Module Handbook

International Elite Graduate Programme

Global Change Ecology (M.Sc.)

Elite Network Bavaria (ENB)

Current Version from 11 June 2018

In cases of legal dispute,
only the German version is valid
and legally binding.

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 the climate and ecosystem characteristics (mass balance, biodiversity). 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 have been supplemented by disciplines in social science.

It is feared that there will be negative consequences on goods and services in ecological systems (e.g. drinking water, food, pharmaceutical resources, carbon storage). Economical, social and political risks and uncertainties are to be expected. There is an urgent need for research and education in process-oriented problem analysis, effective ecological risk management as well as in the development of sustainable, optimised use strategies. These issues are of worldwide significance for the future development of society.

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 management leaders. With a well-founded scientific background and expertise knowledge, such individuals must be able to analyse complex issues, recognize new problems and work out and adopt possible 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 being discussed 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 well-founded 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 temporary and spatial consequences must be taken into consideration reaching 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 will be actively fostered throughout the course of study. Special courses and intensive, individual support differentiates the Elite degree programme from conventional programmes. Direct communication with the instructors is offered and is encouraged between all students; international students are given special attention and 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 (*Lecturen, V*) present a coherent description of the central topics in each respective Module. Lectures can also take place at partner universities.

During Seminars (*Seminaren, 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 optimally

taking advantage of 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 weekly meetings that take place on a regular basis. 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 (CP) is equivalent to 30 hours of work. For on-site classroom attendance, a one-hour class corresponds to 0.5-CP (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 and Courses

The Programme of Study is designed so that students can complete all requirements in four semesters and it 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 are to 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 in order 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) in relationship with „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 one Module in each semester must be chosen. (Fig. 1) Starting in the second semester an individual field of specialised interest (Specialization) will arise out of the selection of two further Modules from the course offerings from each particular Module Area. 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, but this is not necessary.

Additionally, students must take method-oriented courses (Module M) during the first two semesters to round out their knowledge. At this point any possible shortcomings can be compensated for and individual interests can be developed. It is possible to read in the course descriptions about the individual Module parts (see below) where previous knowledge in methods is required. This can be gained in method-oriented courses of different extents. 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 structure as a whole helps students to take responsibility for planning out their course of studies. Within the Modules there are no options to choose from (exceptions: Module F and M). However, under certain conditions student 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 own 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).

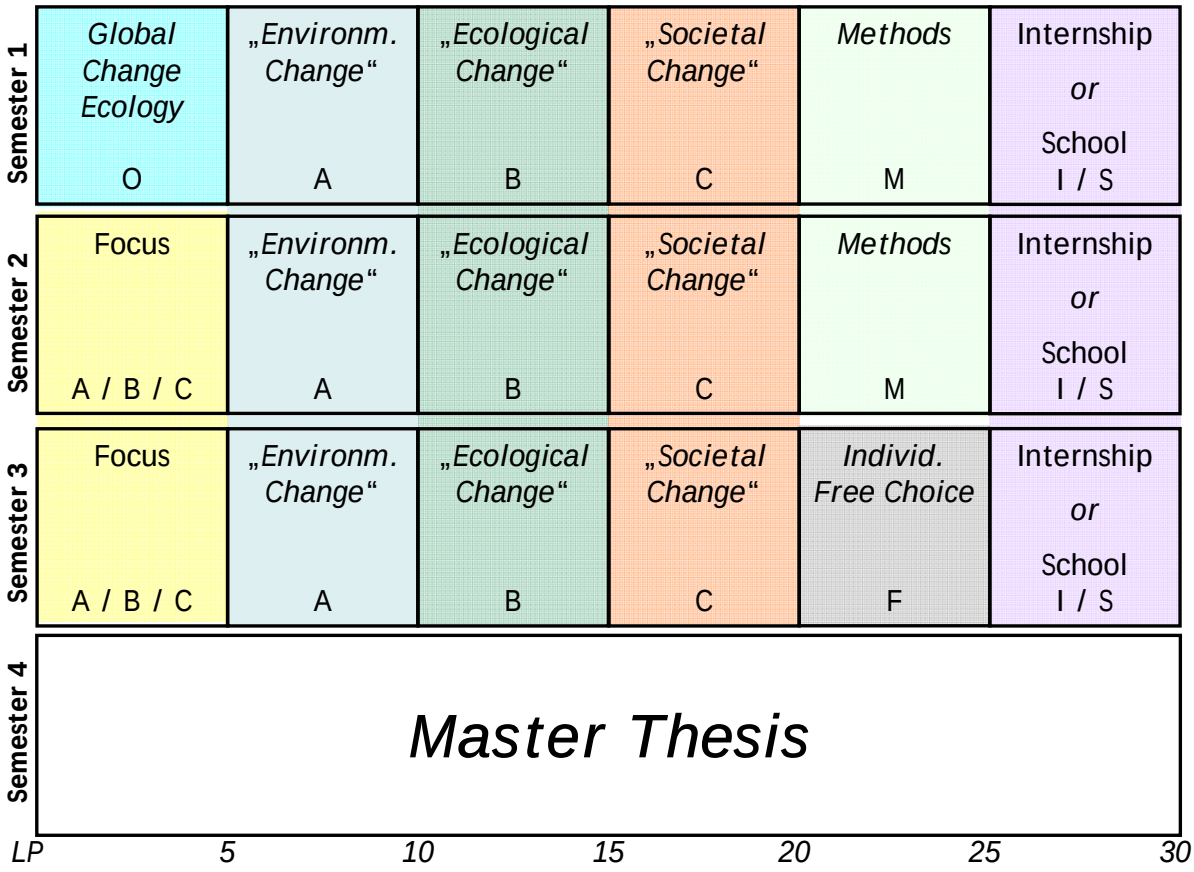

Fig. 1: Organisation of the programme showing topics of the Module Areas „Environmental Change“ (A), „Ecological Change“ (B) and „Societal Change“ (C) as well as Methods (M) and Practice-Oriented Modules. The introductory Module (O) is taught in an interdisciplinary manner. An over-lapping Module in 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 choices make it possible to focus (Specialization) in the areas of „Environmental Change“, „Ecological Change“ and „Societal Change“. The selection of method-oriented courses supports the thematic direction of the Specialised Modules. In each semester, 30-credit points (CP) must be earned, altogether 120-CP.

The small group structure of the courses encourages flexible design of course content as well as intensive discussion. Module Areas and Modules are based on legally valid requirements for academic degree programmes in Bavaria, but not the single courses described here below so that adaption to current developments is possible along with individual design of the course of study according to the area in which each person wishes to specialise. An inclusion of Workshops and Internships in the lecture-free periods makes for an intensive working structure.

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; however, 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 Structure and Course Schedule of Programme

The implications of Global Change will be dealt with 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. 1.2) 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 Modules in one (or two) 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. Three Modules are to be chosen from the course offerings in these Module groups.

Through individualised choice of advanced study, an individualised shaping of the programme is both possible and desired. As specialisation in one of the areas appears sensible, a particular direction or Module area can be chosen to focus on from A, B or C (two Modules can be selected from the course offerings in these Module Areas as well from the transdisciplinary selection in Module Area (F).

Additionally, free chose of courses offered in Module F leads to advanced study of the selection of **Methods** courses in Module M, **Internships** (Practical, Module I) and Science **Schools** (Module S). A Performance Assessment is required in these courses but they are ungraded. (See Fig. 2)

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.

