

*ESUG — August 2023*

# Agent-Based Modelling in Pharo Using Cormas

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CIRAD is the French agricultural research and cooperation organization working for the sustainable development of tropical and Mediterranean regions.

# My Objectives



Inform you about ABM and Cormas



Get you **excited** about the cool things that we can do with it



Encourage you to **participate** in our effort

An aerial photograph of terraced rice fields on a hillside. The fields are arranged in curved, concentric patterns, showing a vibrant yellow-green color. A small, traditional thatched-roof hut is situated in the middle of the terraces. The surrounding area is lush with green vegetation and trees.

Part 1:

# Agent-Based Modelling

# Let's look at the Birds



<https://youtu.be/X0sE10zUYyY>

# Central Questions of ABM

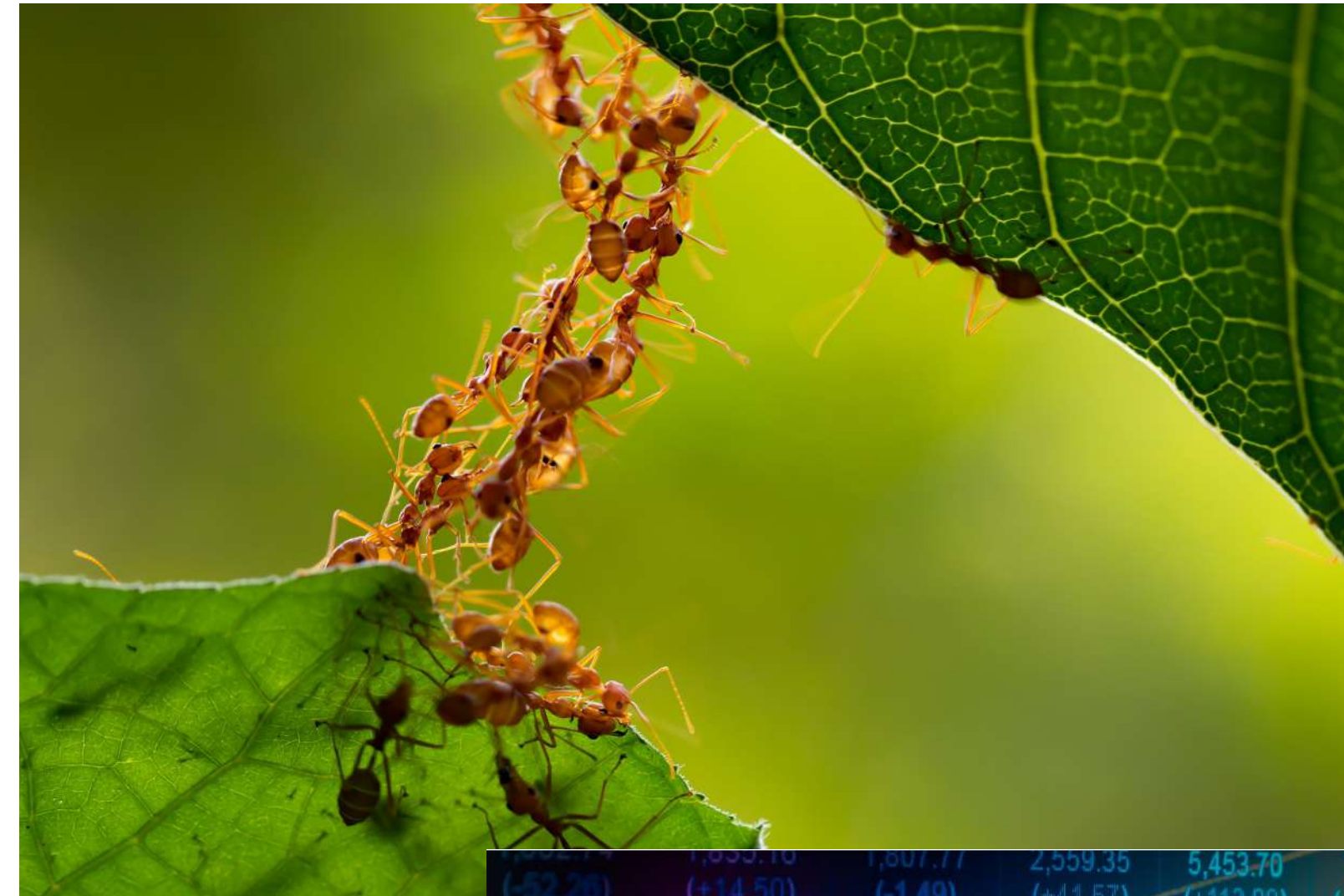


**Q1:** How do individuals that act on their own create beautiful emerging patterns?



**Q2:** How do those patterns of behavior then feed back to affect those individuals?

# Some Applications

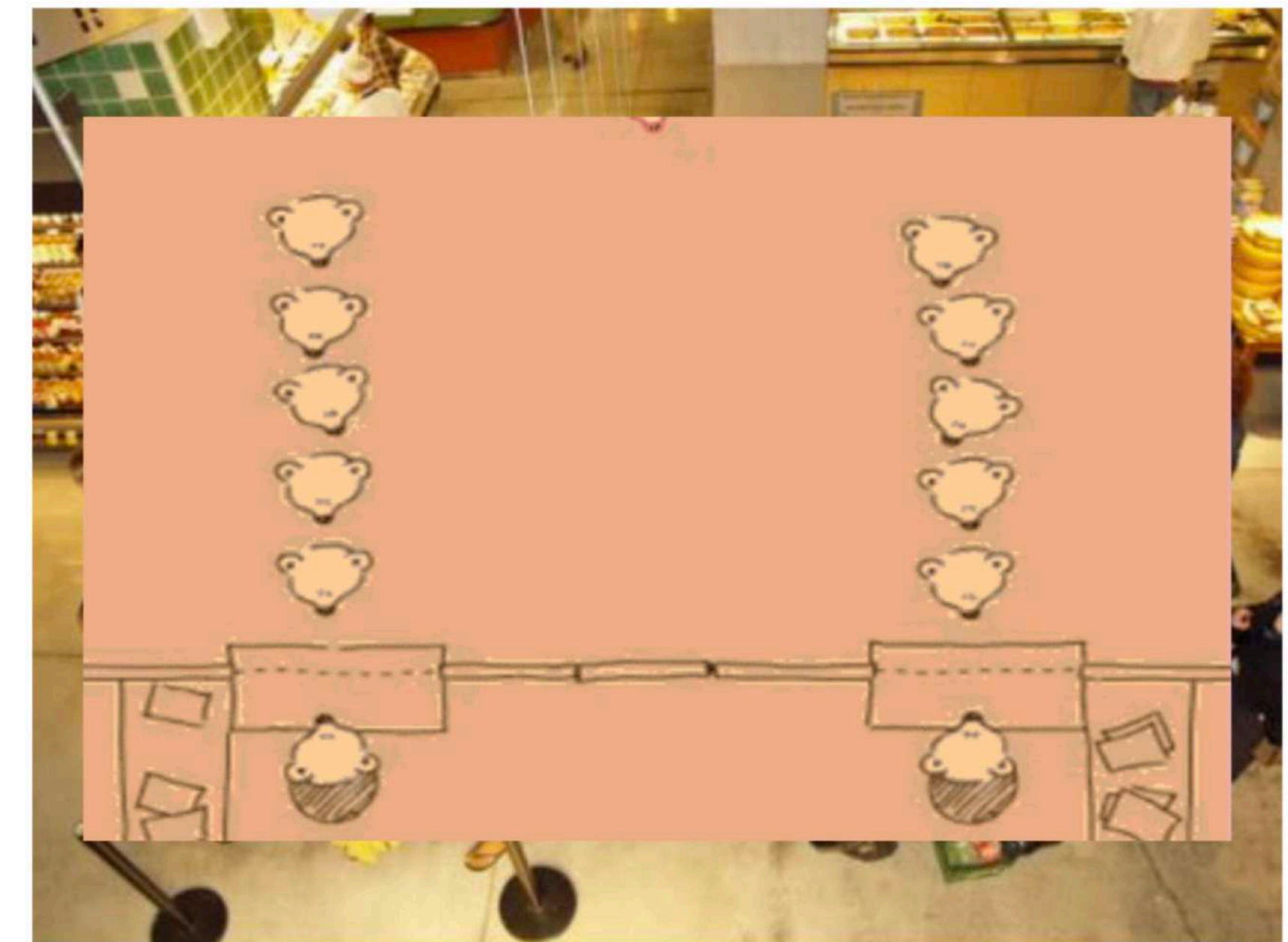


# Which Queue to Choose?

Real world



Model

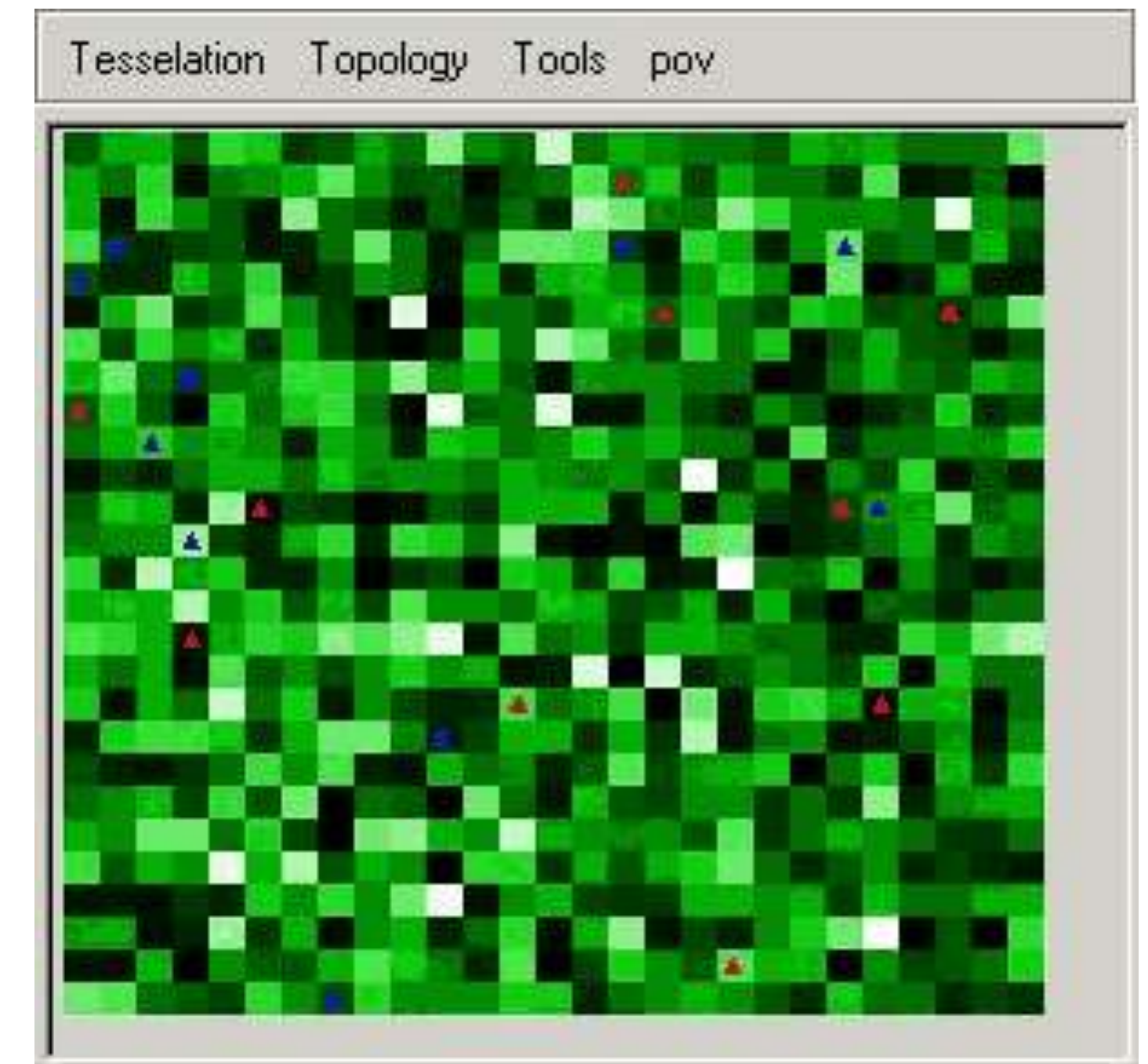
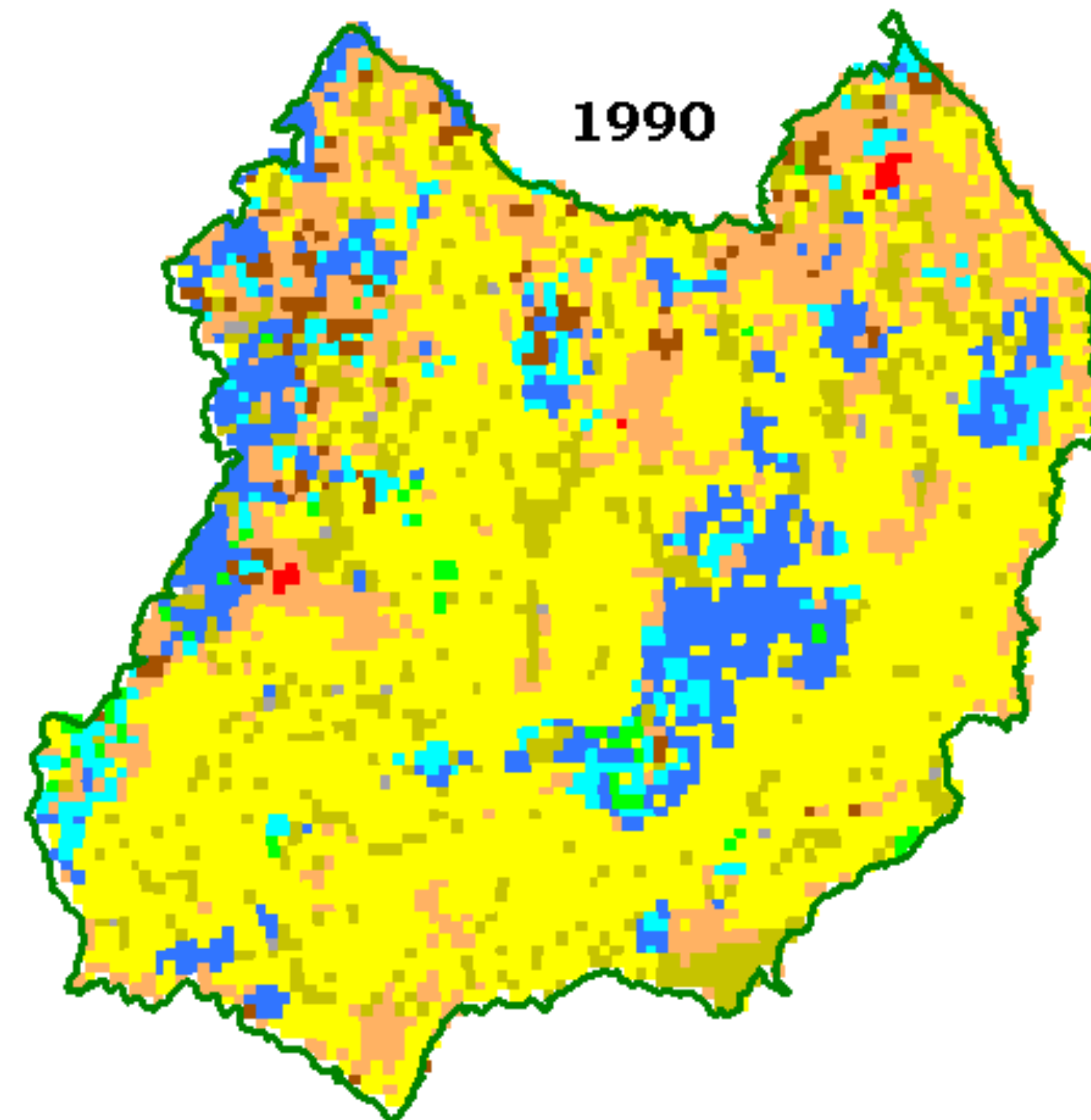
