Module Handbook

International Elite Graduate Programme

Global Change Ecology (M.Sc.)

Elite Network Bavaria (ENB)

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1 Goals and Organisation of the Degree Programme

The Elite Graduate Degree Programme „Global Change Ecology“ addresses the most important and far-reaching environmental issues of the 21st century: global change of climate, biodiversity as well as ecosystem functioning and their services. The study of human reaction and the development of adaptation strategies are also included. Effects of the interaction with other globally relevant developments such as regionally specific land use changes and loss of biodiversity that can intensify the negative effects of global change are also a vital part of course content.

The interdisciplinary and entirely new problems of Global Change demand innovative and highly efficient approaches in research and teaching. For this reason, competencies at the University of Bayreuth, as well as in the Bavarian research community, along with business, public administration and international organisations are pooled together in the programme.

Changes in climate, transformation in land-use and population pressure all brings about drastic changes in the behaviour of ecological systems, making it increasingly difficult to judge. Due to the complex interaction between social and ecological processes, fields in natural science are supplemented by disciplines in social science.

There is apprehension about negative consequences on goods and services in ecological systems (e.g. drinking water, food, pharmaceutical resources, carbon storage). Economic, social and political risks are emerging and uncertainty is growing. Research and training needs are evident in process-oriented problem analysis, effective ecological risk management as well as in the development of optimised management strategies. These issues are of global significance for the sustainable development of societies.

The goal of this programme is to educate and train students to work in science and the environment, in politics and in business as highly qualified experts and decision makers. With a well-founded scientific background and expert knowledge, such individuals must be able to analyse complex issues, recognize new problems, and work out and adopt solid solutions.

Specialised training of qualified scientists in new fields of research is continually gaining importance. The current global developments in the environmental sector are becoming more relevant both in science as well as in the economy. Our graduates are extraordinarily well qualified for careers in research, in advisory or consulting capacities or as leaders in science, politics, public administration and business.

The integrative exchange with research groups and guest lecturers as well as communication with foreign partners in an international consortium of institutions encourages increasing sensitivity for the research approaches that are under debate in the international arena. Students are specifically prepared to work in an international environment through inclusion in the programme of internationally operating businesses and research institutes. Places of work can be found in many fields: as policy advisors, in financial consulting, dealing with environmental policy, managing environmental change and risks, in Global Change research as well as in management of scientific institutions (research centres, public agencies and organisations).

Possible employers can be international organisations (e.g. EU, NGOs), national agencies (government ministries, federal agencies, state offices), departments of

sustainability, consulting businesses, insurance companies, universities and large research centres.

Outstanding graduates with above average knowledge and skills who are able to deal with the practical application of global environmental problems are needed for leading managerial positions. The basis of this work requires thorough training in natural science, but also a background in social science disciplines. By directly involving students in current research projects, they will be encouraged to use personal experience to help them understand the relevant processes within the framework of Global Change. There are no ready-made solutions to the problems needing to be tackled. Single individuals, no matter how extraordinary, cannot accomplish anything on their own. Furthermore, the temporal and spatial consequences that must be taken into consideration reach far beyond an individual's own personal range of experience. For this reason, characteristics such as creativity, flexibility, team spirit and sense of responsibility are particularly encouraged in this programme, as they will be indispensable in later fields of work.

The programme Global Change Ecology places great value on an exchange of scientific knowledge with the professional world and with society in general. To ensure practical application of scientific knowledge, close contact is guaranteed between the university programme with an alliance of non-university partners working on similar subject matter (particularly with research centres). Students interested in the programme should combine extraordinary intellectual skills with a pronounced sense of responsibility and high motivation. Their development is actively fostered throughout their studies. Special courses and intensive, individual support differentiates the Elite degree programme from conventional programmes. Direct communication with instructors is offered and encouraged between all students; international students are given special attention and are integrated into the programme.

The Elite Programme starts where the first academic degree (normally B.Sc.) leaves off. Applicants to the programme must fulfil above-average requirements. The programme is open to excellent, high-achieving and hard-working students from Germany and abroad. Major subject areas in the first degree can be: Biology, Geography, Geo-Ecology, Forestry, Agricultural Science, Hydrology, Limnology, Meteorology, Environmental Physics, Environmental Computer Science, Engineering Ecology, Landscape Ecology, Environmental Economics, Environmental Law and related disciplines. Applicants go through a selective admission process. Criteria for admission include submitting previous degrees and certificates and a personal written application statement. During candidate interviews, personal qualifications, willingness to work hard and motivation will be evaluated.

2 General Information, Forms of Teaching and Knowledge Transfer

The Elite Programme places enormous demands on each student's achievement potential and willingness to work hard.

Lectures (*Vorlesungen, V*) present a coherent description of the central topics in each respective Module. Lectures can also take place at partner universities.

During *Seminars* (*Seminare, S*) current research topics are covered by term papers, homework assignments, presentations and discussions. Classes that take place in another location and which in individual cases might be necessary for optimising specific resources will be linked to participating universities through an e-learning portal. Both asynchronous courses (E-Seminars and Discussion Forums with continual communication between teachers and students) as well as synchronous classes will be offered.

Tutorials (Übungen, Ü) take place in small groups and serve to deepen methodology and to teach technical knowledge through block courses with fieldwork (measurements, experiments, data evaluation). They enable students to deal intensively with methods, current issues and problems. These courses strive to form a heterogeneous structure in all group teams in order to take advantage of the different background experience of each individual student and to encourage discussion. Modelling exercises teach the students to use simulations and forecasts.

Research oriented *Science Schools* (Summer/Winter Schools, Module S) play an important part in the teaching concept as they offer students the opportunity to practice and deepen their specialised knowledge by dealing intensively with a specific topic. Furthermore, they encourage the exchange and contact with international students as well as allowing participants to become familiar with comparable institutions in different locations.

External *Internships* (*Internships*, Module I) that each last for six weeks enable participants to gain practical experience in research and administration, in businesses and in international organisations. Internships take place in institutions dealing with issues included in the Master Programme. The elite feature of the programme is conveyed by, among other aspects, the direct and regular conversations between instructors and students as well as in the regular weekly meetings that take place. This means that individual interests can be particularly encouraged and supported. All courses are offered annually. Examinations and performance assessments take place during the course.

Student workload is listed for each course in the number of credit points. One credit point (ECTS) is equivalent to 30 hours of work. For on-site classroom attendance, a one-hour class corresponds to 0.5-ECTS (1 SWS x 15 weeks = 15 hours). Credit points are given for contingent necessary preparation and follow-up work; depending on amount of time necessary, credit points are also given for exam preparation.

3 Programme Design

3.1 Structure of Study Programme

The Programme of Study is designed so that students can complete all requirements in four semesters and encompasses a total of 120 credit points. This includes the Master Thesis in the fourth semester with 30 credit points.

University instruction is organised in Modules; each one is normally worth 5 credit points. Generally, 30 credit points should be achieved each semester. The Modules are arranged in groups of Modules that all have a similar specialised focus. It is possible to choose courses within each Module group. In the Free Choice Module (F), students can select any 5 credit point course they would like to take. Credit points are also given for external Science Schools (Module S) and Internships (Module I). Course content must, however, be coordinated with the programme and agreed upon in advance for credit to be given.

All Module names, as well as the titles for Module areas, are in English.

In the first semester, relevant issues and approaches, as well as the state of research in general, will be taught in a transdisciplinary overview Module (O): „Global Change Ecology“. The concept of the programme will be introduced in this class and the state of special knowledge that the students might have will also be determined.

The three central Module Areas (A Environmental Change, B Ecological Change, C Societal Change) will be offered parallel to this, out of which at least three Modules must be chosen in each area. (Fig. 1) In the second or third semester an individual field of specialised interest (Specialization/Focus) will arise out of the selection of one further Module with 5 credit points from the courses offered in the Module Areas. In the third semester a further Module or single classes encompassing a total of 5 credit points can be chosen freely. These courses can be taken from the field of specialised interest.

Additionally, students must take method-oriented courses (Module M) during the first two semesters to round out their knowledge. These courses can help to address any potential skills gaps while also developing individual interests. It is possible to read about the individual Module parts in the course descriptions (see below) and see where previous knowledge in methods is required. This can be gained in method-oriented courses of different levels of expertise. In all, 10 credit points must be earned in this area.

The names of the Module Areas and the courses are presented in English in the Module Handbook, just as the courses are taught in English in the Elite Programme itself.

The given structure helps students to take responsibility for planning out their course of studies. Within Modules there are no options to choose from (exceptions: Module F and M). However, following certain rules, students can select modules from the Module Areas and in this way are able to individually design their course of study.

Students are also helped in designing their individual course of study by a Free Choice Module (Module F), as well as with courses in methods for their focus of specialised interest (Module M) and through the choice offered by Summer and Winter Schools (Science Schools, Module S) and career-oriented internships (Internships, Module I).

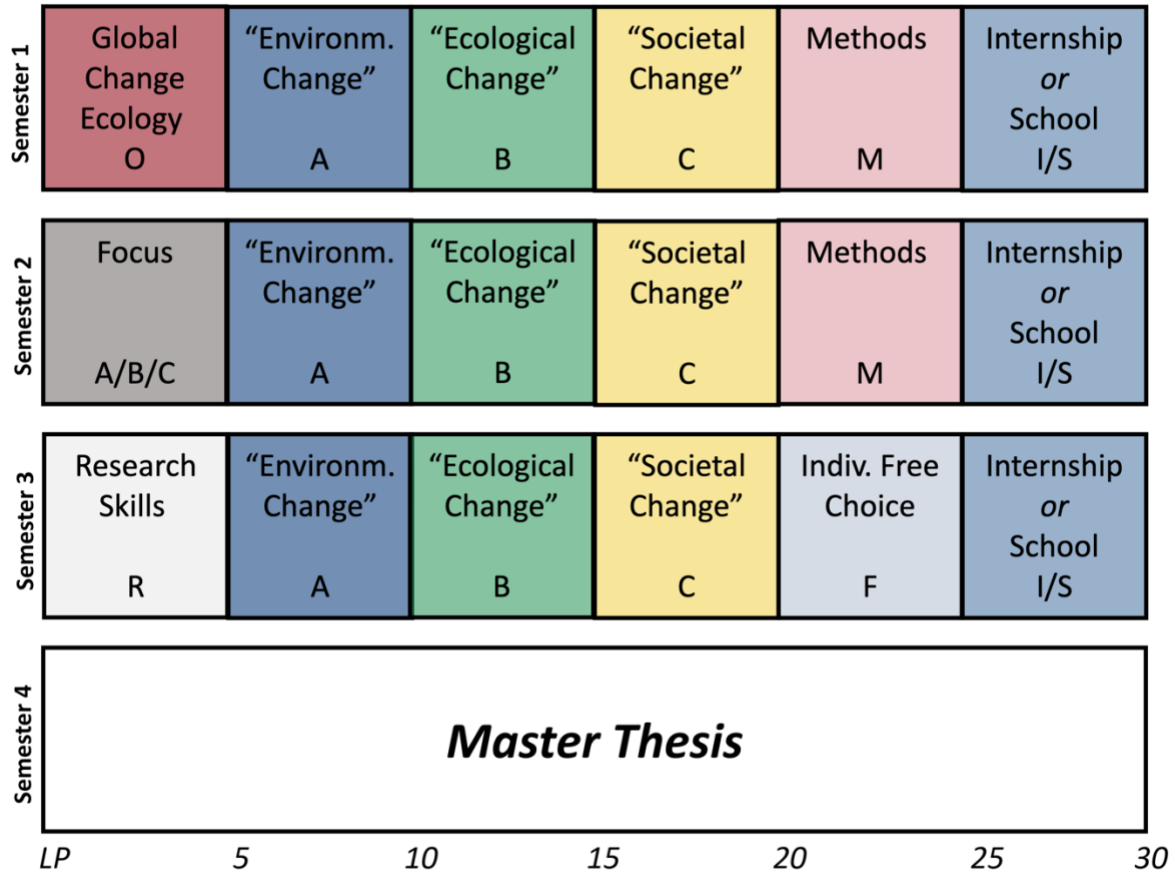

Fig. 1: Organisation of the programme showing the schematic distribution of Module Areas „Environmental Change" (A), „Ecological Change" (B) and „Societal Change" (C) as well as Methods (M) and Practice-Oriented Modules. Research Skills module (R) prepares for the master thesis. The introductory Module (O) is taught in an interdisciplinary manner. This overarching Module in the first Semester introduces the concept of the programme and offers a topical introduction. The possibility to switch between Module Areas encourages individual programme design. The choice of a focus module makes it possible to specialise in one of the areas of „Environmental Change", „Ecological Change" or „Societal Change". The selection of method-oriented courses supports the thematic direction of the Specialised Modules. Students should aim to complete 30 credit points (ECTS) per semester, for a final total of 120 ECTS.

The small group structure of the courses encourages flexible design of course content as well as intensive discussion. Module Areas and Modules provide a structure based on legally valid requirements for academic degree programmes in Bavaria. However, the content of the single courses described below are continuously adapted to current developments. Additionally, attending Science Schools and Internships during lecture-free periods lead to an intensive working structure.

The research module R will prepare students for scientific writing, management of research data, writing the research plan and presenting their thesis.

The Master Thesis (Master Thesis) is to be done in one of the Module Areas. It should, however, demonstrate multidisciplinary features. Normally, it is undertaken as a study within a research project of the affiliated chairs. Under certain conditions, it is also possible to work on external projects, e.g. with a partner in business, an agency or government department or in a large research centre.

„Master of Science (M.Sc.)" is awarded upon completion of the programme.

3.2 Course Schedule of the Study Programme

The implications of Global Change will be dealt with by starting from global social and ecological developments as well as with an understanding of biotic systems. In the first semester, an interdisciplinary Module will be offered that covers the philosophy of the programme and is also an introduction to the topics (**Overview**, Module O).

Due to the differences in educational background and specialised interests of the students in the programme, the teaching process is intentionally designed to be as flexible as possible. The vertical orientation of the structure (Fig. 2) guarantees a wide programme spectrum appropriate to the topics of the programme. At the same time, however, it allows room for individual advancement (specialization) of the students through their choice of an additional module in one of the Module Areas to supplement the required three Modules.

All three main Module Areas: **Environmental Change** (A), **Ecological Change** (B) and **Societal Change** (C) are continually offered up to the final thesis. This ensures intensive training in all areas and in this way links the different qualities of Global Change as a basic component of the programme structure. A minimum of three Modules are to be chosen from the course offerings in each of these Module groups.