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 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. Multidisciplinary specific Modules, listed in this Module Handbook under F, can be chosen as individually selective Modules and for Module specialisation (A/B/C). A total of 15-credit points are to be earned from Internships

(Module I) and Science Schools (Module S). Logistic problems in providing internship places or in the organisation of the Schools are avoided through the flexible manner in which courses are offered. The emphasis in each of these areas, those of Internships or Science Schools, may not exceed10-credit points.

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.

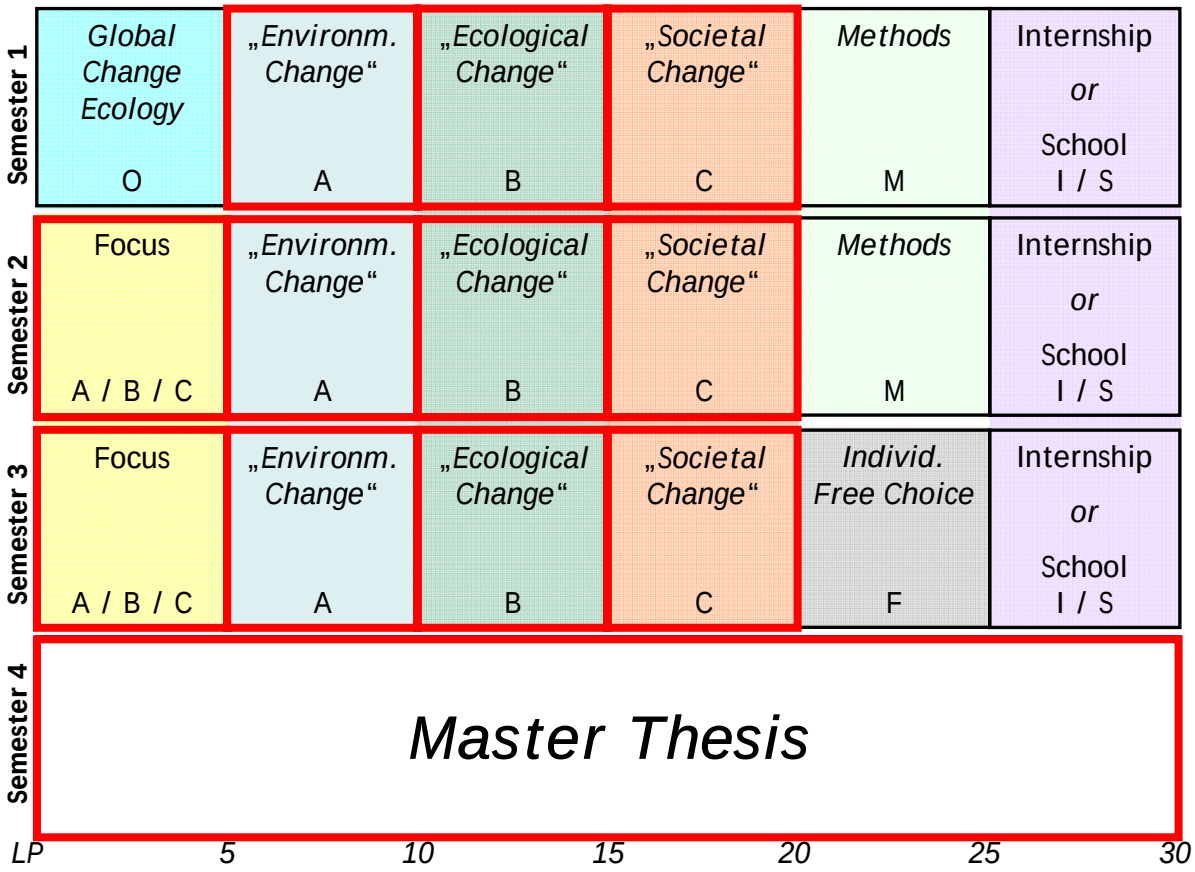

Fig. 2: Areas marked in red are graded Modules (85 of a total of 120-credit points). The end grade is composed of Module grades based on their respective number of credit points and the grade on the Master Thesis. The Module Global Change Ecology Overview (O), Methods (M), Free Choice (F), Internships (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 structure 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 exactly 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; Biogeographic Modelling UBT; Climatology, 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 CP)	
	S Progress in Global Change Research (1 SWS, 2 CP)	
	S Regularly Scheduled Meetings (1 SWS, 1 CP)	
	Excursions (1 SWS, 1 CP)	
Course Entry Requirements	No Special Course Entry Requirements	
Performance Assessment	Seminar contribution (ungraded) and Written Report (ungraded)	
Work Load	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
	Excursions:	15 Hours
	Total:	150 Hours
Credit Points	5 CP	
Scope of Time	One Semester (1st Master Programme Semester)	
When 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 physical and chemical mechanisms in relationship with global environmental changes. Physical and chemical specific aquatic and terrestrial ecological systems are identified. The dynamics of Global Change are handled in great detail whereby different spatial scales are examined. The speed of development in relationship 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 over-use and degradation, erosion and desertification. Finally, the relationship between environmental change and change in bio-chemical action is 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 Terrestrial Ecosystems

A6 Biogeochemical Fluxes

A7 Soil Erosion and Conservation

Total Extent of Module:

At least, 15-credit points. 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 CP) S Climate Variability and Change: Natural and Man-Made (2 SWS; 3 CP)	
Prerequisites	None	
Performance Assessment	Oral examination (graded) and seminar 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 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology 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; Atmospheric Chemistry, 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 analyze 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; 2 CP) Ü Ecological Climatology: Measurements and Analyses (2 SWS; 3 CP).	
Prerequisites	Module C2 Ecosystem Services and Biodiversity (recommended)	
Performance Assessment	Written Report (graded) and seminar contribution (ungraded)	
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 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Global Change Ecology, Physical Geography, Geoecology	
Reference to Other Modules	A4 Changes in Aquatic Ecosystems A5 Changes in Terrestrial Ecosystems	

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	Aim of this module is to teach about occurrence and impact of natural risks, extreme events and shocks. Reoccurring events are included as well as single disasters; those with stabilising effects and those with catastrophic consequences and regime change. The impact 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 catastrophe research and 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, among other things, abrupt climate change and the appearance of extreme weather events like heat waves, drought, intense rainfall, tropical cyclones and extra-tropical severe storms. Furthermore, e.g. large fires, insect calamities, pandemics, volcano eruptions, floods and toxic disasters will be covered and the system response analysed. The ecological consequences of possible future extreme events such as a lack of a cold winter and then late frosts in the northern hemisphere will also be covered.	
Teaching Style	V/Ü Natural Risks and Hazards (2 SWS; 2 CP) S Extreme Events (2 SWS; 3 CP)	
Prerequisites	A1 Climate Change	
Performance Assessment	Seminar contribution (ungraded) and written report (graded): Extended abstract	
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 CP	
Scope of Time	Two semesters (Recommended: 1st and 2nd Global Change Ecology semester)	
Seemster Offered	Winter Semester (V/Ü) Summer Semester (S)	
Target Group	Global Change Ecology, Physical 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	Aim is to teach about the interplay in the field of water as a resource between natural science and demands made by society within a global context.	
Course Content	The module is divided into a basic part about Hydrology (Lecture) and a part with strong practical content and independent work (Seminar/Exercise). The interplay of the three components of water balance in a catchment area (precipitation, evaporation, storage capability) is taught in the lecture, and system behaviour is discussed. The functions of natural hydrologic systems including model building will be dealt with. In the seminar/exercise risks and impairments of global water resources will be considered and discussed. The students investigate independently a topic and present it during the seminar. Seminar presentations will be complemented by contributions of external experts.	
Teaching Style	V Hydrological Systems (2 SWS; 3 CP) S/Ü Water resources in a quickly changing world – impacts and challenges (2 SWS, 2 CP)	
Prerequisites	None	
Performance Assessment	Written exam (graded) and Seminar 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 CP	
Scope of Time	Two semesters (Recommended: 1st and 2nd Global Change Ecology semester)	
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

