What is the ExposUM Doctoral Nexus?

The Doctoral Nexus proposed by the ExposUM Institute are networks of 3 to 4 PhD students from different disciplines and affiliated to at least two different research units.

Compared with a traditional PhD, taking part in a Doctoral Nexus will encourage the ability to work in a team and to design projects in a transdisciplinary way while deepening one's own field of expertise.

A specific teaching programme will be offered and the doctoral students concerned will also have the opportunity to organise a seminar within the Nexus network.

Theses are funded from the outset for 4 years, including the PhD student's salary and an environmental allowance

Multi-scale modeling of the spatial dynamics of coypu populations
The expected start date of the PhD: December 2025.
Supervisors: QUEFFELEC Hoel, UMR IMAG and GIMENEZ Olivier, UMR CEFE; GUERAND Jessica, UMR IMAG

Context

The coypu (Myocastor coypus) is a widespread invasive species in Europe, with significant ecological and health impacts. Its expansion and interaction with both natural and human-modified habitats raise major concerns, particularly due to its potential role in the transmission of zoonotic pathogens such as leptospires. This PhD project aims to combine statistical and mechanistic approaches to better understand the spatial and health dynamics of the coypu, by integrating interactions with the environment and pressures driven by climate change.

Objectives and methods

Axis 1: Analysis of monitoring data to characterize movement and habitat use. This first component will focus on leveraging empirical data to understand coypu movements and habitat use. Two types of analyses will be conducted:

- GPS data analysis: Hidden Markov Models (HMMs) will be used to characterize coypu movement behaviors in relation to environmental conditions (Klappstein et al., 2023; Michelot et al., 2023). These models will incorporate spatial diffusion and temporal dependence to identify behavioral states (resting, foraging, exploring). A key innovation will be the integration of inter-individual dependence (social structure) into these models.

- Opportunistic data analysis: An inhomogeneous Poisson point process (IPPP) model will be applied to relate opportunistic sightings of coypus to habitat structure, particularly with regard to resource availability and anthropogenic pressures. A novel aspect of this work will involve extending classical models to a dynamic framework that accounts for temporal variation.

These analyses will provide deeper insights into habitat preferences and dispersal dynamics, laying the foundation for modeling population–habitat interactions.

Axis 2: Development of mechanistic models of spatial dynamics. This component will focus on building mechanistic models to simulate the spatial and demographic dynamics of coypu populations. Two complementary approaches will be explored:

- Individual-based model (IBM): This model will simulate individual behaviors and social interactions of coypus, calibrated using empirical data from Axis 1 (Banks & Hooten, 2021; Hooten & Wikle, 2010).
- Mechanistic-statistical model ("mecastat" or ecological diffusion): This alternative approach will integrate statistical components into a mechanistic modeling framework, also calibrated using data from Axis 1. It will focus on inferring parameters of a reaction-diffusion model (Roques & Soubeyrand, 2013; Soubeyrand & Roques, 2014), with a novel emphasis on the network topology of river systems.

A health component will be incorporated into both modeling approaches through an SIR (Susceptible–Infected–Recovered) framework, distinguishing between individuals carrying and not carrying pathogens such as Leptospira spp. This will allow evaluation of how spatial dynamics and control efforts influence the persistence and spread of leptospirosis within coypu populations.

Axis 3: Population dynamics projections under climate scenarios. In this final component, the models developed will be used to simulate future trajectories of coypu populations under different climate change scenarios (Dietze et al., 2018). A Bayesian approach using MCMC methods will enable formal propagation of various sources of uncertainty. The objectives are threefold:

- To assess how changes in environmental conditions may affect the expansion and density of coypu populations.
- To examine how these changes influence the interface between coypu populations and human-modified areas.
- To analyze the implications for health risks, particularly regarding increased human exposure to pathogens such as Leptospira spp.

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Expected results

This PhD project will contribute both methodological and applied advances in the modeling of spatial and health dynamics of invasive species in the context of global change. The results will inform management strategies and the mitigation of health risks associated with coypus. We also plan to disseminate the findings through publications in academic journals and presentations at national and international conferences.

Feasability

The project builds on solid methodological foundations and existing resources, ensuring a rapid and effective start to the research. At the beginning of the PhD, GPS tracking data for 15 individuals will already be available, along with presence data (via the SINP: https://inpn.mnhn.fr/informations/sinp/presentation) and detailed habitat characterization. The research team has recognized expertise in the development and application of the statistical models required for data analysis, including HMMs (Gimenez et al., 2012, 2022; Gimenez, 2026a), IPPs (Bonnet-Lebrun et al., 2020; Renner et al., 2019), individual-based models (Bauduin et al., 2020, 2025), the mecastat approach (Louvrier et al., 2020), and Bayesian methods (Gimenez, 2026b).

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Application procedure

The application must include the following

- a CV
- a letter of motivation

- a copy of the degree required for registration
- any additional specific information requested by the doctoral school Information Structures Systèmes (https://edi2s.umontpellier.fr/)

If you would like to apply for this position, please send an e-mail to Olivier Gimenez (olivier.gimenez@cefe.cnrs.fr) and Hoel Queffelec (hoel.queffelec@umontpellier.fr) with Nathalie Charbonnel (Nathalie.Charbonnel@inrae.fr) and exposum-aap@umontpellier.fr to inform them of your interest.

Before Monday 31 May, 2:00 PM CET

The University of Montpellier

KEY FIGURES

51857 students

73 research facilities

15 technology platforms

657 National and institutional diplomas

17 faculties, schools and institutes

9 doctoral schools

TOP 200 in the Shanghai ranking

5132 employees including **2818** teachers, researchers and research assistants

7800 scientific publications in 2022

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More Information: https://www.umontpellier.fr/en/recherche/unites-de-recherche

SCIENTIFIC APPEAL

Open to the world, the University of Montpellier contributes to the structuring of the European higher education area, and strengthens its international positioning and attractiveness, in close collaboration with its partners in the I-SITE Program of Excellence, through programs adapted to the major scientific challenges it faces.

More Information: https://www.umontpellier.fr/en/international/attractivite-scientifique