Name of the subject: MATHEMATICAL AND STATISTICAL METHODS IN BIOLOGICAL RESEARCH

Teacher(s): Dr.Vladimir Kostić

Status of the subject: elective

Number of ECTS points: 15

Condition: -

Goal of the subject

Enabling students to independently use basic modern mathematical and statistical methods in research through the integration of theoretical knowledge and the development of programming skills to analyze empirical data and perform scientific reasoning.

Outcome of the subject

Students will master techniques of mathematical modeling with differential equations and techniques of multivariate statistical analysis, as well as their implementation on selected biological and ecological phenomena using the software package R.

Content of the subject

Theoretical lectures

Introduction to Scientific Modeling - deterministic and statistical models. Mathematical modeling of dynamic processes via differential equations. Model of empirical food webs - model setup, analysis, simulations and conclusions. Basics of statistical modeling. Descriptive data research techniques (EDA) - descriptive statistics in biology and ecology, tables, charts. Basic tests of univariate statistical analysis. Basic tests of multivariate statistical analysis. Cluster analysis. Principal component analysis and factor analysis.

Practical lectures

Introduction to R programming language. Data preparation and processing in R Studio environment. Programming basics in R. Writing algorithms in R for scientific computation - determining the stability indicators of empirical food webs. Descriptive statistical methods in R. Univariate statistical analysis in R. Multivariate statistical analysis in R.

Recommended literature

1. K. Soetaert, P. M. J. Herman, A Practical Guide Ecological Modeling: Using R as a Simulation Platform, Springer (2008)
2. D. Borcard, F. Gillet, P. Legendre, Numerical Ecology with R, Springer (2018)
3. C. Dyltham, Choosing and Using Statistics – A Biologists's Guide, Wiley-Blackwell (2011)

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Within theoretical lectures, starting with an understanding of key mathematical and statistical models in biological research, tools for their deeper analysis are gradually introduced, and finally guidelines for independent scientific research are proposed. Practical training consists of working on a computer in the R programming language using the R Studio package.

Evaluation of knowledge (maximum number of points 100)

Knowledge assessment is in the form of presentation of a self-realized project and consists of an oral exam of theoretical knowledge (50 points) and mastered programming skills in R (50 points).

Name of the subject RESEARCH METHODOLOGY

Teacher(s): Dr. Vesna Milankov

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal

The course aims at enabling students for presenting research results, writing research articles and a PhD thesis and evaluating the scientific research.

Outcome of the subject

Competent presentation and publication of scientific information. Research competence.

Content of the subject

Theoretical lectures

Modern methods of collecting information and processing and analyzing research data in biological disciplines. Methods and techniques of researching and presenting results. Writing and presenting a doctoral thesis and a research article. Preparing manuscripts for publication – from manuscript writing to publishing. Digital data and e-publications. Forms of scientific publications. Scientometrics. Ranking research publications. Reviewing articles. Evaluation of reserchers and publications. Ethics in science – The codex of good scientific practice. Abuses of science. Logic errors. General and subject-specific scientific methods. Analysis of relevant scientific publications.

Recommended literature

Briscoe, M.H. (1996) Preparing scientific illustrations. 2nd ed. Springer-Verlag, New York.

Ebel, H.F., Bliefert, C., Russez, W.E. (2004) The art of scientific writing. Wiley-VCH Verlag GmbH & Co. KGaA.

Milankov, V. & Jakšić P. (2007) Методологија научноистраживачког рада у биолошким дисциплинама. ПМФ. (уџбеник) [*Research methodology in biological disciplines.Faculty of Sciences.textbook*]

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Oral and database searching in computer lab.

Evaluation of knowledge (maximum number of points 100)

Pre-exam obligations: 30

Oral exam: 70

Name of the subject: PHYSIOLOGICAL PLANT ECOLOGY

Teacher(s): Dr. Slobodanka Pajević, Dr. Nataša Nikolić

Status of the subject: Elective

Number of ECTS points: 15

Condition: -

Goal of the subject

The primary objective of the course is developing and understanding relationship between individual plants and the abiotic and biotic components of their environment. The course will focus on how plants function in their natural environments and tolerate stress, what (metabolic) options are available to avoid stress, how plants acquire and allocate resources, and to what extent physiological characteristics enhance ecological success.

Outcome of the subject

Lectures will familiarize students with physiological capacities of plants in different ecological conditions and prepare students to apply concepts and tools of plant physiology to today's complex environmental research questions.

Content of the subject

Theoretical lectures

Abiotic and biotic factors in physiological mechanisms of plant growth and development. Physiological response of plants to water environment. Plant responses to hypoxia and anoxic stress - symptoms and metabolic adaptation. Plants and extreme temperatures in environment - adaptation on cell level. Drought low temperatures. CO2 fixation in different ecological conditions: C3, C4 and CAM plants. Photosynthetical and nonphotosynthetical plant responses to light. Photoperiod, photomorphogenesis. Nutrient cycling in ecosystems. Eutrophication and pollution of freshwater ecosystems. Plant nutrition and plant responses to different ions. Osmotic regulation in plants. Ecophysiology of N2-fixing systems: symbiotic association's plants and bacteria, plants and blue green algae. Allelopathy. Pollution and plants.

Practical lectures

Setting up the experiments in a glasshouse and climate chamber on plant species while simulating specific stress conditions depending on the goals of the experiments related to the doctoral thesis. Laboratory analysis of selected physiological parameters in accordance with the goals of the thesis and scientific papers.

Writing seminar papers.

Recommended literature

Larcher, W. (2003) Physiological Plant Ecology. Springer, ISBN 3540435166, p. 513

Pugnaire, F.I., Valladares, F. (1999) Handbook of Functional Plant Ecology. CRC Press, p. 920

Lambers, H., Pons, T.L., Chapin, F.S. (1998) Plant Physiological Ecology, Springer

Scientific papers

Electronic sources

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Evaluation of knowledge (maximum number of points 100)

Activities on lectures 10

Test 50

Seminar work 40

Name of the subject: SPATIAL DATA

Teacher(s): Dr. Dubravka Milić, Dr. Dejan Stojanović

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

To enable students acquiring knowledge in the area of spatial data modeling, as well as the use of GIS tools and spatial statistics. The emphasis will be on modeling climate change impacts on ecosystems using the ecological niche models. Different possibilities of using modern GIS tools in ecology will be presented. R software environment will be used for statistical analysis and visualization of results through practical examples.

Outcome of the subject

After completing the course, students will be introduced to a series of methodological approaches for modeling the effects of changing ecological conditions on ecosystems and to be able to practicaly apply them in ecology. In addition to analyzing the impact of current climatic conditions, students will gain insights into potential climate change scenarios and their impact on ecosystems.

Content of the subject

Theoretical lectures

1. Application of GIS in Modeling
2. Adaptations to climate change
3. *Current trends and perspectives*

Practical lectures

1. Modeling of Spatial Data in Changing Environment Conditions
2. *Application of the R statistical framework*

Recommended literature

Stojanović (2018). Osnove R-a (inovativnost, zanat, jezik). Institut za nizijsko šumarstvo I životnu sredinu. 153 str.

Bivand, R. S., Pebesma, E. J., & Gómez-Rubio, V. (2008): Applied spatial data analysis with R. New York: Springer.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

At the lectures, the PhD students will use visual and other teaching materials in order to acquire the theoretical basis. PhD students will use modern software tools and familiarize themselves with available methods in their practical work. During the semester, PhD students will make seminar work based on the chosen topic.

Evaluation of knowledge (maximum number of points 100)

Seminar – 50; Oral exam – 50.

Name of the subject: FOREST ECOSYSTEMS AND SUSTAINABLE DEVELOPMENT

Teacher(s): Dr. Saša Orlović

Status of the subject: Elective

Number of ECTS points:15

Condition:

Goal of the subject

The aim of the course is to gain the necessary knowledge for conducting research in forest ecosystems and possibility for sustainable use.

Outcome of the subject

The students will have appropriate knowledge for conducting research in forest ecosystems and they will have opportunity to analyze, improve which are important for multifunctional management.

Content of the subject

Theoretical lectures

Forest ecosystems, Forests- definition, An importance of forests, Functions of forests, Forest biomass, Forest and air, Forest and climate, Forest and water, Forest and soil, Forest and biodiversity, Forest landscape, Landscape management, Forest protection, Conservation of forest genetic resources, Floodplain forests, Silviculture, Sustainable multifunctional management of forest ecosystems.

Practical lectures

Case study.

Recommended literature

1. dr Slobodan Vučićević: Forest and environment, Faculty of Forestry Bepgrade and PU Srbijašume 1999.
2. Group of authors: National Forest Landsape Management. US Dept. Of Agriculture Handbook No. 559
3. Fransoise Burel, Jasques Baundry: Landscape Ecology. Science Publishers, USA, 1999.
4. David Perry, Ram Oren, Stephen Hart. Forest Ecosystems. John Hopkins University press 606.

Number of active classes	Theory: 5	Practice:5

Methods of delivering lectures

Oral presentation and consultation, simulation.

