UNIVERSITÄT KOBLENZ · LANDAU

iES Landau

List of Modules

for the Master's program

Umweltwissenschaften / Environmental Sciences (Master of Science)

at the
University of Koblenz-Landau,
Campus Landau

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Content

1 Introduction

This list of modules informs about structure, intention and contents of the master's program Umweltwissenschaften / Environmental Sciences. It contains descriptions of the modules (chapter 3) and an exemplary curriculum (chapter 4).

The master's program is laid out for four semesters of full-time study with a total amount of 120 credit points (CP). It consists of a compulsory part with 28 CP, an elective part with 54 CP, a Research and Training Internship (8 CP) and the master thesis with colloquium (30 CP). In the elective part each student selects two from the eight elective subjects Environmental Analysis / Umweltanalytik (ANA), Applied Ecology / Angewandte Ökologie (AÖK), Socio-economics and environmental management / Sozioökonomie und Umweltmanagement (SÖU), Aquatic systems / Aquatische Systeme (AQU), Soil Systems / Bodensysteme (SOS), Landscapes and Scales / Landschaften und Skalen (LAS), Chemicals in the Environment / Chemikalien in der Umwelt (CHE) and Modelling / Modellierung (MOD). For each elective subject four modules (24 CP) must be completed from the list of modules (6 CP each) pertaining to each subject. Further, every student must select an additional module (6 CP) from the list of elective modules.

2 Intention and Targeted Learning Outcomes of the Master's Program

General study objectives are detailed understanding and advanced method knowledge in the fields of environmental sciences. On this occasion, interactions between the different environmental compartments at different scale levels (from the molecule up to the landscape, including the purposeful human rather from the individual up to the ecosystem) are examined. The degree programme provides a basic process understanding and system-analytic abilities. Special attention is laid on anthropogenic changes and on methods to differentiate and quantify these as well as on ways of political and economic influence. The students obtain detailed soft skills, e.g. in the fields of interdisciplinary teamwork, presentation and publication. The degree programme enables the graduates to resolve complicated, multidisciplinary problems and tasks and encourage them for independent researchers. In particular, the degree programme prepares for independent and leading activities. Therefore the graduates are competent for the professionalism in varied fields of work as for example in the environmental research and the environmental management (scientific facilities and research institutes, authorities, offices, industry, consulting enterprises, planning offices etc.). In addition, the degree programme prepares for doctorate. During their studies, the graduates gain the following qualifications:

Knowledge:

- Profound subject-specific knowledge in the various disciplines of the environmental sciences.
- Profound knowledge on interdisciplinary relationships and connectedness.

Skills:

- Transfer Skills:
  - The acquired knowledge can be used for scientific problem-solving.
- Methodical (Technical/Statistical) Skills:
  - The graduates are familiar with the respective guidelines and methods of their field of specialization and possess advances methodological and analytical skills.
  - The graduates are able to plan scientific studies and to select and apply complex statistical methods for data analysis.
  - The graduates have obtained advanced skills in system modelling and in the analysis of spatial data (e.g. employing GIS).
- Scientific Working Method and Way of Thinking:
  - The graduates are able to develop solutions for complex problems and tasks in Environmental Sciences and to perform critical appraisals of techniques.
  - The graduates acquire the ability for a well-founded critique of scientific methods.
  - The graduates gain analytical abilities and they are qualified for process analysis, systemic thinking as well as for a goal oriented, structured, efficient working method. They have also a mechanistic understanding.
  - The graduates are able to work interdisciplinary and they have the ability for an interdisciplinary perception.
- Presentation/Publication/Discussion of Scientific Research Results:

- The degree program imparts the ability to present the research results to an international audience and to discuss the results.
- The graduates are able to publish their researches in scientific journals.
- The graduates have the ability to examine and to analyse critically scientific results (e.g. papers in scientific journals) and to assess these results on the basis of their profound knowledge.

 Social skills:

- The graduates are able to mediate discussions between different groups of stakeholders and to reach consensus.
- The degree program develops the ability for successful team work (e.g. within projects or teams), to accept and to positively interact with criticism, as well as to identify, to increase and to use synergy effects.
- The graduates have leadership skills: projects can be structured into tasks which can be distributed competently. The graduates are able to accept interests and suggestions/ideas of the individual staff and to develop further in cooperation with the staff interests and suggestions. They are also able to pass criticism constructively.
- The graduates have extensive intercultural skills. They have the ability to communicate, in particular in English. They are able to socialise, to have conservations as well as to express their interests/knowledge/results etc. clearly. As a result, they can operate in an international context.

 Professional Work Experiences:

- The degree program enhances first professional work experiences in the field of researches at the university as well as in the professional fields of environmental research and management.

3 Description of Modules

3.1 Compulsory modules

Module B1: Sustainability and Global Change°

Module name:	**Sustainability and Global Change**
Module code:	**B1**
Courses:	a) Global Change b) Sustainability and Global Change
Semester:	1./2./3. Semester
Duration of module:	3 semesters
Frequency of offer:	annually
Module coordinator:	Jun.-Prof. Dr. Elisabeth Berger
Lecturer:	a) Dr. Nanki Sidhu / internal as well as external lecturers b) Jun.-Prof. Dr. Elisabeth Berger
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (C, 2/3)
Teaching format / class hours per week / group size:	a) Lecture series / 2 SWS / 60 / *Online Lecture / 2 / SWS / 30** b) Lecture / 2 SWS / 60 / *Online Lecture / 2 / SWS / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 15 h b) 30 h / 45 h Total: 60 h / 60 h
Credit points:	4 LP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	None
Targeted learning outcomes:	The students obtain insights into different sectors of environmental research and get to know current aspects and problems relating to phenomena of global change. They develop an interdisciplinary perspective and learn to put the contents of disciplinary courses into a wider context. Students understand and are able to communicate different aspects of global change. They are familiar with different concepts and methods of sustainability, human-environment interactions and interconnected thinking. They are aware and able anticipate feedback loops, rebound and scale effects when analyzing human problems and adaptation strategies related to changes in the biophysical world
Content:	a) Global Change: Scientists of the University of Koblenz-Landau as well as external institutions present current approaches and results of environmental science research. The specific contents change from year to year. b) Sustainability and Global Change: Sustainable development Syndromes of global change Global biogeochemical cycles The carbon cycle

	Energy and everyday life Renewable energies The nitrogen cycle Planetary boundaries Case study: Social justice and water Biodiversity crisis Sustainable consumption Social-ecological systems Transdisciplinarity
Study / exam achievements:	a) 1-page protocols of 12 lectures (4 per semester) (Studienleistung) b) Written exam (Modulprüfung)
Forms of media:	PowerPoint slides / *Panopto Videos**
Literature:	Will be announced in class

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Module B2: Tools for Complex Data Analysis°

Module name:	**Tools for Complex Data Analysis**
Module code:	**B2, resp. ETX3**
Courses:	a) Tools for univariate data analysis b) Tools for multivariate data analysis
Semester:	1. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Noel Juvigny-Khenafou
Lecturer:	Dr. Noel Juvigny-Khenafou, Prof. Dr. Ralf B. Schäfer
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (C, 1) M.Sc. Ecotoxicology (C, 1)
Teaching format / class hours per week / group size:	a) Exercise / 2 SWS / 30 / *Online Lectures with exercises / 2 SWS / 30** b) Exercise / 2,5 SWS/ 30 / *Online Lectures with exercises / 2,5 SWS / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 82,5 h Total: 60 h / 142,5 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study Univariate data analysis is required before participation in multivariate data analysis
Recommended prerequisites:	Fundamental knowledge in algebra and calculus as well as descriptive and simple inferential statistics.
Targeted learning outcomes:	The students are able to design a study and select corresponding tools for subsequent data analysis. They can link scientific questions to methods of data analysis. They are familiar with different approaches to data analysis including statistical as well as machine learning approaches. The students are able to process research data and apply data analysis tools in a software environment. They know the advantages and disadvantages of the different methods.
Content:	a) Tools for univariate data analysis: ● Overview on data analysis ● Exploratory analysis ● Approaches to data analysis: Statistical and Machine learning approaches ● Simulation-based approaches ● Correlation, regression and analysis of variance ● Statistical inference ● Multiple linear regression modelling ● GLMs ● Supervised classification: CARTs and Random forests b) Tools for multivariate data analysis: ● Ecological distance measures

	● Unconstrained ordination and constrained ordination techniques (e.g. PCA, RDA, CCA, NMDS, db-RDA) ● Algorithm-based and model based multivariate analysis ● Multivariate GLMs ● Unsupervised classification: Cluster analysis ● MANOVA and Permutational MANOVA
Study / exam achievements:	Exam (written)
Forms of media:	Libre Office Impress slides, computer, software (R programming language for statistical computing), Panopto videos
Literature:	Basic and advanced reading: ● Borcard, D., Gillet, F., Legendre, P. 2018: Numerical Ecology with R. Springer: New York; 2nd edition. ● Crawley, M. J. 2012: The R book. Second Edition. Wiley: Chichester. ● Field, A., Miles, J., Field, Z. 2012: Discovering Statistics Using R. SAGE Publications Ltd ● Fox, J. 2015. Applied Regression Analysis and Generalized Linear Models. 3rd edition. Sage Publications, Thousand Oaks, California. ● Harrell F.E. 2015 Regression modeling strategies: with applications to linear models, logistic regression, and survival analysis. 2nd edition. Springer, New York ● James, G., Witten, D., Hastie, T., and Tibshirani, R. 2017. An introduction to statistical learning: with applications in R; Springer: New York. ● Kabacoff, R. 2015. R in Action. 2nd edition. Data Analysis and Graphics with R. Manning Publications ● Legendre, P., and L. Legendre. 2012. Numerical Ecology. Elsevier, Amsterdam. ● Maindonald, J. and J. Braun 2010. Data Analysis and Graphics Using R. Cambridge University Press, Cambridge. ● Matloff, N. S. 2017. Statistical regression and classification: from linear models to machine learning. CRC Press: Boca Raton, 2017. ● Zuur, A. F., Ieno, E. N. and G. M. Smith 2007. Analysing Ecological Data. Series: Statistics for Biology and Health.

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Module B3: Fate and Transport of Pollutants

Module name:	**Fate and Transport of Pollutants**
Module code:	**B3**
Courses:	a) Advanced Environmental Chemistry b) Physical Transport Processes
Semester:	1. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Andreas Lorke
Lecturer:	Prof. Dr. Andreas Lorke / M.Sc. Zacharias Steinmetz
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (C, 1) a) M.Sc. Ecotoxicology (C,1) Course b): M.Ed. Gymnasium Physik
Teaching format / class hours per week / group size:	a) Lecture / 2 class hours / 100 b) Lecture / 2 class hours / 100
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	The lectures build on fundamental university knowledge in physics, chemistry and environmental chemistry
Targeted learning outcomes:	The students gain advanced knowledge about the production, use and effects of various classes of environmental pollutants and their pathways in different ecosystems, and know the current scientific discussion. The students can apply their knowledge on environmental-chemical processes including transfer, transformation and transport of pollutants; they can predict behaviour of organic and inorganic chemicals and judge their relevance for transport, enrichment, toxicity and bioavailability to current scientific problems. The students know the main processes, which are responsible for the transport of mass and energy within environmental systems and across environmental interfaces. They become familiar with the mathematical description of transport, reaction and physicochemical processes and are able to estimate transport and turnover rates in basic applications.
Content:	a) Advanced Environmental Chemistry: Use of chemicals Routes of entry in the environment Physicochemical properties, structure-activity relationships and parameterization of compound properties of organic and inorganic compound classes on the basis of current physicochemical models Chemistry of transfer and transformation processes in compartments soil, water, air and their mathematical description Compound classes (POPs, organic pesticides, metals etc.) Effects of compound classes in compartments water, soil, air

	b) Transport Processes: Diffusion: microscopic view, random walk Diffusion: macroscopic theory, Fick's laws, multivariate calculus Some basic solutions of the diffusion equation Diffusion coefficients in air, water and soil Diffusion with drift, sedimentation Transport properties of flows, turbulent diffusion Sources, sinks, and chemical reactions Interfacial mass transfer, air-water gas exchange Mass, heat and momentum transport analogies Transport processes in water, soil, and the atmosphere
Study / exam achievements:	Written Exam
Forms of media:	PowerPoint slides
Literature:	Basic and advanced reading: Hites, R. (2007): Elements of Environmental Chemistry. Wiley & Sons, Hoboken. Schwarzenbach, R.P. (2002): Environmental Organic Chemistry. J. Wiley & Sons, Hoboken. Walker, C.H., Hopkin, S.P., Sibly, R.M., Peakall, D.B. (2005): Principles of Ecotoxicology. Taylor & Francis, New York. Monteith, J.L., Unsworth, M.H. (2008): Environmental Physics. Academic Press, Elsevier, Amsterdam. Okubo, A., Levin, S.A. (2001): Diffusion and Ecological Problems: Modern Perspectives. Springer-Verlag, New York, Berlin, Heidelberg. Dill, K.A., Bromberg, S. (2010): Molecular driving forces: Statistical thermodynamics in chemistry & biology. Taylor & Francis

Module B4: Land Use and Ecosystems°

Module name:	**Land Use and Ecosystems**
Module code:	**B4, resp. AÖKE**
Courses:	a) Ecoregions and land use b) Anthropogenic Ecosystems
Semester:	1. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Hermann Jungkunst
Lecturer:	Prof. Dr. Hermann Jungkunst / Prof. Dr. Martin Entling / PD Dr. Jens Schirmel
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (C, 3) M.Sc. Ecotoxicology (O, 3) a) Master Ed. Geographie (O, 7-8) b) M.Ed. Biologie Gymnasium (O, 1-4)
Teaching format / class hours per week / group size:	a) Seminar / 2 class hours / 60 / *Online lecture / 2 class hours / 30** b) Lecture / 2 class hours / 60 / *Online lecture / 2 class hours / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	none
Targeted learning outcomes:	Students know the ecoregions of the world. They understand the geoecology of the different regions: global pattern of climate, soil, hydrology, vegetation and fauna and complex correlations between them. They know about typical regional land-use and the sensibility of the system towards human impact. Students understand the ecology of anthropogenic ecosystems. They know the various interactions between biodiversity and human land-use (e.g. agriculture, forestry) and are able to identify synergies and conflicts. Students have an overview of research methods in applied ecology and understand scientific publications.
Content:	a) Ecoregions and land use: The ecozones of the world are presented focussing on global pattern of and complex correlations between - climate, - soils, - hydrology, - vegetation and fauna. Anthropogenic use and the sensibility of the systems including ideas concerning the future development are demonstrated and elaborated on the basis of several case studies. b) Anthropogenic Ecosystems: Ecological processes in agriculture, grassland and urban ecology: plant-environment relationships, populations, interactions, communities and ecosystem services.

