Linkages within a formal body of knowledge related to multidisciplinary issues

In a given research domain, field experiments and observations raise a range of questions for the concerned disciplines. Knowledge acquired by each one represents contributions required to gain insight into the observed natural phenomenon. In the case that interests us, a method is sought to dovetail this wealth of knowledge within the same formal assembly so as to produce the most integrated vision possible of the functioning of communities and populations of rodents and their parasites in different environmental situations. Three avenues are explored to understand this complexity: questions, knowledge and modelling: semantic analysis of interviews of researchers helps understand the field of assessment to represent; structuring of unit information within a network of keywords provides a structured representation of scientific knowledge (*Fig. 1*); and finally a multiprotocol model facilitates the identification of generic terms essential for the production of spatiotemporal dynamics. This latter approach, based on multiagent system computer modelling, enables development of a software architecture linking research at different levels—from genes to ecosystems—in this domain (*Fig. 2*). The three combined approaches generate a knowledge typology conducive to the organization of complex multidisciplinary projects.

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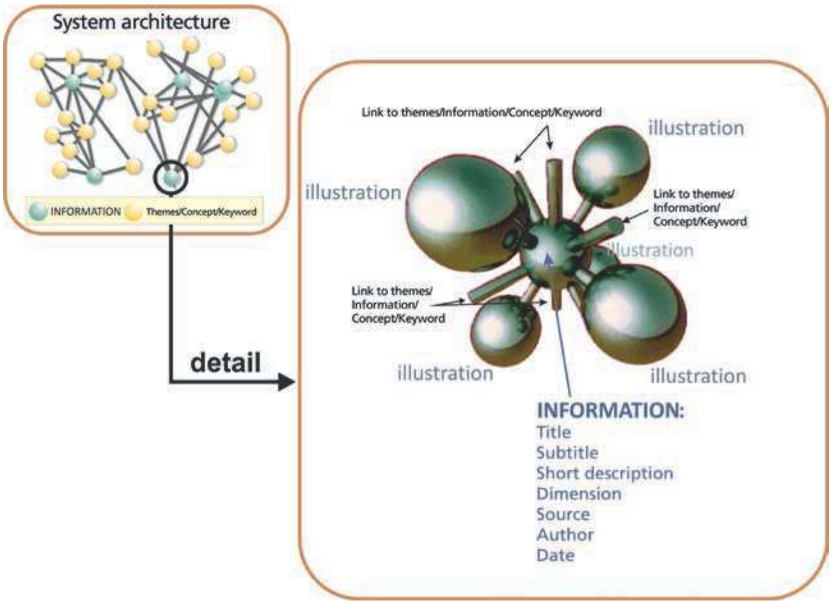
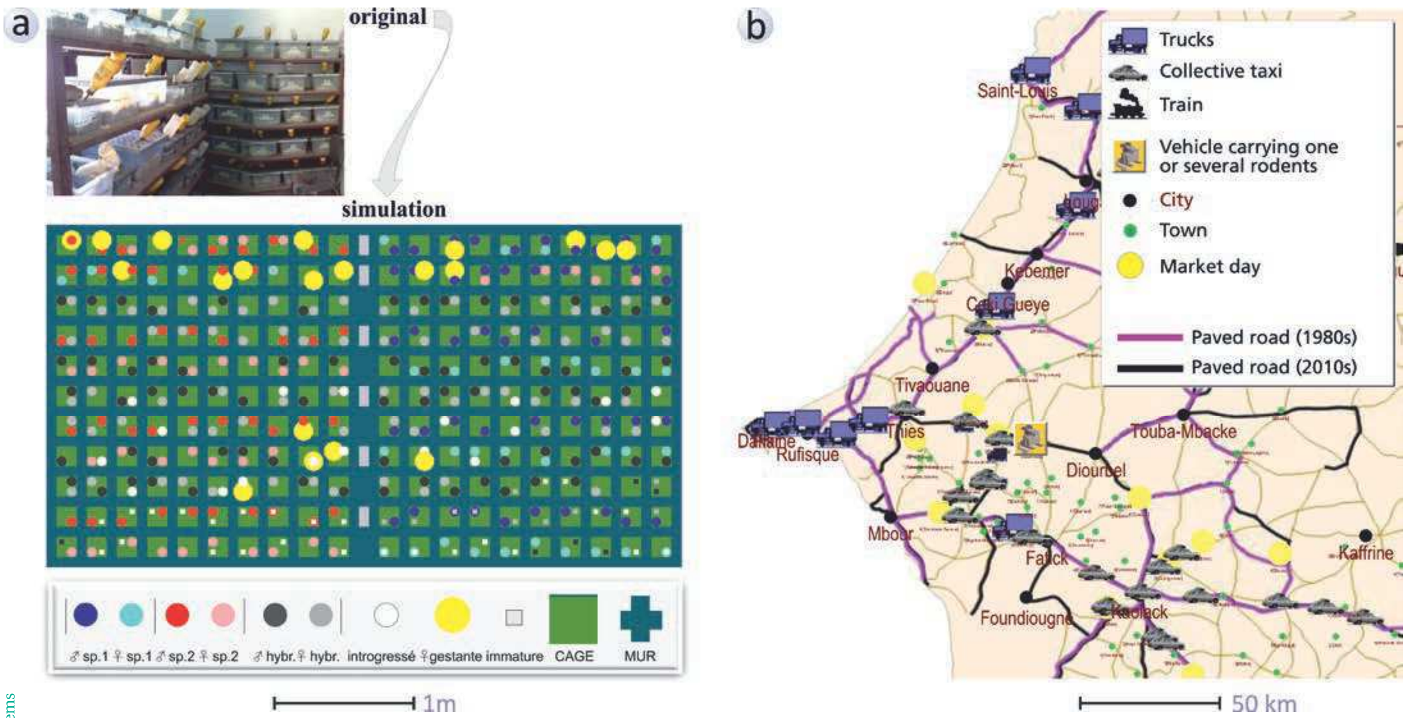


