

forecasting in the face of global sustainability challenges.

### 1.3 Interdisciplinarity and non-incrementality of the research proposed

To succeed with ROBHOOT, it is essential to build an interdisciplinary team that includes scientists from different disciplines, i.e., evolutionary biology, ecology, computational neuroscience, computer science, data science, complex systems and experts in communication and biodiversity sampling methods. Data knowledge discovery gained by the analysis of the computation discovery capabilities of evolutionary-inspired semantic algorithms will be developed by the evolutionary biology, computer science and complex system members of the consortium (EBD-CSIC, IFISC-CSIC, SDSC). Data discovery can be transferred to the causal domain addressed by the other part of the consortium with expertise in ecology, evolutionary biology, data science and causal inference (EAWAG and TARTUR). The whole process will be enriched with full automation, reproducibility and visualization supported by ICREA, SDSC, and our company-partner SCITE, respectively. Conversely, those scientists working on neurobiology and eco-evolutionary dynamics in ecosystems will feed information back on fundamental discovery computational challenges in federated networks (i.e., role of heterogeneity, evolving and diversifying traits and interactions, cooperation, and dimensionality). This allows feedbacks in their implementations to explore to what degree this is reflected also in eco-evolutionary biology-inspired and neurobiology inspired discovery computation models to augmented their models. This cross-fertilizing back-and-forth interaction will allow the project to keep high modularity within the WPs while keeping cross-interactions among the groups to run efficiently the stages of the project. To bring together evolutionary biology-inspired semantic algorithms for data discovery and evolutionary neurobiology-inspired discovery in federated networks require a long stride and this has not been attempted so far. This way, we expect to realize a truly novel, sustainability-driven knowledge-inspired society technology for which there are no predecessors. Thus, ROBHOOT will not be incremental, but a leap opening a new direction for eco-evolutionary diversification-inspired discovery computation.

### 1.4 High risk, plausibility and flexibility of the research approach

ROBHOOT represents a novel approach for complex, adaptive and multidimensional discovery computation in ecosystems. The transfer of eco-evolutionary diversification-inspired principles onto fully reproducible and automated software, progressing towards a process-based discovery technology, will be a major qualitative step, defining ROBHOOT as a high-risk project, fitting into FET-Open. To achieve the ambitious goals, we will combine expertise from all involved areas, mitigating risk in a gradual way, following a strict line and increasing step-by-step in complexity of the problems addressed. We will start with evolutionary biology-inspired semantic algorithms for data discovery applying them to the sustainability of the Seas case study. This is followed by the implementation of more complex eco-evolutionary diversification-inspired AI modeling to infer causality in our case study. Then, we will advance to more complex situations, where the evolutionary neurobiology-inspired modeling will expand the search along many diversifying and cooperative forecasting schemes to find paths of sustainability in our case study. To keep the project technically feasible, and to be able to identify the mechanisms and their properties from data and causal discovery computation to discovery in federated networks, we will limit methods to three main approaches. All of the above will be done by combining theoretical work and numerical simulations with a real empirical case for the sustainability of the seas. The knowledge gained along these three lines will allow us to compactly represent all the steps into a compact science-enabled open-source technology. We will develop the modeling in fast computing languages implementing low-level Agent Based Models (ABM) along all the theoretical development of the proposal (i.e., Julia, C++). We will contrast the ABM with differential/difference equations methods when a large number of agents, traits, and interactions diversify in time and space. This feature represents a very desirable fallback in case of speed and convergence problems for multidimensional and nonlinear systems (Table 1.4a, Critical risks for the research approach). Our implementation activities are all complemented by numerical investigations contrasted for speed, replicability, and robustness with the sustainability of the Seas case study (Figure 2). The success of ROBHOOT would represent a breakthrough in the current discovery computation with direct application to sustainability of ecosystems