	Applied ecology in practice: biocontrol, agri-environment schemes, control of invasive species, creation of habitat analogues, organic farming, agricultural intensification, energy crops, tropical agriculture, sustainable forest management.
Study / exam achievements:	Written exam; presentation in a) (study achievement)
Forms of media:	PowerPoint slides, *Panopto videos**
Literature:	Basic reading: Schultz, J. (2008): Die Ökozonen der Erde. UTB, Stuttgart. (also available in English "The Ecozones of the World" Chapin, F.S. et al. (2013): Principles of Terrestrial Ecosystem Ecology. Springer, New York. Own literature search Advanced reading: Canadell et al. (2007): Terrestrial ecosystems in a changing world. Springer.

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Module B5: Environmental Economics°

Module name:	**Environmental Economics**
Module code:	**B5, resp. SÖUE**
Courses:	a) Environmental and Resource Economics b) Special topics in environmental economics
Semester:	1. Semester
Duration of module:	1-2 semesters
Frequency of offer:	annually, b) every semester
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Prof. Dr. Oliver Frör
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (C, 1) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Lecture / 2 class hours / 100 / *Online lecture / 2 class hours / 30** b) Seminar / 2 class hours / 60/ *Online lecture / 2 class hours / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for MSc. study
Recommended prerequisites:	Basic knowledge in business and classical economics
Targeted learning outcomes:	The students gain an understanding of the interaction between economic processes and the environment and learn the principles of an economically optimal use of natural resources. They can apply the theoretical approaches to analyse the impact of economic activities (consumption, production, resource use) on the environment and the welfare of society.
Content:	The relationship between the economy and the environment Market failure, Pareto optimum External effects, public goods, property rights Instruments of environmental policy Practical examples of implemented policy instruments Intertemporal decision making Discounting and time preference The cake-eating model The optimal use of non-renewable resources The optimal use of renewable resources
Study / exam achievements:	Seminar paper in b), study achievement in a)
Forms of media:	PowerPoint Slides, *Panopto videos**
Literature:	Field, B.C. (2008), Natural Resource Economics: An Introduction, 2nd edition, Waveland Press, Long Grove, Illinois Hackett, S.C. (2006), Environmental and Natural Resource Economics: Theory, Policy and the Sustainable Society, 3rd edition, M.E. Sharpe, Armonk, New York

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Module INT: Research and Training Internship

Module name:	**Research and Training Internship**
Module code:	**INT**
Courses:	
Semester:	3. Semester
Duration of module:	8 weeks
Frequency of offer:	term breaks
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	
Language:	dependent on location of internship
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (C, 3)
Teaching format / class hours per week / group size:	Practical training / 240 h, about 6 weeks (ideally from Aug. – Sept. or Mar. – Apr.)
Workload: Face-to-face teaching / independent study	Seminar/Discussions: 6 h Independent work: 234 h
Credit points:	8 CP
Requirements under the examination regulations:	Admission to M.Sc. study
Recommended prerequisites:	Basic knowledge in Environmental Sciences
Targeted learning outcomes:	The module INT is a six-week internship, which can be performed at an external university, governmental or industrial research institute in Germany or abroad. The students become familiar with the practice on the job, requirements of the job market and career opportunities and can establish business contacts. They apply, confirm and expand knowledge and competences achieved during their study. Following successful completion the students are able to plan an applied scientific work package, conduct the work in an external environment and to discuss and evaluate the results based on the relevant literature.
Content:	Depending on the interests and individual preferences of the students the internship can have a research focus or an applied focus. Students can choose to participate in an ongoing research project either of an external organisation or of the Institute of Environmental Sciences or or to do the internship in an external firm or other institution. The internship serves to get to know different possible professions and to apply and further develop the acquired knowledge and competence. Internships must be approved by the university, represented by the chairman of the examination committee prior to their beginning. Following the practical work, the students write a short report (1-2 pages) including: Exact name of the institution Name and matriculation number of the student Period and place of the internship Short description of the activities

	Concluding evaluation of the personal and general suitability of the internship Moreover the students are supposed to present their internship in a presentation for all students in order to offer an exchange of information and experiences between the students
Study / exam achievements:	Certificate, short report, presentation
Forms of media:	PowerPoint slides, handouts, seminar discussions
Literature:	

Master thesis

Module name:	**Master Thesis**
Semester:	4th Semester
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Lecturers and staff of the Institute for Environmental Sciences
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (C, 4), M.Sc. Ecotoxicology (C, 4)
Teaching format / class hours per week / group size:	independent scientific work
Workload: Face-to-face teaching / independent study	about 900 h work totally
Credit points:	30 CP
Required prerequisites:	At least 90 CP obtained
Recommended prerequisites:	none
Targeted learning outcomes:	The students work independently on a research topic for a total time of about 6 months. The topics depend on the actual research conducted in the various research groups. However, all topics should have an interdisciplinary character covering at least two different disciplines (e.g. chemistry and ecology, or Physics and Risk Assessment). The topics will be studied under the guidance of at least two teaching staff members representing the two science disciplines involved. Following an introductory discussion with the supervisors, the students prepare a written detailed research proposal including their hypothesis, introductory literature and statistical methods. After discussing the proposal with their supervisors they perform the research work on their own and discuss the obtained results regularly with their supervisor. Following the practical work, the students write a thesis including the theoretical background, the methods used, the results obtained and a discussion of the results based on the relevant scientific literature. The students present and defend the outcome of their work as an oral presentation. The thesis is graded by two reviewers. Following successful completion the students therefore are able to independently plan a scientific work package, conduct the work, evaluate the results based on the relevant literature and present the outcomes.
Content:	The content depends on the actual research questions in the research groups associated with the Institute for Environmental Sciences. They include, but are not restricted to the following areas: - Chemical experiments in the lab - Environmental organic chemistry - Physical transport or transfer processes of environmental chemicals - Ecotoxicological lab tests - Ecotoxicological field studies - In situ or monitoring work in the field

	□ Molecular genetics □ GIS data analysis □ Literature reviews □ Exposure, effect or landscape modelling □ Assessment or management of risks
Study / exam achievements:	Master thesis with colloquium
Forms of media:	PowerPoint, Handouts, Seminar discussions
Literature:	General ecotoxicological literature Specific published papers of the respective research group(s) on request

3.2 Elective subjects

Students have to choose two from the eight elective subjects. Here you find a short verbal description of the elective subjects. The table on page 71 shows the correspondence between the elective modules and the elective subjects.

Modelling (MOD)

This elective subject provides a profound knowledge of modelling in the environmental sciences. The main aim is to understand and apply different model types from different fields of environmental sciences such as ecology, economics and physics. The students will acquire the theoretical background of modeling as well as the ability to develop own models and apply existing models. Moreover, the elective subject enables them to critically assess the advantages and limitations of using models to solve environmental problems.
Recommended prerequisites: basic computer skills and interest in learning programming languages.
Core modules that should be elected: MOD1, MOD2, MOD3

Socio-economics and environmental management (SÖU)

Humans interact in many ways with the environment, on the one hand they are beneficiaries of its services, on the other hand they greatly influence its state and functions. But humans have also developed ways to manage the environment with the aim to achieve a multitude of objectives. This elective subject deals with the interactions between humans and the environment taking into account a multitude of perspectives including law, economics, business management, communication sciences and psychology. In the different modules of this subject students will acquire fundamental knowledge of these different perspectives on the environment and become acquainted with analytical and empirical methods typical for the respective discipline.
Recommended prerequisites: basic knowledge in economics, interest in social science theory and methods.
Core module that should be elected: SÖU4

Applied Ecology (AÖK)

Profound knowledge and practical skills in ecological applications can be gained in this elective subject. This includes the handling of selected organism groups for bioindication and scientific study, literature-based understanding and discussion of current topics of applied community ecology as well as practical experience in small research projects. Two modules cover molecular ecological topics and the associated lab and data analysis techniques. Another possible focus is the conservation of biodiversity.
Recommended prerequisites: basic knowledge in ecology, taxonomy, study design and statistics.
Core modules that should be elected: AÖK4 or AÖK6

Aquatic Systems (AQU)

This elective subject provides a comprehensive overview of chemical, physical, ecological, ecotoxicological, and socio-economical aspects of freshwater aquatic systems. In practical courses the students will get familiar with physico-chemical measurement techniques and analyses as well as with the sampling and determination of relevant organism groups. The practical courses are supplemented by lectures and seminars where the students are introduced to basic knowledge and emerging environmental concerns related to the interdisciplinary subjects of freshwater science and management.
Recommended prerequisites: extended knowledge and interest in physics, chemistry and calculus.
Core module that should be elected: ACP1

Chemicals in the Environment (CHE)

This elective subject provides a profound knowledge of the fate and effects of chemicals in the environment. The students develop fundamental understanding on the distribution, transport and environmental transformation of chemicals. They acquire knowledge on the modeling of chemical distribution in the environment and study novel concepts of environmental chemistry. In the environmental chemistry laboratory courses, they will deepen their skills in environmental analysis, applying state-of-the art instrumental analytical techniques. In addition, based on current ecotoxicological research, the students understand the effects of chemical exposure on individuals, populations, communities and ecosystems.

Recommended prerequisites: interest and basic knowledge in environmental-chemical processes
Core modules that should be elected: CHE1, LAB1 or 2

Environmental Analysis (ANA)

Students selecting Environmental Analysis will obtain profound knowledge and experience in environmental analysis from the field scale (geoecology) down to the microscale (trace analysis and physical chemistry). The modules of this elective subject combine experimental and theoretical courses in soil, water and interfacial analysis, such that the students will be able to use their understanding of modern instrumental analytical techniques for development of new analytical methods, planning environmental assessments and judging results of environmental analysis.
Recommended prerequisites: interest and basic knowledge in analytical chemistry
Core modules that should be elected: LAB1 or 2, ACP1 or GEO6

Soil Systems (SOS)

In the Soil Systems elective subject students develop a substantial understanding of one of the most fascinating, but hidden systems in the environment: the soil. It is the buffering zone of our environment. The interpenetration of the atmosphere, lithosphere, hydrosphere and biosphere leads to a sensitive but highly relevant new system from which mankind benefits in various ways. Soils are at the heart of the now called “Earth's critical zone”. The specialty at the University of Koblenz-Landau is the interdisciplinary manner in which this system is taught. The modules offer the opportunity to understand the ecological relevance of the soil, its functioning, its vulnerability towards land use and the relevance of soil for the economic value of ecosystem services. In the experimental modules, students will learn the analytical strategies to characterize soil and its contamination.
Recommended prerequisites: Interest in soils from an interdisciplinary perspective.
Core modules that should be elected: GEO2, ACP2

Landscapes and Scales (LAS)

Measurements are performed at the site scale, underlying processes are understood at the micro scale and environmental problems are to be solved at the landscape scale. To deal across scales with scientific insights and research questions is not trivial but everyday life of an environmental scientist. At the biogeochemical scale, small-scale processes do not simply add up to landscape scales and so hot and cold spots and hot and cold moments have to be identified. For the organismic scale, it would be discussions on alpha, beta and gamma diversity and charismatic species. In the different modules of this subject students will acquire fundamental knowledge of these different perspectives on the environment and become acquainted with analytical and empirical methods typical for the respective discipline.
Recommended prerequisites: extended knowledge in biogeochemistry and biodiversity, high interest in combining organismic and biochemical perspectives to social science, applying models and interest in theory and methods of landscape ecology.
Core module that should be elected: GEO3

