MANAGEMENT OF LIVESTOCK EFFLUENTS IN REUNION ISLAND

Use of a multi-agent system to analyse the economic behaviour of players

S. Farolfi, C. Lepage, M. Tidball & P. Bommel

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Presentation

➔ Stockbreeding wastewaters are rich in nitrogen and phosphorus :

- Useful to fertilise fields
- Source of pollution in massive amounts
- Regions referred as “structural exceeded zones” : Grand-Ilet

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Presentation

- Rules established (92-99) determining quotas
- New water law provides charges to livestock producers
- Pork breeders face new systems of constraints :
  - Large quantities of excess slurry
  - No sufficient arable land to spread
  - Environmental policy enforcement => pollution fees
  - Rapidly evolving context
- Transportation of effluents to the sugar-cane farms

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Approach

- MAS and "standard modelling" in ecological economics
- Use of MAS to simulate the incentives policy rules
- Previous studies
  - Available knowledge (since 1994)
  - => Simple model

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Approach

- Rational and informed stakeholders :
  - Maximise its profits
  - Knows all the system : other agents, the space and the laws
- Analysis of cost functions
- Strategic choices
- Scientific interest :
  - Externality management
  - Tests of scenarios for environmental policies
  - Effects on the concerned actors

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Structure of the MAS model

- A space (100 km^2)
  - Distances and economic implications
  - Diffusion, absorption and mineralisation of organic matter according to the vegetation cover
- Some agents
  - Pork breeders (56, 3 types)
  - Sugar-cane producers (6)
  - Public institution

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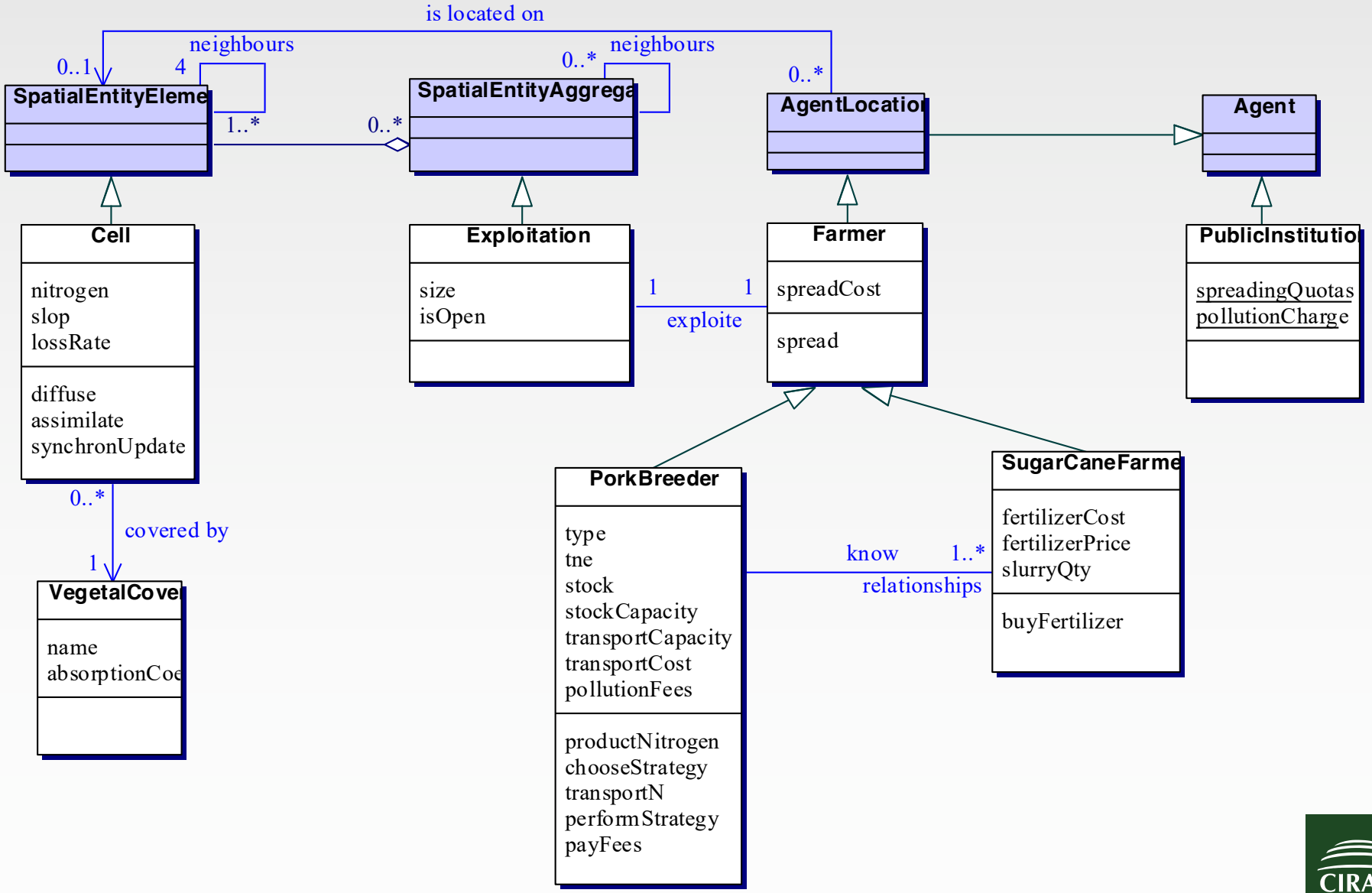
Structure of the MAS model



Dynamic of the MAS

- Monthly time-step
- Spreading practices and transport of stockbreeding wastewater
  - spreading of wastewater on the stockbreeder's farm surface,
  - transport of the wastewater exceeding the spreading standard to the sugar-cane farms of the coastal areas
- Environmental measures
  - Standards (tons/hec/year)
  - Taxes
  - Subsidies

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Dynamic of the agents

➔ sugar-cane farmers of the coastal areas :

- Once a year, the farmers buy and spread mineral nitrogen on the sugarcane (annual demand)

➔ Pork breeders :

- Monthly wastewater production
- 4 strategies :
  - strat 0: spreading of wastewater on their farm surface,
  - strat 1: spreading of wastewater until the standards + on the neighbours + the rest on its own lands
  - strat 2:transport the wastewater exceeding the spreading standard to the open nearest sugarcane farms
  - strat 3:choose between strat 1 or 2, by comparing the cost he paid to the cost he would pay with the other strategy.

