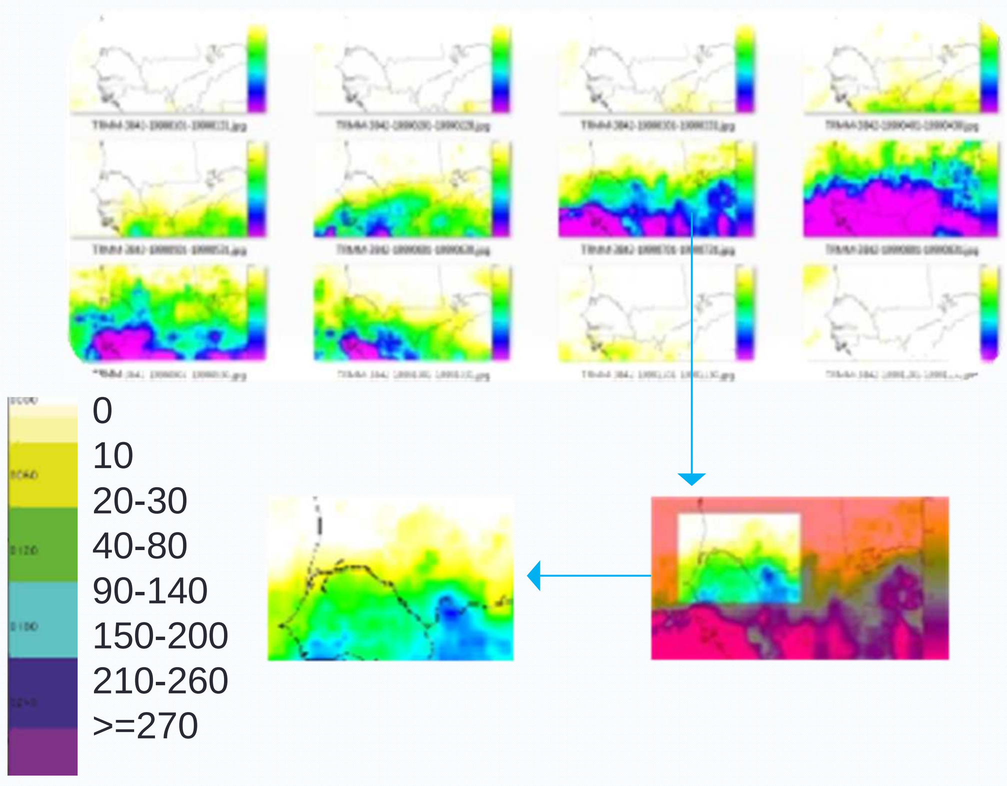
Introduction

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. As part of a multidimensional study of gerbil invasion (Cerise project), we propose a multi-thematic agent-based model that aims at reproducing and understanding the living conditions of this rodent at a local scale.

Method

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

(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 (mm) after reclassification

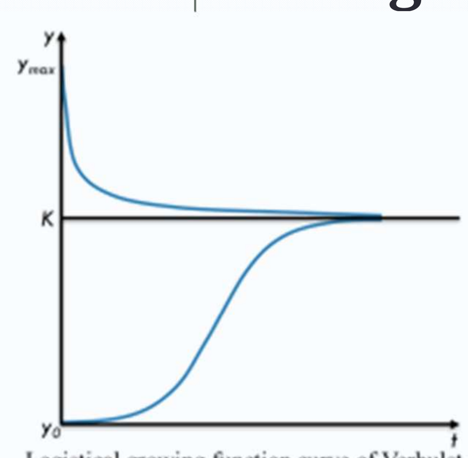
(b) The Verhulst logistic function was used to link vegetation growth to rain evolution.

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 :