Module ACP1: Water Analysis

Module name:	**Water Analysis**
Module code:	**ACP1**
Courses:	a) Laboratory exercise Water Analysis b) Seminar Water Analysis
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Dörte Diehl
Lecturer:	Dr. Dörte Diehl / Dr. Clara Mendoza-Lera
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2) M.Sc. Ecotoxicology (O, 2) 2F-B.Sc. Basisfach Umweltchemie (O, 3/4)
Teaching format / class hours per week / group size:	a) Lab exercise / 3 class hours (block course, total 45 h) / 10 b) Seminar / 1 class hour (block course, total 15 h) / 30
Workload: Face-to-face teaching / independent study	a) 45 h / 75 h b) 15 h / 45 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Modules B3 and B2/ETX3 completed and, additionally, students must meet one of the following criteria: 1. holding a B.Sc. degree in Umweltwissenschaften from the University of Koblenz-Landau or 2. successfully passed the LAB1 module or 3. participated in the lab safety assessment with outcome: "recommendation for LAB2". For details of lab safety assessment see LAB1 module
Recommended prerequisites:	Fundamental knowledge in chemistry and water chemistry (comparable to the lecture "Boden- und Wasserchemie" of the B.Sc. program) and experiences in laboratory work and knowledge in instrumental analysis (comparable to ETX4A).
Targeted learning outcomes:	The students learn how to plan and conduct fundamental chemical and physical water analysis. They become qualified to evaluate and document the results of the analysis in an ecological, ecotoxicological and legal context.
Content:	a) Water Analysis (Laboratory exercise): Measurement of physical environmental parameters within water bodies Organic and inorganic trace analysis in water samples Determination of well-established hydrochemical parameters b) Water Analysis (Seminar): Presentation of the analytical methods and discussion of the results and experiences from a) in a seminar accompanying the lab exercise.
Study / exam achievements:	Portfolio (written)
Forms of media:	

Literature:	Will be announced in the course

Module ACP2: Biogeochemical Interfaces

Module name:	**Biogeochemical Interfaces**
Module code:	**ACP2**
Courses:	a) Biogeochemical Interfaces b) Environmental Processes at Biogeochemical Interfaces
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Christian Buchmann
Lecturer:	Dr. Christian Buchmann
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2) M.Sc. Ecotoxicology (O, 2) 2F-B.Sc. Basisfach Umweltchemie (O, 3/4)
Teaching format / class hours per week / group size:	a) Lecture / 2 class hours (block course, total 30 h) / 60 b) Exercise / 3 class hours (block course, total 45 h) /10
Workload: Face-to-face teaching / Independent study	a) 30 h / 60 h b) 45 h / 45 h Total: 75 h / 105 h
Credit points:	6 CP
Requirements under the examination regulations:	Modules B3 and B2/ETX3 completed and, additionally, students must meet one of the following criteria: 4. holding a B.Sc. degree in Umweltwissenschaften from the University of Koblenz-Landau or 5. successfully passed the LAB1 module or 6. participated in the lab safety assessment with outcome: "recommendation for LAB2". For details of lab safety assessment see LAB1 module
Recommended prerequisites:	Fundamental knowledge in physical chemistry, environmental chemistry, soil sciences and ecotoxicology
Targeted learning outcomes:	The students understand the central role of interfaces for environmental processes such as sorption and transport of environmental contaminants, bioavailability and toxicity. They understand the intense interactions between physics, chemistry and biology. The students gain experience in the analysis of interfacial processes and are competent for independent interdisciplinary process-oriented experiments.
Content:	a) Biogeochemical Interfaces: (I) weak interactions: their principles and relevance in natural systems; (II) water: properties, anomalies, function in biogeochemical systems and hydration; (III) biopolymers: production, properties and function; (IV) biogeochemical interfaces: soil organic matter, minerals and organisms, pores, sediments, biofilms, aquatic systems; (V) dissolved organic matter: properties, function and current models, natural and engineered particles; (VI) physicochemical environmental processes and interfaces: sorption, pollutant mobilization, colloid-facilitated pollutant transport, wetting,

	capillarity; (VII) Interactions between biology and chemistry:, interactions in natural systems, swelling, diffusion, precipitation; (VIII) abiogenesis: current theories and concepts, implications. b) Environmental processes at biogeochemical interfaces: Independent planning, implementation and evaluation of current research projects and environmental issues-oriented experiments to wetting and contact angle, surface tension, precipitation and crystallization of colloids at biogeochemical interfaces, swelling processes, etc.
Study / exam achievements:	Lab work report with oral exam
Forms of media:	PowerPoint slides
Literature:	Basic and advanced reading: Butt, H.-J., Graf, K., Kappl, M. (2006): Physics and Chemistry of Interfaces. Wiley-VCH, Weinheim. Schwuger, M.J. (1996): Lehrbuch der Grenzflächenchemie. Georg Thieme Verlag Stuttgart. Israelachvili, J.N. (2011): Intermolecular and surface forces, Elsevier, Amsterdam Current scientific literature

Module ACP3: Current Developments in Environmental Chemistry

Module name:	**Current Developments in Environmental Chemistry**
Module code:	**ACP3**
Courses:	Current Developments in Environmental Chemistry
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Allan Philippe
Lecturer:	Dr. Allan Philippe
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	Project Seminar / 4 SWS / 30
Workload: Face-to-face teaching / independent study	60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	none
Targeted learning outcomes:	The students are able to conduct scientific literature researches, to choose, find, analyse, present and discuss literature and to work with scientific literature data bases. They are able to become acquainted with new theoretical and practical knowledge, to transfer basic knowledge to specific scientific problems and to discuss on scientific level. The students are able to transfer basic knowledge in chemistry and ecology to specific scientific topics and applications. The students are familiar with environmental-chemical processes in terrestrial and aquatic systems, the physicochemistry behind them, the interactions between the systems and organic and inorganic contaminants and their relevance for transport, enrichment, toxicity and bioavailability.
Content:	Presentation, analysis and discussion of current scientific literature and ongoing research projects on re-use of waste water in agriculture, fate and effects of engineered nanoparticles, soil quality and soil degradation, soil water repellency, sorption of organic and inorganic chemicals on soil particles, suspended matter and colloids, engineered nanoparticles; interactions between contaminants and environment, relation between environmental processes and biological effects of organic chemicals and nanoparticles. The seminar task is to conduct a scientific literature review including data base research in the context of these or related topics.
Study / exam achievements:	Student's presentation and portfolio
Forms of media:	
Literature:	Basic reading:

	Evangelou, V.P. (1998): Environmental soil and water chemistry. John Wiley, New York Weiner, E.R. (2000): Applications of Environmental Chemistry. A practical Guide for Environmental professionals. Boca Raton, CRC Press Andrews, J.E., Brimblecombe, P., Jickells, T.D., Liss, P.S. (2003): An Introduction to Environmental Chemistry. Blackwell, Oxford. Advanced reading: Will be announced in the course.

Module ACP4: Methods in environmental physics

Module name:	**Methods in environmental physics**
Module code:	**ACP4**
Courses:	a) Analysis of complex data b) Methods in Environmental Physics II
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Andreas Lorke
Lecturer:	Prof. Dr. Andreas Lorke
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2)
Teaching format / class hours per week / group size:	a) Exercise / 2 class hours (block course, total 30 h) / 30 b) Seminar / 2 class hours (block course, total 30 h) / 60
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	
Targeted learning outcomes:	The students learn to develop and apply complex data analysis and presentation methods based on sample data from current research projects and publications in environmental physics. They understand the underlying measurement principles and are able to assess measurement and analysis constraints and evaluate their explanatory power.
Content:	a) Analysis of complex data: - physical data acquisition - derivation of target data, quality assurance and visualization - spectral analysis of time series and spatial data b) Methods in environmental physics III: - physical measurement principles - choosing measurement strategies and technologies - evaluation and critical assessment of suitability, accuracy, resolution, stability and costs of measurement systems - Critical evaluation of recent methodological advancements in environmental physics
Study / exam achievements:	Portfolio (written)
Forms of media:	
Literature:	Basic reading: Emery, W.J. (2001): Data analysis methods in physical oceanography. Elsevier. Will be announced in the course. Advanced reading: Current publications

Module ACP5: Process modelling

Module name:	**Process modelling**
Module code:	**ACP5**
Courses:	a) Reaction and transport modeling b) Application of transport modeling tools
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Andreas Lorke
Lecturer:	Prof. Dr. Andreas Lorke / N.N.
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Seminar / 2 class hours / 60 b) Exercise / 2 class hours / 30
Workload: Face-to-face teaching / Independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	none
Targeted learning outcomes:	The students know the physical and mathematical basis of combined transport and reaction modeling in environmental applications. They can set up simple models using the statistics package R and they become familiar with contaminant transport in soil, the numerical implementation application to selected problems.
Content:	a) Reaction and transport modeling: - Transport- and reaction models - Numerical recipes - Model calibration and verification b) Application of transport modeling tools - Application of selected modeling tools in soil physics (Water flow in soil, gas diffusion, contaminant transport)
Study / exam achievements:	Portfolio (written)
Forms of media:	
Literature:	Basic reading: Imboden, D., Koch, S. (2003): Systemanalyse: Einführung in die mathematische Modellierung natürlicher Systeme. Springer, Berlin. Schwarzenbach, R.P. (2002): Environmental Organic Chemistry. J.Wiley & Sons, New Jersey. Soetaert, K., Herman, P.M.J. (2010): A practical guide to ecological modelling: Using R as a simulation platform. Springer. Bittelli, M., Campbell, G. S., & Tomei, F. (2015). *Soil Physics with Python: Transport in the Soil-Plant-Atmosphere System*. OUP Oxford.

Module ACP6: Environmental physics II

Module name:	**Environmental physics II**
Module code:	**ACP6**
Courses:	a) Aquatic Physics b) Current Topics in Environmental Physics
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Andreas Lorke
Lecturer:	Prof. Dr. Andreas Lorke
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Lecture / 2 class hours / 30 b) Seminar / 2 class hours / 30
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	
Targeted learning outcomes:	The students know the physical processes governing the flow and distribution of energy, momentum, and mass in aquatic systems (rivers, reservoirs, lakes and oceans) and are able to apply physical equations for their quantitative analysis.
Content:	a) Aquatic Physics: - Physical processes in aquatic ecosystems - Environmental fluid mechanics - Water-atmosphere interactions - Sediment-water interactions - Flux paths of energy and mass in aquatic systems - Interactions between flow, organisms, and biogeochemical cycles b) Current Topics in Environmental Physics: - Analysis of current scientific publications - Interdisciplinary relevance of physical processes in environmental sciences
Study / exam achievements:	Portfolio (written)
Forms of media:	
Literature:	Basic reading: Fischer, H. B., N. H. Brooks, et al. (1979). Mixing in Inland and Coastal Waters. N.Y., Academic Press, New York. Kundu, P., I.M. Cohen (2008): Fluid Mechanics. Academic Press. Lerman, A., Gat, J.R., Imboden, D.M.: Physics and chemistry of lakes. Springer Advanced reading: Current publications

Module CHE1: Organische Chemie für Fortgeschrittene

odule name:	**Organische Chemie für Fortgeschrittene**
Module code:	**CHE 1**
Courses:	a) Vorlesung Organische Chemie 2 b) Projekt Organische Chemie
Semester:	2./3. Semester
Duration of module:	2 semesters
Frequency of offer:	annually
Module coordinator:	Dr. Katherine Muñoz
Lecturer:	Dr. Katherine Muñoz
Language:	Deutsch
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2/3) M.Sc. Ecotoxicology (O, 2/3) B.Ed. Chemie (C, 1/2) Zwei-Fach Bachelor, Basisfach und Wahlfach Umweltchemie
Teaching format / class hours per week / group size:	a) Vorlesung / 2 SWS / 80 b) Projekt Organische Chemie / 1 SWS / 15
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 15 h / 75 h Gesamt: 45 h / 135 h
Credit points:	6 LP
Requirements under the examination regulations:	Zulassung zum Masterstudiengang Umweltwissenschaften oder Ecotoxicology
Recommended prerequisites:	Grundlagen der Organischen Chemie 1 (Teilmodul UC2), möglichst auch die Inhalte der entsprechenden Bachelormodule UC1, UC2
Targeted learning outcomes:	a) Die Studierenden - haben ein grundlegendes Verständnis organisch-chemischer Zusammenhänge, der Stoffklassen und der Modelle der Organischen Chemie, - kennen die wichtigsten Konzepte der Reaktionsverläufe der von organisch-chemischen Reaktionen (Substitution, Eliminierung, Addition, Oxidations- und Reduktionsreaktionen, sowie Umlagerungen) - können Reaktionen deuten und Synthese-Hypothesen formulieren - kennen ausgewählte Stoffklassen (z.B. Aromaten, Kunststoffe und Proteine) und deren Umwandlungen - sind in der Lage sach- und fachbezogene Informationen zu erschließen und auszutauschen b) Die Studierenden - kennen den Ablauf wissenschaftlichen Arbeitens in der organischen/ökologischen Chemie und sind in der Lage,forschungsorientierte Experimente der organischen Chemie aus Hypothesen abzuleiten, zu entwickeln und durchzuführen - kennen die Grundsätze wissenschaftlichen Publizierens und können über Experimente im Rahmen eines größeren Forschungsprojekts berichten

Content:	a) Grundlegende Konzepte und Arbeitsweisen der Organischen Synthesechemie Synthese wie Retrosynthese von bekannten und unbekannten Verbindungen Reaktionsweisen von organisch-chemischen Substanzen, Abschätzungen von Reaktivitäten anhand von Funktionalisierungen und Substituenteneinflüssen Transfer der Grundlagen in umweltchemische Zusammenhänge, anwendungsbezogene Synthesechemie Vernetzende Reaktionen, Reaktionsmechanismen Transformation funktioneller Gruppen (C-Atom-Heteroatom), Anwendung an praktischen Beispielen Grundlagen zu wichtigen analytischen Methoden Reaktionsmechanismen: Substitution / Addition / Eliminierung / Umlagerung b) Mitarbeit an einem organisch-chemischen Forschungsprojekt hypothesengesteuerte Entwicklung, Durchführung und Auswertung von Experimenten, Wissenschaftliches Arbeiten, Publizieren, Literaturrecherche.
Study / exam achievements:	Klausur
Forms of media:	PowerPoint Folien
Literature:	Begleitende Literatur: Bruice P. Y. (2007). Organische Chemie. Addison-Wesley Brückner R. (2009). Reaktionsmechanismen. Spektrum Clayden J., et al. (2013). Organische Chemie. Springer Spektrum Projekt Organische Chemie: Hier wird Literatur entsprechend des Forschungsgebiets angegeben.