Through personal module choices, an individualised shaping of the programme is both possible and encouraged. One additional module Focus from the areas A, B or C can be chosen to build the **Focus** (graded). The Free Choice Module F allows individual selection of additional courses offered in the MSc GCE or other study programs. Strategically planned choices of Method courses (M), Internships (I), and Science Schools (S) allows the students to further adapt the study program to their individual interest further. A Performance Assessment is required in these courses, but they are ungraded (see Fig. 2).

Suggestions for individual **Free Choice Electives in Module** (F) may be given, but no requirements will be stated. Additional specially oriented courses or languages can be taken. Research-oriented small projects can also be implemented within Module F. This serves as practice in cooperating on research projects as well as transdisciplinary cooperation with external partners in the community or country, in business or politics.

The course selection of **Methods courses** (Module M) allows students to learn specific techniques (e.g. R, Statistics, GIS) that are necessary to understand certain other Modules. A flexible selection of Methods courses to round out what students are learning is particularly necessary due to the heterogeneity of students' previous knowledge. The requirements in each Module are described in this Module Handbook. The Examination Committee may accept additional methods-oriented courses.

A total of 15 credit points are to be earned from **Internships** (Module I) and **Science Schools** (Module S). Logistical problems in providing internship places or in the organisation of the Schools are avoided through the flexible manner in which courses are offered. The total number of credits awarded for either one of these two areas (Internships or Science Schools), may not exceed 10 credit points.

The mandatory, but ungraded module on **Research skills** R prepares for the master thesis.

The Fourth Semester is entirely devoted to the **Master Thesis**. Didactic goals are the independent execution of an analysis of complex interrelations with a trans-disciplinary approach; discussion of global problem areas; transfer of knowledge to current key

environmental issues; use of modern methods and approaches; use of current reference material and research sources.

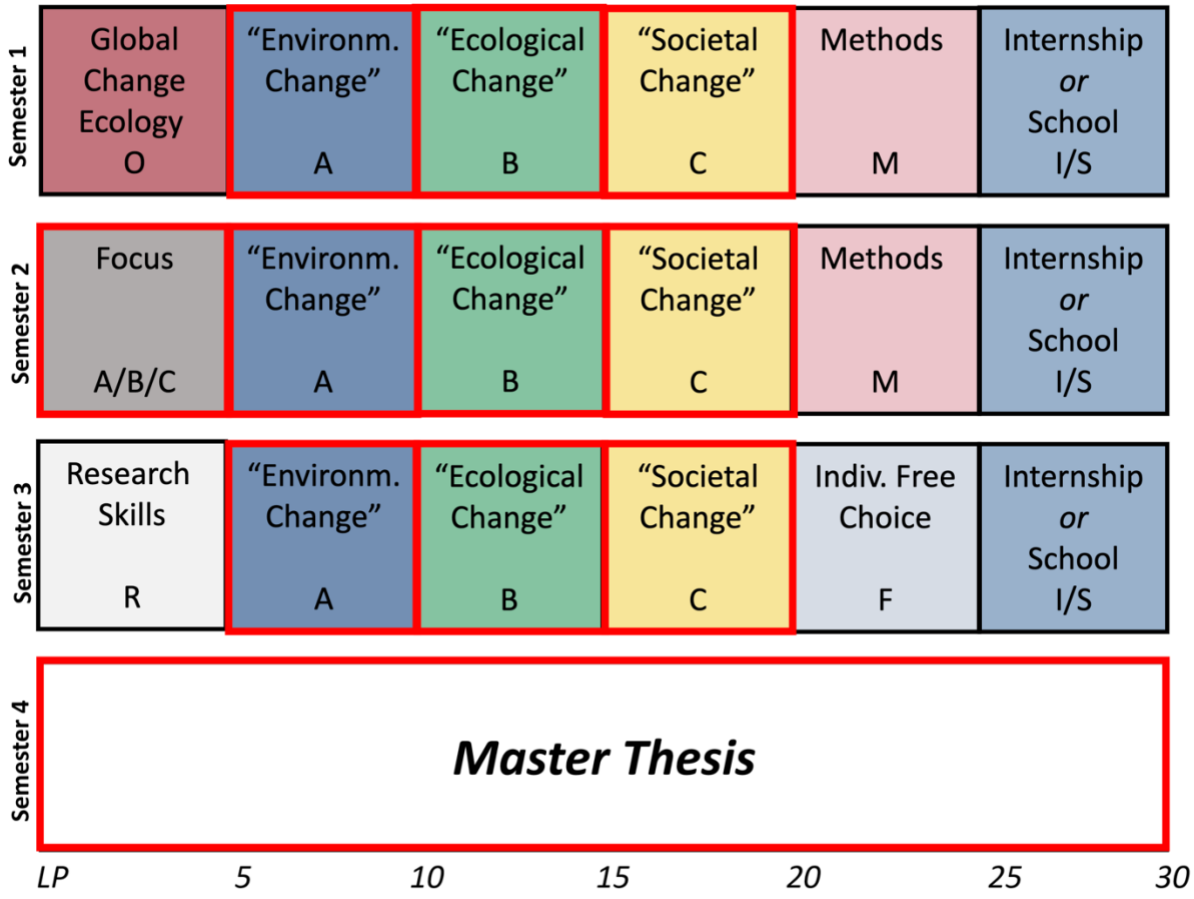

Fig. 2: Areas marked in red are graded Modules (80 of a total of 120-credit points). The end grade is composed of Module grades based on their respective number of credit points and the grade on the Master Thesis. The Module Global Change Ecology Overview (O), Methods (M), Research Skills (R), Free Choice (F), Internships (I) and Science Schools (S) each have a non-graded Performance Assessment; any possible grades are not part of the total grade.

4 Course Content

4.1 Module Area O „Global Change Ecology Overview“

This Module Area gives an overview of the background motivation for the programme as well as the target objectives. The structural concept of the programme and the course sequence are also described, and special characteristics of the German university system, of particular interest for foreign students, will be covered. The students also learn about the organisation of the programme itself, the Coordinating Office and the University of Bayreuth with its research specialties, central institutions and research centres. Tours of the laboratories, the Ecological Botanical Garden and the campus of the University of Bayreuth introduce students to the science facilities.

Finally, current global research developments are covered and the research community dealing with global change is discussed. The most recent developments in the current state of knowledge concerning global change are introduced. An overview of the statements of IPCC reports and other international studies helps students gain insight into the issues. This information is relevant for several different courses in the Global Change Ecology programme.

Pertinent textbooks, studies, as well as important publications are introduced (e.g. Global Change Biology, Global Environmental Change, Nature Climate Change, Global and Planetary Change) and references to appropriate websites and links are given. The development of the political landscape concerning the issues, international lectures, conferences and initiatives are also briefly outlined. Students can contribute their own knowledge as well.

The philosophy of the programme is discussed and special features of the programme are described. Students are given the opportunity to talk about their personal motivation for having chosen this programme and to discuss with instructors about their attitudes toward research and teaching. The goal is to precisely identify expectations and what the programme offers for an accurate match of both. Individual interests should be identified early so that, if possible, the courses can be designed with this in mind.

Programme Extent:

Only one Module with 5 credit points is offered in the first semester. This course is obligatory for all students.

O Global Change Ecology Overview

Responsible for the Module	Biogeography, University of Bayreuth (UBT)	
Structural Content	Biogeography, UBT; Ecological Services, UBT; Soil Physics, UBT	
Learning Objectives	This module covers the conception approach of the Master Programme. Participating disciplines and instructors are introduced. Logistical and organisational details are discussed. Students are also able to share and exchange their individual experience and knowledge.	
Course Content	First, an overview of the information about current and expected global development is given. Not only climate change but also land-use changes and the loss of biodiversity is included. In the advanced seminar, current research results are presented and analysed.	
Teaching Style	This module lasts for one semester and must be taken in the first semester as it sets the basis for the entire programme. The course consists of a one-hour lecture and a one-hour seminar. Additionally, a regularly scheduled weekly meeting is offered to discuss current study issues and for group mentoring. Two daylong excursions about landscape ecology supplement the module.	
	V Global Change Ecology (1 SWS, 1 ECTS)	
	S Progress in Global Change Research (1 SWS, 2 ECTS)	
	S Regularly Scheduled Meetings (1 SWS, 1 ECTS)	
	Two Excursions (1 SWS, 1 ECTS)	
Course Entry Requirements	No Special Course Entry Requirements	
Performance Assessment	Contribution (ungraded)	
Workload	Active Participation in 4 Class Sessions:	60 Hours
	Written Report and Lecture	30 Hours
	Preparation and Follow-Up:	30 Hours
	Regularly Scheduled Meetings:	15 Hours
	Two Excursions (one in the 1st, one in the 2nd semester):	15 Hours
	Total:	150 Hours
Credit Points	5 ECTS	
Scope of Time	Two Semesters (1st and 2nd semester)	
Semester Offered	Winter semester	
Target Group	Global Change Ecology	
Reference to Other Modules	The basics for the entire programme are taught.	

4.2 Module Area A „Environmental Change“

Information on the processes in Global Change is covered in this Module Area. The emphasis is on abiotic processes, which includes the physical and chemical mechanisms associated with global environmental changes and the relevant aquatic and terrestrial ecological systems they interact with. The dynamics of Global Change are handled in detail and different spatial scales are examined. The speed of development in relation to the affected objects, as well as the role of single individual extreme events, is also taken into consideration.

On the landscape level, recent climatic data and historic developments are identified. The relationship to global climate systems is presented. Control data of global developments is discussed, along with climate driving forces and land-use changes as decisive factors in material and biotic change. Of particular interest are overuse and degradation, erosion and desertification. Finally, the relationship between environmental change and change in biochemical action is also taught.

Overview of Modules (each worth 5 credit points):

A1 Climate Change

A2 Ecological Climatology

A3 Extreme Events and Natural Hazards

A4 Changes in Aquatic Ecosystems

A5 Changes in Agroecosystems

A6 N.N.

A7 Rhizosphere Biogeochemistry

A8 Biodiversity in the Tropics

A9 Mathematical Modeling for Climate and Environment

A10 Land Use Change and Microclimate

Total Extent of Module:

At least 15 credit points in this area are required. These can be expanded among the specialised area of interest. A graded Performance Assessment is required in each of the selected Modules.

A1 Climate Change

Responsible for the Module	Physical Geography, University of Augsburg	
Structural Content	Physical Geography, University of Augsburg	
Learning Objectives	The aim of this module is to teach fundamental knowledge about current climate development.	
Course Content	Basic principles of the climate system; naturally occurring climate variability, climate change in the past; reconstruction of past climate; natural forcing-factors, circulation dynamics; human impact on the climate system; global warming; greenhouse effect; land use change; aerosols; ozone depletion; global circulation models; forecasts; scenarios; fundamentals of energy and mass balance; modelling; sensitive parameters of global change	
Teaching Style	V Natural Climate and Human Impacts on Climate (2 SWS; 2 ECTS) S Climate Variability and Change: Natural and Man-Made (2 SWS; 3 ECTS)	
Prerequisites	None	
Performance Assessment	Oral exam (graded) and Contribution (ungraded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	60 hours
	Assessment component determined by instructor:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 1st Semester)	
Semester Offered	Winter semester	
Target Group	Global Change Ecology	
Reference to Other Modules	This is the basis Module for Module Area A	

A2 Ecological Climatology

Responsible for the Module	Climatology, UBT	
Structural Content	Climatology, UBT	
Learning Objectives	Climate Ecology is the interface between Ecology, Micrometeorology and Climatology as an interdisciplinary formation to understand the function of terrestrial ecosystems within the climate system. This course integrates the disciplinary areas of Meteorology, Hydrology, Soil Science, Plant Physiology, etc. to understand the physical, chemical and biological processes relevant to climate with which landscape and atmosphere are connected, and which can mutually influence both systems. In this module, students should develop a problem and process-oriented understanding with a variety of scale levels about the interaction between Pedosphere, Biosphere and Atmosphere. Furthermore, students learn to collect and analyse terrain data.	
Course Content	The seminar deals with climate-relevant material and energy flows in the soil-vegetation-atmosphere system on different scale levels. In particular, the interrelation between single compartments of ecosystems and their ecological relevance on climate will be dealt with. The course looks at examples of the parameters of climate data collection for terrain and analysis and modelling with particular attention given to scale transitions.	
Teaching Style	S Ecological Climatology (2 SWS; 3 ECTS) Ü Ecological Climatology: Measurements and Analyses (2 SWS; 2 ECTS).	
Prerequisites	Knowledge in programming language R	
Performance Assessment	Written report (graded) and presentation (ungraded) in seminar Written report (ungraded) in exercise	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 2nd Semester)	
Semester Offered	Summer semester	
Target Group	Global Change Ecology, Physical Geography, Geoecology	
Reference to Other Modules	A1 Climate Change A4 Changes in Aquatic Ecosystems A5 Changes in Agroecosystems	

A3 Extreme Events and Natural Hazards

Responsible for the Module	Disturbance Ecology, UBT
Structural Content	Disturbance Ecology, UBT; Physical Geography, University of Augsburg;
Learning Objectives	The aim of this module is to teach about occurrence and impact of natural risks and extreme events in ecology. Reoccurring events are included as well as single disasters; those with stabilizing effects and those with catastrophic consequences and regime shift. The impact of climatic, biotic and geomorphological events on biodiversity, ecology, provision of services, and cultural landscapes is covered. The learning objective is the ability to deal with in-depth theories and methods of Disturbance Ecology and to research extreme events. Fundamentals for a scientific study of interdisciplinary disaster research and risk management will be developed.
Course Content	Climate and land-use change are leading to global changes in disturbance regimes and to an increase in the frequency and magnitude of extreme events. In this module, we deal with geomorphological hazards, abrupt climate change and extreme weather events like heat waves, drought, intense rainfall, tropical cyclones and extra-tropical severe storms. Furthermore, avalanches, mass movement, large fires, insect calamities, pandemics, volcano eruptions and floods will be covered. The ecological consequences of possible future extreme events such as a lack of cold winter and occurrence of late frosts in the northern hemisphere will be addressed. Developing and presenting a scientific expert presentation trains students in analyzing and understanding the progress in current scientific literature on extreme events. .
Teaching Style	V/Ü Natural Risks and Hazards (2 SWS; 3 ECTS) S Extreme Events (2 SWS; 2 ECTS)
Prerequisites	None
Performance Assessment	Seminar presentation (graded) in V/Ü Natural Risks Hazards Seminar contribution (ungraded) in S Extreme Events
Workload	Active participation in 2 courses: 60 hours Preparation and follow-up: 60 hours Assessment component determined by instructor: 30 hours Total: 150 hours
Credit Points	5 ECTS
Scope of Time	Two semesters (Recommended: 1st and 2nd Semesters)
Semester Offered	Winter semester (V/Ü) Summer semester (S)
Target Group	Global Change Ecology, Environmental Geography, Biodiversity and Ecology, Geoecology
Reference to Other Modules	A1 Climate Change B3 Disturbance Ecology (and further B-Modules)