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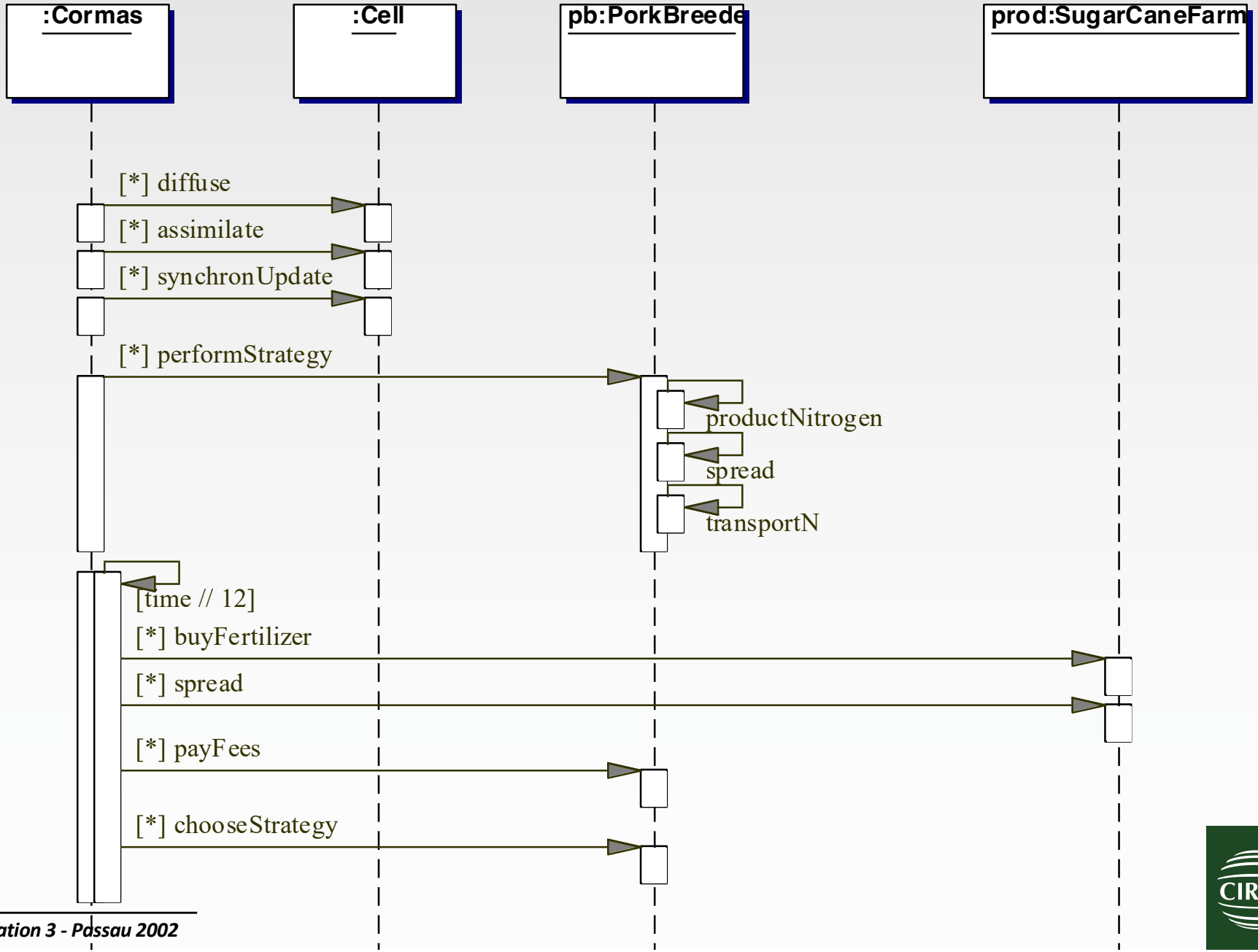
Sequential diagram of the step method



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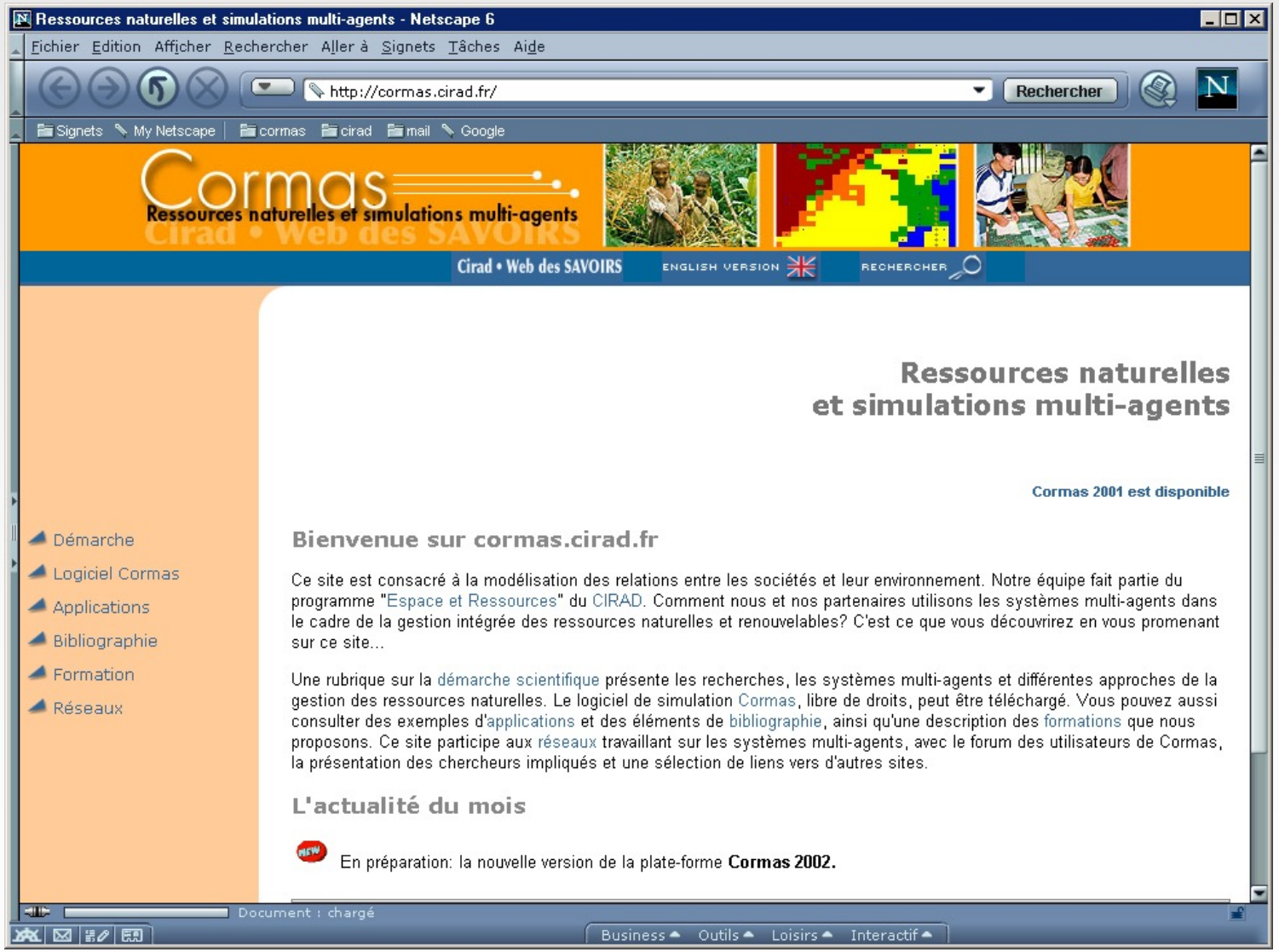
CORMAS : http://cormas.cirad.fr