Module CHE2: Physikalische Chemie

Module name:	**Physikalische Chemie**
Module code:	**CHE2**
Courses:	a) Grundlagen der Kinetik, Elektrochemie und Grenzflächenchemie b) Mathematische und physikalische Grundlagen c) Grundlagen der chemischen Thermodynamik
Semester:	2./3. Semester
Duration of module:	2 semesters
Frequency of offer:	annually
Module coordinator:	Dr. Jan David
Lecturer:	Dr. Jan David
Language:	Deutsch
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2/3) B.Ed. Chemie (C, 3/4) Zwei-Fach Bachelor, Basisfach und Wahlfach Umweltchemie (C, 3/4)
Teaching format / class hours per week / group size:	a) Vorlesung/Übung / 2 SWS / 80 b) Vorlesung/Übung / 1 SWS / 80 c) Vorlesung/Übung / 2 SWS / 80
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 10 h / 20h c) 20 h / 40h Gesamt: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Zulassung zum Masterstudiengang Umweltwissenschaften oder Ecotoxicology
Recommended prerequisites:	Grundlagen der Chemie
Targeted learning outcomes:	Die Studierenden haben ein grundlegendes Verständnis physikalisch-chemischer Phänomene, kennen die wichtigsten Konzepte der Thermodynamik, Reaktionskinetik, Elektrochemie und Grenzflächenchemie
Content:	Grundlegende Konzepte und Arbeitsweisen der Physikalischen Chemie Mathematische physikalische Grundlagen Thermodynamik und Gleichgewichtslehre Grundlagen und Anwendungen der Elektrochemie Reaktionskinetik Grenzflächenchemie
Study / exam achievements:	Klausur
Forms of media:	PowerPoint Folien, Übungsblätter
Literature:	Peter W. Atkins; Julio de Paula: Physikalische Chemie. Wiley-VCH, Weinheim

Module CHE3: Ecological Chemistry

Module name:	**Ecological Chemistry**
Module code:	**CHE3**
Courses:	a) Seminar Ecological Chemistry b) Project Ecological Chemistry
Semester:	1.-3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Katherine Muñoz
Lecturer:	Dr. Katherine Muñoz
Language:	Englisch
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 1/2) B.Ed. Chemie (C, 1/2) M.Sc. Ecotoxicology (O, 1/2)
Teaching format / class hours per week / group size:	a) Seminar / 1 SWS / 30 b) Project Ecological Chemistry / 1 SWS / 30
Workload: Face-to-face teaching / independent study	a) 15 h / 75 h b) 15 h / 75 h Total: 30 h / 150 h
Credit points:	6 LP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	Fundamentals of Organic Chemistry 1 (submodule UC2), if possible also the contents of the corresponding bachelor modules UC1, UC2
Targeted learning outcomes:	a) The students ● Understand the principles of the ecological chemistry, with focus on release pathways and transformation processes of organic pollutants ● Identify the role of chemical and physical properties to assess occurrence and fate of organic compounds ● Analyze the role of matrix composition and chemical concentration level in assessing environmental occurrence and exposure ● Evaluate chemical reactions and microbial transformations for the prediction of stability, persistence and the occurrence of parent compound and transformation products ● Summarize and apply main concepts of ecological chemistry to assess chemical responses and human-environment chemical interactions b) The students ● Know the principles of scientific research and scientific writing ● Critically analyze the scientific literature and integrate knowledge to independently develop research questions

	and to elaborate scientific hypotheses ● Apply integrated knowledge to design empirical studies in the context of ecological chemistry. ● Discuss primary literature in a group and present scientific evidence in a verbal (presentation) and written (report) form
Content:	Seminar ecological chemistry ● Concepts of ecological chemistry Part A: organic chemical pollutants: Entry pathways, transport and transformation processes ● Concepts of ecological chemistry Part B: Role of chemistry in mediating interactions among organisms in example of chemical defense response ● Introduction to chemical methods to assess occurrence, fate and chemical responses ● Physicochemical and biological properties of organic chemicals in the context of occurrence, fate and effect (interaction among species) ● Introduction to scientific uncertainty for evaluation of environmental concentrations ● Human-environment chemical interactions: chemical diversity, occurrence, monitoring strategies, effects to humans, animals and non-target species Project ecological chemistry: ● Hypothesis-driven development, implementation and evaluation of experiments ● Introduction to scientific research, literature revision, management and evaluation ● Scientific writing and publishing in an interdisciplinary context ● Developing experiment-specific connections between different environmental science disciplines ● Recognition of new thinking strategies and conceptual development of new ideas ● Choice or specification of a topic to be worked on from the field of ecological chemistry in a laboratory and or field experiment
Study / exam achievements:	Module exam (consisting of the topics of the seminar)
Forms of media:	PowerPoint presentations, presentation of the issues to be addressed with discussion (approx. 45 min plus 15 min), interactive dynamic teaching content via an online platform.
Literature:	Literature: An accessible, and complete textbook on this topic is absent, therefore the literature is based on recent relevant papers in ecological chemistry

Module LAB1: Basic Lab Course Environmental Chemistry

Module name:	**Basic Lab Course Environmental Chemistry**
Module code:	**LAB1**
Courses:	a) Principles of quantitative chemical analysis b) Analysis of soil and water samples and instrumental analysis of environmental contaminants
Semester:	1st Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Allan Philippe
Lecturer:	current scientific staff of the working group Environmental and Soil Chemistry
Language:	English
Classification within the curriculum: (compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Ecotoxicology (C, 1/2) M.Sc. Umweltwissenschaften / Environmental Sciences (O, 1/2)
Teaching format / class hours per week / group size:	a) + b) Lab exercises / 5 class hours / 7 (block course)
Workload: Face-to-face teaching / independent study	75 h / 105 h
Credit points:	6 CP
Required prerequisites:	(1) Basic knowledge in chemistry (organic and inorganic) and analytical techniques. (2) Modules B3 and B2 must be completed (3) Participation at the lab safety assessment with outcome: "recommendation for LAB1". The test evaluates whether LAB1 or LAB2 is suitable with respect to the student's previous knowledge. It is written in the first week of each winter semester (as announced in KLIPS). In the lab safety assessment the following contents will be examined: ● Knowledge in chemistry (organic and inorganic), and knowledge and experience in analytical techniques ● Knowledge on environmental chemistry (as indicated in this module) ● Experience on handling of laboratory consumables and devices This module is a part of the course "Laborübungen Instrumentelle Umweltanalytik", Modul UC3 and "Chemie für Umweltwissenschaftler", Modul UC 2 of the Bachelor study program. **It can thus not be selected by degree holders graduated in that programme in Landau.** It has been conceived to offer the opportunity for students from other course programmes to adapt to the required lab experience in environmental analytics. **Due to logistic reasons, the course can be offered for 20 students per semester.**

Recommended prerequisites:	Experience on handling of common laboratory consumables and devices Knowledge on lab safety rules
Targeted learning outcomes:	The students understand and get experienced with common laboratory proceedings and techniques and methods used in environmental analysis. At the end of the course, the students can analyze relevant organic and inorganic and contaminants (e.g., polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOC)) in diverse environmental matrices. They know which techniques and methods can be used to quantify environmental pollutants. Moreover, they are able to critically assess and evaluate analytical results.
Content:	Sampling, preparation and treatment of environmental samples (Extraction, enrichment and purification methods) Qualitative analysis of major inorganic and organic group of substances Acid/base reactions and buffer systems Assessment of organic and inorganic pollutants in soil and water samples (Instrumental techniques: TLC, HPLC, GC, AAS, Spectrophotometry) Analysis, interpretation and documentation of experimental results
Study / exam achievements:	Portfolio (written)
Forms of media:	Laboratory equipment and material, independent work in small groups on small research questions
Literature:	Basic reading: Schwarzenbach, R.P (2003): Environmental Organic Chemistry, John Wiley. Merian E., Anke, M., Ihnat, M., Stoeppler, M. (2004): Elements and their Compounds in the Environment - Occurrence, Analysis and Biological Relevance (in 3 Volumes). Oxford, Wiley-VCH. Further literature will be announced at the beginning of the course

Module LAB2: Advanced Lab Course Environmental Chemistry

Module name:	**Advanced Lab Course Environmental Chemistry**
Module code:	**LAB2**
Courses:	a) Characterisation of substances based on their physicochemical properties b) Advanced environmental analysis
Semester:	1st or 3rd Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Allan Philippe
Lecturer:	current scientific staff of the working group Environmental and Soil Chemistry
Language:	English
Classification within the curriculum: (compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Ecotoxicology (C, 1) M.Sc. Umweltwissenschaften / Environmental Sciences (O, 1/3)
Teaching format / class hours per week / group size:	a) + b) Lab exercises / 5 class hours / 7 (block course)
Workload: Face-to-face teaching / independent study	75 h / 105h
Credit points:	6 CP
Required prerequisites:	(1) Advanced knowledge in chemistry (organic and inorganic) and analytical techniques. (2) Modules B3 and ETX3/B2 must be successfully completed. (3) Participation at the lab safety assessment with outcome: "recommendation for LAB2". The test evaluates whether LAB1 or LAB2 is suitable with respect to the student's previous knowledge. It is written in the first week of each winter semester (as announced in KLIPS). In the lab safety assessment following contents will be examined: Knowledge in chemistry (organic and inorganic), and knowledge and experience in analytical techniques Knowledge on environmental chemistry (as indicated in this module) Experience on handling of laboratory consumables and devices
Recommended prerequisites:	(1) Experience on handling of common and major laboratory consumables, devices and instruments (2) Knowledge on lab safety rules and procedures (3) Scientific writing skills
Targeted learning outcomes:	The students understand and are able to apply practically the different parameters determining the fate of pollutants in the environment. The students can analyze different/relevant contaminants at trace concentrations in diverse environmental matrices. They understand fundamental experimental approaches of environmental chemistry and can analyze and describe environmental processes. They know which techniques and methods can be used to quantify environmental pollutants and how analytical methods should be developed and validated. Moreover, they are able to critically assess and

	evaluate analytical results. They are familiar with standard and advanced analytical techniques as mass spectrometry.
Content:	Partition and adsorption coefficients Purification and clean-up techniques of trace analytics with emphasis on pesticides and mycotoxins in environmental samples Identification of degradation products and pathways Kinetics of environmental chemical processes Bio concentration of heavy metals Analytics and characterization of nanoparticles Measurement principles of LC-MS, GC-MS and ICP-OES including limitations and error estimations for methods
Study / exam achievements:	Portfolio (written)
Forms of media:	Laboratory equipment and material, independent work in small groups on small research questions
Literature:	Basic reading: Schwarzenbach, R.P (2003): Environmental Organic chemistry, John Wiley. Merian E., Anke, M., Ihnat, M., Stoeppler, M. (2004): Elements and their Compounds in the Environment - Occurrence, Analysis and Biological Relevance (in 3 Volumes). Oxford, Wiley-VCH. Throck, J., Sparkman, W., Sparkman, D. (2008): Introduction to mass spectrometry - Instrumentation, applications, and strategies for data interpretation. Chichester, Wiley-VHC Further readings will be announced