A4 Changes in Aquatic Ecosystems

Responsible for the Module	Hydrology, UBT	
Structural Content	Hydrology, UBT	
Learning Objectives	The objective of this module is to gain a thorough understanding of natural processes of water flow and storage in and between the various compartments of the environment and to learn about various impacts on global water resources.	
Course Content	The module is divided into a lecture/exercise about fundamental hydrological processes and a seminar with interactive content. The focus of the lecture are the hydrological cycle and the water balance equation. Processes of water movement through the compartments of the atmosphere, biosphere and geosphere and their interactions are discussed in detail. Furthermore, aspects of chemical and ecological water quality and strategies for protecting surface- and groundwater are presented. In the seminar, we discuss current risks for and impacts on water resources in a global context. Students select a topic and present the results of their literature review to their fellow students, with the aim to stimulate a critical discussion also of potential mitigation strategies. The student presentations may be complemented by presentations of external experts.	
Teaching Style	V Hydrological Concepts (2 SWS; 3 ECTS) S/Ü Water resources in a quickly changing world – impacts and challenges (2 SWS, 2 ECTS)	
Prerequisites	None	
Performance Assessment	Written exam (graded) and seminar presentation (ungraded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	45 hours
	Written exam and presentation	45 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	Two semesters (Recommended: 1st and 2nd Semesters)	
Semester Offered	Winter semester (V) Summer semester (S/Ü)	
Target Group	Global Change Ecology, Geoecology	
Reference to Other Modules	A1 Climate Change A2 Ecological Climatology A5 Changes in Agroecosystems	

A5 Changes in Agroecosystems

Responsible for the Module	Soil Physics UBT	
Structural Content	Soil Physics UBT, Agroecology UBT	
Learning Objectives	The module goal is to learn how soil management and various (a)biotic drivers affect the structure of soils and herewith multiple soil functions at different temporal scales.	
Course Content	Agroecosystem management alters soil structure and thus various soil functions. In addition, bioturbation and climatic conditions induce seasonal dynamics in the pore network and thus in the architecture of the soil. Quantifying these changes provides critical information about soil as a habitat and water as a key resource for plant production. In addition, soil structure plays a crucial role for water and matter fluxes in agroecosystems. In this module, we learn about soil structure as a dynamic soil state, methods to quantify structural indicators and how these structural changes modify soil functions. We will further discuss how management systems can be adapted in prospect of future scenarios. The course provides a general overview of soil structure, how it is changing by various drivers (tillage, freezing/thawing, wetting/drying, bioturbation), as well as the feedback mechanisms for soil functions and implications for resource management in agroecosystems.	
Teaching Style	V/Ü Soil Structure and Soil Functions (2 SWS; 2 ECTS) S Global Change and Agroecosystems (2 SWS; 3 ECTS)	
Prerequisites	None. Basic knowledge in soil science is recommended.	
Performance Assessment	Written exam (graded) and seminar contribution (ungraded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	60 hours
	Seminar contribution:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 1st Semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A1 Climate Change A7 Rhizosphere Biogeochemistry	

A6 N.N.

A7 Rhizosphere Biogeochemistry

Responsible for the Module	Agroecology UBT	
Structural Content	Agroecology UBT	
Learning Objectives	The module goal is to learn fundamental biological, chemical and physical processes taking place at the root-soil interface and their larger scale implications	
Course Content	The rhizosphere is one of the most dynamic interfaces in terrestrial ecosystems and certainly the most important zone in terms of defining the quality and quantity of our crops. Interactions in the rhizosphere between living organisms (roots and microorganisms), solids (minerals and organic matter), liquids (water with dissolved nutrients) and gaseous phases are pivotal in controlling ecosystem dynamics, functions and the services they provide.	
Teaching Style	V Rhizosphere Biogeochemistry (2 SWS; 2 ECTS) S Emerging Topics in Rhizosphere Research (2 SWS; 3 ECTS)	
Prerequisites	None	
Performance Assessment	Oral exam (graded) and seminar presentation (ungraded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	60 hours
	Assessment component determined by instructor:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 1st Semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A5 Changes in Agroecosystems	

A8 Biodiversity in the Tropics

Responsible for the Module	Functional and Tropical Plant Ecology, UBT	
Structural Content Learning Objectives	Functional and Tropical Plant Ecology, UBT	
Learning Objectives	Module's aim is to gain a sound overview of tropical ecology and in particular of research on biodiversity in the tropics. Students learn on the basis of examples of different approaches to advance and test an ecological hypothesis. Critically reading and assessing scientific literature, as well as scientific presentations, are also practiced.	
Course Content	First, the module provides an introductory overview of tropical ecology. On the basis of tropical forests, which represents one of the most diverse ecosystems on Earth, we deal with theories and today's state of knowledge on mechanisms of the origin and maintenance of diversity, processes determining the spatial and temporal distribution of diversity, the functions of diversity, impacts of climate change and land use and strategies for protection. In doing so we include genetic, chemical, functional and species diversity as well as different taxonomic groups.	
Teaching Style	Lecture and seminar (4 SWS, 5 ECTS)	
Prerequisites	Recommended: Foundations of animal ecology, plant ecology and evolution. Basic statistical knowledge is required, R knowledge is advantageous.	
Performance Assessment	One overall module examination (graded) consisting of two seminar presentations (graded, each 50%)	
Workload	Active participation in the courses:	60 hours
	Preparation and follow-up:	30 hours
	Literature work, and elaboration of own contributions	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	
Target Group	Global Change Ecology, Biodiversity and Ecology, Molecular Ecology	
Reference to Other Modules	M23 Dynamic Ecosystem Modeling B1 Biogeography and Macroecology B2 Biodiversity and Ecosystem Functioning	

A9 Mathematical Modeling for Climate and Environment

Responsible for the Module	Scientific Computing, UBT	
Structural Content	Scientific Computing, UBT	
Learning Objectives	Knowledge of important physical principles and their representation in mathematical models for main types of climate and environmental models	
	Ability to identify the key interactions between different compartments of a climate model and to express them in mathematical form	
Course Content	Physical principles, mathematical models, and selected numerical methods in climate and environmental sciences	
	Earth system: Main components, driving forces, scales, feedbacks	
	Hierarchy of climate models, regional and global focus	
	Environmental modeling: Main applications and problem settings	
Teaching Style	V Mathematical Modeling for Climate and Environment (4 SWS; 5 ECTS)	
Prerequisites	M22 Mathematical Modeling for Climate and Environment (exercise)	
Performance Assessment	Oral examination (graded)	
Workload	Active participation in course:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester (V)	
Target Group	Global Change Ecology, Scientific Computing	
Reference to Other Modules	M22 Mathematical Modeling for Climate and Environment (exercise)	

A10 Land Use Change and Microclimate

Responsible for the Module	Micrometeorology, UBT	
Structural Content	Micrometeorology, UBT Atmospheric Chemistry, UBT	
Learning Objectives	The learning outcome of this class is to comprehend the fundamental interactions between anthropogenic land use and land cover changes and the cycling of heat, water, carbon and reactive gas species at the land surface, to collect and analyse field observations, and to apply this knowledge across contrasting land uses and covers.	
Course Content	Land use and land cover (LULC) change from local to global scales is an important aspect of global change and acts as both a responder to socio-economic demands and as a driver of societal development. At the heart of these feedback processes is the biogeochemical cycling of heat, water, carbon, and reactive species creating specific microclimates between the land surface and the near-surface air, both of which comprise the 'critical zone' containing almost all terrestrial life including human activities. The microclimate and thus the state of the critical zone is important for identifying sustainable solutions in a rapidly changing world impacted by urbanization, agricultural expansion, afforestation, and desertification. Students will first develop a conceptual problem and process-oriented understanding of how LULC changes impact the microclimatic cycling of heat, water, carbon, and other trace gases in a classroom setting. Next, they will apply their skills by designing, conducting, analysing, and interpreting field measurements of heat, water, and radiative fluxes across the soil-air-plant continuum across contrasting land use types (grassland, urban land cover) to understand the urban heat island and agricultural cool islands. Methods include commonly applied micrometeorological experimental techniques and models including the Bowen-ratio, Penman-Monteith evapotranspiration, and Soil-Vegetation-Atmosphere Transfer (SVAT) models.	
Teaching Style	V/S Land Use Change and Microclimate (2 SWS) S/Ü Microclimatic field experiment across land uses (1 SWS)	
Prerequisites	None	
Performance Assessment	Written elaboration (ungraded) in V/S Land Use Change and Microclimate Seminar contribution (ungraded) with written elaboration (graded) in S/Ü Microclimatic field experiment across land uses	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up incl. problem sets:	30 hours
	Field activities	20 hours
	Presentation and report writing	40 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 2nd Semester)	
Semester Offered	Summer semester (V/Ü/S)	

Target Group	Global Change Ecology, Geoecology, Environmental Geography
Reference to Other Modules	A1 Climate Change A2 Ecological Climatology A5 Changes in Agroecosystems A9 Mathematical Modelling for Climate and Environment M2 Statistical Data Analysis with R

4.3 Module Area B „Ecological Change“

Here, the ecological effects of Global Change are addressed. Courses focus on the responses of organisms and ecological systems to changes in environmental conditions and to human influence, to changes in the energetic and material framework as well as to changing natural disturbance regimes. The impact of changing climate and land-use as well as the influence of growing global connectivity on species and biodiversity is discussed. Functional consequences are identified. The significance of new, more efficient vectors for expansion of organisms will be dealt with as well as the role of invasive species in creating novel systems.

The loss of biodiversity is connected to considerable functional consequences and can intensify the effect of other drivers such as climate change. Changes in land-use are a prominent driving force behind the loss of biodiversity.

Climate Change goes far beyond short-term impact on structural content and functionality of ecological systems. That is why it is important to assess the resilience of ecosystems in order to mitigate and adapt to rapid changes. Among other processes, organismic processes determine the sequestration, storage and release of carbon.

Along with a background in biology, knowledge in methods of modelling and geostatistics is recommended. There is an opportunity to gain experience in data acquisition in the field and in experiments.

Overview of Modules (each worth 5-credit points):

B1 Biogeography and Macroecology

B2 Biodiversity and Ecosystem Functioning

B3 Disturbance Ecology

B4 Spatial Ecology

B5 Global Change Impacts on Species Distributions

B6 Soil Carbon and Global Change

B7 Remote Sensing in Landscape Ecology

B8 Dynamic Vegetation Ecology

B9 Paleoecology and Paleobiology

Total Extent of Course:

At least 15 credit points in this area are required. These can be expanded among the area of specialised interest. A graded Performance Assessment is required in each of the selected Modules.

B1 Biogeography and Macroecology

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	Module aim is to teach about development and distribution of the variety of life on earth. Students learn about the spatial features of organisms and biotic communities on different spatial scales. The role of biodiversity for a functioning ecosystem will be discussed along with global change and its impact. The lecture deals with the evolution of variety on earth, prior major extinctions, the significance of the variety of ecosystem functions and current trends. In the seminar „Progress in Biogeography“, current developments in Biogeography will be dealt with. Students gain practice in working with literature data banks and online-journals. By putting together and giving a presentation, students will be trained in the production of survey articles based on current scientific primary literature.	
Course Content	Through global climate change, material flow, land-use and the links between habitats will greatly impact the biodiversity on earth that has had millions of years to develop. Local, regional and global losses are the result. Possible consequences will be worked out in the course. Biogeography is undergoing great change, as more and more questions about the complex relationships on a global scale are being asked. We will deal intensively with current methods of development.	
Teaching Style	V Development and Change of Biodiversity (2 SWS, 3 ECTS) S Progress in Biogeography (2 SWS, 2 ECTS)	
Prerequisites	None	
Performance Assessment	Seminar presentation (ungraded) and written exam based on the lecture (graded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	40 hours
	Preparation of the presentation:	20 hours
	Preparation for the written exam:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 1st Semester)	
Semester Offered	Winter semester	
Target Group	Global Change Ecology, Environmental Geography, Biodiversity and Ecology, Geoecology	
Reference to Other Modules	none	

B2 Biodiversity and Ecosystem Functioning

Responsible for the Module	Disturbance Ecology, UBT	
Structural Content	Disturbance Ecology, UBT; Biogeography, UBT;	
Learning Objectives	The learning outcome of the module Experimental Ecology is to reach an overview of recent experimental approaches in community ecology. In particular, globally coordinated, geographically distributed experiments such as HerbDivNet, BioDEPTH, EVENT, SUSALPS, DroughtNet or NutrientNet have proven to be very stimulating for understanding design and analysis of standardized experiments and testing ecological theory. The goal of this module is an in-depth look at the relationship between biodiversity and ecological functioning, understanding the scientific approaches and findings on impacts of climate change and land use change on ecosystem services. This course will be composed of several elements including theoretical instruction on experimental design and analysis, participation in ongoing field campaigns as well as collecting and analyzing own data. At the conclusion of this module, students will have a thorough understanding of experimental ecology.	
Course Content	General concepts of experimental ecology will be introduced initially using ongoing field experiments as model ecosystems. Here, the focus is effects of global change drivers on biodiversity and ecosystem functions. Guided by instructors, students will develop their own hypothesis within an ongoing research activity, and collect and evaluate their own data. In doing so, students will learn about the potential limitations of experimental approaches. Thus, students will become familiar with different methods of collecting and evaluating data in experimental ecology	
Teaching Style	Ü Experimental Ecology (4 SWS, 5 ECTS, in small groups)	
Prerequisites	Knowledge based on Module B1 or B3, basic knowledge in R is strongly advised, advanced knowledge very welcome.	
Performance Assessment	Written elaboration (scientific report, graded)	
Workload	Active participation in 1 course:	120 hours
	Assessment component determined by instructor:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	Based on B1 Biogeography and Macroecology or B3 Disturbance Ecology	