Common-pool Resources and Multi-Agent Systems



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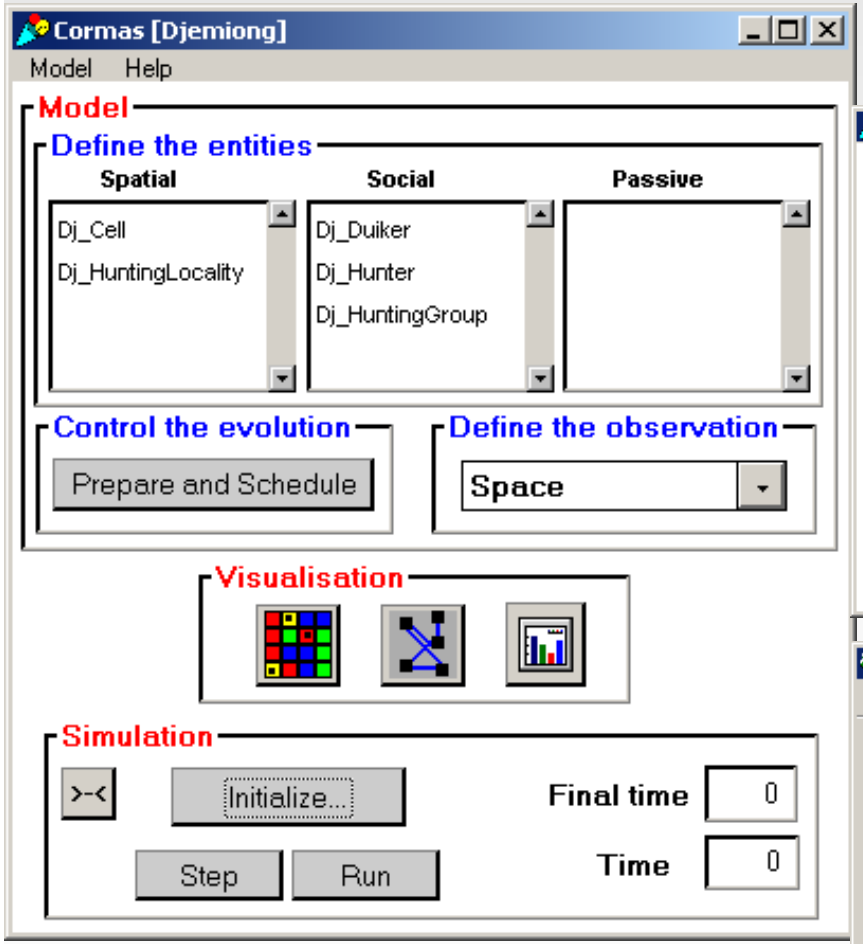