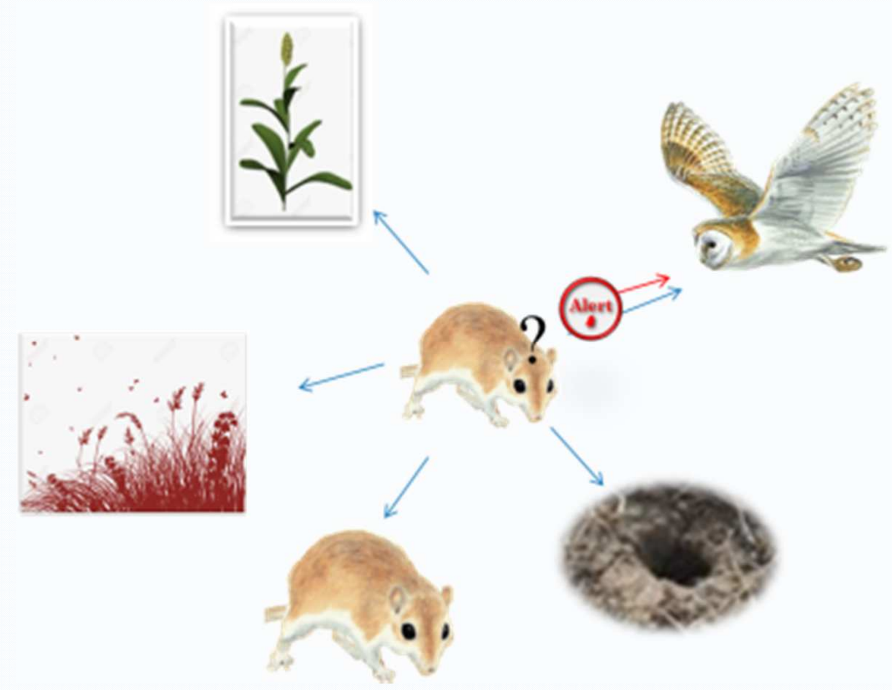
- y : growth at $t \neq 0$
- y_0 : initial growth value ($t = 0$)
- r : growth rate
- K : field carrying capacity



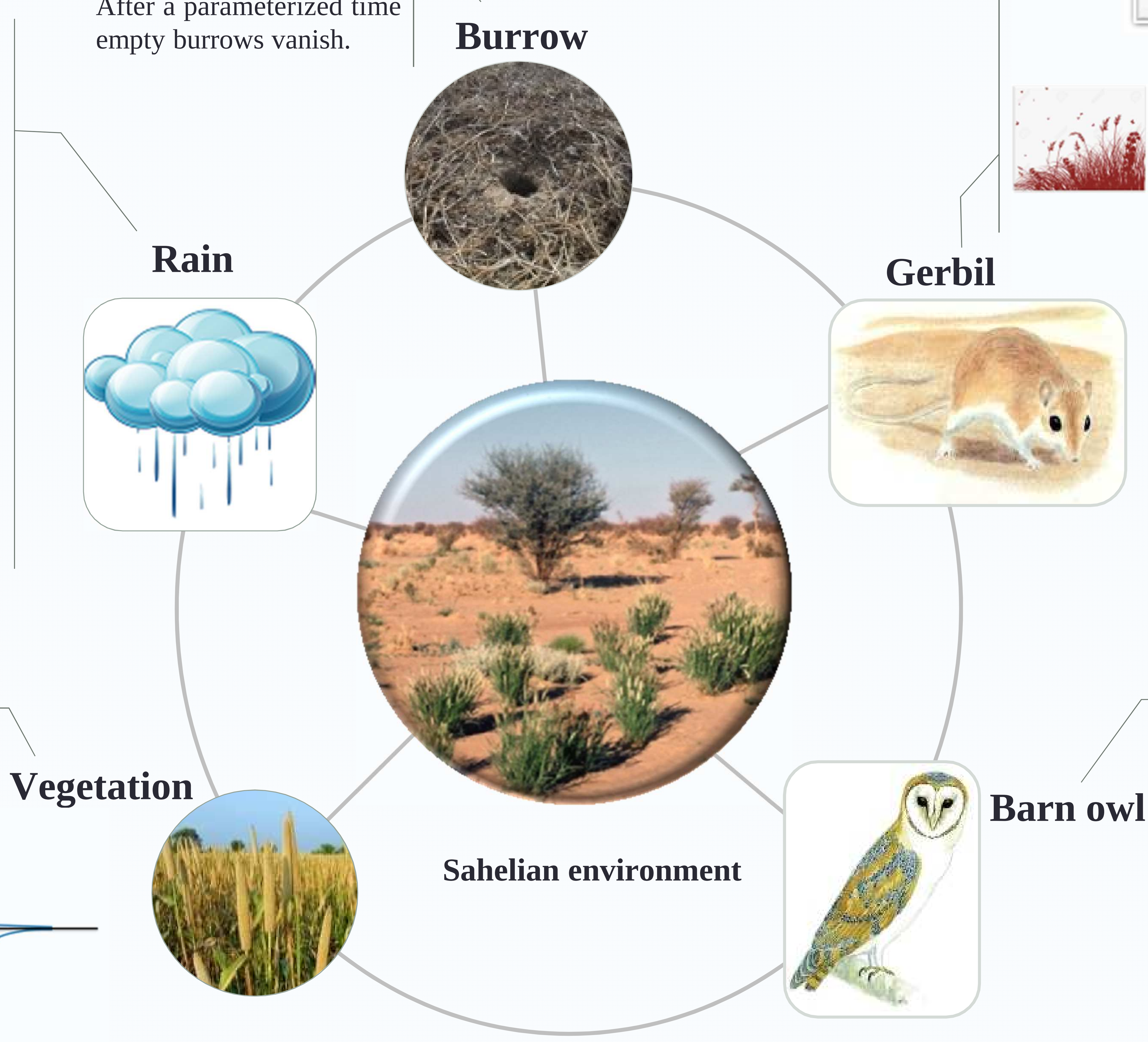
Logistical growing function curve of Verhulst