B3 Disturbance Ecology

Responsible for the Module	Disturbance Ecology, UBT	
Structural Content	Disturbance Ecology, UBT	
Learning Objectives	At the conclusion of this module, students will comprehend how ecosystems in all biomes are affected by natural and anthropogenic disturbance regimes, which create their own dynamics and spatio-temporal phenomena. This knowledge will enable participants to understand the effects of disturbances and extreme events on biodiversity and ecosystem functions, regeneration dynamics, and mechanisms of stability such as functional resilience. The learning outcome of the seminar is to reach an overview of recent scientific literature covering disturbance ecology and pulse dynamics increasingly interacting with climate change and land-use change. This understanding will enable students to evaluate system behavior, contribute to developing adaptation strategies, and tackle current research frontiers in disturbance ecology. At the conclusion of this module, students will comprehend how ecosystems in all biomes are affected by natural and anthropogenic disturbance regimes, which create their own dynamics and spatio-temporal phenomena. This knowledge will enable participants to understand effects of disturbances and extreme events on biodiversity and ecosystem functions, regeneration dynamics, and mechanisms of stability such as functional resilience.	
Course Content	Theory, methodology and application of disturbance ecology and pulse dynamics as well as the relationship between disturbance, vegetation dynamics and ecosystem functions are taught in the lecture “Disturbance Ecology”. Current research frontiers in disturbance ecology, resilience and sustainability science are presented and discussed in the seminar “Resilience”. The significance of understanding disturbance ecology for ecosystem restoration and sustainable land-use planning is also addressed. Temporal variability of ecosystems, their rhythms and recurrent events are discussed with respect to future global changes to assess the dynamics of ecological systems.	
Teaching Style	V Disturbance Ecology (2 SWS, 2 ECTS) S/Ü Stability, Resilience and Inertia (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Written exam (ungraded) and seminar presentation (graded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	60 hours
	Seminar presentation:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	

Target Group	Global Change Ecology, Environmental Geography, Biodiversity and Ecology, Geoecology.
Reference to Other Modules	A3 Extreme Events and Natural Hazards B2 Biodiversity and Ecosystem Functioning

B4 Spatial Ecology

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	Spatial processes play an important role in ecology, e.g. for the persistence of single populations, expansion of invasive species or preservation of species diversity. During this module, students should develop a problem-oriented understanding for the essential spatial processes like expansion and they should also develop skills to apply and develop dynamic models.	
Course Content	The Seminar „Spatial Ecology“ works with examples of ecological spatial phenomena (e.g. source-sink dynamics, metapopulations, invasions, coexistence). The exercise „Modelling of Spatial Ecological Processes“ covers numerical simulations of spatial processes (e.g. cellular automaton models, species distribution models). The relevant modelling approaches will be applied and discussed.	
Teaching Style	S Spatial Ecology (2 SWS; 2 ECTS) Ü Modelling of Spatial Ecological Processes (2 SWS, 3 ECTS)	
Prerequisites	Knowledge in programming language R Basic knowledge about ecological processes and models M4 Foundations of Biogeographical Modelling (recommended)	
Performance Assessment	Seminar presentation (ungraded) and written elaboration (report) (graded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 3rd Semester)	
Semester Offered	Winter semester	
Target Group	Global Change Ecology	
Reference to Other Modules	B1 Biogeography and Macroecology B2 Biodiversity and Ecosystem Functioning M4 Foundations of Biogeographical Modelling M23 Dynamic Ecosystem Modelling	

B5 Global Change Impacts on Species Distributions

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	Ability to analyse changes in the distribution of species (displacement, extinction, invasion), dependent upon environmental conditions, particularly land cover.	
Course Content	Land cover classification, land cover change (e.g. deforestation), texture, species distribution modelling, displacements, extinction and invasion processes, anthropogenic influences on species distributions.	
Teaching Style	V Global Change Impacts on Species Distributions (2 SWS; 2 ECTS)	
	Ü Global Change Impacts on Species Distributions (2 SWS; 3 ECTS)	
Prerequisites	Knowledge in programming language R	
	M2 Statistical Data Analysis with R	
	M5 Remote Sensing	
Performance Assessment	Contribution (ungraded) in lecture	
	Written elaboration (report) (graded) in exercise	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 2nd Semester)	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	M5 Remote Sensing	
	B4 Spatial Ecology	
	B7 Remote Sensing in Landscape Ecology	

B6 Soil Carbon and Global Change

Responsible for the Module	Soil Ecology, UBT	
Structural Content	Soil Ecology, UBT	
Learning Objectives	Knowledge about the storage and loss of carbon in and from soil is crucial to mitigate climate warming. This module offers insights into processes and mechanisms that lead to carbon sequestration in soil. We look at soils from different climate regions, and learn about soil carbon accumulation and greenhouse gas emissions and how this is affected by climate change and land-use.	
Course Content	Lecture: Carbon stocks in soil, mechanisms of carbon stabilisation in soil, influence of climate and land-use change. Characteristics of soil organic matter, the role of dissolved organic carbon compounds and greenhouse gas emissions. Tutorial: Field day on carbon storage in soil. Lab week on carbon analyses in soil.	
Teaching Style	V Soil Organic Matter and Greenhouse Gases – part II (2 SWS, 3 ECTS), Ü Soil Carbon and Global Change (1 SWS, 2 ECTS, as 1 week block course 1 week after lecture exam)	
Prerequisites	Basic knowledge in soil science, basics in chemistry	
Performance Assessment	Written exam (graded) in lecture Written elaboration (report) (ungraded) in exercise	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	50 hours
	Assessment component determined by instructor:	40 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 2nd Semester)	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A5 Changes in Agroecosystems	

B7 Remote Sensing in Landscape Ecology

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	Possibilities of continual surface data collection through remote sensing for biodiversity research are taught. An important objective is to inform about the different ways of closing spatial gaps in field data collection by using remote sensing data. A suitable sampling design comes along with in-situ field data collection as well as processing steps in the evaluation of different data sets (field and remote sensing data). The latter includes statistical procedures and spatial models.	
Course Content	Results of biological assessments and records from applied sciences such as forestry, nature conservation, agriculture in the field (basal area, forest successional stages, species, drought impact, tree mortality etc.) are linked with remote sensing data (hyperspectral data, results from remotely sensed field data and products such as FAO land cover classification system LCCS or Global Land Cover - Sentinel 2; LAI records and hemispheric measuring). With selected examples, the potential and limitations of using aircraft- and satellite-based missions for the collection of biodiversity patterns will be shown. Processing steps like dimension reduction, index calculation as well as spatial filters and measures to determine heterogeneity of habitats and ecosystems will be taught.	
Teaching Style	Ü In-situ Field Data Recording (2 SWS, 2 ECTS) Ü Remote Sensing Data Analysis (graded written report) (2 SWS, 3 ECTS)	
Prerequisites	Skills in R, GIS; M5 Remote Sensing	
Performance Assessment	Written elaboration (report) (graded)	
Workload	Active Participation in field data recording:	60 hours
	Active Participation in remote sensing data analyses	40 hours
	Preparation and follow-up:	20 hours
	written report:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	B2 Biodiversity and Ecosystem Functioning	

B8 Dynamic Vegetation Ecology

Responsible for the Module	Plant Ecology, UBT	
Structural Content	Plant Ecology, UBT	
Learning Objectives	The module's aim is to teach students about the drivers that influence the earth's vegetation distribution as well as to communicate the role of terrestrial vegetation in Earth's ecosystems. Students who successfully participate in this course will be able to critically assess and interpret dynamic vegetation models (DGVMs).	
Course Content	The lecture focuses on the most important ecological processes regarding terrestrial vegetation. The lecture stresses that understanding vegetation dynamics and distribution requires knowledge of biophysical laws and knowledge of the evolutionary history of individual ecosystems. Major topics include photosynthesis, respiration, allocation, birth, death, fire, herbivory and ecosystem assembly. In the seminar we review and discuss seminal contributions to vegetation ecology and use this knowledge to articulate research priorities for plant ecology in the context of global change.	
Teaching Style	V Dynamic Vegetation Ecology (2 SWS, 2 ECTS) S Foundations of Dynamic Vegetation Ecology (2 SWS, 3ECTS)	
Prerequisites	None	
Performance Assessment	Written elaboration (report) (graded) and seminar presentation(s) (ungraded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	60 hours
	Assessment component determined by instructor:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology, Environmental Geography, Biodiversity and Ecology, Geoecology, Physical Geography. Limited number of participants.	
Reference to Other Modules	M20 Methods in Dynamic Vegetation Ecology M23 Dynamic Ecosystem Modeling	

B9 Paleoecology and Paleobiology

Responsible for the Module	Sport Ecology, UBT	
Structural Content	Sport Ecology, UBT	
Learning Objectives	Upon completion of the module “Paleobiology and Paleoecology”, students understand the potentials and limitations of fossils as a research object. They are able to address important research questions and current debates in Quantitative Paleobiology and Paleoecology and illustrate them with practical examples. They can analyse paleontological data with modern quantitative methods using existing scripts and name the most important challenges in taking the fossil record as a basis for analyses.	
Course Content	The module assesses the use of fossils as research objects (e.g. taphonomy, fossil diagenesis, states of preservation, analytical methods) and the meaning of paleobiological and paleoecological analyses for understanding recent ecosystems. Students collaboratively acquire an insight into research questions of palaeontology and learn quantitative methods for the analysis of fossil databases (www.paleobiodb.org) with the help of the programming language R (www.r-project.org).	
Teaching Style	1. Paläobiologie und Paläoökologie (Paleobiology and Paleoecology), Hauptseminar (seminar), 2 SWS 2. Analyse paläontologischer Daten (Analysis of Paleontological Data), Kleingruppenübung (exercise), 2 SWS	
Prerequisites	A basic ecological understanding as well as skills in statistical modelling and in the application of the programming language R are expected.	
Performance Assessment	Written elaboration (report) or seminar presentation or written exam or oral exam (announcement at the outset of module) (graded)	
Work Load	Active participation in courses,	60 hours
	Preparation and follow-up and	60 hours
	Exam preparation	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology, Sport Ecology	
Reference to Other Modules		

4.4 Module Area C „Societal Change“

Global environmental changes on the one hand have anthropogenic causes; on the other hand, society at large bears the consequences of climate change and changes in ecological systems. Module Area C discusses the global interplay between social and ecological changes. The socioeconomic reasons for global climate and land-use change and their ecological consequences for ecosystem functionality, regional climate and biodiversity are covered in this Module. On this basis, the economic consequences of ecological changes are studied, in particular, the changing availability of natural resources (e.g. drinking water) and of ecosystem services (e.g. food production, providing substances for pharmaceutical use, erosion protection, carbon sequestration, or aesthetic value of landscapes).

To better understand the driving forces behind global environmental change, the fundamentals of the functioning of global economic systems as well as formal and informal political systems are covered. Social strategies in dealing with global syndromes (special adaptation to global change) and the available instruments used in markets and politics to influence global change are discussed. Module Area Methods (M) additionally covers the practical use of accounting tools (e.g. eco-balance) that keep social actors informed about the environmental consequences of their decisions and which they use as a basis for decision-making. This Module Area focuses on the quality and quantity of methods of social research and economics as well as the spatial and temporal modelling of socio-ecological systems.

Module Overview (each worth 5 credit points):

C1 Climate Policies and Economics

C2 Ecosystem Services

C3 Global Economy

C4 Global Policy and Governance

C5 Socio-Economic and Political Dimensions of Global Change

C6 Sport Ecology

C7 Land Use Policies, Markets and Ecosystems

C8 Biodiversity, Climate Change and Health

Total Extent of Course:

At least 15 credit points in this area are required. These can be expanded among the area of specialised interest. A graded Performance Assessment is required in each of the selected Modules.

C1 Climate Policies and Economics

Responsible for the Module	Ecological Services, UBT	
Structural Content	Teaching assignments	
Learning Objectives	After attending the lecture (i), students are familiar with various instruments for achieving climate policy goals, (ii) can analyse them in terms of efficiency, distribution effect and uncertainties, and (iii) are able to critically discuss the advantages and disadvantages of real-world political instruments along economic criteria. The course will introduce key concepts such as the “tragedy of the commons” and “collective action problems”, and discuss key academic developments in the understanding of the management of global commons. The course will ensure that the students develop a firm grasp of the fundamental dynamic of climate change negotiations while introducing the main legal instruments that form the backbone of the climate regime. Students will be able to critically assess how the Paris Agreement can mobilize action.	
Course Content	In the first part of the lecture, economic criteria for determining efficient and fair climate policy goals are developed. Then climate policy instruments are dealt with (e.g. regulatory policy; CO_2 tax; emissions trading) and instrument selection is discussed with imperfect information. In interactive phases, economic concepts are deepened along with current case studies, such as the German coal phase-out, national CO_2 pricing (climate package) or European emissions trading (EU ETS). In the second part of the module, an introduction into the climate regime (United Nations Framework Convention on Climate Change, Kyoto Protocol, Paris Agreement) in the context of international environmental governance will be given. This will be discussed against the backdrop of geopolitical developments. Global environmental commons, Introduction into the International Climate Regime, Roles of state and non-state actors, Case Studies, Critical Assessment and Concluding Discussion.	
Teaching Style	V/S Climate Policy and Instruments (2 SWS, 2 ECTS) V/S Climate Diplomacy (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Contribution (ungraded) in Climate Policy and Instruments Written elaboration (report) (graded) in Climate Diplomacy	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 1st Semester)	
Semester Offered	Winter semester	
Target Group	Global Change Ecology	

Reference to Other Modules	A2 Ecological Climatology
	C2 Ecosystem Services
	C3 Global Economy

C2 Ecosystem Services

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	Global change in climate, land use, markets and politics has a major impact on the performance of ecosystems. The aim of this module is to examine the ecosystem services relevant to societies in greater depth (food production, erosion regulation, drinking water purification, risk protection, etc) and their relationship to biodiversity.	
Course Content	The lecture „Ecosystem Services" gives an overview of ecosystem services in regional and global human-environmental systems. Contents include the definition and classification of ecosystem services, their relationship to biodiversity and the role of global change. Furthermore, the physical quantification and socio-economic evaluation, the supply and demand by social actors as well as the management of the performance of the ecosystem by market-related policy instruments are dealt with. The seminar deepens lecture topics with current examples from research.	
Teaching Style	V Ecosystem Services (2 SWS, 2 ECTS) S Current Research in Ecosystem Services (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Written exam (graded) in lecture Contribution (ungraded) in seminar	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A5 Changes in Agroecosystems B2 Biodiversity and Ecosystem Functioning C3 Global Economy C7 Land Use Policies, Markets and Ecosystems	

