

# Game-based tools to transmit freshwater ecology concepts

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### INTRODUCTION

- > There is an increasing awarness of the public on environmental issues
- > Expert knowledge is often required to understand them
  - → A need for simple and understandable tools to explain environmental issues
- > Games provide a virtual world with given boundaries (rules) that the player needs to understand and to follow to win
- Furthermore, games are dynamic and interactive: the player engagement and its knowledge retention increase
  - → Games display interesting features to spread scientific thinking<sup>1</sup>

### **OBJECTIVE**

TO DEVELOP A BOARD GAME AND A **COMPUTER-BASED GAME TO EXPLAIN THE BASIC CONCEPTS OF AQUATIC ECOLOGY** 

The games aim to be **complementary**:

- in term of **player interactions** and **system dynamics**
- in **the targeted players** (groups vs isolated gamers)

## **METHODOLOGY**

> Aim of the games **CONTEXT** > Aquatic species and ecological concepts ➤ Inclusion of **time** and **chance** 

> **Design** of the games (players, token, board) **PROTOTYPES** 

> Size and layout of the board

Coding and calibration of the model

**TEST AND** > Gather player feedbacks

> Refining and adapting the games

➤ Identification of **funding opportunities** 

➤ Construction of a **diffusion network** 

## **BOARD GAME**

### DEVELOPMENT OF THE PROTOTYPE

Context

**PLAYER 1: PREY** 

The roach

Crustaceans and mollusks

The eggs stick to the plants

Systems, 29(8), 1981-1990.

- The **player is a fish**, either a predator or a prey
- The **objective** of the game is **to reach a stable population of fish**
- Concepts illustrated: feeding strategy, reproduction, predation and competition
  - Basis of the board game
- > Species: the roach (Rutilus rutilus) as a prey and the pumpkinseed (Lepomis gibbosus) as a predator, two common european small fish
- Illustration of a native european shoal fish (the roach) and of an invasive species (the pumpkinseed) with specific life history characteristics

### HOW TO PLAY THE GAME

- The board represents the edge of a lake with plants, crustaceans, and mollusks
- > The player choses a fish species and starts the game with 2 token (male +female)
- The players use dices to move the tokens on the board and to find ressources
- Each ressource provides the fish with a given amount of energy that he accumulates
- > This energy can further **be used to reproduce** (adult fish), to **grow** (juvenile) or to **attack** a prey (predator)
- Each turn, the player takes a card « chance » representing the events impacting the lake

**PLAYER 2: PREDATOR** 

The pumpkinseed

Roach juveniles and crustaceans

**COMPETITION** 

**PREDATION** 

**Ecological characteristics of each player:** 

**RESSOURCES** 

**REPRODUCTION** 

A solitary pike is swimmig around... Watch out! You just lost one fish

**EXAMPLE OF « CHANCE » CARD** 

Tonight is full moon. You see as well as in day light: play again

The forestry guards cut threes near the lake: plants become much more light! Snails eat more: they bring twice more energy for 2 turns

A fisherman put his boat onto the water. He repainted antifouling: no mollusk for 2 turns

Opening of a fishing contest. The

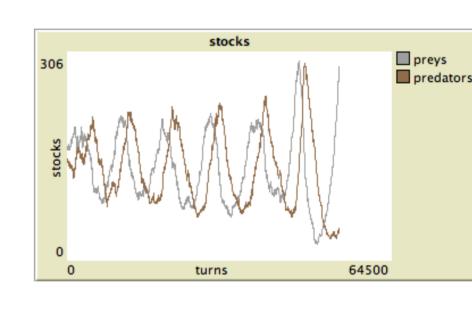
introduced fish destroyed the whole

ressources in the area for 2 turns

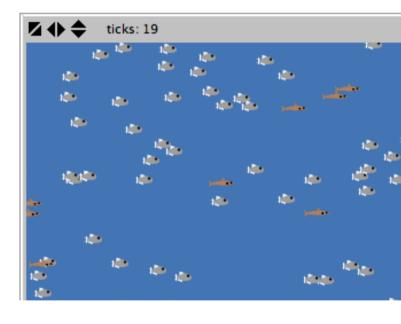
of the lake: no more

# Phase space figuring in Y axis the predators and in X axis the preys

(Netlogo interface)







The **ecosystem**: representation of the fish populations (Netlogo interface)

## DISCUSSION

The eggs are layed in a nest

done by the male

- Demonstration of the proof-of-concept: the prototypes are available for testing
- Both game are complementary as they integrate different time scales and illustrate diverse basic concepts of aquatic ecology
- No knowledge in aquatic ecology is needed to play both games: wide possibilities in targeted audiences
- ✓ The methodology is **flexible** and **adaptable**:
  - > On-going development of the games
  - Refinements and changes are easy to integrate in new versions of the games

# **Short term perspectives:**

 $\triangleright$  Next step of the project: test the games and gather player feedbacks  $\rightarrow$  do players like the games?