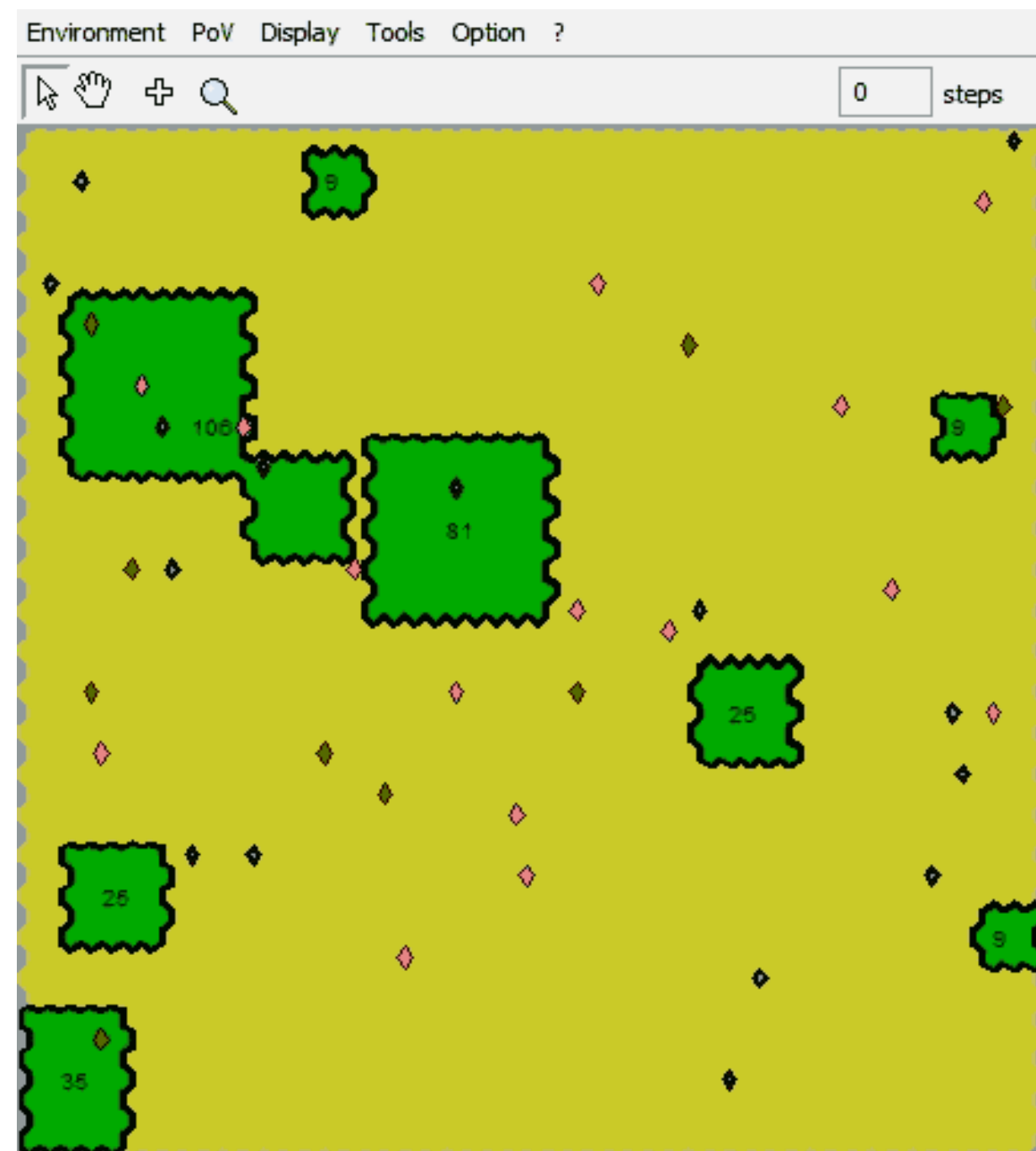




# Your Own Little Lab



*Test theories, explore interactions ...*



# ABM Platforms



The image displays three overlapping windows related to Agent-Based Modeling (ABM) platforms:

- NetLogo - Segregation:** A window showing a 3D visualization of ants on a terrain. The interface includes a control panel with sliders for "Evaporation of the signal (unit/cycle)" and "Rate of diffusion of the signal (%/cycle)", and buttons for "setup", "go once", and "go". A "Command Center" at the bottom shows the command "observer>".
- CORMAS - DundiModel (1.0):** A window with a large logo and the text "Common pool Resources and Multi-Agent Simulations". It features a control panel with "Initialize", "Forward", and "Pause" buttons, and input fields for "current step" (1000) and "final step" (1000).
- CORMAS - Probes - DundiModel (1.0):** A window showing a line graph with multiple colored lines (yellow, blue, green, black) plotted against time. A legend on the left lists probes: "dryGrass", "averageV", "freshGrass", "noGrassF", and "numberC".
- CORMAS - DundiModel (1.0) - Space Interf:** A window showing a 2D spatial visualization of the simulation area, with a color-coded grid representing different states or resources.