C3 Global Economy

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT; VWL VI: Empirical Economics, UBT	
Learning Objectives	The increasing demand for goods and services as well as the globalization of markets has far-reaching economic, ecological and social effects. On the one hand, developing countries could benefit economically from increased export of raw materials (e.g. biofuels) or through direct investment from industrial nations (e.g. in the agricultural sector), on the other hand, ecosystems could be sustainably damaged due to low environmental standards in developing countries. The aim of this module is to understand the flows of goods and services in global financial and raw materials markets and their economic and ecological effects, and to critically examine environmental policy instruments.	
Course Content	The lecture teaches the basics of the functions of, actors, and environmental innovations in the global financial sector. The lecture also provides an introduction to environmental economic theories and policies in an international context. This knowledge enables students to critically examine the influence of globalization in the area of goods and finance on the environment and ecosystems. The seminar discusses what effects global trade, particularly of raw materials, induces due to the use of terrestrial and marine ecosystems. In order to reduce negative effects, environmental policy measures such as environmental standards play a special role. However, national environmental policies and different environmental policy standards between trading partners can also distort competition. Global market changes, environmental impacts and policy measures are critically reflected.	
Teaching Style	V Globalization of Economies and the Environment (2 SWS, 2 ECTS) S Globalization of Economies and the Environment (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Contribution (plenary discussion including written questions) (ungraded) in lecture Seminar presentation (graded) and written elaboration (report) (graded), each 50% in seminar	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	

Target Group	Global Change Ecology
Reference to Other Modules	C2 Ecosystem Services

C4 Global Policy and Governance

Responsible for the Module	Ecological Services, UBT	
Structural Content	Teaching assignments	
Learning Objectives	The aim of the module is to lead students into the economic and political dimensions of global change. Global environmental change confronts societies with problems (e.g. loss of biodiversity, desertification, climate change or soil erosion) that can create considerable costs for society at large. Political solutions are needed to deal with conflicting interests. Environmental governance encompasses a variety of different approaches of social regulation from international treaties across borders to informal networks or market-based competition.	
Course Content	The seminar "Economics of Global Environmental Change" addresses important studies on the topic with a focus on climate change (e.g. the Stern Review), biodiversity loss (e.g. The Economics of Ecosystems and Biodiversity TEEB), or land degradation (e.g. The Economics of Land Degradation ELD). The focus is on 1) assessing the multiple values of ecosystem services (in particular their economic dimension) for informing decision making and 2) the relevance of such information for the design of environmental policies and economic instruments for the conservation and sustainable use of biodiversity. The seminar "Global Change Policy, Contracts and Administrative Strategies" provides an introduction to international political processes in the Convention on Biological Diversity (CBD) and the Intergovernmental Platform on Biodiversity & Ecosystem Services (IPBES).	
Teaching Style	S Economics of Global Environmental Change (2 SWS, 2 ECTS) S Global Change Policy, Contracts and Administrative Strategies (CBD and IPBES) (2 SWS, 3 ECTS)	
Prerequisites	No special prerequisites	
Performance Assessment	Contribution (ungraded) in S Economics of Global Environmental Change Seminar presentation (graded) in S Global Change Policy, Contracts and Administrative Strategies (CBD and IPBES)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	C3 Global Economy C5 Socio-economic and Political Dimensions of Global Change	

C5 Socio-Economic and Political Dimensions of Global Change

Responsible for the Module	Social and Population Geography, UBT	
Structural Content	Social and Population Geography, UBT	
Learning Objectives	The Anthropocene refers to a new geo-chronological era on Earth in which humans make significant impacts on geology, biological processes and ecosystems, not least anthropogenic climate change. The module aims to address foundations and concepts to understand possible causes and impacts of global change, as well as the quality of adaptation measures in various social contexts. Global and environmental change demands a variety of transformation, avoidance, and adaptive strategies that are at the centre of debates in the social sciences; in this connection, system-immanent reflections on neo-liberal economies that can be considered the drivers of global environmental change are also encouraged. The students are exposed to a cross-section of politico-economic and politico-ecological approaches based on relevant studies on global environmental change from the social sciences; they also learn social approaches and approaches from social theory to examine social transition and adaptation.	
Course Content	The seminar “Socio-Economic and Political Dimensions of Global Change” analyses society-environment interrelationships from the perspective of political ecology. Areas of tension include access to natural resources, the distribution of environmental risks, or defining environmental rights and duties. Environmental conflicts often include various spatial and social scale levels, from the local neighbourhood to international relations. In addition, fundamental processes of transformation in the Global South that are not only related to climate and environmental change are also addressed. Moreover, an analysis requires interacting with various dimensions of global change in the context of geographical development research, considering specific social, economic, political, and cultural contexts, and their inherent power structures. Comparing current case studies from the Global South and the Global North helps illustrate the unjust socialization of global change.	
Teaching Style	S “Socio-Economic and Political Dimensions of Global Change” (2 SWS, 5 ECTS)	
Prerequisites	None	
Performance Assessment	Contribution (ungraded) and written elaboration (report) (graded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	60 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	
Target Group	Global Change Ecology, Human Geography	
Reference to Other Modules	C1 Climate Policies and Economics	

C2 Ecosystem Services

C3 Global Economy

C6 Sport Ecology

Responsible for the Module	Sport Ecology, UBT	
Structural Content	Sport Ecology, UBT	
Learning Objectives	Upon completion of the module Sport Ecology, students understand the interactions between sports and ecological systems and are able to illustrate them with practical examples. They can identify quantitative relationships regarding the effect of outdoor sports on ecological systems from scientific publications and reflect them critically.	
Course Content	Student learn the complex and dynamic relationship between sport and the environment. The courses impart the importance of nature sports, their potential for conflict with goals in nature and environmental protection and the potential of sports in conveying ecological understanding and derived action strategies. Students collaboratively develop conceptual, functional, and methodological foundations to an economic view on ecology and nature protection and to an analysis of the interactions between human behaviour and ecological systems in the context of sports.	
Teaching Style	1) Sportökologische Wechselwirkungen (Interactions of sport and ecology), Kleingruppenübung (Exercise), 2 SWS 2) Wirkungsanalyse von Outdoorsportarten (Impact Assessment of Outdoor Sports), Hauptseminar (Seminar), 2 SWS	
Prerequisites	None	
Performance Assessment	Written elaboration (report) or seminar presentation or written exam or oral exam (announcement at the outset of module) (graded)	
Workload	Active participation in the courses,	60 hours
	Preparation and follow-up	60 hours
	Exam preparation;	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	
Target group	Global Change Ecology, Sport Ecology	

Reference to Other Modules

C7 Land Use Policies, Markets and Ecosystems

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	As an outcome of this module, students are able to: • Evaluate different policies and market options in terms of their effect on land use and ecosystem services • Interpret land use model results and put them in the context of real-world policies and markets • Identify feedback mechanisms and trade-offs in human environment systems	
Course Content	Politics, as well as national and international markets, generally have a major impact on regional land use decisions and thus on the provision of ecosystem services. Individual land users (e.g., farmers, foresters, conservationists) are key actors in human environment systems, since they are the ones reacting to policies and market changes with their land use decisions. The lecture "Land Use Policies, Markets, and Ecosystems" addresses causes of changes in land use, in particular by using regional case studies to focus on the influence of markets and politics. In addition, various methods for quantifying land use change and its influence on ecosystem services are introduced and discussed. In the exercise, based on the current development of agricultural and environmental policies as well as markets, possible future land use scenarios are developed and analysed for case study regions. Existing models, such as agent-based models, will be adapted and parameterized. Changes in ecosystem services through land use decisions are integrated into the model using simple estimates.	
Teaching Style	V Land Use Policies, Markets and Ecosystems C7a (2 SWS, 3 ECTS), Ü Modelling Land Use, Markets and Ecosystems C7b (2 SWS, 2 ECTS)	
Prerequisites	None	
Performance Assessment	Written elaboration (graded) in lecture Contribution (ungraded) in exercise	
Workload	Active Participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One Semester (Recommendation: 3rd Semester)	
Semester Offered	Winter semester	
Reference to Other Modules	B5 Global Change Impacts on Species Distributions B7 Remote Sensing in Landscape Ecology C1 Climate Policy and Economics C2 Ecosystem Services	

C8 Biodiversity, Climate Change and Health

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	At the end of this course, the students will have acquired a good understanding of how certain drivers, such as loss of biodiversity, land use change or climate change, can impact on human and animal health.	
Course Content	The lecture synthesizes information on the most important interlinkages between biodiversity, climate change and health. The current global situation of food and nutrition, water scarcity, pollution, migration and urbanization is synthesized and linked with human health. The lecture covers the concepts of One Health, Planetary Health and Ecohealth and includes an overview of reports from WHO, OIC, FAO, CBD, IPBES and related Sustainable Development Goals. In the seminar we review and discuss current contributions which cover impacts of global change on animal and human health, especially for zoonotic infectious diseases, and use this knowledge to articulate future research priorities.	
Teaching Style	V Health implications of Global Change (2 SWS, 2 ECTS) S Current Research in Health implications of Global Change (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Written elaborations and contributions (ungraded) in lecture Seminar presentation (graded) in seminar	
Workload	Active participation in course:	60 hours
	Preparation and follow-up:	30 hours
	Assessment components determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 2nd Semester)	
Semester Offered	Summer Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	C4 Global Policy and Governance B1 Biogeography and Macroecology B5 Global Change Impacts on Species Distributions	

4.5 Module Area M “Methods”

This Module Area contains courses with considerable variety in their content, designed to address the different needs of students. Altogether, courses totalling 10 credit points are to be chosen from the modules listed below.

Selection of these modules should be directed both at previous knowledge students may have and at course requirements. The individual design of methods training helps each individual supplement their knowledge and allows for efficient study of topic-oriented Modules. The spectrum of Methods in Global Change research is thereby covered. Particular attention is paid to data acquisition in ecosystem research, to field research about Global Change and to carrying out experiments. The significance of models in Global Change research is central to many of the courses.

Classes in Statistics Software R are taught as a basis for using many different evaluation procedures. Time series analysis covers investigation of temporal processes. Geographical information systems and remote sensing as modern tools of spatial analysis are included. Knowledge of chemical environmental analysis in different media can also be learned. Classes in environmental economics and environmental legislation enrich the spectrum of methods-oriented courses. Finally, general skills can be gained in the scientific writing and project-management classes.

M Methods

Module area M is obligatory for all students and has an extent of 10-credit points. Students can choose freely in putting together the combination of different Modules listed below. For all modules in Module area M an ungraded performance assessment is required on a pass/fail basis.

M1 Introduction to R
M2 Statistical Data Analysis with R
M3 Vegetation Science
M4 Foundations of Biogeographical Modelling
M5 Remote Sensing
M6 Time Series Analysis
M7 Research at the Natural and Social Science Interface
M8 Ecosystem Services Assessment of Landscapes
M9 Life Cycle Assessment of Products
M10 Scientific Writing in Biogeography and Disturbance Ecology
M11 Project Management
M12 Introduction to GIS
M13 Advanced Multivariate Statistical Methods in Climate Research
M14 International Environmental Law
M15 Science Communication
M16 Modeling Ecosystem Services with the Soil and Water Assessment Tool (SWAT)
M17 Academic Working Methods and Skills
M18 Field Course in Vegetation Science
M19 Quantitative Sport Ecology
M20 Methods in Dynamic Vegetation Ecology
M21 Spatial Statistics and Visualization with R
M22 Mathematical Modeling for Climate and Environment
M23 Dynamic Ecosystem Modelling
M24 Disturbance Ecology Field Trip – Europe
M25 Disturbance Ecology Field Trip – Overseas
M26 Methodology of Social Sciences
M27 Experimental Ecology

Soft skill courses

M10 Scientific Writing in Biogeography and Disturbance Ecology

M11 Project Management

M15 Science Communication

M17 Academic Working Methods and Skills

Statistics, Modelling, Remote Sensing and Geographic Information System

M1 Introduction to R

M2 Statistical Data Analysis with R

M13 Advanced Multivariate Statistical Methods in Climate Research

M21 Spatial Statistics and Visualization with R

M4 Foundations of Biogeographical Modelling

M5 Remote Sensing

M6 Time Series Analysis

M12 Introduction to GIS

M16 Modeling Ecosystem Services with the Soil and Water Assessment Tool (SWAT)

M20 Methods in Dynamic Vegetation Ecology

M22 Mathematical Modeling for Climate and Environment

M23 Dynamic Ecosystem Modelling

Field Methods

M3 Vegetation Science

M18 Field Course Methods in Vegetation Science - Alps

M24 Disturbance Ecology Field Trip – Europe

M25 Disturbance Ecology Field Trip – Overseas

M27 Experimental Ecology

Methods at the Natural/Social Science Interface

M7 Research at the Natural and Social Science Interface

M8 Ecosystem Services Assessment of Landscapes

M9 Life Cycle Assessment of Products

M14 International Environmental Law

M19 Quantitative Sport Ecology

M26 Methodology of Social Sciences

The Modules listed here can be taken additionally from the selection offered in Free Choice Module (F) as long as such courses have not already been given credit for Module M.

