COURSE DESCRIPTION

Phylogeograpghy and Numerical Analysis in Ecology
Academic year 2026-2027

1. Programme-related data

1.1. Higher Education Institution	Babeș-Bolyai University
1.2. Faculty	Faculty of Biology and Geology
1.3. Doctoral Shool	Integrative Biology
1.4. Field of study	Biology
1.5. Level of study	Doctorate

2. Course-related data

2.1. Course title	**Phylogeography and numerical analysis in ecology**			Course code	**BDR1105**
2.2. Course coordinator		Mihai Puşcaş / Dan Gafta			
2.3. Seminar coordinator		Mihai Puşcaş / Dan Gafta			
2.4. Year of study	1	2.5. Semester	1	2.6. Type of assessment	Viva voce
2.7. Course status		Optional		2.8. Course type	Complementary subject

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	4	of which: 3.2. course	2	3.3. seminar/ laboratory/ project	2
3.4. Total of hours in the curriculum	48	of which: 3.5. course	24	3.6. seminar/ laboratory	24
Time allocation for individual study (IS) and self-taught activities (ST)					**hours**
Learning from textbooks, course materials, bibliography, and notes (IS)					31
Additional research in the library, on subject-specific electronic platforms, and on-site					31
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					21
Tutoring (professional guidance)					18
Examinations					26
Other activities					
3.7. Total hours of individual study (IS) and self-taught activities (ST)				127	
3.8. Total hours per semester				175	
3.9. Number of credits				7	

4. Prerequisites (where applicable)

4.1. curriculum-related	• Genetics / Biogeography (undergraduate level) Biostatistics (undergraduate level)	
4.2 skills-related	Tabular calculations and graph production in electronic spreadsheets	

5. Specific conditions (where applicable)

5.1. course-related	Logistic support (digital video projector)	
5.2. seminar/laboratory-related	Logistic support (computer running under Windows 10 for each student) Access of students to the online platform Microsoft Teams Software for numerical analysis (R) Real and simulated datasets in electronic format Mandatory participation in at least 80% of the seminars	

6. Subject-specific learning outcomes

Knowledge
Explains and applies advanced concepts of phylogeography and numerical analysis in ecology to provide the theoretical foundation for studying the spatial distribution of genetic diversity and eco-evolutionary processes.
Critically analyzes quantitative methods and advanced statistical models, including spatial, multivariate, and phylogenetic analyses, applied to the interpretation of population genetic structure and its relationships with environmental factors.
Evaluates and integrates genetic, ecological, and geographic data using numerical analysis and modeling tools to reconstruct evolutionary history and to understand ecological mechanisms across different spatio-temporal scales.
4. ...
Skills
Applies advanced analytical methods to ecological and spatial datasets for investigating population structure and phylogeographic patterns.
Uses computational tools to model eco-evolutionary processes and to interpret relationships between organisms and their environment.
Integrates and critically interprets complex quantitative results, formulating scientifically relevant hypotheses and conclusions for ecological and phylogeographic research.
Responsibility and autonomy
Demonstrates autonomy in designing phylogeographic and ecological research frameworks, selecting appropriate methods according to research objectives and the nature of the available data.
Assumes responsibility for the correct interpretation of results, adhering to principles of academic ethics, reproducibility, and responsible use of scientific data.
Contributes to individual and team-based research activities, effectively communicating analytical results and integrating scientific feedback into decision-making and continuous learning processes

7. Contents

7.1. Course	Teaching and learning methods	Remarks[1]
Introduction in phylogeography: concepts, methods, discipline development and the main historical stages that marked this field	Presentation and discussions	
Quaternary climate variations and their implications for the current distribution of biomes; The concept of glacial refugia	Presentation and discussions	
Molecular techniques used in phylogeographic studies	Presentation and discussions	
Basics of population genetics. Genetic diversity: interpretations of its spatial distribution	Presentation and discussions	
Phytohistorical considerations: Quaternary glaciations and phylogeography of plant species in Romania	Presentation and discussions	
Phylogeographic patterns of Carpathian animal species implications for conservation	Presentation and discussions	
Generalised linear (mixed) models	Presentation and discussions	
Generalised additive models	Presentation and discussions	
Classification and regression trees	Presentation and discussions	
Non-hierarchical cluster analysis	Presentation and discussions	
Redundancy analysis based on ecological distances	Presentation and discussions	
Non-metric multi-dimensional scaling	Presentation and discussions	

