A Meta-Model of Endogenous Overcrowding-Driven Demographic Collapse

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In this work, we propose a first-principles meta-model of the behavioral sink, a form of demographic collapse first observed by John Calhoun in the famous Universe 25 experiment [1], in which a confined population collapses in the absence of predation, disease, or immediate scarcity of resources due to an overcrowding stress. The meta-model interprets this dynamics as an endogenous collapse driven by overcrowding, understood as perceived density rather than as a purely physical measure of population density.

Starting from this conceptual framework, we develop two representations of the phenomenon, an EBM and an ABM. The two models share the same structure and parameterization, enabling a comparison across different representation styles and reducing the influence of specific modeling choices regarding the unit of analysis. For validation, both models are applied to two empirical case studies: the Universe 25 experiment and the reindeer population of St. Matthew Island, with the parameters calibrated on the EBM and applied to the ABM.

Overall, the results indicate that a simple meta-model can provide an interpretation of purely endogenous collapses driven by overcrowding. Future developments include an analysis regarding the generalization of the model in different settings.

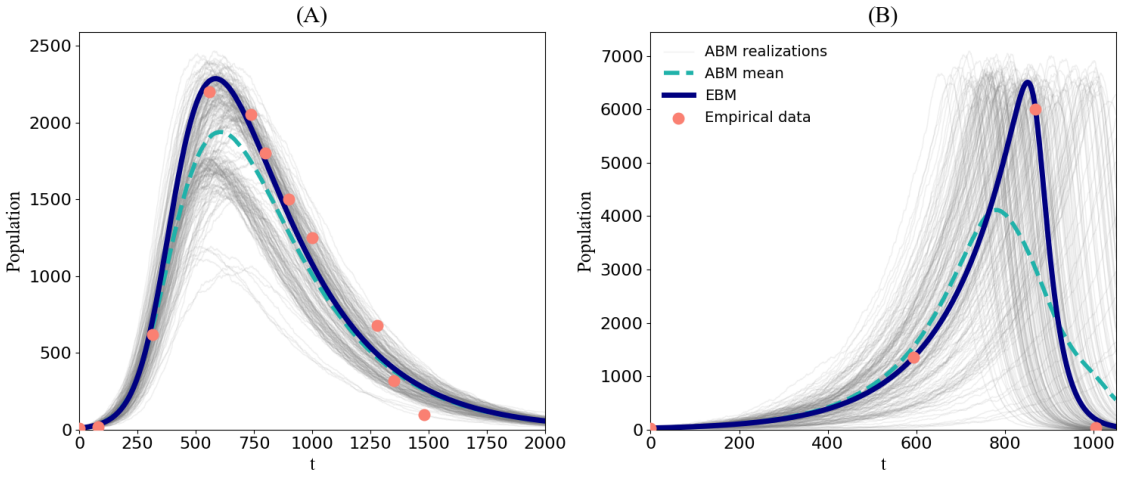

Figure 1: ABM and EBM vs empirical dynamics. (A) Universe 25; (B) St. Matthew Island.

References

[1] John B Calhoun. A behavioral sink. *Roots of behavior*, pages 295–315, 1962.