Simulation of the seasonal supply of entomophilous flower mixtures using Monte Carlo studies.

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Abstract

The objective of this study is to model the seasonal supply of four entomophilous flower species of interest using Monte Carlo (MC) simulations over at least ten years. The goal is to reproduce natural subsistence scenarios by varying mortality and propagation rates, as well as including artificial reseeding events.

Introduction

The availability of floral resources in rural landscapes is key to sustaining arthropod populations that perform ecological functions essential to agriculture, such as pollination [1]. In this interdisciplinary work with researchers specialized in agricultural ecology, the aim was to represent the seasonal variations in the floral supply of different species mixtures selected for establishment in non-farmed areas, optimizing the initial sowing proportions to achieve a homogeneous floral supply over time.

Model

Making use of MC simulations the evolution of floral seasons of annual species was studied. The model employed is the Cellular Automaton. [2] Each MC step is associated with a single day. Square lattice has periodic boundary conditions in one direction and open ones in the other. In each cell, depending on its current state and those of its eight neighbors, it may:

- Grow a plant
- Flourish a plant
- Die a plant or its flower

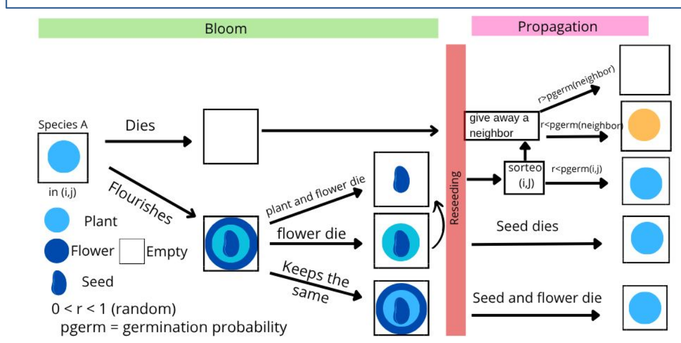

Figure 1: Representative diagram of the simulation dynamics.

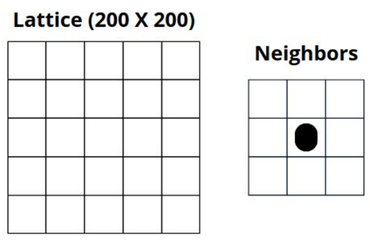

Figure 2: Cellular automaton scheme.

Species of Interest

Simulations were performed for the following species:

- White clover (Trifolium repens)
- Red Clover (Trifolium pratense)
- Yellow sweet clover (Melilotus officinalis)
- Chicory (Cichorium intybus)
- Grass

White clover *Red Clover* *Yellow sweet clover* *Chicory*

Parametrization

Based on the phenology of each species reported in the literature, the following parameters were assigned:

- Death rate
- Date of floral season start
- Flourish probability
- Propagation probability
- Lifetime of a flower

These parameters were also adjusted to reflect different climate scenarios (warm, medium, and cold seasons).

Results*

To test whether the program could reproduce bibliographically reported plant mortality rates, daily mortality was introduced as the only parameter in simulations where plants could only die. Exponential curves were fitted to obtain life expectancy.

Species	Life expectancy (years)	Mortality rate (days)	Fitted life expectancy	Fitted mortality rate
White clover	4-6	0.00055	5.11	0.000536
Red clover	2-3	0.00111	2.84	0.000966
Sweet Clover	3-5	0.00068	4.16	0.000658
Chicory	3-5	0.00068	4.17	0.000657

Tabla 1: life expectancies and mortality rates from bibliography compared to fitted ones.

Figure 3: Using the presented initial plant densities per species (plants/m²), equality in floral supply can be achieved within the desired timeframe.

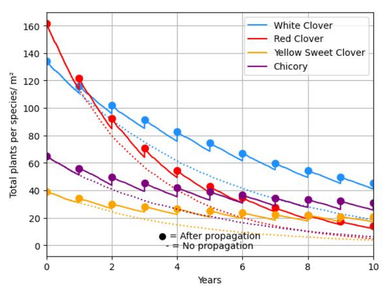

Figure 4: Effect of natural propagation on each species. Solid lines represent results including propagation; dotted lines correspond to cases without propagation. Propagation as a single-day event can be clearly observed.

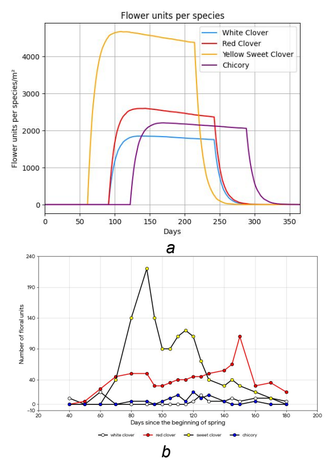

Figure 5: Comparison between simulated (a) and bibliographical data (b) of species in wild state.

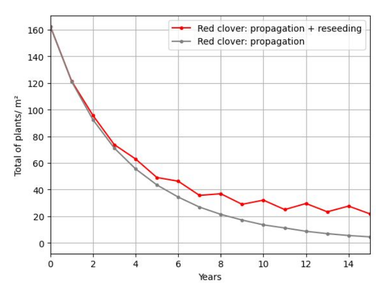

Figure 6: Example for a specific species showing total plant counts. The gray line represents natural propagation; the red line includes reseeding every two years.

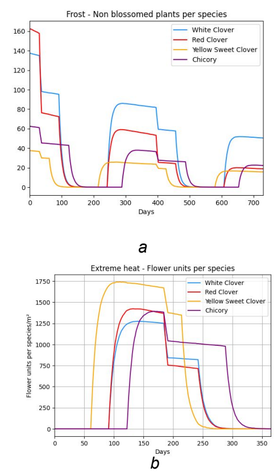

Figure 7: Climatic incidents such as frosts can be simulated, affecting total plant or flower numbers. Other events such as droughts or floods can also be modeled.

**All results shown are from the same type of scenario: warm season.*

Discussion

MC simulations allow us to reproduce the real behavior of the studied species in terms of survival and flowering.

The results for propagation and reseeding are as expected and species survival increases, compared to cases in which they are not propagated or only propagated, respectively.

In this model, parameters might be modified depending on normal climate conditions or anomalous ones such as droughts, floods or frosts. As well, spatial conditions can vary (size of lattice, boundary conditions).

Contact

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References

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