Part 2:

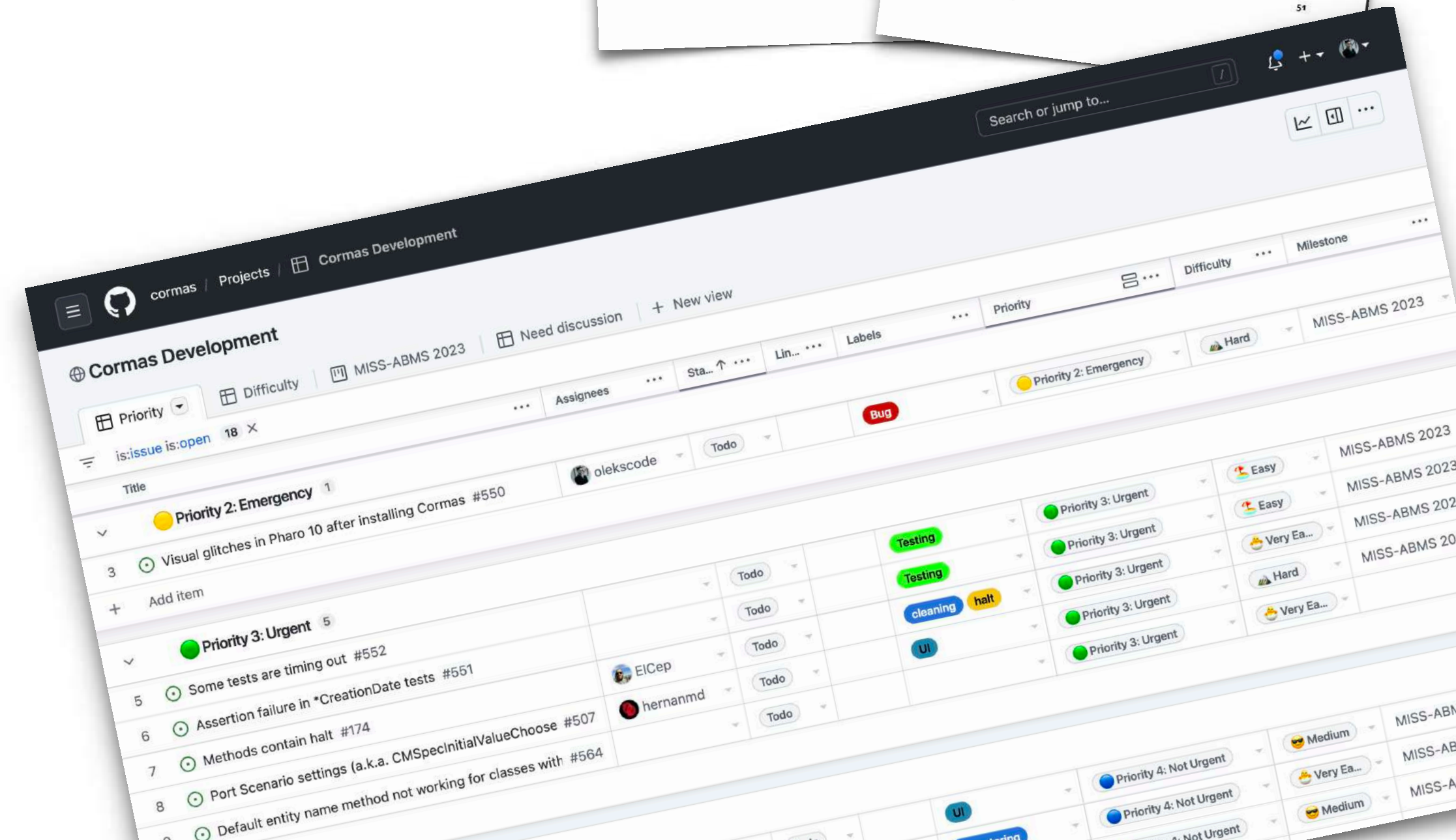
# Cormas Platform

# Cormas Platform

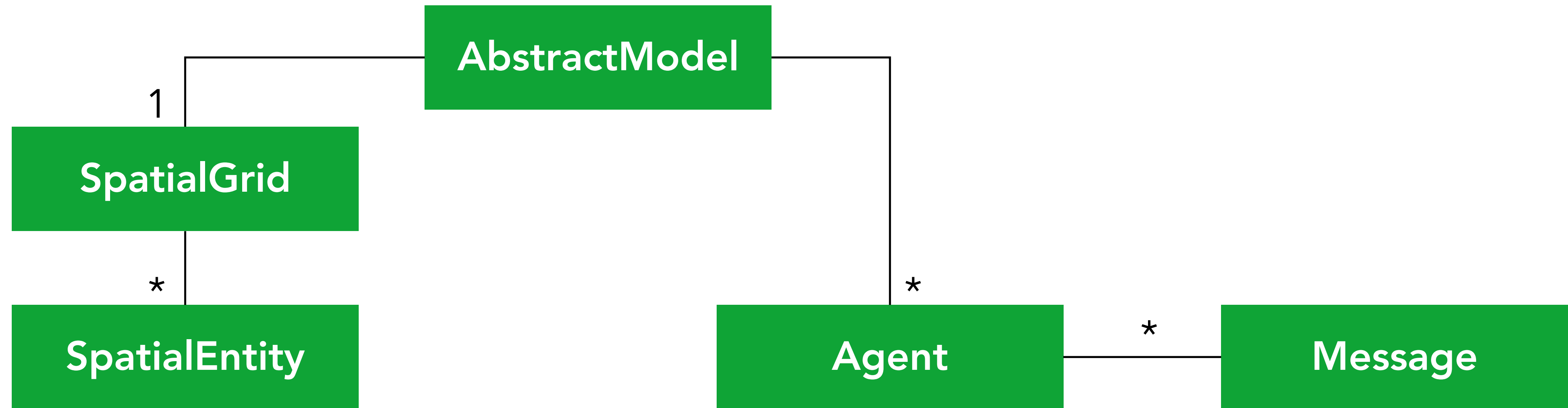


COMmon pool Resources  
and Multi-Agent Simulations

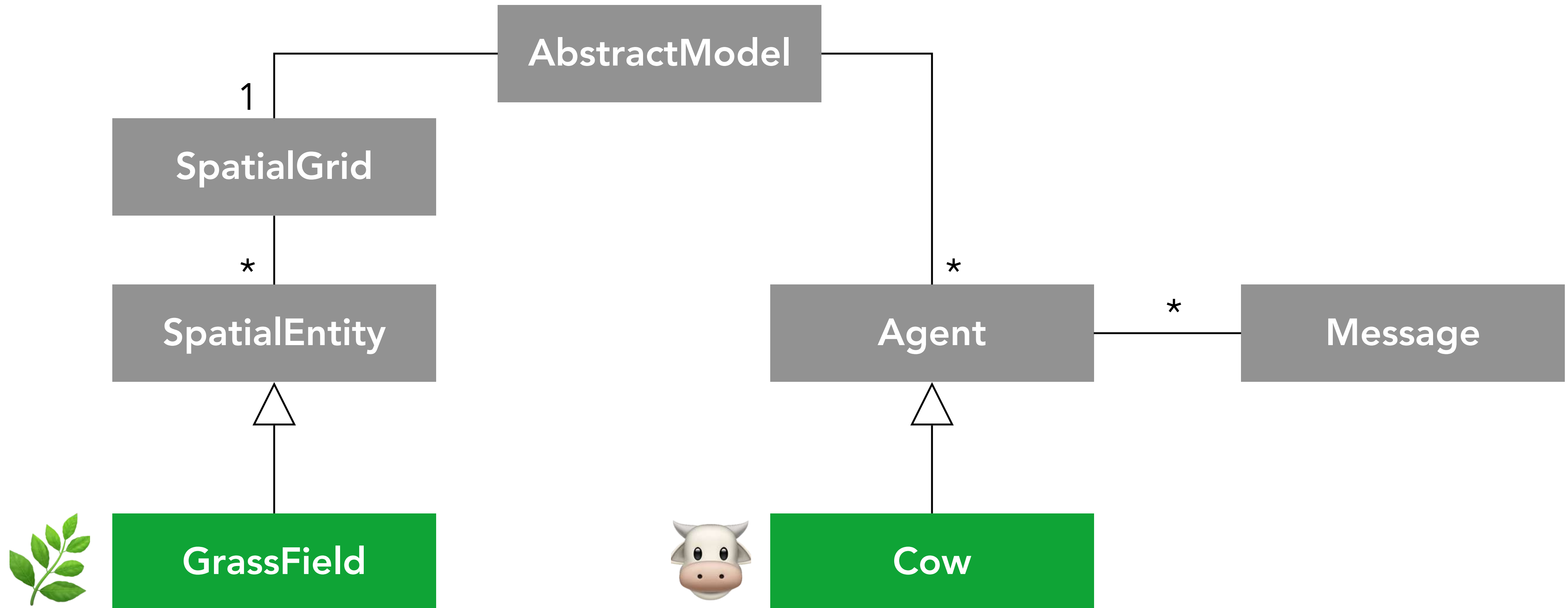
- ✓ Multi-agent simulations
- ✓ Developed in 90s by Green Unit
- ✓ Originally implemented in VisualWorks
- ✓ Ongoing migration to Pharo



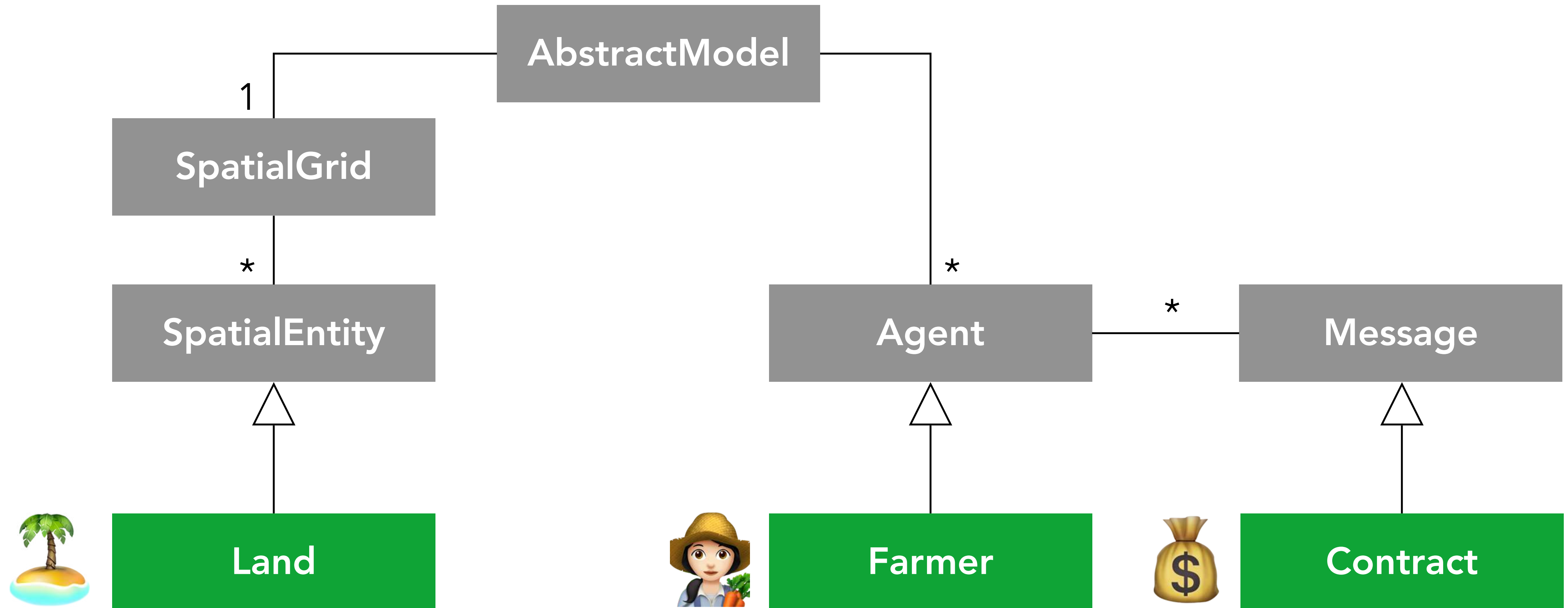
# Basic Classes



# Located Agents



# Communicating Agents



# What Makes Cormas Unique?



Cormas is **interactive** and particularly well adapted for the **participatory** modelling.