Module AÖK1: Indicator Organisms

Module name:	**Indicator Organisms**
Module code:	**AÖK1**
Semester:	1.-3. Semester
Duration of module:	1-3 semesters
Frequency of offer:	every semester
Module coordinator:	Prof. Dr. Martin Entling
Lecturer:	Prof. Dr. Martin Entling / Dr. Jens Schirmel / Dr. Verena Rösch / Dr. Dagmar Lange / Dr. René Sahm
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Ecotoxicology (O, 1-3) M.Sc. Umweltwissenschaften / Environmental Sciences (O, 1-3) B.Sc. Umweltwissenschaften (O, 4-6) 2F-B.Sc. Naturschutzbiologie (O, 4-6) M.Ed. Biologie Gymnasium (O, 1-4)
Teaching format / class hours per week / group size	2 practical courses of 2 class hours each (block courses, total 60 h) / 20
Workload: Face-to-face teaching / independent study	60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study, basic skills in species determination of plants and animals
Recommended prerequisites:	Basic knowledge in taxonomy and study design
Targeted learning outcomes:	The students understand biological indication (advantages, problems, limitations). Students develop special interest in certain groups of indicator organisms and are able to employ them for landscape planning and scientific study. They are able to sample them in the field and to identify species. The students are capable of data analysis and interpretation and how to draw conclusions on the sampled environment.
Content:	Each single course (à 2 SWS) covers sampling and determination of a particular organism group and interpretation of the data. Each student chooses two such courses. Examples for organism groups: Vegetation, spiders, insects, and breeding birds for terrestrial environments Plankton, macrozoobenthos, fishes, and macrophytes for aquatic environments The results are used to describe local characteristics and to recognize possible stresses
Study / exam achievements:	Two partial exams, depending on the single course one of the following: written exam (60 min), oral exam (30 min), term paper, portfolio, presentation (15 min). The examination type will be determined at the beginning of the course.
Forms of media:	Field guides, field study equipment, PowerPoint slides
Literature:	Literature will be announced in the course

Module AÖK2: Community Ecology

Module name:	**Community Ecology**
Module code:	**AÖK2**
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Carsten Brühl
Lecturer:	Dr. Carsten Brühl
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Ecotoxicology (O, 3) M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3)
Teaching format / class hours per week / group size	Lecture/ Seminar / 4 class hours / 60
Workload: Face-to-face teaching / independent study	60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for MSc. study
Recommended prerequisites:	Solid knowledge in general ecology and statistics
Targeted learning outcomes:	The students understand the various influences on the composition of animal, plant and microbial communities in time and space. They are also capable of assessing and recording a community in the field and become familiar with the data analysis and the relevant literature for the selected community. Case studies are presented for temperate and tropical regions. An introduction in complex tropical ecosystems is given. The students are getting familiar with the current scientific literature and debates. They understand to extract the relevant information of a scientific paper and can form critical thoughts on published studies.
Content:	Structuring influences that form communities (predation, competition, resource use), herbivory, Introduction to pollination biology, Macroecology Examples of communities in ecosystems Field margins, Aquatic habitats, Arid grassland Forest, Tropical forest Wetlands, Estuaries, Marine ecosystems Quantitative recording of communities Statistical community analysis of complex data set using various multivariate methods Reading and summarizing of recent scientific texts
Study / exam achievements:	Portfolio (written)
Forms of media:	PowerPoint slides, Demonstration of methods
Literature:	Current scientific literature Morin, P. (1999): Community Ecology. Blackwell.

Module AÖK3: Quantitative Experimental Ecology

Module name:	**Quantitative Experimental Ecology**
Module code:	**AÖK3**
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Jun.-Prof. Dr. Mirco Bundschuh
Lecturer:	Jun.-Prof. Dr. Mirco Bundschuh
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2) M.Sc. Ecotoxicology (O, 2)
Teaching format / class hours per week / group size:	Lab exercises / 4 SWS (Block, total 60 h) / 5
Workload: Face-to-face teaching / independent study	60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	
Recommended prerequisites:	None
Targeted learning outcomes:	Students are able to apply their knowledge on ecological and population biological concepts into practice. They gain hands-on experience in experimentation, quantitative data analysis, literature research and writing reports.
Content:	Using a basic ecological concept, students develop a testable hypothesis and an appropriate study design to test it. The case study is used to demonstrate aspects vital to study design and the conduct of experiments: such as suitable controls, replication, independence, and randomisation. The gained data will be analysed and interpreted using appropriate tools. Finally, the students write a report of high linguistic and scientific quality (publication-level) considering the available scientific literature.
Study / exam achievements:	Project paper
Forms of media:	PowerPoint, computer methods, field and lab work
Literature:	Accompanying Literature/Material: Karban, R., Huntzinger, M. (2006): How to do ecology: a concise handbook. Princeton University Press. Scheiner, S.M., Gurevitch, J. (2001): Design and analysis of ecological experiments. Oxford University Press. Hairston, N.G. (1989): Ecological experiments: purpose, design, and execution. Cambridge University Press.

Module AÖK4: Molecular Ecology I

Module name:	**Molecular Ecology I**
Module code:	**AÖK4, resp. ETX7**
Courses:	a) Molecular Ecology I b) Phylogenetic and Population Genetic Analysis
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Klaus Schwenk
Lecturer:	Prof. Dr. Klaus Schwenk / Dr. Anne Thielsch
Language:	English
Classification within the curriculum: (compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2) M.Sc. Ecotoxicology (C, 2) M.Ed. Biologie Gymnasium (O, 1-4) 2F-B.Sc. Naturschutzbiologie (O, 4-6)
Teaching format / class hours per week / group size:	a) Lecture / 2 class hours (total 30 h) / 100 b) Exercise / 2 class hours (block course, total 30 h) / 30
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Required prerequisites:	
Recommended prerequisites:	None
Targeted learning outcomes:	The students are familiar with major topics in molecular ecology and basic theories of population genetics and phylogenetics. They get an overview of possible methods in molecular ecology and know examples of their application. The students gain practical experience in phylogenetic analysis software and are able to interpret the results.
Content:	Principles of molecular genetics Molecular identification of species, individuals and sex Genetic aspects of behavioural ecology Population genetics Evolutionary ecotoxicology Phylogeography Conservation genetics Genetically modified organisms Analytical methods in molecular ecology and phylogenetics
Study / exam achievements:	Portfolio (written/oral)
Forms of media:	PowerPoint, Phylogenetic analysis software
Literature:	Basic reading: Beebee and Rowe (2008): An introduction to molecular ecology. Oxford University Press Frankham, Ballou and Briscoe. (2005): Introduction to conservation genetics. Cambridge University Press. Advanced reading:

	Bromham (2008): Reading the Story in DNA, Oxford University Press. Ankley, G.T., Miracle, A.L., Perkins, E.J. (2007): Genomics in regulatory ecotoxicology: applications and challenges. CRC Press Inc., Boca Raton. Knoop, V., Müller, K. (2006): Gene und Stammbäume: Ein Handbuch zur molekularen Phylogenetik. Spektrum Akademischer Verlag, Heidelberg.

Module AÖK5: Molecular Ecology II

Module name:	**Molecular Ecology II**
Module code:	**AÖK5**
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Anne Schrimpf
Lecturer:	Dr. Anne Schrimpf
Language:	German, optional English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	Lab exercise / 4 class hours (block course, total 60 h) / 6
Workload: Face-to-face teaching / independent study	60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Module AÖK4: Molecular Ecology I Module B2: Tools for Complex Data Analysis
Recommended prerequisites:	Basic knowledge in community ecology
Targeted learning outcomes:	The students gain practical experiences with molecular-biological lab methods. They are practiced to interpret population-genetic data and to provide conclusions regarding the long-term population dynamics and the potential factors of influence. The students are able to develop a scientific question, to choose and to apply adequate molecular-biological methods as well as to evaluate their results under application of appropriate statistical procedures.
Content:	During this course the application of technologies of the molecular biology is practiced, to show the effect of environmental factors on the genetic diversity within and between populations. Using a concrete example the population structure and genetic diversity is determined to draw conclusions on the long-term population dynamics. The training period encloses among other things the following methods: DNA-Extraction Gel-electrophoresis PCR-based methods (RAPD, Microsatellite analysis, sequencing, real-time PCR)
Study / exam achievements:	Term paper (Studienarbeit)
Forms of media:	Laboratory equipment, computer and analysis software, PowerPoint slides
Literature:	Laboratory script

Module AÖK6: Conservation Biology°

Module name:	**Conservation Biology**
Module code:	**AÖK6**
Courses:	a) Conservation Biology b) Arten-, Biotop- und Landschaftsschutz (auf Deutsch) or Applied Ecology: Conservation (in English)
Semester:	1./2. Semester
Duration of module:	2 semesters
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Martin Entling
Lecturer:	a) Prof. Dr. Martin Entling b) Dr. Verena Rösch, Prof. Dr. Martin Entling
Language:	a) English b) German or English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences 2F-B.Sc. Naturschutzbiologie (C, 3) M.Ed. Biologie Gymnasium (O, 1-4)
Teaching format / class hours per week / group size	a) Lecture / 2 class hours (total 30 h) / 100 / *Online lecture / 2 class hours (total 30h) / 30** b) Seminar or Exercise / 2 class hours (total 30 h) / 30 or 24 / *Online exercise / 2 class hours (total 30h) / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	
Recommended prerequisites:	Knowledge in ecology and environmental sciences
Targeted learning outcomes:	Students can describe Biodiversity at the level of genes, species and ecosystems. They can explain global and regional threats to biodiversity and apply strategies for biodiversity conservation. Students know how to implement conservation in a socioeconomic context and under consideration of other types of land-use. Students are able to search the scientific literature and to comprehend and present scientific findings in the context of conservation biology.
Content:	a) Naturschutzbiologie / Conservation Biology: - Biodiversity and its importance: genes, species and ecosystems Applied population ecology, extinction processes - Threats to biodiversity: habitat loss and degradation, overexploitation, invasive species, climate change - Protection of ecosystems, management of populations, ex-situ conservation b) Arten-, Biotop- und Landschaftsschutz / Applied Ecology: Conservation: - Reintroduction of species, habitat management and protected areas, biological conservation in managed habitats (agriculture, forestry), management of invasive species, habitat fragmentation, legal background of conservation.

Study / exam achievements:	written exam plus presentation/poster
Forms of media:	PowerPoint slides etc., *Panopto videos**
Literature:	Hunter, M., Gibbs, J. (2007): Fundamentals of conservation biology. Blackwell Publishing. Primack, R.B., Sher, A.A. (2016) An introduction to conservation biology. Sinauer Associates. Additional Literature will be announced during the courses.

° Available in dual degree online study program MSc Environmental Sciences

* Restricted admission: This applies exclusively to the dual degree online study program MSc Environmental Sciences

Module GEO1: Human-Environment Systems

Module name:	**Human-Environment Systems**
Module code:	**GEO1**
Courses:	a) Analysing human environment interactions with a special focus on developing countries b) Modelling human environment interactions project course
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Hermann Jungkunst
Lecturer:	Prof. Dr. Hermann Jungkunst / Dr. Mira Kattwinkel
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2)
Teaching format / class hours per week / group size:	a) Seminar / 2 class hours (block course, total 30 h) / 60 b) Exercise / 2 class hours (block course, total 30 h) / 30
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 15 h / 75 h Total: 45 h / 135 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	none
Targeted learning outcomes:	The students acquire methods to analyse the effects of human-environment interactions. They are capable to identify key drivers of environmental problems including their socio-economic background. Moreover, the students gain insights into the particularities of the selected environmental problem in developing countries. Finally, they are able to model the human-environment interaction.
Content:	Analysing human environment interactions with a special focus on developing countries Historical background for a selected environmental problem Tools to analyse human-environment interactions Case examples from developing countries Modelling human environment interactions project course The students use system dynamics simulation models to analyse the relevance of human action in a current environmental problem. They analyse the model behaviour and investigate future development under different scenarios in a modelling project.
Study / exam achievements:	Portfolio (written)
Forms of media:	PowerPoint slides, computer, software (e.g. Matlab, R)
Literature:	Basic reading: Bossel, H. (2007): Systems and Models – Complexity, Dynamics, Evolution, Sustainability. Books on Demand, Norderstedt. ISBN 978-3-8334-8121-5 Bossel, H. (2007): System Zoo 2 Simulation Models – Climate, Ecosystems, Resources. Books on Demand, Norderstedt. ISBN 978-3-8334-8423-0

	Bossel, H. (2007): System Zoo 3 Simulation Models – Economy, Society, Development. Books on Demand, Norderstedt. ISBN 978-3-8334-8424-7 Chapin F.S., P.A. Matson, Mooney H.A. (2002): Principles of terrestrial ecosystem ecology. New York, Berlin, Heidelberg. Farina A. (1997): Principles and methods in landscape ecology. Springer Verlag GmbH. Gunderson, L., Holling, C.S. (2007): Panarchy: Understanding Transformations in Human and Natural Systems. Island Press. Roughgarden, J. 1998. Primer of ecological theory. Prentice Hall, Upper Saddle River. Advanced reading: Current scientific journal articles.