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: simulated owls nest in trees, wander at night in search of gerbils

Result: model overview

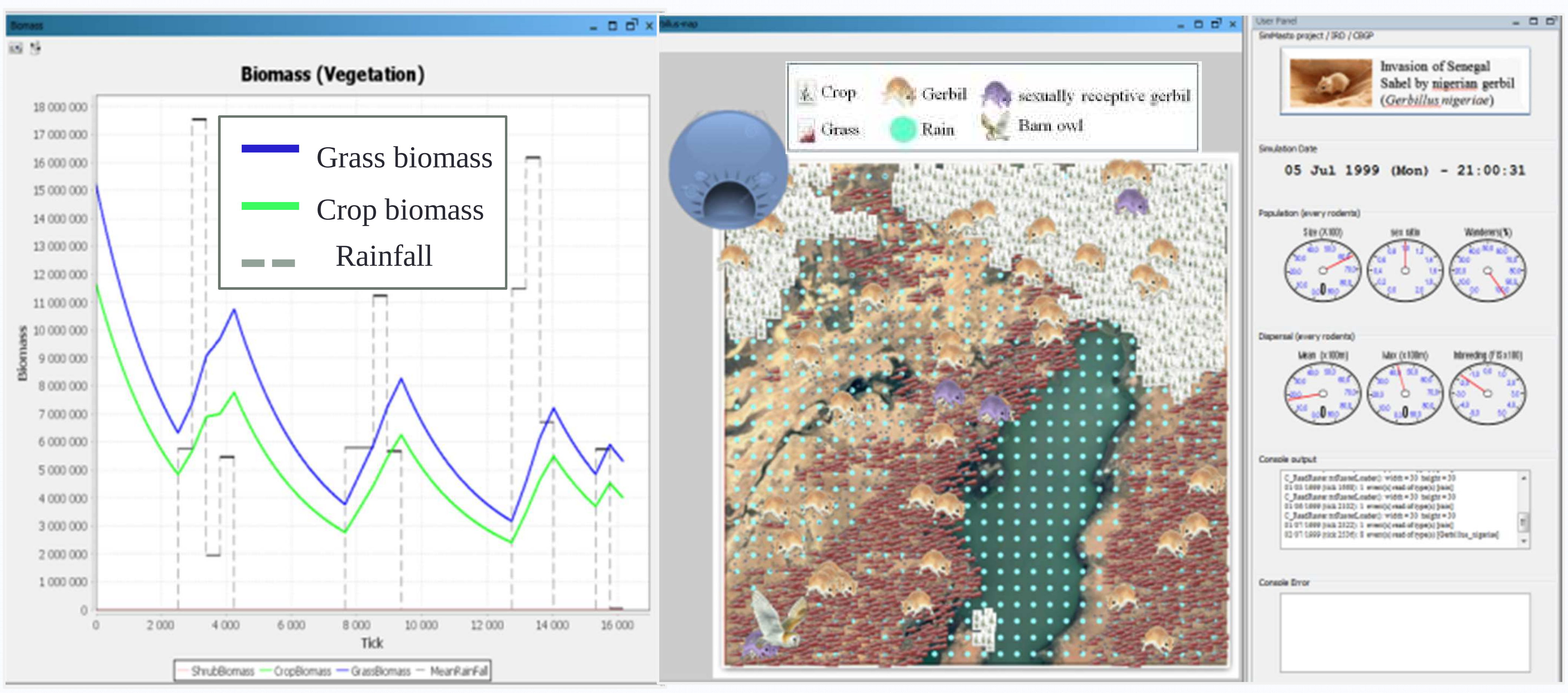


Figure : Snapshot during a simulation

- ***Left:*** Crop, grass biomass and rainfall dynamics;
- ***Middle:*** simulated dynamic environment (area around « Lac de Guiers »)
- ***Right:*** simulation control benchmarks.

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

Discussion

- ✓ The model supports running at different time scales. This proved valuable to better understand the model potential, limitation and functioning.
- ✓ Such model appears difficult to implement due to many unknown or uncertain parameters.

Conclusion

- ✓ The model emulates a sahelian environment as close as possible to the known local environment. This permits to test sets of ecological questions such as here, the extent of 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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- DeAngelis, D.L., Mooij, W.M. (2003) In praise of mechanistically rich models. In: Models in Ecosystem Science. Princeton, New Jersey, pp. 63–82.

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