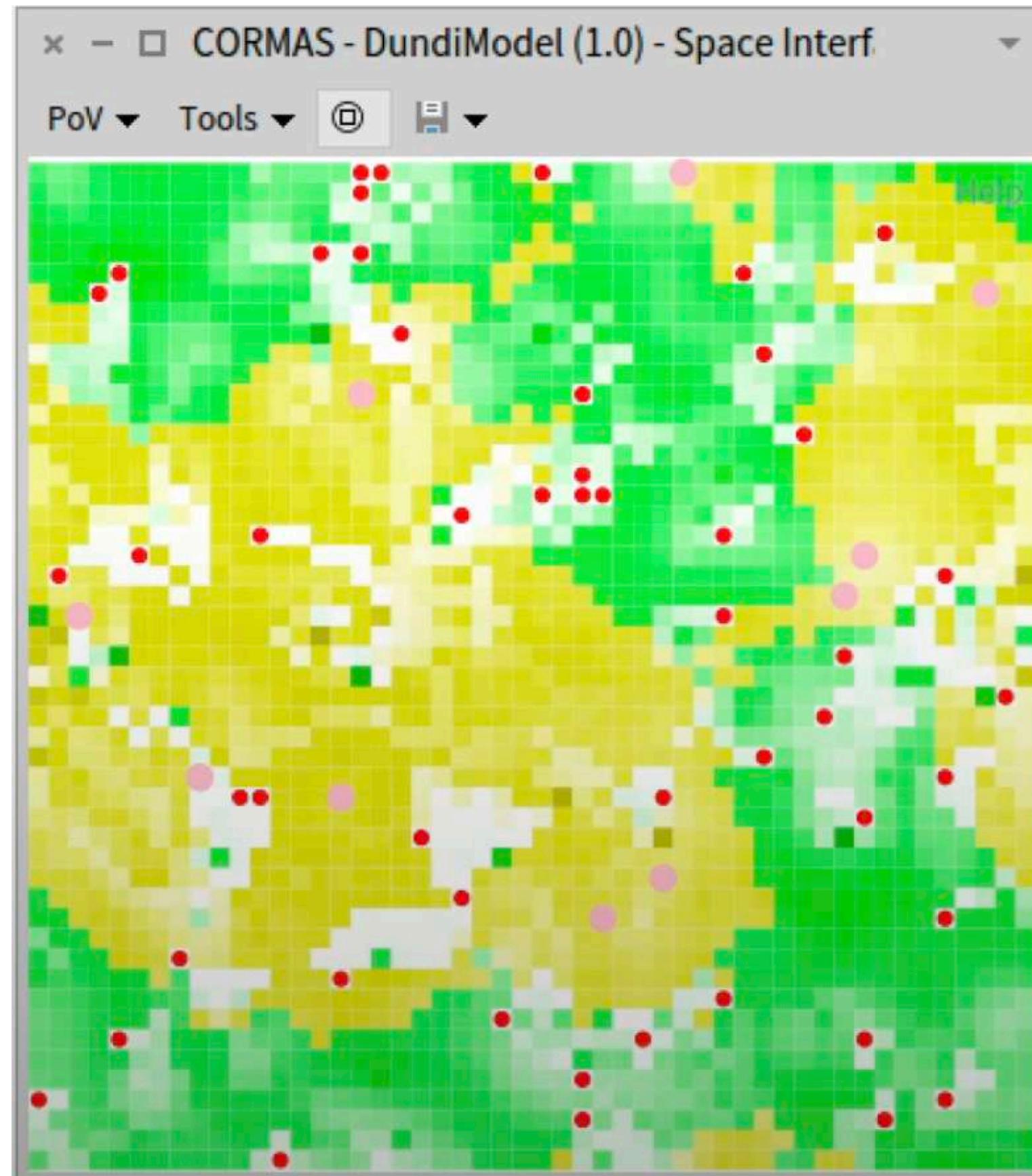
It provides different « points of view », allows users to inspect and control specific agents, allows stepping back in time.



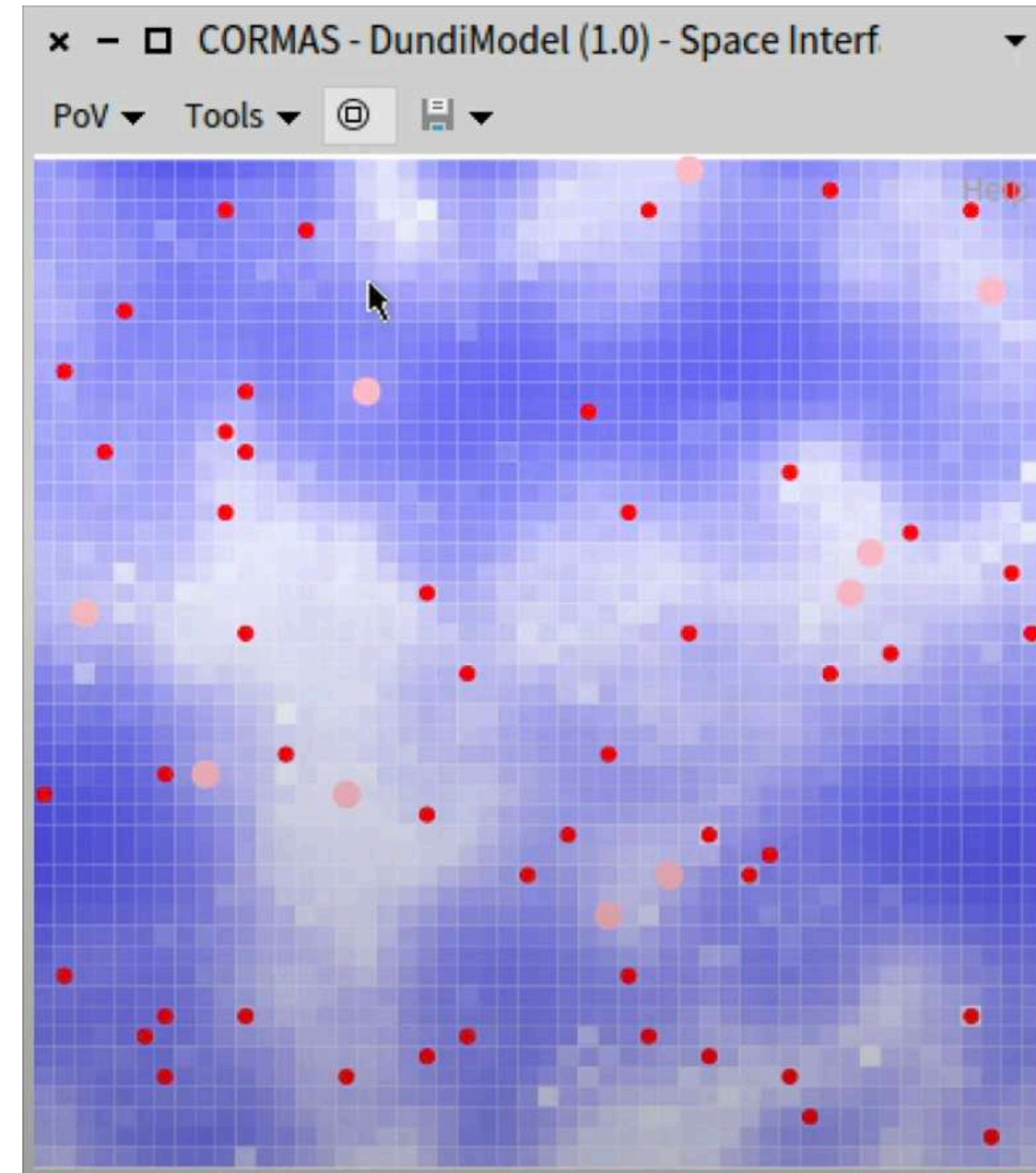
# Different « Points of View »



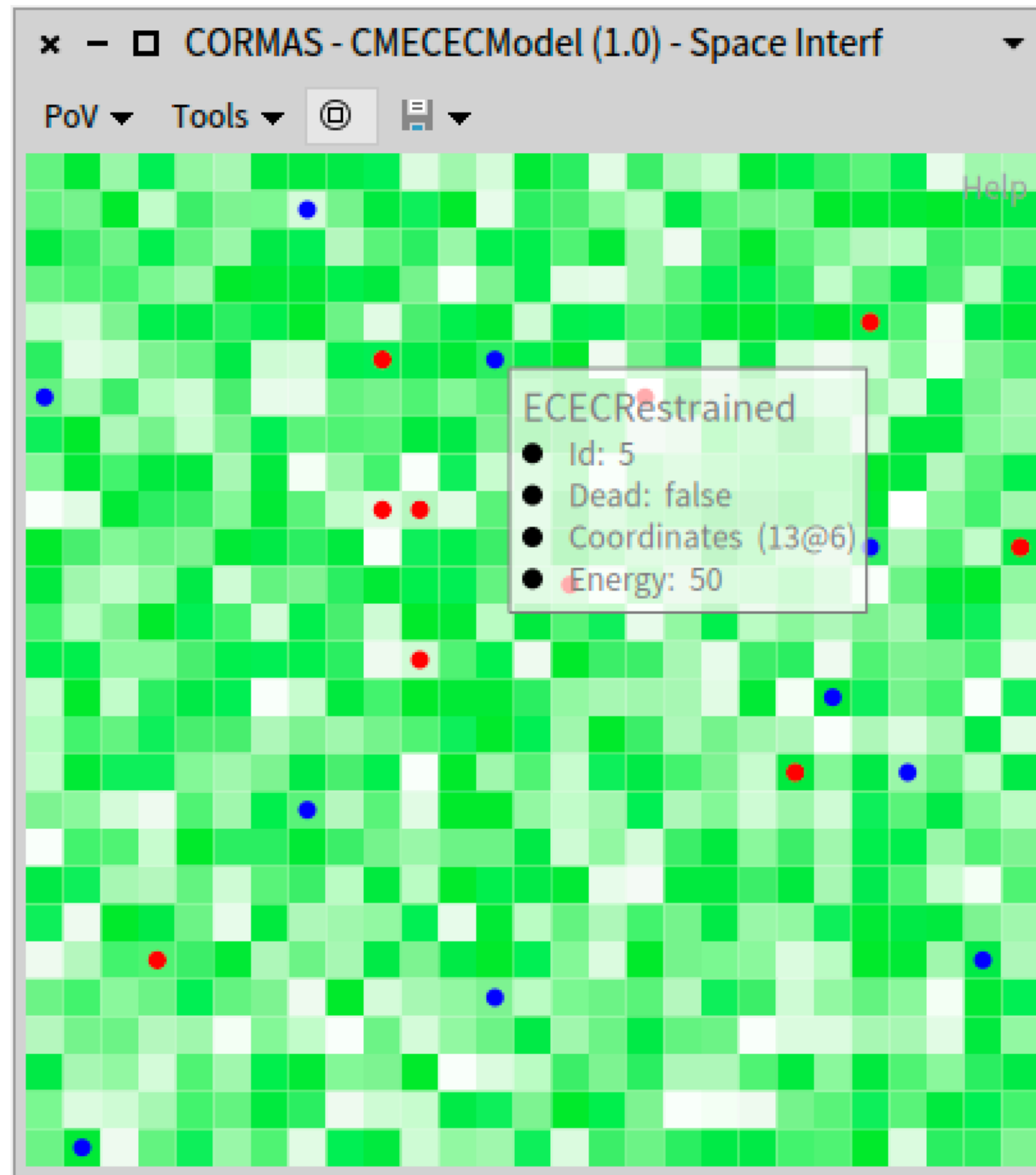
PoV 1: Grass



PoV 2: Water



# Inspect and Control Agents



The screenshot shows the Inspector on a CMECECRestrained -id: 5-coord: (13@6) window. The window displays a table of variables and their values for the selected agent.