Responsible for the Module	Agroecology UBT	
Structural Content	Agroecology UBT, Soil Physics UBT	
Learning Objectives	The module goal is to learn fundamental knowledge about regional and global developments in agroecosystems.	
Course Content	Concepts of agroecosystems research; Ecological mechanisms and processes that are influenced by global change; Drought; Principles of soil and plant water relationships; Implication of drought for agriculture worldwide; Human impact on water balances and resources on different scales; Hydrologic and biogeochemical interactions	
Teaching Style	V Soil and Plant Hydrology (2 SWS; 2 CP)	
	S Global Change and Agroecosystems (2 SWS; 3 CP)	
Prerequisites	None	
Performance Assessment	Written report (graded) and Seminar 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 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A1 Climate Change	

A6 Biogeochemical Fluxes

Responsible for the Module	Micrometeorology, UBT
Structural Content	Micrometeorology, UBT; Plant Ecology, UBT; Atmospheric Chemistry, UBT; Soil Physics, UBT;
Learning Objectives	The module aim is the advanced study about ecological matter and energy flows. Central starting point is the hydrological cycle in the air-water-soil-plant continuum.
Course Content	Measuring methods for bio-geochemical flows in the atmosphere, plants and soil: Profile of state variables, techniques to measure fluxes including Eddy-covariance and gradient approaches, radiation, sap flow, gas exchange, soil chambers, and lysimeter. Models of bio-geochemical flows: approaches like Penman Monteith, mesoscales and interface modules, SVAT models, plant models, soil models, statistic approaches, surface averaging, remote sensing, top-down and bottom-up approaches. Field campaigns with measurements in a forest eco-system, data analysis, modules of experimental data and modelling.
Teaching Style	Ü Transport Systems (4 SWS; 5 CP, in small groups) 1-day field exercises
Prerequisites	Knowledge of Modules A1 to A3
Performance Assessment	Exercise sheets with individual written reports (Micrometeo. Atm. Chem., Plant Ecol.) (graded); oral presentation (Soil Physics) (graded)
Workload	Active participation in 1 course: 120 hours Assessment component determined by instructor: 30 hours Total: 150 hours
Credit Points	5 CP
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)
Semester Offered	Summer Semester
Target Group	Global Change Ecology
Reference to Other Modules	Modules A1 to A3 A5 Changes in Terrestrial Ecosystems

A7 Environmental Soil Physics and Rhizosphere Biogeochemistry

Responsible for the Module	Soil Physics UBT	
Structural Content	Soil Physics UBT, Agroecology UBT	
Learning Objectives	The module goal is to learn fundamental soil physical and biogeochemical processes taking place at the root-soil interface and their larger scale implications.	
Course Content	Basic and advanced principles of soil physics and biophysics; Soil hydrology; Solute transport in the vadose; Root-soil interactions; Biogeochemical processes in soils; Water-carbon cycles in terrestrial systems; Physical and biogeochemical methods in soil science; Root-soil interactions in a changing climate and impacts on agricultural practices.	
Teaching Style	V Soil Physics (2 SWS; 3 CP)	
	S Rhizosphere biogeochemistry and biophysics (2 SWS; 2 CP)	
Prerequisites	None	
Performance Assessment	Written report (graded) and Seminar 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 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A5 Change in Agroecosystems	

4.3 Module Area B „Ecological Change“

The ecological effects of Global Change are dealt with in this Module. Interest is focused on the reaction 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 change in climate and land-use as well as growing global networking of natural habitats on species and biodiversity of ecological systems is discussed. Functional consequences will be derived from these processes. The significance of new, more efficient vectors for expansion of organisms will be dealt with as well as the impact of invasive species on ecological systems.

Loss of biodiversity is connected to considerable functional consequences and can intensify the direct impact of climate change. However, change in land-use as an important driving force behind loss of biodiversity is also a factor in climate change. This Module Area identifies different types of impact and their correlation to each other.

Climate Change goes way beyond short-term impact on structural content and functionality of ecological systems. That is why it is important to be able to evaluate resilience or strength in order to early recognize possible abrupt changes in systems and their consequences.

Organism processes determine the sequestration, storage and release of carbon. To better understand the expected atmosphere-chemical conditions, soil carbon dynamics must be studied.

Along with a background in biology, knowledge in methods of modelling and geostatistics is necessary. There is an opportunity to gain experience in data acquisition in Ecology Fieldwork, in using the equipment and in the execution of ecological experiments as well as in learning about data evaluation.

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 Biodiversity Research

B8 Dynamic and Vegetation Ecology

Total Extent of Course:

At least 15 credit points. 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. Putting together and presenting a presentation trains students in the production of survey articles based on current scientific primary literature.	
Course Content	Through global climate change, material flow, land-use and the linking 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, 2 CP) S Progress in Biogeography (2 SWS, 3 CP)	
Prerequisites	None	
Performance Assessment	Seminar presentation (graded)	
Work Load	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 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology, Environmental Geography, Biodiversity and Ecology, Geoecology	
Reference to Other Modules	B2 Biodiversity and Ecosystem Functioning	

B2 Biodiversity and Ecosystem Functioning

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT; Disturbance Ecology, UBT; Ecological-Botanical Garden, UBT	
Learning Objectives	Topics in ecological research have become prominent in this module over the past years. In particular, experiments like BioDEPTH have proven to be very stimulating for theory formation. The results, however, have also been relevant for practical use. Goal of this module is, therefore, an in-depth look at the relationship between biodiversity and ecological complexity and eco-system functions. This will be taught by using data as well as at the theoretical level.	
Course Content	Using model ecosystems as an example, the basic mechanisms showing a relationship between biodiversity and eco-system functions will be discussed. Guided by instructors, students will collect and evaluate data. In doing so, students will learn about the limitations of experimental approaches, while also showing how this contributes to gain of knowledge. Students will become familiar with different methods of collecting and evaluating data.	
Teaching Style	Ü Ecological Experiments with Model Ecosystems (4 SWS, 5 CP, in small groups)	
Prerequisites	Knowledge based on Module B1	
Performance Assessment	Written report (graded): Data evaluation (manuscript form)	
Workload	Active participation in 1 course:	120 hours
	Assessment component determined by instructor:	30 hours
	Total:	150 hours
Credit Points	5 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	Based on B1 Biogeography and Macroecology	