Evaluation of knowledge (maximum number of points 100)

Activity: 10
Acitivities during lectures: 10
Practical work: 20
Seminar: 60

Name of the subject: EXTREME BIOCHEMISTRY

Teacher(s): Dr. Danijela Kojić, Dr. Željko Popović

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The aim of this course is to introduce students to broad biochemical and physiological strategies of organisms adapted to extreme habitats – high/low temperatures, high/low pH, high salinity, drought, anoxia etc.

Outcome of the subject

After finishing the course, students should be able to use the knowledge of biochemical processes and biomolecular forms to distinguish specific adaptation mechanisms which enable organisms to survive extreme enviromental conditions.

Content of the subject

Theoretical lectures

Lectures will cover the following topics: Introduction to extremophiles and their habitats; Water-solute problems: osmosensors and regulation of osmolytes, supercooling, anhydrobiosis; Protein stability and flexibility; Protein structural and functional adaptation to extreme conditions: heat shock proteins (HSPs), late embryogenesis abundant proteins (LEA proteins), aquaporins, intrinsically disordered proteins (IDPs) etc.; Structure and adaptation of the cell membrane; Cold hardiness, diapause, estivation, hibernation;

Practical lectures

Student research paper in the relevant field which will cover browsing of literature, preparation and defence of paper.

Recommended literature

Hochachka W. P. Somero G.N.(2002): Biochemical Adaptation, Oxford University Press
Nikolić, N., Kojić, D., Popović Ž.D. (2019) Mehanizmi ekoloških adaptacija organizama. PMF, Novi Sad
Denlinger, D., & Lee, Jr, R. (Eds.). (2010). Low Temperature Biology of Insects. Cambridge: Cambridge University Press
Wilmer P., Stone G., Johnston I.(2000): Environmental Physiology of Animals, Blackwell Science Ltd.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, consultation, preparation and defence of research paper.

Evaluation of knowledge (maximum number of points 100)

Preparation and defence of research paper – 50 points; oral exam – 50 points

Name of the subject: SELECTED CHAPTERS OF MICROBIAL ECOLOGY		
Teacher(s): Dr. Dragan Radnović		
Status of the subject: elective		
Number of ECTS points: 15		
Condition: course selection is conditioned by prior consultations with the subject teacher in order to achieve the optimum form of engagement and certain subject tasks which in one part of the planned activities should be directed to the subject of the candidate's doctoral dissertation		
Goal of the subject The objective of the course is to acquire knowledge about the role and importance of microorganisms in natural and artificial habitats		
Outcome of the subject After successful completion of pre-exam and exam obligations, the student should be able to: - Explain the role and importance of microbial communities in different habitats and environments - to plan and conduct microbial community testing and interprets the obtained results - explain what environmental factors caused the emergence of a specific microbial community and draw adequate conclusions		
Content of the subject *Theoretical lectures* Compulsory chapters are: Taxonomy and evolution of microorganisms, habitats of microorganisms (diversity, adaptation and interactions), significance and functioning of microbial ecosystems and methods in ecology of microorganisms. The selected chapters will be processed in consultation with the subject teacher. *Student research work:* The student research work will be conducted under the mentorship of the subject teacher, and will be related to the selected field of microorganism ecology, which is the subject of interest of the student or is related to the topic of his doctoral dissertation.		
Recommended literature Jean-Claude Bertrand, Pierre Caumette, Philippe Lebaron, Robert Matheron, Philippe Normand (2015): Environmental microbiology. Fundamentals and applications. Microbial ecology. Springer. ISBN 978-94-017-9117-5 Atlas R.M, Bartha R. (1998): Microbial Ecology. Fundamental and applications. 4/th ed. Benjamin/Commings Publisching Company. ISBN-0-8053-0655-2 Burlage R.S., Atlas R., Stahl D., Greesey G., Sayler G. (1998): Tehnicques in Microbial Ecology. Ed Burlage R. Oxford University Press. ISBN-0-19-509223-6 Review of the recent articles related to frontiers of microbial of microorganisms.		
Number of active classes	Theory:5	Practice:5
Methods of delivering lectures Classes are taught according to a system of consultations in defined units. In agreement with the teacher and the mentor, the student selects a topic for a seminar paper that relates to biochemical methods in microbiology with the obligation to search the Internet and / or standard library documentation. Seminar work involves presentation on a given topic in the form of a presentation before a group and subject teacher and a defense at the end of the presentation. Journal club - presentation and discussion of scientific work in the field. Practical work is performed in the laboratory work using new methods that is necessary for the microbial community analysis on the different levels.		
Evaluation of knowledge (maximum number of points 100):		
Assignment - up to 30, Seminar up to 30, Project Presentation of scientific work up to 10. Oral exam up to 30 points		

Name of the subject: ECOTOXICOLOGY 2

Teacher(s): Dr. Ivana Teodorović

Status of the subject: elective

Number of ECTS points: 15

Condition: Chemistry / Environmental chemistry, Biochemistry, Plant and animal physiology

Goal of the subject

Understanding, assessing and predicting the biological and ecological effects of chemicals in environmentally realistic multi-stress conditions.

Outcome of the subject

Successful students will understand the effects of chemical pressure in multi-stress conditions. They will gain a solid in-depth knowledge on fate, behaviour, toxicokinetics and toxicodynamics of the selected class(es) of the ecotoxicologically relevant pollutants as well as the effects of environmentally realistic mixtures / cocktails of chemicals on different levels of biological organisation: sub-individual, individual, population and ecosystem level. Successful students will be skilled to independently conduct an array of in situ, in vivo, in vitro and omic based assays and apply selected ecotoxicological models, to process and analyse results and interpret own as well as literature data, in accordance with the contemporary ecotoxicological theories and principles and in compliance with the current national and EU environmental regulations in the field of chemicals and ecological risk assessment.

Content of the subject

Theoretical lectures: Comprehensive overview of the ecotoxicologicaly most relevant toxic pollutants (including their metabolites and transformation products), fate and behaviour in various environmental media and ecosystems, with special emphasis on pesticides, biocides, selected industrial chemicals, humane and veterinary pharmaceuticals, personal care products, nanomaterials, micro/nanoplastics. Advanced analytical and bioinformatic tools for identification of key environmental pollutants. Environmental fate, toxicokinetics, toxicodynamics and mode-of-action on individual (including humans), population and ecosystem level. Ecotoxiclogically relevant chemical mixtures and mixture effects. Environmentally realistic chemical cocktails and their ecological effects in multi-stress conditions. Integration of advanced analytical, bioinforamtic, effect-based and ecological tools and methods for monitoring and identification of key toxic pollutants and mixtures causing stress in various types of ecosystems. Risk characterisation, assessments and mitigation of chemically stressed ecosystems. Ecological status decline as a consequence of toxic stress. Overview of relevant international conventions, EU and national environmental regulations.

Practical lectures: Selected in situ, in vivo tests; in vitro and omic based assays and important ecotoxicologically relevant effect and predictive models.

Recommended literature

Basic reading: Newman M.C. and Clements W.H. (2008) Ecotoxicology. A Comprehensive Treatment. CRC Press and Taylor and Fransis Group, Boca Raton, Fl, USA. (book and e-book available)

Further reading: scientific reviews and research papers published in relevant international journals (available via KOBSON)

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures/consultations, discussion groups. independent literature research, independent / supervised laboratory research

Evaluation of knowledge (maximum number of points 100)

Topical mini-review 50 points, oral exam 50 points

Name of the subject: CYANOBACTERIAL TOXINS

Teacher(s): Dr. Zorica Svirčev

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The objective of the course is to systematize current knowledge of cyanobacterial toxins and to recognize the problems that cyanobacteria cause in aquatic ecosystems and their environment and the problems related to human and animal health.

Outcome of the subject

Enabling students to: recognize all aspects of cyanobacterial mass development in aquatic ecosystems, learn cyanotoxin detection methods, prevent human and animal exposure to these toxins, and cure humans and animals in the cases of exposure.

Content of the subject

Theoretical lectures

Ecological strategies of cyanobacteria. Cyanobacterial bloom and cyanotoxin occurence in aquatic ecosystems. Cyanobacterial toxins - cyanotoxins, basic characteristics and division. Mechanisms of cyanotoxin action. Cyclic peptides: microcystins and nodularin; alkaloids: anatoxin-a, anatoxin-s, cylindrospermopsin, saxitoxins; neurotoxic amino acids - BMAA; endotoxins - lipoplisaccharides. Cyanotoxin detection methods. Toxicity tests. Ways of human exposure to cyanotoxins. Protection against the harmful effects of cyanotoxins on human and animal health. Situation in Serbia. Cyanotoxins of terrestrial crusts, their importance and role.

Practical lectures

Students would be actively involved in experimental work in the framework of research and applicative projects.

Recommended literature

1) Свирчев З. (2005): Микроалге и цијанобактерије у Биотехнологији. Природно математички факултет. Универзитет у Новом Саду, Нови Сад.

2) Svirčev Z., Baltić V. (2009): Serbian guideline for cyanobacterial blooms. Environmental and health risks. Departman za biologiju i ekologiju, PMF i Medicinski fakultet, Univerzitet u Novom Sadu, Novi Sad.