◀ ***Figure 1. Structure of a navigation system in a knowledge domain devoted to the linkage of multidisciplinary and multiformat knowledge.***

Figure 1. Structure of a navigation system in a knowledge domain devoted to the linkage of multidisciplinary and multiformat knowledge.
(a) Information of various origins is associated by hyperlinks to various descriptors (date, source, keyword, etc.); users can move from item to item via thematic trails blazed by each information item. The network is gradually built through the input of new information.
(b) Detail of the internal structure of an information item: application of the system to various multidisciplinary domains leads to a parsimonious structure for the definition of scientific information that is compatible between disciplines. For further information: http://centreinfo.science



▲ ***Figure 2. Two distinct examples of simulations performed with the same platform.***
(a) Animal breeding experiment involving hybridization of twin African rodent species.
(b) Simulation of the movement/colonization dynamics of commensal rodents in Senegal. Linkages between disciplines facilitates building of a broad range of different simulation models at specific spatiotemporal scales. Each represented protocol or case study constantly enhances previous approaches while also benefitting.
From Le Fur et al., *2017. A Simulation Model for Integrating Multidisciplinary Knowledge in Natural Sciences. Heuristic and Application to Wild Rodent Studies. Proc. 7th Internat. Conf. Simul. and Model. Method., Technol. and Applic. (Simultech), Madrid, July 2017: 340-347. www.scitepress.org/DigitalLibrary/Link.aspx?doi=10.5220/0006441803400347*

Development of 'mechanically-rich' models to assess the complexity of population-environment relationships

Wild rodent management in agricultural areas requires a good overall understanding of how these populations function. Geographical, ecological, biological and ethological, etc., studies all highlight explanatory factors that differ from the legitimate observed dynamics. Simulation studies on the joint and simultaneous effects of these determinants and their interdependence may provide some insight on how these populations function. The so-called mechanically-rich modelling approach (DeAngelis and Mooij, 2003) is designed to assess such systems. This approach uses individual-centric simulators to integrate the most significant elements of known processes. The figure below shows an example of the results obtained using this type of model for studying vole populations in a heterogeneous agricultural landscape. Seasonal and sexual behaviour, genetic transmission between simulated individuals, different crop management sequences and rotations were all taken into account. Each agent is semi-autonomous and lives its lifecycle, in addition to various activities, according to its physiological status, other agents with which it interacts and landscape changes. Simulators—by accounting for this complexity—can highlight the importance of unique factors related to the complexity of the represented nature, such as sensitivity to the evolution of interactions over time (*see figure below*).

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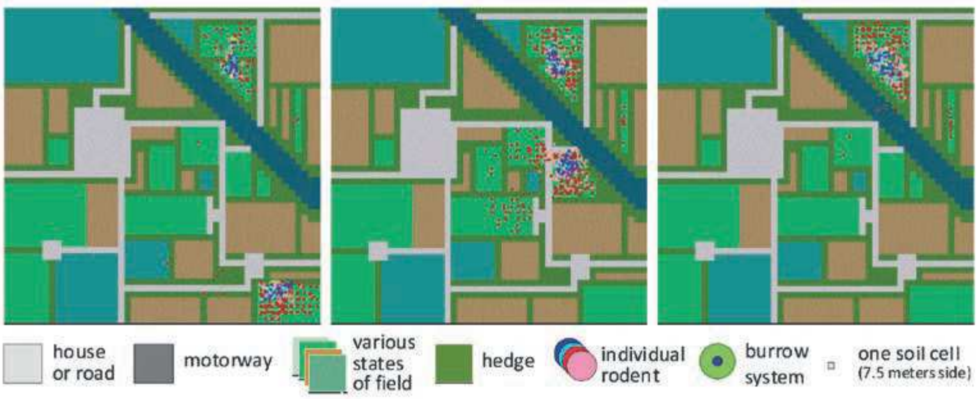
For further information: DeAngelis D.L., Mooij W.M., 2003. In praise of mechanistically rich models. In: Canham, C.D., Cole, J.J., Lauenroth, W.K. (Eds.), Models in Ecosystem Science. Princeton University Press, Princeton, New Jersey, pp. 63–82