M1 Introduction to R

Responsible for the Module	Micrometeorology; Ecosystem analysis and simulation, UBT	
Structural Content	Micrometeorology; Ecosystem analysis and simulation, UBT	
Learning Objectives	The aim of this course is to teach practically-oriented information about data handling, including the analysis and graphical presentation of data, as well as simulation with the programming language R.	
Course Content	Assignments, objects, data types, data structures, and how to handle them; input and output of data; graphs; functions; efficient programming;	
Teaching Style	V/Ü Introduction to R (2 SWS, 2 ECTS)	
Prerequisites	None	
Performance Assessment	Written elaboration (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 ECTS	
Scope of Time	One semester (Recommended: 1st semester)	
Semester Offered	Winter semester	
Target Group	Ecology-oriented master's programmes	
Reference to Other Modules	Basis for Modelling Courses	

M2 Statistical Data Analysis with R

Responsible for the Module	Ecosystem Analysis and Simulation, UBT	
Structural Content	Ecosystem Analysis and Simulation, UBT	
Learning Objectives	In this course, the participants will learn and practice different methods of data analysis using the programming language R, which is the de facto standard for statistical data analysis. They will be enabled to understand basic concepts of statistics, to choose appropriate statistical methods to answer common ecological questions, to apply these methods in R and to interpret the results correctly.	
Course Content	Topics covered in the course include using R and RStudio, descriptive statistics and visualization, hypothesis testing, linear models, generalized linear Models, mixed models, confounders, causality and Directed Acyclic Graphs (DAGs), data management and experimental design.	
Teaching Style	V/Ü Statistical data analysis with R (2 SWS; 3 ECTS)	
Prerequisites	None	
Performance Assessment	Written report on a personal project (pass/fail)	
Workload	Active participation in course:	45 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	15 hours
	Total:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester (Ü/S)	
Target Group	Global Change Ecology, Geoecology	
Reference to Other Modules	B5 Global Change Impacts on Species Distributions	
	M6 Time Series Analysis	
	M13 Advanced Multivariate Statistical Methods in Climate Research	

M3 Vegetation Science

Responsible for the Module	Disturbance Ecology, UBT	
Structural Content	Disturbance Ecology, UBT Biogeography, UBT;	
Learning Objectives	The module's aim is an advanced knowledge of theories and methods in vegetation science, vegetation mapping and vegetation monitoring. Students will be introduced to the full spectrum of historical and modern approaches in vegetation science. The lecture offers fundamentals for and bridging concepts to experimental community ecology, plant functional trait research, disturbance ecology, restoration ecology, ecosystem and landscape ecology, nature conservation, remote sensing and vegetation-based ecosystem service analysis. Theory will be connected with practical experience in plant determination during various floristic field excursions.	
Course Content	The contents of the module include current approaches in vegetation science, in vegetation mapping and in monitoring changes in vegetation pattern and dynamics. Students will develop an understanding of the functional characterization of habitats and of scale dependence in vegetation ecology. They will develop the ability to recognize the role of disturbance regimes for vegetation dynamics and develop an understanding of data processing requirements for linking vegetation ground data with remote sensing derived information. Thus, students will become familiar with different theories and methods of collecting and evaluating data in plant ecology.	
Teaching Style	V Methods in Vegetation Science (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Written exam (ungraded)	
Workload	Active participation:	30 hours
	Preparation and follow-up:	30 hours
	Preparation for written exam:	30 hours
	Total:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	B1 Biogeography and Macroecology B2 Biodiversity and Ecosystem Functioning B3 Disturbance Ecology M18 Field Course in Vegetation Science	

M4 Foundations of Biogeographical Modelling

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	"Biogeographical Modelling" concentrates on quantitative descriptions of expansion and frequency of organisms on different spatial standards as well as recording of underlying mechanisms. Aim of the course is to teach practical knowledge about the most important modelling approaches, from data sources to data processing and from process oriented, individually based models to traditional statistical methods.	
Course Content	Data sources, data processing, variable selection, vegetation models, distribution models, home range analyses	
Teaching Style	V/Ü Foundations of Biogeographical Modelling (2 SWS, 2 ECTS)	
Prerequisites	Knowledge in programming language R (obligatory) V/S Concepts in Biogeographical Modelling (recommended)	
Performance Assessment	Contribution (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	Concepts in Biogeographical Modelling B4 Spatial Ecology	

M5 Remote Sensing

Responsible for the Module	Biogeography, UBT	
Structural Content	NN, University of UBT	
Learning Objectives	Teaches theoretical and practical background of Remote Sensing, adapted to implementation in the context of global change	
Course Content	Theoretical basics of Remote Sensing; Optical, Thermal, and Microwave Sensing; Sensor Systems and Properties of Remote Sensing Data; Image Processing and Classification using Open Source software and coding approaches	
Teaching Style	Ü Remote Sensing (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Written elaboration (ungraded): Data evaluation & minutes of class meeting about a final project	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	20 hours
	Assessment component determined by instructor:	40 hours
	Total:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester (Recommended: 1st semester)	
Semester Offered	Winter semester	
Target Group	Geography-oriented master's programmes	
Reference to Other Modules	B7 Remote Sensing in Landscape Ecology M12 Introduction to GIS M15 Science and Communication	

M6 Time Series Analysis

Responsible for the Module	Ecosystem Analysis and Simulation, UBT	
Structural Content	Ecosystem Analysis and Simulation, UBT	
Learning Objectives	In this module, students should learn to evaluate, analyse and assess on their own typical environmental time series (climate and ecological data). In doing so, they will gain practice in using R.	
Course Content	In this module linear and non-linear time series analysis will be taught and practiced by using different data sets from various environmental monitoring. Along with the classic procedure (auto and cross correlation, trend analysis, Fourier analysis, ARIMA-models) a focus is on non-linear methods recurring analysis, singular system analysis, wavelets, dimension reduction, etc.). The selection of procedures can change and is based on the interests of the students and current research projects. In the lecture, the single procedures will be talked about and then with examples of short time series, this will be practiced in the tutorials. The second part of the module consists of a Block – Practical(?). Students will choose appropriate methods to use for predetermined data sets and the results of the different procedures will be interpreted.	
Teaching Style	V/Ü Time Series Analysis (2 SWS, 2 ECTS) P Time Series Analysis (2 SWS, 3 ECTS)	
Prerequisites	Introductory course in statistics, basic knowledge in R	
Performance Assessment	Seminar presentation (ungraded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	60 hours
	Assessment component determined by instructor:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 3rd Semester)	
Semester Offered	Winter semester	
Target Group	Ecology-oriented master's programmes	
Reference to Other Modules	Knowledge in programming language R M2 Statistical Data Analysis with R Examples of time series are done in agreement with Climatology and Meteorology; in a practicum the model-based climate constructions are compared with observation data.	

M7 Research at the Natural and Social Science Interface

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	Environmental problems require not only expert knowledge but also the ability to work together with different disciplines and societal actors. The aim of this module is to impart knowledge about the interface in inter- and transdisciplinary research. The possibilities and limits of these approaches are conveyed using examples.	
Course Content	This course teaches theory and practice of inter- and transdisciplinary research.	
Teaching Style	S Research at the Natural and Social Science Interface (1 SWS, 1 ECTS)	
Prerequisites	None	
Performance Assessment	Contribution (ungraded) and seminar presentation (ungraded)	
Workload	Active participation in the courses:	15 hours
	Assessment component determined by instructor:	15 hours
	Total:	30 hours
Credit Points	1 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	
Target Group	Global Change Ecology	
Reference to Other Modules		

M8 Ecosystem Services Assessment of Landscapes

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	The aim of the exercise „Ecosystem Services Assessment of Landscapes“ is to introduce natural science and/or social science assessment methods that can be used by actors in business and politics to balance the environmental consequences of their decisions in landscape systems.	
Course Content	In the exercise ecosystem services will be quantified or optimized in selected regions using spatially explicit models. Following this, scenarios of future land-use change are developed and impacts on different ecosystem services are simulated.	
Teaching Style	Ü Ecosystem Services Assessment of Landscapes (2 SWS, 2 ECTS)	
Prerequisites:	Basic knowledge in GIS (obligatory) and C2 Ecosystem Services (recommended)	
Performance Assessment:	Written elaboration (report) (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester	
Target Group	Ecology and geography-oriented master’s programmes	
Reference to Other Modules	C2 Ecosystem Services	

M9 Life Cycle Assessment of Products

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	Aim of the exercise „Life Cycle Assessment of Products“ is to introduce assessment methods that can be used by business and political actors to assess the environmental consequences of their decision in product systems.	
Course Content	The method of Life Cycle Assessment LCA is introduced and students learn to use the LCA software with practical examples (e. g. assessment of energy products with Jatropha or wind energy).	
Teaching Style	Ü Life Cycle Assessment of Products (1,5 SWS, 2 ECTS)	
Prerequisites	None	
Performance Assessment	Written elaboration (report) (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	
Target Group	Ecology and geography-oriented master’s programmes	
Reference to Other Modules	C2 Ecosystem Services	
	C3 Global Economy	

M10 Scientific Writing in Biogeography and Disturbance Ecology

Responsible for the Module	Biogeography, UBT	
Structural Content	Disturbance Ecology, UBT Biogeography, UBT	
Learning Objectives	Students learn the rules of scientific writing.	
Course Content	Students will get an overview of relevant publications and corresponding research instruments. Literature data banks will be discussed. Students will practice writing abstracts. An efficient way to title articles will also be discussed. Students will get practice in writing a „letter to the editor“. Using current manuscripts, their strengths and weaknesses will be discussed. Rules for pictures and tables will be dealt with.	
Teaching Style	S/Ü Scientific Writing (1 SWS, 1 ECTS)	
Prerequisites	None	
Performance Assessment	Written elaboration (report) (ungraded)	
Workload	Active participation in 1 course:	10 hours
	Preparation and follow-up:	20 hours
	Total:	30 hours
Credit Points	1 ECTS	
Scope of Time	One semester (Recommended: 3rd Semester)	
Semester Offered	Winter semester	
Target Group	Students writing their thesis in Biogeography and Disturbance Ecology from different study programs	
Reference to Other Modules	Basis for Master Thesis	

M11 Project Management

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	The aim of this module is to provide practical insight into project management, especially in a scientific environment. It seeks to prepare students to carry out tasks relating to coordination in research and the professional world.	
Course Content	Depending on the needs and interests of the course participants, practical tasks in science management are addressed (the national and international research funding landscape, requesting funding, setting up research associations and international research networks, communication and quality control, public relations). In addition to such insights, the course also reflects on chances and risks in project management based on personal experience.	
Teaching Style	S Project Management and Scientific Coordination (3 SWS, 2 ECTS, in small groups)	
Prerequisites	No special prerequisites	
Performance Assessment	Seminar presentation (ungraded) and/or written elaboration (report) (ungraded)	
Workload	Active contribution to the project and active participation in one course:	50 hours
	Seminar presentation and written report:	10 hours
	Total:	60 hours
Credit Points	2 ECTS	
Scope of Time	One semester	
Semester Offered	Winter semester	
Target Group	Ecology and geography-oriented master's programmes and BayNAT	
Reference to Other Modules	M modules depending on the selected project	

M12 Introduction to GIS

Responsible for the Module	BayCEER, UBT;	
Structural Content	BayCEER (IT and Databases), UBT	
Learning Objectives	Students will become familiar with the most important concepts and functions of Geographical Information Systems (GIS). After completing the course, they will be able to conduct a simple spatial analysis independently.	
Course Content	Training in GIS software and its functionality: modelling spatial information, spatial reference systems, ways to produce geodata, spatial and factual queries for geodata, selected methods of spatial analysis, formulation of analyses using process models, basic techniques of cartographic presentation.	
Teaching Style	Ü Introduction to GIS (2 SWS, 2 ECTS)	
Prerequisites	None	
Performance Assessment	Written elaboration (report) (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 ECTS	
Scope of Time	One semester (Recommended: 1st Semester)	
Semester Offered	Winter semester	
Reference to Other Modules	B4 Spatial Ecology	
	M5 Remote Sensing	
	M17 Academic working methods and skills	

M13 Advanced Multivariate Statistical Methods in Climate Research

Responsible for the Module	Physical Geography with focus on climate research, University of Augsburg	
Structural Content	Physical Geography with focus on climate research, University of Augsburg	
Learning Objectives	Knowledge in Fundamental and Advanced Methods of multivariate Statistics	
Course Content	Principal Component Analysis; Multiple Regression Analysis; Canonical Correlation Analysis; Cluster Analysis; Discriminant Analysis, Random Forests.	
Teaching Style	V Advanced Multivariate Statistical Methods (1 SWS, 1 ECTS) Ü Advanced Multivariate Statistical Methods (1 SWS, 2 ECTS)	
Prerequisites	Basic knowledge of statistics and statistics software R (e.g. from Module M2)	
Performance Assessment	Written elaboration (ungraded): Exercise with protocol	
Workload	Active participation in 2 courses:	30 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester	
Reference to Other Modules	M2 Statistical Data Analysis with R	

M14 International Environmental Law

Responsible for the Module	African Legal Studies, UBT	
Structural Content	African Legal Studies	
Learning Objectives	Aim of this module is to teach fundamental knowledge in international environmental law.	
Course Content	After a general introduction to structures, functions, sources and implementation of international law, the basic principles of environmental law will be discussed (sustainability, prevention, "producer pays" and liability principles). In particular, the course deals with international law and agreements between nations on climate protection, biodiversity and other fundamentals for human existence on earth (e.g. the UN Convention UN-FCCC and UN-CBD).	
Teaching Style	V International Environmental and Sustainable Development Law (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Written exam (ungraded) or written elaboration (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	40 hours
	Assessment component determined by instructor:	20 hours
	Total:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Reference to Other Modules	C4 Global Policy and Governance	

M15 Science Communication

Responsible for the Module	Biogeography, UBT	
Structural Content	Teaching assignment	
Learning Objectives	The course provides an overview of the challenges associated with scientific communication, especially science outreach typically conducted by scientists to non-expert audiences. At the end of this course, the students will have acquired a good understanding of the multiple factors shaping the success of different communication strategies and tools. Importantly, this course aims to help support the development of critical thinking and decision making among students, while enhancing their communication skills.	
Course Content	Science communication skills are needed to get support for scientific research, to inform decision-making, or to engage stakeholders. A major component of this course will be to provide students with the chance to apply knowledge acquired in previous modules to defend their envisaged solution to typical climate change or conservation challenges or discussions.	
Teaching Style	V/Ü Science and Communication (2 SWS, 3 ECTS)	
Prerequisites	None	
Performance Assessment	Seminar presentation (ungraded) or Contribution (ungraded)	
Workload	Active participation in course:	30 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules		

M16 Modeling Ecosystem Services with the Soil and Water Assessment Tool (SWAT)