B3 Disturbance Ecology

Responsible for the Module	Disturbance Ecology, UBT	
Structural Content	Disturbance Ecology, UBT; Biogeographic Modelling UBT	
Learning Objectives	Module aim is to teach how ecosystems in all biomes are affected by natural and anthropogenic disturbance regimes, which create their own dynamics and temporary phenomena. Temporary deviations appear in different measures and in different qualities in all ecosystems. These can be necessary for system sustainability and demand stability features, such as, functional resilience, for example. This module tries to show the significance of temporary variety in ecological systems. Due to climate and land-use change, this is essential in order to evaluate system behaviour and for the conception of adaptation strategies.	
Course Content	Theory, methodology and application fields of Disturbance Ecology as well as the relationship between disturbance or deviation and vegetation dynamics are taught in this course. The development in this field of ecological basic research is also shown. Theories and hypotheses of Disturbance Ecology as well as methodological approaches are covered. The significance of Disturbance Ecology on ecosystem research, conservation and land-use are also worked out. Temporary variability of ecosystems, their rhythms and individual events are discussed to illustrate the dynamics of ecological systems.	
Teaching Style	V Disturbance Ecology (2 SWS, 3 CP) S/Ü Stability, Resilience and Inertia (2 SWS, 2 CP)	
Prerequisites	None	
Performance Assessment	Written Exam (graded) and seminar 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 CP	
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 CP) Ü Modelling of Spatial Ecological Processes (2 SWS, 3 CP)	
Prerequisites	B1 Biogeography and Macroecology (recommended) B2 Biodiversity and Ecosystem Functioning (recommended) M1 Introduction to R (obligatory) M4 Foundations of Biogeographical Modelling (recommended)	
Performance Assessment	Written report (graded) and seminar contribution (ungraded)	
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 CP	
Scope of Time	One semester (Recommended: 3rd Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules		

B5 Global Change Impacts on Species Distributions

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT, Remote Sensing, University of Würzburg	
Learning Objectives	Ability to analyze 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 CP)	
	Ü Global Change Impacts on Species Distributions (2 SWS; 3 CP)	
Prerequisites	M1 Introduction to R	
	M2 Statistical Modelling with R	
	M5 Remote Sensing	
Performance Assessment	Written report (graded) and seminar contribution (ungraded)	
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 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	M5 Remote Sensing	
	B4 Spatial Ecology	
	B7 Remote Sensing in Biodiversity Research	

B6 Soil Carbon and Global Change

Responsible for the Module	Soil Ecology, UBT	
Structural Content	Soil Ecology, UBT	
Learning Objectives	Knowledge of carbon reserves in the soil of different biomes, influence factors on soil carbon levels and soil carbon reserves. Impact on reserves by global climate changes as well as land-use. Technique of carbon inventory in soil.	
Course Content	Lecture: Carbon reserves in the soil, mechanisms of carbon stabilisation in soil, influence of climate and land-use change. The role of dissolved organic carbon compounds, models of carbon turnover in soils. Seminar: Current questions of carbon turnover in soil and manipulation by human beings: variety of topics. Tutorial: Carbon storage in different soil. Determining carbon levels in different soil. Extraction of water-soluble fractions. Qualitative features of organic substances.	
Teaching Style	V Soil Carbon Turnover (2 SWS, 2 CP), S Soil Carbon and Global Change (1 SWS, 1 CP) Ü Soil Carbon and Global Change (1 SWS, 2 CP)	
Prerequisites	Basic knowledge of soil science	
Performance Assessment	Written exam (graded) and written report (ungraded)	
Workload	Active participation in 3 courses:	60 hours
	Preparation and follow-up:	50 hours
	Assessment component determined by instructor:	40 hours
	Total:	150 hours
Credit Points	5 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A5 Changes in Terrestrial Ecosystems	

B7 Remote Sensing in Biodiversity Research

Responsible for the Module	Remote Sensing, University of Würzburg	
Structural Content	Remote Sensing, University of Würzburg Biogeography, UBT	
Learning Objectives	Possibilities of continual surface data collection through remote sensing for biodiversity research are taught. An important objective is to teach about the different ways of closing spatial gaps in field data collection by using hyperspectral remote sensing data. A suitable sampling design will be taught 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 field methods (Bitterlich, succession stage, dominant species, percentage of deadwood etc.) are compared with remote sensing data (hyperspectral data, results from remotely sensed field data like FAO land cover classification system LCCS; LAI records and hemispheric measuring). With selected examples, the potential and limitations of using different 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 Field Quantification of Biodiversity (2 SWS, 2 CP) Ü Remote Sensing Data Analysis (2 SWS, 2 CP) Ex Excursion (1 SWS, 1 CP)	
Prerequisites	M5 Remote Sensing B5 Global Change Impacts on Species Distributions	
Performance Assessment	Seminar presentation (ungraded) und written report (graded)	
Workload	Active Participation in 2 courses:	60 hours
	Active Participation on the Excursion	20 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	40 hours
	Total:	150 hours
Credit Points	5 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	M1 Introduction to R M5 Remote Sensing B2 Biodiversity and Ecosystem Functioning B5 Global Change Impacts on Species Distributions	

B8 Dynamic and Vegetation Ecology

Responsible for the Module	Vegetation Ecology, UBT	
Structural Content	Vegetation Ecology, UBT	
Learning Objectives	The module's aim is to teach students about the drivers that influence earth's vegetation distribution as well as to communicate the role of terrestrial vegetation in earth's ecosystems. Students will gain the skills to critically assess and interpret dynamic vegetation models.	
Course Content	The Lecture focuses on the most important ecological processes regarding terrestrial vegetation. The lecture stresses that the knowledge of biophysical laws is as crucial as the evolutionary history of individual sites to understand vegetation patterns. Major topics are for example the carbon-storage of leaves, carbon allocation in plant crowns and vegetation stands, birth and mortality as well as the structure of plant communities and ecosystems. The Seminar investigates case studies of applications of dynamic global vegetation models (DVGVMS, "Dynamic Global Vegetation Models") based on actual studies.	
Teaching Style	V Dynamic Vegetation Ecology (2 SWS. 2 CP) S Applications in Dynamic Vegetation Modelling (2 SWS. 3CP)	
Prerequisites	Basic R knowledge recommended	
Performance Assessment	Written report (graded) and seminar presentation (ungraded)	
Work Load	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 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology 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	

4.4 Module Area C „Societal Change“

Global environmental changes have on one hand, anthropogenic causes and on the other, 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 social-economic 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 of landscape aesthetical value).