Module GEO2: Applied Geoecology I

Module name:	**Applied Geoecology I**
Module code:	**GEO2**
Courses:	Geoecological Field Course
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Hermann. Jungkunst
Lecturer:	Prof. Dr. Hermann. Jungkunst
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2) M. Sc. Ecotoxicology (O, 2)
Teaching format / class hours per week / group size:	Field exercise / 4 class hours (block course 60 h) / 20
Workload: Face-to-face teaching / independent study	60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	Pedological and geomorphological basic knowledge
Targeted learning outcomes:	The students acquire the most important geoecological field methods and the ability of transfer from theory to praxis. They get to know geoecological methods, get the ability to do practical field and group work.
Content:	Fundamental field survey methods are carried out on the basis of a certain theme in a specific region: Pedological field survey (soil and sediment identification, sampling, drawing) Geomorphological field survey (topographic survey, field mapping) Vegetation Analyses (structure, composition, Ellenberg Indicators) Land use mapping Hydrological and microclimatic measurements and field mapping
Study / exam achievements:	Term paper (Studienarbeit)
Forms of media:	Field work
Literature:	Basic and advanced reading: Barsch, H., Billwitz, K. u. H.-R. Bork [Hrsg.] (2000): Arbeitsmethoden in Physiogeographie und Geoökologie. Klett-Perthes, Gotha und Stuttgart. Birkeland, P. W. (1999) Soils and Geomorphology. Oxford University Press, N.Y. Gabler, R.E., Petersen, J.F., Trapasso, L.M. (2007) Essentials of Physical Geography. Brooks Cole.

Module GEO3: Applied Geoecology II

Module name:	**Applied Geoecology II**
Module code:	**GEO3**
Courses:	Project Seminar Geoecology
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Hermann Jungkunst
Lecturer:	Prof. Dr. Hermann Jungkunst
Language:	German or English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2) M. Sc. Ecotoxicology (O, 2)
Teaching format / class hours per week / group size:	Project seminar / 4 class hours (block course, total 60 h) / 20
Workload: Face-to-face teaching / independent study	60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	Basics in the fields of physical geography, ecology, and GIS
Targeted learning outcomes:	The students shall learn the methods to measure and analyse geoecological parameters in the field or laboratory. In contrast to Applied Geoecology I (GEO2), there will be an abiotic focus particularly on biogeochemical fluxes (e.g. greenhouse gases). They should be able to summarize, discuss and present the results. Practical work will focus on methods to understand natural processes and their relationships to human influences. Students will get experience in field and/or laboratory skills.
Content:	Content and methods will vary on focused field and/or laboratory methods in the field of geoecology (e.g. soil analyses, geomorphic or hydrologic measurements).
Study / exam achievements:	Term paper (Studienarbeit)
Forms of media:	PowerPoint slides
Literature:	Depending on topic and focused methods.

Module GEO4: Geosysteme

Module name:	**Geosysteme**
Module code:	**GEO4**
Courses:	a) Prozesse in Agrarökosystemen I b) Prozesse in Agrarökosystemen II
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Ralf Schulz
Lecturer:	Prof. Dr. Roland Kubiak, Jakob Wolfram
Language:	Deutsch
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M. Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Vorlesung / 2 SWS / 100 b) Seminar / 2 SWS / 60
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Gesamt: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Zulassung zum Masterstudiengang
Recommended prerequisites:	Grundkenntnisse in Statistik, Umweltchemie, Ökotoxikologie, Bodenkunde und GIS.
Targeted learning outcomes:	Die Studierenden bekommen einen vertieften Einblick in die relevanten Prozesse in Agrarökosystemen. Sie verstehen, wie diese Systeme funktionieren und es wird ihnen anhand der gängigen Konzepte verdeutlicht, wie Agrarökosysteme durch den Menschen genutzt werden können. Das Wissen wird durch ein eigenständiges weitergehendes Literaturstudium und Präsentation im Seminar vertieft.
Content:	a) Prozesse in Agrarökosystemen I: - Aufbau und Eigenschaften - Nutzungskonzepte - Anthropogene Eingriffe - Agrarökosysteme als Produktionsstandort für Nahrung und Energie - Anthropogene Eingriffe: Exposition, Wirkungen, Untersuchungsmethoden - Systemanalyse von Agrarlandschaften b) Prozesse in Agrarökosystemen II: - Seminar zu den o.g. Themen
Study / exam achievements:	Portfolio (schriftlich)
Forms of media:	PowerPoint Folien
Literature:	Wird in der Veranstaltung bekannt gegeben

Module GEO5: Landschaftsplanung

Module name:	**Landschaftsplanung**
Module code:	**GEO5**
Courses:	a) Raum- und Landschaftsplanung b) Umweltplanung
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Jakob Wolfram
Lecturer:	Dr. Jürgen Ott
Language:	Deutsch
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M. Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Seminar / 2 SWS / 60 b) Seminar / 2 SWS / 60
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Gesamt: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Zulassung zum Masterstudiengang
Recommended prerequisites:	Keine
Targeted learning outcomes:	Die Studierenden verstehen Grundlagen und Aufgabenbereiche der Raumordnung, Landes- und Umweltplanung und beherrschen die Fachterminologie. Die Rahmenbedingungen, gesetzlichen Hintergründe und Verfahren der Landes- und Umweltplanung sind den Studierenden bekannt. Konkreter in- oder ausländischer Raum kann unter raum- bzw. umweltplanerischen Aspekten analysiert, Planungsentwürfe und -konzepte erstellt sowie kritisch analysiert und mögliche Alternativen aufzeigt werden.
Content:	a) Raum- und Landschaftsplanung: - Planungen zur Entwicklung, Ordnung und Sicherung des Raumes auf Landes-, Bundes- und EU-Ebene, Raumplanerische Zusammenarbeit zwischen Gebietskörperschaften innerhalb von und zwischen Staaten - Raumplanerische Konzepte in der Bevölkerungs-, Wirtschafts-, Siedlungs- und Infrastrukturentwicklung, Fachplanungen und Planungsebenen - Nationale und internationale Planungen im Vergleich, Planungskonzepte, Planungsziele, Planungsinstrumente, Planungsverfahren - Ökologische Dimension von Planung, Raumanalyse als Grundlage von Planung, Zielkonflikte von Planungen b) Umweltplanung: - Kartierungen (Kartengrundlagen, Maßstäbe, Koordinationssysteme, Luftbilder), Biotische Kartierungen (Methoden, Material)

	□ Population Vulnerability Analysis (PVA), Fauna-Flora-Habitat-Richtlinie (FFH-R), Fauna-Flora-Habitat-Verträglichkeitsprüfung (FFH-VP), Wasserrahmenrichtline (WRRL) □ Umweltverträglichkeitsprüfung (UVP), Umweltverträglichkeitsuntersuchung (UVU) / Umweltverträglichkeitsstudie (UVS)
Study / exam achievements:	Klausur
Forms of media:	PowerPoint Folien, Gesetze und Verordnungen
Literature:	Wird in der Veranstaltung zur Verfügung gestellt

Module GEO6: Soil Chemistry

Module name:	**Soil Chemistry**
Module code:	**GEO6**
Courses:	a) Soil Chemistry b) Soil Analysis
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Dörte Diehl
Lecturer:	Dr. Dörte Diehl
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M. Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Seminar / 1 class hours / 30 b) Laboratory Exercises / 3 class hours / 10
Workload: Face-to-face teaching / independent study	a) 15 h / 30 h b) 45 h / 90 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Modules B3 and B2/ETX3 completed and, additionally, students must meet one of the following criteria: 1. holding a Bachelor's degree in Umweltwissenschaften from the University of Koblenz-Landau or 2. having successfully passed the LAB1 module or 3. having participated in the lab safety assessment with outcome: "recommendation for LAB2". For details on lab safety assessment see LAB1 module
Recommended prerequisites:	Fundamental knowledge in chemistry and soil chemistry (comparable to the lecture "Boden- und Wasserchemie" of the Bachelor course programme) Experiences in laboratory work and fundamental knowledge in instrumental analysis (comparable to LAB1).
Targeted learning outcomes:	The students know and understand the soil chemical processes and their relevance for soil quality, soil development, as well as for the transport, bioavailability and toxicity of contaminants. The knowledge of instrumental analysis is deepened. The students are able to plan and perform a soil chemical analysis (nutrients, soil parameters and contaminants) and to evaluate and judge the analysis result in the ecological context as well as in the context of current environmental laws.
Content:	a) Soil Chemistry: Chemical processes of soil development Mobilization and precipitation of soil components Sorption, ion exchange

	Sesquioxides, soil redox processes and their role for mobilization and immobilization of nutrients and pollutants Relation between speciation, bioavailability, toxicity and mobilization Discussion of the current status and experiences in the laboratory exercises b) Soil Analysis: Case-oriented investigation of a location for contaminants and soil chemical parameters Methods of soil chemical analysis, contaminant analysis including planning, sampling, sample preparation, enrichment, purification Techniques of sequential extraction for inorganic and organic compounds, instrumental analysis and sum parameters Advanced knowledge of chromatography and spectrometry Evaluation of analysis results in the ecologic and legislative context
Study / exam achievements:	Portfolio (written)
Forms of media:	
Literature:	Basic and advanced reading: Current soil chemical literature Appelo, C.A. J., Postma, D. (1994): Geochemistry, groundwater and pollution. Balkema, Rotterdam. Alfred R. Conklin Jr. (2005): Introduction to Soil Chemistry. Wiley.Cresser, M.S., Kilham, K., Edwards, A. (1993) Soil Chemistry and its Applications. Cambridge Univ. Pr. Sparks, D.L. (2008) Environmental soil chemistry. Acad. Press. György F. (1999) Soil Chemistry: Processes and Constituents. Akadémiai Kiadó. Foth, H.D. (1990) Fundamentals of soil science. Wiley. Foth, H.D., Ellis, B.G. (1997) Soil Fertility. Lewis.

Module SÖU1: Sustainability and Society°

Module name:	**Sustainability and Society**
Module code:	**SÖU1**
Courses:	a) Sustainability and Development Economics b) Socioeconomic aspects of sustainability
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Prof. Dr. Oliver Frör / Sören Weiß / Dr. Melanie Ströbel / Jun.-Prof. Dr. Elisabeth Berger / Dr. Daniel Callo-Concha
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2)
Teaching format / class hours per week / group size:	a) Lecture / 2 SWS / 100 */ Online lecture / 2 SWS / 30** b) Seminar / 2 SWS / 60*/ Online seminar / 2 SWS / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Admission to M.Sc. studies
Recommended prerequisites:	Module B5, basic knowledge in economics
Targeted learning outcomes:	After successful attendance of the classes students will understand the different dimensions and perspectives of sustainability from an economic perspective. The will have a good knowledge about the importance of environmental and social resources for a durable and sustainable development of economies.
Content:	a) Sustainability and Development Economics: - Limits to the substitutability between natural and human-made capital - The problem of discounting future benefits and costs - Taking uncertainty into account in economic decisions - Sustainable use of essential environmental goods (atmosphere, biodiversity etc.) - The development of economies - Economic development and economizing on essential environmental goods and resources - Globalization and environmental protection - Institutions between development and preservation

	b) Socio-economic aspects of sustainablity: Seminar dealing with special topics in the field of sustainability, society and development
Study / exam achievements:	a) Exercises (study achievement) b) Term paper and presentation (module examination)
Forms of media:	Powerpoint slices, problem sets, *Panopto Videos**
Literature:	Literature: Lopez, R., Toman, M.A. (2006): Economic Development and Environmental Sustainability: New Policy Options, Oxford University Press Krol, G-J., Karpe, J. (1999): Ökonomische Aspekte von Nachhaltigkeit. Die Umweltproblematik aus sozioökonomischer Sicht. Umweltforschung Band 1. Herausgegeben vom Umweltbundesamt, Münster. Diamond, Jared. (2005) Collapse: How Societies Choose to Fail or Succeed. New York: Viking. Harper, Charles (2004). Environment and Society: Human Perspectives on Environmental Issues. Upper Saddle River, New Jersey: Pearson Education Durth, R., Körner, H., Michaelowa, K. (2002): Neue Entwicklungsökonomik, UTB Stuttgart

° Available in dual degree online study program MSc Environmental Sciences

* Restricted admission: This applies exclusively to the dual degree online study program MSc Environmental Sciences

Module SÖU2: Environmental Policy and Law°

Module name:	**Environmental policy and law**
Module code:	**SÖU2**
Courses:	a) European environmental law – legislation, implementation and perspectives b) Current developments in environmental law and policy
Semester:	2./3. Semester
Duration of module:	2 semesters
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Prof. Dr. Hannes Kopf / Prof. Dr. Oliver Frör
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Lecture / 2 SWS / 100 */ Online lecture / 2 SWS / 30** b) Seminar / 2 SWS / 60 */ Online seminar / 2 SWS / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Admission to M.Sc. study
Recommended prerequisites:	Successful participation in module B5
Targeted learning outcomes:	a) This course focuses on the following questions: ● What are the legal grounds for EU environmental policy and what principles are directives and regulations based upon? ● To what extent does EU environmental regulation more preclude stringent national environmental standards? ● What social and economic challenges have to be overcome? Relevant aspects will be discussed based on actual cases and law suits. b) Current developments in environmental law and policy: Students will be acquainted with the theory and practical examples of domestic and international environmental law and policy and will learn to critically analyze real cases.
Content:	a) European Environmental Law (starting winter 2016/17): ● Development of European Environmental Law ● General Principles of Union Law in relation to Environmental Protection, Art. 191 TFEU ● Legal Basis, Scope of Harmonization, Implementation –The Duty to transpose Environmental Directives into National Law ● Legal Protection – The Direct Effect of Union Environmental Law b) Current developments in environmental law and policy: ● In this seminar current topics of domestic and international environmental law and policy will be independently researched, a

	term paper will be written and presented orally. In this process, analytical as well as team skills, communication behavior and ability to present will be trained.
Study / exam achievements:	Term paper and presentation (module examination)
Forms of media:	Powerpoint
Literature:	Literature will be indicated in class