| Variable    | Value  |
|-------------|--|
| self        | a CMECECRestrained -id: 5-coord: (13@6)            |
| translator  | nil  |
| Σ id        | 5  |
| flag        | nil  |
| collector   | a CMCollector                                      |
| request     | nil  |
| cormasModel | a CMECECModel (init: true, time: 0, entities: 749) |
| dead        | false  |
| patch       | a CMECECVegetationUnit -id: 148 -n: 8 -o: 1        |
| Σ energy    | 50   |

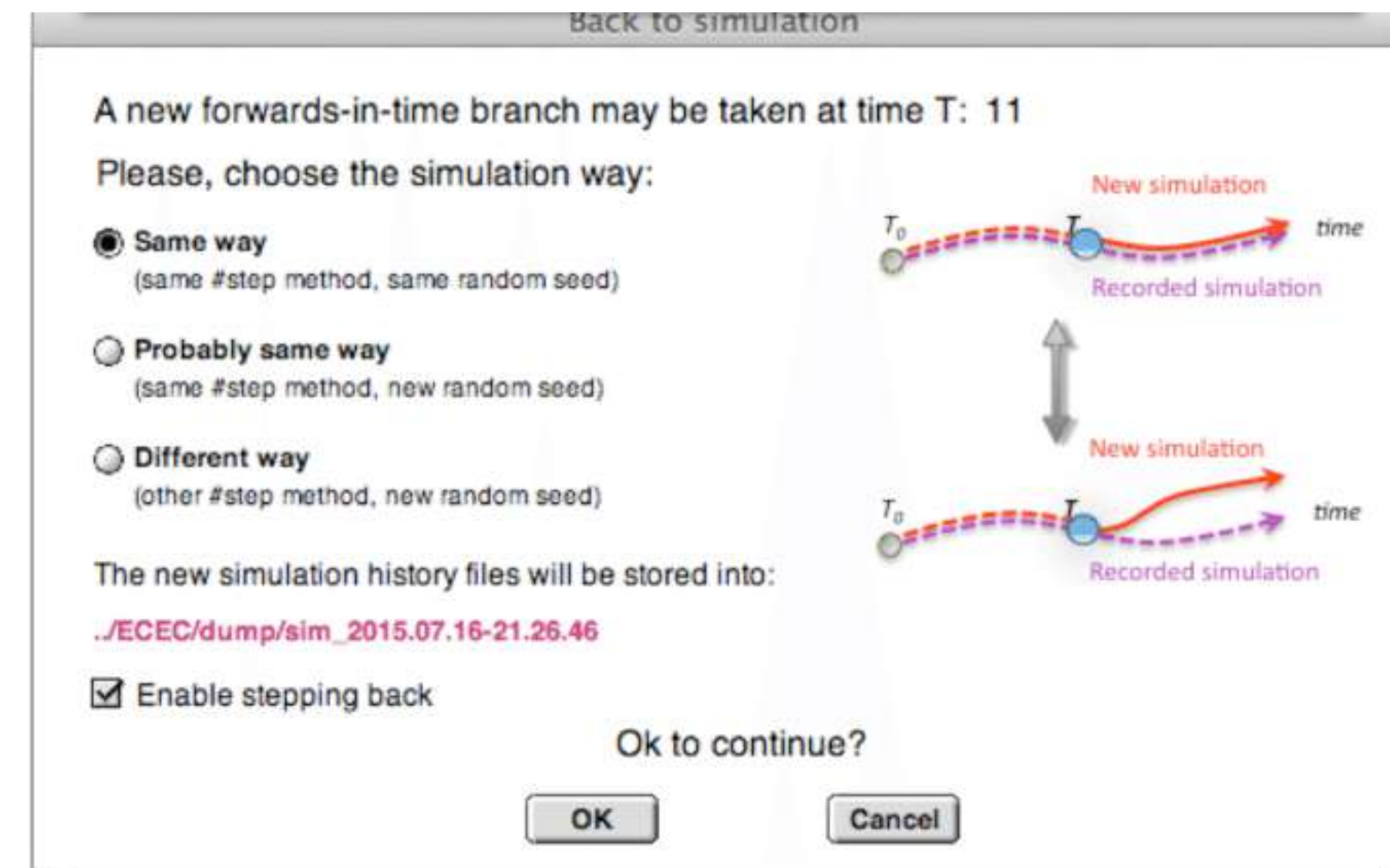
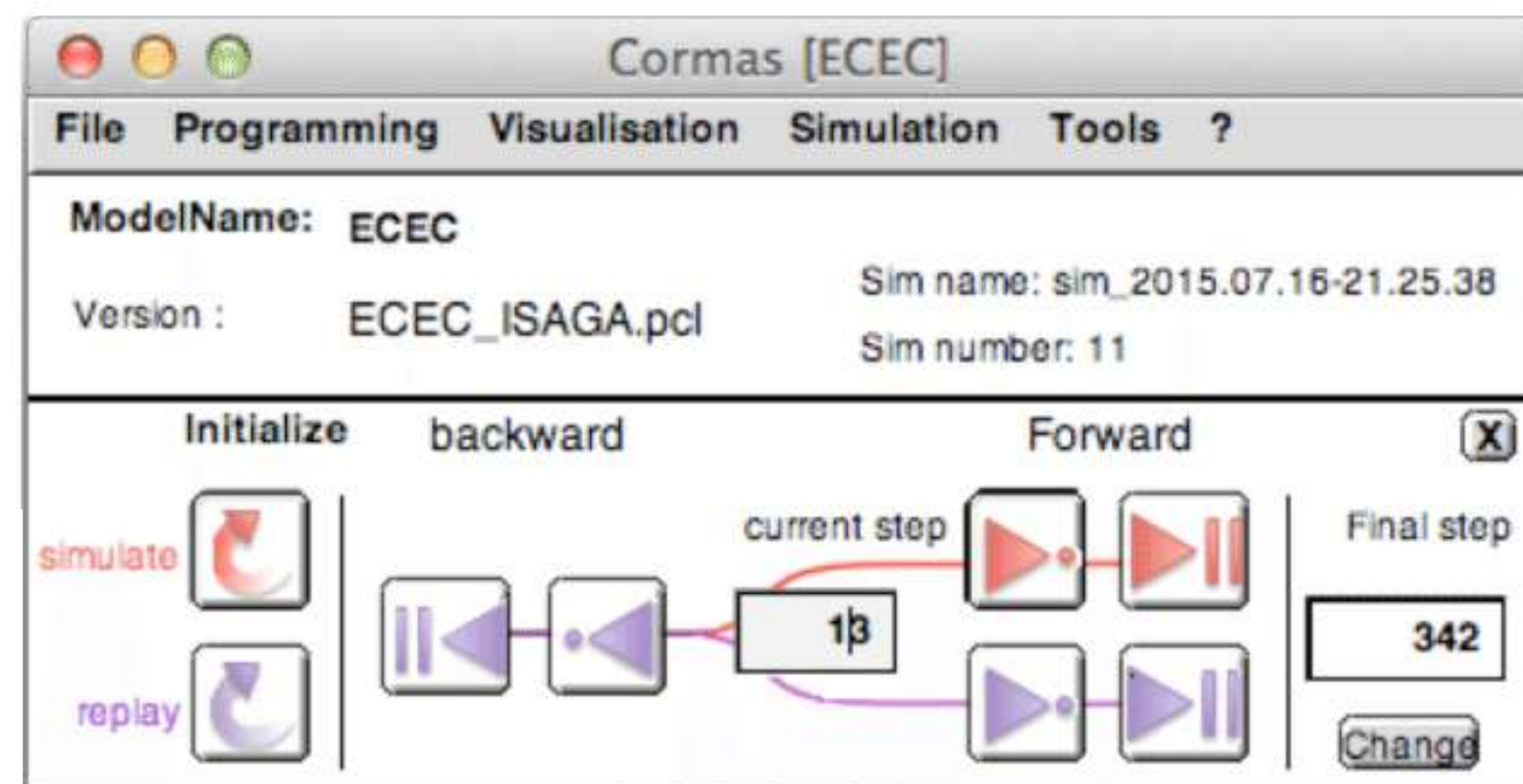
Below the table, there is a list of raw data:

```
1 "a CMECECRestrained -id: 5-coord: (13@6)"
2 self
```

# Stepping Back in Time



Not yet supported in Pharo version

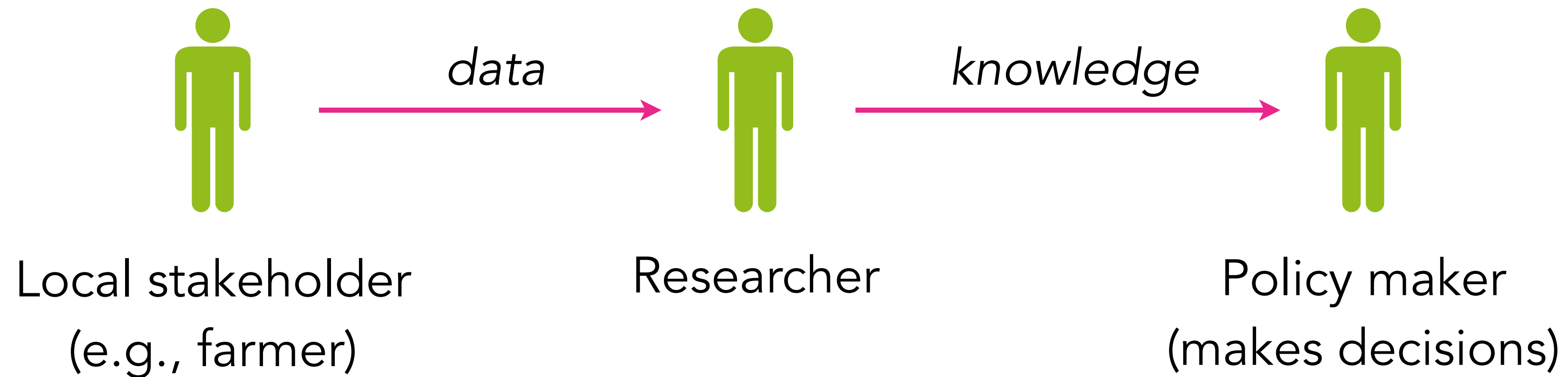




Part 3:

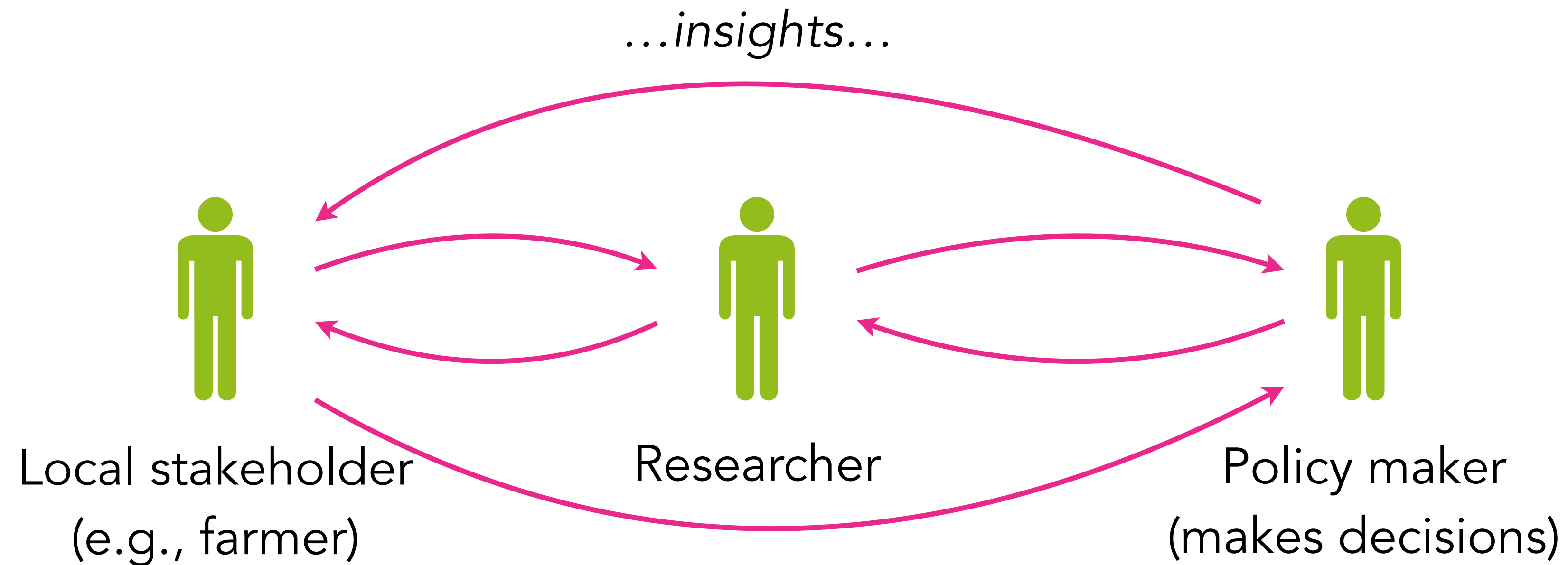
# Research Directions

# « Conventional » Modelling



Local stakeholders are only contacted for data collection

# Participatory Modelling

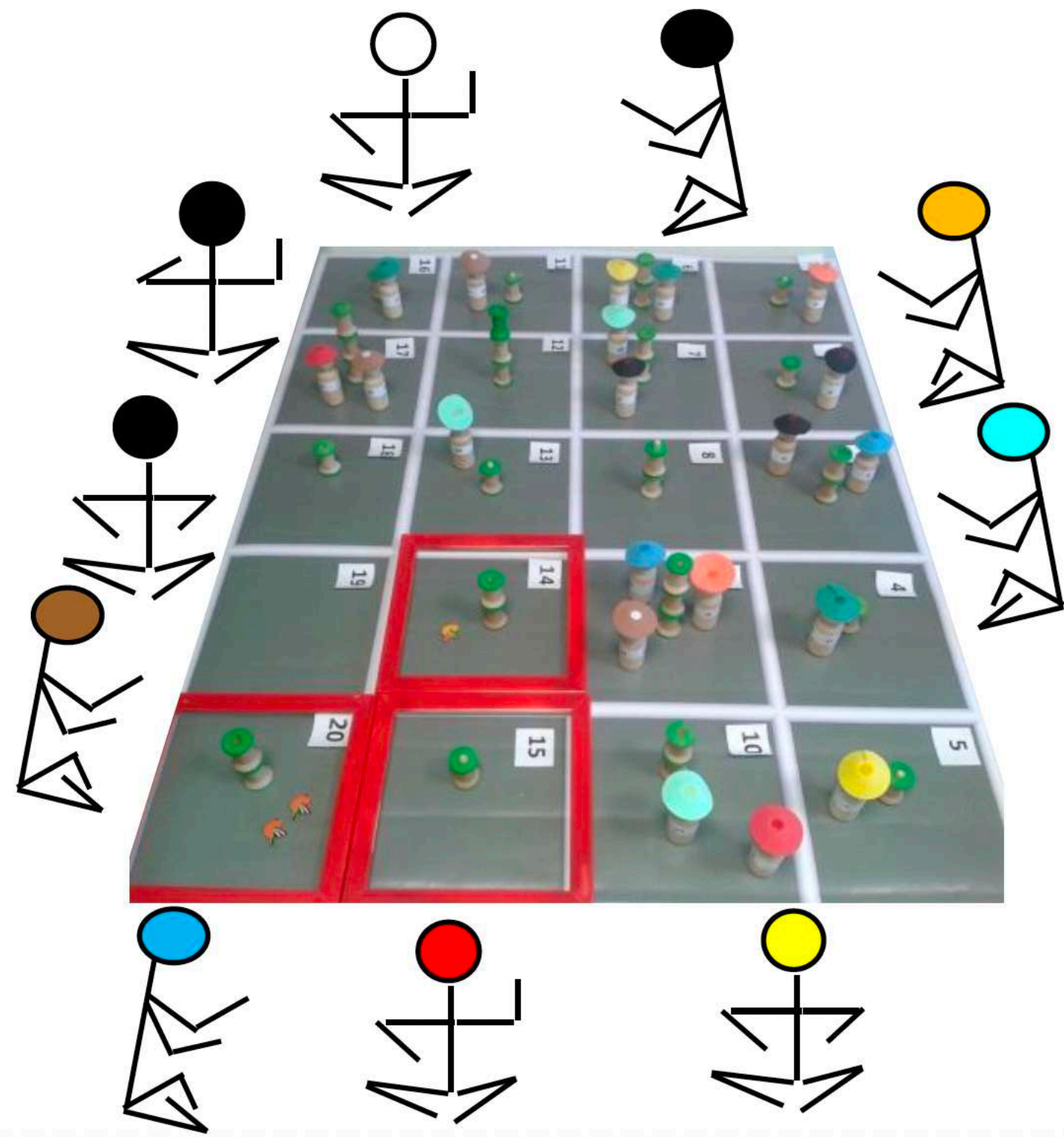


Local stakeholders are involved in every step of modelling: data collection, model building, model exploration

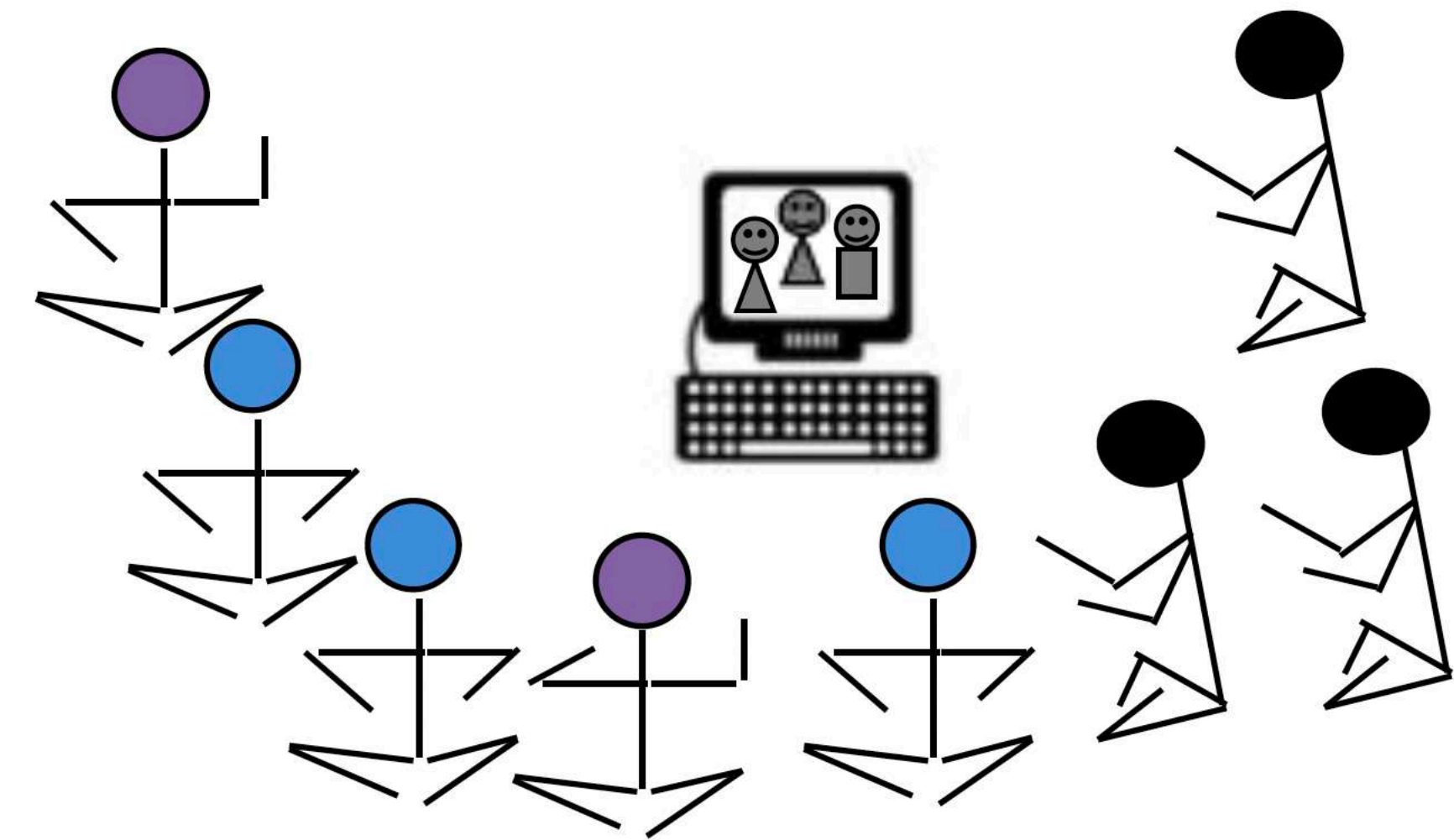
# Our Two Activities at CIRAD



## Role-Playing Games



## Agent-Based Modelling



# Role-Playing Games (no computers)



## Pros:

- Accessible
- Personal
- Interactive

## Cons:

- Slow
- Imprecise
- Analysed later



# Agent-Based Modelling



## Pros:

- Fast & Powerful
- Immediate analysis (statistical, visual)

## Cons:

- Unaccessible (too technical)
- Impersonal (barrier between researcher and participants)

# Hybrid Approach



Combine the  
benefits of both

- People have real (tangible) interactions
- Computer observes and supports them

# Computerization



## One way to do it:

Use software, AI, and IoT to replace humans in cumbersome tasks

## Another way:

Empower citizens to be the actors of their own social transformation.

Use software, AI, and IoT to build tools for effective communication, exploration, and knowledge sharing

# Three Research Directions



## Topic 1: Modelling Language

*What is the language that would allow non-programmers to define models easily?*

## Topic 2: Tangible Interaction

*Can we help stakeholders to build and control models through physical interaction?*

## Topic 3: Collaborative Modelling

*Can multiple people interact with the same model simultaneously with different PoV?*

# Topic 1: Modelling Language



*What is the language that would allow non-programmers to define models easily?*

## Problem:

Modelling involves programming.

Programming is difficult for non-programmers

*How hard would it be for geographer  
or biologist to use an ABM platform  
for the first time?*

Can we make it easier?

More intuitive?