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 practical use of accounting tools (e.g. eco-balance) that keep the 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 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 Drivers and Consequences of Land Use and Land Cover Change

C2 Ecosystem Services and Biodiversity

C3 Global Economy

C4 Global Policy and Governance

C5 Socio-Economic and Political Dimensions of Global Change

C6 Inter- and Transdisciplinary Concepts of Change

C7 Patterns of Land Use and Ecosystem Dynamics

Total Extent of Course:

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

C1 Drivers and Consequences of Land Use and Land Cover Change

Responsible for the Module	Micrometeorology, UBT	
Structural Content	Ecological Services, UBT; Micrometeorology, UBT	
Learning Objectives	Land-use change on a global and regional scale is an important aspect of global change and therefore must been seen both as a reaction to social-economic and climatic changes as well as one of the drivers. Feedback processes between land surface and atmosphere can create local and regional changes in land-use, have scale-independent results in the climatic system, and a sustainable impact on the living situation of the population. Students will develop a problem- and processoriented understanding of change in land cover and land-use in the last centuries and the resulting changes in climatic system (focussing on bioclimatic impacts, ecology and social consequences). Furthermore, the interrelation between social-political decisions and changes in land-use will be closely examined and future, sustainable strategies for action will be discussed.	
Course Content	The lecture deals with the spatial and temporal dynamics and the biophysical processes of land-use change and the resulting changes in (regional) climatic systems. Thereby, students will study how land-use change alters energy and material flows in the soil-vegetation-atmosphere system and sustaintainably influences the climate system as well as the regional climate. The seminar deals with the interrelation of land-use and social-economic changes and sustainable strategies for action within the context of global change.	
Teaching Style	V/S Land Use Change and Climate C1a (2 SWS, 2 CP) V/S Land Use Change and Socio-Economy C1b (2 SWS, 3 CP)	
Prerequisites	None	
Performance Assessment	Written Report (graded) and seminar contribution (ungraded)	
Workload	Active participation in 2 courses:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined byy instructor:	60 hours
	Total:	150 hours
Credit Points	5 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A2 Ecological Climatology C2 Ecosystem Services and Biodiversity C3 Global Economy	

C2 Ecosystem Services and Biodiversity

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	Global change of climate, land-use, markets and political systems has a strong influence on the productivity of an economic system. Aim of this module is an advanced discussion of the aspects of the productivity of economic systems relevant for society (food production, erosion regulation, drinking water purification, risk protection, etc) and their relationship to biodiversity.	
Course Content	The lecture „Ecosystem Services" provides an overview of economic system services in regional and global human environmental systems. Contents include the definition and classification of ecosystem services, as well as their relationship to biodiversity and the role of global change. Furthermore, topics include physical quantification and socio-economic evaluation, the supply and demand through social agents as well as the management of ecosystem productivity with policy instruments that are close to the market. The seminar supplements lecture topics with current research examples.	
Teaching Style	V Ecosystem Services (2 SWS, 2 CP) S Current Research in Ecosystem Services and Biodiversity (2 SWS, 3 CP)	
Prerequisites	None	
Performance Assessment	Written exam (graded) and seminar presentation (ungraded)	
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 CP	
Scope of Time	One semester	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	A5 Changes in Terrestrial Ecosystems B2 Biodiversity and Ecosystem Functioning C1 Drivers and Consequences of Land Use and Land Cover Change C3 Global Economy	

C3 Global Economy

Responsible for the Module	Ecological Services, UBT
Structural Content	Ecological Services, UBT; Empiric Economic Research, UBT
Learning Objectives	The worldwide increase in the need for goods and services as well as the globalisation of markets has international ecological and social impacts. On the one hand, developing countries can profit economically by increased export of raw material (e.g. bio fuel) or by direct investment from industrialised nations (e.g. in the agrarian sector); on the other hand, ecosystems with lower environmental standards such as in developing countries are being sustainably damaged. Aim of the module is to understand the flow of goods and services in global finance and raw material markets as well as their ecological impacts and to ask critical questions about environmental-political instruments.
Course Content	The lecture covers the fundamentals of the function and agents as well as evolution and crisis in the financial sector. Following this, there will be a discussion of ecological innovations in financial markets ("green" investment funds) and in public finance (environmental criteria in federal and state finance equalisation. This will help students to view critically the influence of the financial sector on environmental and ecosystems. Topics discussed in the seminar include which effect world trade has on raw materials due to terrestrial and marine ecosystem use. To reduce negative effects, environmental standards play an essential part in open economies. At the same time, a discrepancy in environmental policy standards between trade partners can distort competition. Global market changes, environmental consequences and political measures will be critically discussed.
Teaching Style	V Environmental Finance (2 SWS, 2 CP) S Globalization of Economies and the Environment (2 SWS, 3 CP)
Prerequisites	None
Performance Assessment	Written report (graded) and seminar presentation (ungraded)
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 CP
Scope of Time	One semester
Semester Offered	Summer Semester
Target Group	Global Change Ecology

Reference to Other Modules	C1 Drivers and Consequences of Land Use and Land Cover Change
	C2 Ecosystem Services and Biodiversity

C4 Global Policy and Governance

Responsible for the Module	Biogeography, 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 topics with a focus on climate change (e.g. the Stern Review), loss of biodiversity (e.g. The Economics of Ecosystems and Biodiversity TEEB), or land degradation (e.g. The Economics of Land Degradation ELD). Apart from their significance for politics and research, the focus is on the methodological and economic assessments and economic instruments of environmental policy. 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 CP) S Global Change Policy, Contracts and Administrative Strategies (CBD and IPBES) (2 SWS, 3 CP)	
Prerequisites	No special prerequsites	
Performance Assessment	Seminar presentation (graded), seminar contribution (ungraded)	
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 CP	
Scope of Time	One semester	
Semester Offered	Summer Semester"	
Target Group	Global Change Ecology	
Reference to Other Modules	C3 Global Economy C5 Socio-economic responses to global change M14 International Environmental Law	

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 human beings became the most important factor in biological, geological, and atmospheric processes. The module aims to address foundations and concepts to understand possible causes of global change and adaptation 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 is 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 the relationships between society and the environment from the perspective of political ecology. Areas of tension are 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 CP)	
Prerequisites	None	
Performance Assessment	Written report (graded), seminar contribution (ungraded)	
Workload	Active participation in 1 course:	60 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	60 hours
	Total:	150 hours
Credit Points	5 CP	
Scope of Time	One semester	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology, Human Geography	
Reference to Other Modules	C1 Drivers and Consequences of Land Use and Land Cover Change C2 Ecosystem Services and Biodiversity	

C6 Inter- and Transdisciplinary Concepts of Change

Responsible	Ecological Modelling, UBT
Structural Content:	Ecological Modelling, UBT; Ethnology, UBT; Ecological Services, UBT
Learning Objectives	Knowledge of theoretical approaches in which change in natural science, economy and cultural studies is described; application and critique of terms based on a study of current and historical examples of the relationship between human beings and the ecosystem. Integrability and transferability of research questions and results between scientific and other social groups.
Course Content	Environmental problems require not only expert knowledge but also the ability to work together with different disciplines and authorities. The aim of this module is to teach about the interface in interdisciplinary and transdisciplinary research. The possibilities and limits of these approaches will be discussed with examples. The course focuses on the terms ecosystem, landscape and wilderness. Historic examples of the human relationship to environment will be shown by lost cultures in regards to ecology, climatic, social and cultural aspects.
Teaching Style	S Research at the Natural and Social Science Interface (2 SWS, 2 CP) S Concepts of Change in Natural & Social Systems (2 SWS, 3 CP)
Prerequisites	None
Performance Assessment	Seminar presentation (graded), seminar 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 CP
Scope of Time	One semester
Semester Offered	Winter Semester
Target Group	Global Change Ecology
Reference to Other Modules	B3 Disturbance Ecology