3)Sedmak B., Svirčev Z. (2011): Cijanobakterije i njihovi toksini – ekološki i toksikološki rizici i cvetanje cijanobakterija u Srbiji. Visoka škola za varstvo okolja, Velenje.

4) Svirčev Z., Drobac D., Tokodi N., Đenić D., Simeunović J., Hiskia A., Kaloudis T., Mijović B., Šušak S., Protić M., Vidović M., Onjia A., Nybom S., Važić T., Palanački Malešević T., Dulić T., Pantelić D., Vukašinović M., Meriluoto J. (2016): Lessons from the Užice case: how to complement analytical data. In: Handbook of Cyanobacterial Monitoring and Cyanotoxin Analysis (J. Meriluoto, L. Spoof & G.A. Codd, Eds.), Chichester: Wiley, pp. 298-308.

5) Codd G.A., Testai E., Funari E., Svirčev Z. (2017): Cyanobacteria, Cyanotoxins and Human Health. In Handbook: Water Treatment for Purification from Cyanobacteria and Cyanotoxins (A. Hiskia, D. Dionysiou, M. Antoniou, T. Kaloudis, T. Triantis, Eds.), Chichester: Wiley, pp. Chapter 2 .

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Consultations, presentations, lab work, scientific papers and communications.

Evaluation of knowledge (maximum number of points 100)

Project presentation and defense - 50 points Oral exam - 50 points

Name of the subject: MICROBIOLOGY OF GROUNDWATERS AND DRINKING WATERS

Teacher(s): Dr. Petar Knežević

Status of the subject: elective

Number of ECTS points: 15

Condition: -

Goal of the subject

The objective of the course is to gain knowledge about the species and significance of particular groups of microorganisms role in biogeochemical cycles and oxidative reduction processes in natural environments, as well as their health significance. The goal of the course is to get acquainted with the legal regulations in the field of groundwater and drinking water.

Outcome of the subject

Within the course, knowledge and skills will be gained related to: the basic biological characteristics of groundwater as potential water sources, the types and quality of drinking water, the methods of detection of certain groups of microorganisms in these environments, the new methods and techniques of testing and legislation (WHO regulations and EU directives).

Content of the subject

Theoretical lectures

Groundwater as a natural resource and problems of water supply quality. Specificities of groundwater ecosystems. Abundance and distribution of bacteria in groundwater, growth and reproduction. Possibilities of biodegradation of anthropogenically induced contaminants in groundwater systems. Natural organics in groundwater and the impact on the microbiological quality of drinking water. Iron and manganese in groundwater and control of iron bacteria in the water supply system. Application of activated carbon in groundwater treatment technologies for drinking water. Presence and functional role of certain groups of microorganisms (viruses, bacteria, protozoa, algae, fungi) in drinking water. Detection methods for individual groups, contemporary test methods and techniques. Application and efficiency of disinfection procedures. The problem of biofilm and water supply system reinfection. Legislation and protection.

Practical lectures

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Recommended literature

Basic literature:

- Bitton, G. Microbiology of Drinking Water: Production and Distribution. Wiley Blackwell, 2014.
- Chapelle, F., H. Ground-water Microbiology and Geochemistry. John Wiley& Sons Inc, 2000.
- Cullimore, R. Microbiology of Well Biofouling. Lewis Publishers, USA, 2000.
- Petrović O., Radnović D., Gajin S., Matavulj M. , Svirčev Z. (2001): Mikroorganizmi u vodi za piće, uticaj dezinfekcije, zakonska regulativa. Ed. Dalmacija B. "Kontrola kvaliteta voda", Prirodno-matematički fakultet,Institut za hemiju, Novi Sad, pp.439-451.
- Petrović O., Gajin S., Knežević P. (2005): Mikrobiološki aspekti primene i efikasnost dezinfekcije vode zapiće. U knj. "Dezinfekcija vode" ed B. Dalmacija et al., PMF, Departman za hemiju, Novi Sad, str.88-104

Selection of literature for study research work (seminar paper).

Number of active classes	Theory: 5	Practice:5

Methods of delivering lectures

Presentations, consultations and individual work

Evaluation of knowledge (maximum number of points 100)

Oral exam: 50

Study research: 50

Name of the subject: MICROBIOLOGY OF POLLUTED WATERS

Teacher(s): Dr. Jelica Simeunović

Status of the subject: elective

Number of ECTS points: 15

Condition: -

Goal of this course is to familiarize students with the metabolic diversity of microorganisms, especially bacteria and their functional role in the processes of biodegradation of organic components in polluted waters, as well as in interactions with various pollutants (petroleum, phenols, pesticides, heavy metals). Indicator microorganisms and legislation in the field of polluted waters.

Outcome of the subject

Acquisition of knowledge about basic microbiological characteristics of different types of polluted waters, treatment options, microbial communities and their active involvement in the process, their bioindicative significance and detection methods.

Content of the subject

Theoretical lectures

Sources, types and degrees of water pollution. Ecophysiological and biochemical properties of contaminated water microorganisms. Indicator microorganisms in monitoring of the quality of polluted waters. Thermotolerant coliforms as indicators. Pathogens and potentially pathogenic microorganisms and health risk assessment. The problem of eutrophication, cyanobacterial and microalgal proliferation, and the presence of toxins in water. Application of different methods of detection of particular microbial groups in monitoring of polluted waters (spectrophotometry, biosensors, molecular methods, electron microscopy etc.). Microorganisms as active participants in the process of purification of polluted waters. Biological characteristics of wastewater and application of microorganisms in biological treatment processes. Regulation of microbiological quality in the hydrological cycle. Legislation in the field of polluted waters

Practical lectures

Recommended literature

1. Gaćeša S., Klašnja M. (1994): Tehnologija vode i otpadnih voda. Jugoslovensko udruženje pivara, Beograd
2. Popović M., Krsmanović G., Brković-Popović I. (1968): Prilaženje problemu tretiranja industrijskih otpadnih voda – metodologija rada.ITEN, Beograd.
3. Gabriel Bitton (2013): Wastewater Microbiology. John Wiley & Sons, ISBN 8126538422 p. 781.
4. Jorge W. Santo Domingo, Michael J. Sadowsky (2007): Microbial Source Tracking. ASM Press,ISBN 1555813747, p.285.
5. Duncan Mara, Nigel J. Horan (2003): Handbook of Water and Wastewater Microbiology. Academic Press, Elsevier,UK, ISBN 0-12-470100-0, p.832
6. Andriy Lutsenko, Vasyl Palahniuk (2009): Water Microbiology: Types, Analyses and Disease-causing Microorganisms, Nova Science Publishers, ISBN 160741273X, p. 364.
7. Helen Bridle (2013): Waterborne Pathogens Detection Methods and Applications. Academic Press**,** eBook ISBN: 9780444595461, p.416.
8. Cloete T.E. , Muyima N.Y.O. (1997): Microbial Community Analysis – The Key to the Design of Biological Wastewater Treatment Systems. Scientific and technical Report No.5
9. Aly E. Abo-Amer (2011): Molecular Approach for Detection of Waterborne Pathogens. Nova Science Publisher's, ISBN 1612095720, p. 92.
10. Jef Huisman, Hans C.P. Matthijs, Petra M. Visser (2005): Harmful Cyanobacteria. Springer, The Netherlands
11. Eikelboom H.D. (2000): Process Control of Activated Sludge Plants by Microscopic Investigation.IWA Publishing, London.
12. Božena Tušar (2004): Ispuštanje i pročišćavanje otpadne vode s zakonskom regulativom. Croatia knjiga, Zagreb

Number of active classes	Theory: 5	Practice:5

Methods of delivering lectures

Consultations, PP presentations, seminar presentations

Evaluation of knowledge (maximum number of points 100)

Seminar work: 50

Oral exam: 50

Name of the subject: DIVERSITY OF VERTEBRATE FAUNA OF SERBIA

Teacher(s): Dr. Desanka Kostić

Status of the subject: elective subject

Number of ECTS points: 15

Condition:

Goal of the subject

Familiarizing with factors that have affected the diversity of vertebrate fauna in Serbia; review of species coverage according to regions and subregions of Serbia; endemism; international importance of species; red books and lists.

Outcome of the subject

Students should acquire wider knowledge on the diversity of vertebrate fauna in Serbia.

Content of the subject

Theoretical lectures

The importance of biodiversity and its preservation. Cyclostomata diversity (Monorhina); freshwater fish (Osteichthyes); amphibia (Amphibia); reptiles (Reptilia); birds (Aves) and mammals (Mammalia) of Serbia with the overview of species of international importance. The factors that negatively affect biological diversity. Biodiversity in sensitive ecosystems, protected areas and areas of international importance on the territory of Serbia. Laws, rulebooks, regulations and orders of the Republic of Serbia for preservation of biodiversity. International laws, agreements, standards and programmes of importance for preservation of the biodiversity in Serbia.

Practical lectures

Field work and seminar papers.

Recommended literature

Stevanović, V., Vasić, V. (1995): Biodiverzitet Jugoslavije. Biološki fakultet Univerziteta u Beogradu

Simonović, P. (2001): Ribe Srbije. NNK International, Zavod za zaštitu prirode Srbije, Biološki fakultet. Beograd.

