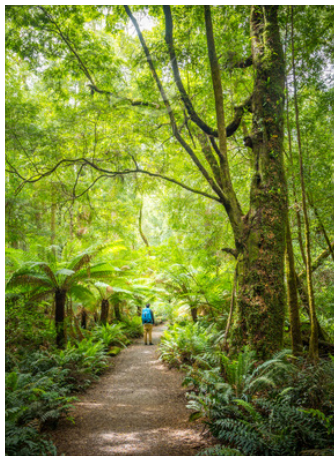
Spatiotemporal modelling of a synthetic rangeland ecosystem to check ecological hypotheses and theories

François Guerrin





Managing cumulative risks through model-based processes

2017 MODSIM

Abstracts

EDITORS: Syme, G., Hatton MacDonald, D., Fulton, B. and Piantadosi, J.

Hobart
3–8 December
TASMANIA
AUSTRALIA

22nd International Congress on Modelling and Simulation

25th National Conference of the Australian Society for Operations Research — ASOR 2017

DST Group led Defence Operations Research Symposium — DORS 2017

mssanz.org.au/modsim2017

MODELLING & SIMULATION SOCIETY OF AUSTRALIA & NEW ZEALAND INC.

asor

Defence Operations Research Symposium
DORS
MODSIM 2017
3–8 December 2017

Spatiotemporal modelling of a synthetic rangeland ecosystem to check ecological hypotheses and theories

F. Guerrin [a]

[a] *UMR Selmet, Cirad, Inra, SupAgro, Montpellier, France*

Email: francois.guerrin@cirad.fr

Abstract: The model presented allows the spatial dynamics stemming from the interactions between mobile agents (like herbivores) and their environment (like rangeland) to be simulated. This model thus features a herd grazing on a pasture. For the sake of sustainability a dynamical balance must be found between the grass consumption by the animals and the herbage growth. However, two behaviours may threaten this equilibrium: overgrazing, possibly leading to desertification; under-grazing, that may lead to excessive vegetation growth and the landscape "closure" by invasive shrubs. Both processes may lead the herd to extinction by starving.

This model's aim is not, actually, to mimic real specific rangelands but to offer a generic simple synthetic ecosystem to check ecological hypotheses and theories. Although deliberately naive, it has been parameterized with real rangeland and cattle values and implemented with the agent simulation platform NetLogo <ccl.northwestern.edu/netlogo>.

Simulations have been made to check variants of the ecosystem's structure and animal behaviours:

- Spatial distribution of vegetation and animals;
- Foraging strategies: staying or moving; local or global search;
- Animal ways of movement: directed vs. random walks, short vs. long step length;
- Heterogeneity vs. homogeneity among individual animals or land patches.

The main criteria of simulation assessment are the production of animal and vegetal biomasses, herd demography and landscape fragmentation.

In the simulations made, the most sustainable strategies are those emphasizing space occupation, local foraging, short walk steps and anticipating resource exhaustion.

Whereas the main focus to date has been put on the comparison of animal walk types, showing the strong importance of animal movement in the rangeland system's dynamics, the emphasis has been put, since then, on other uses of the model:

- Exploration of issues regarding ecosystem complexity (e.g. adding trophic levels), percolation of products through space, resilience in front of disturbances;
- Hypothesis testing: optimal foraging, ideal free distribution, marginal value theorem.

Without challenging the deliberately naive approach followed so far, for the sake of realism, some improvements have been (or are being) introduced into the model:

- Interactions among animals to reproduce herding behaviour or sexual mating, interaction among land patches to propagate the vegetation;
- Structuring landscape elements (e.g. water holes) or behavioural features (e.g. preference or aversion for some kinds of vegetation) influencing animal movement;
- Climatic characteristics and seasonality influencing animal behaviour or the herbage growth;
- Heterogeneity among individuals in the herd and land patches in the landscape;
- New relevant criteria and metrics for landscape assessment.

The main features of the model and simulations demonstrating its relevance to deal with hypothesis checking will be presented.

Keywords: *Agent-based modelling, landscape simulation, grazing ecosystem*