Closed loop purification of water resources

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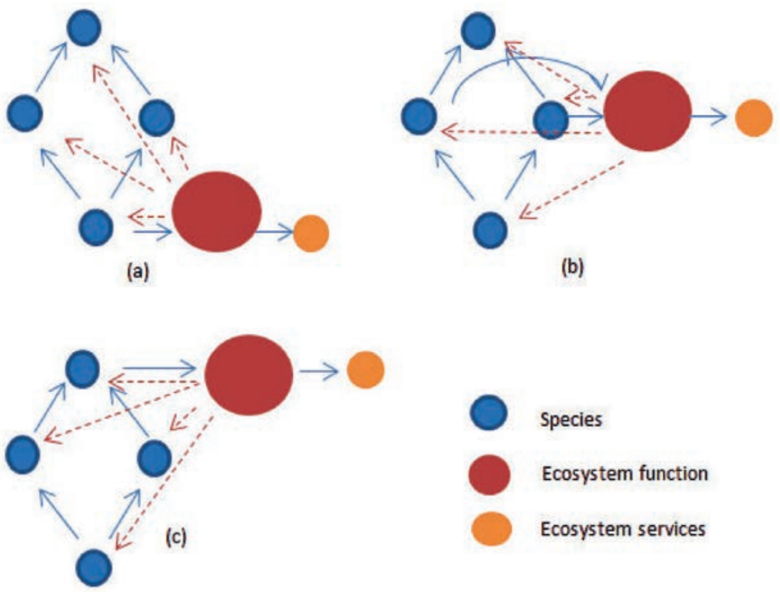
New decision-support models

Decision models for agroecology on a territorial scale

The Modelling of Agroecosystems and Decision research team (UR INRA-MIAT) conducts statistical, computer science and economics research in collaboration with its agriculture and ecology partners for the purpose of modelling and simulating agroecological management issues on a territorial scale. It also develops mathematical, computer and participatory tools for devising innovative agroecological strategies. The agroecological management issues we address with our partners are related to ecosystem service management on a territorial scale, in relation to agriculture, forestry, etc., while also seeking tradeoffs between these ecosystem services. To this end, the team develops:
1. Models of decision-making behaviours of farmers or forest managers in unstable conditions, which may take into account: (i) decision-makers' attitudes towards risk, (ii) 'limited rationality' behaviour, or (iii) biophysical and technical resource limitations. The relevant approaches are based on economics and artificial intelligence.
2. Simulation tools that facilitate the study or streamlining of complex decision-making processes on a territorial scale, potentially involving many interacting agents. This computer science and applied mathematics research is embodied in the simulation environments (spatial and multiagent) that we are co-developing: Virtual Laboratory Environment* and GAMA platform (*see p. 50*).
3. Research at the probabilistic graphical modelling-artificial intelligence interface focuses on modelling and approximate solving of problems of sequential decision-under-uncertainty in structured environments. These studies aim at finding tradeoffs between ecosystem services and biodiversity on a territorial scale, while also taking ecological interactions into account for the conservation of species communities. These issues require the development of innovative and powerful problem-solving methods to deal with decision problems that are too complex to be solved with conventional problem-solving tools.



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For further information: https://mia.toulouse.inra.fr/MAD_English

* www.vle-project.org

◀ *Identification—for management purposes—of an ecological network and ecosystem services provided by a species community.* © MAD/MIAT

Closed loop purification of water resources

Biological depollution in wastewater treatment plants involves the use of microorganisms that degrade pollutant substances which they feed on for their growth. These microorganisms cannot be released into natural environments (lakes, ponds, reservoirs, etc.) because they would develop to the detriment of other life-forms, particularly through oxygen consumption—it would then be hard to remove them without draining the water resources. The contaminated water can nevertheless be pumped for continuous treatment in an external treatment unit (bioreactor) followed by its reintroduction after purification, while keeping the resource volume constant. A tradeoff between treatment rate and quality is thus sought by adjusting the flow rates and pump positioning to ensure timely purification of the water resources. The hydrodynamics of resources subject to pumping and discharge flows (governed by Navier-Stokes equations) is complex and depends on the resource geometry and pollutant diffusivity, thus making it very difficult to optimize the treatment time. A method combining numerical simulations of partial differential equations and simplified models of spatial heterogeneity representations has been developed, which helps:
• to optimize the pump flow rate, which is automatically adjusted to the pollution measurements at the pumping points over time
• and to determine the most efficient pump locations.

This method includes a first phase of calibration of a reduced model based on a more complex model while taking the geometry of the medium into account. The second operational phase uses optimal control tools to estimate the optimal treatment time.

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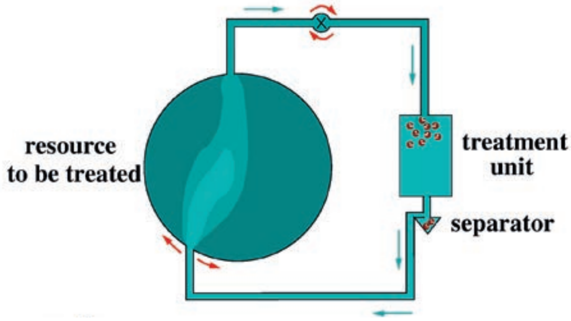

▲ *Closed-loop water treatment principle.*
From Barbier et al. J. Scientific Computing. 68:3 (2016).

▼ *Example of the rate of microorganism degradation according to the sought-after substrate concentration at the treatment unit outlet.*