° Available in dual degree online study program MSc Environmental Sciences

* Restricted admission: This applies exclusively to the dual degree online study program MSc Environmental Sciences

Module SÖU3: Environmental Life Cycle Assessment°

Module name:	**Environmental Life Cycle Assessment**
Module code:	**SÖU3**
Courses:	a) Environmental Life Cycle Assessment b) Project seminar LCA
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually *(currently not offered)*
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Dr. Jens Peters / N.N.
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Lecture/ 2 SWS / 60 */ Online lecture / 2 SWS / 30** b) Project seminar / 2 SWS / 20 / *Project seminar online / 2 SWS / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Admission to M.Sc. study
Recommended prerequisites:	Module B5/SÖUE
Targeted learning outcomes:	The students learn the basics about life cycle assessment (LCA) and the underlying methodologies. They develop an awareness of the need for life-cycle thinking and the relevance of the different life cycle stages for the total environmental impact of a product or process. The students can use the corresponding LCA software (openLCA / GEMIS) and are able to create LCA and material and energy flow studies independently even for complex application cases. The underlying methods and databases are familiar and can be chosen adequately according to the context and the aim of the study. The results of an LCA study can be interpreted critically and can be presented clearly and comprehensively also to non-expert stakeholders. The students are able to identify environmentally relevant aspects of technical processes and can point relevant improvement potentials. They can interpret and critically review existing LCA studies and are able to evaluate the environmental friendliness of a product.
Content:	- The students learn the basics about life cycle assessment (LCA) and the underlying methodologies. They develop an awareness of the need for life-cycle thinking and the relevance of the different life cycle stages for the total environmental impact of a product or process. The students can use the corresponding LCA software (openLCA / GEMIS) and are able to create LCA and material and energy flow studies independently even for complex application cases. The underlying methods and databases are familiar and can be

	chosen adequately according to the context and the aim of the study. The results of an LCA study can be interpreted critically and can be presented clearly and comprehensively also to non-expert stakeholders. The students are able to identify environmentally relevant aspects of technical processes and can point relevant improvement potentials. They can interpret and critically review existing LCA studies and are able to evaluate the environmental friendliness of a product.
Study / exam achievements:	a) Exercises (study achievements) b) Project paper and presentation (module exam)
Forms of media:	Powerpoint, *Panopto Videos**
Literature:	Accompanying Literature: · H. Baumann, A.M. Tillman: The hitchhiker's guide to LCA. Studentlitteratur, Lund. 2004. ISBN-10: 9144023642 · W. Klöpffer, B. Grahl: Ökobilanz (LCA). Ein Leitfaden für Ausbildung und Beruf. Wiley-VCH, Weinheim, 2009. ISBN: 978-3-527-32043-1 · J-A. Böning: Methoden betrieblicher Ökobilanzierung. "Hochschulschriften", Metropolis. Band 16, Marburg, 1995. ISBN-10: 3895180149 · EC-JRC, “ILCD Handbook: General Guide for Life Cycle Assessment - Detailed guidance,” European Commission - Joint Research Centre. Institute for Environment and Sustainability, Ispra, Italy: EC-JRC - Institute for Environment and Sustainability, 2010. J.B. Guinée et al. LCA - An operational guide to the ISO-standards. Final Report. Centre of Environmental Science, Leiden University (CML), 2001

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Module SÖU4: Environmental Management°

Module name:	**Environmental Management**
Module code:	**SÖU4**
Courses:	a) Environmental management I b) Environmental management II
Semester:	2. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Paul Averbeck /Dr. Melanie Ströbel
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2)
Teaching format / class hours per week / group size:	a) Lecture / 2 SWS / 60 */ Online lecture / 2 SWS / 30** b) Seminar / 2 SWS / 60*/ Online seminar / 2 SWS / 30**
Workload: Face-to-face teaching / Independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Admission for M.Sc. study
Recommended prerequisites:	Successful participation in module B5 / SÖUE
Targeted learning outcomes:	Students are familiar with the fundamentals and structures of environmental management systems as well as the respective instruments of environmental audits, controlling and information management. Approaches for the necessary implementation of legal requirements into the business management system can be developed independently by the students.
Content:	a) Environmental management I: - Structure of environmental management systems following DIN EN ISO 14001 and EG-Verordnung 761/2001 (EMAS) - Transfer of legal requirements into the business and management practice - Environmental audit - Environmental controlling - Environmental information management The acquired knowledge will be deepened by practical exercises. b) Environmental management II: In the seminar students deal independently with topics in the fields of corporate and public environmental management. They will research current literature, write a term paper and present it orally. In this process, analytical as well as team skills, communication behavior and ability to present will be trained.
Study / exam achievements:	a) Exam / Exercises (study achievements) b) Term paper and presentation (Module examination)

Forms of media:	PowerPoint slides, management norms and -standards, *Panopto Videos**
Literature:	Literature: ISO-Norms further literature will be provided in class

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Module SÖU5: Environmental Cost-Benefit Analysis°

Module SÖU5: Environmental Cost-Benefit Analysis Module name:	**Environmental Cost-Benefit Analysis**
Module code:	**SÖU5**
Courses:	a) Economic valuation and cost-benefit analysis b) Special project in environmental CBA
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Prof. Dr. Oliver Frör
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Lecture / 2 SWS / 60 */ Online lecture / 2 SWS / 30** b) Project seminar / 2 SWS / 60 */ Online project seminar / 2 SWS / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission for M.Sc. study, basic knowledge in microeconomics
Recommended prerequisites:	Successful participation in module B5/SÖUE
Targeted learning outcomes:	The students achieve the qualification for conducting environmental economic analyses (such as cost-benefit analyses) and for solving decision problems within the public and business context. They gain insights into the theory and practice of preference-based valuation methods. Thereby, they will acquire the ability to create a well-founded basis for decision making, both under certainty and uncertainty/ risk.
Content:	a) Economic valuation and cost-benefit analysis - Basics of economic welfare theory - Structure of environmental economic valuation analyses - Requirements for measures of well-being - Measures of well-being according to Marshall und Hicks - Empirical valuation methods - Cost-benefit analysis in practice b) Special project in environmental CBA - Student groups will jointly work on a methodical and policy paper regarding environmental valuation in a selected country.
Study / exam achievements:	a) Exercises (study achievement) b) Term paper (Modulprüfung)
Forms of media:	Powerpoint presentations, Exercises, *Panopto Videos**
Literature:	Basic and advanced reading:

	Will be announced in class

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Module SÖU6: Öffentlichkeit und Medien

Module name:	**Öffentlichkeit und Medien**
Module code:	**SÖU6**
Courses:	a) Aktuelle Themen der Umweltkommunikation(-sforschung) b) Die Studierenden wählen eines der zwei folgenden Seminare: i) Lehrforschungsprojekt Umweltkommunikation ii) Praxisfelder der Umweltkommunikation
Semester:	1/2. Semester
Duration of module:	2 semesters
Frequency of offer:	annually
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	Fachvertreter/innen des Instituts für Kommunikationspsychologie und Medienpädagogik (IKM) sowie der Interdisziplinären Forschungsgruppe Umwelt (IFG Umwelt
Language:	Deutsch
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2/3) B.Sc. Mensch und Umwelt (C, 3/4) BA Sozial- und Kommunikationswissenschaften
Teaching format / class hours per week / group size:	a) Seminar / 2 SWS / 30 b) Seminar / 2 SWS / 30
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Gesamt: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Zulassung zum Masterstudiengang
Recommended prerequisites:	keine
Targeted learning outcomes:	Die Studierenden kennen die grundlegenden Begriffe und Modelle der Kommunikationswissenschaft, zentrale Kommunikatoren und Akteure, Kommunikationsinhalte sowie Ansätze der Nutzung und Wirkung von Kommunikation unter besonderer Berücksichtigung der Umwelt- kommunikation. Die Studierenden haben ein Verständnis für die unterschiedlichen Forschungsfelder der Kommunikationswissenschaft entwickelt und können diese auf Fragen der Umweltkommunikation anwenden. Die Studierenden können: ● die Forschungsfelder einordnen ● Arbeitsroutinen zentraler Akteure der (Umwelt-)Kommunikation umreißen ● Untersuchungsansätze zur Nutzung und Wirkung von (Umwelt-)Kommunikation erklären ● aktuelle Entwicklungen und Diskussionen in der (Umwelt-) Kommunikationswissenschaft darstellen
Content:	Die Umweltkommunikation bedient sich kommunikationswissenschaftlicher Theorien, Modelle und Begrifflichkeiten. Das Modul gibt daher zunächst eine Einführung in

	die Kommunikationswissenschaft unter Berücksichtigung der Umweltkommunikation im Speziellen. Im Mittelpunkt steht ein Überblick über das Fach und seine Grundlagen sowie Übertragung dieser Inhalte auf die Umweltkommunikation, z. B. Kommunikationsformen, zentrale Kommunikatoren und Akteure, Kommunikationsinhalte.
Study / exam achievements:	a) Term paper and presentation, b) study achievement
Forms of media:	Powerpoint Folien
Literature:	Wird zum Beginn der Seminare bekannt gegeben.

Module SÖU7: Business Administration for Environmental Scientists°

Module name:	**Business Administration for Environmental Scientists**
Module code:	**SÖU7**
Courses:	a) Introduction to Business Administration for Environmental Scientists b) Advanced Business Administration for Environmental Scientists
Semester:	2./3. Semester
Duration of module:	2 semesters
Frequency of offer:	annually **(currently not offered)**
Module coordinator:	Prof. Dr. Oliver Frör
Lecturer:	currently not offered
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, /2/3)
Teaching format / class hours per week / group size:	a) Lecture with Exercises / 2 SWS / 100 / *Online lecture with exercises / 2 SWS / 30** b) Lecture with Exercises / 2 SWS / 100 / *Online lecture with exercises / 2 SWS / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Admission to M.Sc. study
Recommended prerequisites:	none
Targeted learning outcomes:	This course provides knowledge in Business Administration focused on the specific requirements of environmental scientists. The participants will learn how to define the concept of a company and its institutional and legal framework and how to analyze the functional areas in the company. In this course students will be enabled to evaluate investment projects from an economic stance, to identify sources of funding in a company, to analyze the company from an economic and financial perspective and to craft sustainable strategies
Content:	□ Introduction to Business Administration □ Analysis of Management Functions □ Principles of Marketing Management □ The Decision-Making Process □ Fundamentals of Financial Management □ Financial Statement Analysis □ Valuation of Financial Operations □ Capital Budgeting □ Corporate Financing and Cost of Capital

Study / exam achievements:	exam
Forms of media:	PowerPoint slides, problem sets, *Panopto Videos**
Literature:	Literature will be provided in class

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Module SÖU8: Environmental Psychology

Module name:	**Environmental Psychology**
Module code:	**SÖU8**
Courses:	a) Lecture “Environmental Psychology” b) Project seminar “Environmental Psychology”
Semester:	1./2. Semester
Duration of module:	2 semesters
Frequency of offer:	annually
Module coordinator:	Dr. Claudia Menzel
Lecturer:	Dr. Claudia Menzel
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 1/2)
Teaching format / class hours per week / group size:	a) Lecture / 2 SWS / 53 b) Project seminar / 2 SWS / 33
Workload: Face-to-face teaching / independent study	a) 30 h / 30 h b) 30 h / 90 h Total: 60 h / 120 h
Credit points:	6 LP
Requirements under the examination regulations:	Admission to M.Sc. study
Recommended prerequisites:	None. The course SÖU8a) (lecture) must be completed before visiting SÖU8b) (project seminar)
Targeted learning outcomes:	Knowledge: The students will learn about the above mentioned topics of environmental psychology. They will also gain knowledge on the research methods used in the field. Understanding: The students will learn about and understand the complexity of human-environment interactions and the various factors that influence human (pro-environmental) behaviour. Furthermore, they will understand the challenges of conducting a research project with students from other disciplines. Skills: Students will be able to understand human-environment-interactions, to formulate relevant research questions, and to conduct empirical studies on the topics of environmental psychology. Furthermore, students will understand the implications of this psychological research to related topics, such as health and political psychology, urban planning and architecture, as well as environmental science, protection, education, communication, and economics.
Content:	Environmental psychology is a diverse field of research that covers the interaction of humans with their environment. It is usually seen as a sub-discipline of psychology that also touches many other disciplines, such as environmental science, conservation biology,

	sociology, public health, architecture, communication and education science, politics, and economics. In this module, we will address various aspects of environmental psychology including the effects of different environmental characteristics on humans and their health, the perception of environmental risks (e.g., climate change), and pro-environmental behaviour. The lecture will provide an overview of different aspects, theories, and approaches of environmental psychology. During the project seminar, students will work in interdisciplinary groups on an empirical research project related to environmental psychology.
Study / exam achievements:	a) Oral and written exercises (study achievement) b) Seminar paper (Modulprüfung)
Forms of media:	Powerpoint
Literature:	Suggested literature: Steg, L., van den Berg, A. E., & de Groot, J. I. M. (Eds.) (2012). Environmental Psychology: An Introduction. Chichester: Wiley. Further literature will be named by the lecturer