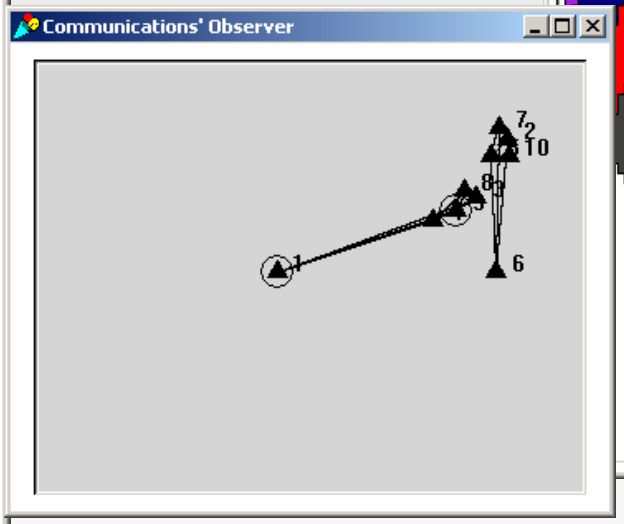

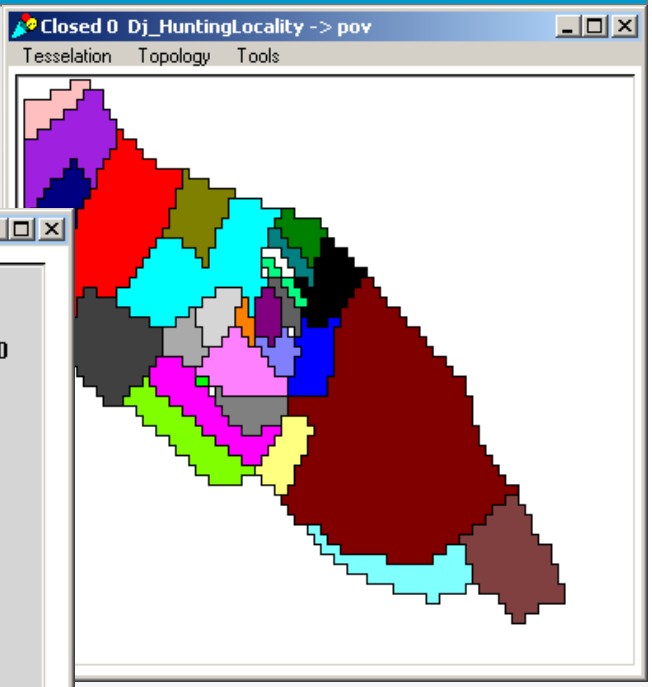

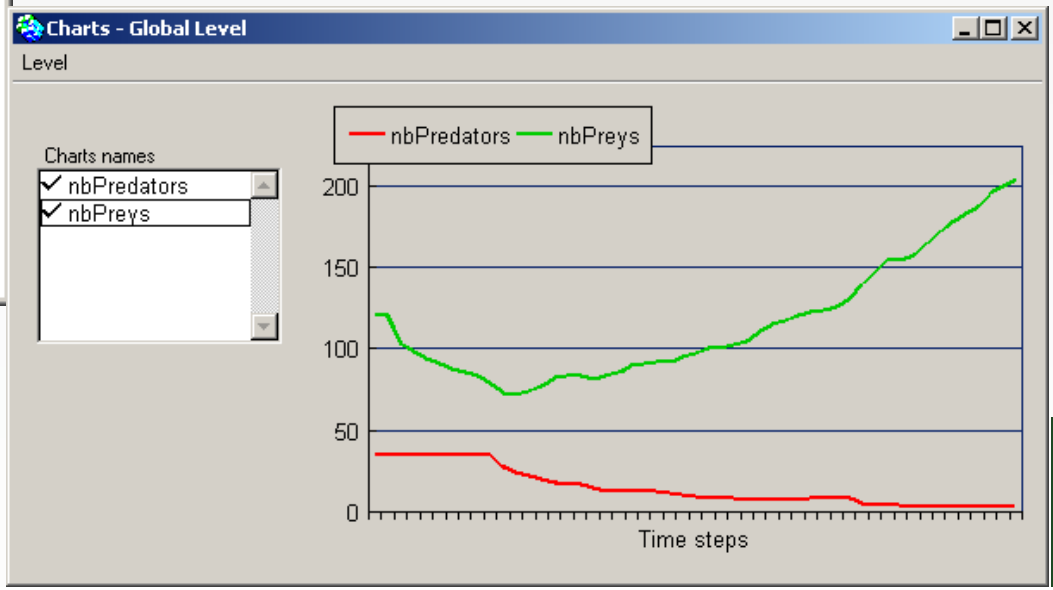

Results

- 6 producers, 56 pork breeders, Strategy 3
- 4 scenarios :
  - Scenario 1 :
    - Standard = 170 Kg.N / ha
    - Pollution tax = 0
    - Sugarcane farms areas between 20 to 40 ha
  - Scenario 2 :
    - Standard = 170 Kg.N / ha
    - Progressive pollution tax (every 2 years, + 2 FF for each additional Kg.N)
    - Sugarcane farms areas between 20 to 40 ha
  - Scenario 3 :
    - As scenario 2, except
    - Sugarcane farms areas between 40 to 80 ha
  - Scenario 4 :
    - As scenario 2, except
    - Standard = 300 Kg.N / ha

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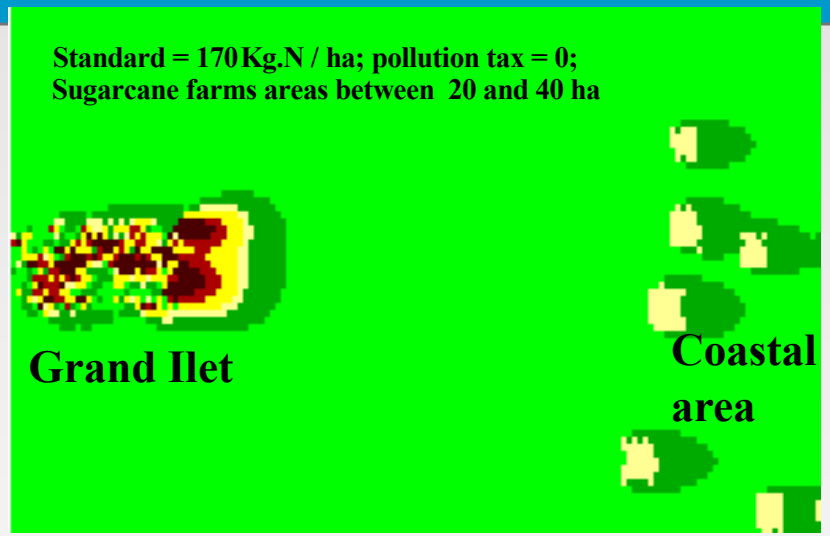
Nitrogen Concentration in the soil after 10 years (120 time-steps) according to 4 combinations of environmental policies



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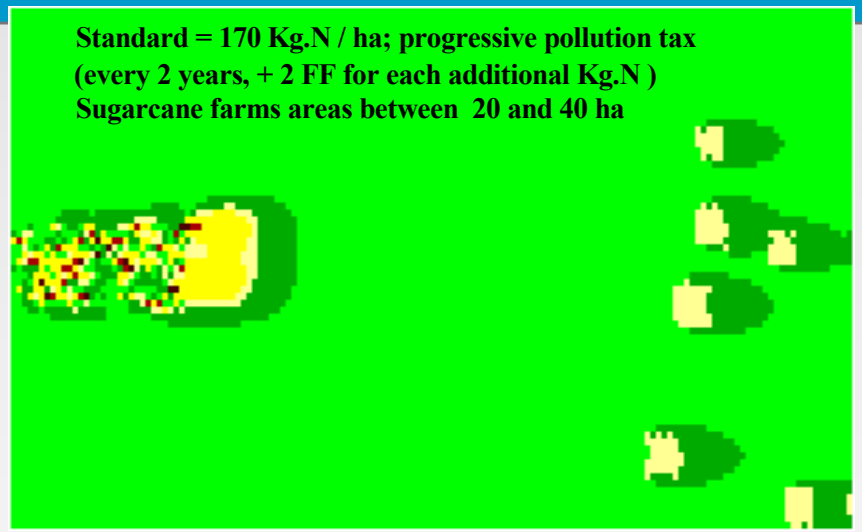

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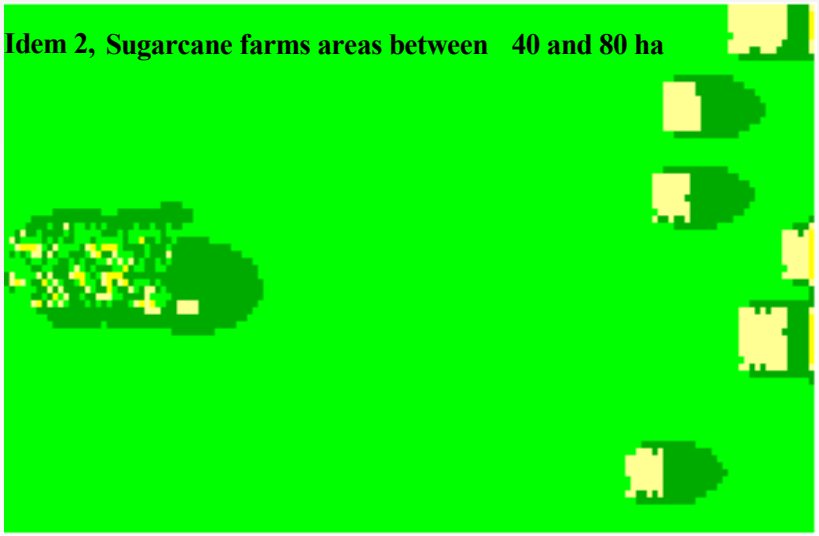

