

Course guide

480USE003 - Biodiversity and Modelling of Socio-Ecological Systems

Last modified: 08/06/2026

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 724 - MMT - Department of Heat Engines.
731 - OO - Department of Optics and Optometry.

Degree: MASTER'S DEGREE IN SUSTAINABILITY AND STRATEGIES FOR A JUST GLOBAL TRANSITION (Syllabus 2026). (Compulsory subject).

Academic year: 2026 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Rosas Casals, Martí

Others: Morató Farreras, Jordi

PRIOR SKILLS

Those to accessing the master's studies.

TEACHING METHODOLOGY

MD.1.- Active expository teaching (participatory master class)
MD.3.- Problem-based learning (PBL)
MD.4.- Case studies

LEARNING OBJECTIVES OF THE SUBJECT

- 1.Master's Learning Outcomes (RAM)
 - a.Knowledge
 - i.K04.1 - Explain social metabolism and its implications for urban and territorial development.
 - b. Skills
 - i. RAT_UPC_6.1 - Use digital technologies to model and simulate socio-environmental dynamics.
 - ii. S05.2 - Use modeling and simulation techniques for decision-making in the field of sustainability.
 - iii. S06.1 - Implement methodologies for analysis and sustainable management of natural resources.
 - c. Competencies
 - i. C04.2 - Formulate innovative methodological strategies to analyze socio-ecological systems.
2. Narrative
 - a. Know the fundamental principles, concepts and instruments of ecology to analyze the relationships between living organisms and the physical environment, as well as the structure and dynamics of populations and ecosystems.
 - b. Understand the metabolism of socio-ecological systems (energy and material flows) and the main indicators and instruments available for their measurement, management and valuation.
 - c. Know and understand the systemic dimension of sustainability, identifying the properties that determine its temporal dynamics (resilience, stability, feedbacks, thresholds and regime changes) and the particularities of socio-ecological systems.
 - d. Efficiently apply mathematical and computational modeling techniques and instruments to address problems related to biodiversity, sustainability and development, using open source computer tools for simulation, data analysis and reproducibility of results.
 - e. Integrate and critically analyze the results obtained with models (deterministic and stochastic), assessing their hypotheses, uncertainties and limitations, and using them as support for defining and comparing strategies and solutions for sustainability and development.
 - f. Incorporate data and knowledge from actors (citizen science, governance, participation) in the formulation and validation of models, and clearly communicate the results (scenarios, sensitivity, uncertainty) to facilitate decision-making and adaptive management.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	11,4	9.11
Self study	80,0	63.95
Hours small group	11,0	8.79
Hours large group	22,7	18.15

Total learning time: 125.1 h

CONTENTS

1 Introduction to biodiversity and complex systems modeling

Description:

- 1.1 Introduction to biodiversity
 - 1.1.1 Definition of biodiversity
 - 1.1.2 Creation, maintenance and distribution of biodiversity in time and space
 - 1.1.3 Impacts and loss of biodiversity (ecosystem services and nature's contribution to people)
 - 1.1.4 Measures and frameworks for conservation
- 1.2 Introduction to modeling complex systems
 - 1.2.1 Biodiversity and complexity
 - 1.2.2 Modeling with equations. Discrete and continuous models
 - 1.2.3 Modeling with agents
 - 1.2.4 Modeling with networks

Related activities:

- A1.1 - NetLogo Introduction Tutorials
- A1.2 - Biodiversity Calculation: Shannon Index and Evenness (Pielou)

Full-or-part-time: 16h 36m

Theory classes: 6h

Self study : 10h 36m

2 Ecosystems. Function and dynamics

Description:

- 2.1 Energy flows and primary productivity.
- 2.2 Food webs.
- 2.3 Functional redundancy and the insurance effect of biodiversity.
- 2.4 Feedback loops, nonlinearity and multistability.
- 2.5 Population and community dynamics.
- 2.6 Population models with equations and agents
- 2.7 Models with ecological networks

Related activities:

- A2.1 - Analysis of the Lotka–Volterra model with equations and agents
- A2.2 - Food webs. Redundancies and disturbance simulation

Full-or-part-time: 16h 36m

Theory classes: 6h

Self study : 10h 36m

3 Biogeochemical cycles

Description:

- 3.1 Water, carbon, nitrogen, phosphorus and sulfur cycles
- 3.2 Ecological stoichiometry and the catalytic role of microorganisms and biofilms
- 3.3 Gaia hypotheses and planetary homeostasis
- 3.4 Land–water–atmosphere fluxes and global processes (retention, transformation and internal release in soils, waters and sediments)
- 3.5 General / global ecosystem models

Related activities:

- A3.1 - Analysis of ecological models with equations (i.e., Tiger bush)
- A3.2 - Analysis of Ecological Models with Agents (i.e., Daisyworld)

Full-or-part-time: 16h 36m

Theory classes: 6h

Self study : 10h 36m

4 Microbial Biodiversity. Microbiomes and biofilms, from structure to function

Description:

- 4.1 Genetic, specific, functional and phylogenetic biodiversity
- 4.2 Relationship between functional diversity and process stability
- 4.3 Key transformations (i.e., nitrification, denitrification, carbon and sulfur cycles)
- 4.4 Diagnosis, biophysical indicators, sampling techniques and structural $\square$ function analysis
- 4.5 Models of chemical reactions with agents

Related activities:

- A4.1 - The nitrogen cycle in treatment wetlands

Full-or-part-time: 16h 36m

Theory classes: 6h

Self study : 10h 36m

5 Planetary thresholds and resilience

Description:

- 5.1 Ecosystem resilience (Holling) and panarchy.
- 5.2 Regime changes (catastrophes), tipping points and early warning signals.
- 5.3 Catastrophic systems with equations
- 5.4 Robustness and fragility in complex networks

Related activities:

- A5.1 - Catastrophic Model Analysis with Equations

Full-or-part-time: 16h 36m

Theory classes: 6h

Self study : 10h 36m

6 Nature-based solutions

Description:

- 6.1 Definition according to international standards and typologies
- 6.2 Principles of design and co-benefit evaluation
- 6.3 Models with adaptive agents

Related activities:

A6.1 - Advanced Agent Model Analysis (Wolf Sheep Predation - Agent Cognition)

Full-or-part-time: 16h 36m

Theory classes: 6h

Self study : 10h 36m

7 Socioecological systems

Description:

- 7.1 Traditional Ecological Knowledge (TEK)
- 7.2 Intangible Cultural Heritage (ICH)
- 7.3 Modeling of coupled social-ecological systems

Related activities:

A7.1 Analysis of models of past societies (Artificial Anasazi)

A7.2 Analysis of coupled models, cooperation and rebellion (Lansing, Rebellion and Fruit Wars)

Full-or-part-time: 16h 36m

Theory classes: 6h

Self study : 10h 36m

GRADING SYSTEM

Any academic fraud, plagiarism or use or possession of unauthorised means in an assessment activity leads to a mark of zero (0) for the affected test or assignment. Furthermore, in accordance with the University's regulations, if disciplinary proceedings are initiated the subject is recorded as "Pending Assessment" until a decision is reached. These incidents are managed in accordance with the [Action Framework for Academic Integrity in Assessment at the UPC](#).

Self-assessment questionnaires (QA) grades = 20%

Practice report grades (AP) = 20%

Midterm exam (EP) = 30%

Final exam (EF) = 30%

Final grade (Nf): $0.20 \cdot QA + 0.20 \cdot AP + 0.30 \cdot EP + 0.30 \cdot EF$

EXAMINATION RULES.

1. There will be an assessment of guided activities (face-to-face or non-face-to-face) corresponding to the submission of proposed works (AD type) and the submission of practice reports (AP type). These can be individual or in groups, according to the criteria of each teacher.
2. There will be a partial exam (EP) in the first half of the subject and a final exam (EF), of a maximum of 2 hours duration, which will consist of questions related to applied knowledge of the subject syllabus and aimed at assessing the learning objectives achieved by the students.



BIBLIOGRAPHY

Basic:

- Kunming–Montreal Global Biodiversity Framework (GBF) [on line]. 2022 [Consultation: 10/06/2026]. Available on: <https://www.cbd.int/gbf>.
- Global Biodiversity Outlook 5 (GBO-5) [on line]. 2020 [Consultation: 10/06/2026]. Available on: <https://www.cbd.int/gbo5>.
- Chapin III, F. S.; Matson, P. A.; Vitousek, P. M. Principles of Terrestrial Ecosystem Ecology [on line]. 2nd ed. New York, NY: Springer, 2011 [Consultation: 29/07/2026]. Available on: <https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-1-4419-9504-9>. ISBN 9781441995049.
- Piñol, J.; Martínez-Vilalta, J. Ecología con números: una introducción a la ecología con problemas y ejercicios de simulación. Barcelona: Lynx, 2006. ISBN 9788496553019.
- Railsback, S.F.; Grimm, V. Agent-based and individual-based modeling: a practical introduction. Princeton: Princeton University Press, 2011. ISBN 9780691136745.

RESOURCES

Other resources:

Class material available at ATENEA

NetLogo modeling environment (<https://www.netlogo.org/>) />