A screenshot of the NetLogo code editor window titled "NetLogo - Fire". The window has tabs for "Interface", "Info", and "Code", with "Code" selected. Below the tabs are icons for "Find...", "Check", and a "Procedures" dropdown menu. There are also checkboxes for "Indent automatically" (checked) and "Code Tab in separate window" (unchecked). The main area contains a NetLogo script for a fire model. The script includes global variables for "initial-trees" and "burned-trees", breed procedures for "fires" and "embers", a "to setup" procedure that initializes the environment, a "to go" procedure that runs the simulation loop, and an "ignite" patch procedure. The line "ask neighbors4 with [pcolor = green]" is highlighted in yellow.

```
globals [
  initial-trees ;; how many trees (green patches) we started with
  burned-trees ;; how many have burned so far
]

breed [fires fire] ;; bright red turtles -- the leading edge of the fire
breed [embers ember] ;; turtles gradually fading from red to near black

to setup
  clear-all
  set-default-shape turtles "square"
  ;; make some green trees
  ask patches with [(random-float 100) < density]
  [ set pcolor green ]
  ;; make a column of burning trees
  ask patches with [pxcor = min-pxcor]
  [ ignite ]
  ;; set tree counts
  set initial-trees count patches with [pcolor = green]
  set burned-trees 0
  reset-ticks
end

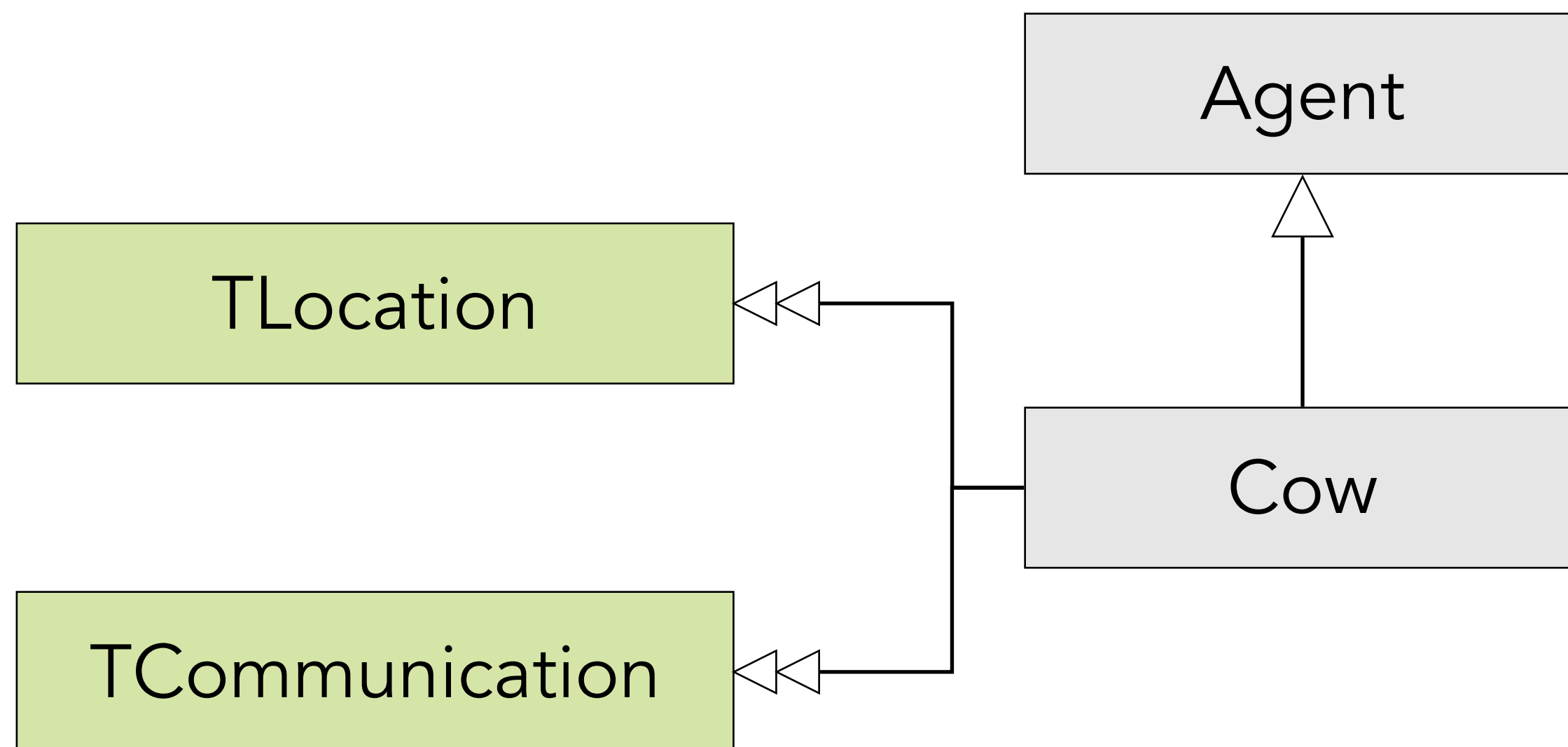
to go
  if not any? turtles ;; either fires or embers
  [ stop ]
  ask fires
  | [ ask neighbors4 with [pcolor = green]
    [ ignite ]
    set breed embers ]
  fade-embers
  tick
end

;; creates the fire turtles
to ignite ;; patch procedure
  sprout-fires 1
  [ set color red ]
  set pcolor black
  set burned-trees burned-trees + 1
end
```

# Topic 1: Modelling Language



*What is the language that would allow non-programmers to define models easily?*



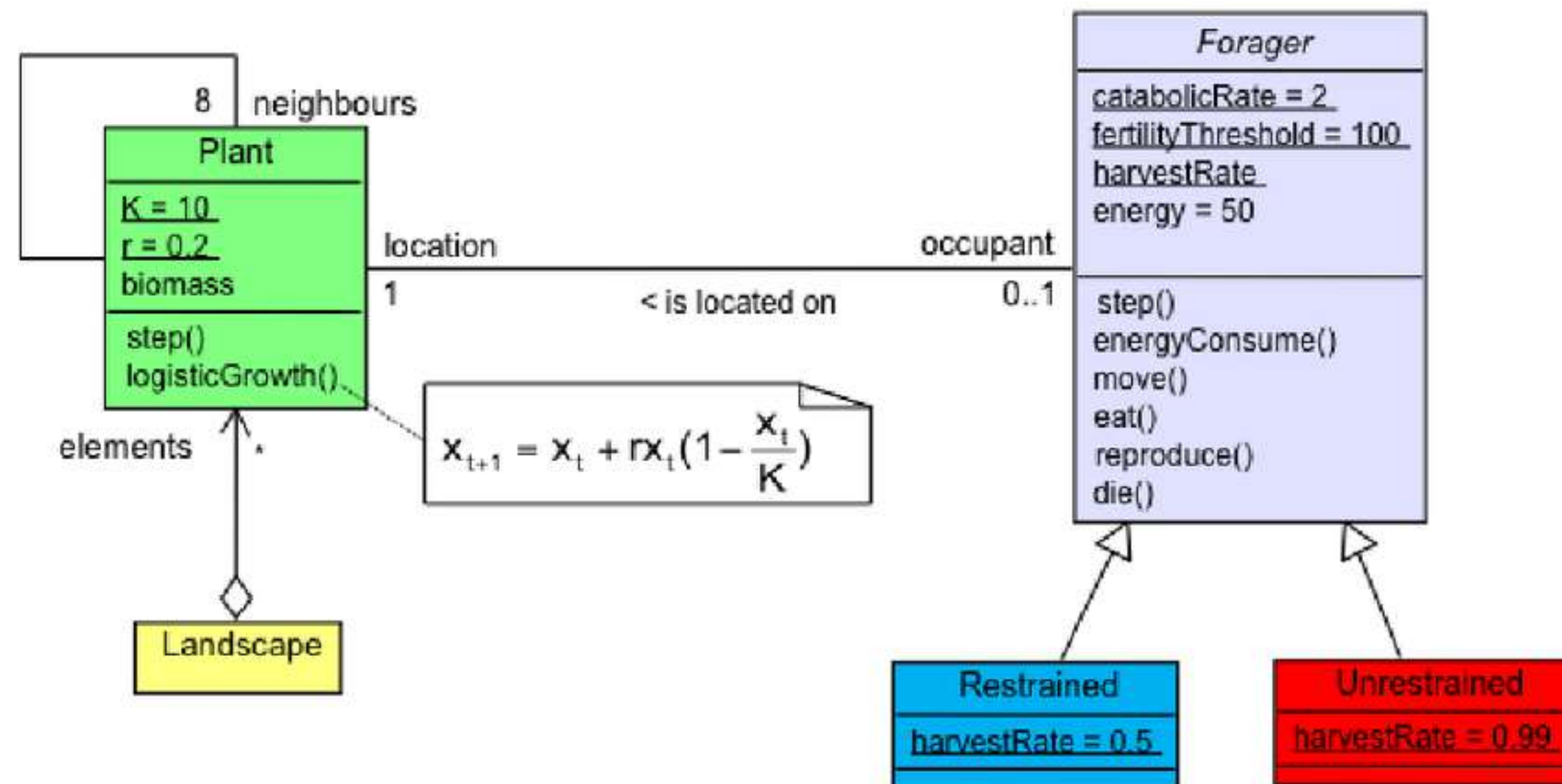
## Solution 1: Object-oriented ABM

- Intuitive OOP framework
- Traits - composable units of behaviour
- Model testing framework

# Topic 1: Modelling Language



What is the language that would allow non-programmers to define models easily?



## Solution 2: Executable diagrams




- ARDI / PARDI diagrams
- UML class diagrams
- UML activity diagrams

# Topic 2: Tangible Interaction

*Can we help stakeholders to build and control models through physical interaction?*

## Problem:

During the participatory sessions in the field, it is often difficult to put every participant in front of a computer and make them manipulate the model.

-  Access to electricity
-  Access to computers
-  Computer literacy



Caroline Dangleant

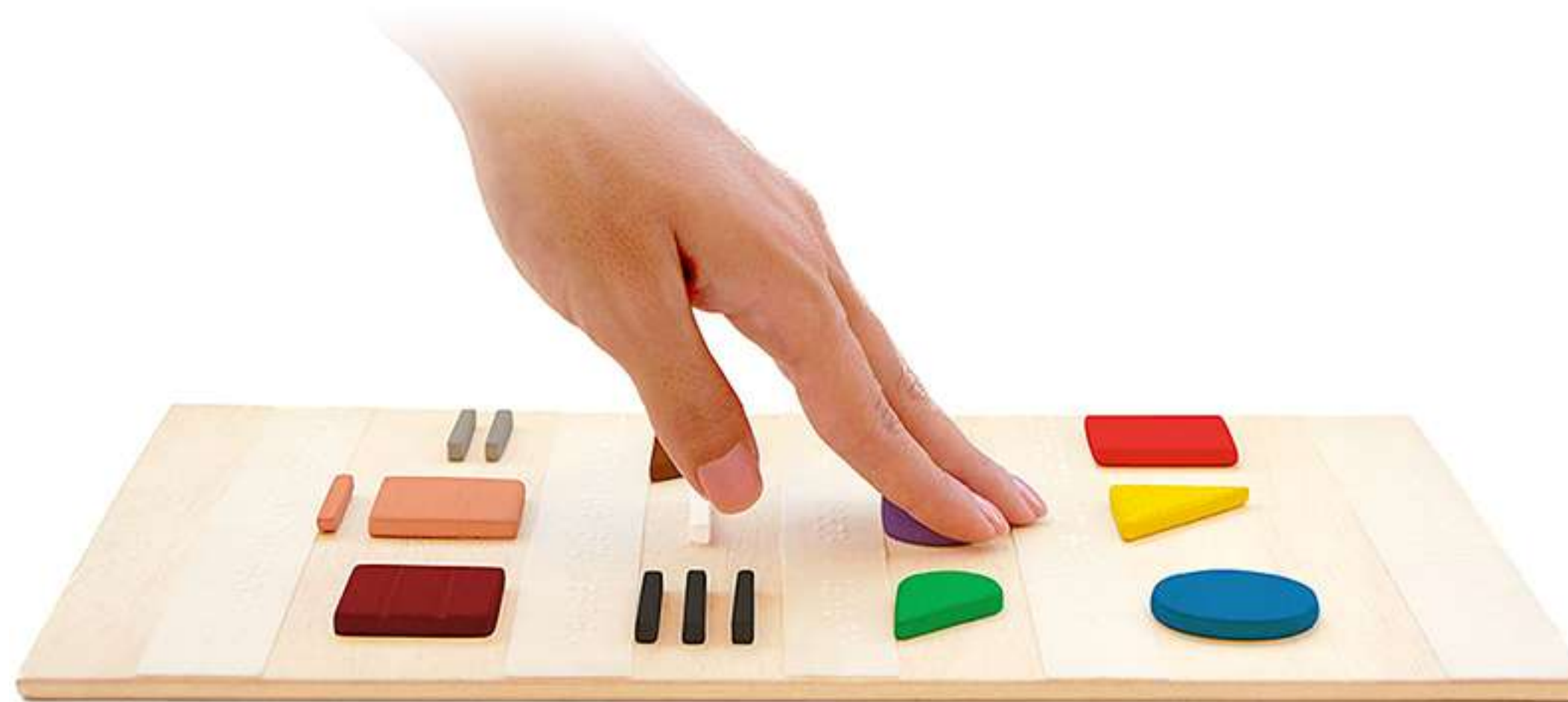
Caroline Dangleant © Cirad



# Topic 2: Tangible Interaction



*Can we help stakeholders to build and control models through physical interaction?*