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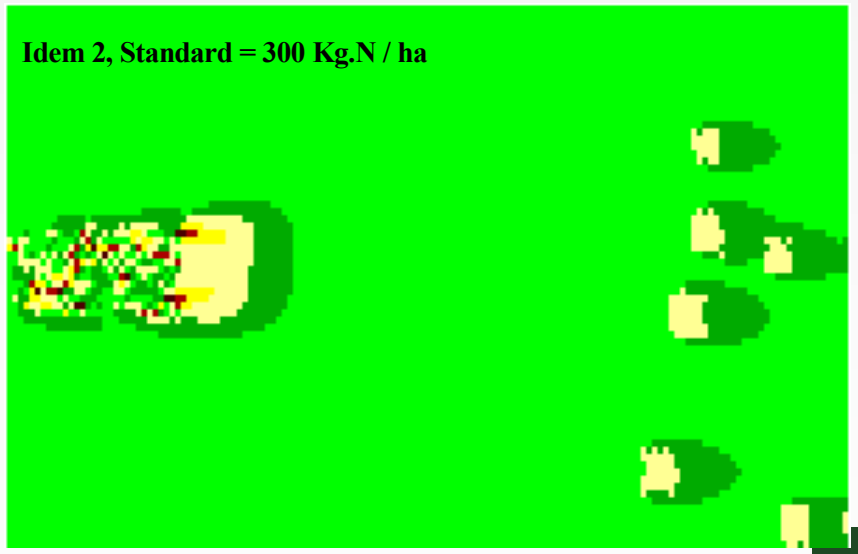
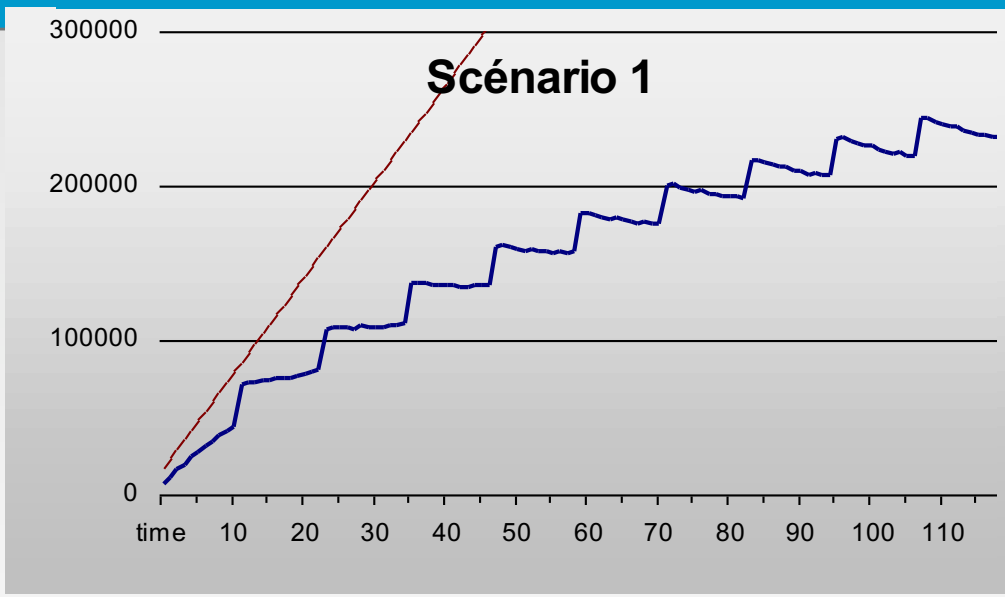


4

Standard = 170 Kg.N / ha
Pollution tax = 0
Sugarcane farms areas between 20 to 40 ha



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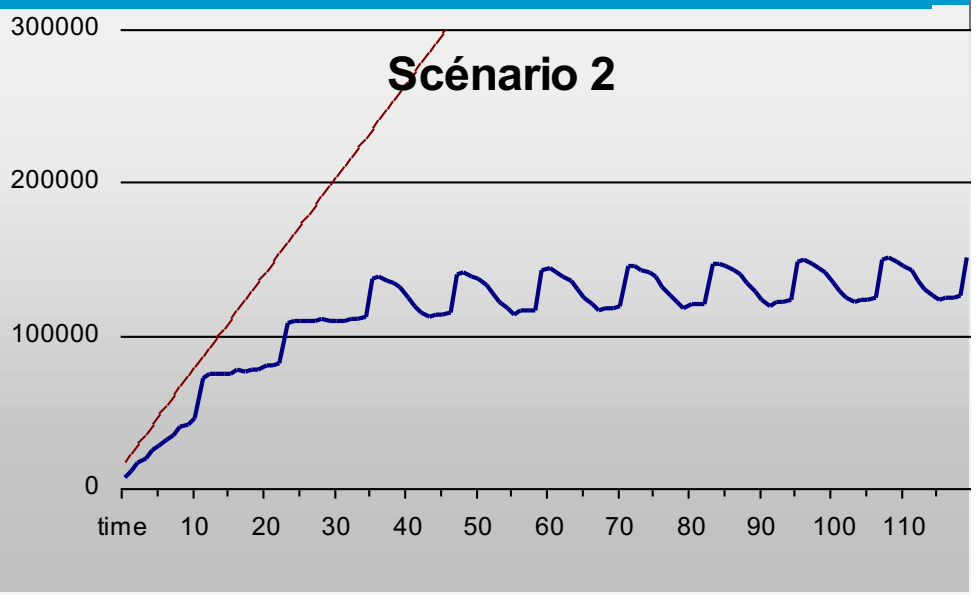