C7 Patterns of Land Use and Ecosystem Dynamics

Responsible for the Module	Remote Sensing, University of Würzburg
Structural Content	Remote Sensing, University of Würzburg Ecological Services, UBT
Learning Objectives	Remote sensing makes an important contribution in the quantitative and qualitative study of anthropogenic ally formed or natural ecosystems. The analysis of satellite data makes it possible to estimate the status and development of land surface. Main components are: a) study of land surface and its change, and b) multi-temporary analyses of ecosystem parameters that normally consist of a conglomerate of land surface classifications. Students will be able to study and analyse land cover changes and ecosystem parameters with data from remote sensing. This module strengthens previous knowledge of remote sensing and ecosystem functions and enables students to carry out remote sensing work on ecosystem functions. This is done through different spatial definitions and methods as well as modelling approaches.
Content	This module teaches information about the application of remote sensing methods to analyse land cover and ecosystem functions. The lecture “Land Use Policies, Markets, and Ecosystems” addresses causes of changes in land use, in particular by using global and 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 functions are introduced and discussed. In the lecture and tutorial “Patterns of Land Use and Ecosystem Dynamics”, methods of remote sensing to record and assess land use change are examined in detail. Relevant sensor systems, data properties, and the development of standardized remote sensor products are addressed and important questions concerning spatial and temporal resolution are discussed. The practical part contains three components: a) Analysis land cover change, b) remote sensor models of selected (biophysical)) ecosystem parameters, like e.g. *Fraction of absorbed Photosynthetically Active Radiation* (FaPAR) or *Leaf Area Index* (LAI) and c) derivation of selection indicators to analyse ecosystem functions.
Teaching Style	V Land Use Policies, Markets and Ecosystems (2 SWS, 2 CP), V/Ü Patterns of Land Use and Ecosystem Dynamics (2 SWS, 3 CP)
Prerequisites	M5 Remote Sensing
Performance Assessment	Seminar presentation (graded), seminar contribution (ungraded)
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 CP
Scope of Time	One Semester (Recommendation 1st Global Change Ecology Semester)
Semester Offered	Winter Semester
Reference to Other Modules	B5 Global Change Impacts on Species Distributions

B7 Remote Sensing in Biodiversity Research

C1 Drivers and Consequences of Land Use and Land Cover Change

C2 Ecosystem Services and Biodiversity

4.5 Module Area M “Methods”

This Module Area contains courses with a variety of content and range that are able to address the different needs of the students. Altogether, courses to the extent of 10-credit points are to be chosen from the methods-oriented partial modules listed below.

The selection is directed on one hand at previous knowledge students might already have and on the other, 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 eco-system research, in measuring and in field research about Global Change as well as in carrying-out of 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 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 Partial-Modules listed below. For all Partial-Modules in Module M an ungraded Performance Assessment is required:

M1 Introduction to R

M2 Statistical Modelling with R

M3 Vegetation Science

M4 Foundations of Biogeographical Modelling

M5 Remote Sensing

M6 Time Series Analysis

M7 Environmental Forensics

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 Geostatistical Methods

M14 International Environmental Law

M15 Conservation, Science and Communication

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

M17 Academic Working Methods and Skills

M18 Impact Assessment of Markets and Policies on Land Use and Ecosystem Services

M19 Multivariate Analyses in Ecology

M20 Methods in Dynamic Vegetation Ecology

The Partial-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	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	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	Allocations, Objects, Data Types, Data Structures and their treatment; Constructions; In and Output of Data; Graphics; Functions; Efficient Programming;	
Teaching Style	V/Ü Introduction to R (2 SWS, 2 CP)	
Prerequisites	None	
Performance Assessment	Written Exam (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Ecology-oriented master's programmes	
Reference to Other Modules	Basis for Modelling Courses	

M2 Statistical Modelling with R

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	The aim of the course is to teach practical-oriented information about statistic modelling and implementation with R.	
Course Content	Probability theory; Estimation, Tests, Confidence Intervals, Linear Models; Generalised Linear Models; Mixed Models	
Teaching Style	V/Ü Statistical Modelling with R (2 SWS, 2 CP)	
Prerequisites	M1 Introduction to R (recommended)	
Performance Assessment	Written exam (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 CP	
Scope of Time	One semester (Recommended in 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Ecology-oriented master's programmes	
Reference to Other Modules	Basis for Modelling Courses	

M3 Vegetation Science

Responsible for the Module	Disturbance Ecology, UBT Biogeography, UBT	
Structural Content	Biogeography, UBT; Disturbance Ecology, UBT	
Learning Objectives	Module aim is an advanced theoretical and practical examination of methods and processes relating to vegetation science, vegetation mapping, and vegetation monitoring.	
Course Content	Learning current processes in vegetation science, vegetation mapping, monitoring changes in vegetation, patterns and dynamics, and understanding of the functional characterization of habitats, of scale dependence, the ability to recognize the role of disturbance regimes for vegetation dynamics, an understanding of data processing requirements and requirements for linking with remote sensing, a critical discussion of historical concepts in vegetation science.	
Teaching Style	V Vegetation Science (2 SWS, 2 CP) P Vegetation Mapping and Sampling (field course) (3 SWS, 3°CP)	
Prerequisites	None	
Performance Assessment	Written report (ungraded): protocol	
Workload	Active participation:	30 hours
	Field course:	80 hours
	Preparation and follow-up:	20 hours
	Written report:	20 hours
	Total:	150 hours
Credit Points	5 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Ecology-oriented master's programmes	
Reference to Other Modules	B1 Biogeography and Macroecology	
	B2 Biodiversity and Ecosystem Functioning	
	B3 Disturbance Ecology	

M4 Foundations of Biogeographical Modelling

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	"Biogeographic Modelling" concentrates on quantitative description 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 process oriented, individually based models to traditional statistical methods.	
Course Content	Vegetation models, distribution models, handling of spatial data in models, home range analyses	
Teaching Style	V/Ü Foundations of Biogeographical Modelling (2 SWS, 2 CP)	
Prerequisites	M1 Introduction to R (recommended) V/S Concepts in Biogeographical Modelling (recommended)	
Performance Assessment	Written report (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Ecology-oriented master's programmes	
Reference to Other Modules	M1 Introduction to R	

M5 Remote Sensing

Responsible for the Module	Remote Sensing, University of Würzburg	
Structural Content	Remote Sensing, University of Würzburg	
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 CP)	
Prerequisites	None	
Performance Assessment	Written report (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 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Geography-oriented master's programmes	
Reference to Other Modules	B7 Remote Sensing in Biodiversity Research M12 Introduction to GIS M15 Conservation, Science and Communication	

M6 Time Series Analysis

Responsible for the Module	Ecological Modelling, UBT	
Structural Content	Ecological Modelling, 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 analyse, Fourier analyse, ARIMA-models) a focus is on non-linear methods recurring analysis, singular system analysis, wavelets, dimension reduction, etc.). The selection of procedure 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-Practicum. 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 CP) P Time Series Analysis (2 SWS, 3 CP)	
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 CP	
Scope of Time	One semester (Recommended: 3rd Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Ecology-oriented master's programmes	
Reference to Other Modules	M1 Introduction to R M2 Statistical Modelling 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 Environmental Forensics