Responsible for the Module	Ecological Services, UBT	
Structural Content		
Learning Objectives	The Soil and Water Assessment Tool (SWAT) is a widely used, powerful simulation model used to predict the impacts of climate, land use and management changes on hydrology and matter fluxes in river basins of various sizes. The objective of this module is to teach the major principles and theoretical background of the SWAT model, and its practical application for the investigation, interpretation, and assessment of environmental issues, specifically ecosystem services	
Course Content	The theoretical part introduces the different subroutines of the model including climate, hydrology, erosion, nutrient cycles, and plant growth, and explains the major input and output parameters. In the practical part, students will learn how to perform the model setup, parameterization, and calibration for a case study watershed. We will develop potential climate, land use change and management changes scenarios and evaluate their impacts with respect to ecosystem services.	
Teaching Style	V/Ü Modeling Ecosystem Services with the Soil and Water Assessment Tool (SWAT) (2 SWS; 3 ECTS)	
Prerequisites	None	
Performance Assessment	Seminar presentation (ungraded) or written elaboration (report) (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	90hours
Credit Points	3 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Ecology and geography-oriented master’s programmes	
Reference to Other Modules	A4 Changes in Aquatic Ecosystems A5 Changes in Agroecosystems A10 Land Use Change and Microclimate C7 Land Use Policies, Markets and Ecosystems	

M17 Academic Working Methods and Skills

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	The aim of this module is to train students with hands-on experiences in academic working methods and skills. The participants gain an overview of the central steps in knowledge processing, beginning with the selection of suitable sources of information up to structuring content and preparing written reports and oral presentations.	
Course Content	Literature data bases, structuring with Mind Map, visualization, organization of written and oral presentations (poster, talk), discussion phase, stage fright, body language, feedback, video analysis of presentations.	
Teaching Style	V/Ü Academic Working Methods and Skills (2 SWS; 2 ECTS)	
Prerequisites	None	
Performance Assessment	Contributions (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	30 hours
	Total:	60 hours
Credit Points	2 ECTS	
Scope of Time	One semester (Recommended: 1st Semester)	
Semester Offered	Winter semester	
Target Group	Global Change Ecology	
Reference to Other Modules		

M18 Field Course in Vegetation Science

Responsible for the Module	Disturbance Ecology, UBT	
Structural Content	Disturbance Ecology, UBT Biogeography, UBT;	
Learning Objectives	The module's aim is an advanced practical experience in methods in vegetation science, vegetation mapping, and vegetation monitoring. Students are trained in the field across a variety of ecosystems and will understand the effort and the skills needed for ecological assessments. The field work will be affected at the scale of plant communities and ecosystems ranging from the inner-alpine arid valley slopes to the alpine zone and from bogs and mires to forests and natural grasslands. As all ecosystems require a specific scale of investigation and research questions need to be tackled with appropriate approaches, the methods learned beforehand in theory are applied under field conditions. The recorded data will be analysed and compiled in written protocols. The final product will be an individual textbook of vegetation methods based on own work and experience.	
Course Content	Based on theoretical knowledge about different approaches and schools in vegetation science, different ways of data recording are applied in the complex terrain of the Alps, which offers a large diversity of habitats and vegetation structures. Site conditions and ecosystem processes are related to key traits of vegetation including floristic and phytosociological relevés, transects, systematic data recording, biometry, biomass, and spatial assessments (mapping, remote sensing).	
Teaching Style	Ü Field Course Methods in Vegetation Science (4 SWS, 5 ECTS)	
Prerequisites	The knowledge from the lecture M3 Vegetation Science is prerequisite and also knowledge in plant determination.	
Performance Assessment	Field talk (ungraded) and written protocol (ungraded)	
Workload	Active participation:	90 hours
	Preparation and follow-up:	15 hours
	Written protocol:	45 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	B1 Biogeography and Macroecology	
	B2 Biodiversity and Ecosystem Functioning	
	B3 Disturbance Ecology	
	M3 Vegetation Science	

M19 Quantitative Sport Ecology

Responsible for the Module	Sport Ecology, UBT	
Structural Content	Sport Ecology, UBT	
Learning Objectives	Upon completion of the module Quantitative Sport Ecology, students are familiar with the measuring methods of Sport Ecology. They are able to evaluate collected data and critically reflect the results of the analyses. This enables them to efficiently quantify the interactions between sports activities and ecological systems.	
Course Content	The module Quantitative Sport Ecology imparts methods for quantifying human user behaviour and the reaction of ecological systems using digital and technological advancements. This comprises the management and analysis of movement data, the data acquirement through wearables, automatic image classification, the linkage of health data with spatial use information as well as social media analyses.	
Teaching Style	Quantitative Sportökologie (Quantitative Sport Ecology), Hauptseminar (Seminar), 3 SWS	
Prerequisites	Module Sport Ecology	
Performance Assessment	Written elaboration or seminar presentation or written exam or oral exam (ungraded) (announcement at the outset of module)	
Workload	Active participation in main seminar	45 hours
	Preparation and follow-up	75 hours
	Exam preparation	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Semester Offered	Winter term	
Responsible for the Module	Sport Ecology, UBT	
Structural Content	Sport Ecology, UBT	
Target Group		
Reference to Other Modules		

M20 Methods in Dynamic Vegetation Ecology

Responsible for the Module	Plant Ecology, UBT	
Structural Content	Plant Ecology, UBT	
Learning Objectives	The module's aim is to teach empirical methods used to estimate the primary production of ecosystems.	
Course Content	Students learn how to use non-destructive methods to estimate net primary production (NPP). To achieve this, the leaf area, photosynthesis, transpiration and respiration rates will be measured in field exercises. These data are used to derive estimates of NPP using the statistical script language R. Students learn how to access and use Earth observation data. The Geographical Information System functionality of R is used to analyze NPP trends observed in the satellite data. The NPP-estimates derived from the satellite and field measurements are compared and assessed. The findings are summarized in a report written in the style of an R tutorial.	
Teaching Style	Ü Methods in Dynamic Vegetation Ecology (5 SWS. 5 ECTS)	
Prerequisites	Basic R knowledge recommended	
Performance Assessment	Written elaboration (report) (ungraded)	
Workload	Active participation in exercise	60 hours
	Preparation and follow-up:	40 hours
	Assessment component determined by instructor:	50 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester	
Target Group	Global Change Ecology, Environmental Geography, Biodiversity and Ecology, Geoecology, Physical Geography. Limited number of participants	
Reference to Other Modules	B8 Dynamic Vegetation Ecology	

M21 Spatial Statistics and Visualization with R

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	Spatial data often require specific methods of analysis. The aim of this exercise is the development of skills in dealing with different types of spatial datasets. The focus is on learning statistical methods for the analysis of spatial patterns.	
Course Content	Different methodological approaches will be presented and implemented with the statistical software R. An exemplary selection of covered topics is: visualization of spatial data, spatial point pattern analysis, variograms, and the modelling of areal data using SAR and CAR models.	
Teaching Style	Ü Spatial Statistics and Visualization with R (2 SWS, 3 ECTS)	
Prerequisites	Experience in the use of the software R as well as basic statistical knowledge (e.g. from module M2)	
Performance Assessment	Written exam (ungraded), seminar presentation (ungraded) or written elaboration (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	30 hours
	Sum:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester (Recommended: 2nd semester)	
Semester Offered	Summer semester	
Target Group	Ecology and geography-oriented master's programmes	
Reference to Other Modules	M2 Statistical Data Analysis with R	
	M12 Introduction to GIS	
	M13 Advanced Multivariate Statistical Methods in Climate Research Methods	

M22 Mathematical Modeling for Climate and Environment

Responsible for the Module	Scientific Computing, UBT	
Structural Content	Scientific Computing, UBT	
Learning Objectives	Skills to implement and apply simple data assimilation techniques	
	Ability to formulate simple environmental and climate models and skills to implement them using e.g. Matlab	
Course Content	Physical principles, mathematical models, and selected numerical methods in climate and environmental sciences	
	Environmental modeling: main applications and problem settings	
Teaching Style	Ü Mathematical Modeling for Climate and Environment (2 SWS; 5 ECTS)	
Prerequisites	A9	
Performance Assessment	Oral examination (on a pass/fail basis)	
Workload	Active participation in course:	30 hours
	Preparation and follow-up:	80 hours
	Assessment component determined by instructor:	40 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology, Scientific Computing	
Reference to Other Modules	A9 Mathematical Modeling for Climate and Environment	

M23 Dynamic Ecosystem Modeling

Responsible for the Module	Ecosystem Analysis and Simulation, UBT	
Structural Content	Ecosystem Analysis and Simulation, UBT	
Learning Objectives	After successful completion, the participants are familiar with the basic methods in working with dynamic ecosystem models and can select, apply, and interpret these methods in hands-on model examples and according to a specific research question.	
Course Content	Complex dynamic ecosystem models are crucial to understand the mechanisms that shape ecosystems, project their fate under different scenarios and communicate ecosystem functioning and the consequences of human-ecosystem interactions. This course covers the basic tools that are necessary to apply such models, e.g., choose the right model structure and complexity, run sensitivity analyses, calibrate the parameters, and quantify model uncertainty and performance. In addition to theoretical instruction, all methods are applied in hands-on examples and further developed by the participants within the framework of a final project.	
Teaching Style	V/Ü Dynamic Ecosystem Modelling (4 SWS; 5 ECTS)	
Prerequisites	Confident use of R	
Performance Assessment	Written elaboration in form of a report on the final project (ungraded on pass/fail basis)	
Workload	Active participation in one course:	60 hours
	Preparation and follow-up:	35 hours
	Assessment component determined by instructor:	55 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology, Geoecology	
Reference to Other Modules	A8 Biodiversity in the Tropics	
	B1 Biogeography and Macroecology	
	B4 Spatial Ecology	
	B8 Dynamic Vegetation Ecology	

M24 Disturbance Ecology Field Trip - Europe

Responsible for the Module	Disturbance Ecology UBT	
Structural Content	Disturbance Ecology UBT	
Learning Objectives	Aim of this module is an advanced practical experience in disturbance ecology and vegetation dynamics while travelling and hiking through remote landscapes. Students are trained in the field across a variety of ecosystems and altitudinal gradients and will understand the effort and the skills needed for analyzing natural and anthropogenic disturbance regimes and their effects on ecosystem dynamics in various regions. Field talks and scientific fieldwork will be carried out at the scale of plant communities and ecosystems targeting various biomes. Concepts and methods taught in disturbance ecology and resilience, biodiversity and vegetation science are applied under field conditions. The final product will be an individual field book of disturbance ecology and vegetation dynamics based on own work and experience.	
Course Content	Based on theoretical and methodological knowledge about different approaches in disturbance ecology and vegetation science, various ecological field talks and methods of data recording are applied to a large diversity of habitats and ecosystem dynamics. Site conditions and ecosystem processes are related to key plant functional traits and vegetation pattern. Methods include floristic relevés, vegetation transects, trait data recording as well as assessment of ecosystem functioning and resilience.	
Teaching Style	Ü/S Field Trip (5 SWS; 5 ECTS)	
Prerequisites	Knowledge based on the Modules B3 and M3. Skills in plant species determination are welcome. Physical fitness is needed.	
Performance Assessment	Field talk (ungraded) and written protocol (ungraded)	
Workload	Preparation of the field talk:	30 hours
	Attendance of field trip with data collection and species determination:	90 hours
	Final protocol:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	This module is offered every other year during the spring/autumn semester break or Pentecost week and shall be completed within one semester. It is taught in German and English	
Semester Offered	Irregular; according to announcement	
Target Group	Global Change Ecology, Geoecology, Environmental Geography, Biodiversity and Ecology	
Reference to Other Modules	A3 Extreme Events and Natural Hazards B2 Biodiversity and Ecosystem Functioning B3 Disturbance Ecology	

M25 Disturbance Ecology Field Trip - Overseas

Responsible for the Module	Disturbance Ecology UBT	
Structural Content	Disturbance Ecology UBT	
Learning Objectives	Aim of this module is an advanced practical experience in disturbance ecology and vegetation dynamics while travelling and hiking through remote landscapes. Students are trained in the field across a variety of ecosystems and altitudinal gradients and will understand the effort and the skills needed for analyzing natural and anthropogenic disturbance regimes and their effects on ecosystem dynamics in various regions. Field talks and scientific fieldwork will be carried out at the scale of plant communities and ecosystems targeting various biomes. Concepts and methods taught in disturbance ecology and resilience, biodiversity and vegetation science are applied under field conditions. The final product will be an individual field book of disturbance ecology and vegetation dynamics based on own work and experience.	
Course Content	Based on theoretical and methodological knowledge about different approaches in disturbance ecology and vegetation science, various ecological field talks and methods of data recording are applied to a large diversity of habitats and ecosystem dynamics. Site conditions and ecosystem processes are related to key plant functional traits and vegetation pattern. Methods include floristic relevés, vegetation transects, trait data recording as well as assessment of ecosystem functioning and resilience.	
Teaching Style	Ü/S Field Trip (5 SWS; 5 ECTS)	
Prerequisites	Knowledge based on the Modules B3 and M3. Skills in plant species determination are welcome. Physical fitness is needed.	
Performance Assessment	Field talk (ungraded) and written protocol (ungraded)	
Workload	Preparation of the field talk:	30 hours
	Attendance of field trip with data collection and species determination:	90 hours
	Final protocol:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	This module is offered every other year during the spring/autumn semester break or Pentecost week and shall be completed within one semester. It is taught in German and English	
Semester Offered	Irregular; according to announcement	
Target Group	Global Change Ecology, Geoecology, Environmental Geography, Biodiversity and Ecology	
Reference to Other Modules	A3 Extreme Events and Natural Hazards B2 Biodiversity and Ecosystem Functioning B3 Disturbance Ecology	

M26 Methodology of social sciences

Responsible for the Module	Chair of Social and Population Geography	
Structural Content	Chair of Social and Population Geography	
Learning Objectives	Objectives and learning outcomes of the module: 1. Make students familiar with the language(s) of social science methodology and provide both a solid grounding in the key issues and a critical understanding of them. 2. Introduce students to basic epistemological questions, approaches, and debates in the philosophy of social sciences. 3. Introduce students to common methods in social science (both quantitative and qualitative).	
Course Content	This module provides a general and broadly understood introduction to problems, approaches, and debates in social science methodologies. The main aim is to make MSc scholars familiar with prominent 'epistemological schools', methodological angles and language(s), to provide a solid grounding in the key issues and a critical understanding of them. The method course is divided into two parts: (1.) Philosophy of social science, epistemology and ontology and (2) Introduction into understanding and applying relevant geographical methodological approaches (with some prominent methods to be addressed).	
Teaching Style	L/S Overview lectures on epistemology and methodology, short presentations, and reading/debating seminar style.	
Prerequisites	None	
Performance Assessment	Seminar contribution (ungraded on a pass/fail basis) Seminar presentation (ungraded on a pass/fail basis) Written elaboration (essay) (ungraded)	
Workload	Active participation in the lessons:	30 hours
	Preparation and follow-up:	30 hours
	Written essay:	30 hours
	Total:	90 hours
Credit Points	3 ECTS	
Scope of Time	One semester	
Semester Offered	Summer semester	
Target Group	Global Change Ecology	
Reference to Other Modules	The basics for social science research are taught.	