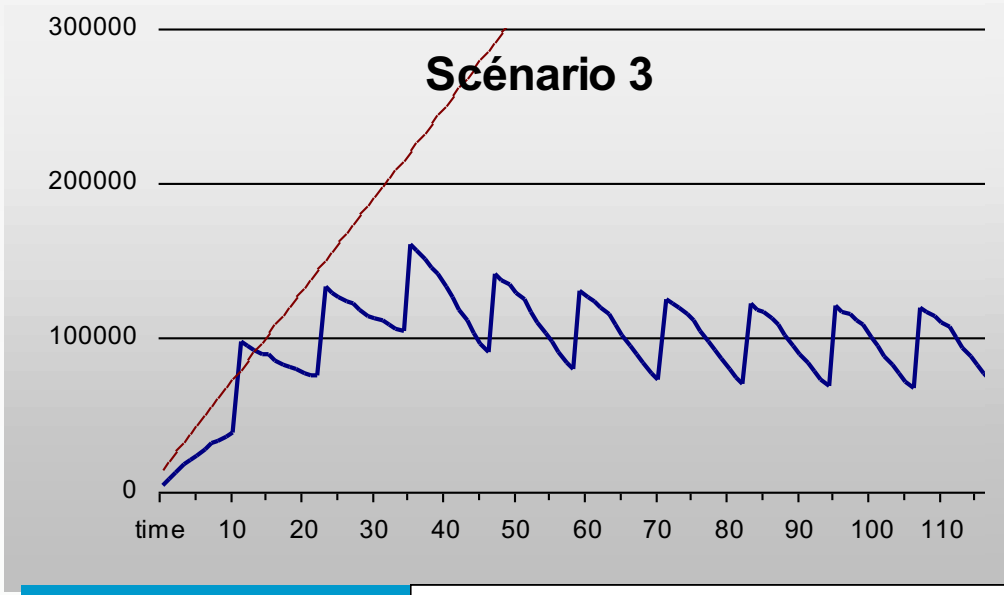

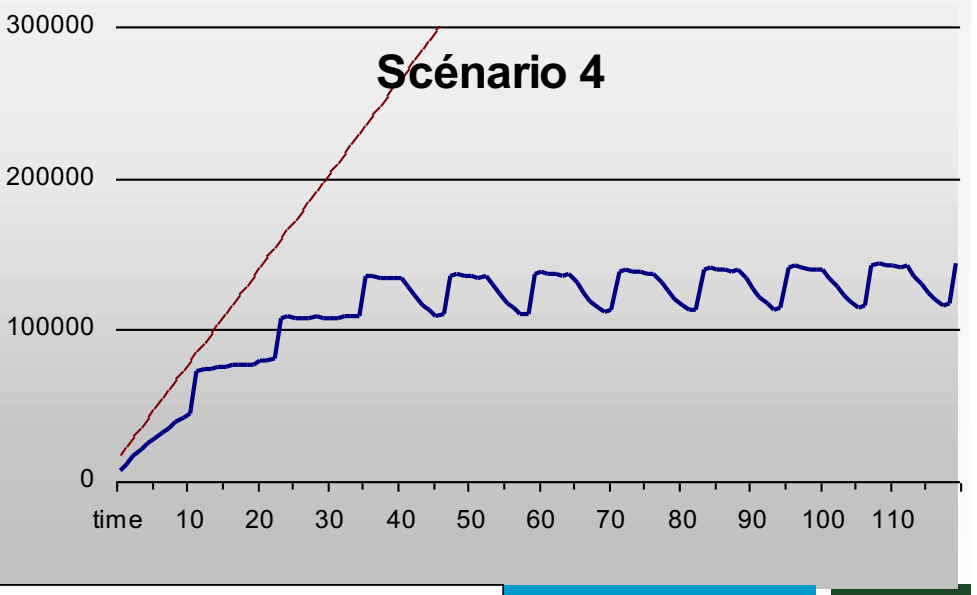

As scenario 2, except
Sugarcane farms areas between 40 to 80 ha

N_EGI_CumulProd N_Environment

As scenario 2,
Standard = 300 Kg.N / ha

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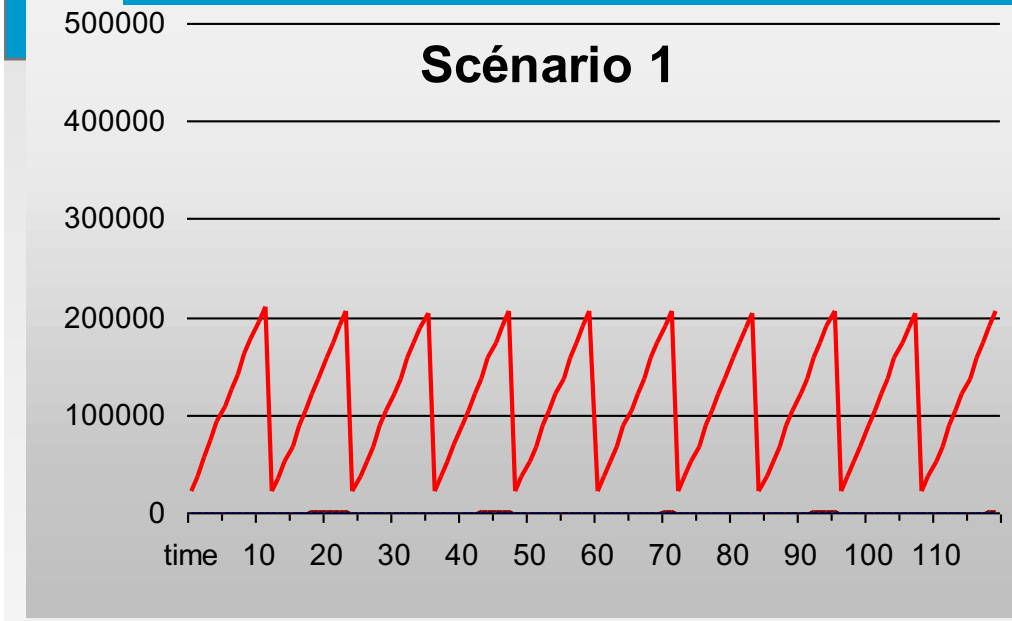

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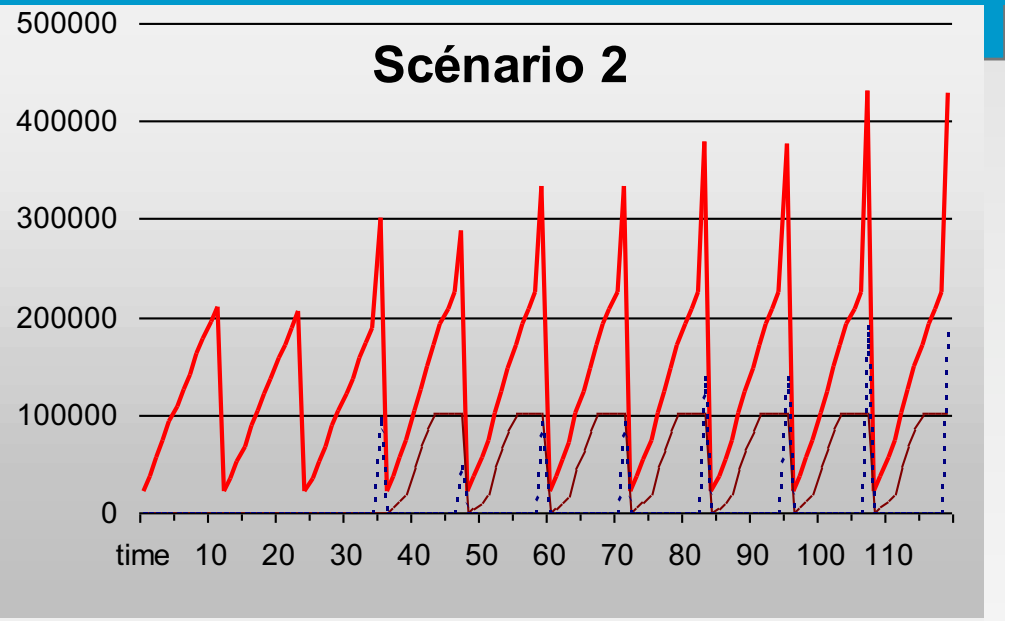