[1] For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

Bibliography

- Avise JC (2000). Phylogeography: the history and formation of species. Harvard University Press: Cambridge, Massachusetts, London.
- Avise JC, Arnold J, Ball RM, Bermingham E, Lamb T, Neigel JE *et al* (1987). Intraspecific phylogeography: the mitochondrial DNA bridge between population genetics and systematics. *Annu Rev Ecol Syst* **18:** 489-522.
- Bhagwat SA, Willis KJ (2008). Species persistence in northerly glacial refugia of Europe: a matter of chance or biogeographical traits? J Biogeogr 35: 464-482.
- Hickerson MJ, Carstens BC, Cavender-Bares J, Crandall KA, Graham CH, Johnson JB et al (2010). Phylogeography's past, present, and future: 10 years after Avise, 2000. Mol Phylogenet Evol 54: 291-301.
- Holderegger R, Thiel-Egenter C (2009). A discussion of different types of glacial refugia used in mountain biogeography and phylogeography. J Biogeogr 36: 476-480.
- Hurdu BI, Escalante T, Puscas M, Novikoff A, Bartha L, Zimmermann NE (2016). Exploring the different facets of plant endemism in the South-Eastern Carpathians: a manifold approach for the determination of biotic elements, centres and areas of endemism. Biol J Linn Soc 119: 649-672.
- Ozenda P (1985). La Végétation de la Chaîne Alpine dans l'Espace Montagnard Européen. Masson: Paris.
- Puşcaş M, Taberlet P, Choler P (2008). No positive correlation between species and genetic diversity in European alpine grasslands dominated by Carex curvula. Diversity and Distributions 14: 852-861.
- Schönswetter P, Stehlik I, Holderegger R, Tribsch A (2005). Molecular evidence for glacial refugia of mountain plants in the European Alps. Mol Ecol 14: 3547-3555.
- Taberlet P (1998). Biodiversity at the intraspecific level: the comparative phylogeographic approach. Journal of Biotechnology 64: 91-100.
- Taberlet P, Cheddadi R (2002). Quaternary refugia and persistence of biodiversity. Science 297: 2009-2010.
- Taberlet P, Gielly L, Pautou G, Bouvet J (1991). Universal Primers for Amplification of 3 Noncoding Regions of Chloroplast DNA. *Plant Mol Biol* **17:** 1105-1109.
- Tribsch A (2004). Areas of endemism of vascular plants in the Eastern Alps in relation to Pleistocene glaciation. J Biogeogr 31: 747–760.
- Borcard D., Gillet F., Legendre P., 2018. Numerical Ecology with R. Springer, New York.
- Legendre P., Legendre L., 2012. Numerical Ecology. 3rd edition. Elsevier, Amsterdam.
- Crawley M.J., 2013. The R book. 2nd edition. John Wiley & Sons, Chichester.
- Wiley M., Wiley J.F., 2019. Advanced R Statistical Programming and Data Models: analysis, machine learning and visualization. Apress, New York.

7.2. Seminar/ laboratory	**Teaching and learning methods**	**Remarks**
Journal Club exercises, using representative articles of phylogeography	Case studies and exercises	
Spatio-temporal information (geographical, historical) on macroclimatic variations and their interpretation; analysis of the concept of glacial refugia and its importance for various groups of organisms	Case studies and exercises	
Notions of methods used in phylogeography: genetic markers (mitochondrial DNA in animals, chloroplastic DNA, mitochondrial DNA in plants, nuclear DNA, perspectives)	Case studies and exercises	
Analysis and interpretation of various patterns of intraspecific diversity: identification of glacial refugia and postglacial colonization routes	Case studies and exercises	
Analysis and interpretation of various current patterns of intraspecific diversity for dominant and key species of Romania's major ecosystems (I): the plant world	Case studies and exercises	
Analysis and interpretation of various current patterns of intraspecific diversity for dominant and key species of Romania's major ecosystems (II): the animal world	Case studies and exercises	
Performing generalised linear (mixed) models with real data	Case studies and exercises	
Performing generalised additive models	Case studies and exercises	

with real data		
Performing classification and regression trees with real data	Case studies and exercises	
Performing non-hierarchical cluster analyses with real data	Case studies and exercises	
Performing the redundancy analysis with real data	Case studies and exercises	
Performing the non-metric multi-dimensional scaling with real data	Case studies and exercises	

Bibliography

- Avise JC (2000). Phylogeography: the history and formation of species. Harvard University Press: Cambridge, Massachusetts, London.
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8. Evaluation

Type of activity	8.1 Evaluation criteria[2]	8.2 Evaluation methods[3]	8.3 Percentage in the final grade
8.4. Course	Assessment of knowledge	Interview	50%

[2] The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

[3] Both final evaluation methods and ongoing evaluation strategies should be established.

8.5. Seminar/ laboratory	Assessment of the acquired expertise and abilities	Testing queries Practical test on a PC	50%
8.6 Minimum standard for passing			
• ... Knowledge of 50% of the information contained in the course Acquisition of 60% of the skills practiced during seminars			

9. SDG labels (Sustainable Development Goals)[4]

	○ Sustainable Development Generic Label							
	2 FOAMETE „ZERO"	3 SĂNĂTATE ȘI BUNĂSTARE	4 EDUCAȚIE DE CALITATE	5 EGALITATE DE GEN	6 APĂ CURATĂ ȘI SANITAȚIE	7 ENERGIE CURATĂ ȘI LA PREȚURI ACCESIBILE	8 MUNCĂ DECENTĂ ȘI CREȘTERE ECONOMICĂ	9 INDUSTRIE, INOVAȚIE ȘI INFRASTRUCTURĂ
○	○	○	○	○	○	○	○	○
10 INEGALITĂȚI REDUSE	11 ORAȘE ȘI COMUNITĂȚI DURABILE	12 CONSUM ȘI PRODUCȚIE RESPONSABILE	13 ACȚIUNE CLIMATICĂ	14 VIAȚA ACVATICĂ	15 VIAȚA TERESTRĂ	16 PACE, JUSTIȚIE ȘI INSTITUȚII EFICIENTE	17 PARTENERIATE PENTRU REALIZAREA OBIECTIVELOR	No label applies
○	○	○	○	○	x	○	○	○

Date of issue
20.02.2026

Signature of the teacher responsible for lectures
Prof. dr Mihai Pușcaș
Conf. dr. Dan Gafta

Signature of the teacher responsible for seminars
Prof. dr Mihai Pușcaș
Conf. dr. Dan Gafta

Date of approval by the doctoral school council

27.02.2026

Signature of the doctoral school director

[4] Select a single label which, according to the *Implementation of SDG labels in the academic process*, best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: *"No label applies."*