Šćiban, M. i sar. (2015): Ptice Srbije. Pokrajinski zavod za zaštitu prirode, Društvo za zaštitu i proučavanje ptica Srbije. Novi Sad.

Puzović S. (2009): Značajna područja za ptice u Srbiji. Ministarstvo životne sredine i prostornog planiranja, Zavod za zaštitu prirode Srbije, Pokrajinski sekretarijat za zaštitu životne sredine i održivi razvoj.

Ajtić, R. i sar. (2015): Crvena knjiga faune Srbije I – Vodozemci. Zavod za zaštitu prirode Srbije, Biološki fakultet Univerziteta u Beogradu.

Ajtić, R. i sar. (2015): Crvena knjiga faune Srbije II – Gmizavci. Zavod za zaštitu prirode Srbije, Biološki fakultet Univerziteta u Beogradu.

Radišić, D. i sar. (2018): Crvena knjiga faune Srbije III –Zavod za zaštitu prirode Srbije;Univerzitet u Novom Sadu Prirodno-matematički fakultet Departman za biologiju i ekologiju; Društvo za zaštitu i proučavanje ptica Srbije.

All available papers from the given field that correlate to the interest of the PhD students.

Number of active classes	Theory: 5	Practice: 5

Methods of deliveringlectures

Oral presentation with the aid of modern techniques, active teaching

Evaluation of knowledge (maximum number of points 100)

Seminar 70 Oral exam 30

Name of the subject: ECOLOGY AND DIVERSITY OF TETRAPOD HELMINTHS

Teacher(s): Dr. Olivera Bjelić Čabrilo

Status of the subject: elective

Number of ECTS points: 15

Condition: none

Goal of the subject

An understanding of the significance of monitoring the composition of tetrapod helminth fauna, in light of the helminths' pathogenicity and effects on domestic and wild animals and man.

Outcome of the subject

Students are capable of recognizing and collecting different types of helminths and understand their significance in animal, public and environmental health, which allows them to become involved in laboratory work.

Content of the subject

Theoretical lectures

A historic review of helminthology and its importance as a science. Classification of tetrapod helminths. An overview of helminth types:

a) Digeneans. Effects of ecological factors on the infection of the first intermediate host. Effects of ecological factors on the infection of the second intermediate and definitive hosts. Hostal specificity and localization. Interspecific interactions of different digenean species. Main directions of digenean evolution. Classification of digeneans parasitizing in tetrapods.

b) Cestodes. The biology and structure of cestodes. Development cycles of various cestode species. Classification. Hostal specificity. Environmental factors that lead to infection with specific cestode species.

c) Nematodes. Infection pathways and localization. Hostal specificity. Effects of abiotic and biotic factors on host infection. Classification.

d) Acanthocephalans.

Interactions between different helminth types. Helminthic zoonoses and the role of tetrapods in their expansion.

Practical lectures

Helminthological examination of different tetrapod hosts. Creation of permanent microscopic slides of digeneans and cestodes. Illumination of nematodes and acanthocephalans in lactic acid. Helminth identification and morphometry.

Recommended literature

1. Kulišić Z. Helmintologija. Veterinarska komora Srbije, Beograd, 2001.
2. Lalošević V i saradnici. Parazitologija. Poljoprivredni fakultet, Novi Sad, 2012.
3. Lalošević V. Parazitološki praktikum. Poljoprivredni fakultet, Novi Sad, 2008.
4. Morand S, Krasnov BR, Poulin R (Eds.). Micromammals and macroparasites: From Evolutionary Ecology to Management. Springer. 2006.
5. Anderson RC. Nematode Parasites of Vertebrates: Their Development and Transition. 2nd Edition. CABI Publishing, Wallingford, UK. 2000.
6. Anderson RC, Chabaud AG, Willmott S. Keys to the Nematode Parasites of Vertebrates. CABI Publishing, Wallingford, UK. 2009.
7. Popović E, Kostić D, Bjelić-Čabrilo O, Hristovski N. Helminthofauna of tailless amphibians (Amphibia: Anura) of the Vojvodina province. Bitola, 2009.

All available scientific papers relating to the course subject, in line with the student's interest.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, practical and theoretical work in the lab.

* research papers on selected and/or given topics

Evaluation of knowledge (maximum number of points 100)

Colloquium 20 Oral exam 50 Research paper 30

Name of the subject: MANAGEMENT OF PROTECTED AREAS AND ECOSYSTEMS

Teacher(s): Dr. Ante Vujić, Dr. Dubravka Milić

Status of the subject: Elective

Number of ECTS points: 15

Condition:

Goal of the subject

The main objective of the course is learning about the management of protected areas, with special emphasis on the sustainable management of resources. Students learn about environmental management, gain a broader insight into the affairs of conservation and ecosystem management, ecosystem modeling, landscape management and restoration processes. Analysis of experiences in managing protected areas in the world and our country is one of the tasks of the course. Special attention is given to development of projects on conservation and restoration of ecosystems on concrete examples.

Outcome of the subject

At the end of the course student will be qualified to engage in practical projects related to conservation and preservation of ecosystems and will acquire basic knowledge necessary for successful participation in the teams that manage the protected natural resources.

Content of the subject

Theoretical lectures

Management of protected areas. Natural processes and environmental management in protected areas. Environmental sustainability in protected areas. Fragmentation of natural units. Management of vulnerable populations in protected areas. Management of overreproduced species in protected areas. Cultural and natural resources in protected areas. Conservation and management of ecosystems. The choice of data relevant to ecosystem management. Modeling of ecosystems. Landscape management processes. Types of restoration, criteria and valuation. Protocols, procedures and examples of successful ecological restoration.

Practical lectures

Examples of protected areas management: national parks, nature reserves and natural monuments in the world. The practice of management of protected natural resources in Serbia. Practical examples of the role of science in protecting the resources of National parks. Analysis of experience of managing protected areas in the world. Analysis of national practices. Examples of degradation of habitats and their restoration. Seminars related to the practical examples of conservation and restoration of ecosystems and the theoretical models of methods of conservation and restoration of ecosystems.

Recommended literature

1. Worboys, G., Lockwood, M., De Lacy, T. (2001): Protected area management: principles and practice. Oxford University Press.
2. Van Dyke, F. (2003): Conservation Biology. Foundations, Concepts, Applications. McGraw-Hill
3. Pullin, A. S. (2002): Conservation Biology. Cambridge University Press
4. http://www.cr.nps.gov/history/books-title.htm
5. http://www.world-national-parks.net/
6. http://www.forestshop.com/f-mngmnt.html

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Video presentation, seminar preparation and defense.

*Preparation and defense of the project in the field of conservation of ecosystems and natural resource management.

Evaluation of knowledge (maximum number of points 100)

Pre-exam testing 30

Project presentation 70

Name of the subject: INFLUENCE OF ECOLOGICAL FACTORS ON HUMAN POPULATIONS

Teacher(s): Dr. Rada Rakić, Dr. Tatjana Pavlica

Status of the subject: Elective Course

Number of ECTS points: 15

Condition: -

Goal of the subject

Students acquire knowledge related to the influence of environmentaland stresogenic factors on human traits, distribution and density of human populations.

Outcome of the subject

Students are educated about the activities of improving environmental conditions which are basis for obtaining stable human populations.

Content of the subject

Theoretical lectures

The role of abiotic factors in man adaptation; The role of biotic factorsin man adaptation; The influence of modern age upon human population; Anthropological investigations of human population adaptation in specific living conditions. Man adaptation in tropical environment; Morpho-physiological characteristics of population in subtropical regions; Anthropological characteristics of population in high mountain regions; Biological characteristics of populations in moderate climate regions; Biological characteristics of populations in continental parts of North Asia; Morpho-physiological characteristics of populations in north regions; The influence of environmenral and social factors on morpho-physiological characteristics; Growth and development of man in different ecological niches.

Practical lectures -

Recommended literature

1. Алексеева Т.И: Географическа среда и биологиа человека, Издателъство Москва 1977.
2. Алексеева Т.И: Адаптациа человека в различних екологических ничах земли, Издателъство Москва,1988.
3. Bernard Campbell: Human ecology, ALDINE Publishing Company, New York, 1985.
4. Harrison G.A., Tanner J.M., Pilbeam D.R., Baker P.T.: Human Biology, An introduction to human evolution, variation, growth, and adaptability, Oxford University Press, 1988.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Seminar papers and consultations by defined units. The students themselves or in agreement with the teacher choose topics for seminar work.

Evaluation of knowledge (maximum number of points 100)

Seminar paper earns 70 points, while the student earns 30 points at the final examination

Name of the subject: DATA ANALYSIS IN AQUATIC BIOLOGY

Teacher(s): Dr.Tamara Jurca

Status of the subject: elective

Number of ECTS points: 15

Condition: students are obliged to have passed the elementary course of Hydrobiology

Goal of the subject

The objective of the course is to teach students about the main principles of the data analysis, by using the most up-to-date statistical techniques applicable in the freshwater biology research.