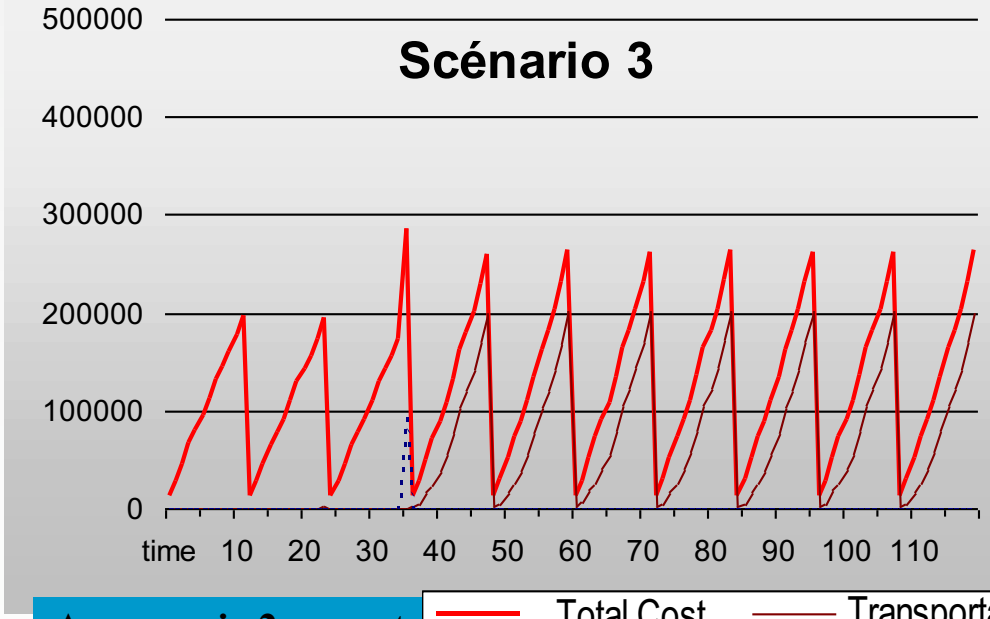

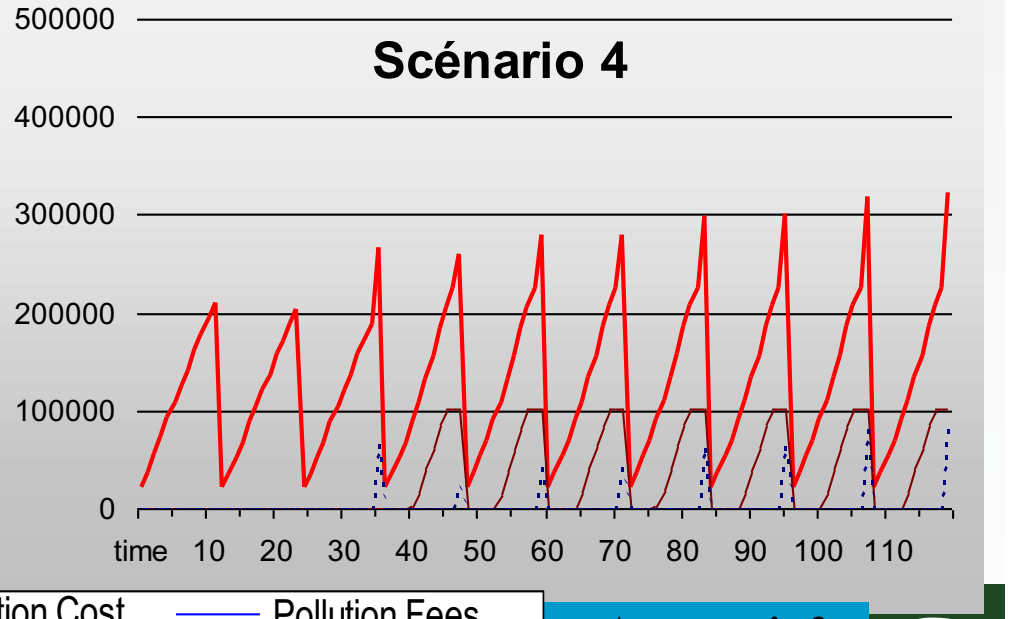

Total Cost — Transportation Cost — Pollution Fees

As scenario 2, except
Sugarcane farms areas between 40 to 80 ha

As scenario 2,
Standard = 300 Kg.N / ha

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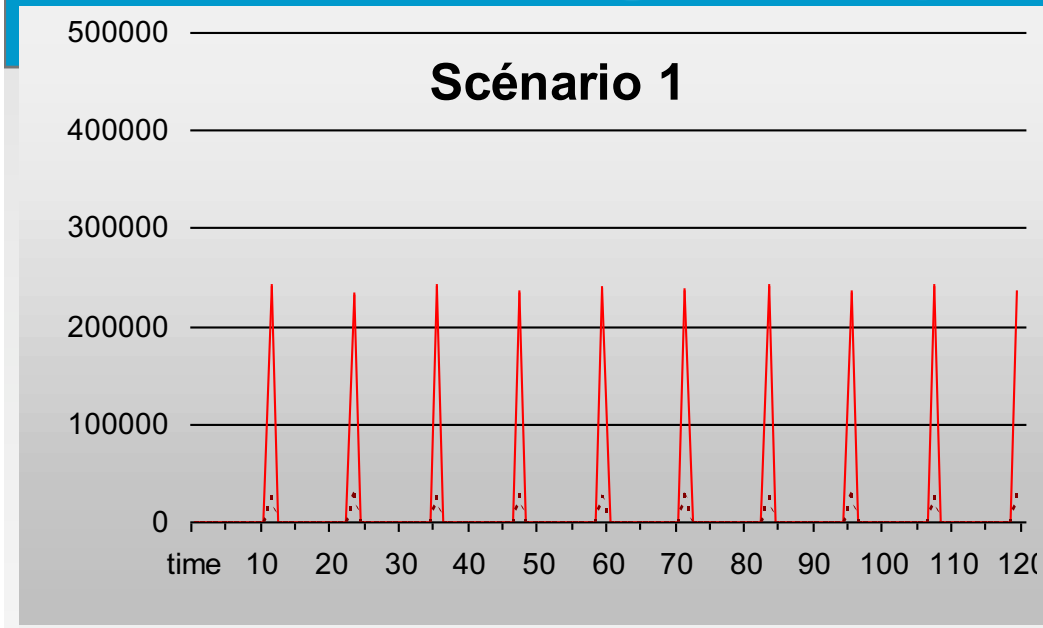

