DISCIPLINE SHEET

1. Program data

1.1 Institute	"Babeş-Bolyai" University
1.2 Faculty	Faculty of Biology and Geology
1.3 Department	Hungarian Department of Biology and Ecology
1.4 Study domain	Biology
1.5 Level	Master degree studies / 4 semesters / full-time
1.6 Study program / Qualification	Terrestrial and aquatic ecology / Expert biologist, ecologist

2. Discipline data

2.1 Name of the discipline	Ecological modeling in R and python with GIS elements						
2.2 Holder of course activities	Assoc. prof. dr. László Zoltán						
2.3 Holder of seminar activities	Assoc. prof. dr. László Zoltán						
2.4 Year of study	1	2.5 Semester	2	2.6. Evaluation	E	2.7 Discipline regime	Ob.

3. Estimated total time (hours per semester of didactic activities)

3.1 Number of hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2
3.4 Total hours from the education plan	154	Of which: 3.5 course	56	3.6 seminar/laboratory	28

Distribution of the time fund:	hours
Study according to the textbook, course support, bibliography and notes	28
Additional documentation in the library, on specialized electronic platforms and in the field	20
Preparation of seminars/laboratories, assignments, reports, portfolios and essays	18
tutoring	4
EXAMINATION	0
Other activities:	
3.7 Total hours of individual study	70
3.8 Total hours per semester	154
3.9 Number of Credits	6

4. Preconditions (where applicable)

4.1 of the curriculums	
4.2 skills	

5. Conditions (where applicable)

5.1 Conducting the course	• Logistic support: multimedia projector • Course support for internal use
5.2 Conducting the seminar/laboratory	• Multimedia projector • Modeling and statistical analysis programs (R, QGIS, etc.), computers (desktop/laptop) • Participation in at least 80% of the laboratory work is a condition for participation in the exam

6. The specific skills accumulated

Professional skills	Solving problems through modeling, algorithmizing, etc.; Description of states, systems, processes, phenomena;
Transversal skills	Research skills, creativity; The ability to conceive projects and carry them out; Ability to solve problems;

7. The objectives of the discipline (resulting from the grid of accumulated skills)

7.1 The general objective of the discipline	• At the end of the course, the student should be able to recognize and use mathematical models associated with biological and ecological phenomena to create scenarios and formulate ecological models
7.2 Specific objectives	• At the end of the course, the student must be able to recognize and use the mathematical models associated with the following types of biological phenomena: population dynamics, predator-prey dynamics, competitive species dynamics; ordinary differential equation models for modelling habitat occupancy, persistence and resilience of ecological networks, random and directed dispersal.

8. Contents

8.1 Course	teaching methods	Remarks
1. Introduction to food webs. Types of networks. Properties of networks: trophic relationships, link density, compartmentalization, trophic levels.	Exposition, description, explanation, examples, case study discussions	2 hours each
2. The waterfall model and the trophic cascade. Food web patterns.		
3. Food web experiments: (i) chain length and (ii) the relationship between food web complexity and stability.		
4. Classification of species in trophic networks based on various criteria: indicator species, umbrella species, key species, invasive species. Properties of key species.		
5. Ecological networks. Common properties of ecological networks. Stability of ecological networks. Preferential logging. The "six degrees of separation" theory.		
6. Metapopulation theory: predation and oscillations, spatial heterogeneity, immigration, habitat heterogeneity, habitat fragmentation and loss. The Levins model.		
7. Demographic changes: cycles of extinction and colonization, survival time of metapopulations. Metapopulation models: implicit and explicit models in space, realistic models.		
8. Deterministic and stochastic models. The Monte Carlo method. The "Mersenne twister" method. Markov chains and Markov processes.		
9. Occupancy models of the "patches". Reaction-diffusion models. The Lande model.		
10. Case studies: (i) impact of fungal infections on host and parasite metapopulation dynamics; (ii) metapopulation patterns in fish communities.		
11. Random moves. Lévy flight. Pareto distribution. Density-independent and density-dependent dispersion. Dispersal mechanisms of plants and animals.		
12. Synthesis and grouping of movement types. Measuring Dispersal: Genetic and Demographic Approaches Case Study: Fire Ant Dispersal.		
13. Measurement and modeling of plant dispersal. Determination of dispersion curves, empirical dispersion curves.		
14. Use of space: territoriality, dispersal behavior, choice of habitats. Epidemiological models: SIR models. Case Study: The Bombay Bubonic Plague Epidemic.		

Bibliography 1. **Trexler, M.**, et al. Modeling complex ecological dynamics: an introduction into ecological modeling for students, teachers & scientists. Springer Science & Business Media, 2011. 2. **Barabási, A.-L.**Network science. Cambridge university press, 2016. 3. **Pascual, M., Jennifer A.D.**, eds. Ecological networks: linking structure to dynamics in food webs. Oxford University Press, 2006. 4. **Bullock, JM**, et al., eds. Dispersal ecology: 42nd symposium of the British ecological society. Vol. 42. Cambridge University Press, 2002. 5. **Gilpin, ME, Ilkka A.H**. Metapopulation biology: ecology, genetics, and evolution. No. 504.7 MET. 1997.

8.2 Seminar / laboratory	teaching methods	Remarks
1. Introduction to the R language - vectors, matrices, data tables, lists.	Individual practical exercises on the computer	2 hours each
2. Writing own functions in the R language.		
3. Management of tables and databases in the R language. Statistical distributions and randomizations in the R language.		
4. Statistical distributions: binomial, Poisson, negative binomial, Cauchy, Lévy.		
5. The solution of first-order ordinary differential equations and the Lotka-Volterra competition model.		
6. Lotka-Volterra and Rosenzweig-MacArthur model.		
7. Modeling food webs - the effect of chain lengths.		
8. Modeling food webs - the effect of omnivory.		
9. Metapopulation models - Levins' model and its generalization.		
10. Metapopulation methods - simulation of community construction, emergence function model.		
11. Dynamics of infections. Density-dependent and frequency-dependent SIR models.		
12. Infection dynamics and numerical optimization.		
13. Random 1D, 2D and 3D movements.		
14. Recapitulation exercises.		
Bibliography 1. **Stevens, MH**A Primer of Ecology with R. Springer Science & Business Media, 2009. 2. **Bolker, BM**Ecological models and data in R. Princeton University Press, 2008. 3. **Bivand, RS**, et al. Applied spatial data analysis with R. Vol. 747248717. New York: Springer, 2008.		

9. Corroboration of the contents of the discipline with the expectations of representatives of the epistemic community, professional associations and representative employers in the field related to the program

By using computer simulations of various ecological and biological phenomena, the objectives achieved during the semester help to deepen the understanding of mathematical tools and their use in the various ecological problems related to nature conservation, environmental conservation - what in research/on the labor market is compliance with current requirements.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 evaluation methods	10.3 Weight of the final grade
10.4 Course	Evaluation of the skills to identify ecological phenomena and the corresponding	Verification of a prepared and	100%

10.5 Seminar/ laboratory	mathematical models, as well as the ability to formulate mathematical models in the R language.	taught manuscript, based on own modeling from the chosen ecology theme.	
10.6 Minimum Performance Standard			
75% of the courses are compulsory Successful completion of the practical exam is mandatory. The result of the final exam must be at least 5.			

Date of completion	Course holder's signature	Signature of the seminar holder
26.03.2023	Prof. dr. László Zoltán	Prof. dr. László Zoltán

Date of approval in the department	Signature of the department director
26.03.2023	Prof. dr. László Zoltán