Outcome of the subject

After passed exam a student should be able to independently analyse any type of hydrobiological data, to adequately apply the analytical protocol in the data analysis and to be able to make an independent statement regarding the results of the statistical analyses.

Content of the subject

Theoretical lectures

Types of data in hydrobiology and analytical protocol, Study design and planning of the hydrobiological research, Exploratory and preliminary data analysis, Univariate and multivariate response, Analysis of variance and covariance, Correlation and Regression, Multiple regression, Statistical models, Data analysis using computer language "R", Presentation and discussion of results.

Practical lectures

Fulfilment of the research project within which the student would apply the statistical techniques of data analysis. In the course of the research, a student would have used the software package "Statistica" or "R".

Recommended literature

Quinn, G. & Keough, M. (2002) *Experimental Design and Data Analysis for Biologists*. Cambridge University Press, Cambridge, UK.

Zuur A., Ieano E. & Smith G. (2007) *Analysing Ecological Data*. Springer, New York.

Clarke K.R. & Warwick R.M. (2001) *Change in marine communities: an approach to statistical analysis and interpretation*, PRIMER-E: Plymouth, UK.

Elliot, J. (1971) Some methods for the statistical analysis of samples of benthic invertebrates. Sci. Publ. 25. Freshwater Biological Association, Ambleside, Westmorland, U.K.

Zuur A., Ieno E., Walker N., Saveliev A. & Smith G. (2009) *Mixed Effects Models and Extensions in Ecology with R*. Springer-Verlag, New York.

Number of active classes	Theory: 5	Practice (student research): 5

Methods of delivering lectures

Lectures – oral presentations using video bim, practical work as student research assigment.

Evaluation of knowledge (maximum number of points 100)

During the semester

student research project **50** points

Final exam

oral exam **50**points

Name of the subject: WATER QUALITY MONITORING USING FRESHWATER MACROINVERTEBRATES

Teacher(s): Dr. Tamara Jurca

Status of the subject: elective

Number of ECTS points: 15

Condition: students are obliged to have passed the course Hydrobiology

Goal of the subject

The course is focusing on the potential of littoral and profundal communities of aquatic macroinvertebrates as bioindicators in monitoring of freshwater ecosystems.

Outcome of the subject

After the course students should be capable of identifying the most common species of aquatic macroinvertebrates, able to successfully analyse the results of the ecological status assessments (according to the Water Framework Directive) and use indicator systems (saprobic, diversity and multimetric indices) in water quality assessments.

Content of the subject

Theoretical lectures

History of the role of macroinvertebrates in biomonitoring. Freshwater invertebrates as bioindicators. Mechanisms of effects of ecological factors on macroinvertebrates communities. Identification of freshwater macroinvertebrates for purposes of ecological explorations. Data analysis and results discussion. Rapid assessment of the ecological status and biological aspect of water quality. Macroinvertebrates as model organisms in toxicity tests. Paleoreconstruction using the macroinvertebrates.

Practical lectures

Laboratory practice would aim for students to differentiate the major taxonomic groups of aquatic macroinvertebrates.

Recommended literature

1. Rosenberg, D.M. & Resh, V.H. (1993) Freshwater Biomonitoring and Benthic Macroinvertebrates, Chapman and Hall, London.

2. Wright, J., Sutcliffe, D. & Furse, M. (1997) Assessing the biological quality of freshwaters. RIVPACS and other techniques. FBA, Ambleside, Cumbria, UK.

3. Karr, J. & Chu, E. (1999) Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington, D.C.

4. Elliot, J. (1971) Some methods for the statistical analysis of sampIes of benthic invertebrates. Sci. Publ. 25. Freshwater Biological Association, Ambleside, Westmorland, U.K

5. Loeb, S. & Spacie, A. (1993) Biological Monitoring of Aquatic Systems. Lewis Publishers

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures - oral presentation using pptand video bim, practical part – identification of samples collected in the field using standard methods.

Evaluation of knowledge (maximum number of points 100)

During the semester

student research project **50** points

Final exam

oral exam **50** points

Name of the subject: NUMERICAL ECOLOGY

Teacher(s): Dr. Djuradj Milošević, Dr. Dušanka Cvijanović

Status of the subject: elective

Number of ECTS points:15

Condition:

Goal of the subject

The aim of this course is to provide the knowledge required for statistical analysis of data in ecology using modern data techniques in the R Project for Statistical Computing (R). Students will gain skills for: 1) data processing using the R; 2) data base preparation and data standardization; (3) development of appropriate statistical design for data analysis; 4) visualize the variance in data; and (4) interpretation of statistical results.

Outcome of the subject

Working in multidisciplinary environment, students will gain broad understanding of the various statistical techniques for data storage, processing and interpretation with respect to the types of research and data sets in ecology.

Content of the subject

Introduction into the numerical ecology. Introduction into the R Project (variables, syntax, R functions, R built-in functions, R environment set up, list objects, export and import of data, vectors (numerical, character, logical), matrices, R-loops formation). Types of data (biological and environmental data sets), data transformation and variables coding, development of statistical design using visual analysis and descriptive statistics. Similarity coefficients and matrices (types of similarity coefficients, calculation, analysis and visual comparation of similarity matrices. Univariate statistics in ecology. Exploring relationship among variables (correlation, multiple regression, logistic regression, factor analysis). Parametric and nonparametric tests for hypothesis testing: Student t test, ANOVA, Kruskal Wallis test, Mann–Whitney U test, Chi-squared test etc.). Multivariate analysis: linear and nonlinear modeling of biological communities. Alpha diversity, species abundance models (the geometric series, the logarithmic series, the lognormal and MacArthur's). Beta diversity. Classification of biological communities (similarity coefficients, agglomerative methods, divisive methods). Ordination of community matrices: Detrended/ Canonical/ Correspondence analysis, Principal Component analysis, multidimensional scaling, Artificial Neural Networks, Kohonen and other self-organizing maps, multilayer perceptron. Metacommunity dynamic and analysis of spatial processes structuring biological communities (Moran's eigenvector maps -MEM, Mantel test, Distance-decay relationships framework - DDR). Bioenergetic cycles. Energy flow in ecosystems. Network Analysis - Energy storage-flow based trophic networks. Ecosystem functioning. Structural Equation Modelling (SEM). Other software packages for data processing in ecology: Primer V6+PERMANOVA, MathLab, PC-ord, SPSS, PAST, CANOCO, STATISTICA.

Recommended literature

Numerical Ecology with R (Use R!), 2nd ed. 2018 Edition by Daniel Borcard, François Gillet, Pierre Legendre

Lepš, J., Šmilauer, P. 2003. Multivariate Analysis of Ecological Data using CANOCO. Cambridge University Press. ISBN-10 0-521-89108-6

Karadžić, B. & Marinković, S. 2009. Kvantitativna ekologija. IBISS, Beograd

Zhang, W. 2010. Computational Ecology. Artificial Neural Networks and Their Applications. World Scientific Co. Pte. Ltd. Singapore, London

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures with computer exercises.

Evaluation of knowledge (maximum number of points 100)

Project development and preparation: 70. Project presentation: 30

Name of the subject: INVASIVE PLANTS ECOLOGY

Teacher(s): Dr. Snežana Radulović

Status of the subject: Elective course

Number of ECTS points:15

Condition:

Goal of the subject

The goal of this course is to provide methodology and guidelines for the prevention of biodiversity loss as a result of biological invasion. This course provides knowledge in invasive species as a threat to environment, nature conservation, economy and human health worldwide.

Outcome of the subject

Students should gain broad understanding of the ecology of plant invasions, prediction, mechanism of propagule pressure (introduction efforts) and the characters of successful invaders.

Content of the subject

Theoretical lectures

Invasive alien species as one of the most important threats to global biodiversity. A neutral terminology of invasive species. Flexibility in invasion terminology IUCN guidelines for the prevention of biodiversity loss due to biological invasion. Invading plants: their potential contribution to population biology. European map and database of alien plant invasions based on the quantitative assessment across habitats. Predicting invasions. Allelopathic potential of invasiveness. Juglone Index.

Practical lectures

Individual field work

Recommended literature

1. IUCN (World Conservation Union) (1999) IUCN guidelines for the prevention of biodiversity loss due to biological invasion. *Species* 31–32, 28–42
2. Mack, R.N. (1995) Invading plants: their potential contribution to population biology. *Studies in plant demography*, (ed. J. White), pp. 127–142. Academic Press, London, UK.
3. Cleland EE, Smith MD, Andelman SJ, Bowles C, Carney KM, Horner-Devine MC, Drake JM, Emery SM, Gramling JM, Vandermast DB. 2004. Invasion in space and time: non-native species richness and relative abundance respond to interannual variation in productivity and diversity, *Ecology Letters* 7: 947–957
4. Chytry, M., Jarosík, V., Pysek, P., Hájek, O., Knollová, O., Tichy, L. & Danihelka, J. (2008) Separating habitat invasibility by alien plants from the actual level of invasion. *Ecology*, 89, 1541–1553.
5. Pysek, P., Jarosík, V. & Kucera, T. (2002) Patterns of invasion in temperate nature reserves. *Biological Conservation*, 104, 13–24
6. Chytry M, Pysek P, Wild J, Pino J, Maskell LC, Vilà M. 2009. European map of alien plant invasions based on the quantitative assessment across habitats. *Diversity and Distributions* 15: 98–107.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Individual consultations, individual field work.