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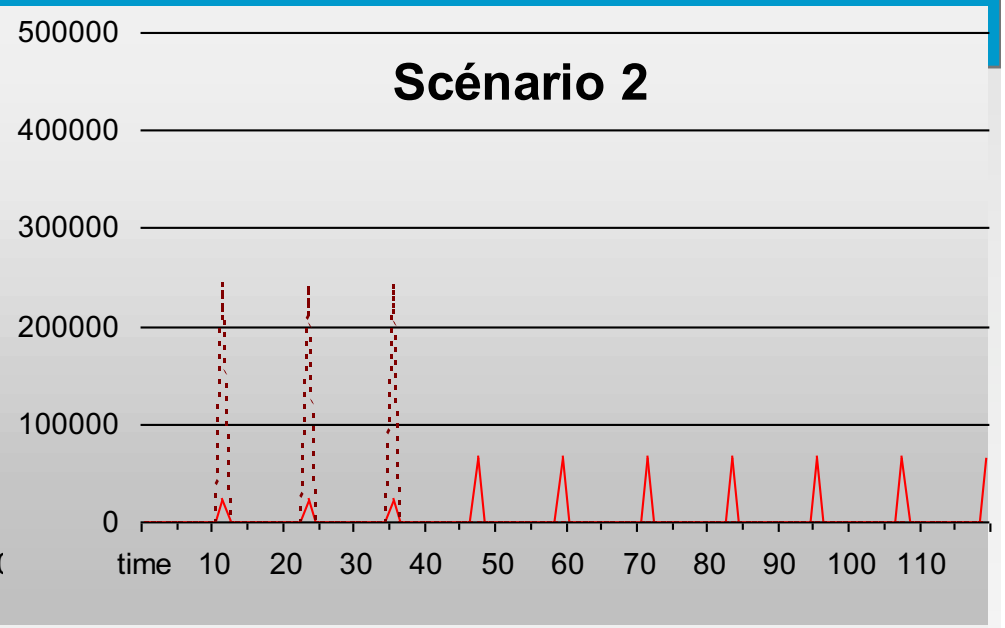

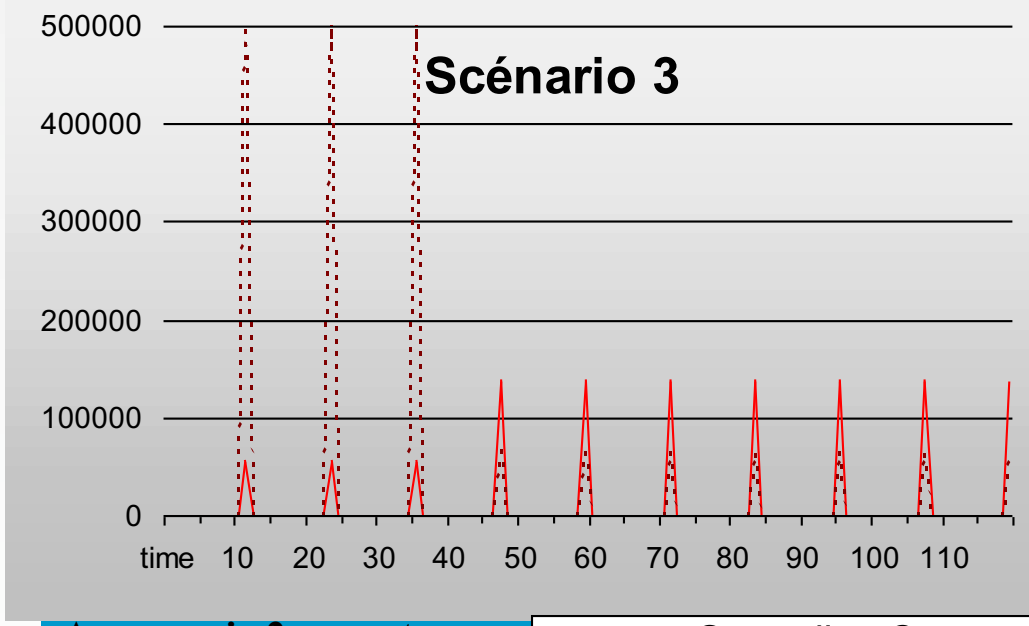

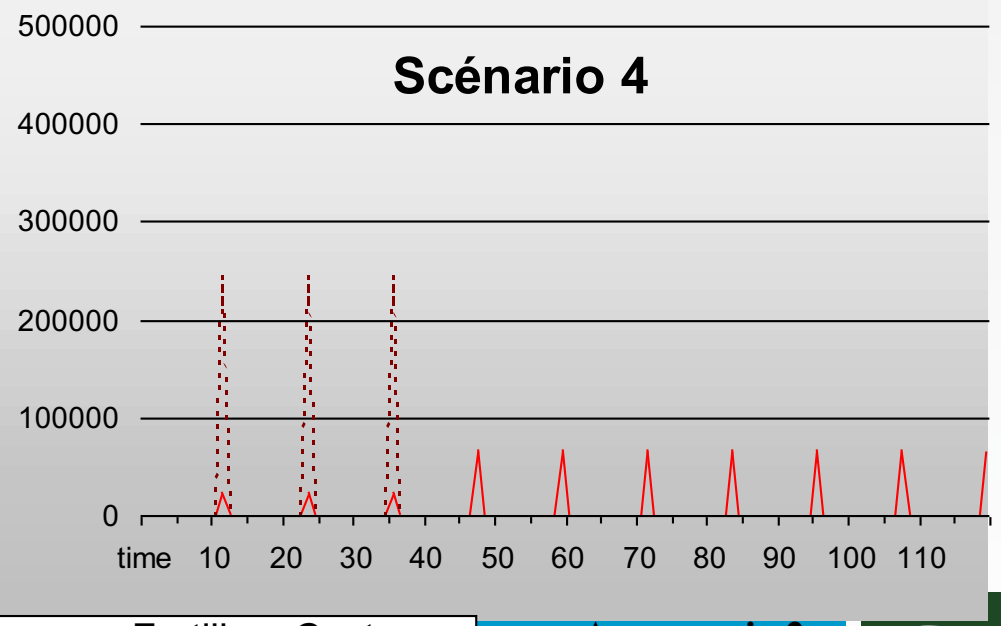

Spreading Cost — Fertiliser Cost

As scenario 2, except
Sugarcane farms areas between 40 to 80 ha

As scenario 2,
Standard = 300 Kg.N / ha

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Conclusion

- Advantage of the MAS
  - allows to study in the same time economical and ecological consequences of policies
- The wastewater tax seems to allow a control of the pollution (=> rational agents)
- An exceeded increase of the tax is useless:
  - it doesn't modify the pollution in the environment and
  - it increases the social cost
- The environmental measures are efficient if there is enough spreadable place on the coast area

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Further modelling steps

- Introduction of heterogeneous behaviours
  - Agents not entirely rational
  - Agents partly informed
  - Other behaviours
- Introduction of collective management alternatives
- Coordination processes between agents
- How nitrogen evolve in the soil
- Improvement of the costs calculation

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