## Hypothesis:

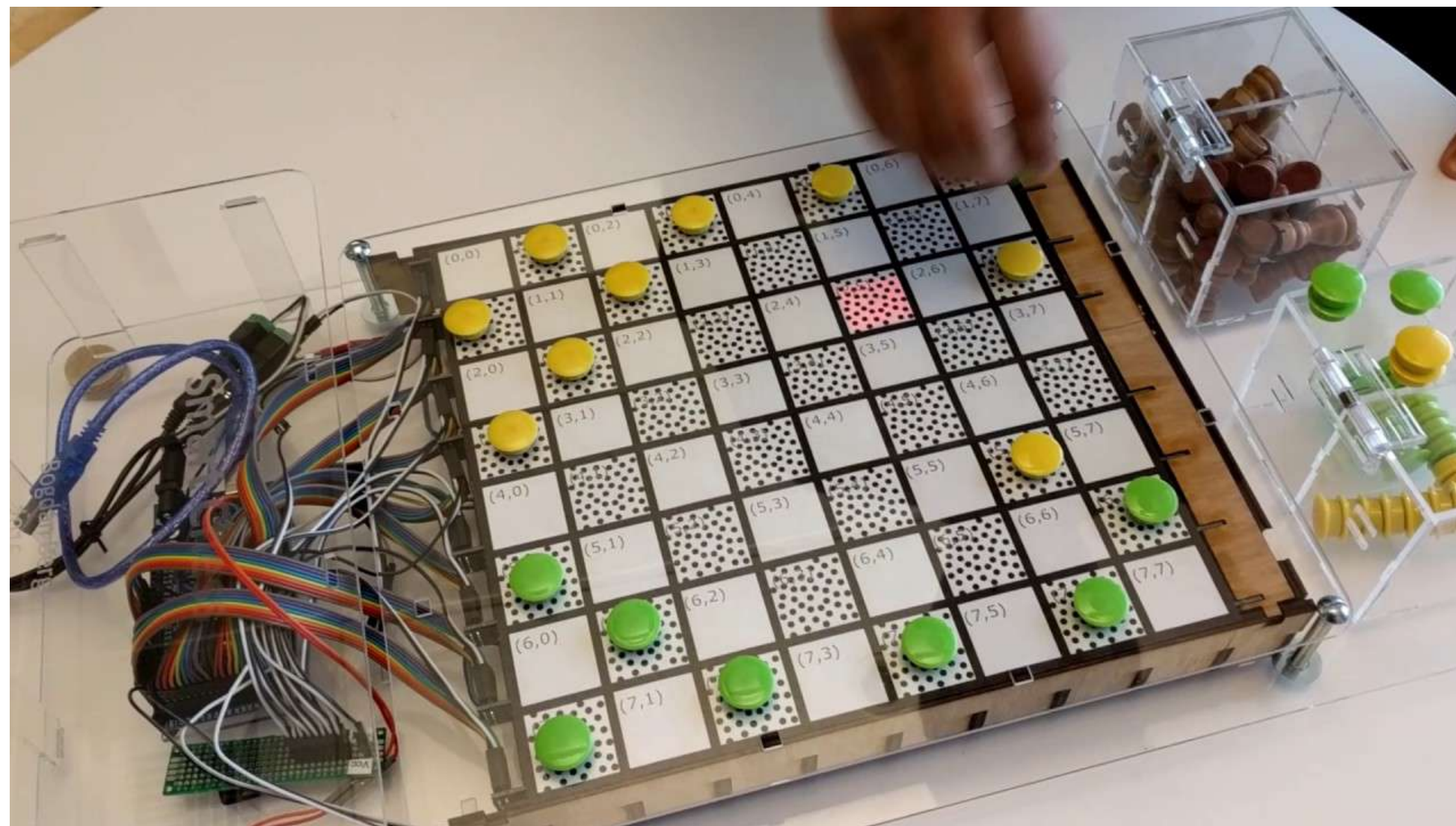
We communicate ideas better when they are tangible.  
Touching something is better than seeing it on a screen

# Topic 2: Tangible Interaction



*Can we help stakeholders to build and control models through physical interaction?*

## Solution 1: Sensory game board



- Game board can detect the position of pieces using sensors
- Implement using Raspberry Pi or Arduino and PharoThings library



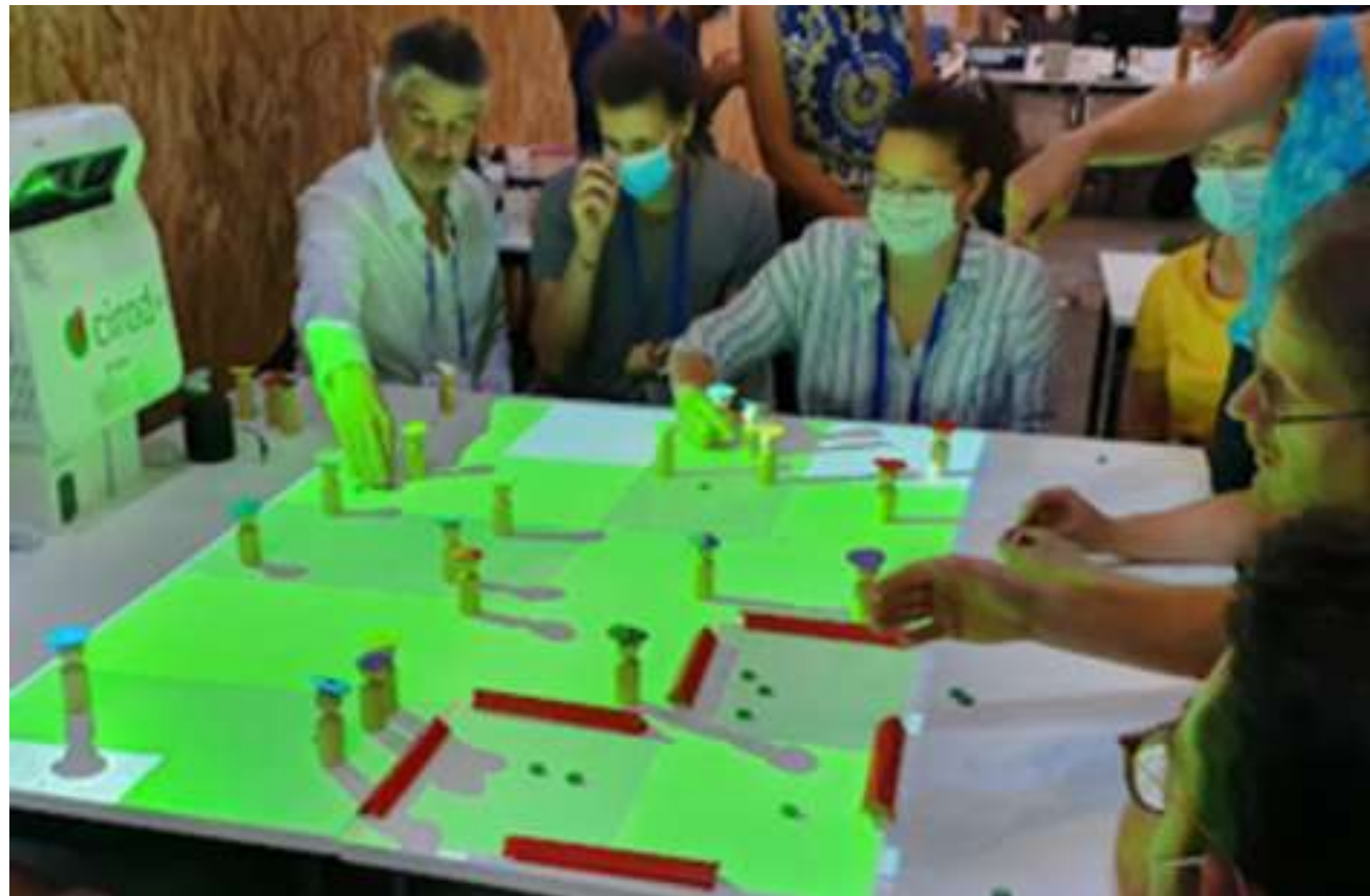
**Mouhamadou Falilou BALL**

Intern at CIRAD  
from UMISSCO, Senegal

# Topic 2: Tangible Interaction



*Can we help stakeholders to build and control models through physical interaction?*



*Christophe LePage © Cirad*

## Solution 2: Computer vision

- AI algorithm that detects game pieces on a table
- Can be paired with simulation projection that was done with Cormas (ReHab?)

# Topic 2: Tangible Interaction



*Can we help stakeholders to build and control models through physical interaction?*

## Solution 3: Augmented reality

Interactive modelling experience with **virtual reality** (full immersion) or **augmented reality** (enhance real world with computer-generated perceptual information)



# Topic 3: Collaborative Modelling



*Can multiple people interact with the same model simultaneously with different PoV?*

**Problem:** Farmers think about crops, pastoralists think about cows.  
How can we help them understand each other and collaborate?

Farmer



*Thierry Brevault © Cirad*

Pastoralist



*Patrick Dugue © Cirad*

Fisherman



*Eric Malezieux © Cirad*

Policy maker



*I. Duriez © Cirad*

# Topic 3: Collaborative Modelling



*Can multiple people interact with the same model simultaneously with different PoV?*

**Solution:** One model — many devices.  
Different « point of view » and different set of controls for each participant



Farmer controls the growth of crops.



Pastoralist manages the behaviour of kettle.



Fisherman observes the amount of fish in the river.



Policy maker calculates the expenses.



*... modelling for citizens by citizens*

Modelling environment that is inclusive and takes into account the nature of its target communities, adapts to their particular needs and helps them overcome their limitations

## Modelling Language

- Object-oriented modelling
- Executable diagrams

## Tangible Interaction

- Sensory game board
- Computer vision
- Augmented reality

## Collaborative Modelling

- One model — many devices
- Multiple « points of view »