Written scientific essay

Evaluation of knowledge (maximum number of points 100)

Project development and preparation: 70. Project presentation: 30

Name of the subject: SYNTAXONOMY		
Teacher(s): Dr. Snežana Radulović, Dr. Dušanka Cvijanović		
Status of the subject: Elective		
Number of ECTS points: 15		
Condition: Phytocoenology		
Goal of the subject The goal of this course is to introduce the elements and practicalities of the International Code of Phytosociological Nomenclature - the Code definitions, principles, rules and recommendations.		
Outcome of the subject Students should gain broad understanding of the the Code definitions, principles, rules and recommendations, which will facilitate the proper use of syntaxonomical names for the denomination of syntaxonomical units.		
Content of the subject *Theoretical lectures* Fundamental environmental studies of plant ecosystems (synecology). Syntaxonomy Codex. Nomenclatural stability and correct usage of syntaxonomic names by fundamental and applied vegetation ecologists such as foresters, agriculturalists and nature conservationists. The origin of phytocoenoses, vegetation dynamics, classification and ordination. Sample analyses from the ecosystem to the landscape level. Reproduction, dispersal and population biology in plant communities. Relevés. Syntaxa; Hierarchy of ranks. Nomenclatural type; Homonyms; Synonyms, Basionym; Author citation *Practical lectures* Field work and phytocoenological data base revisions.		
Recommended literature Weber H.E, Moravec J. & Theurillat JP. (2000): The International Code of Phytosociological Nomenclature. 3rd edition, Journal of Vegetation Sciencel 1: 739-768, Opulus Press, Uppsala		
Number of active classes	Theory: 5	Practice: 5
Methods of delivering lectures Individual consultations and individual field work.		
Evaluation of knowledge (maximum number of points 100) Project development and preparation: 70. Project presentation: 30		

Name of the subject: THE IMPORTANCE OF DIPTERA IN THE SUSTAINABLE USE OF RESOURCES

Teacher(s): Dr. Ante Vujić

Status of the subject: elective course

Number of ECTS points: 15

Condition: without conditions

Goal of the subject

The main objective of the course is to familiarize students with the potential of cultivating differents species of Diptera (Insecta) with a view to sustainable resource management, with multiple benefits for the economy and the environment. Insect farming is an innovative approach to addressing global challenges such as growing demand for food, high levels of organic waste and wastewater problems. Students will gain knowledge of the technology of cultivating particular species and will be introduced to the benefits of these processes that solve various environmental problems.

Outcome of the subject

At the end of the course, students are expected to be familiar with the potential of using insects to address global challenges, with a view to using resources sustainably and environmentally.

Content of the subject

Theoretical lectures

The use of organic waste as a substrate for mass insect breeding on the example of the black fly (*Hermetia illucens*), technology and products. Aquatic saprophagic dipteran larvae as decomposers of organic matter in polluted waters. Insects as food of the future.

Practical lectures

Specific examples of insect rearing technology or their larvae to address global challenges such as increasing demand for food, high levels of organic waste and wastewater problems.

Recommended literature

1. Huis, A.V. & Tomberlin, J.K. (2016). Insects as food and feed: from production to consumption. Insects as food and feed: from production to consumption. Wageningen Academic Publishers.

2.Dossey, A.T., Morales-Ramos, J.A., & Rojas, M.G. (Eds.). (2016). Insects as sustainable food ingredients: production, processing and food applications. Academic Press.

3.Caruso, D., Devic, E.,Subamia, I.W., Talamond, P. & Baras, E. (Eds). (2014). Technical handbook of domestication and production of diptera Black Soldier Fly (BSF) Hermetia illucens, Stratiomyidae. PT Penerbit IPB Press.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Video presentation, consultation.

Evaluation of knowledge (maximum number of points 100)

Oral exam (40), writing and presentation of seminar paper (60).

Name of the subject: VERTEBRATE NUTRITIONAL ECOLOGY

Teacher(s): Dr. Olivera Bjelić Čabrilo

Status of the subject: elective

Number of ECTS points: 15

Condition: none

Goal of the subject

An appreciation and understanding of the study and monitoring of dietary habits (selection of adequate quantities of suitable food, foraging and feeding behavior, dietary preferences and the possibility of changing preferences) of different vertebrate species, primarily endangered taxa. The course aims to instill the significance of this aspect of ecology in the protection, preservation and later management of species.

Outcome of the subject

Students will learn modern methods for analyzing and monitoring the diet of different vertebrate groups, and understand the principles that guide selection and acquisition of food. The knowledge can be applied to preserve and protect species and habitats in protected areas, as well as outside of them.

Content of the subject

Theoretical lectures

The fundamentals of digestive system morphology in vertebrates and its connection to diet. Theoretical models of food selection (OFT, CINE, GF, ES). Foraging behavior. Interactions between herbivores and plants. Predator-prey interaction. Effects of food necessity on consumers. Dietary preferences and preference shift. Dietary spectrum width from the aspect of optimal foraging. Modern methods of nutritional ecology. Anthropogenic influences on the environment (habitat loss, pollution, invasive species) and their effect on feeding. Effects of climate change on feeding. Conservation implications of the diet of endangered species.

Practical lectures

Analysis and monitoring of diet of selected vertebrate groups. Creating plans for selection of most suitable habitats for repopulation and conservation of specific vertebrate species based on available food resources.

Recommended literature

1. Krebs CJ. Ecological Methodology, Second Edition. Addison Wesley Longman, Inc. 1999.
2. Simpson, SJ, Raubenheimer D. The Nature of Nutrition. A Unifying Framework from Animal Adaptation to Human Obesity.Princeton University Press.2012.
3. Van Soest PJ. Nutritional Ecology of the Ruminant. Cornell University Press. 1994.
4. Rockwood LL. Introduction to Population Ecology. Blackwell Publishing**.** 2006.

All available scientific papers relating to the course subject, in line with the student's interest.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, practical and theoretical work in the lab.

* research papers on selected and/or given topics

Evaluation of knowledge (maximum number of points 100)

Project presentation 30 Oral exam 50 Research paper 20

Name of the subject: INSECT POLLINATORS

Teacher(s): Dr. Snežana Radenković, Dr. Andrijana Andrić

Status of the subject: elective

Number of ECTS points: 15

Condition: none

Goal of the subject

The aim of the course is to familiarize students with the basics and specifics of the complex relationship of insect pollinators and their host plants, as well as to indicate the complexity of the pollination process itself. Students will be informed about the basic morphological characteristics of the most important groups of insect pollinators (bees, bumblebees and hoverflies), with an emphasis on differences both in the structure of the oral apparatus and in morphological adaptations (mechanisms) for collecting and transplanting pollen. Special attention is paid to the significance of insects as pollinators, both in natural and agricultural ecosystems, as well as to the factors endangering the diversity of insect pollinators and the pollination process itself.

Outcome of the subject

Through this course, students acquire knowledge about the role and importance of insects in the pollination process, which is a key ecosystem service for maintaining both the diversity of wild plants and the production of agricultural crops used in human nutrition. By explaining the morphology and ecological needs of selected groups of cultivated and wild insect pollinators, this course enables the comprehension of the topic of the pollination from various aspects, including global environmental changes, threats caused by the anthropogenic factor and current trends in the conservation of the most significant insect pollinators in both natural and agricultural ecosystems.

Content of the subject

Theoretical lectures

1. Ecological basics of interactions between insect pollinators and plants; 2. Basics of morphology and anatomy of plants and insects in the context of pollination process – (co-)evolution, (co-)adaptation, (co-)speciation; 3. The diversity of the life cycles of insect pollinators – biology and ecology of developmental stages; 4. The role and significance of pollinators in natural and agro- ecosystems – insect pollination as ecosystem service; 5. The role of cultivated and wild insects in agricultural crops pollination;

Practical lectures

6. The effects of climate change on both the plant-insect interactions and the pollination process; 7. The effects of different anthropogenic factors (habitat loss, pollution, pesticides, invasive species and pathogens) on the pollination; 8. Status and vulnerability of insect pollinators – challenges and trends in conservation; 9. Agro-ecology: pollinators in sustainable agriculture; 10. Integrative approach and up-to-date methods in pollination management.

Recommended literature

1. Abrol, D.P. 2012. Pollination biology: Biodiversity conservation and agricultural production. Springer Science+Business Media B.V., 792 pp.
2. Goulson, D. 2010. Bumblebees Behaviour, Ecology, and Conservation. Second Edition. Oxford University press, UK, 311 pp.
3. Michener, C.D. 2007. The Bees of the World. Second edition. The Johns Hopkins University Press, Baltimore, 953 pp.
4. Nieto, A. et al. 2014. European Red List of bees. Publication Office of the European Union, Luxembourg, 84 pp.
5. Rotheray, G.E. & Gilbert, F.S. 2011. The Natural History of Hoverflies. Forrest text, UK, 334 pp.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Interactive methods.