M27 Experimental Ecology

Responsible for the Module	Disturbance Ecology UBT	
Structural Content	Disturbance Ecology UBT	
Learning Objectives	The learning outcome of the module Experimental Ecology is to reach an overview over recent experimental approaches in community ecology. In particular, globally coordinated, geographically distributed experiments have proven to be very stimulating for understanding design and analysis of standardized experiments and testing ecological theory. The goal of this module is an in-depth look at the relationship between biodiversity and ecological functioning, understanding the scientific approaches and findings on impacts of climate change and land use change on ecosystem services. This course will be composed of several elements including theoretical instruction on experimental design and analysis, participation in ongoing field campaigns as well as collecting and analyzing own data. At the conclusion of this module, students will have a thorough understanding of experimental ecology.	
Course Content	General concepts of experimental ecology will be introduced initially using ongoing field experiments as model ecosystems. Here, the focus is on effects of global change drivers on biodiversity and ecosystem functions. Guided by instructors, students will develop their own hypothesis within an ongoing research activity, collect and evaluate their own data. In doing so, students will learn about the potential and limitations of experimental approaches. Thus, students will become familiar with different methods of collecting and evaluating data in experimental ecology.	
Teaching Style	Ü/S Field Course (5 SWS; 5 ECTS)	
Prerequisites	Basic knowledge in R is strongly advised, advanced knowledge very welcome. Skills in plant species determination are welcome.	
Performance Assessment	Written scientific report (ungraded)	
Workload	Introduction to experimental ecology:	30 hours
	Development of own research approach, data collection and data analysis:	60 hours
	Active contribution to ongoing field campaigns:	30 hours
	Written scientific report:	30 hours
	Total:	150 hours
Credit Points	5 ECTS	
Scope of Time	This module is offered annually in the summer semester. It is taught in English.	
Semester Offered	Summer semester	
Target Group	Global Change Ecology, Geoecology, Environmental Geography, Biodiversity and Ecology	
Reference to Other Modules	B2 Biodiversity and Ecosystem Functioning	
	B3 Disturbance Ecology	
	M3 Vegetation Science	

4.6 Module Area F „Free Choice“

Modules with an extent of 5-credit points are allowed as well as single classes (in total 5-ECTS).

This Free Choice Module should be used to advance students´ knowledge in their individually chosen areas of specialisation. Classes can be taken that are offered in other GCE-Modules, but which do not belong to a person’s areas of specialisation. In general, modules from adjacent programmes can be chosen. Additionally, students are permitted to request credit for other courses and science schools as well.

In Module F, Performance Assessment must take place. No grades are given or are calculated into the total grade.

4.7 Module Area S “International Science Schools”

Summer and Winter Schools play an important part in our teaching concept. Each year the UBT offers a relevant “Science School” with a workshop character. However, courses at other venues will be accepted if they deal with the issues of Global Change and its impact. The programme’s Coordinating Office provides students with a course list being offered by the instructors. The Examination Committee for the Programme must accept any External Schools where courses might be taken; prior agreement for this is necessary.

This type of course is directed at connecting students to issues dealing with current developments in a rapidly changing field of science. Furthermore, such workshops and intensive courses enable participants to have contact not only with instructors and experts from practical backgrounds, but also to peers from other academic programmes, study venues and countries. In this way the Schools are useful for developing individual networks that, particularly for this course of study, might be significant for later career opportunities.

The students provide written proof of the workload of each School from the organisers of the School. The credit points can have different values due to the heterogeneity of international course offerings, so the Global Change Ecology coordination must approve the conversion of the credit points.

The total number of credit points earned in Module Area S may not be less than 5-credit points and not more than 10-credit points.

The Module listed here can be taken additionally from the selection offered in Free Choice Module (F) as long as such Science Schools have not already been given credit for Module S.

The following Module is offered as an example.

S International Science Schools

Responsible for the Module	Biogeography, UBT	
Structural Content	Alternating; International Consortium of Study Locations	
Learning Objectives	Aim of this module is to provide a setting for advanced discussion and debate in small groups about current ecological topics dealing with Global Change.	
Course Content	Different current topics (both in content and method) will be offered.	
Teaching Style	S/Ü Science School	
Prerequisites	None	
Performance Assessment	Confirmation of active participation and short written report (ungraded)	
Workload	Active Participation:	150-300 hours
	Total:	150-300 hours
Credit Points	2 to 10 ECTS per school depending on the length, overall total may not be less than 5 ECTS	
Scope of Time	The length of time can be organised in a flexible manner	
Semester Offered	No specification	
Target Group	Global Change Ecology	
Reference to Other Modules	Basis for Master Thesis	

4.8 Module Area I “Internships”

With the help of the Coordination Office, Programme instructors provide information on specific internship positions in four areas. Students are free to select in which area they would like to do their Internship. Internships must take place at institutions accepted by the Examination Committee, as well as in agreement with them concerning cooperation contracts, if required, for the position. The timing of the internships between the first and second semesters, as well as between the second and third, gives students an early opportunity of dealing with professional situations.

Internship in Economy (Business Internship)

Collaboration in a Business Enterprise with international business relations.

Internship in Science (Research Internship)

Collaboration with an internationally known research institution (e.g. Max-Planck-Institutes, Helmholtz-Centers, Leibniz Institutes, Smithsonian Conservation Biology Institute (SCBI), Zoological Society of London (ZSL) etc.).

Internship in Administration (Internship in a national or international agency or administrative department)

Placement and collaboration with national or international agencies or institutions (e.g. Bavarian State Department of the Environment, Bavarian State Office for Water Sources Management, Federal Agency of Nature Conservation (BfN), Environmental Agency in the EU).

Internship in International Organisations (Placement in a supranational organisation or non-governmental organisation (e.g. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Convention on International Trade in Endangered Species (CITES), Gesellschaft für Internationale Zusammenarbeit (GIZ), World Wildlife Fund (WWF), United Nations Environment Programme (UNEP), United Framework Convention on Climate Change (UNFCCC), International Union for Conservation of Nature (IUCN), Food and Agriculture Organisation (FAO)).

Teaching staff advises students about the selection of appropriate Internship positions. Help is given to make it easier to gain access to high-ranking and popular internship positions. There is great demand for our students heading towards the institutions named here.

I Internships in Economy, Science, Agency Administration or International Organisation (Internships)

Responsible for the Module	Coordinating Office Global Change Ecology	
	Internship in Economy Collaboration with an international business enterprise *or*	
	Internship in Science Collaboration with an internationally well-known research institution *or*	
	Internship in Administration Placement in and Collaboration with an international Agency Administration *or*	
	Internship in International Organization Placement in and collaboration with a supranational or international organisation or NGO	
Learning Objectives	The aim of this module is that students gain practical experience in an international business, an internationally oriented research institute, and a national or international agency or with an internationally oriented organisation.	
Course Content	Implementation of theoretical knowledge in a practical context that was gained in the previous courses.	
Teaching Style	P Internship	
Prerequisites	None	
Performance Assessment	Confirmation of active participation and short written report (ungraded)	
Workload	For 5 ECTS:	Six weeks fulltime internship
		or
	For 10 ECTS:	Twelve weeks fulltime internship
Credit Points	5 to 10 ECTS depending on the length of the individual internship	
Scope of Time	The length of the mandatory internship (one time six or twelve weeks; or two times six weeks) is chosen by the student	
Semester Offered	No specification	
Target Group	Global Change Ecology	
Reference to Other Modules	Depends on individual student	

5.1 R Research Skills

Responsible for the Module	Ecological Services, UBT
Structural Content	All instructors involved in the programme
Learning Objectives	The learning objective is to impart the research skills for the preparation of the master's thesis.
Course Content	The seminar "Scientific writing and organizing research data" deals with fundamental questions of writing scientific texts: overall structure, structure and content of individual sections, meaning of the hypotheses, authorship, formalities (legends, citations, etc.) and scientific misconduct. Presentation techniques are practiced in short presentations. The students will prepare their own manuscript and correct the manuscripts of their fellow students. In addition, students learn the basic principles of research data management: transparency and reproducibility, metadata, data management plan, and long-term archives. The structure and content of the exercise "Creating a research plan" is individually coordinated with the supervisor of the master's thesis or a supervisor of the subject in which the master's thesis is being carried out. It includes a study of literature focused on the master's thesis with a corresponding evaluation, the acquisition of additional professional and work-related skills and, if necessary, the implementation of measurements and model simulations in preparation for the master's thesis. The presentation takes place in the respective working groups. In the symposium "Environmental System Sciences: Global Change Ecology", the students present their master's thesis with a lecture or poster to their fellow students and lecturers of the degree program before or after they have submitted it. The symposium may also include other courses in the field of geoecology.
Teaching Style	Seminar S, Exercise Ü, Seminar (Symposium) S
Prerequisites	None
Performance Assessment	Seminar contribution, written report in exercise and presentation in seminar (symposium)
Workload	Scientific Writing and Management of Research Data: 60 hours Writing and Presentation of Research Plan: 60 hours Symposium „Environmental System Sciences: Global Change Ecology“ (all instructors): 30 hours Total: 150 Hours
Credit Points	5 ECTS
Scope of Time	Two semesters
Semester Offered	The module is offered partly in the winter and summer semester. The seminar “Scientific writing and research data” will be offered in the summer. Writing and presentation of the research plan should happen in the third semester. The symposium takes place in winter or summer semester.

Target Group	Global Change Ecology
Reference to Other Modules	Preparation of master thesis

5.2 T Master Thesis

Responsible for the Module	All instructors involved in the programme	
Learning Objectives	The Master Thesis provides the opportunity for students to demonstrate their ability to do independent research in their selected field of specialised interest. Using the qualifications they have gained, students should implement this knowledge in a practical manner by working on a topic of their own choice. The aim is for students to apply the theories and methods they have acquired through their course of studies. The Master Thesis centres on a specific direction in method and discipline while at the same time showing a clearly recognizable relationship to the programme of study. This can take place through discussion of the issues (e.g., ecological consequences of climate change), of observation of shared criterion (global or at least, large-scale), of the object (ecological zones).	
Course Content	Identification of a research question and discussion of a hypothesis, selection and application of a wide range of methods that have been taught, implementation and evaluation of literature research, data collection and evaluation, writing a scientific paper.	
Performance Assessment	Master Thesis (graded)	
Workload	Completion time / individual mentoring (6 months):	900 hours
	Total:	900 hours
Credit Points	30 ECTS; The grade on the Master Thesis is the grade for the Module	
Scope of Time	The Master Thesis is to be completed during the fourth semester, total time: 6 months	
Reference to Other Modules	The Master Thesis enables an overall reflection of all skills and competencies gained in the entire course of studies	

6 Course of Studies and Requirements (3 Examples)

6.1 Selected Field of Specialisation in Module Area A „Environmental Change“

Module	Module	ECTS
1st Semester (Winter)		
O	Global Change Ecology Overview	5
A1	Climate Change	5
B1	Biogeography and Macroecology	5
C1	Climate Policies and Economics	5
M17	Academic Working Methods and Skills	2
M2	Statistical Data Analysis with R	2
M10	Scientific Writing in Biogeography and Disturbance Ecology	1
Semester Break (Winter)		
S	Science School	5
Total:		**30**
2nd Semester (Summer)		
A10	Land Use Change and Microclimate	5
A2	Ecological Climatology	5
A8	Biodiversity in the Tropics	5
B2	Biodiversity and Ecosystem Functioning	5
C8	Biodiversity, Climate Change and Health	5
Semester Break (Summer)		
I	Internship	5
Total:		**30**
3rd Semester (Winter)		
C2	Ecosystem Services	5
B3	Disturbance Ecology	5
F	Free Choice	5
M6	Times Series Analysis	5
R	Research Skills	5
Semester Break (Winter)		
S	Science School	5
Total:		**30**
4th Semester (Summer)		
	Master Thesis	30
Total:		**30**
Entire Total:		**120**

6.2 Selected Field Module Area B „Ecological Change“

Module	Module	ECTS
1st Semester (Winter)		
O	Global Change Ecology Overview	5
A1	Climate Change	5
B1	Biogeography and Macroecology	5
C1	Climate Policies and Economics	5
F	Free Choice	5
Semester Break (Winter)		
S	Science School	5
Total:		**30**
2nd Semester (Summer)		
A2	Ecological Climatology	5
B2	Biodiversity and Ecosystem Functioning	5
B8	Dynamic Vegetation Ecology	5
C4	Global Policy and Governance	5
M4	Foundations of Biogeographical Modelling	2
M14	International Environmental Law	3
Semester Break (Summer)		
I	Internship	5
Total:		**30**
3rd Semester (Winter)		
A5	Changes in Agroecosystems	5
B3	Disturbance Ecology	5
C2	Ecosystem Services	5
M6	Time Series Analysis	5
R	Research Skills	5
Semester Break (Winter)		
I	Internship	5
Total:		**30**
4th Semester (Summer)		
	Master Thesis	30
Total:		**30**
Entire Total:		**120**

6.3 Selected Field Module Area C „Societal Change“

Module	Module	ECTS
1st Semester (Winter)		
O	Global Change Ecology Overview	5
A1	Climate Change	5
B1	Biogeography and Macroecology	5
C1	Climate Policies and Economics	5
M5	Remote Sensing	3
M9	Life Cycle Assessment of Products	2
Semester Break (Winter)		
S	Science School	5
Total:		**30**
2nd Semester (Summer)		
A3	Extreme Events and Natural Hazards	5
B8	Dynamic Vegetation Ecology	5
C3	Global Economy	5
C4	Global Policy and Governance	5
F	Free Choice	5
Semester Break (Summer)		
S	Science School	5
Total:		**30**
3rd Semester (Winter)		
A5	Changes in Agroecosystems	5
B4	Spatial Ecology	5
C2	Ecosystem Services	5
M19	Quantitative Sport Ecology	5
R	Research Skills	5
Semester Break (Winter)		
I	Internship	5
Total:		**30**
4th Semester (Summer)		
	Master Thesis	30
Total:		**30**
Entire Total:		**120**