Responsible for the Module	Atmospheric Chemistry, UBT	
Structural Content	Environmental Geo-Chemistry, UBT; Atmospheric Chemistry, UBT;	
Learning Objectives	Module aim is to teach the subject and work techniques dealing with environmental chemical analytics with examples of contamination cases in the hydrosphere and atmosphere.	
Course Content	Environmental contamination subjected to law or public debate: basic analytical methods in environmental chemistry, air and water sampling, sample preparation, field analytical methods, laboratory analytical methods, formal discussion of analytical results: public hearing/court trial roleplay	
Teaching Style	V/Ü Analytical Methods in Environmental Chemistry) (2 SWS, 2 CP)	
	V/S Environmental Forensics (2 SWS, 3 CP)	
Prerequisites	Basic knowledge in environmental chemistry	
Performance Assessment	Seminar presentation (ungraded) and written report (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 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Ecology-oriented master's programmes	
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 valuation methods that can be used by leaders in business and politics to balance the environmental consequences of their decisions in landscape systems.	
Course Content	In the exercise ecosystem services in selected regions will be quantified with the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model. 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 CP)	
Prerequisites:	Basic knowledge in GIS (obligatory) and C2 Ecosystem Services and Biodiversity (recommended)	
Performance Assessment:	Written report (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Ecology and geography-oriented master’s programmes	
Reference to Other Modules	C2 Ecosystem Services and Biodiversity	

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 leaders to audit the environmental consequences of their decision.	
Course Content	The method of eco-auditing is introduced and with practical examples (e. g. auditing of energy products with Jatropha or wind energy), students learn to use the eco-auditing software SimaPro. Focus is on assessment of biodiversity and eco-system service providers.	
Teaching Style	Ü Life Cycle Assessment of Products (1,5 SWS, 2 CP)	
Prerequisites	None	
Performance Assessment	Written report (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 CP	
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 and Biodiversity 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 CP)	
Prerequisites	None	
Performance Assessment	Written report (ungraded)	
Workload	Active participation in 1 course:	10 hours
	Preparation and follow-up:	20 hours
	Total:	30 hours
Credit Points	1 CP	
Scope of Time	One semester (Recommended: 3rd Global Change Ecology 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	BayCEER, UBT;	
Structural Content	BayCEER (Administrative Office), UBT; Disturbance Ecology, UBT; 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 CP, in small groups)	
Prerequisites	No special prerequisites	
Performance Assessment	Seminar presentation (ungraded) and/or written 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 CP	
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	
	C6 Inter- and Transdisciplinary Concepts of Change	

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 CP)	
Prerequisites	None	
Performance Assessment	Written report (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	60 hours
Credit Points	2 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Reference to Other Modules	B4 Spatial Ecology M5 Remote Sensing	

M13 Advanced Geostatistical Methods

Responsible for the Module	Physical Geography, University of Augsburg	
Structural Content	Physical Geography, University of Augsburg	
Learning Objectives	Knowledge in Fundamental and Advanced Methods of Geostatistics	
Course Content	Principal Component Analysis; Multiple Regression Analysis; Canonical Correlation Analysis; Cluster Analysis; Discriminant Analysis.	
Teaching Style	V Advanced Geostatistical Methods (1 SWS, 1 CP)	
	Ü Advanced Geostatistical Methods (1 SWS, 2 CP)	
Prerequisites	Basic knowledge of statistics and statistic-software R (e.g. from Modules M1 and M2)	
Performance Assessment	Written report (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 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Reference to Other Modules	M1 Introduction to R	
	M2 Statistical Modelling with R	
	M6 Time Series Analysis	

M14 International Environmental Law

Responsible for the Module	Public Law, International Law and European Law, UBT	
Structural Content	Public Law, International Law and European Law, UBT	
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 Law (2 SWS, 3 CP)	
Prerequisites	None	
Performance Assessment	Written or oral exam (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 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Reference to Other Modules	C4 Global Policy and Governance	

M15 Conservation, Science and Communication

Responsible for the Module	Remote Sensing, University of Würzburg	
Structural Content	Remote Sensing, University of Würzburg; Zoological Society of London	
Learning Objectives	The course provides an overview of the challenges associated with scientific communication while discussing the potential for remote sensing to support real-world conservation efforts. At the end of this course, the students will have acquired a good understanding of the multiple factors shaping the success of management actions on the ground. They will also be provided with an overview of the institutions and policies relevant to natural resource management at the European and international scales. Importantly, this course aims to help support the development of critical thinking and decision making among students, while enhancing their presentation skills.	
Course Content	This course will present previously acquired knowledge in the light of current conservation needs. Faced with a suite of classical conservation issues and possible responses (e.g., invasive species management, translocations, REDD projects, protected area creation), the students will learn to appreciate the pros and cons of various scientific approaches and implementation processes. 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 conservation challenges. Actual conservation projects will therefore be developed by small teams of students, and presented to the whole group at the end of the course.	
Teaching Style	S/Ü Advanced Methods in Nature Conservation (2 SWS, 3 CP)	
Prerequisites	None	
Performance Assessment	Seminar presentation (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	90 hours
Credit Points	3 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology semester)	
Semester Offered	Summer Semester	
Target Group	Global Change Ecology	
Reference to Other Modules	B7 Remote Sensing in Biodiversity Research M5 Remote Sensing	

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

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	The Soil and Water Assessment Tool (SWAT) is a widely used, powerful simulation model to predict the impacts of climate and land use change on hydrology and matter fluxes in large river basins. The objective of this module is to teach the major principles and theoretical background of this model, and the practical application for the investigation, interpretation, and assessment of environmental problems.	
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, we will learn how to perform the model setup, parameterization, and calibration for a case study watershed. We will develop potential climate and land use change scenarios and evaluate their impacts with respect to ecosystem services.	
Teaching Style	V/Ü Modeling Ecosystem Functions with the Soil and Water Assessment Tool (SWAT) (4 SWS; 5 CP)	
Prerequisites	None	
Performance Assessment	Seminar presentation (ungraded) or written report (ungraded)	
Workload	Active participation in 1 course:	60 hours
	Preparation and follow-up:	60 hours
	Assessment component determined by instructor:	30 hours
	Total:	150 hours
Credit Points	5 CP	
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 Terrestrial Ecosystems A6 Biogeochemical Fluxes C7 Patterns of Land Use and Ecosystem Dynamics	

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 scientific working methods and skills. The students gain an overview and apply central elements: beginning with the selection of suitable sources of information and organizational skills up to written reports and oral presentations.	
Course Content	Literature data bases, structuring, visualization, written and oral presentations, poster design, body language, feeback, video analysis of presentations	
Teaching Style	V/Ü Academic Working Methods and Skills (2 SWS; 2 CP)	
Prerequisites	None	
Performance Assessment	Seminar presentation (ungraded) or written report (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	30 hours
	Total:	60 hours
Credit Points	2 CP	
Scope of Time	One semester (Recommended: 1st Global Change Ecology semester)	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology	
Reference to Other Modules		

M18 Impact Assessment of Markets and Policies on Land Use and Ecosystem Services

Responsible for the Module	Ecological Services, UBT	
Structural Content	Ecological Services, UBT	
Learning Objectives	National and international markets and policies can have significant impacts on regional land use and management decisions with substantial consequences for the provision of ecosystem services. The objective of this course is the development of potential land use scenarios for a case study region using available economic and political information and their assessment with respect to ecosystem services.	
Course Content	Based on market projections and present agricultural and environmental policies, we will identify potential scenarios of future land use and land cover trends for a selected case study region. We will use the Soil and Water Assessment Tool (SWAT) to quantify and evaluate the potential consequences of those scenarios for ecosystem services such as food production, erosion control, and water quality.	
Teaching Style	Ü Impact Assessment of Markets and Policies on Land Use and Ecosystem Services (2 SWS; 3 CP)	
Prerequisites	M16 Modeling Ecosystem Functions with the Soil and Water Assessment Tool (recommended)	
Performance Assessment	Seminar presentation (ungraded) or written report (ungraded)	
Workload	Active participation in 1 course:	30 hours
	Preparation and follow-up:	30 hours
	Assessment component determined by instructor:	30 hours
	Total:	90 hours
Credit Points	3 CP	
Scope of Time	One semester	
Semester Offered	Winter Semester	
Target Group	Ecology and geography-oriented master’s programmes	
Reference to Other Modules	C1 Drivers and Consequences of Land Use and Land Cover Change C2 Ecosystem Services and Biodiversity C7 Patterns of Land Use and Ecosystem Dynamics	

