PhD PROGRAM: EVOLUTIONARY BIOLOGY AND ECOLOGY UNIVERSITY OF FLORENCE, UNIVERSITY OF PARMA (ITALY)

UNIVERSITY OF PARMA, CAMPUS, PARCO AREA DELLE SCIENZE

INTERNATIONAL SUMMER SCHOOL



"...there are always connections: you have only to find them" Umberto Eco – Foucault's Pendulum

"Nothing is more practical than theory" Richard Levins – Harvard University

TITLE 2025: "Network analysis in ecology: different approaches for complex ecological systems"

June 17-19, 2025

Instructors:

Antonio Bodini – Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Italy.

Ferenc Jordan – Institute of Biological Research Cluj, National Institute of Research and Development in Biological Sciences (INCDSB) Bucharest.

Marco Scotti – GEOMAR Helmholtz Center for Ocean Research Kiel, Germany and National Research Council, Florence, Italy

Program

Tuesday, June 17, 2025 (9:30-9:45)

Antonio Bodini (School Coordinator)

Opening lecture: presentation of the school, aims, topics and their relevance in the current pathways of scientific investigation.

Lectures by Antonio Bodini

Title – The qualitative analysis of complex systems: an introduction to loop analysis

Loop analysis is a qualitative modelling technique that allows predicting the response of ecosystem variables to external events such as press perturbations that alter parameters in their growth rate such as fecundity, mortality and so forth. Also, it allows disentangling the mechanisms of such responses. All is based on a graphic algorithm, the foundations of which are given in this first set of lectures. Becoming familiar with the concepts of feedback and path in an operational way is a primary goal of the lectures, as well as identifying counterintuitive effects to educate intuition to cope with complexity. The first day will end with a case study which will show how model predictions can be used to identify sources of variations so that cause and effect in real ecosystem can be disentangled combining model results with data.

Morning (9:30-13.00)

- Loop analysis as a predicting tool: essential concepts and graphic algorithm
- How to describe ecological systems using signed di-graphs
- Ecosystem response to perturbations: concomitant perturbations and ecosystem response
- Predictions as diagnostic tool for sources of change
- -. Introducing the software Levins_Analysis

Afternoon (14.30-17.00)

- Class exercises on building and analyzing signed digraphs
- The models and the data: using data as a benchmark for model predictions
- Causes and effects in ecosystem. A case study from a biomanipulation experiment (The lake Mosvatn, Norway)

Wednesday, June 18, 2025

Lectures by Marco Scotti

Morning (9:30-13.00)

Title: Ecological interactions drive the spread of anthropogenic disturbance across marine food webs

Marine food webs are impacted by multiple stress factors of anthropogenic origin. Besides direct effects on organisms' physiology and on the standing stocks of targeted species, these stress factors may propagate across food webs, thus altering their functioning and resilience. Morning lectures will illustrate diverse case studies, ranging from mesocosm experiments to large-scale ecosystem models, explaining how a focus on ecological interactions may help predict the indirect effects of disturbance. For instance, we showed that in benthic coastal communities of temperate ecosystems, exposure to sequential, sublethal heatwaves throughout spring and summer may facilitate mesograzers' acclimation, whereas a single heatwave at the end of summer significantly alters their physiology. The

physiological stress caused by a single heatwave triggers a series of indirect effects that ultimately modify the architecture of energy flows in the food web, thus impairing its resilience. In a second case study, the first ecosystem model of the western Baltic Sea will be introduced and used to simulate how different fish management strategies alter the structure and health of the food web. The model will enable predicting optimal levels of fish mortality that account for the consequences of forage fish declines for top predators such as harbor porpoises, which occupy fragile positions in the food web. The lecture will present how research findings can be transferred to influence the development of ecosystem-based fisheries management and marine spatial planning at the national, regional, and EU levels.

Afternoon (14.30-17.00)

Title: Disentangling the effects of stress factors on marine food web dynamics with loop analysis The status of marine ecosystems is threatened by the concurrent action of multiple stress factors. Ecosystem models may be applied to simulate the dynamics of large basins and thus enable assessing the relative impact of specific stressors (e.g., fisheries, ocean warming, and eutrophication) on biodiversity and food web functioning. These models are highly parameterized and often require coupling with biogeochemical and oceanographic models. However, there are areas where data availability is limited, and the lack of monitoring surveys impairs the possibility of constructing quantitative models, especially when integrating ecological and socioeconomic dimensions. Under these circumstances, the use of qualitative loop analysis may represent a suitable solution, as it helps clarify synergies and trade-offs among variables across different domains (e.g., ecological, social, economic, and governmental) even in the presence of limited data. During the afternoon, we will learn how to construct qualitative socio-ecological networks, which will be modeled with custom scripts developed in the R programming environment. We will also introduce functions for visualizing both the graphs and the outcomes of loop analysis, which participants will then apply themselves.

Thursday, June 19, 2025

Lectures by Ferenc Jordán

Title – Variability of network topology at various levels of organization

In this module, I overview several kinds of ecological networks and their variability in space and time. I will also speak about how can variability be the key to adaptability in the era of global change.

Morning (9:00-13.00)

Ecological networks at several organizational levels

We discuss the network perspective in ecology. We define nodes and links in food webs, animal social networks, habitat networks and microbial networks. Local (e.g. centrality) and global (e.g. density) network measures will be presented, compared and their relevance will be discussed.

Afternoon (14:30-17.00)

Network diversity and systemic adaptability

Based on the morning examples, a special attention will be given to the variability of network measures. We will discuss how is this variability is related to evolution, resilience and climate change.

Software tools needed (participants are requested to download these programs):

- UCINET: www.analytictech.com
- R: http://www.r-project.org/
- R-studio: https://www.rstudio.com/products/rstudio/download/R-studio

R packages to install: igraph, msm, MASS, DiagrammeR, DiagrammeRsvg, rsvg, rlist, gplots

⁻ Microsoft Excel

REGISTRATION

The course is mandatory for the PhD students enrolled in the program "Ecology and Evolutionary Biology" (Universities of Florence and Parma). Other PhD students and postdoctoral Researchers are welcome. Attendance is free of charge although participants are requested to provide on their own for living and travel expenses. Registration will be open until May 31, 2025. To be registered, an e-mail message with CV must be sent to <u>antonio.bodini@unipr.it</u> (school coordinator) within the deadline (May 31). Participants will be granted with 3 CFU and will receive a certification of attendance. An account for accessing the web during the days of the school will be provided to any attendant (if needed).

Dates and location

The school will be held June 17-19, 2025 at the University Campus, Santa Elisabetta Center, Parco Area delle Scienze, University of Parma (Italy).





From the train station or city center the University Campus is served by buses n. 7 and 21. The map below provides a view. From the "Capolinea" (see the map below) the Centro Santa Elisabetta can be reached in 5 minutes (walking).