**PERSPECTIVES** 

> Identification of potential players (children, school/university, family, adults...) and adaptation of the games accordingly (simplication/complexification)

## Long term perspectives:

- Potential uses of the games as educational tools (with educative support) or sensibilisation tools (e.g. adapting the species and perturbations)
- Funding and diffusion of the board game through crowdfunding plateforms and game festivals
- > **Diffusion** of the **computer-based game**: open online access through **Netlogoweb** and development of mobile applications

# Context

> The player controls an ecosytem with preys (the roach) and predators (the pumpkinseed)

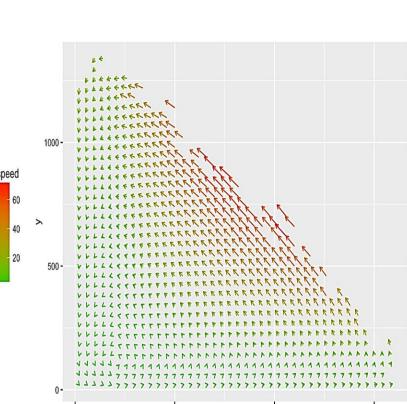
**EVALUATION** 

**DIFFUSION** 

**COMPUTER-BASED GAME** 

DEVELOPMENT OF THE PROTOTYPE

- The **objective** of the game is to **maintain the stability of the ecosystem**
- Concepts illustrated: population dynamic and ecosystem resilience
  - Basis of the computer-based game:
- An agent-based model<sup>2</sup> (ABM) for a simple prey-predator system is proposed as a basis of the computer game (Netlogo software)
- ABM simulate the behavior and interactions between agents (fish) to reconstruct the **population dynamic** (bottom-up approach)
- > Stochasticity is included with spatialized interactions (smoothed brownian motions), illustrating the randomisation of prey-predator interactions



Parameter: survival rate

**Parameter: reproduction rate** 

**Parameter: predator** 

hunting rate

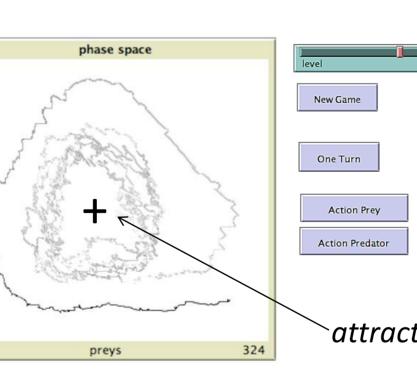
**PREDATION** 

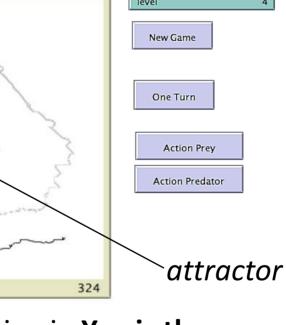
**Model calibration:** 

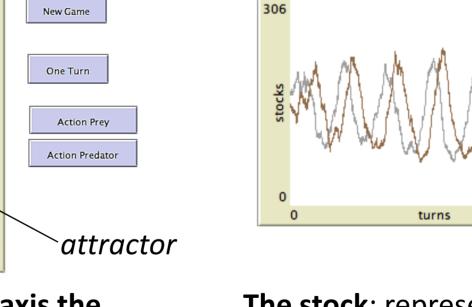
Systematic exploration of parameter **space** using OpenMole software<sup>3</sup>, to verify theoretical average trajectories in phase allows analytical numerical determination of initial position (attractor) and justify the use of this system for the game. The figures show estimated average trajectories for two points in parameter space.

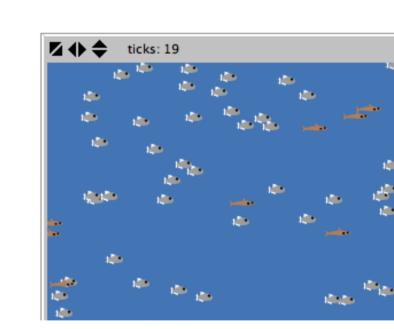
# HOW TO PLAY THE GAME

- The player starts the game with a stable ecosystem: the initial position is the attractor
- The button « one turn » makes the ecosystem evolve during 50 time steps
- > The player sees the changes in the fish populations simustaneoulsy on the screen
- > The trajectory can be corrected towards the attractor in the phase space by changing the parameters of the model (predator survival, prey reproduction and hunting behavior)
- External events randomly perturbate the ecosystem
- > The game includes 5 levels of difficulty based on event strength









Open source: code available at https://github.com/JusteRaimbault/MediationEcotox

(2013). OpenMOLE, a workflow engine specifically tailored for the distributed exploration of simulation models. Future Generation Computer