M19 Multivariate Analyses in Ecology

Responsible for the Module	Biogeography, UBT	
Structural Content	Biogeography, UBT	
Learning Objectives	“Multivariate Analyses in Ecology“ imparts knowledge to analyze diverse and voluminous ecological data sets about their spatial and environmental composition. Competences to extract causal drivers of ecologic processes shall be developed in the course.	
Course Content	Different multivariate data and analyze methods will be proposed. Applications such as classification (hierarchical and divisive cluster analysis) and ordination (PCA, CCA, RDA, NMDS) methods will be shown with complex ecologic data sets and analyzed with the free open source statistic software R.	
Teaching Style	Ü Multivariate Analyses in Ecology (2 SWS, 2 CP)	
Course Entry Requirements	Basic knowledge in univariate statistics, skills in R are helpful, but not mandatory	
Performance Assessment	Written exam (ungraded)	
Work load	Active participation in 1 course:	30 hours
	Preparation and follow-up:	30 hours
	Total:	60 hours
Credit Points	2 CP	
Scope of Time	One semester	
Semester Offered	Winter Semester	
Target Group	Global Change Ecology, Environmental Geography, Geoecology, Biodiversity and Ecology, Motivated bachelor students with good statistical skills are welcome	
Reference to Other Modules	M1 Introduction to R	
	M2 Statistical Modelling with R	

M20 Methods in Dynamic Vegetation Ecology

Responsible for the Module	Vegetation Ecology, UBT	
Structural Content	Vegetation Ecology, UBT	
Learning Objectives	The module's aim is to teach practical empirical methods, which follow the principal models of primary production and dynamic vegetation models.	
Course Content	The exercise course teaches students how to use non-destructive methods to estimate net-primary-production (NPP). Photosynthesis, transpiration, aspiration and leaf area will be measured in field exercises and analyzed with R to ultimately estimate the NPP. Further exercises in the Computer Lab focus on the use of open access earth observation data and how to utilize them in vegetation ecology to analyze NPP trends. The functionality of R as a geographical information system is used in the computer exercises. The results of the exercises will be summarized in a report written in the style of a scientific publication.	
Teaching Style	Ü Methods in Dynamic Vegetation Ecology (5 SWS. 5 CP)	
Prerequisites	Basic R knowledge recommended	
Performance Assessment	Written report (ungraded)	
Work Load	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 CP	
Scope of Time	One semester (Recommended: 2nd Global Change Ecology 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	

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-CP).

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 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 workshop character. However, courses at other venues will be accepted if they deal with the issues of Global Change and its impact. The Programme 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 very useful for developing individual networks that, particularly for this course of study, might be very significant for later career opportunities.

The credit points have different values due to the heterogeneity of international course offerings so that the students will not necessarily earn 5-credit points for each School. The students themselves choose the workload of each School.

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 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 written report (ungraded): short report	
Workload	Active Participation:	150-300 hours
	Total:	150-300 hours
Credit Points	5 to 10 CP per school depending on the length	
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	Alternates according to the topic	
	Basis for Master Thesis	

4.8 Module Area I “Internships”

With the help of the Coordination Office, Programme instructors provide 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 (e.g. MunichRe, Nature (München)

Internship in Science (Research Internship)

Collaboration with an internationally known research institution (e.g. Max- Plack-Institutes (MPI), Helmholtz-Center for Environmental Research Leipzig (UFZ), DLR Oberpfaffenhofen, PIK Potsdam, Smithsonian Conservation Biology Institute (SCBI), Zoological Society of London (ZSL)).

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 a 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	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 written report (ungraded): short report
Workload	For 5 CP: Six weeks fulltime internship *or* For 10 CP: Twelfe weeks fulltime internship
Credit Points	5 to 10 CP depending on the length of the individual internship
Scope of Time	The length of the mandatory internship (one time six or twelfe 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 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 centers 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 CP; 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 extent of 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	CP
1st Semester (Winter)		
O	Global Change Ecology Overview	5
A1	Climate Change	5
B1	Biogeography and Macroecology	5
C1	Drivers and Consequences of Land Use and Land Cover Change	5
M1	Introduction to R	2
M5	Remote Sensing	3
Semester Break (Winter)		
S	Science School	5
Total:		**30**
2nd Semester (Summer)		
A6	Biogeochemical Fluxes	5
A7	Soil Erosion and Conservation	5
B2	Biodiversity and Ecosystem Functioning	5
C3	Global Economy	5
M7	Environmental Forensics	5
Semester Break (Summer)		
S	Science School	5
Total:		**30**
3rd Semester (Winter)		
A4	Changes in Aquatic Ecosystems	5
A5	Changes in Terrestrial Ecosystems	5
B3	Disturbance Ecology	5
C7	Patterns of Land Use and Ecosystem Dynamics	5
M6	Times Series Analysis	5
Semester Break (Winter)		
I	Internship	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	CP
1st Semester (Winter)		
O	Global Change Ecology Overview	5
A1	Climate Change	5
B1	Biogeography and Macroecology	5
C1	Drivers and Consequences of Land Use and Land Cover Change	5
M1	Introduction to R	2
M5	Remote Sensing	3
Semester Break (Winter)		
S	Science School	5
Total:		**30**
2nd Semester (Summer)		
A2	Ecological Climatology	5
B2	Biodiversity and Ecosystem Function	5
B5	Global Change Impacts on Species Distributions	5
C5	Socio-Economic and Political Dimensions of Global Change	5
M4	Foundations of Biogeographical Modelling	2
M15	Conservation, Science and Communication	3
Semester Break (Summer)		
I	Internship	5
Total:		**30**
3rd Semester (Winter)		
A5	Changes in Terrestrial Ecosystems	5
B3	Disturbance Ecology	5
B4	Spatial Ecology	5
C2	Ecosystem Services and Biodiversity	5
M6	Time Series Analysis	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	CP
1st Semester (Winter)		
O	Global Change Ecology Overview	5
A1	Climate Change	5
B1	Biogeography and Macroecology	5
C1	Drivers and Consequences of Land Use and Land Cover Change	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
B5	Global Change Impacts on Species Distributions	5
C3	Global Economy	5
C5	Socio-Economic and Political Dimensions of Global Change	5
M7	Environmental Forensics	5
Semester Break (Summer)		
S	Science School	5
Total:		**30**
3rd Semester (Winter)		
A5	Changes in Terrestrial Ecosystems	5
B4	Spatial Ecology	5
C2	Ecosystem Services and Biodiversity	5
C7	Patterns of Land Use and Ecosystem Dynamics	5
M5	Remote Sensing	3
M10	Scientific Writing in Biogeography and Disturbance Ecology	2
Semester Break (Winter)		
I	Internship	5
Total:		**30**
4th Semester (Summer)		
	Master Thesis	30
Total:		**30**
Entire Total:		**120**