◀ *Results of daily time step simulations over a 5-year period of a common vole (*Microtus arvalis*) population in a dynamic fragmented landscape in Poitou-Charentes region (France). The three maps highlight differences between the rodent distributions obtained (with all other factors remaining unchanged) for three initially centred populations whose sizes (N0) only differed by 1/1,000. Here the simulations highlighted the sensitivity of the modelled system to individual trajectories and the interaction history.*

Regional responses of populations to a complex landscape structure

Currently, it is essential to understand the impact of agricultural landscape management decisions on the populations (heritage, harmful or more common) they support. Hence, we have developed a numerical model inferring population dynamics at the regional scale based on the (generic) behaviours of target species at local and landscape unit levels—in previous studies, this approach has also provided a tool to manage these complex agricultural systems. Specialists on these spatial ecological issues generally separate the landscape compositional properties (i.e. the main attributes of landscape units, generally the land-use proportions) and configurations (i.e. the spatial sizes, shapes and arrangements of the units). These two properties are not independent. It was long assumed that the landscape composition prevailed over and guided the regional dynamics of the hosted populations. This hypothesis was tested here by modelling diverse landscapes with perfectly controlled compositions and configurations, as well as several dynamics of local populations within and between each landscape unit. The challenge was to couple these two models to achieve the upscaling and deduce the regional response of populations. Surprisingly, this model revealed that a population's regional (landscape) response could strongly differ from its fine-scale (unit) dynamics, and could depend as much on the landscape configuration as on its composition. This regional response also largely depends on the scale at which the aggregation of non-linear local dynamics is considered, and this response is even more acute when the aggregation scale is close to that of landscape units. We hope that such coupled models will set a precedent for a better understanding of the complex ecological systems on which we depend.

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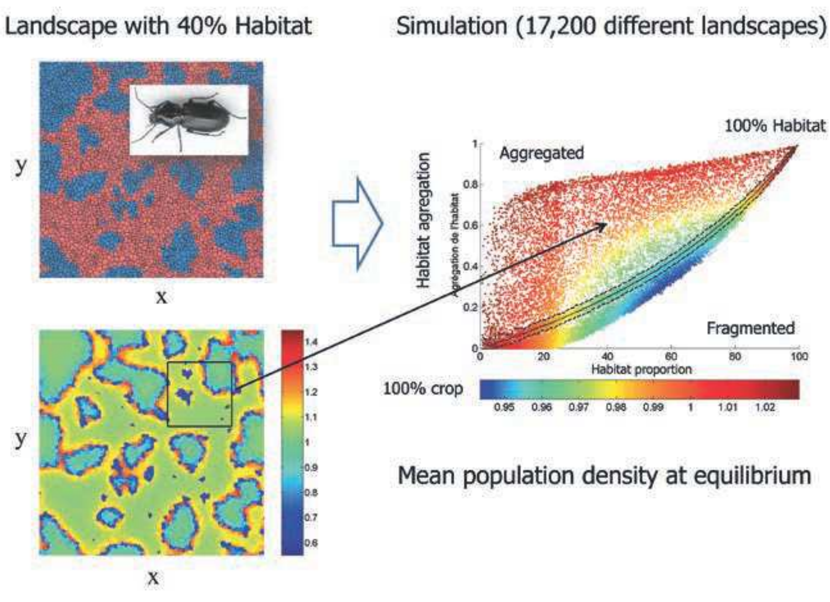


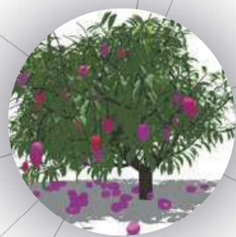
◀ *Examples of functional responses of modelled populations. Based on a set of simulated landscapes (left), the population dynamics of generic insects are modelled within each landscape unit and within the landscape as a whole. Migrations between these units are taken into account depending on the landscape composition and configuration (here set at 40% and 0.6). The population is unable to completely settle in landscapes (right: low mean densities in cold colours) when they are more fragmented and when they include intermediate proportions of habitats.* © C. Gaucherel/INRA.

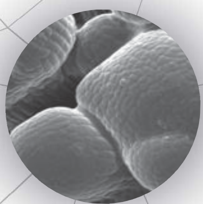
les dossiers d'AGROPOLIS INTERNATIONAL

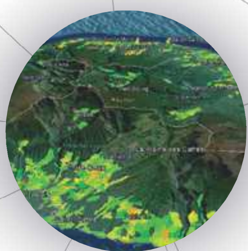
Expertise of the scientific community in the Occitanie area (France)

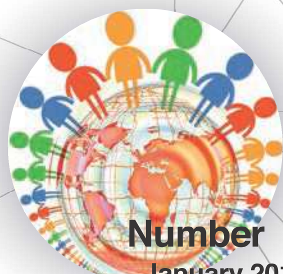
COMPLEX SYSTEMS

From biology to landscapes









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