Preparation and defense of seminar papers by given and / or selected topics.

Evaluation of knowledge (maximum number of points 100)

seminar paper 30 points; test 70 points

Name of the subject: CONSERVATION GENETICS

Teacher(s): Dr. Mihajla Djan, Dr. Nevena Veličković, Dr. Nataša Kočiš Tubić

Status of the subject: elective

Number of ECTS points: 15

Condition:

Goal of the subject

The goal of the course is to adopt knowledge about the application of genetic and genomic methods in solving different problems of ecology, nature protection and conservation biology.

Outcome of the subject

After successful fulfillment of pre-exam and exam obligations student is capable to:
- Understand and explain genetic diversity as the basis of biodiversity
- understand and explain genetic mechanisms and forces acting in small populations
- depending on biological question, to select and apply appropriate molecular tools
- use and apply appropriate software in genetic and genomic data analyses

Content of the subject

Theoretical lectures

Introduction to conservation genetics. Overview of molecular markers in conservation biology. Genetic analyses of populations. Quantification of genetic diversity and detection of population genetic structure. Gene flow. Genetic drift. Selection. Phylogeography. Molecular aspects in ecology. Molecular taxonomy. Estimation of effective population size. Population dynamics. Inbreeding. Application of conservation genetics in ecological management. Overview of available software for genetic data analyses.

Research work

Analyses, presentation and critical review of novel data published in relevant papers from the field of conservation genetics. Data analyses in appropriate software.

Recommended literature

1. Joanna R. Freeland, Stephen D. Petersen, Heather Kirk. 2011. Molecular Ecology, 2nd Edition. Wiley-Blackwell.
2. Matthew Hahn. 2018. Molecular Population Genetics. Oxford University Press.
3. Review papers published in peer-review scientific journals

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures; consultations; “Journal Club” – presentations and discussion on selected topics; Seminar – presentation of the assigned topic

Evaluation of knowledge (maximum number of points 100)

Project presentation/seminar – 40; Oral exam - 60

Name of the subject: LANDSCAPE ECOLOGY

Teacher(s): Dr. Snežana Popov

Status of the subject: Elective course

Number of ECTS points: 15

Condition:

Goal of the subject

This course is designed to introduce students to the principles of landscape ecology, and to point out the importance of interrelation between landscape patterns and ecological processes. The course is designed to help students understand and learn how various natural and anthropogenic processes lead to changes in landscape structures and landscape composition, and to learn how to apply the principles of landscape ecology in natural resources management. Finally, in this course students will be introduced to the main tools for landscape ecology analyses.

Outcome of the subject

By the end of the course, student will be able to:

- understand theoretical principles of landscape ecology;
- recognize the impact of landscape patterns on diversity and distribution of a given taxon;
- apply principles of landscape ecology to conservation practices.

Content of the subject

Theoretical lectures

Topics include: Introduction to landscape ecology: definition and main principles; Landscape elements; Landscape structure: composition and configuration; Landscape heterogeneity; Landscape function and landscape change; Quantification of landscape structure: Functional diversity and landscape; Landscape perception; Urban landscapes; Application landscape ecology principles in conservation.

Practical lectures

Introduction to R, software environment for statistical computing and graphics; analysis of ecological parameters: biodiversity parameters, assessment of functional and taxonomic diversity of landscapes; quantification of landscapes changes.

Recommended literature

Turner, M. G., Gardner, R.&O'Neill, R.(2001).*Landscape Ecology in Theory and Practice*.Springer.

Tscharntke, T., Tylianakis, J. M., Rand, T. A., Didham, R. K., Fahrig, L., Batary, P., ... & Ewers, R. M. (2012). Landscape moderation of biodiversity patterns and processes-eight hypotheses. *Biological reviews*, *87*(3), 661-685.

Zuur, A., Ieno, E. N., & Meesters, E. (2009). *A Beginner's Guide to R*. Springer Science & Business Media.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

The course will use a combination of lectures, class discussions, individual and group exercises, software demonstration, and written assignments.

Evaluation of knowledge (maximum number of points 100)

Pre-exam assignments/activities: 40 Points **Oral exam:** 60Points

Name of the subject: ENVIRONMENTAL ECONOMICS

Teacher(s): Dr. Zlata Markov Ristić

Status of the subject: Elective course

Number of ECTS points: 15

Condition:

Goal of the subject

Environmental economics course is designed to introduce students to the environmental and natural resource management from an economic point of view. The purpose is to present economic instruments in the function of efficient use of natural resources in accordance with the environmental protection. Special attention is given to techniques for evaluation of the environment, natural resources and ecosystem services, as well as emphasizing the synergy between ecology and economy.

Outcome of the subject

By the end of the course, student will be able to:

- economic view of the environment through the sphere of micro and macroeconomics;
- recognize how to apply economic principles for the purpose of sustainable use of natural resources;
- apply techniques and methodology for evaluating particular segments of the environment.

Content of the subject

1. Economy and Environment (micro and macro environmental economics); 2. Natural resources, environment and economic development; 3. Environmental externalities (external costs and benefits, positive and negative externalities, basic supply and demand theory); 4. Common resources and public goods (environment as public good, global common property); 5. Resource allocation over time; 6. Environmental valuation (cost-benefit analysis, valuation techniques); 7. Economics of renewable and non-renewable resources; 8. Ecological Economics - Basics.

Recommended literature

1. Jonathan, M. H. 2006. Environmental and Natural Resource Economics: A Contemporary Approach, 2nd Edition. Houghton Mifflin Company.
2. Croitoru, L. & Sarraf, M. 2010. The Cost of Environmental Degradation. Directions in Development. The World Bank, Washington DC.
3. Пешић, В.Р. 2002. Економија природних ресурса и животне средине. Пољопривредни факултет Универзитета у Београду.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

The course will use a combination of lectures, class discussions, individual and group seminars.

Evaluation of knowledge (maximum number of points 100)

Pre-exam assignments/activities	**Points**	**Exam**	**Points**
Written assignment	30	Written exam	70

Name of the subject: BRYOPHYTE ECOLOGY

Teacher(s): Dr. Miloš Ilić

Status of the subject: elective

Number of ECTS points: 15

Condition: -

Goal of the subject

Acquiring broad knowledge about ecology, diversity and distribution of bryophytes, their role in different types of ecosystems, as well as factors that affect the diversity of these plants.

Outcome of the subject

Students acquire a broader knowledge about the ecology and diversity of bryophytes that will form the basis for independent research.

Content of the subject

Theoretical lectures

Morphology and life cycle of bryophytes; Sexual strategies; Life and growth forms; Ground bryophytes in different types of ecosystems; Ecology of epiphytic; epilithic and epixylic bryophytes; Bryophyte role in ecosystem; Bryophytes – Invertebrates relations; Basic principles of physiological ecology of bryophytes: mineral nutrition; water relations, temperature and light responses, stress response; Influence of different ecological factors on bryophyte diversity; Bryophytes as indicators of environmental conditions; Ecology of peatlands; Different aspects of bryophyte biogeography; Bryophytes and pollution; Quantitative approaches in bryophyte ecology; Threatened bryophytes; Economic values of bryophytes.

Practical lectures

Student research work, which is in line with the field of study of the candidate and the topic of the doctoral thesis.

Recommended literature

Veljić, M., Vukov, D., Sabovljević, M. 2018. Biologija briofita I: morfologija i sistematika. Biološki fakultet Univerziteta u Beogradu, Prirodno-matematički fakultet Univerziteta u Novom Sadu. Beograd-Novi Sad.

Glime, J. M. 2017. Bryophyte ecology. Available online at: http://www.bryoecol.mtu.edu/

Smith, A. (ed.) 1982. Bryophyte ecology. Springer Netherlands.

Vanderpoorten, A., Goffinet, B. 2009. Introduction to bryophytes. Cambridge University Press

Goffinet, B., Shaw, J. 2000. Bryophyte biology. Cambridge University Press. New York

Hodgetts, N. G. 2015. Checklist and country status of European bryophytes – towards a new Red List for Europe. Irish Wildlife Manuals, No. 84. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht, Ireland.

Number of active classes	Theory: 5	Practice: 5

Methods of delivering lectures

Lectures, consultations, field and laboratory work, student essay.

Evaluation of knowledge (maximum number of points 100)

Oral exam: 50

Essay: 50

Course title: MACROECOLOGICAL PATTERNS IN PLANT COMMUNITIES

Teachers: Dr. Dragana Vukov, Dr. Ružica Igić

Course status: Elective

Number of ECTS: 15

Condition: -

Objective of the course:

The aim of this course is to learn about the values and diversity of plant communities in the broader geographical aspect - at the European level, as well as introduction to the diversity gradients among them at continental scale.

Outcome of the course

Within the course, students will be introduced to sampling methods and vegetation data analysis in order to study plant communities and macroecological gradients of their habitats, as well as relationships to local and regional ecological processes.