Module MOD1: Environmental Modelling II°

Module name:	**Environmental Modelling**
Module code:	**MOD1**
Courses:	a) Geoinformation Systems (GIS) Application b) Environmental Modelling II
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Mira Kattwinkel
Lecturer:	Dr. Nanki Sidhu / Dr. Mira Kattwinkel
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) Course a): M.Sc. Ecotoxicology (C, 3)
Teaching format / class hours per week / group size:	a) Project Seminar / 2 class hours (block course: periodical project meetings and final presentations) / 30 / *Online seminar / 2 class hours / 30** b) Exercise / 2 class hours / 30 / *Online lecture / 2 class hours / 30**
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission to the M.Sc. program
Recommended prerequisites:	Course: Umweltmodellierung I (MSI2), Solid knowledge in GIS
Targeted learning outcomes:	a) GIS Application: The students are able to handle, analyse and visualise heterogeneous geospatial- and environmental data as well as to work independently in the context of an environmental research question. b) Environmental Modelling II: The students become familiar with different modelling approaches and apply them in exercises and own projects.
Content:	a) GIS Application: In the context of a (self chosen) project, the students work on complex environmental problems with the help of GIS. This may include: ● Collection and handling of data (e.g. remote sensing images, ATKIS, LIDAR, external databases) ● Modelling and analysis (e.g. geostatistics, calculation of landscape metrics) ● Visualisation (e.g. map design, export into web-applications, virtual 3-D design) b) Environmental Modelling II: □ Overview of ecological modelling □ System Dynamic models/differential equation models

	- Matrix population models - Individual-based models and cellular automata - Spatial ecological modelling
Study / exam achievements:	Presentation
Forms of media:	PowerPoint slides, computer, software (PostGIS, GRASS GIS, QGIS, Vensim, R, Netlogo, spreadsheet calculations), Panopto videos*
Literature:	Basic and advanced reading: Jopp, F., Reuter, H., Breckling, B. (2011): Modelling complex ecological dynamics. Springer: New York, NY. Jørgensen, S. E., Fath, B. D. (2011): Fundamentals of ecological modelling. 4. ed.; Elsevier: Amsterdam [u.a.]. Petzoldt, T., Rinke, K. (2007): simecol: An Object-Oriented Framework for Ecological Modeling in R. Journal of Statistical Software, 22, (9), 1-30. Stevens, M. H. (2009): A Primer of Ecology with R. In Springer-Verlag New York: New York, NY. Hengl, T. (2009): A Practical Guide to Geostatistical Mapping, 2nd ed. University of Amsterdam, 291 p. Neteler, M., Mitasova, H. (2008): Open Source GIS: A GRASS GIS Approach, 3rd ed. Springer. 406 p. Obe, R., Hsu, L. (2011): PostGIS in Action. Manning Publications, p. 425.

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Module MOD2: Models in Ecotoxicology

Module name:	**Models in Ecotoxicology**
Module code:	**MOD2, resp. ETX8**
Courses:	a) Exposure Modelling b) Effect Modelling
Semester:	3rd Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Nanki Sidhu
Lecturer:	Dr. André Gergs / Dr. Wenkui He/ Dr. Carola Schriever/ Dr. Bernhard Jene
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 2/3)
Teaching format / class hours per week / group size:	a) Exercise / 2,5 class hours (block course, total 40 h) /30 b) Exercise / 2,5 class hours (block course, total 40 h) / 30
Workload: Face-to-face teaching / independent study	a) 37,5 h / 52,5 h b) 37,5 h / 52,5 h Total: 75 h / 105
Credit points:	6 CP
Required prerequisites:	
Recommended prerequisites:	Basic knowledge in modelling. Solid basic knowledge in GIS.
Targeted learning outcomes:	The students know the basic principles of models to be used in the exposure or effect assessment in ecotoxicology. They know the restrictions, sources of errors and are able to quantify the uncertainty associated with the use of models and GIS. They are able to use models/GIS and to identify situations in which a modelling approach can be of help. They gain the ability to independently analyse a problem situation, to apply a suitable modelling approach and to interpret the results obtained.
Content:	a) Exposure Modelling: □ Surface water models □ Soil persistence models □ Groundwater models □ FOCUS approach □ Decision support systems □ Implementation of risk mitigation measures □ Spatially explicit modelling using GIS □ QSAR modelling □ Fugacity models □ EUSES model b) Effect Modelling: □ Population models □ Metapopulation models □ Spatially explicit models

	□ Community models □ Food web models □ Ecosystem models
Study / exam achievements:	Exam (written)
Forms of media:	Projector, computer, software: FOCUS models, EUSES, Canoco, R, MS Access, MS Excel, ArcGIS, GRASS GIS, QGIS.
Literature:	Will be announced at the beginning of the course. The courses will use up to date online-tutorials and external internet support.

Module MOD3: Advanced Data Science

Module name:	**Advanced Data Science**
Module code:	**MOD3**
Courses:	a) Data Science Tools b) Advanced Problems in Data Science
Semester:	3. Semester
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Noel Juvigny-Khenafou
Lecturer:	Dr. Noel Juvigny-Khenafou, Prof. Dr. Ralf B. Schäfer, Dr. Mira Kattwinkel, Dr. Nanki Sidhu
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Umweltwissenschaften / Environmental Sciences (O, 3) M.Sc. Ecotoxicology (O, 3)
Teaching format / class hours per week / group size:	a) Exercise / 2 class hours / 30 b) Project Seminar / 2 class hours / 30
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 15 h / 75 h Total: 45 h / 135 h
Credit points:	6 CP
Requirements under the examination regulations:	Admission to the M.Sc. program
Recommended prerequisites:	Tools for complex data analysis
Targeted learning outcomes:	a) Data Science Tools: The students know and can apply current tools for modern data science. They have the ability of retrieving, handling, pre-processing and analysing complex data sets from the social and natural sciences. Moreover, they are capable of setting up a computer environment and workflow for a data analysis problem from scratch. b) Advanced Problems in Data Science: The students can reproducibly solve a complex data science problem during an own project. They know and can apply different solutions and approaches to typical data analysis research questions. They can automate repeated steps in the workflow, rendering the analysis more reproducible and efficient compared to manual handling.
Content:	a) Data Science Tools: ● Overview of software tools for data science ● Version control and joint software development using github ● Creating reports and websites with (R)markdown ● Dynamic data analysis with R, markdown and knitr ● Automated processing using the Shell ● Scraping data from the internet ● Relational databases for spatial and non-spatial databases (PostgreSQL, PostGIS) ● Parallel computing and working with servers ● Specific approaches of data analysis: Bayesian statistics, Generalized and linear mixed models, Artificial neural networks and Deep learning, Non-linearity and GAMs, Advanced tools for

	multivariate analysis b) Advanced Problems in Data Science: In the first part of the course, the students develop and discuss theoretical solutions for selected data analysis problems. In the second part of the course, they apply the tools and knowledge acquired in the module during an own project.
Study / exam achievements:	Project with presentation (Module exam), a) Successful completion of exercises (Study achievement)
Forms of media:	Presentation slides, tutorials, computer, software
Literature:	Basic and advanced reading: ● Gandrud C. (2014) Reproducible research with R and R Studio. CRC Press/Taylor & Francis Group, Boca Raton. ● Goodfellow I., Bengio Y. & Courville A. (2016). Deep learning. The MIT Press, Cambridge, Massachusetts. ● Haddock S.H.D. & Dunn C.W. (2011) Practical computing for biologists. Sinauer Associates, Sunderland, Mass. ● Matloff N.S. (2016) Parallel computing for data science: with examples in R, C++ and CUDA. CRC Press, Boca Raton. ● Obe, R., Hsu, L. (2011): PostGIS in Action. Manning Publications. ● Zarrelli G. (2017) Mastering Bash: automate daily tasks with Bash. Packt Publishing.

Module ETX2: Principles of Ecotoxicology°

Module name:	**Principles of Ecotoxicology**
Module code:	**ETX 2**
Courses:	a) Aquatic Ecotoxicology b) Terrestrial Ecotoxicology
Semester:	1st Semester (or 3rd semester for M.Sc. Umweltwissenschaften)
Duration of module:	1 semester
Frequency of offer:	annually
Module coordinator:	Dr. Carsten Brühl
Lecturer:	a) Jun.-Prof. Dr. Mirco Bundschuh b.) Dr. Carsten Brühl
Language:	English
Classification within the curriculum: (Compulsory or optional, semester) [C = compulsory; O = optional]	M.Sc. Ecotoxicology (C, 1) M.Sc. Umweltwissenschaften / Environmental Sciences (O, 1/3)
Teaching format / class hours per week / group size:	a) Lecture / 2 class hours / 100 b) Lecture / 2 class hours / 100
Workload: Face-to-face teaching / independent study	a) 30 h / 60 h b) 30 h / 60 h Total: 60 h / 120 h
Credit points:	6 CP
Required prerequisites:	Admission for MSc. study
Recommended prerequisites:	Knowledge in ecology
Targeted learning outcomes:	The students understand the fundamentals of terrestrial and aquatic ecotoxicology, i.e. biological effects of chemicals on the individual level. The students know the basic principles of ecotoxicological effects at the population, community and ecosystem level in aquatic and terrestrial environments. They know the endpoints relevant at the population and community level and which processes are of importance in addition to the individual level. The students are able to identify the potential effects at the population and community level related with the presence of chemicals in the environment. The students are able to identify, suggest and evaluate testing procedures for ecotoxicological effects at the population and community level. They are familiar with international strategies of addressing ecotoxicological problems in nature. Examples include a variety of special cases in developing countries such as e.g. the decline of vultures in India, amphibian decline in Central America, malaria or locust control in Africa. Moreover, risk management strategies will be presented also focussing on the situation in developing countries.
Content:	a) Aquatic Ecotoxicology: - Characteristics of environmental chemicals and related processes - Bioaccumulation, Biomagnification - Acute, chronic and life cycle toxicity

	□ Effects on individuals, populations and communities □ Ecotoxicological metrics (e.g. EC50, LC50, NOEC) □ Endpoints □ Dose response relationships (linear, non linear) □ Combined effects (chemical & biological stressor) □ Resistance, recovery, recolonisation □ Mixture toxicity □ Species sensitivity distributions (SSD) □ Mesocosm studies □ Basics of environmental risk assessment b) Terrestrial Ecotoxicology: Identification of pollutants □ Metals □ Pesticides □ POPs □ Entry ways into the ecosystem □ Fate of chemicals □ Assessment of Toxicity (introduction in testing strategies) □ Physiological effects □ Population level effects □ Community level effects □ Direct and indirect effects □ Additional stressors in the agricultural landscape
Study / exam achievements:	Exam (written)
Forms of media:	PowerPoint slides, handouts, *Panopto Videos**
Literature:	Basic reading: □ Newman, M., Clements, W. (2007): Ecotoxicology – a comprehensive treatment. Taylor & Francis, Boca Raton □ Walker, C.H., Hopkin, S.P., Sibly, R.M., Peakall, D.B. (2012): Principles of Ecotoxicology. 4th ed., Taylor & Francis, New York. Advanced reading: □ Clements W. (2002): Community Ecotoxicology. Wiley, New York □ Newman M. (2001): Population Ecotoxicology. Wiley, New York.
° Available in dual degree online study program MSc Environmental Sciences * Restricted admission: This applies exclusively to the dual degree online study program MSc Environmental Sciences	

Correspondence between modules and elective subjects

Students fulfill the requirements for an elective subject by completing 4 modules from the column of the respective subject.

ANA: Environmental analysis
SÖU: Socioeconomics and environmental management
SOS: Soil systems
CHE: Chemicals in the environment
AÖK: Applied ecology
AQU: Aquatic systems
LAS: Landscapes and scales
MOD: Modelling

Module	Elective subjects							
	ANA	AÖK	SÖU	AQU	SOS	LAS	CHE	MOD
ACP1	x			x				
ACP2	x				x	x		
ACP3				x	x		x	
ACP4				x				
ACP5				x			x	x
ACP6				x				
CHE1							x	
CHE2	x						x	
CHE3							x	
LAB1	x						x	
LAB2	x						x	
AÖK1		x		x		x		
AÖK2		x						
AÖK3		x						
AÖK4		x						
AÖK5		x						
AÖK6		x				x		
GEO1			x					x
GEO2	x				x			
GEO3					x	x		
GEO4					x			
GEO5						x		
GEO6	x				x			
SÖU1			x			x		
SÖU2			x					
SÖU3			x					x
SÖU4			x				x	
SÖU5			x	x	x	x		
SÖU6			x					
SÖU7			x					
SÖU8			x					
MOD1						x		x
MOD2							x	x
MOD3		x						x
ETX2		x		x			x	x

4 Exemplary Curriculum

(In parenthesis the credit points of the modules respectively courses are given.)