Contents of the course

Theoretical lectures

Introduction to the habitats and vegetation types of the Republic of Serbia. European vegetation diversity. Characteristics of selected vegetation orders and gradients of diversity among their alliances. Basic patterns in shifts of vegetation types from local to continental level. Numerical processing of large vegetation data sets. Basic sets of additional data for determining of macroecological diversity among related vegetation types. Classification of vegetation data and ordination of classified groups. Correlation between vegetation data and other macroecological parameters.

Practical lectures

Practical lectures continues on theory and involves getting acquainted with plant material in order to learn about the diversity of flora and vegetation of Serbia. Introduction to the methodology of vegetation data analysis. Processing of vegetation data by software tools.

References:

1. Mucina et al.. (2016): Vegetation of Europe: hierarchical floristic classification system of vascular plant, Диклић, Н., Јанковић, М., Јовановић, Б., Јовановић, Р., Којић, М., Мишић, В., (2006): Вегетација Србије II1, САНУ.
2. Јанковић, М., Пантић, Н., Мишић, В., Диклић, Н., Гајић, М. (1984): Вегетација СР Србије I, САНУ.
3. Mucina et al. (2016): Vegetation of Europe: hierarchical floristic classification systemof vascular plant, bryophyte, lichen, and algal communities. - Applied Vegetation Science 19 (Suppl. 1): 3–264.
4. Стевановић, В., Јовановић, С., Лакушић, Д. (1995): Диверзитет вегетације Југославије. - : Стевановић, В., Васић, В. (ур.): Биодиверзитет Југославије са прегледом врста од међународног значаја. Ecolibri, Београд, Биолошки факултет, Београд. 219-242.

Number of active teaching hours	**Theoretical lectures:** 5	**Practical lectures:** 5

Teaching methods

Lectures and practical classes (individual and group work of students). Lectures, lab work, field work, seminar work on selected topics.

Knowledge score (maximum points 100)

Pre-exam obligations

Practical lectures **20**

seminar work **20**

Final exam

written exam **30**

oral exam **30**

Name of the subject: PREPARATION OF DOCTORAL DISSERTATION

Teacher(s): -

Status of the subject: Obligatory

Number of ECTS points: 20

Condition:
The doctoral dissertation is defended after passing the exams in all subjects and after fulfilling all the obligations determined by the study program. It consists of the preparation and public defense of the doctoral dissertation. The doctoral dissertation is submitted and produced during the second or third year of doctoral studies. The application procedure, the conditions for drafting and the manner of defending the doctoral dissertation are laid down in the Statute and the corresponding acts of the Faculty of Science and the University.

Goal
The doctoral dissertation is a student's independent research work and represents a synthesis of theoretical knowledge and practical work through which the student acquires the ability for scientifically based interpretation of experimental data from a selected narrow scientific field of Ecology.

Outcome of the subject
Through the process of developing and defending a doctoral dissertation, the student gains the ability of
- independent collection of information and data from professional and scientific literature;
- logical thinking, formulation of working hypotheses and goals of the dissertation and drawing conclusions;
- placing different scientific and professional information, giving opinions and exchanging ideas;
- planning and carrying out experimental work;
- team research work;
- scientifically based interpretation of experimental data and obtained results;
- successful application of the principles of good laboratory practice in the planning, execution and control of experiments;
- successful synthesis of relevant scientific data with conclusions drawn.

Content of the subject
As a rule, the doctoral dissertation contains the following chapters:
Content, Introduction, Objective, Literature Review, Material and Methods, Results, Discussion, Conclusions, Literature.
In addition to the aforementioned chapters, each doctoral dissertation contains a biography of the candidate and key documentation in Serbian and English. In the case of teaching in English, the doctoral dissertation is written in English with a broader statement in the Serbian language and legends of pictures and tables in the Serbian language.
In addition to the above elements, the doctoral dissertation may contain additional elements such as List of Tables, List of Figures, Attachments, List of Abbreviations, etc.

Recommended literature
Relevant scientific and professional literature in the field of doctoral dissertation.

Number of active classes	Theory:-	Practice: -

Methods of delivering lectures
- collecting and studying literature
- collecting data for experimental work
-planning and performing experiments
-data processing
-writing and oral defense of the doctoral dissertation

Evaluation of knowledge (maximum number of points 100)
1. The doctoral dissertation is defended before the Commission.
2. The dissertation defense is oral and public.
3. The day, place and time of the defense of the doctoral dissertation shall be published on the notice board of the relevant Department and / or on the Faculty website at least three days before the defense.
4. Upon the defense of the doctoral dissertation, the Commission shall withdraw and then make a public announcement decision on whether the dissertation was successfully defended.
5. The Commission for the Defense of the Doctoral Dissertation shall decide by a majority vote.

Name of the subject: PREPARATION OF A SCIENTIFIC PAPER FOR PUBLICATION IN A JOURNAL FROM THE SCI LIST		
Teacher(s): -		
Status of the subject: Obligatory		
Number of ECTS points: 10		
Condition: -		
Goal Independent student scientific-research work through which the ability to synthesize theoretical knowledge and practical work and present the results to the international scientific community is acquired.		
Outcome of the subject Through the process of writing a scientific paper for publication in a journal from the SCI list, the student acquires the ability of: - independent collection of information and data from professional and scientific literature; - logical thinking, formulation of working hypotheses, goals and drawing conclusions; - placing various scientific and professional information, giving opinions and exchanging ideas; - scientifically based interpretation of experimental data and obtained results; - successful synthesis of relevant scientific data with conclusions.		
Content of the subject The student is obliged to publish at least 1 scientific paper in a journal on the SCI list, in the field of the topic of the doctoral dissertation, which contains the results obtained by working on the doctoral dissertation and on which the student is the first author.		
Recommended literature Relevant scientific and professional literature in the field of the topic of the doctoral dissertation		
Number of active classes	Theory:	Practice: 20
Methods of delivering lectures -collection and study of literature -processing the results of research work in the field of the topic of the doctoral dissertation -writing a scientific paper and active participation in the process of submitting a paper to a journal from the SCI list		
Evaluation of knowledge (maximum number of points 100) After accepting a scientific paper for publication in a journal from the SCI list, the student advisor or mentor of a doctoral student submits proof to the Student Services that the paper has been accepted and / or a printed version of the published paper, thus giving the student the maximum number of points and ECTS.		

Name of the subject: SEMINAR I		
Teacher(s):		
Status of the subject: Obligatory		
Number of ECTS points: 30		
Condition: -		
Goal The objective of the course is to acquaint students with the most up-to-date methods and results in the relevant narrow scientific field of research, as well as training them in the planning and preparation of the doctoral dissertation.		
Outcome of the subject The final outcome of the course is the successful preparation and realization of research work leading to the preparation of a doctoral dissertation.		
Content of the subject The seminar is a thematic, narrowly oriented, specialized form of teaching that is conducted in specific terms with students, and is in the direct function of research leading to the preparation of a doctoral dissertation. The program of work of each seminar is formed in accordance with the needs of the preparation of doctoral dissertations and depends on the topic, structure and complexity of the doctoral dissertation. Seminars are the basis of study research work. The student, in consultation with the advisor, prepares Seminar I in the form of a presentation, which includes the presentation and explanation of the topic of the doctoral dissertation in the light of the literature and presentation of the methods that will be used during the research work. The defense of the seminar will be conducted in joint terms. The student defends the seminar publicly before a five-member committee nominated by the Departmental Council for each school year and before the PhD students attending the course.		
Recommended literature Scientific and professional literature in the field of doctoral dissertation subject as agreed with the advisor (mentor).		
Number of active classes	Theory:	Practice: 20
Methods of delivering lectures The basic form of teaching at the seminar is the independent research work of the student, which is realized in agreement with the advisor (mentor).		
Evaluation of knowledge (maximum number of points 100) Presentation - 30 points Seminar defense - 70 points		

Name of the subject: SEMINAR II		
Teacher(s):		
Status of the subject: Obligatory		
Number of ECTS points: 30		
Condition: -		
Goal The objective of the course is to train the student to prepare a doctoral dissertation.		
Outcome of the subject The final outcome of the course is a critical analysis of the results in order to successfully complete the doctoral dissertation.		
Content of the subject The seminar is a thematic, narrowly oriented, specialized form of teaching that is conducted in defined terms with students, and is in the direct function of developing a doctoral dissertation. The program of work of each seminar is formed in accordance with the needs of developing a specific doctoral dissertation and depends on the topic, structure and complexity of the doctoral dissertation. The student, in consultation with the advisor (mentor), prepares Seminar II in the form of a presentation that includes presentation of the results obtained during the doctoral dissertation, their critical discussion and conclusions. The defense of the seminar will be conducted in joint terms. The student defends the seminar publicly before a five-member committee nominated by the Departmental Council for each school year and before the PhD students attending the course.		
Recommended literature Scientific and professional literature in the field of doctoral dissertation subject to agreement with the advisor (mentor).		
Number of active classes	Theory:	Practice:20
Methods of delivering lectures The basic form of teaching at the seminar is the independent research work of the student, which is realized in agreement with the advisor (mentor).		
Evaluation of knowledge (maximum number of points 100) Presentation - 30 points Seminar defense - 70 points		